5001 GENERAL. The purpose of this specification is to govern the furnishing of all materials, labor, equipment, tools, superintendence, and other services necessary to construct water mains, complete with appurtenances including extensions and relocations at the locations shown on the plans.

5002 MATERIALS.

A. Scope. This section governs materials for water mains having diameter of four inches and larger.

B. Pipe and Fittings.

1. Ductile-Iron Pipe. Unless indicated otherwise on the construction plans or directed by the Engineer, all 6 inch pipes and larger shall be Class 50 ductile iron, all 4 inch pipes shall be Class 51 Ductile iron complete with all accessories and conforming to ANSI A21.51, AWWA C151, ASTM A536, and Grade 60-42-10.

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

   The lining for use under normal conditions shall be a cement-mortar lining in accordance with ANSI/AWWA C104/A21.4, unless otherwise specified.

   Joints, unless otherwise specified, shall be of the push-on type conforming to ANSI A21.11/AWWA C111, except gaskets shall be synthetic rubber. Natural rubber will not be acceptable.

   Restrained joints (if required) shall be Loc-Tite, Meg-a-Lug, or approved equal.

2. Ductile-Iron Fittings. Ductile-iron fittings shall be complete with all accessories and shall be ASTM A536, Grade 70-50-05, conforming to ANSI A21.10/AWWA C110, ANSI A21.53/AWWA C153, 350 psi pressure rating. Joints shall be of the standard mechanical joint type conforming to ANSI A21.11/AWWA C104 and shall be coated inside and out with a bituminous coating. Fittings shall have distinctly cast upon them the pressure rating and letters "DI" or "DUCTILE".

3. PVC Pipe. The non-restrained PVC pipe will be push-on joints. PVC pipe will be DR14 C-900 DIPS or C-909 PC150 DIPS. Restrained joints will be Certainteed Certa-lok C-900 Restrained Joint Pipe, EBAA bell restrained harnesses, or Diamond Plastic Bulldog Restraint Joint System.

   Bends may either be Certa-lok sweeps or MJ ductile iron bends. Tees and

valves will be ductile iron mechanical joints. For changes in alignment less than 11-1/4 degrees but more than the allowable joint deflection, then Certainteed High Deflection Couplings shall be used. Romac Grip Rings or EBAA Iron Mega-Lugs designed for PVC for MJ fittings and valves shall be used.

4. HDPE Pipe. HDPE will be AWWA C906 with a working pressure rating of PC 160 (Diameter Ratio, DR11), nominal Ductile Iron Pipe Size (DIPS).

   A. Butt Fusion Fittings – All butt fusion fittings will be AWWA C906 and have nominal burst values of three and one-half times the Working Pressure Rating (WPR) of the fitting.

   B. Electrofusion Fittings – All electrofusion fittings will be PE3408 HDPE. Electrofusion fittings shall have a pressure rating equal to the pipe unless otherwise specified on the plans. All electrofusion fittings shall be suitable for use as pressure conduits, and per AWWA C906, have nominal burst values of three and one-half times the working pressure rating (WPR) of the fitting.

   C. Mechanical Joint Adapters – Mechanical joint adapters shall be PE 3408 HDPE, Cell Classification of 345464C as determined by ASTM D3350-02. Flanged and mechanical joint adapters shall have a manufacturing standard of ASTM D3261. Fittings shall have a pressure rating equal to the pipe unless otherwise specified on the plans.

C. Valves and Valve Boxes.

1. Gate Valves. Generally, and unless otherwise directed by the Engineer, gate valves shall be used on all water mains, 12 inches nominal diameter and smaller. The type, size and location of valves shall be as shown on the Plans. Except as modified or provided herein all gate valves in pipelines shall be 250 psi, ductile iron body, gate valves with non-rising stems. Gate valves shall be resilient-seated conforming to all applicable requirements of ANSI/AWWA C509 and shall be epoxy coated inside and outside conforming to ANSI/AWWA C550. All exposed valve bolts and nuts shall be stainless steel. Acceptable resilient wedge gate valve manufacturers are as follows:

   Clow Model 2639
   Kennedy Model KS-RW
   American Series 2500
   American Series 2500 with ALPHA restrained joint ends
   EJ FlowMaster Resilient Wedge

2. Butterfly Valves. Butterfly valves shall be used for water line valves larger than twelve (12) inches in diameter otherwise directed by the City Engineer. Butterfly valves shall be of the rubber-seat, tight-closing type. Valve discs shall seat at 90 deg. with the pipe axis. Mechanical joint end valves shall

be of the short body type. Packing shall be O-ring cartridge designed for permanent duty in underground service.

All butterfly valves and operators shall conform to AWWA C504. Metal mating seat surfaces shall be 18-8 stainless steel or more. Each valve shall be provided with an operator with a torque rating at least equal to the torques listed in AWWA C504, Table 1. Butterfly valves shall be epoxy coated inside and outside conforming to ANSI/AWWA C550. All exposed valve bolts and nuts shall be stainless steel. Acceptable Butterfly valve manufacturers are as follows:

Clow Style 4500
Kennedy 4500
Mueller Lineseal Series

3. Valve Ends. Valve ends shall be of the mechanical joint type, conforming to ANSI A21.11/AWWA C111 except where flange ends are required on the plans.

   The end flanges of flange gate valves shall conform in dimensions and drilling to ANSI B16.1 for cast-iron flanges and flange fittings, Class 125, unless explicitly provided otherwise on the plans and Special Provisions. The laying lengths of the flange valves shall conform to the dimensions of ANSI B16.10.

4. Bonnet Thrust Plates. The bonnet shall have a removable thrust plate to permit the removal and replacement of the valve stem and "O" ring seal while the valve is in service. All bolts and nuts in bonnet shall be stainless steel.

5. Tapping Valves and Sleeves. The size and location of the tapping valves, shall be as shown on the plans. The valves shall be 200 psi, iron body, resilient-seated gate valves with non rising stems conforming with all applicable requirements of ANSI/AWWA C509, except that the outlet end shall be standard mechanical joint end conforming to ANSI A21.11/AWWA C111 and the inlet end shall have an inlet flange conforming to ANSI B16.1 for cast iron flanges, Class 125.

   Tapping sleeves shall have a body of 18-8 Type 304 Stainless Steel. The flange shall be CF8 cast Stainless Steel - equivalent to 18-8 Type 304 Stainless Steel. ANSI 150 lb. Drilling, recessed for tapping valve per MMSS-SP 60. Bolts shall be Stainless Steel, Type 304. The Branch Outlet shall be heavy Stainless Steel Pipe. The body shall be provided with anti-extrusion rings welded to each end of the sleeve body. The gasket shall be full circumferential compounded for use with water, salt solutions, mild acids, bases and sewage.

6. Stem Seals and Coatings. All valves shall be provided with stem seals of the "O" ring type. Two "O" rings shall be used with at least one "O" ring inserted above the thrust collar. The packing plate shall be attached to the

valve bonnet by not less than three (3) bolts and one "O" ring below the thrust collar.

7. Valve Operation. All valves shall be equipped with a 2 inch square wrench nut and the direction of rotation to open the valve shall be to the left (counterclockwise). Each valve body or operator shall have cast thereon the word "Open" and an arrow indicating the direction to open.

