

[Return to Main Menu](#)

[Return to List of Standards](#)

[Return to History of Standards](#)



**American Water Works
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ANSI/AWWA C600-17
(Revision of ANSI/AWWA C600-10)

AWWA Standard

Installation of Ductile- Iron Mains and Their Appurtenances

Effective date: July 1, 2017.

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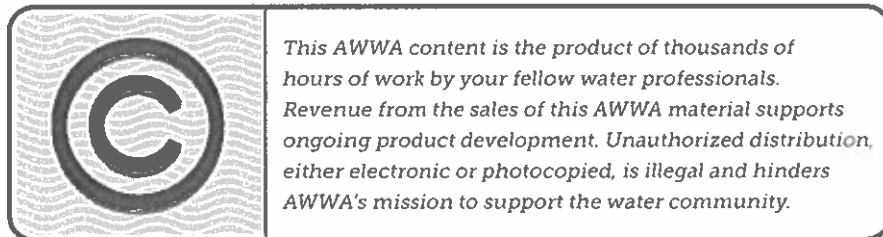
AWWA Standard

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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.

SEC.	PAGE	SEC.	PAGE
Foreword		4.5	Highway and Railroad Crossings..... 21
I	Introduction..... ix	4.6	Trenchless Applications..... 21
I.A	Background..... ix	4.7	Subaqueous Crossings..... 22
I.B	History..... ix	4.8	Service Taps..... 23
I.C	Acceptance..... x	5	Verification
II	Special Issues..... xi	5.1	Inspection..... 25
II.A	Use as Reference..... xi	5.2	Hydrostatic Testing..... 25
II.B	Chlorine and Chloramine Degradation of Elastomers..... xii	6	Delivery
III	Use of This Standard..... xii	6.1	Handling, Unloading, and Storage..... 30
III.A	Purchaser Options and Alternatives..... xii	6.2	Affidavit of Compliance..... 32
III.B	Modification to Standard..... xii		
IV	Major Revisions..... xii		
V	Comments..... xiii		
Standard			
1	General		
1.1	Scope..... 1	Figures	
1.2	Purpose..... 2	1	Laying Conditions for Ductile-Iron Pipe..... 10
1.3	Application..... 2	2	Push-on-Joint Assembly..... 11
2	References 2	3	Mechanical-Joint Assembly..... 12
3	Definitions 3	4	Pipeline Curve Geometry..... 15
4	Requirements	5	Preferred Method for Making Direct Service Taps on Polyethylene-Encased Iron Pipe..... 24
4.1	Permeation..... 4		
4.2	Materials..... 4		
4.3	Installing Ductile-Iron Mains..... 4		
4.4	Disinfection..... 21		
		Tables	
		1	Mechanical-Joint Bolt Torque..... 13
		2	Maximum Joint Deflection Full-Length Pipe—Push-on-Type Joint Pipe..... 14

SEC.		PAGE	SEC.		PAGE
3	Maximum Joint Deflection		5B	Hydrostatic Testing Allowance	
	Full-Length Pipe—			per 300 m of Pipeline—	
	Mechanical-Joint Pipe	15		L/hr.....	28
4	Maximum Recommended		6	Maximum Stacking Heights—	
	Direct Tap Size.....	24		Ductile-Iron Pipe	31
5A	Hydrostatic Testing Allowance				
	per 1,000 ft of Pipeline—				
	gph.....	27			

Foreword

This foreword is for information only and is not a part of ANSI/AWWA C600.

I. Introduction.

I.A. *Background.* The provisions of this standard are intended to act as a guide for installing extensions to existing distribution systems and in preparing contract documents for the construction of new systems or extensions. The standard is to be used as a guide for installing bell-and-spigot ductile-iron pipe (that includes push-on joint, mechanical joint, and restrained joint) and does not cover the provision and delivery of material, any other type of pipe, or any other type of joint. The standard includes information to be used as a part of the purchaser's documents.

I.B. *History.* The first edition of this AWWA standard, titled "Standard Specifications for Laying Cast-Iron Pipe" (7D.1-1938), was adopted in April 1938. The standard was published in the February 1938 edition of *Journal AWWA*. The standard was revised in 1949, including a change of title to "Standard Specifications for Installation of Cast-Iron Water Mains" (7D.1-T-1949 and C600-49T). The standard was expanded by adding numerous tables and installation guidelines. The model addendum was also expanded. The revised standard was published in the December 1949 edition of *Journal AWWA*. Section 9b, Joining of Mechanical-Joint Pipe, was added in May 1954. Section 9c, Joining of Push-on Joint Pipe, was added in 1964.

In 1975, the AWWA Standards Council formed the present C600 committee to revise ANSI/AWWA C600 to reflect current practices and to add ductile iron as a pipe material. To do this, the committee decided to completely change the character of the standard, removing the model addendum and making the standard consistent with the style of other AWWA standards.

In 1980, an addendum to the standard was approved that revised parts of Sec. 3.4 regarding mechanical-joint assembly.

The revisions made in the 1982 edition included the elimination of references to gray cast-iron pipe as a material for new pipeline installation because it was no longer manufactured for water utility service. Also, metric conversions were included in the 1982 revision; these were direct conversions of customary US inch-pound units, rather than those shown in International Organization for Standardization (ISO) standards.

* American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY10036.

The revisions made in 1987 included new references, a caveat against prolonged exposure of polyethylene film to sunlight, revised sections on thrust restraint and hydrostatic testing, and a discussion on making service taps on polyethylene-encased iron mains.

Revisions made in the 1993 edition included the addition of 60-in. (1,500 mm) and 64-in. (1,600 mm) pipe, revisions to the hydrant installation section, a new section on subaqueous crossings, and a recommended procedure for tapping through polyethylene encasement.

For the 1999 revision, there were no major changes to the standard. Review responsibility was transferred to the A21 committee, but there were no changes to the alphanumeric designation of the standard.

Revisions made in the 2005 edition included restrictions on filling the void between carrier and casing pipe for highway and railroad crossings, the introduction of trenchless applications, and a modification of the hydrostatic testing allowance formula.

Revisions made in the 2010 edition included additional instructions for the selection and installation of polyethylene encasement, including subaqueous installations, and a reference to high-pressure water cleaning in the flushing section.

This edition was approved on Jan. 14, 2017.

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

In the United States, authority to regulate products for use in, or in contact with, drinking water rests with individual states.† Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health effects of products and drinking water additives from such products, state and local agencies may use various references, including

1. Specific policies of the state or local agency.

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

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

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

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

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

Annex A, “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 C600 does not address additives requirements. Users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements, including applicable standards.
2. Determine the status of certifications by all parties offering to certify products for contact with, or treatment of, drinking water.
3. Determine current information on product certification.

II. Special Issues.

II.A. *Use as Reference.* ANSI/AWWA C600, *Installation of Ductile-Iron Mains and Their Appurtenances*, can be used as a reference when making extensions to existing distribution or transmission systems or when constructing new distribution or transmission systems using ductile-iron mains with either mechanical or push-on joints. It is not intended for this standard to be used as a purchase document, but it may be used as a reference in purchaser's documents. It is based on a consensus of the committee on the minimum practice consistent with sound, economical service under normal conditions, and its applicability under any circumstances must be reviewed by a responsible engineer. The standard is not intended to preclude the manufacture, marketing, purchase, or use of any product, process, or procedure.

⁴ Both publications available from National Academy of Sciences, 500 Fifth Street, NW, Washington, DC 20001.

II.B. *Chlorine and Chloramine Degradation of Elastomers.* The selection of materials is critical for water service and distribution piping in locations where there is a possibility that elastomers will be in contact with chlorine or chloramines. Documented research has shown that elastomers such as gaskets, seals, valve seats, and encapsulations may be degraded when exposed to chlorine or chloramines. The impact of degradation is a function of the type of elastomeric material, chemical concentration, contact surface area, elastomer cross section, and environmental conditions as well as temperature. Careful selection of and specifications for elastomeric materials and the specifics of their application for each water system component should be considered to provide long-term usefulness and minimum degradation (swelling, loss of elasticity, or softening) of the elastomer specified.

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 C600, Installation of Ductile-Iron Mains and Their Appurtenances, 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).

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 revisions to this edition of the standard include the following:

1. New Sec. II.B, Chlorine and Chloramine Degradation of Elastomers, was added.
2. Added references to raw water throughout the standard.
3. Provided additional clarification on Pipe Cleanliness section (Sec. 4.3.3.3) for polyethylene pipe.
4. Updated Table 1, Mechanical-Joint Bolt Torque, to include reference through 64-in. (1,600-mm) joint size.
5. Clarified allowable backfill material (Sec. 4.3.5.1.2).
6. Added provisions for air-release and vacuum vents (Sec. 4.3.6.3.2).
7. Added recommendations for tapping (see Sec. 4.8.1) and Table 4, Maximum Recommended Direct Tap Size.

8. Clarified recommendations in Sec. 5.2.1.4, Testing Allowance, and in Sec. 5.2.1.5, Acceptance of Installation.

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

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AWWA Standard

Installation of Ductile-Iron Mains and Their Appurtenances

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes installation procedures for ductile-iron mains and their appurtenances for potable water, wastewater, reclaimed water, and raw water.

1.1.1 *Conditions not discussed.* Installations that require special attention, techniques, and materials are not discussed. Each of these installations requires special considerations based on many influencing factors that cannot be discussed adequately in a single standard. These installations may require design by a competent engineer and consultation with representatives of the material manufacturing industry. Some of these special installations include the following:

1. Piping through rigid walls.
2. Piping on supports aboveground or belowground.
3. Piping requiring insulation.
4. Treatment plant or pump-station piping.
5. Flanged-joint piping.
6. Ball and socket piping.
7. Grooved and shouldered piping.
8. Restrained joint piping.
9. Industrial piping.

10. Piping through geologically hazardous areas.
11. Piping in high-density, stray-current environments.
12. Piping through unstable soil.

Sec. 1.2 Purpose

The purpose of this standard is to provide the minimum requirements for the installation of ductile-iron potable water, wastewater, reclaimed water, and raw water mains and their appurtenances, including materials, dimensions, tolerances, and testing procedures.

