American Water Works Association

ANSI/AWWA C600–77

Revision of
C600–64

AMERICAN NATIONAL STANDARD

for

INSTALLATION OF GRAY AND DUCTILE CAST-IRON WATER MAINS AND APPURTENANCES

Approved by AWWA Board of Directors May 8, 1977.
Approved by American National Standards Institute Jun. 22, 1977.

AMERICAN WATER WORKS ASSOCIATION
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The AWWA Standards Committee on Installation of Cast-Iron Water Mains, which developed this standard, had the following personnel at the time of approval:

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Foreword

This foreword is for information only and is not a part of AWWA C-600.

I. History of Standard

The first AWWA standard specifications, "Laying Cast Iron Pipe," (7D.1–1938) were adopted in Apr. 1938. They were intended as a guide in making extensions to existing distribution systems, and in preparing specifications for contracts for the construction of new systems or extensions. The standard was to be used as a guide for installing bell-and-spigot cast-iron pipe and did not cover the furnishing and delivery of material, any other type of pipe, or any other type of joint. The standard included a model addendum, which was to be used with project specifications, and was designed to be used as a part of the contract document. The standard was published in the Feb. 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, adding numerous tables and installation guidelines. The model addendum was also expanded. The revised standard was published in the Dec. 1949 edition of *Journal AWWA*.

An additional section, Sec. 9b—Jointing of Mechanical-Joint Pipe—was added in May 1954. Section 9c—Joining of Push-on Joint Pipe—was added in 1964.

In 1975 the Standards Council formed the present C–600 Committee to revise C–600 to current practices and to add ductile iron as a pipe material.

In order to do this, the committee decided to completely change the character of the standard, removing the model addendum and making the standard more in compliance with the style of other AWWA standards.

II. Information Regarding the Use of This Standard

The AWWA standard, "Installation of Gray and Ductile Cast-Iron Water Mains and Appurtenances," can be used as a reference when making extensions to existing or constructing new distribution systems, using either ductile or gray cast-iron mains, with either mechanical- or push-on joints. It is not the intent for this standard to be used as a contract document but it may be used as a reference in the contract documents. It is based upon 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.

III. Major Revisions

The standard has been rewritten completely and restructured to conform with the present style of AWWA standards. Ductile-iron pipe has been added to the standard, and normal installation practices have been updated completely. The addendum has been deleted.

Allowable leakage for both mechanical- and push-on joints has been reduced to one half of the value prescribed in the 1964 standard.

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for

Installation of Gray and Ductile Cast-Iron Water Mains and Appurtenances

Section 1—General

Sec. 1.1—Scope

This standard covers installation procedures for gray and ductile cast-iron pipe and appurtenances for water service.

1.1.1 *Conditions not covered.* Installations that require special attention, techniques, and materials are not covered. Each such installation requires special considerations based on many influencing factors and cannot be covered adequately in a single standard. This type of installation can best be accomplished by competent engineering design in consultation with representatives of the material manufacturing industry. Some of these typical installations are

1. Piping through rigid walls.
2. Subaqueous piping.
3. Piping on supports above or below ground.
4. Piping requiring insulation.
5. Plant- or pump-station piping.

Sec. 1.2—References

This standard references the following documents. They form a part of this standard to the extent specified herein. In any case of conflict, the requirements of this standard shall prevail.

AWWA C101, Thickness Design of Cast-Iron Pipe.

AWWA C104, Cement–Mortar Lining for Cast-Iron and Ductile-Iron Pipe and Fittings for Water.

AWWA C105, Polyethylene Encasement for Gray and Ductile Cast-Iron Piping for Water and Other Liquids.

AWWA C106, Cast-Iron Pipe Centrifugally Cast in Metal Molds, for Water or Other Liquids.

AWWA C108, Cast-Iron Pipe Centrifugally Cast in Sand-Lined Molds, for Water or Other Liquids.

AWWA C110, Gray-Iron and Ductile-Iron Fittings, 3 in. Through 48 in., for Water and Other Liquids.

AWWA C111, Rubber-Gasket Joints for Cast-Iron and Ductile-Iron Pressure Pipe and Fittings.

AWWA C115, Flanged Cast-Iron and Ductile-Iron Pipe With Threaded Flanges.

AWWA C150, Thickness Design of Ductile-Iron Pipe.

AWWA C151, Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.

AWWA C500, Gate Valves—3-in. Through 48-in.—for Water and Other Liquids.

AWWA C502, Dry-Barrel Fire Hydrants.

AWWA C503, Wet-Barrel Fire Hydrants.

AWWA C504, Rubber Seated Butterfly Valves.

AWWA C601, Disinfecting Water Mains.

AWWA No. 20104, Handbook of Occupational Safety and Health Standards for Water Utilities.

*AASHTO * T-99, Standard Method of Test for Moisture-Density Relationship for Soils.*

Sec. 1.3—Definitions

Under this standard, the following definitions shall apply:

1.3.1 *Gray cast iron.* Cast ferrous material in which a major part of the carbon content occurs as free carbon in the form of flakes interspersed through the metal.

1.3.2 *Ductile cast iron.* Cast ferrous material in which a major part of the carbon content occurs as free carbon in nodules or spheroidal form.