8. Extension Stems. Extension stems and stem guides shall be provided where shown, specified, or required for proper operation. Extension stems shall be fabricated from solid steel shafting not smaller in diameter than the stem of the valve or from galvanized steel piping having an ID not smaller than the OD of the valve stem. Extension stems shall be connected to the valve by a flexible, socket-type coupling. All connections shall be pinned, keyed, or socket type. Pipe couplings will not be acceptable.

   Extension stems shall be provided for buried valves when the operating nut is more than three feet below finished grade. Each extension stem for a buried valve shall extend to between three (3) feet and three (3) feet six (6) inches of the ground surface, NO EXCEPTIONS WILL BE ALLOWED, and shall be provided with spacers, which will center the stem in the valve box, and shall be equipped with a wrench nut.

9. Valve boxes, Bases, Lids and Covers.

   a. All buried valves shall be provided with valve boxes. Valve boxes shall be of cast iron, extension sleeve screw type, suitable for the depth of cover required by the drawings. Valve boxes shall be Clay & Bailey No. P-1108 or approved equal. Valve boxes outside of the traveled roadway may be 6 inch, PVC Class 150 pipe.

   b. All parts of valve boxes, bases, and covers shall be coated by dipping in bituminous varnish.

      Valves and valve boxes shall be set plumb. Each valve box shall be placed directly over the valve it serves, with the top of the box brought flush with the finished grade. Each valve box shall be fitted with a debris plug equipped with a handle for easy removal. CKR, Infactory or approved equal shall be used. After being placed in proper position, earth shall be filled in around each valve box and thoroughly tamped on each side of the box. An 18" square reinforced (#4 steel rebar), concrete collar, 6 inches thick shall be placed around the valve box flush with the surface.

D. Fire Hydrants. Fire hydrants shall be furnished with a six (6)-inch auxiliary gate valve. The fire hydrants shall be pressure rated at 150 psi. working pressure and 300 psi. test pressure. Hydrants shall be traffic model with breakaway flange or coupling. Fire hydrants shall conform to AWWA C502 with information required as follows:

| | |
|---|---|
| Type of Shutoff | Compression |
| Size of Hydrant | 5 1/4 inches |
| Inlet Connection | 6 inches |
| Outlet Nozzles | 2 – 2 ½ inch hose and 1 – 4 inch Storz pumper connection with integral locking mechanism |
| Outlet Nozzle Threads | ANSI B-26 |
| Direction to Open | Counterclockwise (left) |
| Stem Seals | O-ring |
| Outlet Nozzle Cap Chains | Required |
| Drain Outlet | Required |
| Finish Paint | Factory or field painted above the ground line with yellow enameled paint. Sherwin Williams industrial yellow No. B54 Y37. |
| Operating Nut | Pentagon shaped |
| Weather Cap on Operating Nut | Required |
| Oil Reservoir | Required |
| Boot Connection | 4" M.J. boot |

Acceptable Fire Hydrant manufacturers are as follows:

Clow Medallion
Kennedy Guardian K-81D
American Darling B-84-B5
EJ 5CD250

Hydrants shall be furnished with all joint glands, gaskets, bolts, and nuts required for installation. Hydrants shall be set so that at least the minimum pipe cover is provided for the branch supply line. Each hydrant shall be set on a concrete foundation at least eighteen (18) inches square and 6 inches thick. Each hydrant shall be suitably anchored.

Hydrant drainage shall be provided by installing around the hydrant, and below the top of the hydrant supply pipe, at least one-half (1/2) cubic yard of three-fourths (3/4)-inch rock.

Fire hydrant installations shall conform to the Standard Detail. All hydrants shall stand plumb. The Engineer shall determine the exact direction the nozzles will be facing.

An 18" square, reinforced (#4 steel rebar), concrete collar, 6 inches thick shall be placed around the valve box flush with the surface.

E. Flushing Assembly. The flushing assembly shall include a line valve, straddle block, adequate piping to reach the surface, and concrete collar as shown in detail drawing D50-6.

F. Specials:

1. General. Air release, meter, and pressure-reducing valve vaults shall be precast concrete conforming to ASTM C478. Access lid castings shall be as noted in the Special Provisions or as shown on the plans.

   Vaults, which, by their special nature, must be cast in place, shall conform to the plans and concrete specifications in Section 2000 "Concrete".

2. Pressure-Reducing Valves. Pressure-reducing valves shall be designed to provide tight shutoff under conditions of no flow and shall not "hunt" under ordinary flow conditions. Pressure-reducing valves shall be as noted in the Special Provisions, selected and sized as recommended by the valve manufacturer. Pressure-reducing valves shall be suitable for operation under the pressure and flow conditions as shown on the plans.

3. Combination Air Valves. Combination air-release and vacuum-relief valves shall be installed at the locations indicated on the plans. Each valve assembly shall be installed complete with appropriate piping and valves as shown on the plans. All piping and isolation valves shall be brass except for the air outlet from the valve, which shall be brass or copper tubing.

   Air releases for mains 12 inches in diameter or smaller shall have 1 inch combination air-release valves, APCO No. 143C or approved equal.

G. Bedding Aggregate. All materials used for pipe bedding shall be one half (1/2) to three-quarter (3/4) inch clean/screened rock and conform to the requirements of MCIB Section 4 – Materials for Coarse Aggregate – Table 2, Column III, modified to meet the following gradations:

| Sieve Size Gradations | Percentage Passing |
|---|---|
| 3/8” | 20-35 |
| No. 4 | 0-5 |
| No. 8 | 0-2 |

Bedding aggregate shall fully encase the pipe from six (6) inches below bottom of pipe to six (6) inches above top of pipe, trench wall to trench wall.

## 5003 CONSTRUCTION REQUIREMENTS.

A. Grading and Excavation.

1. Scope. Excavation and trenching work shall include the necessary clearing, grubbing, and preparation of the site; removal and disposal of all debris; excavation and trenching as required; the handling, storage, transportation and disposal of all excavated material; all necessary sheeting, shoring and

protection work; preparation of sub-grades; pumping and dewatering as necessary or required; protection of adjacent property; and other appurtenant work.

2. General. Excavation and trenching work shall be performed in a safe and proper manner with suitable precautions being taken against all hazards.

   The Contractor shall explore and expose any and all obstructions in advance of excavation so that minor changes in grade and alignment may be made.

   In paralleling existing water, sewer, and gas mains, the Contractor shall protect all service connections and shall arrange to furnish service to the consumers with minimum interruption.

   All excavated material shall be piled in a manner that will not endanger the work and that will avoid obstructing sidewalks and driveways. Gutters shall be kept clear or other satisfactory provisions made for street drainage.

3. Classification of Excavated Material. No classification of excavated materials will be made unless otherwise indicated on the contract drawings. Excavation and trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the contract work regardless of the type, character, composition, or condition thereof.

4. Unauthorized Excavation. Any part of the trench excavated below grade shall be corrected with material approved by the Engineer placed and compacted by the Contractor.