Sec. 1.3 Application

This standard can be referenced in purchase documents for installing ductile-iron mains and their appurtenances. The stipulations of this standard apply when this document has been referenced and then only to the installation of ductile-iron mains and their appurtenances.

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 this standard. In any case of conflict, the requirements of this standard shall prevail.

AASHTO* T99—Standard Method of Test for the Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop.

ANSI†/AWWA C105/A21.5—Polyethylene Encasement for Ductile-Iron Pipe Systems.

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

ANSI/AWWA C150/A21.50—Thickness Design of Ductile-Iron Pipe.

ANSI/AWWA C151/A21.51—Ductile-Iron Pipe, Centrifugally Cast.

ANSI/AWWA C500—Metal-Seated Gate Valves for Water Supply Service.

ANSI/AWWA C515—Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service.

ANSI/AWWA C509—Resilient-Seated Gate Valves for Water Supply Service.

ANSI/AWWA C651—Disinfecting Water Mains.

* American Association of State Highway and Transportation Officials, 444 North Capitol Street, NW, Suite 429, Washington, DC 20001.

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

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

AWWA Manual M27—*External Corrosion Control for Infrastructure Sustainability.*

AWWA Manual M41—*Ductile-Iron Pipe and Fittings.*

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

1. *Constructor:* The party that provides the work for placement or installation. Materials may be provided by the constructor or other parties.

2. *Ductile iron:* Cast ferrous material in which a major part of the carbon content occurs as free graphite in a substantially nodular or spheroidal form.

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

4. *Mechanical joint:* The gasketed and bolted joint as detailed in ANSI/AWWA C111/A21.11.

5. *Plans:* Drawings normally prepared by an engineer employed or retained by the ultimate system-operating company showing the location and details of the construction of the pipeline and appurtenances.

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

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

8. *Purchaser's documents:* The package consisting of the plans, specifications, and the contract under which the products are being purchased and installed.

9. *Push-on joint:* The single rubber-gasket joint as described in ANSI/AWWA C111/A21.11.

10. *Raw water:* Water from supply source prior to treatment.

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

12. *Restrained joint:* A pipe joint designed to resist forces that act to separate a joint, such as thrust caused by internal pressure, external pulling forces, and so on.

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

14. *Surge pressure:* The transient internal hydrostatic pressure that the pipeline is subjected to because of pressure waves created by the conveying fluid's velocity change.

15. *Test pressure:* The internal hydrostatic pressure specified in the contract documents to which the pipeline shall be subjected during the hydrostatic pressure test and the resting allowance test.

16. *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.

17. *Working pressure:* The internal hydrostatic pressure that the pipeline is subjected to, not including surge pressure.

SECTION 4: REQUIREMENTS

Sec. 4.1 Permeation

The selection of materials is critical for potable water, wastewater, and reclaimed water service and distribution piping in locations where there is likelihood the pipe will be exposed to significant concentrations of pollutants composed of low-molecular-weight petroleum products or organic solvents or their vapors. Documented research has shown that pipe materials, such as polyethylene, polyvinyl chloride, and elastomers, such as those used in jointing gaskets and packing glands, are subject to permeation by low-molecular-weight organic solvents or petroleum products. If a potable water, wastewater, reclaimed water, or raw water pipe must pass through a contaminated area or an area subject to contamination, consult with the manufacturer regarding permeation of pipe walls, jointing materials, and so on *before* selecting materials for use in that area.

Sec. 4.2 Materials

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

Sec. 4.3 Installing Ductile-Iron Mains

4.3.1 *Alignment and grade.* The water mains shall be laid and maintained on lines and grades established by the purchaser's documents for the project. Fittings, valves, tapped or bossed outlets, and hydrants shall be installed at the required locations, unless field conditions warrant otherwise and these changes are

approved in accordance with the purchaser's documents. Valve-operating stems shall be oriented to allow proper operation. Hydrants shall be installed plumb.

4.3.1.1 *Prior investigation.* Prior to excavation, an investigation shall be conducted to determine the location of existing underground structures, conflicts, and potential for corrosive soil conditions. During excavation, damage to existing structures should be avoided. Special precautions shall be taken when the water main being installed crosses or is adjacent to a facility that is cathodically protected.

4.3.1.2 *Unforeseen obstructions.* When obstructions not indicated on the purchaser's documents interfere with the progress of work, alteration of the purchaser's documents is required. Alterations or deviations in line and grade or the removal, relocation, or reconstruction of the obstructions shall be performed in accordance with the purchaser's documents.

4.3.1.3 *Clearance.* When crossing existing pipelines or other structures, alignment and grade shall be adjusted as necessary, in accordance with the purchaser's documents, to provide clearance as required by federal, state or provincial, and local regulations or as deemed necessary to prevent future damage or contamination of either structure.

4.3.2 *Trench construction.* The trench shall be excavated to the required alignment, depth, and width specified or shown in the purchaser's documents and shall conform to all federal, state or provincial, and local regulations for the protection of the workers.

4.3.2.1 *Trench preparation.* Trench preparation shall proceed in advance of pipe installation as stated in the purchaser's documents.

4.3.2.1.1 *Discharges from trench dewatering pumps* shall be directed away from the trench to prevent trench instability and shall be in accordance with federal, state or provincial, and local point-discharge requirements.

4.3.2.1.2 *Excavated material* shall be placed in a manner that will not obstruct the work nor endanger workers or the public nor obstruct sidewalks, driveways, roadways, or other structures. Excavated material shall be placed in compliance with federal, state or provincial, and local regulations.

4.3.2.2 *Pavement removal.* Pavement and road surfaces shall be removed as part of the trench excavation. The amount removed shall depend on the width of trench required for the installation of the pipe and the dimensions of the area into which valves, hydrants, specials, manholes, or other structures will be installed. The dimensions of pavement removed shall not exceed the dimensions of the opening required for installation of pipe, valves, hydrants, specials, manholes, and other

structures by more than 6 in. (150 mm) in any direction, unless otherwise stipulated in the purchaser's documents. Sawing, drilling, or chipping shall be used to ensure the breakage of pavement along straight lines.

4.3.2.3 Width. The width of the trench at the top of the pipe shall permit the pipe to be laid and joined properly and to allow the backfill to be placed in accordance with the purchaser's documents. As a guide, trench widths should be the nominal pipe diameter plus 24 in. (610 mm). When required, trenches shall be wider to permit the placement of timber supports, sheeting, bracing, and appurtenances as required by the safety requirements of the agency having jurisdiction.

4.3.2.4 Bell holes. Holes for the bells shall be provided at each joint, and they shall be no larger than necessary to allow joint assembly and to ensure the pipe barrel will lie flat on the trench bottom. The dimensions of bell-hole depressions for push-on-type joints should be large enough to ensure the pipe is not resting on the bells and is supported by the full length of the pipe barrel. In installations where polyethylene encasement film is used for corrosion control, the bell-hole depression shall allow for specified film overlap as described in ANSI/AWWA C105/A21.5.

4.3.2.4.1 Other than noted previously, the trench bottom shall be true and even to provide support for the full length of the pipe barrel. A slight depression may be provided to allow withdrawal of pipe slings or other lifting tackle without damaging coating or polyethylene encasement.

4.3.2.5 Rock conditions. When excavation of rock is necessary, all rock shall be removed to provide a clearance below and on each side of all pipe, valves, and fittings of at least 6 in. (150 mm) for nominal pipe sizes 24 in. (610 mm) or smaller and 9 in. (230 mm) for nominal pipe sizes 30 in. (762 mm) and larger. When excavation is completed, a layer of appropriate backfill material (see Sec. 4.3.5) shall be placed on the bottom of the trench to the appropriate depths, then leveled and tamped.

4.3.2.5.1 These clearances and bedding procedures shall also be observed for pieces of concrete or masonry and other debris or subterranean structures, such as masonry walls, piers, or foundations that may be encountered during excavation.

4.3.2.5.2 This installation procedure shall be followed when gravel formations containing loose cobbles or boulders greater than approximately 8 in. (200 mm) in diameter are encountered.

4.3.2.5.3 In all cases, the specified clearances shall be maintained between the bottom of all pipe and appurtenances and any part, projection, or point of rock, boulder, or stone of sufficient size and placement that could cause a fulcrum point or point load.

4.3.2.6 Previous excavations. If the trench passes over a previous excavation, such as a sewer, the trench bottom shall be sufficiently compacted to provide support equal to that of the native soil or conform to other regulatory requirements in a manner that will prevent damage to the existing installation.

4.3.2.7 Blasting. Blasting for excavation shall be permitted only after securing approval(s) and establishing the hours of blasting as required by the purchaser's documents. The blasting procedure, including protection of persons and property, shall be in strict accordance with federal, state or provincial, and local regulations.

4.3.2.8 Protecting property. Trees, shrubs, fences, and all other property and surface structures shall be protected during construction, unless their removal is shown in the purchaser's documents.

4.3.2.8.1 Any cutting of tree roots or branches shall be performed in accordance with the purchaser's documents.

4.3.2.8.2 Temporary support, adequate protection, and maintenance of all underground and surface structures, drains, sewers, and other obstructions encountered during the work shall be provided in accordance with purchaser's documents or applicable regulations.

4.3.2.8.3 All properties that have been disturbed shall be restored as completely as practical to their original condition, unless otherwise indicated in the purchaser's documents.

4.3.2.9 Unsuitable material. When material is found to include ashes, cinders, refuse, organic material, or other unsuitable material, this material shall be removed to a minimum of at least 6 in. (150 mm) below the bottom of the pipe or to the depth required by the purchaser's documents. The removed material shall be replaced with clean, stable backfill material. When these potentially corrosive materials are encountered, polyethylene encasement should be used to protect the pipe (see Sec. 4.3.3.8). The bedding shall be consolidated and leveled so that the pipe may be installed in accordance with Sec. 4.3.2.4.

4.3.2.10 Unstable material. When the bottom of the trench consists of material that is unstable to such a degree that its removal is impractical, a foundation for the pipe or appurtenance shall be constructed using piling, treated timber, concrete, or other materials, in accordance with the purchaser's documents.

4.3.2.11 Traffic control. Appropriate traffic-control devices shall be provided in accordance with federal, state or provincial, and local regulations to regulate, warn, and guide traffic at the work site.

