DUCTILE IRON WATER MAIN SPECIFICATIONS

SECTION 1: GENERAL

SEC. 1.1 Scope

1.1.1 This standard covers water system main piping, valves, hydrants, fittings, anchors, air vents and other associated equipment or materials as indicated on the construction plans.

1.1.2 Installation procedures for ductile-iron mains and their appurtenances for water distribution service.

1.1.3 Procedures for disinfecting new and repaired water mains. All new water mains shall be disinfected before they are placed in service. All water mains taken out of service for inspection, repair, or other activities that might lead to contamination of water shall be disinfected before they are returned to service.

SEC. 1.2 References

This section references the following documents. The latest current edition of each document forms a part of this specification. In case of any conflict, the requirements in this specification shall prevail.

ANSI/AWWA C104/A21.4 - American National Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.

ANSI/AWWA C105/A21.5 - American National Standard for Polyethylene Encasement for Ductile-Iron Piping for Water and Other Liquids.

ANSI/AWWA C111/A21.11 - American National Standard for Rubber-Gasket Joints for Ductile-Iron Pipe.

ANSI/AWWA C150/A21.5 - American National Standard for the Thickness Design of Ductile-Iron Pipe.

ANSI/AWWA C151/A21.51 - American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.

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

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

AWWA Manual M27, *External Corrosion-Introduction to Chemistry and Control.*

SEC. 1.3 Definitions

The following definitions shall apply:

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

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

1.3.3 *Manufacturer*: The party that manufactures, fabricates, or produces material or products.

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

1.3.5 *Plans*: Drawings normally prepared by an engineer showing the location and details for the construction of the pipeline and appurtenances.

1.3.6 *Purchaser*: The party entering into a contract or agreement for the purchase of any materials or work to be performed. A purchaser may or may not be the owner.

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

SEC. 1.4 Permeation

The selection of materials is critical for water service and distribution piping in locations where it is likely the pipe will be exposed to significant concentrations of pollutants composed of low-molecular-weight petroleum products or organic solvents or their vapors. Research has documented that some pipe materials, and elastomers, such as used in jointing gaskets and packing glands, may be subject to premeation by lower–molecular-weight organic solvents and petroleum products. If a water pipe must pass through such a contaminated area or an area subject to contamination, consult with engineer regarding premeation of pipe walls, jointing materials, and so forth, **before** installing materials for use in that area.

SEC. 1.5 Affidavit of Compliance

The contractor shall, if so specified by the purchaser, furnish an affidavit that all delivered and installed materials conform to the requirements of this specification.

SECTION 2: MATERIALS

SEC. 2.1 Pipe Materials

2.1.1 *Pipe*: Ductile Iron, class 52, .

2.1.2 *Interior Lining*. Pipe interior shall be cement-lined bituminous seal coating conforming to ANSI/AWWA C104/A21.4

2.1.3 *Exterior Coating*. The outside coating for use under normal conditions shall be an asphaltic coating approximately 1 mil thick. The coating shall be applied to the outside of all pipe, unless otherwise specified. The finished coating shall be continuous, smooth, neither brittle when cold nor sticky when exposed to the sun, and shall be strongly adherent to the pipe.

2.1.4 *Joints*: Ductile-Iron pipe joints shall be rubber gasket push-on type conforming to ANSI/AWWA C111/A21.11.

2.1.5 *Fitting Joints*. Joints for fittings shall be mechanical joint conforming to ANSI/AWWA C111/A21.11.

2.1.6 *Gasket*. The gaskets shall be plain rubber, of heavy section and high durometer, single molded.

2.1.7 *Lubricant*. The lubricant shall be non-toxic, tasteless, odorless grease that will not support bacteria and shall meet or exceed AWWA standards and/or those of the NSF.

SECTION 3: INSPECTION, UNLOADING, HANDLING AND STORAGE

SEC. 3.1 Inspection

3.1.1 *Inspection on delivery*: All pipe and appurtenances are subject to inspection at the point of delivery. Neither inspection nor failure to provide inspection shall relieve manufacturer of the responsibility to furnish materials meeting the specifications. Materials found to be defective due to manufacture or damaged in shipment shall be rejected or recorded on the bill of lading and removed from the job site. Tests may be performed as specified in the applicable AWWA standard to ensure conformance with the standards. Pipe or appurtenances that fail to comply with specified tests shall be rejected.

3.1.2 *Workmanship*: All pipe and appurtenances shall be installed and joined in conformance with the standard and tested under pressure for defects and leaks in accordance with Sec. 5 of these specifications.

SEC. 3.2 Unloading, Handling, and Storage

All pipe, fittings, valves, hydrants, and accessories shall be loaded and unloaded by lifting with lift 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 other pipe.

3.2.1 *Unloading pipe*. Trucks shall be parked on level ground for unloading.

3.2.1.1 Before the release of chains, cables, and strapping around the pipe, 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 chains or other binders 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.

3.2.1.2 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.

3.2.2 *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, fittings, or related products.

3.2.3 *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.

3.2.3.1 Pipe shall not be stacked higher than the limits shown on Table 1. 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 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.

Table 1 Maximum stacking heights – ductile-iron pipe*

Nominal Pipe Size (in.)	Number of Tiers
3	18
4	16
6	13
8	11
10	10
12	9
14	8
16	7
18, 20	6
24	5
30, 36	4
42, 48, 54, 60, 64	3

*For 18- or 20-ft lengths

3.2.3.2 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.

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

3.2.3.4 Prolonged exposure to sunlight will eventually deteriorate polyethylene film. Therefore, such exposure prior to backfilling the wrapped pipe should be kept to a minimum. If several weeks of exposure prior to backfilling are anticipated, class C material should be used (see ANSI/AWWA A105/A21.5).

SECTION 4: INSTALLATION

SEC. 4.1 Alignment and Grade

The water main shall be laid and maintained to lines and grades established by the plans for the project. Fittings, valves, tapped outlets, and hydrants must be installed at the required location unless field conditions warrant otherwise, and such changes are approved by the engineer and local municipal authority.