5. Removal of Water. The Contractor shall provide and maintain adequate dewatering equipment to remove and dispose of all surface and groundwater entering excavations, trenches, or other parts of the work. Each excavation shall be kept dry during sub grade preparation and continually thereafter until the structure is built, or the pipe to be installed therein, is completed to the extent that no damage from hydrostatic pressure, flotation or other cause will result.

   All excavations for concrete structures or trenches which extend down to or below static groundwater elevations shall be dewatered by lowering and maintaining the groundwater surface beneath such excavations a distance of not less than 12 inches below the bottom of the excavation.

   Surface water shall be diverted or otherwise prevented from entering excavated areas or trenches to the greatest extent practicable without causing damage to adjacent property.

   The Contractor will be held responsible for the condition of any pipe or conduit which he may use for drainage purposes, and all such pipes or conduits shall be left clean and free of sediment.

6. Sheeting and Shoring. Except where banks are cut back on a stable slope, excavation for structures and trenches shall be properly and substantially sheeted, braced, or shored as necessary to prevent caving or sliding, to provide protection for workmen and the work, and to provide protection for existing structures and facilities. Sheeting, bracing, shoring, and trench boxes shall be designed and built to withstand all loads that might be caused by earth movement or pressure and shall be rigid, maintaining shape and position under all circumstances.

   Trench sheeting shall not be pulled unless pipe strength is sufficient to carry trench loads based on trench width to the back of sheeting. Sheeting may not be pulled after backfilling, as directed by the Engineer.

   Where trench sheeting is left in place, such sheeting shall not be braced against the pipe, but shall be supported in a manner, which will preclude concentrated loads or horizontal thrusts on the pipe. Cross braces installed above the pipe to support sheeting may be removed after pipe embedment has been completed.

7. Stabilization. Trench bottoms shall be firm, dense, and thoroughly compacted and consolidated; shall be free from mud and muck; and shall be sufficiently stable to remain firm and intact under the feet of the workmen.

   Trench bottoms which are otherwise solid but which become mucky on top due to construction operations shall be reinforced with one or more layers of crushed stone or gravel. Not more than 1/2 inch depth of mud or muck shall be allowed to remain on stabilized trench bottoms when the pipe bedding material is placed thereon.

8. Trench Excavation. The Contractor shall not open more trenches in advance of pipe laying than is necessary to expedite the work. One block or 300 feet whichever is the shorter, shall be the maximum length of open trench ahead of pipe laying unless by written permission of the Engineer.

   Except where tunneling or boring and jacking is specified and shown on the plan by the Engineer, all trench excavations shall be open cut.

9. Alignments and Grade. The alignment and grade or elevation of the pipeline shall be as shown on the plans.

   The Contractor must maintain a constant check of the pipe alignment and trench depth and will be held responsible for any deviations there from.

   Unless otherwise shown or indicated on the plans or unless otherwise set forth by the Engineer, the horizontal and vertical alignment of the water main shall be maintained to within the following tolerances:

| Horizontal | Vertical |
|---|---|
| 3" | 42" to 48" |

10. Minimum Cover. Except where otherwise shown, trenches shall be excavated to a depth sufficient to provide a minimum depth of backfill cover over the top of the pipe as indicated above. Greater pipe cover depths may be necessary on existing pipe, conduits, drains, drainage structures, or other obstruction encountered at normal pipe grades.

    Measurement of pipe cover depth shall be made vertically from the outside top of pipe to finish grade or pavement surface elevations.

11. Limiting Trench Width. Trenches shall be excavated to a width, which will provide adequate working space and pipe clearances for proper pipe installation, jointing and embedment. However, the limiting trench width below an elevation 6 inches above the top of the installed pipe shall be as follows:

| Pipe Size | Minimum Trench Width in Earth | Maximum Trench Width In Earth | Minimum Clearance In Rock |
|---|---|---|---|
| 4” | 18” | 30” | 6” |
| 6” | 24” | 30” | 6” |
| 8” | 26” | 32” | 6” |
| 10” | 28” | 34” | 6” |
| 12” | 28” | 34” | 6” |

    Where necessary to reduce earth load on trench banks to prevent sliding and caving, banks may be cut back on slopes which shall not extend lower than 1 foot above the top of the pipe.

12. Unauthorized Trench Widths. When, for any reason, the width of the lower portion of the trench as excavated at any point exceeds the maximum permitted in the foregoing tables, either pipe of adequate strength, special pipe embedment, or arch concrete encasement, as required by loading conditions and as determined by the Engineer, shall be furnished and installed by and at the Contractor's expense.

13. Trench Bottom in Earth. The trench in earth shall have a flat bottom the full width of the trench and shall be excavated to the grade to which the pipe is to be laid. The surface shall be graded to provide a uniform bearing and continuous support for each pipe at every point along its entire length.

14. Rock Exploration. Unless shown otherwise on the plans or noted in the Special Provisions, no rock exploration has been made. On those projects where rock exploration has been made, test holes have been drilled at locations and intervals as shown on the plans or subsurface information report to determine the approximate location and depth of rock. Resistance to penetration was assumed to be "solid rock". This information is furnished for general reference purposes only.

The Contractor must form his own opinion as to the character of materials, which will be encountered from an inspection in the ground, from his own investigation of the test hole information, or from such other investigations, as he may desire.

15. Trench Bottoms in Rock. All rock excavation shall be carried to a minimum of 6 inches below the bottom of the pipe. Granular pipe embedment material shall be used to restore the trench bottom to the desired elevation and grade and to provide a uniform bearing and continuous support for the pipe along its entire length. Care shall be exercised to prevent any portion of the pipe from coming to bear on solid rock or boulders.

16. Mechanical Excavation. The use of mechanical equipment will not be permitted in locations where its operations would cause damage to trees, buildings, culverts, or other existing property, utilities or structures above or below ground. In all such locations, hand-excavating methods shall be used.

    Mechanical equipment used for trench excavation shall be of the type, design and construction and shall be so operated that the rough trench excavation bottom elevation can be controlled, that uniform trench widths and vertical sidewalls are obtained at least from the bottom of the trench, and that trench alignment will be centered in the trench with adequate clearance between the pipe and sidewalls of the trench. Undercutting the trench sidewall to obtain clearance will not be permitted.

    All mechanical trenching equipment, its operating conditions, and the manner of its operations shall be subject at all times to the approval of the Engineer.

17. Stream Crossings. Stream crossings shall be made in accordance with these specifications and as shown on the plans.

    The trench width shall be as required for proper pipe installation and the trench depth shall be as required to give minimum cover shown on the plans. Pipe encasement, where required, shall be in accordance with the specifications and placed as indicated on the plans.

18. Highway and Railroad Crossings. The Contractor shall make highway and railroad crossing in accordance with these specifications, the Special Provisions and as shown on the plans.

    All construction or work performed and all operations of the Contractor, his employees, or his subcontractors within the limits of highway or railroad right-of-ways shall be in conformity with all the requirements, regulations and be under the control (through the Engineer) of the authority owning or having jurisdiction over and control of the right-of-way.

    The Contractor shall pay fees and obtain permits to make the crossings

unless otherwise directed.

5004 INSTALLATION.

A. General. Laying of ductile-iron pipe; PVC pipe; HDPE pipe; installation of valves, and hydrants; and embedment and backfill shall conform to the following specifications and the details as shown on the plans.