4.3.3 *Installing pipe.* The proper implements, tools, and facilities shall be provided and used for the safe and convenient performance of the work. All pipe, fittings, valves, and hydrants shall be lowered carefully into the trench using a backhoe, a crane, ropes, or other suitable tools or equipment in such a manner as to prevent damage to water main materials, coatings, polyethylene encasement, and linings. Polyethylene encased pipe shall be hoisted using wide-belt nylon slings, padded caliper clamps, or an equivalent method that will not cause damage to the encasement film. Under no circumstances shall pipe materials be dropped or dumped into the trench. The trench should be dewatered prior to installation of the pipe.

4.3.3.1 *Examining material.* All pipe, fittings, valves, hydrants, and other appurtenances shall be examined carefully for damage and other defects immediately before installation. Defective materials shall be marked and held for final disposition as required by the purchaser's documents.

4.3.3.2 *Pipe ends.* All lumps, blisters, and excess coating shall be removed from the socket and plain ends of each pipe, and the outside of the plain end and the inside of the bell shall be wiped clean and dry and be free of dirt, sand, grit, or any foreign materials before the pipe is laid.

4.3.3.3 *Pipe cleanliness.* Foreign material shall be prevented from entering the pipe while it is being placed in the trench. No debris, tools, clothing, or other materials shall be placed in the pipe at any time. On pipes that are to be polyethylene encased, the surface of the pipe shall be cleaned of all lumps of clay, mud, cinders, and so on prior to installation of the encasement.

4.3.3.4 *Pipe placement.* As each length of pipe is placed in the trench, the joint shall be assembled and the pipe brought to correct line and grade. The pipe shall not be bumped with a backhoe bucket to obtain the correct line or grade because of the possibility of such practice causing damage to the pipe and/or lining. The pipe shall be secured in place with approved backfill material.

4.3.3.5 *Direction of bells.* It is common practice to lay pipe with the bells facing the direction in which work is progressing; however, it is not mandatory. For example, when the main is being laid on a slope, the pipe is frequently laid with the bells facing uphill for ease of installation. The direction of the bells is not functionally related to the direction of flow within the main.

4.3.3.6 *Pipe plugs.* When pipe-laying is not in progress, the open ends of pipe shall be closed by watertight plugs or other means as specified. A plug shall be fitted with a means for venting. When practical, the plug shall remain in place

until the trench is pumped completely dry. Care must be taken to prevent pipe flotation if the trench fills with water.

4.3.3.6.1 Before removal of a plug for extending the line or for any other reason, air and water pressure in the line shall be released.

4.3.3.7 Ductile-iron laying conditions. The laying conditions for ductile-iron pipe shall be completed in accordance with ANSI/AWWA C150/A21.50 as illustrated in Figure 1 of this standard and as required by the purchaser's documents.

4.3.3.7.1 Loosely placed backfill above the pipe may allow settlement that could be detrimental to improvements subsequently placed over the trench.

4.3.3.8 Polyethylene encasement.

4.3.3.8.1 Material. For any installation requiring polyethylene encasement for corrosion control of ductile-iron pipe, the encasement shall be specified and selected in accordance with ANSI/AWWA C105/A21.5 and as required by the purchaser's documents. The manufacturer of polyethylene film for corrosion protection encasement of ductile-iron pipe shall have a verifiable quality control system to ensure that it complies with all requirements of this referenced standard.

4.3.3.8.2 Installation. The polyethylene encasement shall be installed by personnel trained or experienced in proper application of the encasement as described in ANSI/AWWA C105/A21.5. At all times during construction of the pipeline, precautions shall be taken to prevent damage to the encasement film. No metal tools or heavy objects shall be permitted to contact the encasement unnecessarily. Workers shall not be permitted to walk on the encasement film except when necessary. Any damage to the pipe or the encasement film from any cause during installation shall be repaired.

4.3.3.9 Other forms of corrosion protection. For installations requiring other forms of corrosion protection, refer to AWWA Manual M27, *External Corrosion Control for Infrastructure Sustainability*.

4.3.3.10 Specials. Special transition couplings or gaskets are required and are available for joining different types of pipe, such as steel pipe, asbestos-cement pipe, and plastic pipe. When ordering specials, the actual outside diameter of the pipe should be provided.