4.1.1 *Prior investigation.* The contractor shall call Miss Utility (1-800-552-7001) at least 48 hours, excluding Saturdays, Sundays, and legal state and national holidays, prior to the commencement of excavation or demolition. Investigation shall be made to the extent necessary to determine the location of existing underground structures and conflicts. Care shall be exercised during excavation to avoid damage to existing structures. Special precautions shall be taken when the water main being installed crosses or is adjacent to a facility that is cathodically protected.

4.1.2 *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, such alterations or deviations in line and grade, or the removal, relocation, or reconstruction of the obstruction shall be performed in accordance with the specifications.

4.1.3 *Public Right of Way.* Within public R-O-W's, utility construction shall prevent the encroachment of underground utilities (electric, telephone, television cables, gas, storm water, etc.) within five (5) feet of water mains. This distance shall be extended to accommodate 1:1 embankment slopes if water pipe has greater than five (5) feet depth of cover.

4.1.4 *Parallel Installation.* When water and sewer pipelines are in parallel alignment.

4.1.4.1 *Normal conditions.* Water lines shall be laid at least ten (10) feet horizontally from a sewer or sewer manhole whenever possible, The distance shall be measured edge-to-edge.

4.1.4.2 *Unusual conditions.* When local conditions prevent a horizontal separation of ten (10) feet, the water line may be laid closer to a sewer or sewer manhole provided that:

i. The bottom (invert) of the water main shall be at least eighteen (18) inches above the top (crown) of the sewer pipe.

ii. Where the vertical separation cannot be obtained, the sewer shall be constructed of AWWA approved water pipe, pressure tested in place without leakage prior to backfilling.

iii. The sewer manhole shall be of watertight construction and tested in place.

4.1.5 *Crossings non-sewer.* Underground utilities (electric, telephone, television cables, gas, storm water, etc.) shall provide an absolute minimum eight (8) inches clearance with water (outside of pipe to outside of pipe) and eighteen (18) inches clearance within two (2) feet of a joint in either structure. Utility pipes fifteen (15) inches and larger shall be specially designed and detailed on the plans by engineer if clearance is less than eighteen (18) inches.

4.1.6 *Crossings sewer.* When water and sewer pipelines cross.

4.1.6.1 *Normal conditions.* Waterlines crossing sewers shall be laid to provide a separation of at least eighteen (18) inches between the bottom of the waterline and the top of the sewer whenever possible.

4.1.6.2 *Unusual conditions.* When local conditions prevent a vertical separation described in sec. 4.1.6.1, the following construction shall be used:

i. Sewer passing over or under water lines shall be constructed of the materials required for water main construction.

ii. Water lines passing under sewers shall, in addition, be protected by providing:
1. A vertical separation of at least eighteen (18) inches between the bottom of the sewer and the top of the water line.
2. Adequate structural support for the sewers to prevent excessive deflection of the joints and the settling on and breaking of the water line.
3. That the length of the water line be centered at the point of the crossing so that joints shall be equidistant and as far as possible from the sewer.

4.1.7 *Minimum cover.* The minimum cover for new water pipe installation shall be three (3) feet.

4.1.8 *Maximum cover.* The maximum cover for water pipe shall be eight (8) feet in all cases. If field conditions warrant otherwise, changes require written approval by the engineer and or local municipal authority.

4.1.9 *Altered grade.* Existing water pipes shall be lowered or raised when proposed site grading alters cover to less than two and one-half (2 ½) feet or greater than five (5) feet.

Sec. 4.2 Trench Construction

The trench shall be excavated to the required alignment, depth, and width specified or shown on the plans and shall be in conformance with all federal, state or provincial, and local regulations for the protection of the workers.

4.2.1 *Trench preparation.* Trench preparation shall proceed in advance of pipe installation for only as far as one (1) day of pipe installation or as stated on the plans.

4.2.1.1 Discharges from trench dewatering pumps shall be directed away from the trench in order not to affect trench stability, and shall be in accordance with federal, state or provincial, and local point-discharge requirements.

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

4.2.2 *Pavement removal.* Removal of pavement and road surfaces shall be a part of the trench excavation. The amount removed shall depend on the width of trench required for 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 six (6) inches in any direction, unless otherwise stipulated on the drawings. Methods such as sawing, drilling, or chipping shall be used to ensure the breakage of pavement along straight lines.

4.2.3 *Width.* The width of the trench at the top of the pipe shall be the same as that afforded by the single-pass capabilities of normally available excavating equipment. The width shall be ample to permit the pipe to be laid and joined properly and to allow the backfill to be placed in accordance with the specifications. Trench widths shown in Table 2 may be used as a guide. Trenches shall be of such extra width, when required, to permit the placement of timber supports, sheeting, bracing, and appurtenances as required by the safety requirements of the agency having jurisdiction.

Table 2 Suggested trench widths at the top of the pipe

Nominal Pipe Size inches	Trench Width* inches
3, 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
60	84
64	88

* trench width = NPS + 24"

4.2.4 *Bell holes.* Holes for the bells shall be provided at each joint, but shall be no larger than necessary to allow joint assembly and to ensure that the pipe barrel will lie flat on the trench bottom. The dimensions of the bell-hole depressions for push-on-type joints only need to be large enough to ensure that the pipe is not resting on the bells and is supported by the full length of the pipe barrel.

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

4.2.5 *Rock conditions*. When excavation of rock is necessary, all rock shall be removed to provide a clearance below and on each side of all pipes, valves, and fittings of at least six (6) inches for nominal pipe sizes twenty-four (24) inches or smaller and nine (9) inches for nominal pipe sizes thirty (30) inches and larger. When excavation is completed, a layer of appropriate backfill material (see Sec. 4.5) shall be placed on the bottom of the trench to the previously mentioned depths, leveled, and tamped.

4.2.5.1 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.