1.3.3 *Owner.* The municipality or other organization that will own and operate the completed piping system. The owner may designate agents, such as an engineer, purchaser, or inspector for specific responsibilities with regard to piping construction projects.

1.3.4 *Contractor.* The party responsible for water main construction.

1.3.5 *Mechanical joint.* The gasketed and bolted joint as detailed in AWWA C111.

1.3.6 *Push-on joint.* The single rubber-gasket joint as described in AWWA C111.

Section 2—Inspection, Receiving, Handling, and Storage

Sec. 2.1—Inspection

At the discretion of the owner, all materials furnished by the contractor are subject to inspection and approval at the manufacturer's plant.

2.1.1 *Post delivery.* All pipe and appurtenances are subject to inspection at the point of delivery by the owner. Material found to be defective due to manufacture or damage in shipment shall be rejected or recorded on the bill of lading and removed from the job site. The owner may perform tests as specified in the applicable AWWA standard to ensure conformance with the standard. In case of failure of the pipe or appurtenance to comply with such specifications, responsibility for replacement of the defective materials becomes that of the manufacturer.

* American Association of State Highway and Transportation Officials, 341 National Press Bldg., Washington, D.C. 20004.

2.1.2 *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. 4 of this standard.

Sec. 2.2—Handling and Storage

All pipe, fittings, valves, hydrants, and accessories shall be loaded and unloaded by lifting with hoists or skidding in order to avoid shock or damage. Under no circumstances shall such material be dropped. Pipe handled on skidways shall not be rolled or skidded against pipe on the ground.

2.2.1 *Padding.* Slings, hooks, or pipe tongs shall be padded and used in such a manner as to prevent damage to the exterior surface or internal lining of the pipe.

2.2.2 *Storage.* Materials, if stored, 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.

2.2.2.1 Pipe shall not be stacked higher than the limits shown in Tables 1 and 2. The bottom tier shall be kept off the ground on timbers, rails, or concrete. Pipe in tiers shall be alternated: bell, plain end; bell, plain end. At least two rows of 4-in. × 4-in. timbers shall be placed between tiers and chocks affixed to each end in order to prevent movement.

2.2.2.2 Gaskets for mechanical- and push-on joints to be stored shall be placed 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.

TABLE 1

Maximum Stacking Heights—Gray Cast-Iron Pipe

Pipe Size (in.)	Number of Tiers	
	18-ft length	20-ft length
3	18	18
4	16	16
6	13	13
8	11	11
10	9	8
12	8	7
14	7	7
16	6	6
18	6	5
20	5	4
24	4	3

TABLE 2

*Maximum Stacking Heights—Ductile Cast-Iron Pipe**

Pipe Size (in.)	Number of Tiers
3	18
4	16
6	13
8	11
10	10
12	9
14	8
16	7
18	6
20	6
24	5
30	4
36	4
42	3
48	3
54	3

* For 18- or 20-ft lengths.

2.2.2.3 Mechanical-joint bolts shall be handled and stored in such a manner that will ensure proper use with respect to types and sizes.

Section 3—Installation

Sec. 3.1—Alignment and Grade

The water mains shall be laid and maintained to lines and grades established by the plans and specifications with fittings, valves, and hydrants at the required locations unless otherwise approved by the owner. Valve-operating stems shall be oriented in a manner to allow proper operation. Hydrants shall be installed plumb.

3.1.1 *Prior investigation.* Prior to excavation, investigation shall be made to the extent necessary to determine the location of existing underground structures and conflicts. Care should be exercised by the contractor during excavation to avoid damage to existing structures.

3.1.2 *Unforeseen obstructions.* When obstructions that are not shown on the plans are encountered during the progress of work and interfere so that an alteration of the plans is required, the owner will alter the plans or order a deviation in line and grade or arrange for removal, relocation, or reconstruction of the obstructions.

3.1.3 *Clearance.* When crossing existing pipelines or other structures, alignment and grade shall be adjusted as necessary, with the approval of the owner, to provide clearance as required by federal, state, or local regulations or as deemed necessary by the owner to prevent future damage or contamination of either structure.

Sec. 3.2—Trench Construction

The trench shall be excavated to the required alignment, depth, and width and in conformance with all federal, state, and local regulations for the protection of the workmen.

3.2.1 *Trench preparation.* Trench preparation shall proceed in advance of pipe installation for only as far as stated in the specifications.

3.2.1.1 Discharge from any trench dewatering pumps shall be conducted to natural drainage channels, storm sewers, or an approved reservoir.

3.2.1.2 Excavated material shall be placed in a manner that will not obstruct the work nor endanger the workmen, obstruct sidewalks, driveways, or other structures and shall be done in compliance with federal, state, or local regulations.

3.2.2 *Pavement removal.* Removal of pavement and road surfaces shall be a part of the trench excavation and the amount removed shall depend upon the width of trench required for installation of the pipe and the dimensions of area required for the installation of valves, hydrants, specials, manholes, or other structures. 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. in any direction unless otherwise required or approved by the owner. Methods, such as sawing, drilling, or chipping, shall be used to ensure the breakage of pavement along straight lines.