1. Unless otherwise specified or shown on the plans, the water mains shall be laid to have a minimum cover of 42 inches, measured from the finished grade or from established street grades shown on the plans.

2. Whenever pipe laying is stopped, the open end of the line shall be sealed with a watertight plug that will prevent trench water from entering the pipe.

3. Where the pipe is to be installed inside a casing pipe or tunnel liner, polyethylene casing spacers shall be strapped to each pipe before it is placed in the casing pipe or tunnel liner in accordance with these specifications and as shown on the plans. The ends of each casing pipe or tunnel liner shall be closed with a minimum 1/8-inch neoprene rubber end seal with stainless steel bands or as shown on the plans. The closures for each casing pipe or tunnel line shall not be constructed until all testing of the line has been completed and accepted.

B. Ductile-Iron Pipe.

1. Handling. Pipe, fittings and accessories shall be handled in a manner that will ensure installation in a sound, undamaged condition. Equipment, tools, and methods used in unloading, reloading, hauling, and laying pipe and fittings shall be such that the pipe, pipe coating, and fittings are not damaged. Hooks shall not be used. Under no circumstances shall pipe or accessories be dropped or dumped.

   The Contractor shall repair all pipe coating, which has been damaged, before installing the pipe.

2. Cutting Pipe. Ductile-iron pipe shall be cut with either a saw or an abrasive wheel. Cutting of existing cast-iron pipe shall be done with mechanical pipe cutters. The cutting of pipe with a torch will not be permitted.

   Cutting shall be done in a neat manner without damage to the pipe, or the cement lining. Cuts shall be smooth, straight, and at right angles to the pipe axis. After cutting, the end of the pipe shall be dressed with a file or beveled by mechanical means to remove all roughness and sharp corners.

3. Cleaning. The interior of all pipe and fittings shall be thoroughly cleaned of foreign matter before being installed and shall be kept clean until the work has been accepted. Such surfaces shall be wire brushed, if necessary, wiped clean, and kept clean until jointing is completed.

4. Inspection. Pipe and fittings shall be carefully examined for cracks and other defects immediately before installation. Spigot ends shall be examined with particular care since they are vulnerable to damage from handling. All defective, damaged, or unsound pipe and fittings shall be rejected and marked as such and removed from the site of the work.

5. Push-on Joints. The gasket seat in the bell shall be wiped clean after which the gasket should be placed. A thick film of lubricant should be applied to the entire inner surface of the gasket and on the spigot end of the pipe.

   The lubricant and the gaskets shall be as recommended and supplied by the manufacturer of the pipe being used. The lubricant shall be odorless, tasteless, nontoxic, and suitable for use in potable water.

   Field-cut pipe shall be beveled by filing or by mechanical means to remove any sharp or rough edges that might otherwise damage the gasket.

6. Mechanical Joints. Mechanical joint pipe shall be used only when shown on the plans and shall be installed in strict accordance with the manufacturer's recommendations.

7. Flanged Joints. When bolting flanged joints, care shall be taken to ensure that there is no restraint on the opposite end of the pipe or fitting which would prevent uniform gasket compression or which would cause unnecessary stress in the flanges. One flange shall be free to move in any direction while the flange blots are being tightened. Bell-and-spigot joints shall not be packed or assembled until all flanged joints affected thereby have been tightened. Bolts shall be tightened gradually and at a uniform rate so that gasket compression is uniform.

8. Restrained Joints. Restrained joints and anchoring joints shall be installed in strict accordance with the pipe manufacturer's recommendations.

9. Alignment of Bell-and-Spigot Pipe. Pipelines or runs intended to be straight shall be laid straight. Deflections from a straight line or grade shall not exceed the quantities stipulated in Tables 4 and 5 of ANSI/AWWA C600.

10. Laying Pipe. Pipe shall be protected from lateral displacement by pipe embedment material installed as specified. Under no circumstances shall the pipe be laid in water, and no pipe shall be laid under unsuitable trench conditions.

C. PVC Pipe. This section covers installation of AWWA C-900, C-905, and C-909 PVC pipe. Ductile Iron fittings and valves are covered in other sections. PVC pipe shall be installed to the minimum of AWWA C605 latest revision and per these specifications.

1. Handling. PVC Pipe, fittings, and accessories shall be handled in a manner that will ensure installation in sound, undamaged condition. Equipment, tools, and methods used in handling and installing pipe and fittings shall not damage

the pipe and fittings. Hooks inserted in ends of pipe shall have broad, well-padded contact surfaces.

2. Laying Pipe. Pipe shall be laid with the bell ends facing the direction of laying except when reverse laying is specifically authorized or as directed by the Engineer.

3. Assembly. For push on pipe, the spigot shall be inserted into the bell to the line on the spigot. The previously completed joints must be braced so the line does not become "stacked", "over belled", or inserted past the reference mark on the spigot. If the insertion mark is not visible after assembly, the joints shall be dissembled and done correctly.

4. Alignment. Piping shall be laid to the lines and grades as specified, as indicated on reference points, or as indicated on the drawings. The Contractor must obtain approval from the Engineer for any changes in the alignment or grade.

5. Joint Deflection. Pipelines or runs intended to be straight shall be laid straight. Deflections from a straight line using joint deflection shall not exceed the pipe manufacturer's published axial joint deflection or 1°, whichever is less.

6. Bending pipe. The Contractor will not be allowed to bend PVC pipe. The Contractor shall use the Ceterainteed High Deflection Coupling if joint deflection is insufficient and an 11-1/4 bend is too large of an angle.

7. Mechanical Joints. Mechanical joints shall be carefully assembled in accordance with the manufacturer's recommendations. If effective sealing is not obtained, the joint shall be disassembled, thoroughly cleaned, and reassembled. Kor-Blue bolts, or approved equal, shall be used for all necessary assembly. Bolts shall be uniformly tightened to the torque values listed in ANSA/AWWA C111/A21.11. Over-tightening of bolts to compensate for poor installation practice will not be permitted.

8. Push-on Joints. All joint surfaces shall be lubricated with heavy vegetable soap solution immediately before the joint is completed. Lubricant shall be stored in closed containers and shall be kept clean. Each spigot end shall be suitably beveled to facilitate assembly.

9. Fittings. Unless directed otherwise by Engineer, Contractor shall determine the type and locations of bends required to complete the main installation. Mains shall be installed with the least number of bends practical.

   The Contractor will cut off the bevel of the PVC pipe before insertion into an MJ fitting.

10. Trace Wire. The Contractor shall install trace wire in the trench with the PVC pipe per the Tracer Wire detail in 50-11.

11. Thrust Restraint for PVC. Certa-lok restrained joint PVC shall be used or

installed using the EBBA Iron 1900 Series restraint harness or approved equal according to the manufacturer's recommendations.

Thrust restraint devices shall be provided on all pipe installed in encasement pipes and installed for street crossings.

12. Reaction Anchorage and Blocking. Where thrust restraint devices are inappropriate or when directed by the Engineer, concrete thrust blocks, thrust collars, or gravity blocks shall be used to prevent movement of the pipe caused by internal pressure. Reaction Anchorages and Blocking are covered in the Thrust Restraint section and should be installed according to Thrust Block detail 50-7.