4.2.5.2 This installation procedure shall be followed when gravel formations containing loose boulders greater than approximately eight (8) inches in diameter are encountered.

4.2.5.3 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 pointload.

4.2.6 *Previous excavations*. If the trenches 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.

4.2.7 *Blasting*. Blasting for excavation shall be permitted only after securing approval(s) from local municipal authority. Blasting shall be conducted during daylight hours or as required by the plans. The blasting procedure, including protection of persons and property, shall be in strict accordance with federal, state or provincial, and local regulations.

4.2.8 *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.

4.2.8.1 Any cutting of tree roots or branches shall be performed in accordance with the plans.

4.2.8.2 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 provided in accordance with specifications or applicable regulations.

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

4.2.9 *Unsuitable subgrade material*. When the subgrade is found to include ashes cinders, refuses, organic material, or other unsuitable material, such material shall be removed to a minimum of at least six (6) inches below the bottom of the pipe or to the depth required by the specifications. The removed material shall be replaced with clean, stable backfill material. When such potentially corrosive materials are encountered, polyethylene encasement should be used to protect the pipe (see Sec. 4.3.8). The bedding shall be consolidated and leveled so that the pipe may be installed in accordance with Sec. 4.2.4.

4.2.10 *Unstable subgrade.* When the bottom of the trench or the subgrade is found to consist of material that is unstable to such a degree that it cannot be removed, a foundation for the pipe and/or appurtenance shall be constructed using piling, treated timber, concrete, or other materials, in accordance with the specifications.

4.2.11 *Safety.* 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.

Sec. 4.3 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 backhoe, a crane, ropes, or other suitable tools or equipment, in such 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. Where practical, the trench should be dewatered prior to installation of the pipe.

4.3.1 *Examination of material.* All pipes, fittings, valves, hydrants, and other appurtenances shall be examined carefully for damage and other defects immediately before installation. Defective materials shall not be installed but marked and held for final disposition.

4.3.2 *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 materials before the pipe is laid.

4.3.3 *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.

4.3.4 *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.

4.3.5 *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.

4.3.6 *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 as specified. The 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.

4.3.6.1 Prior to removal of the plug for extending the line or for any other reason, air and/or water pressure in the line shall be released.

4.3.7 *Ductile-iron laying conditions.* The laying conditions for ductile-iron pipe shall be completed in accordance with ANSI/AWWA C151/21.50 as illustrated in Figure 1, and as required by the specifications.

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

4.3.8 For any installation requiring polyethylene encasement for corrosion protection of ductile-iron pipe, the encasement shall be installed in accordance with ANSI/AWWA C150/A21.5.

4.3.9 For installations requiring other forms of corrosion protection, refer to AWWA Manual M27.

4.3.10 Special transition couplings and/or gaskets are required for joining different types of pipe, such as steel pipe, asbestos-cement pipe, and plastic pipe. Such transition devices are available. When ordering, the actual outside diameter of the pipe should be given.

Sec. 4.4 Joint Assembly

4.4.1 *Push-on joints*. Push-on joints shall be assembled as described.

4.4.1.1 Thoroughly clean the groove and the bell socket of the pipe or fitting; also clean the plain end of the mating pipe. Using a gasket of the proper design for the joint to be assembled, make a small loop in the gasket and insert it in the socket, making sure the gasket faces the correct direction and that it is properly seated. NOTE: In cold weather, it is necessary to warm the gasket to facilitate insertion.

4.4.1.2 Apply lubricant to the gasket and plain end of the pipe in accordance with the pipe manufacturer's recommendations. Lubricant is furnished in sterile containers, and every effort should be made to protect against contamination of the container's contents. In some cases, manufacture's recommendations on joint lubrication require that the gasket groove not be lubricated; in others, lubrication of the groove is necessary. It is important to follow the pipe manufacturer's instructions.

4.4.1.3 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.

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

4.4.2 *Mechanical joints*. Mechanical joints shall be assembled as described.

4.4.2.1 Clean the socket and plain end. Lubrication and additional cleaning should be provided by brushing both the gasket and plain end with soapy water or an approved pipe lubricant meeting the requirements of ANSI/AWWA C111/A21.11, just prior to slipping the gland into the plain end for joint assembly. 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.

4.4.2.2 Insert the pipe into the socket and press the gasket firmly and evenly into the gasket recess. Keep the joint straight during assembly.

4.4.2.3 Push the gland toward the socket and center it around the pipe with the gland lip against the gasket. Insert bolts and hand tighten nuts. Make deflection after joint assembly but before tightening bolts.

4.4.2.4 Tighten the bolts to the normal range of bolt torque as indicated in Table 3 while as all times maintaining approximately the same distance between the gland and the face of the flange at all points around the socket. This can be accomplished by partially tightening the bottom bolt first, then the top bolt, next the bolts at either side, finally the remaining bolts. Repeat the process until all bolts are within the appropriate range of torque. In large sizes (30-48 inches), five or more repetitions may be required. The use of a torque indicating wrench will facilitate this procedure.

Table 3 Mechanical-Joint bolt torque

Joint Size inches	Bolt Size inches	Range of Torque foot-pounds
3	5/8	45 - 60
4-24	¾	75 - 90
30-36	1	100 - 120
42-48	1 ¼	120 - 150

4.4.3 *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 4. 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 1 illustrates the maximum offset *S* and approximate radius curve R, which are listed in Tables 4.

Table 4 Maximum joint deflection L = 18' pipe

	Push-On Type Joint Pipe			**Mechanical-Joint Pipe**		
Nominal Pipe Size Inch	Deflection Angle deg-min	Max. Offset inches	Radius of Curve feet	Deflection Angle deg-min	Max. Offset inches	Radius of Curve feet
3	5 – 0	19	205	8 – 18	31	125
4	5 - 0	19	205	8 – 18	31	125
6	5 - 0	19	205	7 – 07	27	145
8	5 - 0	19	205	5 – 21	20	195
10	5 - 0	19	205	5 – 21	20	195
12	5 - 0	19	205	5 – 21	20	195
14	3 - 0	11	340	3 – 35	13.5	285
16	3 - 0	11	340	3 – 35	13.5	285
18	3 - 0	11	340	3 – 00	11	340
20	3 - 0	11	340	3 – 00	11	340
24	3 - 0	11	340	2 – 23	9	240

30	3 - 0	11	340
36	3 - 0	11	340
42	3 - 0	11	340
48*	3 - 0	11	380
54*	3 - 0	11	380
60*	3 - 0	11	380
64*	3 - 0	11	380

* Pipe length L = 20'.