3.2.3 *Width.* The width of the trench at the top of the pipe shall be that of the single-pass capabilities of normally available excavating equipment and ample to permit the pipe to be laid and joined properly and allow the backfill to be placed as specified. Trench widths as shown in Table 3 may be used as a guide. Trenches shall be of such extra width, when required, to permit the placement of tim-

TABLE 3

*Suggested Trench Widths at the Top of the Pipe**

Nominal Pipe Size in.	Trench Width in.
4	28
6	30
8	32
10	34
12	36
14	38
16	40
18	42
20	44
24	48
30	54
36	60
42	66
48	72
54	78

* The trench should never be wider than the width used as design criteria.

ber supports, sheeting, bracing, and appurtenances.

3.2.4 *Bell holes.* Holes for the bells shall be provided at each joint but shall be no larger than necessary for joint assembly and assurance that the pipe barrel will lie flat on the trench bottom. Other than noted previously, the trench bottom shall be true and even in order to provide support for the full length of the pipe barrel, except that a slight depression may be provided to allow withdrawal of pipe slings or other lifting tackle.

3.2.5 *Rock conditions.* When excavation of rock is encountered, all rock shall be removed to provide a clearance of at least 6 in. below and on each side of all pipe, valves, and fittings for pipe sizes 24 in. or smaller, and 9 in. for pipe sizes 30 in. and larger. When excavation is completed, a bed of sand, crushed stone, or earth that is free from stones, large clods, or frozen earth, shall be placed on the bottom of the trench to the previously mentioned depths, leveled, and tamped.

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.

3.2.5.2 This installation procedure shall be followed when gravel formations containing loose boulders greater than 8 in. in diameter are encountered.

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 stones of sufficient size and placement which, in the opinion of the owner, could cause a fulcrum point.

3.2.6 *Previous excavations.* Should the trench pass over a sewer or other previous excavation, 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.

3.2.7 *Blasting.* Blasting for excavation shall be permitted only after securing the approval of the owner who will establish the hours of blasting. The blasting procedure, including protection of persons and property, shall be in strict accordance with federal, state, and local regulations.

3.2.8 *Protection of property.* Trees, shrubs, fences, and all other property and surface structures shall be protected during construction unless their removal is shown in the plans and specifications or approved by the owner.

3.2.8.1 Any cutting of tree roots or branches shall be done only as approved by the owner.

3.2.8.2 Temporary support, adequate protection, and maintenance of all underground and surface structures, drains, sewers, and other obstructions encountered in the progress of the work shall be furnished by the contractor.

3.2.8.3 All properties that have been disturbed shall be restored as nearly as practical to their original condition.

3.2.9 *Unstable subgrade.* When the subgrade is found to be unstable or to include ashes, cinders, refuse, organic material, or other unsuitable material, such material shall be removed, to a minimum of at least 3 in., or to the depth ordered by the owner and replaced under the directions of the owner with clean, stable backfill material. When such materials are encountered, polyethylene encasement should be provided (see paragraph 3.4.5). The bedding shall be consolidated and leveled in order that the pipe may be installed in accordance with Sec. 3.2.4.

3.2.9.1 When the bottom of the trench or the subgrade is found to consist of material that is unstable to such a degree that, in the judgment of the owner it cannot be removed, a foundation for the pipe and/or appurtenance shall be constructed using piling, timber, concrete, or other materials at the direction of the owner.

3.2.10 *Safety.* Appropriate traffic control devices shall be provided in accordance with federal, state, or local regulations to regulate, warn, and guide traffic at the work site.

Sec. 3.3—Pipe Installation

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 by means of a derrick, ropes, or other suitable tools or equipment, in such a manner as to prevent damage to water-main materials and protective coatings and linings. Under no circumstances shall water-main materials be dropped or dumped into the trench. The trench should be dewatered prior to installation of the pipe.

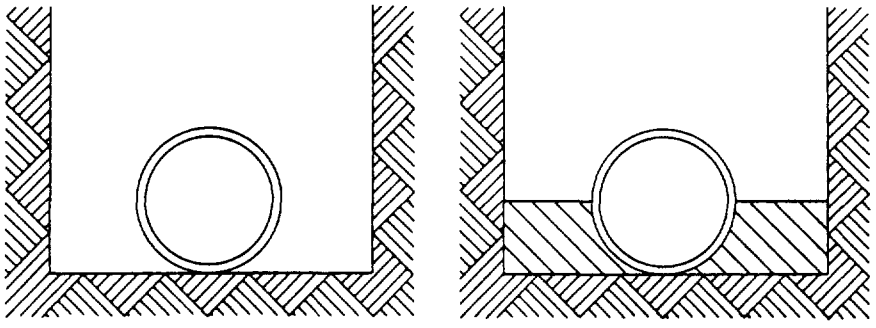
3.3.1 *Examination of material.* All pipe fittings, valves, hydrants, and other appurtenances shall be examined carefully for damage and other defects immediately before installation. Defective materials shall be marked and held for inspection by the owner, who may prescribe corrective repairs or reject the materials.

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 from dirt, sand, grit, or any foreign material before the pipe is laid.

3.3.3 *Pipe cleanliness.* Foreign material shall be prevented from entering the pipe while it is being placed in the trench. During laying operations, no debris, tools, clothing, or other materials shall be placed in the pipe.