4.3.4 *Joint assembly.*

4.3.4.1 Push-on joints. Push-on joints shall be assembled as described and illustrated in Figure 2.

4.3.4.2 Mechanical joints. Mechanical joints shall be assembled as described and illustrated in Figure 3 and Table 1.

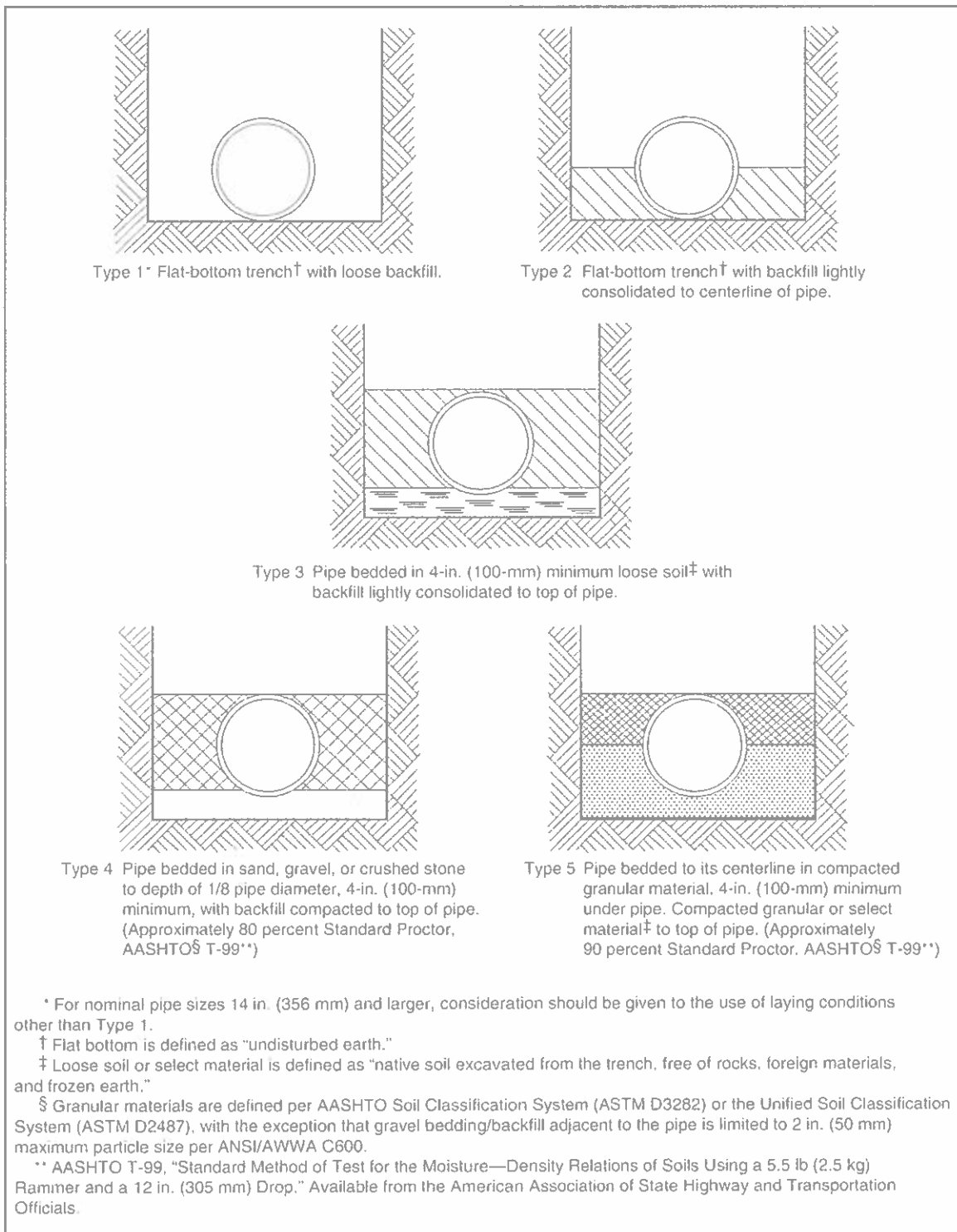


Figure 1 Laying conditions for ductile-iron pipe

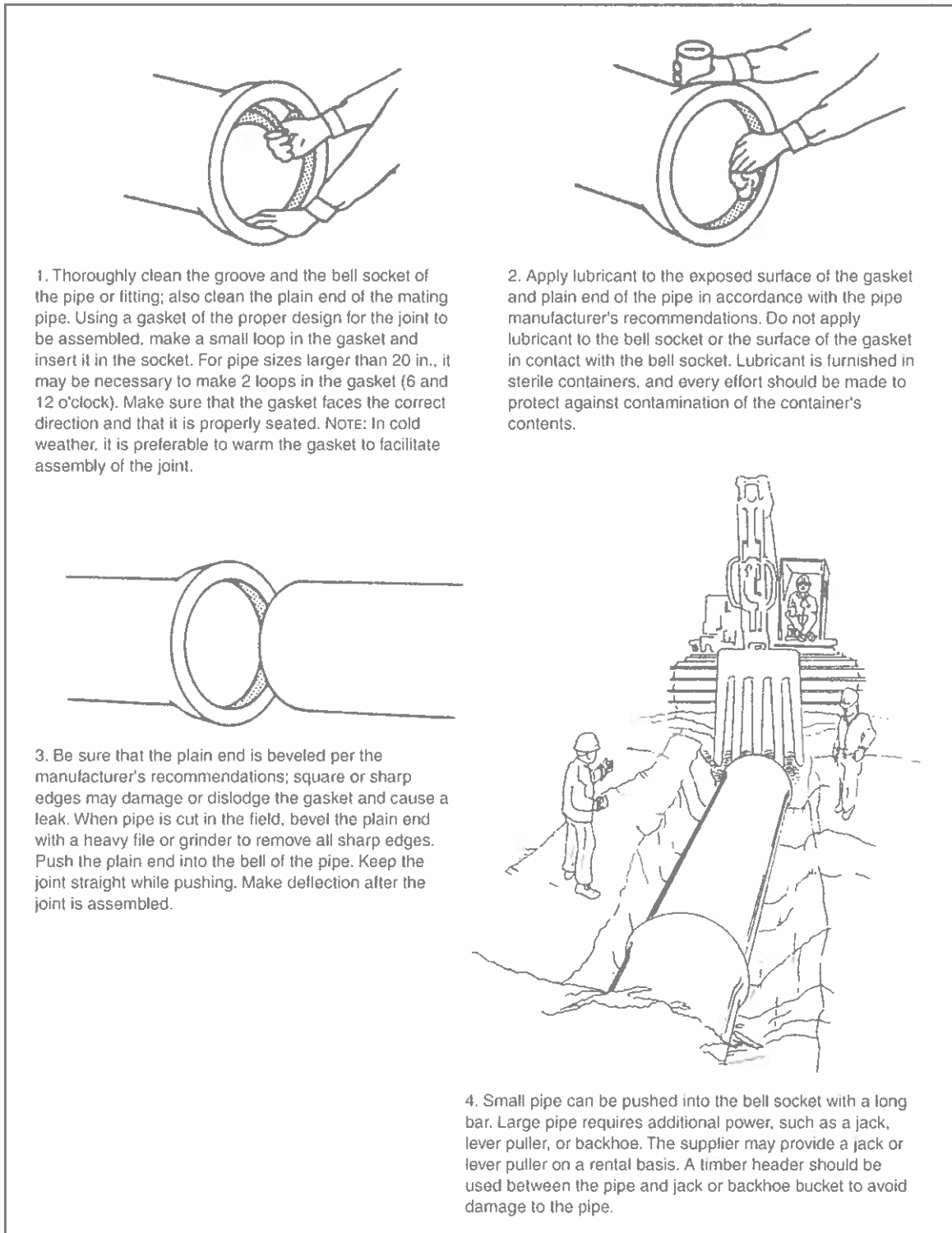


Figure 2 Push-on-joint assembly

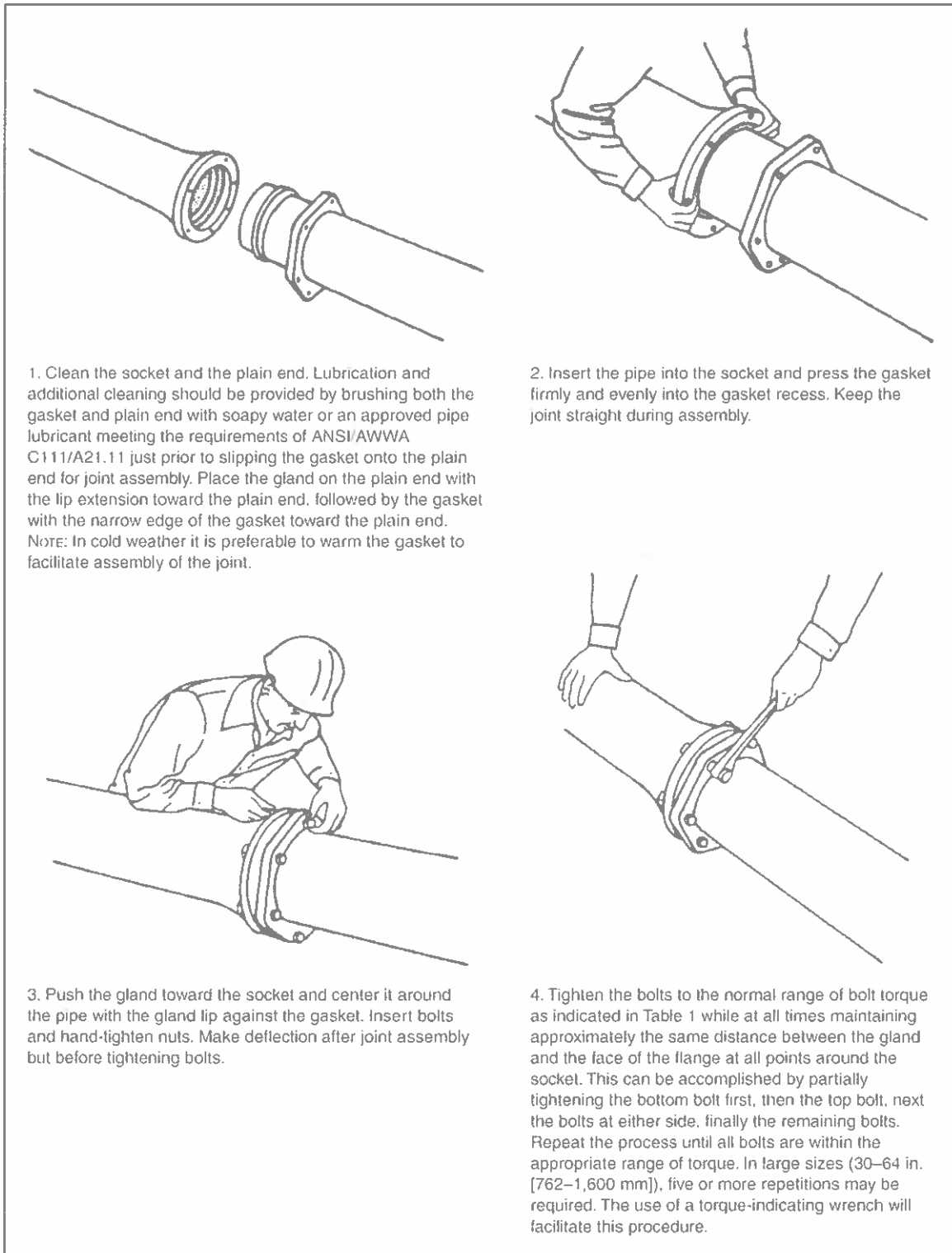


Figure 3 Mechanical-joint assembly

Table 1 Mechanical-joint bolt torque

Joint Size		Bolt Size		Range of Torque		Length of Wrench*	
<i>in.</i>	<i>(mm)</i>	<i>in.</i>	<i>(mm)</i>	<i>ft-lb</i>	<i>(N·m)</i>	<i>in.</i>	<i>(mm)</i>
3	(76)	$\frac{5}{8}$	(16)	45–60	(61–81)	8	203
4–24	(102–610)	$\frac{3}{4}$	(19)	75–90	(102–122)	10	254
30–36	(762–914)	1	(25)	100–120	(136–163)	14	356
42–64	(1,067–1,600)	1 $\frac{3}{4}$	(32)	120–150	(163–203)	16	406

* The torque loads may be applied with torque-measuring or torque-indicating wrenches, which may also be used to check the application of approximate torque loads applied by a worker trained to give an average pull on a definite length of regular socket wrench. If effective sealing is not attained at the maximum torque indicated, the joint should be disassembled, thoroughly cleaned, and reassembled. Overstressing bolts to compensate for poor installation practice is not acceptable.

4.3.4.3 Restrained joints. Restrained joints shall be installed where required by the purchaser's documents in accordance with applicable sections of this standard and the manufacturer's guidelines and requirements.

4.3.4.4 Joint deflection. When it is necessary to deflect pipe from a straight line in either the horizontal or vertical plane, the amount of joint deflection shall not exceed that shown in Tables 2 and 3. The deflections listed are maximum deflections and should not be exceeded. For design purposes, deflection should be limited to 80 percent of the values shown. Figure 4 illustrates the maximum offset S and approximate radius curve R , which are listed in Tables 2 and 3.

4.3.4.5 Pipe cutting. Cutting pipe for insertion of valves, fittings, or closure pieces shall conform to all safety recommendations of the manufacturer of the cutting equipment. Cutting shall be done in a safe, professional manner to prevent damage to the pipe or cement–mortar lining.

4.3.4.5.1 Existing gray-iron pipe may be cut using a hydraulic squeeze cutter, abrasive pipe saw, rotary wheelcutter, guillotine pipe saw, or milling wheel saw.

4.3.4.5.2 Ductile-iron pipe may be cut using an abrasive pipe saw, rotary wheelcutter, guillotine pipe saw, milling wheel saw, or oxyacetylene torch, if recommended by the pipe manufacturer.

4.3.4.5.3 Cut ends and rough edges shall be ground smooth, and for push-on joint connections, the cut end shall be beveled by methods recommended by the manufacturer.

Table 2 Maximum joint deflection* full-length pipe—push-on-type joint pipe

Nominal Pipe Size		Deflection Angle, θ	Maximum Offset, S^\ddagger				Approximate Radius of Curve, R , [†] Produced by Succession of Joints			
			<i>in. (m)</i>				<i>ft (m)</i>			
<i>in.</i>	<i>(mm)</i>	<i>degree</i>	$L^\ddagger = 18$ ft (5.5 m)		$L^\ddagger = 20$ ft (6 m)		$L^\ddagger = 18$ ft (5.5 m)		$L^\ddagger = 20$ ft (6 m)	
3	(76)	5	19	(0.48)	21	(0.53)	205	(62)	230	(70)
4	(102)	5	19	(0.48)	21	(0.53)	205	(62)	230	(70)
6	(152)	5	19	(0.48)	21	(0.53)	205	(62)	230	(70)
8	(203)	5	19	(0.48)	21	(0.53)	205	(62)	230	(70)
10	(254)	5	19	(0.48)	21	(0.53)	205	(62)	230	(70)
12	(305)	5	19	(0.48)	21	(0.53)	205	(62)	230	(70)
14	(356)	3*	11	(0.28)	12	(0.30)	340	(104)	380	(116)
16	(406)	3*	11	(0.28)	12	(0.30)	340	(104)	380	(116)
18	(457)	3*	11	(0.28)	12	(0.30)	340	(104)	380	(116)
20	(508)	3*	11	(0.28)	12	(0.30)	340	(104)	380	(116)
24	(610)	3*	11	(0.28)	12	(0.30)	340	(104)	380	(116)
30	(762)	3*	11	(0.28)	12	(0.30)	340	(104)	380	(116)
36	(914)	3*	11	(0.28)	12	(0.30)	340	(104)	380	(116)
42	(1,067)	3*	11	(0.28)	12	(0.30)	340	(104)	380	(116)
48	(1,219)	3*			12	(0.30)			380	(116)
54	(1,400)	3*			12	(0.30)			380	(116)
60	(1,500)	3*			12	(0.30)			380	(116)
64	(1,600)	3*			12	(0.30)			380	(116)

* For 14-in. and larger push-on joints, maximum deflection angle may be larger than shown above. Consult the manufacturer.