13. Cutting Pipe. PVC cutting shall be done in a neat manner, without damage to the pipe. Cuts shall be smooth, straight, and at right angles to the pipe axis. After cutting, the end of the pipe shall be deburred to remove the PVC shavings. The cut ends of push-on joint pipe shall be suitably beveled as necessary to provide proper installation.When cutting pipe with couplings, mark the field cut pipe at the same distance in as the mark appeared on the original full-length pipe section.

14. Cleaning. The interior of all pipe and fittings shall be thoroughly cleaned of foreign matter before being installed and shall be kept clean until the work has been accepted. Such surfaces shall be wire brushed, if necessary, wiped clean, and kept clean until jointing is completed.

D. HDPE Pipe.

1. Handling. HDPE pipe and fittings shall be handled to insure installation in a sound undamaged condition.

   During loading, transportation and unloading, every precaution shall be taken to prevent injury to the pipe. No pipe shall be dropped from cars or trucks, or allowed to roll down slides without proper retaining ropes. During transportation each pipe shall rest on suitable pads, strips, skids, or blocks securely wedged or tied in place. Any pipe that is scratched more than 10% of the wall thickness shall not be used.

2. Laying Pipe. HDPE pipe shall not be installed when trenches or weather conditions are not suitable for such work.

   HDPE pipe shall be installed in a trench with engineered embedment and backfill per the Excavation and Trenching section, except the bedding material particle size shall not exceed ½ inch for pipe smaller than 4 inches in diameter. The bedding material may be sliced in around the pipe.

3. Fusion. Sections of polyethylene pipe should be joined into continuous lengths on the jobsite above ground. The preferred joining method shall be the butt fusion method. The butt fusion equipment used in the joining procedures should be capable of temperature requirements of 400 degrees Farenheit, alignment, and an interfacial fusion pressure of 75 PSI.

Electrofusion couplings shall be used when butt fusion equipment cannot be used. Electrofusion coupling assembly shall be completed as scribed in the attachment at the end of this section.

Socket fusion, hot gas fusion, threading, solvents, and epoxies will not be used to join HDPE pipe.

The operator of the butt fusion or electrofusion machine shall be trained and certified by the fusion equipment supplier to operate the fusion machine.

4. Trace Wire. The Contractor shall install trace wire in the trench with the HDPE pipe per the Tracer Wire detail in 50-11.

5005 TRACER WIRE SYSTEM AND DETECTION MARKING TAPE. Tracer wire and detection tape shall be installed on all plastic sanitary sewer mains and service lines within the public right-of-way per Section 9100 Tracer Wire Pipe Detection System.

5006 CONNECTION TO EXISTING MAINS. The Contractor shall furnish and install all fittings necessary to join the existing and new water mains as shown on the plans.

No connections to existing mains shall be started without prior approval of the Engineering Department, and each connection with an existing main shall be made at a time and under conditions which will least interfere with service to customers affected thereby.

In all cases where it is necessary to take an existing main or service line out of service in order to accomplish the work to the performed, the Contractor shall notify the Engineering Department at least twenty-four (24) hours in advance as to the approximate length of time the main or service line will be out of service. The contractor shall also be responsible for notifying all customers to be affected by loss or interruption of service by means of printed information sheets (door hangers, furnished by the City) forty-eight (48) hours in advance of taking the main or service line out of operation.

When the closing of a valve to make the connections affects a customer who cannot be without service, the Contractor shall arrange to supply a temporary service and schedule the time, which is most convenient to the customer for making the connection to the existing mains.

Facilities shall be provided for properly dewatering and for disposal of all water removed from the dewatered lines and excavations without damage to adjacent property.

5007 POLYETHYLENE ENCASEMENT. Polyethylene encasement shall be used around all mechanical connections, including mechanical joints, valves and fire hydrant assemblies. Polyethylene protection shall be installed in accordance with ANSI/AWWA C105/A21.5, Method A. Preparation of the pipe fittings shall include, but is not limited to, removing lumps of clay, mud, cinders, etc., prior to installation. Where pipe is also embedded or encased in concrete, the polywrap shall be installed over the pipe fittings prior to placing the concrete.

5008 SETTING VALVES, FITTINGS AND HYDRANTS.

A. Valves and Fittings. All valves, fittings, plugs and caps shall be set and joined to the pipe in the manner heretofore specified for cleaning, laying and joining pipe,

except that large valves may require special support so that the pipe will not be required to support the valve weight.

Each valve shall be inspected before installation to ensure that all foreign substances have been removed from within the valve body, and shall be opened and closed to see that all parts are in first-class working condition. Gate valves shall be set vertical in the horizontal pipeline. Valves and pipe shall be supported in such a manner as to prevent stress in either with no deflection in the valve/pipe joint.

Valve boxes and lids shall be installed at each valve and shall be supported and maintained centered and plumb over the operating nut of the valve. The valve box shaft shall not transmit shock or stress to the valve. Install valve box covers flush with the surface of the finished area or as directed by the Engineer.

All bends and tees shall be provided with thrust blocks of plain concrete, as specified. All dead ends on new mains shall be closed with plugs or caps suitably restrained to prevent blowing off under test pressure.

B. Hydrants. All new hydrant installations shall be as shown on the plans or Standard Drawings and shall include all necessary excavation and backfill to make the installation complete.

Each hydrant shall be inspected before installation for direction of opening, nozzle size and threading, nozzle caps and chains, operating nut, and cap nut dimensions, tightness of pressure-containing bolting, cleanliness of inlet elbow and weep hole openings, and handling damage and cracks. Defective hydrants shall be corrected or replaced.

All hydrants shall stand plumb. The weep holes of the hydrant shall be kept clear and free to drain. The areas around each hydrant and hydrant valve shall be thoroughly compacted to prevent settlement of these areas.

Hydrants shall be set to a grade that allows their proper operation. Traffic hydrants with breakaway joint must be set with the joint above the ground line. Hydrants behind curbs shall be placed with the hydrant centerline at least 30 inches from the back of curb. Hydrants shall be rotated so as to have the pumper nozzle facing the street or rotated to face any direction as required by the Engineer.

## 5009 THRUST RESTRAINTS

A. Hydrants. The back of the base elbow of each hydrant shall be braced against a sufficient area of unexcavated earth or rock and be restrained by suitable restrained joints as shown on the plans or the Standard Drawings.

B. Fittings. All plugs, caps, tees, bends and other fittings, unless otherwise specified, shall be provided with reaction blocking or suitable restrained joints as shown on the plans or Standard Drawings.

C. Thrust Blocks. Vertical and horizontal reaction blocking shall be concrete as specified herein. Thrust blocks shall be installed between solid ground and the

fitting to be restrained. Concrete shall be located to contain the resultant thrust force and permit access to pipe and fitting joint for repairs and installed according to the Thrust Block detail 50-7. All nuts and bolts shall be protected with polyethylene encasement to prevent covering or contaminating with concrete.

D. Restrained Joints. Restrained push-on or mechanical joints, mechanical joint anchoring fittings, and Meg-A-Lug retainer glands may be used in lieu of concrete thrust blocking if so indicated on the plans or approved by the Engineer.