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 be secured in place with approved backfill material.

3.3.5 *Pipe plugs.* At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the owner. When practical, the plug shall remain in place until the trench is pumped completely dry. Care must be taken to prevent pipe flotation should the trench fill with water.

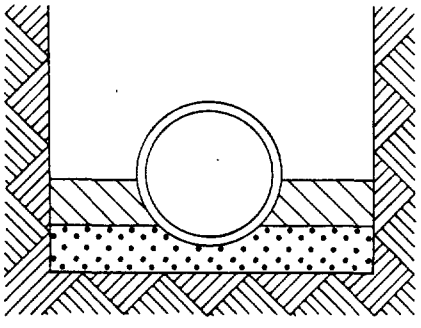


A

Flat bottom trench, untamped backfill.

B

Flat bottom trench, tamped backfill.



F

Pipe bedded in sand or gravel, tamped backfill.

Fig. 1. Laying Conditions for Gray Cast-Iron Pipe

3.3.6 *Gray-iron laying conditions.* The specified laying conditions for gray cast-iron pipe shall be completed in accordance with AWWA C101 and as illustrated in Fig. 1.

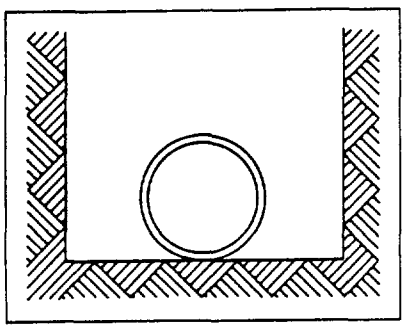
3.3.7 *Ductile-iron laying conditions.* The specified laying conditions for ductile-iron pipe shall be completed in accordance with AWWA C150 and as illustrated in Fig. 2 (page 8).

Sec. 3.4—Joint Assembly

3.4.1 *Push-on joints.* Push-on joints shall be assembled as described and illustrated in Fig. 3 (page 9).

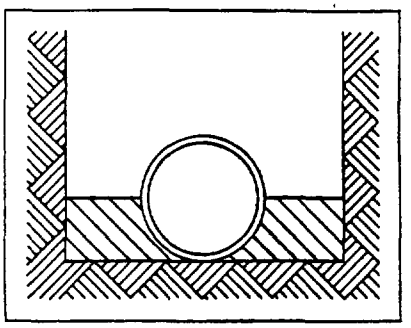
3.4.2 *Mechanical joints.* Mechanical joints shall be assembled as follows:

1. Wipe clean the socket and plain end. The plain end, socket, and gasket should be washed with a soap solution to improve gasket seating.



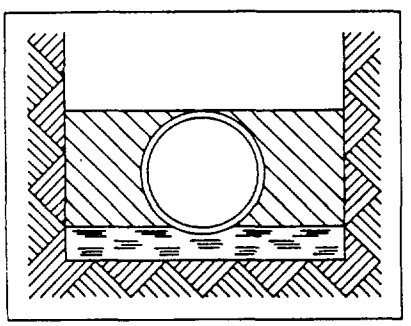
Type 1 *

Flat-bottom trench.† Loose backfill.



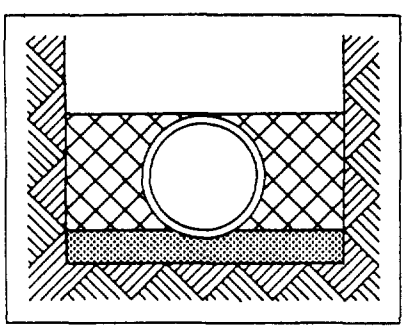
Type 2

Flat-bottom trench.† Backfill lightly consolidated to centerline of pipe.



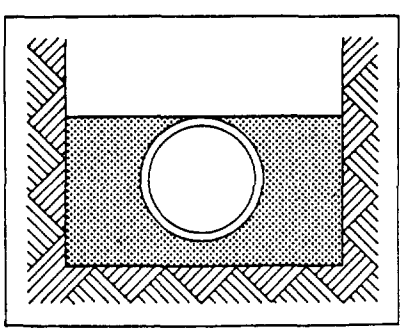
Type 3

Pipe bedded in 4-in. minimum loose soil.‡ Backfill lightly consolidated to top of pipe.



Type 4

Pipe bedded in sand, gravel, or crushed stone to depth of ⅛ pipe diameter, 4-in. minimum. Backfill compacted to top of pipe. (Approximately 80 per cent Standard Proctor, AASHTO T-99.)

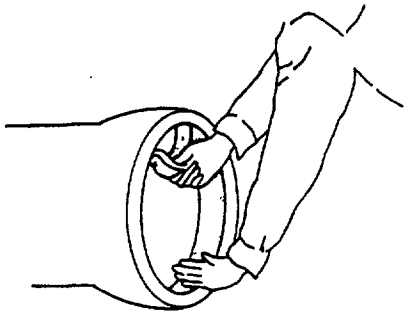


Type 5

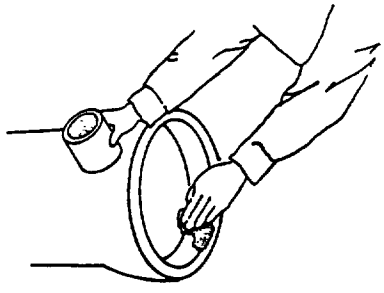
Pipe bedded in compacted granular material to centerline of pipe. Compacted granular or select‡ material to top of pipe. (Approximately 90 per cent Standard Proctor, AASHTO T-99.)