θ = deflection angle
S = joint deflection offset
L = laying length
R = radius of curve

$$R = \frac{L}{2 \tan (\theta/2)}$$

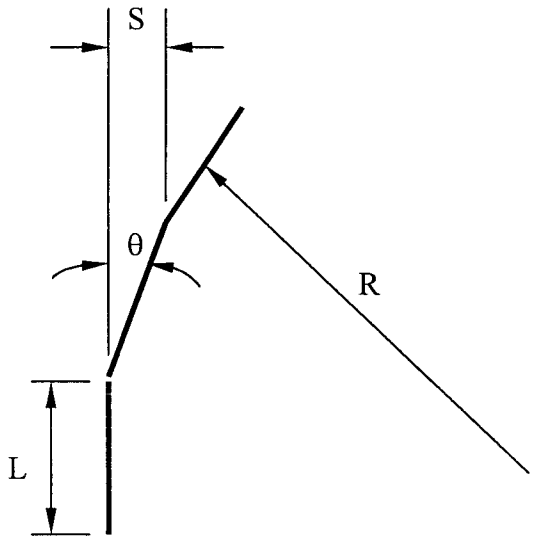

Figure 1 Pipeline curve geometry

4.4.4 *Pipe cutting.* Cutting pipe for insertion of valves, fittings, or closure pieces shall be done in conformance with all safety recommendations of the manufacturer of the cutting equipment. Cutting shall be done in a safe, workmanlike manner without creating damage to the pipe or cement-mortar lining.

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

4.4.4.2 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.

4.4.4.3 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.

4.4.4.4 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 (MJ) gland inserted over the barrel might serve as a convenient indicator for this purpose.

Sec. 4.5 Backfilling

Backfill shall be accomplished in accordance with the specified laying conditions described in Sec. 4.3.

4.5.1 *Backfill material.* All backfill material shall be free from cinders, ashes, refuse, vegetable or organic material, boulders, rocks or stones, frozen soil, or other unsuitable material.

4.5.1.1 From one (1) foot above the top of the pipe to the subgrade of the pavement, material containing stones up to eight (8) inches in their greatest dimension may be used, unless otherwise specified.

4.5.1.2 When the type of backfill material is not indicated on the plans or is not specified, the excavated material may be used, provided that such material consists of loam, clay, sand, gravel, or other suitable materials.

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

4.5.1.4 For purposes of definition: (a) *sand* is material graded from fine to coarse, containing less than 10 percent by weight of loam and clay that passes a three quarter (¾) inch sieve with no more than five (5) percent by weight remaining on a US No. 4 sieve; (b) *gravel* is a reasonably uniform combination, containing no boulders and loam; and (c) *crushed stone* is limestone or dolomite ledge-rock material that completely passes a half (½) inch sieve with no more than twenty-five (25) percent passing a US No. 100 sieve.

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

4.5.3 *Partial backfilling during testing.* Newly installed pipelines are normally tested after backfilling. When unusual conditions require that pressure and leakage testing be accomplished 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, and due consideration shall be 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.

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

Sec. 4.6 Valve and Fitting Installation

4.6.1 *Examination of material.* Prior to 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 called for by the specifications. 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 recommendation from the manufacturer.

4.6.2 *Placement.* Valves, fittings, plugs, and caps shall be set and joined to the pipe in the manner specified in Sec. 4.3 for cleaning and laying, and Sec. 4.4 for joining pipe, except that twelve (12) inches and larger valves 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.

4.6.3 *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 plans.

4.6.3.1 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 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 backsiphonage into the distribution system.

4.6.3.2 Air-release and/or vacuum vents shall be provided at high points in the line and in areas of potential negative pressure. The air-release and/or vacuum vents shall not be connected to any storm or sanitary sewer and they shall be protected from freezing in locations where cold temperatures are encountered.

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

4.6.4.1 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 such other level as specified.

4.6.4.2 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 to protect the valve and pipe form impact where they pass through the vault walls.

4.6.4.3 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.

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

4.6.5 *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.

4.6.6 *Additional information.* Additional information regarding installation of gate valves can be found in the appendices of ANSI/AWWA C500 and ANSI/AWWA C509.

Sec. 4.7 Hydrant Installation

4.7.1 *Examination of material.* Prior to 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 as called for by the specifications.

4.7.2 *Placement.* All hydrants shall stand plumb and shall have their nozzles parallel with or at right angles to the curb, with pumper nozzle facing the curb, except that hydrants having two-hose nozzles 90° apart shall be set with each nozzle facing the curb at an angle of 45°.

4.7.2.1 Hydrants shall be set to the established grade, with the lowest nozzle at least twelve (12) inches above the ground or as required by the specifications. 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 shall be installed so that the breakaway flange is not less than two (2) inches, nor more than six (6) inches, above established grade.

4.7.2.2 Each hydrant shall be connected to the main with a six (6) inch or larger-diameter branch controlled by an independent valve, unless otherwise specified. The valve shall be restrained to allow shutoff when the hydrant is to be removed.

4.7.2.3 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 six (6) inches above the drain-port opening in the hydrant and to a distance of one (1) foot around the elbow. Where groundwater rises above the drain port or when the hydrant is located within eight (8) feet(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.

4.7.2.4 When a dry-barrel hydrant with an open drain port is set in clay or other impervious soil, a drainage pit 2 ft $\times$2 ft $\times$2 ft (0.6 m $\times$ 0.6 m $\times$ 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 and to a level of six (6) inches above the drain port. To prevent possible contamination of the water supply, do not connect hydrant drains to a sanitary sewer or storm sewer.