† See Figure 4.

4.3.4.5.4 ANSI/AWWA C151/A21.51 requires factory gauging of the spigot end to ensure that the outside diameter of each spigot end falls within the tolerances stipulated in that standard.

Accordingly, pipes selected for cutting should be field-gauged. A mechanical-joint gland inserted over the barrel might serve as a convenient indicator for this purpose. When glands are not available, pipe can be selected by measuring with a tape in accordance with the manufacturer's recommendation.

4.3.5 *Backfilling.* Backfill shall be accomplished in accordance with the specified laying conditions as described in Sec. 4.3.3.

Table 3 Maximum joint deflection full-length pipe—mechanical-joint pipe

Nominal Pipe Size		Deflection Angle, θ	Maximum Offset, S^*				Approx. Radius of Curve, R^* Produced by Succession of Joints			
			in. (m)		ft (m)		ft (m)		ft (m)	
in.	(mm)	degree	$L^* = 18$ ft (5.5 m)	$L^* = 20$ ft (6 m)	$L^* = 18$ ft (5.5 m)	$L^* = 20$ ft (6 m)	$L^* = 18$ ft (5.5 m)	$L^* = 20$ ft (6 m)	$L^* = 18$ ft (5.5 m)	$L^* = 20$ ft (6 m)
3	(76)	8–18	31.0 (0.79)	35 (0.89)	125 (38)	140 (43)				
4	(102)	8–18	31.0 (0.79)	35 (0.89)	125 (38)	140 (43)				
6	(152)	7–07	27.0 (0.69)	30 (0.76)	145 (44)	160 (49)				
8	(203)	5–21	20.0 (0.51)	22 (0.56)	195 (59)	220 (67)				
10	(254)	5–21	20.0 (0.51)	22 (0.56)	195 (59)	220 (67)				
12	(305)	5–21	20.0 (0.51)	22 (0.56)	195 (59)	220 (67)				
14	(356)	3–35	13.5 (0.34)	15 (0.38)	285 (87)	320 (98)				
16	(406)	3–35	13.5 (0.34)	15 (0.38)	285 (87)	320 (98)				
18	(457)	3–00	11.0 (0.28)	12 (0.30)	340 (104)	380 (116)				
20	(508)	3–00	11.0 (0.28)	12 (0.30)	340 (104)	380 (116)				
24	(610)	2–23	9.0 (0.23)	10 (0.25)	450 (137)	500 (152)				

* See Figure 4.

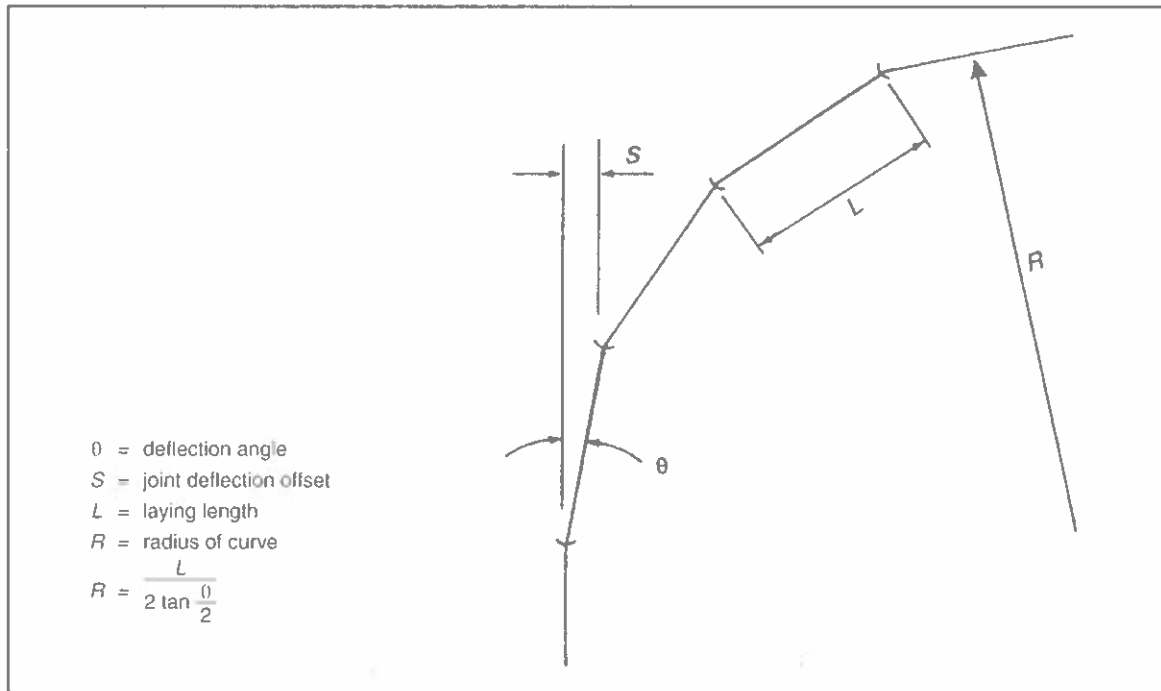


Figure 4 Pipeline curve geometry

4.3.5.1 Backfill material. All backfill material shall be free from cinders, ashes, refuse, vegetable or organic material, boulders, sharp rocks or stones, large pieces of concrete or masonry, frozen soil, or other unsuitable material that may be detrimental or cause damage to the pipe, fittings, valves, and/or polyethylene encasement.

4.3.5.1.1 From 1 ft (300 mm) above the top of the pipe to grade or to the subgrade of the pavement, material containing stones up to 8 in. (200 mm) in their greatest dimension may be used, unless otherwise specified.

4.3.5.1.2 When the type of backfill material is not indicated in the purchaser's documents or is not specified, the excavated material may be used, provided that this material consists of loam, clay, sand, gravel, or other suitable materials and does not contain peat or other organic materials.

4.3.5.1.3 If excavated material is indicated in the purchaser's documents or specified for backfill and there is a deficiency because a part of that material has been rejected, the required amount of sand, gravel, or other approved material shall be provided.

4.3.5.1.4 For purposes of definition: (1) *sand* is material graded from fine to coarse, containing less than 10 percent by weight of loam and clay that passes a 3/4-in. (19-mm) sieve with no more than 5 percent by weight remaining on a US No. 4 sieve; (2) *gravel* is a reasonably uniform combination, containing no boulders or stones larger than 2 in. (50 mm) and not containing excessive amounts of clay and loam; and (3) *crushed stone* is limestone or dolomite ledge-rock material that all passes a 1/2-in. (13-mm) sieve with no more than 25 percent passing a US No. 100 sieve.

4.3.5.2 Compaction. When special backfill compaction procedures are required, they shall be performed in accordance with the purchaser's documents or applicable federal, state or provincial, and local regulations.

4.3.5.3 Partial backfilling during testing. Newly installed pipelines are normally tested after backfilling. When unusual conditions require that pressure and leakage testing be performed before completion of backfilling or with pipe joints accessible for examination, sufficient backfill material shall be placed over the pipe barrel between the joints to prevent movement, with consideration given to restraining thrust forces during the testing. In particular, restrained-joint systems, which derive their stability from the interaction of the pipe and soil, should be backfilled prior to testing.

4.3.5.4 Repairs. If polyethylene encasement is used, any damage that occurs to the wrap shall be repaired in accordance with ANSI/AWWA C105/A21.5.

4.3.6 *Valve and fitting installation.*

4.3.6.1 Examining material. Before installation, valves shall be inspected for direction of opening, number of turns to open, freedom of operation, tightness of pressure-containing bolting and test plugs, cleanliness of valve ports, and especially seating surfaces, handling damage, and cracks. Defective valves shall be marked and held for final disposition as required by the purchaser's documents. All bolts and nuts, with the exception of seat-adjusting bolts or screws in butterfly valves, shall be checked for proper tightness. Seat-adjusting bolts in butterfly valves shall only be adjusted on the recommendation from the manufacturer.

4.3.6.2 Placement. Valves, fittings, plugs, and caps shall be set and joined to the pipe according to Sec. 4.3.3 for cleaning and laying, and to Sec. 4.3.4 for joining pipe. Valves 12 in. (305 mm) and larger should be provided with special support, such as treated timbers, crushed stone, concrete pads, or a sufficiently tamped trench bottom, so that the pipe will not be required to support the weight of the valve. Valves installed aboveground or in plant piping systems shall be supported to prevent bending of the valve end connections as a result of pipe loading. Valves shall be installed in the closed position.

4.3.6.3 Valve location. Valves in water mains shall, where practical, be located within or immediately adjacent to the street property lines unless shown otherwise on the purchaser's documents.

4.3.6.3.1 Mains shall be drained through drainage branches or blowoffs. Drainage branches, blowoffs, and appurtenances shall be provided with control valves and shall be located and installed as shown in the purchaser's documents. Drainage branches or blowoffs shall not be directly connected to any storm or sanitary sewer, submerged in any stream, or installed in any other manner that will permit backsiphonage into the distribution system.

4.3.6.3.2 Air-release and vacuum vents. Provisions for air-release should be considered at high points in the line and vacuum vents should be considered in areas of potential negative pressure. The air-release or vacuum vents shall not be connected to any storm or sanitary sewer, unless as specifically required as part of the design, and they shall be protected from freezing in cold locations.

4.3.6.4 Valve protection. A valve box or a vault shall be provided for every valve.

4.3.6.4.1 A valve box shall be provided for every valve that has no gearing or operating mechanism or in which the gearing or operating mechanism is fully protected with a gear case. The valve box shall not transmit shock or stress to the valve. The valve box shall be centered over the operating nut of the valve, with the box cover flush with the surface of the finished area or another level as specified.

4.3.6.4.2 A valve vault designed to prevent settling on the pipe shall be provided for every valve that has exposed gearing or operating mechanisms. The operating nut shall be readily accessible for operation through the opening in the valve vault. The opening shall be set flush with the surface of the finished pavement or another level as specified. Vaults shall be constructed to permit minor valve repairs and to protect the valve and pipe from impact where they pass through the vault walls.