5010 TRENCH BACKFILLING. Compacted backfill shall be required for the full depth of the trench above the embedment where beneath structures, street, road, or highway right-of-way or abutting easements, driveways, walks, parking areas, and at all locations shown on the plans or as directed by the Engineer during the progress of the work.

The top portion of the backfill beneath established sodded areas shall be finished with at least twelve (12) inches of topsoil corresponding to, or better than, that underlying adjoining sodded areas. The Engineer prior to placement shall approve topsoil, and unless otherwise directed, shall be material previously excavated and stockpiled for the purpose during excavating and grading operations. Grades on areas to receive topsoil shall be established and maintained as a part of the grading operations. Immediately prior to dumping and spreading topsoil, the surface shall be loosened by disking or scarifying to a depth of two (2) inches to permit bonding of the topsoil to the underlying surface.

At the option of the Contractor, compacted backfill may be job-excavated material or material obtained "off-site" except that all street crossings shall be backfilled with MoDOT Type I rock, or on-site material provided testing is performed in one (1) foot lifts in the trench four (4) feet back of curb to four (4) feet back of curb. Job-excavated material may be used for compacted backfill (outside of Street Right of Ways) when the job-excavated material is finely divided and free from debris, organic material, cinders, or other corrosive material, and stones larger than three (3) inches in greatest dimension. Large masses of moist, stiff clay shall not be used. Job-excavated material shall be compacted to ninety-five (95) percent of maximum density at optimum moisture content as determined by ASTM D698 when the test is appropriate, or to seventy (70) percent relative density as determined by ASTM D2049 when that test is appropriate.

The method of compaction and the equipment used shall be appropriate for the material to be compacted and shall not transmit damaging shocks to the pipe.

The combination of the thickness of the layer, the method of compaction and the type of compaction equipment used shall be at the discretion of the Contractor subject to obtaining the densities as specified above.

Backfill shall not be placed when material contains frost, is frozen, or a blanket of snow prevents proper compaction. Backfill shall not contain waste material, organic material, or debris of any kind.

Trench backfill above pipe embedment in locations other than those specified shall be compacted to ninety (90) percent of maximum density at optimum moisture content as determined by ASTM D698, unless otherwise permitted by the City Engineer.

Uncompacted earth backfill material to be placed above embedment shall be free of brush, roots

more than two (2) inches in diameter, debris, cinders, or other corrosive material, and junk, but may contain rubble and detritus from rock excavation, stones, and boulders in certain portions of the trench depth. Uncompacted backfill material above embedment may be placed by any method acceptable to the Engineer which will not impose excessive concentrated or unbalanced loads, shock, or impact on and which will not result in displacement of installed pipe. Uncompacted backfill shall be placed to the extent necessary to prevent excessive future settlement.

Compact masses of stiff clay or other consolidated material more than one (1) cubic foot in volume shall not be permitted to fall more than five (5) feet into the trench unless cushioned by at least two (2) feet of loose backfill above pipe embedment.

No uncompacted trench backfill material containing rocks, or rock excavation detritus, shall be placed in the upper eighteen (18) inches of the trench except with specific permission of the Engineer, nor shall any stone larger than eight (8) inches in its greatest dimension be placed within three (3) feet of the top of pipe.

5011 DENSITY TESTING. At the option of the Engineer, in-place field density testing to determine compliance with specified compaction requirements may be performed using a nuclear moisture-density measuring device. The laboratory shall furnish field results to the inspector immediately. If, as a result of this field-testing, the engineer determines that further compaction is required, the Contractor shall revise his compaction procedures to obtain the results specified.

5012 DRAINAGE MAINTENANCE. Trenches across roadways, driveways, walks, or other traffic ways adjacent to drainage ditches or water courses shall not be backfilled prior to completion of backfilling the trench on the upstream side of the traffic way, to prevent impounding water after the pipe has been laid. Bridges and other temporary structures required to maintain traffic across such unfilled trenches shall be constructed and maintained by the contractor. Backfilling shall be done so that water will not accumulate in unfilled or partially filled trenches. All material deposited in roadway ditches or other watercourses crossed by the line of trench shall be removed immediately after backfilling is completed and the original section, grades, and contours of ditches or watercourses shall be restored. Surface drainage shall not be obstructed longer than necessary.

5013 DISPOSAL OF EXCESS EXCAVATED MATERIALS. Except as otherwise permitted, all excess excavated materials shall be disposed of away from the site of work at a site approved by the Engineer, unless otherwise specified in the plans. Broken concrete and other debris resulting from pavement or sidewalk removal, excavated rock in excess of the amount permitted to be and actually installed in trench backfill, junk, and debris encountered in excavation work and other similar waste materials shall be disposed of away from the site of the work.

Excess earth from excavations located in unimproved property shall be distributed directly over the pipe trench and within the pipeline right-of-way to a maximum depth of six (6) inches above the original ground surface elevation at and across the trench and sloping uniformly. Drag with blade machine or other suitable tool to a smooth, uniform surface without obstructing drainage at any point. Wasting of excess excavated material in the above manner will not be permitted where the line of trench crosses or is within a railroad, public road, or highway right-of-way. The disposal of waste and excess excavated materials, including hauling, handling, grading, and surfacing shall be a subsidiary obligation of the contractor and no separate payment will be made therefore.

5014 SETTLEMENT. The contractor shall be responsible for all settlement of backfill, fills and

embankments, which may occur within two (2) years of time after final acceptance of the contract under which the work was performed.

The Contractor guaranteeing the maintenance of the construction under which the contract was performed shall furnish a suitable maintenance bond in an amount approved by the City Engineer to the City of Liberty. Said bond shall remain in effect for the period mentioned above from the date of completion and acceptance of the work by the City.

5015 DISINFECTION AND TESTING.

A. Disinfection. After installation, the entire main shall be flushed and disinfected by chlorination. Flushing shall be carried out until turbidity-free water is obtained from all points along the main.

Immediately prior to disinfection, the main to be disinfected shall be flushed at the maximum velocity, which can be developed. The flushing velocity shall be at least 2.5 feet per second.

All flushing work shall be done in the presence of the Engineer. The contractor shall notify the Engineer at least 24 hours in advance of the times and places at which flushing work is to be done.

1. Chlorination by the Contractor shall conform to AWWA C651 and be performed using a 1 percent chlorine solution prepared from granular calcium hypochlorite (1 pound of HTH per 8 gallons of water). Water entering the new main shall receive a dose of the chlorine solution fed at a constant rate such that the water will have not less than 50 mg/l free chlorine.

**Chlorine Required to Produce 50 mg/l Concentration in 100 feet of Pipe**

| Pipe Diameter (in) | 1 percent Chlorine Solution (gal) |
|---|---|
| 4 | 0.16 |
| 6 | 0.36 |
| 8 | 0.65 |
| 10 | 1.02 |
| 12 | 1.44 |

2. The chlorinated water shall be retained in the main for at least 24 hours, during which time all valves and hydrants in the section treated shall be operated in order to disinfect the appurtenances.