* For 30-in. and larger pipe, consideration should be given to the use of laying conditions other than Type 1.
† "Flat-bottom" is defined as undisturbed earth.
‡ "Loose soil" or "select material" is defined as native soil excavated from the trench, free of rocks, foreign materials, and frozen earth.

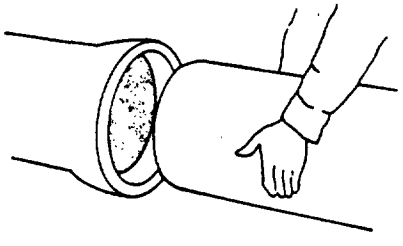
Fig. 2. Laying Conditions for Ductile Cast-Iron Pipe



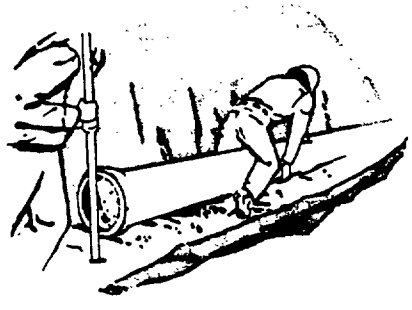
1. Thoroughly clean the groove and bell socket and insert the gasket, making sure that it faces the proper direction and that it is correctly seated.



2. After cleaning dirt or foreign material from the plain end, apply lubricant in accordance with the pipe manufacturer's recommendations. The lubricant is supplied in sterile cans and every effort should be made to keep it sterile.



3. Be sure that the plain end is beveled; square or sharp edges may damage or dislodge the gasket and cause a leak. When pipe is cut in the field, bevel *the plain end with a heavy file or grinder to remove all sharp edges. Push the plain end into the bell of the pipe. Keep the joint straight while pushing. Make deflection after the joint is assembled.*



4. Small pipe can be pushed into the bell socket with a long bar. Large pipe require additional power, such as a jack, lever puller, or backhoe. The supplier may provide a jack or lever pullers on a rental basis. A timber header should be used between the pipe and jack or backhoe bucket to avoid damage to the pipe.

Fig. 3. Push-on Joint Assembly

2. Place the gland on the plain end with the lip extension toward the plain end, followed by the gasket with the narrow edge of the gasket toward the plain end of the pipe.

3. Insert the pipe into the socket and press the gasket firmly and evenly into the gasket recess. Keep the joint straight during assembly. Make deflection after joint assembly but before tightening the bolts.

4. Push the gland toward the bell

and center it around the pipe with the gland lip against the gasket.

5. Align bolt holes and insert bolts, with bolt heads behind the bell flange, and tighten opposite nuts to keep the gland square with the socket.

6. Tighten the nuts in accordance with Table 4.

3.4.3 *Pipe deflection.* When it is necessary to deflect pipe from a straight line in either the vertical or horizontal plane, or where long radius curves are permitted, the amount of deflection shall not exceed that shown in Tables 5 or 6.

TABLE 4

Mechanical Joint—Bolt Torques

Bolt Diameter *in.*	Torque *ft-lb*
⅝	45–60
¾	75–90
1	85–100
1¼	105–120

3.4.4 *Pipe cutting.* Cutting pipe for the insertion of valves, fittings, or closure pieces shall be done in a neat, workmanlike manner without creating damage to the pipe or cement–mortar lining.

3.4.4.1 Gray cast-iron pipe may be cut using a hydraulic squeeze cutter, abrasive pipe saw, rotary wheel cutter, guillotine pipe saw, or milling wheel saw.

3.4.4.2 Ductile cast iron may be cut using an abrasive pipe saw, rotary wheel cutter, guillotine pipe saw, milling wheel saw, or oxyacetylene torch.

3.4.4.3 Cut ends and rough edges shall be ground smooth, and for push-on joint connections, the cut end shall be beveled.

3.4.5 *Polyethylene encasement.* When polyethylene encasement is specified for gray and ductile cast-iron pipe, it shall be installed in accordance with Sec. 5–4 of AWWA C105.