4.7.3 *Location.* Hydrants shall be located as shown on the plans or as specified.

4.7.4 *Protection.* In the case of hydrants that are intended to fail at the ground-line joint on 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 six (6) inches thick to a diameter of two (2) feet at or near the ground line around the hydrant barrel.

4.7.5 *Additional information.* Additional information regarding installation of hydrants can be found in AWWA Manual M17.

Sec. 4.8 Thrust Restraint

4.8.1 *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 on the plans or as specified.

4.8.2 *Fittings.* All plugs, caps, tees, reducers, and bends, unless otherwise specified, shall be provided with thrust blocks or suitably restrained joints, as shown on the plans or as specified.

4.8.3 *Design.* The 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 expected to be applied. In most cases, this 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 in such a manner that joint separation will not occur in unrestrained joints.

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

4.8.5 *Restrained joints.* If so indicated in the plans and specifications, restraining mechanisms for push-on or mechanical joints may be used instead of concrete thrust blocking. Tie rods, clamps, or other components shall be of corrosion-resistant material or suitably protected against corrosion.

Sec. 4.9 Flushing

Foreign material left in pipelines during installation often results in valve- or hydrant-seat leakage during pressure tests. Every effort shall be made to keep lines 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.

SECTION 5: HYDROSTATIC TESTING

Warning: The testing methods in this section are specific for water-pressure testing. These procedures should not be applied for air-pressure testing because of the serious safety hazards involved.

Sec. 5.1 Pressure and Leakage Test

5.1.1 Test restrictions.

- Test pressure shall not be less than 1.25 times the working pressure at the highest point along the test section.
- Test pressure shall not exceed pipe or thrust-restraint design pressures.
- The hydrostatic test shall be of at least a two (2) hour duration.
- Test pressure shall not vary by more then ± 5 psi for the duration of the test.
- Valves shall not be operated in either direction at a differential pressure exceeding the rated valve working pressure. Use of a test pressure greater than the rated valve pressure can result in trapped test pressure between the gates of a double-disc gate valve. For tests at these pressures, the test setup should include a provision, independent of the valve, to reduce the line pressure to the rated valve pressure on completion of the test. The valve can then be opened enough to equalize the trapped pressure with the line pressure, or fully opened if desired.
- The test pressure shall not exceed the rated pressure of the valves when the pressure boundary of the test section includes closed, resilient-seated gate valves or butterfly valves.

5.1.2 Pressurization. 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 times the working pressure at the point of testing. Each valved section of pipe shall be slowly filled with water, 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 gauge) shall be applied by means of a pump connected to the pipe. Valves shall not be operated in either the opening or closing direction at differential pressures above the rated pressure. It is good practice to allow the system to stabilize at the test pressure before conducting the leakage test.

5.1.3 Air removal. Before applying the specified test pressure, air shall be expelled completely from the section of piping under test. If permanent air vents are not located at all high points, corporation cocks shall be installed 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 as required by the specifications.

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

5.1.5 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 pipe has been filled with water and the air has been expelled. Leakage shall not be measured by a drop in pressure in a test section over a period of time.

5.1.6 Allowable leakage. No pipe installation will be accepted if the leakage is greater than that determined by the following formula:
In inch-pound units,

$$L = \frac{S D P^{1/2}}{133{,}200}$$

Where:

L	=	allowable leakage, in gallons per hour
S	=	length of pipe tested, in feet
D	=	nominal diameter of the pipe, in inches
P	=	average test pressure during the leakage test, in pounds per square inch (gauge)

These formulas are based on an allowable leakage of 11.65 gpd/mi/in. of nominal diameter at a pressure of 150 psi.

5.1.6.1 When testing against closed metal-seated valves, an additional leakage per closed valve of 0.0078 gallons per hour per inch (gal/h/in) of nominal valve size shall be allowed.

5.1.6.2 When hydrants are in the test section, the test shall be made against the main valve in the hydrant.

5.1.7 Acceptance of installation. Acceptance shall be determined on the basis of allowable leakage. If any test of laid pipe discloses leakage greater than that specified in Sec. 5.1.6, repairs or replacements shall be accomplished in accordance with the specifications.

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

SECTION 6: **DISINFECTION**

A newly installed main shall be disinfected in accordance with ANSI/AWWA C651. Following cholorination, the main should be flushed as soon as possible (within twenty-four 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, or flushing of newly installed mains.

Sec. 6.1 Forms of Chlorine for Disinfection

The forms of chlorine that may be used in the disinfection operations are liquid chlorine, sodium hypochlorite, and calcium hypochlorite granules or tablets.

6.1.1 *Liquid Chlorine.* Liquid chlorine conforming to ANSI/AWWA B301 contains 100 percent available chlorine and is packaged in steel containers usually of 100-lb, 150-lb, or 1-ton net chlorine weight. Liquid chlorine shall be used only (1) in combination with appropriate gas-flow chlorinators and ejectors to provide a controlled high-concentration solution feed to the water to be chlorinated; (2) under the direct supervision of a person who is familiar with the physiological, chemical, and physical properties of liquid chlorine, and who is trained and equipped to handle any emergency that may arise; and (3) when appropriate safety practices are observed to protect working personnel and the public.

6.1.2 *Sodium Hypochlorite.* Sodium hypochlorite conforming to ANSI/AWWA B300 is available in liquid form in glass, rubber-lined, or plastic containers typically ranging in size from one (1) quart to five (5) gallons. Containers of thirty (30) gallons or larger may be available in some areas. Sodium hypochlorite contains approximately five (5%) percent to fifteen (15%) percent available chlorine, and care must be taken to control conditions and length of storage to minimize its deterioration. *(Available chlorine is expressed as a percent of weight when the concentration is 5 percent or less, and usually as a percent of volume for higher concentrations. Percent $\times 10$ = grams of available chlorine per litre of hypochlorite.)*

6.1.3 *Calcium Hypochlorite.* Calcium hypochlorite conforming to ANSI/AWWA B300 is available in granular form or in five (5) gram tablets, and contains approximately sixty-five (65%) percent available chlorine by weight. The material should be stored in a cool, dry, and dark environment to minimize its deterioration.