4.3.6.4.3 In no case shall valves be used to bring misaligned pipe into alignment during installation. Pipe shall be supported to prevent stress on the valve.

4.3.6.4.4 Thrust resulting from closure of valves shall be carefully considered in the design of the piping system and vaults.

4.3.6.5 Plugs and caps. All dead ends on new mains shall be closed with plugs or caps that are suitably restrained to prevent blowing off under test pressure. If a blowoff valve precedes the plug or cap, it too shall be restrained against blowing off. All dead ends shall be equipped with suitable blowoff or venting devices.

4.3.6.6 Additional information. Additional information regarding installation of gate valves can be found in the appendixes of ANSI/AWWA C500, ANSI/AWWA C509, and ANSI/AWWA C515.

4.3.7 *Installing hydrants.*

4.3.7.1 Examining materials. Before installation, all hydrants shall be inspected for direction of opening, nozzle threading, operating-nut and cap-nut dimensions, tightness of pressure-containing bolting, cleanliness of inlet elbow, handling damage, and cracks. Defective hydrants shall be marked and held for final disposition required by the purchaser's documents.

4.3.7.2 Placing hydrants. All hydrants shall stand plumb and shall have their nozzles parallel with or at right angles to the curb, with the pumper nozzle facing the curb. Hydrants having two-hose nozzles 90 degrees apart shall be set with each nozzle facing the curb at an angle of 45 degrees.

4.3.7.2.1 Hydrants shall be set to the established grade, with the lowest nozzle at least 12 in. (300 mm) above the ground or as required by the purchaser's documents. The lowest nozzle shall be installed away from the curb line at a

sufficient distance to avoid damage from or to vehicles. Traffic-model hydrants (hydrants that are intended to fail at the ground line on vehicle impact) shall be installed so that the breakaway flange is not less than 2 in. (50 mm), nor more than 6 in. (150 mm), above the established grade.

4.3.7.2.2 Each hydrant shall be connected to the main with a 6-in. (152-mm) or larger-diameter branch controlled by an independent valve, unless otherwise specified. The valve shall be restrained to maintain shutoff when the hydrant is to be removed.

4.3.7.2.3 When a dry-barrel hydrant is set in soil that is impervious, drainage shall be provided at the base of the hydrant by placing coarse gravel or crushed stone mixed with coarse sand from the bottom of the trench to at least 6 in. (150 mm) above the drain-port opening in the hydrant and to a distance of 1 ft (300 mm) around the elbow. Where groundwater rises above the drain port, or when the hydrant is located within 8 ft (2.4 m) (or the distance required by the applicable regulatory agency) of a sanitary sewer main, or where drainage is not permitted by the applicable regulatory agency, the drain port shall be plugged and water pumped from the hydrant when freezing may occur.

4.3.7.2.4 When a dry-barrel hydrant with an open drain port is set in clay or other impervious soil, a drainage pit 2 ft × 2 ft × 2 ft (0.6 m × 0.6 m × 0.6 m) shall be excavated below each hydrant. The drainage pit shall be filled with coarse gravel or crushed stone mixed with coarse sand under and around the elbow of the hydrant to a level of 6 in. (150 mm) above the drain port. To prevent possible contamination of the water supply, do not connect hydrant drains to a sanitary sewer or storm sewer.

4.3.7.3 Location. Hydrants shall be located as shown in the purchaser's documents or as specified.

4.3.7.4 Protection. In the case of traffic hydrants, adequate soil resistance must be provided to avoid transmitting shock moment to the lower barrel and inlet connection. In loose or poor load-bearing soil, this may be accomplished by pouring a concrete collar approximately 6 in. (150 mm) thick to a diameter of 2 ft (0.6 m) at or near the ground line around the hydrant barrel.

4.3.7.5 Additional information. Additional information regarding installation of hydrants can be found in AWWA Manual M17, *Installation, Field Testing, and Maintenance of Fire Hydrants*.

4.3.8 *Thrust restraint.*

4.3.8.1 Hydrants. The bowl of each hydrant shall be well braced against a sufficient area of unexcavated earth at the end of the trench with thrust blocks of concrete or other specified blocking materials, or it shall be tied to the pipe with suitable metal tie rods, clamps, or restrained joints as shown in the purchaser's documents or as specified.

4.3.8.2 Fittings. All plugs, caps, tees, reducers, and bends, unless otherwise specified, shall be provided with thrust blocks or suitably restrained joints as shown in the purchaser's documents or as specified.

4.3.8.3 Design. The thrust restraint design pressure is the maximum pressure to which the pipeline will be subjected, with consideration given to the vulnerability of the pipe-soil system, when the pressure is applied. In most cases, this pressure will be the test pressure of the pipe, applied shortly after installation, when the pipe-soil system is normally most vulnerable.

For buried pipelines, thrust restraint is achieved by transferring the thrust force to the soil structure outside the pipe. The objective of the design is to distribute the thrust forces to the soil structure, preventing joint separation in unrestrained joints.

4.3.8.4 Concrete thrust blocks. Vertical and horizontal thrust blocks shall be made of concrete having a compressive strength of not less than 2,000 psi (13.8 MPa) after 28 days. The blocks shall be placed between solid ground and the fitting(s) to be anchored. The mass of the block or the area of bearing on the pipe and on the ground in each instance shall be that shown in the purchaser's documents or as specified. The blocking shall, unless otherwise shown or specified, be located so as to contain the resultant thrust force in such a way that the pipe and fitting joints will be accessible for repair.

4.3.8.5 Restrained joints. If indicated in the purchaser's documents, restraining mechanisms for push-on or mechanical joints may be used instead of concrete thrust blocking. Tie rods, clamps, or other components shall be made of corrosion-resistant material or suitably protected against corrosion.

4.3.9 *Flushing.* Foreign material left in the pipelines during installation often results in valve-seat or hydrant-seat leakage during pressure tests. The pipelines shall be kept clean during installation. Thorough flushing is recommended prior to a pressure test. Flushing should be accomplished by partially opening and closing valves and hydrants several times under expected line pressure, with flow velocities adequate to flush foreign material out of the valves and hydrants. High-

pressure water cleaning shall be conducted in accordance with the pipe manufacturer's recommendations.

Sec. 4.4 Disinfection

A newly installed potable water main shall be disinfected in accordance with ANSI/AWWA C651. Following chlorination, the main should be flushed as soon as possible (within 24 hours), because prolonged exposure to high concentrations of chlorine might damage the asphaltic seal coating.

NOTE: Provisions should be made to avoid contamination of existing mains by cross-connection during testing/disinfection/flushing of newly installed mains.

Sec. 4.5 Highway and Railroad Crossings

4.5.1 *Casing pipe.* When protective casing pipe is specified for highways or railroad crossings, the project shall be completed in accordance with applicable federal, state or provincial, and local regulations. In the case of railroad crossings, the project should also comply with regulations established by the railroad company. Crossings are normally made by boring, jacking, or tunneling.

4.5.2 *Carrier pipe (ductile-iron pipe).* The casing pipe should be 6–8 in. (150–200 mm) larger than the outside diameter of the ductile-iron pipe bells. Carrier pipe may be pushed or pulled through the completed casing pipe in accordance with the manufacturer's recommendations. Insulating chocks, skids, or spacers should be placed on or under the carrier pipe to ensure approximate centering within the casing pipe and to prevent damage during installation. Metal-to-metal contact must be avoided. End caps or other methods of sealing the casing pipe shall be provided as specified.

4.5.3 *Restrictions.* At very long crossings, it is often necessary to partially fill the space between the ductile-iron carrier pipe and the casing pipe (e.g., with sand) to prevent movement. To avoid the transfer of earth and live loads to the carrier pipe, the space between the carrier pipe and the casing pipe should not be filled completely. Pressure grouting of the entire annular space between the pipeline and casing pipe is not recommended unless grouting pressure is controlled to pressures below that which could cause buckling failure of the pipeline.

Sec. 4.6 Trenchless Applications

4.6.1 *Methods.* There are several methods of installing ductile-iron pipe in trenchless applications, including directional drilling and microtunneling. Ductile-iron pipe, manufactured in accordance with ANSI/AWWA C151/A21.51, can be installed using various pipe pushing/pulling methods and directional drilling. The

methods involve forming a hole slightly larger than the outside diameter of the pipe joint, after which the ductile-iron pipe is pushed or pulled through the hole. When pipe is pulled into position, restrained joints are used. Also, specially designed and manufactured microtunneling pipe is currently available.

Sec. 4.7 Subaqueous Crossings

4.7.1 *Subaqueous installations.* When it is necessary to cross a body of water requiring only a small deflection in the joints and joint restraint is not a consideration, standard mechanical-joint or push-on joint pipe can be used. If the water is deep and the angle of deflection in the joint necessary to follow the contour of the riverbed is great or if changing bottom conditions are anticipated, ball-and-socket pipe or fittings, which will deflect up to 15 degrees, should be used. A combination of restrained and river-crossing joints may be used, depending on bottom conditions and service requirements. When polyethylene encasement is specified for subaqueous installations and installations in areas of fluctuating water table, the tube form of encasement shall be used with both ends thoroughly sealed with adhesive tape or plastic tie straps at the joint overlap. Also circumferential wraps of tape shall be placed at 2-ft (0.6-m) intervals along the barrel of the pipe to minimize the space between the polyethylene and the pipe.

4.7.1.1 *Strongback.* There are several methods of installing subaqueous ductile-iron pipe. Ductile-iron pipe can be assembled in sections of three or four lengths, either on shore or on the deck of a barge, attached to a "strongback." The assembly is then lowered to the streambed where the sections are connected by divers. Ball-and-socket pipes use joints with positive locking devices. This type of pipe can also be assembled on a chute affixed to the barge and lowered into position as the assembly progresses.

4.7.1.2 *Drag or float.* Another method of installation is to assemble the pipeline on shore and either drag it into position along the bottom or float it into position using barrels or floats attached to the pipe. The barrels or floats are punctured or released in a controlled fashion when the pipe reaches the desired position. Regardless of the method used, joints should not be allowed to become overly deflected or subjected to excessive beam load during the installation process.