TABLE 5

Maximum Deflection Full Length Pipe—Push-on Type Joint

Pipe Diameter *in.*	Deflection Angle *deg*	Maximum Deflection—*in.*		Approx. Radius of Curve Produced by Succession of Joints—*ft*	
		(18-ft length)	(20-ft length)	(18-ft length)	(20-ft length)
3	5	19	21	205	230
4	5	19	21	205	230
6	5	19	21	205	230
8	5	19	21	205	230
10	5	19	21	205	230
12	5	19	21	205	230
14	3	11	12	340	380
16	3	11	12	340	380
18	3	11	12	340	380
20	3	11	12	340	380
24	3	11	12	340	380
30	3	11	12	340	380
36	3	11	12	340	380
42	2	7½	8	510	570
48	2	7½	8	510	570
54	1½	5½	6	680	760

TABLE 6

Maximum Deflection Full Length Pipe—Mechanical Joint Pipe

Size of Pipe *in.*	Deflection Angle *deg–min*	Maximum Deflection—*in.*		Approx. Radius of Curve Produced by Succession of Joints—*ft*	
		(18-ft length)	(20-ft length)	(18-ft length)	(20-ft length)
3	8–18	31	35	125	140
4	8–18	31	35	125	140
6	7–7	27	30	145	160
8	5–21	20	22	195	220
10	5–21	20	22	195	220
12	5–21	20	22	195	220
14	3–35	13½	15	285	320
16	3–35	13½	15	285	320
18	3–0	11	12	340	380
20	3–0	11	12	340	380
24	2–23	9	10	450	500
30	2–23	9	10	450	500
36	2–5	8	9	500	550
42	2–0	7½	8	510	570
48	2–0	7½	8	510	570

Sec. 3.5—Backfilling

Backfill shall be accomplished in accordance with the specified laying condition as described in Sec. 3.3.

3.5.1 *Backfill material.* All backfill material shall be free from cinders, ashes, refuse, vegetable or organic material, boulders, rocks or stones, frozen soil, or other material that, in the opinion of the owner, is unsuitable.

3.5.1.1 From 1 ft above the top of the pipe to the subgrade of the pavement, material containing stones up to 8 in. in their greatest dimension may be used, unless otherwise specified.

3.5.1.2 When the type of backfill material is not indicated on the drawings or is not specified, the excavated material may be used, provided that such material consists of loam, clay, sand, gravel, or other materials that, in the opinion of the owner, are suitable for backfilling.

3.5.1.3 If excavated material is indicated on the drawings or specified for backfill, and there is a deficiency due to a rejection of part thereof, the required amount of sand, gravel, or other approved material shall be provided.

3.5.1.4 All sand used for backfill shall be clean, graded from fine to coarse, not lumpy or frozen, and free from slag, cinders, ashes, rubbish, or other material that, in the opinion of the owner, is objectionable or deleterious. It should not contain a total of more than 10 per cent by weight of loam and clay, and all material must be capable of being passed through a ¾-in. sieve. Not more than 5 per cent shall remain on a No. 4 sieve.

3.5.1.5 Gravel used for backfill shall consist of clean gravel having durable particles graded from fine to coarse in a reasonably uniform combination with no boulders or stones larger than 2 in. in size. It shall be free from slag, cinders, ashes, refuse, or other deleterious or objectionable materials. It shall not contain excessive amounts of

loam and clay and shall not be lumpy or frozen. No more than 15 per cent shall pass a No. 200 sieve.

3.5.1.6 Screenings used for backfill shall consist of the products obtained from crushing sound limestone or dolomite ledge rock and shall be free from shale, dust, excessive amounts of clay, and other undesirable materials. All materials shall pass a ½-in. sieve, and no more than 25 per cent shall pass a No. 100 sieve.

3.5.2 *Compaction.* When special backfill compaction procedures are required, they shall be accomplished in accordance with project specifications or applicable federal, state, and local regulations.

3.5.3 *Partial backfilling during testing.* When specified by the owner, pressure and leakage testing may be accomplished before completion of backfilling and with pipe joints accessible for examination. In such cases, sufficient backfill material shall be placed over the pipe barrel between the joints to prevent movement.

Sec. 3.6—Valve-and-Fitting Installation

3.6.1 *Examination of material.* Prior to installation, valves shall be inspected for direction of opening, freedom of operation, tightness of pressure-containing bolting, cleanliness of valve ports and especially seating surfaces, handling damage, and cracks. Defective valves shall be corrected or held for inspection by the owner.

3.6.2 *Placement.* Valves, fittings, plugs, and caps shall be set and joined to the pipe in the manner specified in Sec. 3.3 for cleaning, laying, and joining pipe, except that 12-in. and larger valves should be provided with special support, such as treated timbers, crushed stone, concrete pads, or sufficiently tamped trench bottom so that the pipe will not be required to support the weight of the valve.

3.6.3 *Valve location.* Valves in water mains shall, where practical, be located on the street property lines extended in unpaved areas unless shown otherwise on the plans.

3.6.3.1 Mains shall be drained through drainage branches or blowoffs. Drainage branches, blowoffs, air vents, and appurtenances shall be provided with valves and shall be located and installed as shown on the plans. Drainage branches or blowoffs shall not be directly connected to any storm or sanitary sewer, submerged in any stream, or be installed in any other manner that will permit back siphonage into the distribution system.

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

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 and shall be centered over the operating nut of the valve, with the box cover flush with the surface of the finished area or such other level as may be directed by the owner.

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 which shall be set flush with the surface of the finished pavement or such other level as may be specified. Vaults shall be constructed to permit minor valve

repairs and afford protection to the valve and pipe from impact where they pass through the vault walls.

3.6.4.3 In no case shall valves be used to bring misaligned pipe into alignment during installation. Pipe shall be supported in such a manner as to prevent stress on the valve.

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 facilities.

Sec. 3.7—Hydrant Installation

3.7.1 *Examination of material.* Prior to installation, inspect all hydrants 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 corrected or held for inspection by the owner.