3. At the end of the 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. Mains shall be flushed prior to placing in service. The water shall be disposed of without damage to public or private property. Disposal of Heavily-

Chlorinated Water: The heavily-chlorinated flush water shall be dechlorinated in a manner complying with AWWA C651.

Pounds of Chemicals Required to Neutralize Various Residual Chorine Concentrations in 100,000 gal of water:

| **Residual Chlorine Concentration (mg/L)** | **Sulfur Dioxide ($SO_2$)** | **Sodium Bisulfate ($NaHSO_3$)** | **Sodium Sulfite ($Na_2SO_3$)** | **Sodium Thiosulfate ($Na_2S_2O_35H_2O$)** |
|---|---|---|---|---|
| 1 | 0.8 | 1.2 | 1.4 | 1.2 |
| 2 | 1.7 | 2.5 | 2.9 | 2.4 |
| 10 | 8.3 | 12.5 | 14.6 | 12.0 |
| 50 | 41.7 | 62.6 | 73.0 | 60.0 |

5. Following the flushing of the mains, water samples shall be taken from the new main and tested by the City for bacteria. In accordance with AWWA Standard 651, additional samples shall be taken at least 24 hours later and tested by the City for bacteria. No less than three (3) sample points shall be installed on any water main. A corporation cock with a copper-tube gooseneck assembly shall be used at all line sampling locations. Locations shall be as follows:

    a. Within fifty (50) feet of the beginning of the pipeline, mid-way in the pipeline, and within fifty (50) feet of the end of the pipeline.

    b. Sample points shall be located at a minimum of every one thousand (1000) feet in addition to the locations at the beginning and end of the line, in addition to which sample points shall be located on all branch lines.

6. The contractor shall repeat disinfection procedure should initial treatment fail to yield satisfactory results.

B. Pressure and Leakage Testing of Water Mains. All newly installed mains must be pressure and leakage tested prior to final acceptance. This memorandum provides recommended standards for pressure and leakage testing ductile iron and PVC water mains. These recommendations closely follow relevant AWWA Standards and industry specifications. The applicable AWWA Standards are C600 for ductile iron mains and C605 for PVC mains, or their most recent revision. Pressure and leakage testing requirements for materials other than ductile iron or PVC will be determined on a case-by-case basis. Alternate pressure and leakage criteria for ductile iron or PVC mains are acceptable provided they are shown to be at least as stringent as the criteria presented in this memorandum or most recent revision of applicable AWWA Standards.

Simultaneous or separate pressure and leakage tests may be performed. The test durations and pressures for each option are specified in Table 1. If separate tests are made, the pressure test should be conducted prior to the leakage test.

**TABLE 1 – PRESSURE AND LEAKAGE TEST METHODS**

| Procedure | Test Pressure | Duration of Test |
|---|---|---|
| Simultaneous Pressure & Leakage Test | 150% of working pressure* at point of test, but not less than 125% of normal working pressure at highest elevation. | 2 Hours |
| Separate Pressure Test | 150% of working pressure* at point of test, but not less than 125% of normal working pressure at highest elevation. | 1 Hour |
| Separate Leakage Test | 150% of working pressure* of segment tested. | 2 Hours |

* Working pressure is defined as the maximum anticipated sustained operating pressure. However, in no case shall the test pressure exceed the pressure rating for the pipe, valves, appurtenances, or thrust restraints.

1. Pressure Test. The purpose of the pressure test is to locate defects in materials or workmanship. Before testing, the pipeline must be backfilled and braced sufficiently to prevent movement under pressure.

   If concrete thrust blocks are used, sufficient time must be allowed before testing to ensure that the concrete has cured sufficiently. The test ends also should be restrained to withstand thrusts potentially developed under the test pressures.

   A pressure test should be conducted at 150 psi in the line. Care must be taken not to exceed the pressure rating of pipes, valves, fittings, thrust restraints, or other appurtenances. Pressures in the main may exceed the specified test pressure if the water pressure is read from a gauge located at a high point in the main.

   Potable water is introduced into the main through a temporary connection to a hydrant, corporation stop in the new main, or valved connection with the existing line. While filling the new main, air must be expelled from the pipeline by venting through service connections, hydrants, or air-release valves. Corporation stops may be required at high points in the line if there are insufficient valves to release air from the main. It is important to completely expel air from each section of the main to be tested. Compressed entrapped air may amplify surges within the main or cause erroneous pressure test results.

   After filling the main with water and expelling air, a pump is utilized to increase the water pressure within the line up to the required test pressure and to maintain that pressure for the required duration (See Table 1). An accurate method for measuring the amount of water pressure within the line must be provided. A key criterion for the pressure test is that the measured water pressure within the main (after reaching the required test pressure) should not vary by more than 5 psi during the duration of the test. While the line is under pressure, the system and all exposed pipe, fittings, valves, and hydrants should be examined for leakage. Any damaged or defective pipe, fittings, valves,

hydrants, or joints should be repaired or replaced and the pressure test repeated until satisfactory results are obtained.

2. Leakage Test. The purpose of the leakage test is to establish that the section of main being tested, including all joints, fittings and other appurtenances, will not leak or that leakage is within acceptable limits. If the leakage test is to be performed simultaneously with the pressure test, the system should be allowed to stabilize at the test pressure before conducting the leakage test.

   Equipment necessary for conducting the leakage test includes a pump equipped with a make-up reservoir and a pressure gauge for measuring water pressure in the main. In addition, there must be an accurate method for measuring the quantity of water pumped into the main being tested. Methods used to measure water volume include a calibrated make-up reservoir, a calibrated positive-displacement pump, or a water meter.

   The specified test pressure for the leakage test is the same as for the pressure test (See Table 1) and the test should be conducted for at least 2 hours in duration. Leakage is defined as the quantity of water that must be supplied into the main in order to maintain the water pressure within 5 psi of the specified test pressure after the pipe has been filled with water and air expelled. No pipe installation will be acceptable if the leakage is greater than that determined by the following formulas:

   For PVC or DIP:

$$L = \frac{\mathrm{SD}\sqrt{\mathrm{P}}}{148{,}000}$$

   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

   The above equation is based on a leakage rate of 10.5 gallons per day per mile per inch of nominal diameter of pipe. Leakage values determined by the above formula for 1000 feet of pipe are presented in Table 2.