Sec. 6.2 Methods of Chlorination

Three methods of chlorination are explained in this section: tablet, continuous feed, and slug. Information in the foreword will be helpful in determining the method to be used. The tablet method gives an average chlorine dose of approximately 25 mg/L; the continuous-feed method gives a 24-hour chlorine residual of not less than 10 mg/L; and the slug method gives a 3-hour exposure of not less than 50 mg/L free chlorine.

6.2.1 *Tablet Method.* The tablet method consists of placing calcium hypochlorite granules or tablets in the water main as it is being installed and then filling the main with potable water when installation is completed.

This method may be used only if the pipes and appurtenances are kept clean and dry during construction.

6.2.1.1 *Placing of calcium hypochlorite granules.* During construction, calcium hypochlorite granules shall be placed at the upstream end of the first section of pipe, at the upstream end of each branch main, and at five hundred (500) feet intervals. The quantity of granules shall be as shown in Table 5.
WARNING: *This procedure must not be used on solvent-welded plastic or on screwed-joint steel pipe because of the danger of fire or explosion from the reaction of the joint compounds with the calcium hypochlorite.*

Table 5 Ounces of calcium hypochlorite at beginning and at each 500 foot

Nominal Pipe Size inches	Calcium Hypochlorite ounces
4	0.5
6	1.0
8	2.0
12	4.0
16 and larger	8.0

6.2.1.2 *Placing of calcium hypochlorite tablets.* During construction, a five (5) gram calcium hypochlorite tablets shall be placed in each section of pipe. Also, one such tablet shall be placed in each hydrant, hydrant branch, and other appurtenances. The number of tablets required for each pipe section shall be $0.0012\ d^2L$ rounded to the next higher integer, where d is the inside pipe diameter, in inches, and L is the length of the pipe section, in feet. Table 6 shows the number of tablets required for commonly used sizes of pipe. The tablets shall be attached by a food-grade adhesive. * There shall be no adhesive on the tablet except on the broadside attached to the surface of the pipe. Attach all the tablets inside and at the top of the main, with approximately equal numbers of tablets at each end of a given pipe length. If the tablets are attached before the pipe section is placed in the trench, their position shall be marked on the section so it can be readily determined that the pipe is installed with the tablets at the top.

Table 6 Calcium hypochlorite tablets required for 25 mg/L* dose

Pipe Size inches	Length of Pipe Section				
	< 13	18	20	30	40
	Number of 5 gram tablets				
4	1	1	1	1	1
6	1	1	1	2	2
8	1	2	2	3	4
10	2	3	3	4	5
12	3	4	4	6	7
16	4	6	7	10	13

* *Based on 3.25 grams available chlorine per tablet; any portion of tablet rounded to next higher integer.*

6.2.1.3 *Filling and contact.* When installation has been completed, the main shall be filled with water at a rate such that water within the main will flow at a velocity no greater than one (1) foot per second. Precautions shall be taken to ensure that air pockets are eliminated. This water shall remain in the pipe for at least twenty-four (24) hours. If the water temperature is less than 41°F, the water shall remain in the pipe for at least forty-eight (48) hours. As an optional procedure (if specified by the purchaser), water used to fill the new main shall be supplied through a temporary connection that shall include an appropriate cross-connection control device, consistent with the degree of hazard, for backflow protection of the active distribution system.

6.2.2 *Continuous-Feed Method.* The continuous-feed method consists of placing calcium hypochlorite granules in the main during construction (optional), completely filling the main to remove all air pockets, flushing the completed main to remove particulates, and filling the main with potable water. The potable water shall be chlorinated so that after a twenty-four (24) hours holding period in the main there will be a free chlorine residual of not less than 10 mg/L.

6.2.2.1 *Placing of calcium hypochlorite granules.* At the option of the purchaser, calcium hypochlorite granules shall be placed in pipe sections as specified in Sec. 6.2.1.1. The purpose of this procedure is to provide a strong chlorine concentration in the first flow of flushing water that flows down the main. In particular, this procedure is recommended when the type of pipe is such that this first flow of water will flow into annular spaces at pipe joints.

6.2.2.2 *Preliminary flushing.* Before being chlorinated, the main shall be filled to eliminate air pockets and shall be flushed to remove particulates. The flushing velocity in the main shall not be less than 2.5 ft/s unless the purchaser (or purchaser's representative) determines that conditions do not permit the required flow to be discharged to waste. Table 7 shows the rates of flow required to produce a velocity of 2.5 ft/s in commonly used sizes of pipe. Note that flushing is no substitute for preventive measures during construction. Certain contaminants, such as caked deposits, resist flushing at any feasible velocity.

For twenty-four (24) inches or larger diameter mains, an acceptable alternative to flushing is to broom-sweep the main, carefully removing all sweepings prior to chlorinating the main.

Table 7 Required flow and opening to flush pipeline (40 psi residual pressure)

Pipe Size inches	Flow Required* gpm	Size of Tap, (inches) 1	1 1/2	2	Number of 2 ½ in. Hyd. Outlets
		Number of Taps on Pipe			
4	100	1	-	-	1
6	200	-	1	-	1
8	400	-	2	1	1

10	600	-	3	2	1
12	900	-	-	2	2
16	1,600	-	-	4	2

* *Flow required to produce 2.5 ft/s (approx.) velocity in main.*

6.2.2.3 *Procedure for chlorinating the main.*

1. Water supplied from a temporary, backflow protected connection to the existing distribution system or other approved source of supply shall be made to flow at a constant, measured rate into the newly installed water main. In the absence of a meter, the rate may be approximated by methods such as placing a Pitot gauge in the discharge, or measuring the time to fill a container of known volume.
2. At a point not more than ten (10) feet downstream from the beginning of the new main, water entering the new main shall receive a dose of chlorine fed at a constant rate such that the water will have not less than 25 mg/L free chlorine. To ensure that this concentration is provided, measure the chlorine concentration at regular intervals in accordance with the procedures described in the current edition of *Standards Methods for the Examination of Water and Wastewater* or AWWA Manual M12, or using appropriate chlorine test kits.
   Table 8 gives the amount of chlorine required for each one hundred (100) feet of pipe of various diameters. Solutions of one (1%) percent chlorine may be prepared with sodium hypochlorite or calcium hypochlorite. The latter solution requires one (1) pound of calcium hypochlorite in eight (8) gallon of water.