4.7.1.3 *Skids.* A similar method is to assemble the pipe on shore, attach floats, and pull the pipe down skids into the water as each length is connected. The line extends farther into the water as each successive length is laid, and the finished line is submerged appropriately.

4.7.1.4 *Covered.* Subaqueous lines laid in navigable streams must be placed in trenches and covered to protect them from damage or displacement by ship or boat traffic. Where applicable, procedures should conform to appropriate governmental regulations.

Sec. 4.8 Service Taps

4.8.1 *Tapping.* Corporation stops may be installed either before or after pipe installation. Generally, they are located at 10 o'clock or 2 o'clock on the circumference of the pipe* and may be screwed directly into the tapped and threaded main without any additional appurtenances. When more than one tap is necessary to deliver the required flow in an existing gray-iron pipe, the taps should be staggered around the circumference at least 12-in. (300-mm) apart (not in a straight line). These restrictions do not apply to ductile-iron pipe. Furthermore, ductile-iron pipe in all classes, including standard pressure-class pipe, may be directly tapped with standard corporation stops; however, the torque requirement for the installation may be effectively reduced by the application of two layers of 3-mil (0.1-mm) pipe-thread sealant tape to the male threads of the corporation stop. The maximum recommended direct tap sizes, to ensure a watertight tap, for 3-in. through 24-in. ductile-iron pipe are shown in Table 4. All classes of ductile-iron pipe 24 in. and larger in diameter can be direct tapped for 2-in. corporation stops.

4.8.1.1 *Polyethylene.* Service taps on gray-iron and ductile-iron mains encased in polyethylene may be accomplished by making an X-shaped cut in the polyethylene and temporarily folding back the film. After the tap has been completed, cuts in the polyethylene and any other areas of damage to the film shall be repaired with tape as described in ANSI/AWWA C105/A21.5. Direct service taps may also be made through the polyethylene, with any resulting damaged areas being repaired as described previously. The preferred method of making direct service taps consists of applying two or three wraps of polyethylene adhesive tape completely around the pipe to cover the area where the tapping machine and chain will be mounted. This method minimizes possible damage to the polyethylene during the direct tapping procedure. After the tapping machine is mounted, the corporation stop is installed directly through the tape and polyethylene, as shown in Figure 5. This method is effective in eliminating damage to the polyethylene

* In cold climates with deep frost penetration, freezing of service lines can be a problem. In these localities, installing corporation stops horizontally at the 3 o'clock or 9 o'clock position on the pipe circumference will conserve available cover over the service line or reduce the necessary depth that the main pipeline should be buried.

Table 4 Maximum recommended direct tap size

Size (in.)	Pressure Class				
	150	200	250	300	350
	Maximum Recommended Direct Tap Size (in.)				
3	—	—	—	—	3/4
4	—	—	—	—	3/4
6	—	—	—	—	1
8	—	—	—	—	1
10	—	—	—	—	1
12	—	—	—	—	1 1/4
14	—	—	1 1/4	1 1/2	1 1/2
16	—	—	1 1/2	2	2
18	—	—	2	2	2
20	—	—	2	2	2
24	—	2	2	2	2

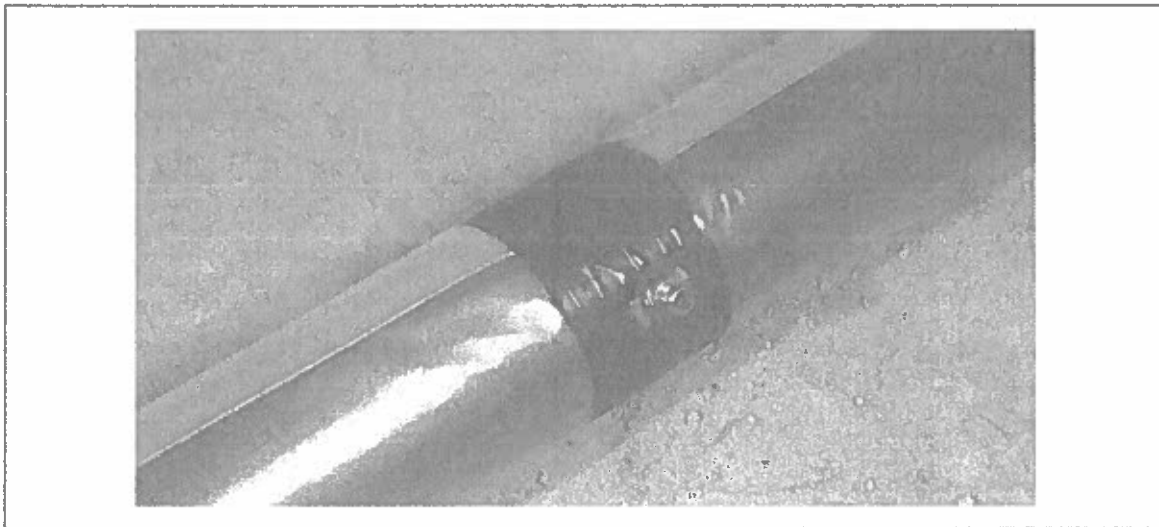


Figure 5 Preferred method for making direct service taps on polyethylene-encased iron pipe

encasement by the tapping machine and chain during the tapping operation. After the direct tap is completed, the entire circumferential area should be closely inspected for damage and repaired if needed. Service lines of dissimilar metals also shall be wrapped with polyethylene or a suitable dielectric tape for a minimum clear distance of 3 ft (0.9 m) away from the gray-iron or ductile-iron main.

SECTION 5: VERIFICATION

Sec. 5.1 Inspection

If stipulated by the purchaser, all materials are subject to inspection and approval at the manufacturer's plant.

5.1.1 *Inspection on delivery.* All pipe and appurtenances are subject to inspection on delivery. Neither inspection nor failure to provide inspection shall relieve the manufacturer of the responsibility to provide materials meeting the requirements of the purchaser's documents. Materials not conforming to the requirements of this standard shall be made satisfactory or replaced. Tests may be performed as specified in the applicable AWWA standard to ensure conformance with the standard. Pipe or appurtenances that fail to comply with specified tests shall be made satisfactory or replaced.

5.1.2 *Workmanship.* All pipe and appurtenances shall be installed and joined in conformance with this standard and tested under pressure for defects and leaks in accordance with Sec. 5.2 of this standard.

Sec. 5.2 Hydrostatic Testing

WARNING: *The testing methods described in this section are specific for water-pressure testing only. These procedures should not be applied for air-pressure testing because of the serious safety hazards involved with compressed air. Also, pipelines intended for buried service should generally be tested with the backfill in place.*

5.2.1 *Hydrostatic pressure test.*

5.2.1.1 Test restrictions.

5.2.1.1.1 The test pressure shall not be less than 1.25 times the stated working pressure of the pipeline measured at the highest elevation along the test section and not less than 1.5 times the stated working pressure at the lowest elevation of the test section.

5.2.1.1.2 The test pressure shall not exceed the thrust restraint design pressures or 1.5 times the pressure rating of the pipe or joint, whichever is less (as specified by the manufacturer).

5.2.1.1.3 Valves shall not be operated in either direction at a differential pressure exceeding the rated valve working pressure. A test pressure greater than the rated valve working pressure can result in trapped test pressure between the gates of a double-disc gate valve. For tests exceeding the rated valve working pressure, the test setup should include a provision, independent of the valve, to reduce

the line pressure to the rated valve working pressure on completion of the test. The valve can then be opened enough to equalize the trapped pressure with the line pressure, or the valve can be fully opened if desired.

5.2.1.1.4 The test pressure shall not exceed the rated working pressure of the valves when the pressure boundary of the test section includes closed resilient-seated gate valves or butterfly valves.

5.2.1.2 Test setup and pressurization. Following the installation of any new pipeline, all newly laid pipe or any valved section thereof shall be subjected to a hydrostatic pressure test. Each valved section of pipeline shall be slowly filled with water. When venting air from pipelines, it is important to limit the pipeline fill rate to avoid excessive surge pressures when the water reaches the air venting opening(s). The specified test pressure shall be applied using a suitable pump connected to the pipeline. (NOTE: The specified test pressure shall be based on the elevation of the lowest point of the pipeline or section under test and corrected to the elevation of the test gauge—see Sec. 5.2.1.1, Test Restrictions.) Before applying the specified test pressure, air shall be expelled completely from the pipeline section under test. If permanent air vents are not located at all high points, corporation stops shall be installed at these points to expel any air as the line is filled with water. Corporation stops should be rated for the design pressure of the pipeline. Exceeding design pressure is not recommended and should be checked with the product manufacturer before proceeding. Following removal of any air, the corporation stops shall be closed and the test pressure applied (at the conclusion of the pressure test, the corporation stops shall be removed and the pipe plugged, or left in place as required by the purchaser's documents). After filling the pipeline and before application of the test pressure, the test section shall be maintained at the working pressure for a sufficient period of time for it to stabilize with respect to line movement under pressure, water absorption by the lining, and so on. This may require several cycles of pressurizing and bleeding trapped air prior to beginning the test. The hydrostatic test shall be of at least a 2-hour duration. The test pressure shall not vary by more than ± 5 psi (34.5 kPa) for the duration of the test. Test pressure shall be maintained within this tolerance by adding makeup water through the pressure test pump into the pipeline. The amount of makeup water added shall be accurately measured (in gallons or liters per hour) by suitable methods and shall not exceed the applicable testing allowance as specified in Tables 5A or 5B (see Sec. 5.2.1.4).