3.7.2 *Placement.* 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, except that hydrants having two-hose nozzles 90 deg apart shall be set with each nozzle facing the curb at an angle of 45 deg.

3.7.2.1 Hydrants shall be set to the established grade, with the centerline of the lowest nozzle at least 12 in. above the ground, or as directed by the owner.

3.7.2.2 Each hydrant shall be connected to the main with a 6-in. branch controlled by an independent 6-in. valve, unless otherwise specified by the owner.

3.7.2.3 When a dry-barrel hydrant is set in soil that is pervious, 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. above the waste opening in the hydrant and to a distance of 1 ft around the elbow. Where ground water rises above the drain port or when the hydrant is located within 8 ft of a sewer, the drain port shall be plugged and water pumped from the hydrant when freezing may occur.

3.7.2.4 When a dry-barrel hydrant with an open drain is set in clay or other impervious soil, a drainage pit 2 ft × 2 ft × 2 ft shall be excavated below each hydrant and filled with coarse gravel or crushed stone mixed with coarse sand, under and around the elbow of the hydrant and to a level of 6 in. above the drain port.

3.7.3 *Location.* Hydrants shall be located as shown on the plans or as directed by the owner.

3.7.4 *Protection.* In the case of hydrants that are intended to fail at the ground-line joint upon vehicle impact (traffic hydrants), specific care must be taken to provide adequate soil resistance 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. thick to a diameter of 2 ft at or near the ground line around the hydrant barrel.

Sec. 3.8—Thrust Restraint

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 stone slabs or concrete backing, or it shall be tied

to the pipe with suitable metal tie rods, clamps, or restrained joints as shown or directed by the owner.

3.8.1.1 Tie rods, clamps, or other components of dissimilar metal shall be protected against corrosion by hand application of a bituminous coating or by encasement of the entire assembly with 8-mil thick, loose polyethylene film in accordance with AWWA C105.

3.8.1.2 Thrust-restraint design pressure should be equal to the test pressure.

3.8.2 *Fittings.* All plugs, caps, tees, and bends, unless otherwise specified, shall be provided with reaction backing, or suitably restrained by attaching metal rods, clamps, or restrained joints as shown or specified by the owner.

3.8.3 *Restraint materials.* Vertical and horizontal reaction backing shall be made of concrete having a compressive strength of not less than 2000 psi after 28 days.

3.8.3.1 Backing shall be placed between solid ground and the fitting to be anchored; the area of bearing on the pipe and on the ground in each instance shall be that shown or directed by the owner. The backing shall, unless otherwise shown or directed, be so located as to contain the resultant thrust force and so that the pipe and fitting joints will be accessible for repair.

3.8.3.2 Restrained push-on joints, mechanical joints utilizing set-screw retainer glands or metal harness of tie rods, or clamps may be used instead of concrete backing if so indicated in the plans and specifications. Tie rods, clamps, or other components of dissimilar metal shall be protected against corrosion by hand application of a bituminous coating or by encasement of the entire assembly with 8-mil thick, loose polyethylene film in accordance with AWWA C105.

Section 4—Hydrostatic Testing

Sec. 4.1—Pressure Test

After the pipe has been laid, all newly laid pipe or any valved section thereof shall be subjected to a hydrostatic pressure of at least 1.5× the working pressure at the point of testing.

4.1.1 *Test pressure restrictions.* Test pressures shall

1. Not be less than 1.25× the working pressure at the highest point along the test section.
2. Not exceed pipe or thrust restraint design pressures.
3. Be of at least 2-hr duration.
4. Not vary by more than ±5 psi.
5. Not exceed twice the rated pressure of the valves or hydrants when

the pressure boundary of the test section includes closed gate valves or hydrants.

6. Not exceed the rated pressure of the valves if resilient-seated butterfly valves are used.

4.1.2 *Pressurization.* Each valved section of pipe shall be filled with water slowly and the specified test pressure, based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gage, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the owner.

4.1.3 *Air removal.* Before applying the specified test pressure, air shall be expelled completely from the pipe, valves, and hydrants. If permanent air vents are not located at all high points, the contractor shall install corporation cocks at such points so that the air can be expelled as the line is filled with water. After all the air has been expelled, the corporation cocks shall be closed and the test pressure applied. At the conclusion of the pressure test, the corporation cocks shall be removed and plugged, or left in place at the discretion of the owner.

4.1.4 *Examination.* All exposed pipe, fittings, valves, hydrants, and joints shall be examined carefully during the test. Any damage or defective pipe, fittings, valves, or hydrants that are discovered following the pressure test shall be repaired or replaced with sound material and the test shall be repeated until it is satisfactory to the owner.

Sec. 4.2—Leakage Test

A leakage test shall be conducted concurrently with the pressure test.

4.2.1 *Leakage defined.* Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe, or any valved section thereof, to maintain pressure within 5 psi of the specified test pressure after the air in the pipeline has been expelled and the pipe has been filled with water.