Table 8 Chlorine required to produce 25 mg/L in 100 ft. of pipe

Pipe Size inches	100 % Chlorine pounds	1% Chlorine Solution gallons
4	.013	.16
6	.030	.36
8	.054	.65
10	.085	1.02
12	.120	1.44
16	.217	2.60

3. As an optional procedure, water used to fill the new main during the application of chlorine shall be supplied through a temporary connection. This temporary connection shall be installed with an appropriate cross-connection control device, consistent with the degree of hazard, for backflow protection of the active distribution system. Chlorine application shall not cease until the entire main is filled with heavily chlorinated water.

The chlorinated water shall be retained in the main for at least twenty-four (24) hours during which time all valves and hydrants in the treated section shall be operated to ensure disinfection of the appurtenances. At the end of this twenty-four (24) hour period, the treated water in all portions of the main shall have a residual of not less than 10 mg/L free chlorine.

4. Direct-feed chlorinators, which operate solely from gas pressure in the chlorine cylinder, shall not be used for the application of liquid chlorine. (The danger of using direct-feed chlorinators is that water pressure in the main can exceed gas pressure in the chlorine cylinder. This allows a backflow of water into the cylinder, resulting in severe cylinder corrosion and escape of chlorine gas.) The preferred equipment for applying liquid chlorine is a solution-feed, vacuum-operated chlorinator and a booster pump. The vacuum-operated chlorinator mixes the chlorine gas in solution water; the booster pump injects the chlorine-gas solution into the main to be disinfected. Hypochlorite solutions may be applied to the water main with a gasoline or electrically powered chemical-feed pump designed for feeding chlorine solutions. Feed lines shall be of such material and strength as to safely withstand the corrosion caused by the concentrated chlorine solutions and the maximum pressures that may be created by the pumps. All connections shall be checked for tightness before the solution is applied to the main.

6.2.3 *Slug Method.* The slug method consists of placing calcium hypochlorite granules in the main during construction, completely filling the main to eliminate all air pockets, flushing the main to remove particulates, and slowly flowing through the main a slug of water dosed with chlorine to a concentration of 100 mg/L. The slow rate of flow ensures that all parts of the main and its appurtenances will be exposed to the highly chlorinated water for a period of not less than three (3) hours.

6.2.3.1 *Placing calcium hypochlorite granules.* Same as Sec. 6.2.2.1.

6.2.3.2 *Preliminary flushing.* Same as Sec. 6.2.2.2.

6.2.3.3 *Chlorinating the main.*

1. Same as Sec. 6.2.2.3(1).
2. At a point not more than ten (10) feet downstream from the beginning of the new main, water entering the new main shall receive a dose of chlorine fed at a constant rate such that the water will have not less than 100 mg/L free chlorine. To ensure that this concentration is achieved, the chlorine concentration should be measured at regular intervals. The chlorine shall be applied continuously and for a sufficient period to develop a solid column, or "slug," of chlorinated water that will, as it moves through the main, expose all interior surfaces to a concentration of approximately 100 mg/L for at least three (3) hours.
3. The free chlorine residual shall be measured in the slug as it moves through the main. If at any time it drops below 50 mg/L, the flow shall be stopped, chlorination equipment shall be relocated at the head of the slug, and, as flow is resumed, chlorine shall be applied to restore the free chlorine in the slug to not less than 100 mg/L.

4. As the chlorinated water flows past fittings and valves, related valves and hydrants shall be operated so as to disinfect appurtenances and pipe branches.

Section 6.3: Final Flushing

6.3.1 *Clearing the Main of Heavily Chlorinated Water.* After the applicable retention period, heavily chlorinated water should not remain in prolonged contact with pipe. In order to prevent damage to the pipe lining or corrosion damage to the pipe itself, the heavily chlorinated water shall be flushed from the main until chlorine measurements show that the concentration in the water leaving the main is no higher than that generally prevailing in the distribution system or is acceptable for domestic use.

6.3.2 *Disposing of Heavily Chlorinated Water.* The environment into which the chlorinated water is to be discharged shall be inspected. If there is any possibility that the chlorinated discharge will cause damage to the environment, then a neutralizing chemical shall be applied to the water to be wasted to neutralize thoroughly the chlorine residual remaining in the water. (See Appendix B for neutralizing chemicals.) Where necessary, federal, state, provincial, and local regulatory agencies should be contacted to determine special provisions for the disposal of heavily chlorinated water.

Section 6.4: Bacteriological Tests

6.4.1 *Standard Conditions.* After final flushing and before the new water main is connected to the distribution system, two consecutive sets of acceptable samples, taken at least twenty-four (24) hours apart, shall be collected from the new main. At least one set of samples shall be collected from every 1,200 feet of the new water main, plus one set from the end of the line and at least one set from each branch. All samples shall be tested for bacteriological quality in accordance with *Standard Methods for the Examination of Water and Wastewater*, and shall show the absence of coliform organisms. A standard heterotrophic plate count may be required at the option of the purchaser (or purchaser's representative).

6.4.2 *Special Conditions.* If trench water has entered the new main during construction or, if in the opinion of the purchaser (or purchaser's representative), excessive quantities of dirt or debris have entered the new main, bacteriological samples shall be taken at intervals of approximately two hundred (200) feet and shall be identified by location. Samples shall be taken of water that has stood in the new main for at least sixteen (16) hours after final flushing has been completed.