Table 5A Hydrostatic testing allowance per 1,000 ft of pipeline*—gph[†]

Average Test Pressure, <i>psi</i>	Nominal Pipe Diameter, <i>in.</i>																	
	3	4	6	8	10	12	14	16	18	20	24	30	36	42	48	54	60	64
450	0.43	0.57	0.86	1.15	1.43	1.72	2.01	2.29	2.58	2.87	3.44	4.30	5.16	6.02	6.88	7.74	8.60	9.17
400	0.41	0.54	0.81	1.08	1.35	1.62	1.89	2.16	2.43	2.70	3.24	4.05	4.86	5.68	6.49	7.30	8.11	8.65
350	0.38	0.51	0.76	1.01	1.26	1.52	1.77	2.02	2.28	2.53	3.03	3.79	4.55	5.31	6.07	6.83	7.58	8.09
300	0.35	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	6.32	7.02	7.49
275	0.34	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	6.05	6.72	7.17
250	0.32	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	5.77	6.41	6.84
225	0.30	0.41	0.61	0.81	1.01	1.22	1.42	1.62	1.82	2.03	2.43	3.04	3.65	4.26	4.86	5.47	6.08	6.49
200	0.29	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	5.16	5.73	6.12
175	0.27	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	4.83	5.36	5.72
150	0.25	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	4.47	4.97	5.30
125	0.23	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	4.08	4.53	4.83
100	0.20	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	3.65	4.05	4.32

* If the pipeline under test contains sections of various diameters, the testing allowance will be the sum of the testing allowance for each size.

† Calculated on the basis of Eq 1.

Table 5B Hydrostatic testing allowance per 300 m of pipeline^{*}—L/hr[†]

Average Test Pressure kPa	Nominal Pipe Diameter, mm																	
	76	102	152	203	254	305	356	406	457	508	610	762	914	1,067	1,219	1,400	1,500	1,600
3,000	1.57	2.11	3.14	4.20	5.25	6.31	7.36	8.39	9.45	10.50	12.61	15.75	18.90	22.06	25.20	28.94	31.01	33.06
2,800	1.52	2.04	3.04	4.05	5.07	6.09	7.11	8.11	9.13	10.15	12.18	15.22	18.26	21.31	24.35	27.96	29.96	31.96
2,600	1.46	1.96	2.93	3.91	4.89	5.87	6.85	7.81	8.80	9.78	11.74	14.67	17.59	20.54	23.46	26.95	28.87	30.79
2,400	1.41	1.89	2.81	3.75	4.70	5.64	6.58	7.51	8.45	9.39	11.28	14.09	16.90	19.73	22.54	25.89	27.74	29.59
2,200	1.35	1.81	2.69	3.59	4.50	5.40	6.30	7.19	8.09	8.99	10.80	13.49	16.18	18.89	21.58	24.79	26.56	28.33
2,000	1.28	1.72	2.57	3.43	4.29	5.15	6.01	6.85	7.71	8.58	10.30	12.86	15.43	18.01	20.58	23.63	25.32	27.01
1,800	1.22	1.63	2.43	3.25	4.07	4.88	5.70	6.50	7.32	8.14	9.77	12.20	14.64	17.09	19.52	22.42	24.02	25.62
1,600	1.15	1.54	2.29	3.06	3.83	4.60	5.37	6.13	6.90	7.67	9.21	11.50	13.80	16.11	18.40	21.14	22.65	24.16
1,400	1.07	1.44	2.15	2.87	3.59	4.31	5.03	5.73	6.45	7.17	8.62	10.76	12.91	15.07	17.22	19.77	21.18	22.60
1,200	0.99	1.33	1.99	2.65	3.32	3.99	4.65	5.31	5.98	6.64	7.98	9.96	11.95	13.95	15.94	18.31	19.61	20.92
1,000	0.91	1.22	1.81	2.42	3.03	3.64	4.25	4.85	5.45	6.06	7.28	9.10	10.91	12.74	14.55	16.71	17.90	19.10
800	0.81	1.09	1.62	2.17	2.71	3.26	3.80	4.33	4.88	5.42	6.51	8.14	9.76	11.39	13.01	14.95	16.01	17.08
600	0.70	0.94	1.41	1.88	2.35	2.82	3.29	3.75	4.23	4.70	5.64	7.05	8.45	9.87	11.27	12.94	13.87	14.79

* If the pipeline under test contains sections of various diameters, the testing allowance will be the sum of the testing allowance for each size.

† Calculated on the basis of Eq. 2.

5.2.1.3 Examination. Any exposed pipe, fittings, valves, hydrants, and joints shall be examined carefully during the pressure test. Any damaged or defective pipe, fittings, valves, hydrants, or joints that are discovered during or following the pressure test shall be repaired or replaced with reliable material, and the test shall be repeated until satisfactory results are obtained.

5.2.1.4 Testing allowance. Testing allowance shall be defined as the maximum quantity of makeup water that can be added into a pipeline undergoing hydrostatic pressure testing, or any valved section thereof, to maintain pressure within ± 5 psi (34.5 kPa) of the specified test pressure (after the pipeline has been filled with water and the air has been expelled¹). The testing allowance is exceeded if the quantity of makeup water is greater than that determined by the following formula:

In inch-pound units,

$$L = \frac{SD\sqrt{P}}{148,000} \tag{Eq 1}$$

Where:

L = testing allowance (makeup water) (gph)

S = length of pipe tested (ft)

D = nominal diameter of the pipe (in.)

P = average test pressure during the hydrostatic test (psi [gauge])

In metric units,

$$L_m = \frac{SD\sqrt{P}}{794,797} \tag{Eq 2}$$

Where:

L_m = testing allowance (makeup water) (L/hr)

S = length of pipe tested (m)

D = nominal diameter of the pipe (mm)

P = average test pressure during the hydrostatic test (kPa)

5.2.1.4.1 These formulas are based on a testing allowance of 10.49 gpd/mi/in. (0.971 L/d/km/mm) of nominal diameter at a pressure of 150 psi (1,034 kPa). Values of testing allowance at various pressures are shown in Tables 5A and 5B. When testing against closed metal-seated valves, an additional testing allowance

¹ The testing allowance may not be reasonable if the pressure boundary of the test section includes appurtenances subjected to pressures above their rated working pressures because of possible leakage by those appurtenances.

per closed valve of 0.0078 gal/hr/in. (1.2 mL/hr/mm) of nominal valve size shall be allowed. When hydrants are in the test section, the test shall be made against the main valve in the hydrant.

5.2.1.5 Acceptance of installation. Acceptance shall be determined on the basis of testing allowance only. If any test of a new pipeline requires a quantity of makeup water greater than the testing allowance specified in Sec. 5.2.1.4, repairs or replacements shall be accomplished in accordance with the purchaser's documents. All visible leaks are to be repaired regardless of the allowance used for testing.

SECTION 6: DELIVERY

Sec. 6.1 Handling, Unloading, and Storage

6.1.1 *Handling.* All pipe, fittings, valves, hydrants, and accessories shall be loaded and unloaded by lifting with lift hoists or skidding to avoid shock or damage. Under no circumstances shall this material be dropped. Pipe handled on skidways shall not be rolled or skidded against other pipe. If the requirements of this standard and ANSI/AWWA C.651 are adhered to, the use of pipe end covers to reduce contamination during normal transit and storage is not required.

6.1.2 *Unloading pipe.* Trucks shall be parked on level ground for unloading. Rail sidings are generally level enough for unloading purposes.

6.1.2.1 *Strapping.* Before releasing any restraint, binder, or strapping, the loads shall be checked to ensure that all chock blocks are securely in place on both ends of all support timbers. If not, chocks or other suitable wedges shall be nailed into position to prevent the pipe from rolling when the other restraints are removed. Under no circumstances shall the chocks be removed while there is any possibility of pipe rolling out of control and causing damage or injury. Only after all chocks are in place shall the binders or strapping securing the load to the truck or railcar be released. Personnel shall never remain on, in front of, or alongside the load of pipe after the restraints are removed.

6.1.2.2 *Off-loading.* Unloading shall be done by lifting with a fork truck, a crane, or other suitable lifting device. Pipe shall never be rolled off the truck or railcar. When pipe is being unloaded one at a time or in single layers, the restraining bands or straps shall be removed only from the layer being unloaded. Steel bands shall be cut with a long-handled bolt cutter or similar tool. Do not cut the

bands with an ax, chisel, or other tool likely to cause product damage or personal injury. Personnel not directly involved in the unloading operation shall stand clear. Never stand under a lifted load. Inspect, repair, and replace lifting devices on a timely basis.

6.1.3 *Padding.* Slings, hooks, or pipe tongs shall be padded, and the padding shall be used to prevent damage to the exterior surface or internal lining of the pipe, fitting, or related product.

6.1.4 *Storage.* If stored, materials shall be kept safe from damage. The interior of all pipe, fittings, and other appurtenances shall be kept free from dirt or foreign matter at all times. Valves and hydrants shall be drained and stored in a manner that will protect them from damage by freezing.

6.1.4.1 *Stacking.* Pipe shall not be stacked higher than the limits shown in Table 6. The bottom tier shall be kept off the ground on timbers, rails, or other suitable supports. Pipe in tiers shall be alternated as follows: bell, plain end; bell, plain end. At least two rows of timbers shall be placed between tiers, and chocks

Table 6 Maximum stacking heights—ductile-iron pipe*

Nominal Pipe Size		Number of Tiers
<i>in.</i>	<i>(mm)</i>	
3	(76)	18
4	(102)	16
6	(152)	13
8	(203)	11
10	(254)	10
12	(305)	9
14	(356)	8
16	(406)	7
18	(457)	6
20	(508)	6
24	(610)	5
30	(762)	4
36	(914)	4
42	(1,067)	3
48	(1,219)	3
54	(1,400)	3
60	(1,500)	3
64	(1,600)	3

* For 18- or 20-ft (5.5- or 6.1-m) lengths.

shall be affixed to each timber in order to prevent movement. The timbers shall be large enough to prevent contact between the pipe in adjacent tiers.

6.1.4.2 Gaskets. Gaskets shall be stored in a cool location, out of direct sunlight. Gaskets shall not come in contact with petroleum products. Gaskets shall be used on a first-in, first-out basis.

6.1.4.3 Mechanical joints. Mechanical-joint bolts shall be stored in a dry location and handled in a manner that will ensure proper use with respect to types and sizes.

6.1.4.4 Sunlight. Prolonged exposure to sunlight will eventually deteriorate polyethylene film. Therefore, exposure to sunlight before backfilling the wrapped pipe should be kept to a minimum.

Sec. 6.2 Affidavit of Compliance

The purchaser may require an affidavit of compliance or test reports from the constructor stating that the material installed or tests performed comply with all applicable requirements of this standard.

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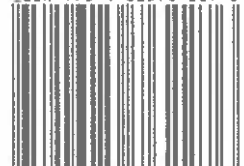
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