4.2.2 *Allowable leakage.* No pipe installation will be accepted if the leakage is greater than that determined by the following formula:

$$L = \frac{ND\sqrt{P}}{7400}$$

in which L is the allowable leakage, in gallons per hour; N is the number of joints in the length of pipeline tested; D is the nominal diameter of the pipe, in inches; and P is the average test pressure during the leakage test, in pounds per square inch gage.

4.2.2.1 Allowable leakage at various pressures is shown in Table 7 (page 16).

4.2.2.2 When testing against closed metal-seated valves, an additional leakage per closed valve of 0.0078 gal/hr/in. of nominal valve size shall be allowed.

4.2.2.3 When hydrants are in the test section, the test shall be made against the closed hydrant.

4.2.3 *Acceptance of installation.* Acceptance shall be determined on the basis of allowable leakage. If any test of pipe laid discloses leakage greater than that specified in Sec. 4.2.2, the contractor shall, at his own expense, locate and repair the defective material until the leakage is within the specified allowance.

4.2.3.1 All visible leaks are to be repaired regardless of the *amount* of leakage.

TABLE 7

*Allowable Leakage per 1000 ft of Pipeline** gph

Avg. Test Pressure psi	Nominal Pipe Diameter in.																	
	2	3	4	6	8	10	12	14	16	18	20	24	30	36	42	48	54
450	0.32	0.48	0.64	0.95	1.27	1.59	1.91	2.23	2.55	2.87	3.18	3.82	4.78	5.73	6.69	7.64	8.60
400	0.30	0.45	0.60	0.90	1.20	1.50	1.80	2.10	2.40	2.70	3.00	3.60	4.50	5.41	6.31	7.21	8.11
350	0.28	0.42	0.56	0.84	1.12	1.40	1.69	1.97	2.25	2.53	2.81	3.37	4.21	5.06	5.90	6.74	7.58
300	0.26	0.39	0.52	0.78	1.04	1.30	1.56	1.82	2.08	2.34	2.60	3.12	3.90	4.68	5.46	6.24	7.02
275	0.25	0.37	0.50	0.75	1.00	1.24	1.49	1.74	1.99	2.24	2.49	2.99	3.73	4.48	5.23	5.98	6.72
250	0.24	0.36	0.47	0.71	0.95	1.19	1.42	1.66	1.90	2.14	2.37	2.85	3.56	4.27	4.99	5.70	6.41
225	0.23	0.34	0.45	0.68	0.90	1.13	1.35	1.58	1.80	2.03	2.25	2.70	3.38	4.05	4.73	5.41	6.03
200	0.21	0.32	0.43	0.64	0.85	1.06	1.28	1.48	1.70	1.91	2.12	2.55	3.19	3.82	4.46	5.09	5.73
175	0.20	0.30	0.40	0.59	0.80	0.99	1.19	1.39	1.59	1.79	1.98	2.38	2.98	3.58	4.17	4.77	5.36
150	0.19	0.28	0.37	0.55	0.74	0.92	1.10	1.29	1.47	1.66	1.84	2.21	2.76	3.31	3.86	4.41	4.97
125	0.17	0.25	0.34	0.50	0.67	0.84	1.01	1.18	1.34	1.51	1.68	2.01	2.52	3.02	3.53	4.03	4.53
100	0.15	0.23	0.30	0.45	0.60	0.75	0.90	1.05	1.20	1.35	1.50	1.80	2.25	2.70	3.15	3.60	4.05

* For pipe with 18-ft nominal lengths. To obtain the recommended allowable leakage for pipe with 20-ft nominal lengths, multiply the leakage calculated from the table by 0.9. If the pipeline under test contains sections of various diameters, the allowable leakage will be the sum of the computed leakage for each size.

Section 5—Disinfection

Upon completion of a newly installed main or when repairs to an existing pipe are made, the main shall be disinfected according to instructions listed in AWWA C601 of latest revision.

Section 6—Highway and Railroad Crossings

Sec. 6.1—Casing Pipe

When casing pipe is specified for highways or railroad crossings, the project shall be completed in accordance with applicable federal, state, and local regulations. In the case of railroad crossings, the project should comply further with regulations established by the railroad company. General practice permits boring for casing diameters through 36 in. with maximum length of about 175 ft; jacking for diameters 30 in. through 60 in. with lengths of about 200 ft; and tunneling for pipes 48 in. and larger for longer lengths.

Sec. 6.2—Carrier Pipe

The casing pipe should be 6–8 in. larger than the outside diameter of the gray or ductile cast-iron pipe bells. Carrier pipe may be pushed or pulled through the completed casing pipe. Chocks or skids should be placed on the carrier pipe to ensure approximate centering within the casing pipe and to prevent damage during installation. Care must be exercised in order to avoid metal-to-metal contact. In order to avoid the transfer of earth and live loads to the carrier pipe, the space between the carrier and casing pipes should not be filled completely.

Section 7—Service Taps

Sec. 7.1—Tapping

Corporation stops may be installed either before or after pipe installation. Generally, they are located at ten or two 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 in a gray cast-iron pipe is necessary to deliver the required flow, they should be staggered around the circumference at least 12 in. apart (not in a straight line). Ductile-iron pipe in all classes may be directly tapped with standard corporation stops; however, torque requirement for the installation may be effectively reduced by the application of two layers of 3-mil TFE tape to the male threads of the corporation stop.

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