6.4.3 *Sampling Procedure.* Samples for bacteriological analysis shall be collected in sterile bottles treated with sodium thiosulfate as required by *Standard Methods for the Examination of Water and Wastewater*. No hose or fire hydrant shall be used in the collection of samples. A suggested combination blowoff and sampling tap useful for mains up to and including eight (8) inch diameter is shown in Figure 2. A corporation cock may be installed in the main with a copper-tube gooseneck

assembly. After samples have been collected, the gooseneck may be removed and retained for future use.

Sec. 6.5: Redisinfection

If the initial disinfection fails to produce satisfactory bacteriological results, the new main may be reflushed and shall be resampled. If check samples also fail to produce acceptable results, the main shall be rechlorinated by the continuous-feed or slug method of chlorination until satisfactory results are obtained.
NOTE: High velocities in the existing system, resulting from flushing the new main, may disturb sediment that has accumulated in the existing mains. When check samples are taken, it is advisable to sample water entering the new main.

Sec. 6.6: Disinfection Procedures When Cutting into or Repairing Existing Mains

The following procedures apply primarily when existing mains are wholly or partially dewatered. After the appropriate procedures have been completed, the existing main may be returned to service prior to completion of bacteriological testing in order to minimize the time customers are out of water. Leaks or breaks that are repaired with clamping devices while the mains remain full of pressurized water present little danger of contamination and require no disinfection.

6.5.1 *Trench Treatment.* When an existing main is opened, either by accident or by design, the excavation will likely be wet and may be badly contaminated from nearby sewers. Liberal quantities of hypochlorite applied to open trench areas will lessen the danger from such pollution. Tablets have the advantage in such a situation because they dissolve slowly and continue to release hypochlorite as water is pumped from the excavation.

6.5.2 *Swabbing with Hypochlorite Solution.* The interior of all pipe and fittings (particularly couplings and sleeves) used in making the repair shall be swabbed or sprayed with a one (1%) percent hypochlorite solution before they are installed.

6.5.3 *Flushing.* Thorough flushing is the most practical means of removing contamination introduced during repairs. If valve and hydrant locations permit, flushing toward the work location from both directions is recommended. Flushing shall be started as soon as the repairs are completed and shall be continued until discolored water is eliminated.

6.5.4 *Slug Chlorination.* When practical, in addition to the procedures above, the section of main in which the break is located shall be isolated, all service connections shut off, and the section flushed and chlorinated as described in Sec. 6.2.3, except that the dose may be increased to as much as 300 mg/L and the contact time reduced to as little as fifteen (15) minutes. After chlorination, flushing shall be resumed and continued until discolored water is eliminated, and the water is free of noticeable chlorine odor.

6.5.5 *Sampling.* Bacteriological samples shall be taken after repairs are completed to provide a record for determining the procedure's effectiveness. If the direction of flow is unknown, then samples shall be taken on each side of the main break. If

positive bacteriological samples are recorded, then the situation shall be evaluated by the purchaser (or purchaser's representative) who can determine corrective action, and daily sampling shall be continued until two consecutive negative samples are recorded.

SECTION 7: **HIGHWAY AND RALIROAD CROSSINGS**

Sec. 7.1 Casing Pipe

When 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. General practice permits boring for nominal casing diameters through thirty-six (36) inches with a maximum length of about one hundred seventy-five (175) feet; jacking for nominal diameters thirty (30) inches through sixty (60) inches with lengths of about two hundred (200) feet; and tunneling for pipes forty-eight (48) inches in nominal diameter and larger for longer lengths.

Sec. 7.2 Carrier Pipe

The casing pipe should be six to eight (6-8) inches larger than the outside diameter of the ductile-iron pipe bells. Carrier pipe may be pushed or pulled through the completed casing pipe. Chocks or skids should be placed under 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 8: **SUBAQUEOUS CROSSINGS**

Sec. 8.1 Subaqueous Installations

When it is necessary to cross a shallow body of water requiring only a small deflection in the joints, 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 river bed is great, or if changing bottom conditions are anticipated, ball-and-socket pipe and/or fittings, which will deflect up to 15°, should be used. A combination of restrained and river crossing joints may be used depending on bottom conditions and service requirements.

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," and the assembly lowered to the bed of the stream where divers connect the sections. Subaqueous 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.

Another method of installation is to assemble the entire length of line on shore and either drag it into position along the bottom or float it into position by means of barrels or floats attached to the pipe, which are punctured or released in a controlled fashion when the pipe reaches the desired position. Joints should not be allowed to become overly deflected or subjected to excessive beam load during the installation process.

A somewhat 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 in the manner described previously.

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.

SECTION 9: **SERVICE TAPS**

Sec. 9.1 Tapping

Corporation stops may be installed either before or after pipe installation. Generally, they are located at ten o'clock 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 is necessary to deliver the required flow in an existing gray cast-iron pipe, the taps should be staggered around the circumference at least twelve (12) inches apart (not in a straight line). 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.

Table 9 Maximum tap size into Ductile-Iron class 52 pipe*

Pipe Size Inches	Pipe Wall Thickness inches	Pipe Outside Diameter inches	Maximum Tap Size inches
3	0.28	3.96	1/2
4	0.29	4.80	3/4
6	0.31	6.90	3/4
8	0.33	9.05	1 1/4
10	0.35	11.10	1 1/2
12	0.37	13.20	2
14	0.39	15.30	2
16	0.40	17.40	2
18	0.41	19.50	2
20	0.42	21.60	2

24	0.44	25.80	2

* Tap size as per ANSI/ASME B1.20.1 for Standard Taper Pipe threads with three (3) full threads.

Service taps on gray cast-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. Experience has shown that this method is very effective in eliminating damage to the polyethylene 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 three (3) feet away from the gray cast-iron or ductile-iron main.