**TABLE 2 - ALLOWABLE LEAKAGE (gal/hr) FOR 1000 FT OF GASKETED PVC OR DIP PIPE**

| Nominal Pipe Size | Average Test Pressure in Pipeline, psi | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (in) | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 | 350 | 400 | 450 |
| 2 | 0.10 | 0.12 | 0.14 | 0.15 | 0.17 | 0.18 | 0.19 | 0.20 | 0.21 | 0.22 | 0.23 | 0.25 | 0.27 | 0.29 |
| 3 | 0.14 | 0.18 | 0.20 | 0.23 | 0.25 | 0.27 | 0.29 | 0.30 | 0.32 | 0.34 | 0.35 | 0.38 | 0.41 | 0.43 |
| 4 | 0.19 | 0.23 | 0.27 | 0.30 | 0.33 | 0.36 | 0.38 | 0.41 | 0.43 | 0.45 | 0.47 | 0.51 | 0.54 | 0.57 |
| 6 | 0.29 | 0.35 | 0.41 | 0.45 | 0.50 | 0.54 | 0.57 | 0.61 | 0.64 | 0.67 | 0.70 | 0.76 | 0.81 | 0.86 |
| 8 | 0.38 | 0.47 | 0.54 | 0.60 | 0.66 | 0.72 | 0.76 | 0.81 | 0.85 | 0.90 | 0.94 | 1.01 | 1.08 | 1.15 |
| 10 | 0.48 | 0.59 | 0.68 | 0.76 | 0.83 | 0.89 | 0.96 | 1.01 | 1.07 | 1.12 | 1.17 | 1.26 | 1.35 | 1.43 |
| 12 | 0.57 | 0.70 | 0.81 | 0.91 | 0.99 | 1.07 | 1.15 | 1.22 | 1.28 | 1.34 | 1.40 | 1.52 | 1.62 | 1.72 |
| 14 | 0.67 | 0.82 | 0.95 | 1.06 | 1.16 | 1.25 | 1.34 | 1.42 | 1.50 | 1.57 | 1.64 | 1.77 | 1.89 | 2.01 |
| 16 | 0.76 | 0.94 | 1.08 | 1.21 | 1.32 | 1.43 | 1.53 | 1.62 | 1.71 | 1.79 | 1.87 | 2.02 | 2.16 | 2.29 |
| 18 | 0.86 | 1.05 | 1.22 | 1.36 | 1.49 | 1.61 | 1.72 | 1.82 | 1.92 | 2.02 | 2.11 | 2.28 | 2.43 | 2.58 |
| 20 | 0.96 | 1.17 | 1.35 | 1.51 | 1.66 | 1.79 | 1.91 | 2.03 | 2.14 | 2.24 | 2.34 | 2.53 | 2.70 | 2.87 |
| 24 | 1.15 | 1.40 | 1.62 | 1.81 | 1.99 | 2.15 | 2.29 | 2.43 | 2.56 | 2.69 | 2.81 | 3.03 | 3.24 | 3.44 |
| 30 | 1.43 | 1.76 | 2.03 | 2.27 | 2.48 | 2.68 | 2.87 | 3.04 | 3.21 | 3.36 | 3.51 | 3.79 | 4.05 | 4.30 |
| 36 | 1.72 | 2.11 | 2.43 | 2.72 | 2.98 | 3.22 | 3.44 | 3.65 | 3.85 | 4.03 | 4.21 | 4.55 | 4.86 | 5.16 |
| 42 | 2.01 | 2.46 | 2.84 | 3.17 | 3.48 | 3.75 | 4.01 | 4.26 | 4.49 | 4.71 | 4.92 | 5.31 | 5.68 | 6.02 |
| 48 | 2.29 | 2.81 | 3.24 | 3.63 | 3.97 | 4.29 | 4.59 | 4.86 | 5.13 | 5.38 | 5.62 | 6.07 | 6.49 | 6.88 |
| 54 | 2.58 | 3.16 | 3.65 | 4.08 | 4.47 | 4.83 | 5.16 | 5.47 | 5.77 | 6.05 | 6.32 | 6.83 | 7.30 | 7.74 |
| 60 | 2.87 | 3.51 | 4.05 | 4.53 | 4.97 | 5.36 | 5.73 | 6.08 | 6.41 | 6.72 | 7.02 | 7.58 | 8.11 | 8.60 |
| 64 | 3.06 | 3.75 | 4.32 | 4.83 | 5.30 | 5.72 | 6.12 | 6.49 | 6.84 | 7.17 | 7.49 | 8.09 | 8.65 | 9.17 |

**Note: The allowable leakage for test sections with different diameters is the sum of the computed leakage for each pipe size.**

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

Leakage less than the quantity specified by the above equation may be considered "allowable leakage" resulting from such factors as trapped air, take-up of restraints, and temperature variations during testing. However, observed leaks should be repaired regardless of leakage measurements through metering equipment.

A swift loss of water pressure in the main could be the result of a break in the line, major valve opening, loose mechanical joint bolts, missing or dislodged gasket, or inadequate thrust block. A slow loss of pressure in excess of allowable limits could be the result of minor problems such as a leaking valve or a corporation stop not completely shut off. In addition, air entrapped in the line can result in an apparent leakage in excess of the allowable limit.

Recommendations for avoiding minor leaks include the following:

a. Vent all high points in the line by use of air release valves or corporation stops.
b. Check all mechanical joint bolted connections.
c. Cure thrust blocks before testing.
d. Insure that exposed gasket grooves are properly cleaned before inserting gaskets.
e. When inserting pipe into a mechanical joint or gasket joint, insure that the spigot end is squarely cut and beveled properly for the hub.

One approach for determining if the apparent leakage is the result of air entrapped in a line is to immediately repeat the leakage test (i.e., continue the test for another two hours) and determine the amount of make-up water required to fill the line a second time. If this amount is significantly less than the first filling, the difference in apparent leakage is probably the result of air being present in the line. If no significant difference in make-up water is recorded, a leak is probable.

5016 SEPARATION OF WATER MAINS AND SANITARY SEWERS.

A. General. The following factors should be considered in providing adequate separation:

a. Materials and type of joints for water and sewer pipes;
b. Soil conditions;
c. Service and branch connections into the water main and sewer line;
d. Compensating variations in the horizontal and vertical separations;
e. Space for repair and alterations of water and sewer pipes; and
f. Off-setting of water mains around manholes.

B. Parallel Installation. Water mains shall be laid at least ten feet horizontally from any existing or proposed sewer. The distance shall be measured edge to edge. In cases where it is not practical to maintain a ten-foot separation, the department may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such deviation may allow installation of the water main closer to a sewer, provided that the water main is laid in a separate trench or on an undisturbed earth shelf located on one side of the sewer and on either case, at such an elevation that the bottom of the water main is at least 18 inches above the top of the sewer. In areas where the recommended separations cannot be obtained, either the waterline or the sewer line shall be constructed of mechanical joint pipe or cased in a continuous casing.

C. Crossings. Water mains crossing sewers shall be laid to provide a minimum vertical clear distance of 18 inches between the outside of the water main and the outside of the sewer. This shall be the case where the water main is either above or below the sewer. At crossings, the full length of water pipe shall be located so both joints will be as far from the sewer as possible but in no case less than ten feet. Special structural support for the water and sewer pipes may be required. In areas where the recommended separations cannot be obtained either the waterline or the sewer line shall be constructed of mechanical joint pipe or cased in a continuous casing that extends no less than ten feet on both sides of the crossing.

D. Exceptions. Any variance from the specified separation distances in paragraphs 5016.B and 5016.C must be approved by the City Engineer.

E. Force Mains. There shall be at least a ten-foot horizontal separation between water mains and sanitary sewer force mains and they shall be in separate trenches. In areas where these separations cannot be obtained, either the waterline or the sewer line shall be cased in a continuous casing.

F. Sewer Manholes. No waterline shall be located closer than ten (10) feet to any part of a sanitary or combined sewer manhole.

G. Disposal Facilities. No waterline shall be located closer than 25 feet to any on-site wastewater disposal facility, agricultural waste disposal facility, or landfill.