COLLECTION & CONVEYANCE SEWER SPECIFICATIONS

SECTION 1: GENERAL

SEC. 1.1 Scope

1.1.1 This standard covers sewer system piping, manholes and other associated equipment or materials as indicated on the construction plans.

1.1.2 Installation procedures for sewer mains and their appurtenances for sewerage connection and transport.

1.1.3 Procedures for testing new and repaired sewer pipes. All new sewer pipes shall be tightness tested before they are placed in service.

SEC. 1.2 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. 1.3 Permeation

The selection of materials is critical for sewer 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 permeation by lower–molecular-weight organic solvents and petroleum products. If a sewer pipe must pass through such a contaminated area or an area subject to contamination, consult with engineer regarding permeation 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 Gravity Pipe (12" and less in diameter)

2.1.1 Gravity sewer pipe materials selection is to be in accordance with the following installation application.

2.1.1.1 One to three (1 - 3) feet of cover above pipe: Case-by-case approval by engineer and local authority.

2.1.1.2 Three to ten (3 – 10) feet of cover above pipe: **SJDIP, MJDIP, PVC-SDR35, PVC-SDR21.**

2.1.1.3 Ten to twenty (10 – 20) feet of cover above pipe: **SJDIP, MJDIP, PVC-SDR21.**

2.1.1.4 Greater than twenty (20) feet of cover: Case-by-case approval by engineer and the local authority.

2.1.1.5 Pipe placed in fill material: **MJDIP.**

2.1.1.6 Pipe within 10 feet slope embankment: **MJDIP.**

2.1.1.7 Pipe within steel casing: **SJDIP, MJDIP.**

2.1.1.8 Pipe within concrete encasement: **SJDIP, MJDIP.**

2.1.1.9 Pipe "meeting watermain specifications": **MJDIP, SJDIP.**

2.1.1.10 Pipe under ponds, and detention ponds: **MJDIP.**

2.1.1.11 Pipe for stream crossings and aerial sewers: **RJDIP.**

2.1.2 Sewer Pipe Materials

2.1.2.1 *Ductile Iron Pipe:* (**SJDIP** = slip joint; **MJDIP** = mechanical joint; **RJDIP** = restrained joint)

a. *Ductile Iron Pipe Class 52* – Pipe and fittings shall be centrifugally cast conforming to ANSI/AWWA, C-151/A21.51 and ANSI/AWWA, C-110/A21.10, respectively.

b. *Pipe interior* shall be cement-lined with bituminous seal coating conforming to ANSI/ASWWA, C-104/A21.4.

c. *Joints* used for ductile iron pipe shall be rubber gasket push-on type (SJDIP) conforming to ANSI/AWWA, C-110/A21.11 or mechanical joint conforming to ANSI/AWWA, C-111/A21.11 (MJ & RJ).

d. *Gaskets* shall be plain rubber, of heavy section and high durometer, single molded.

e. L*ubricant* shall be non-toxic, tasteless, odorless grease that will not support bacteria and shall meet or exceed AWWA standards and/or those of the National Sanitation Foundation.

f. E*xterior coating* shall be a bituminous coating conforming to ANSI/AWWA, C=151/A21.5.

g. RESTRAINED JOINT DIP – Low alloy, high strength steel ring, factory-welded onto plain end of pipe to provide positive restraint against joint separation when retaining ring and lock ring are in place.

2.1.2.2 Polyvinyl Chloride (PVC) – SDR 35

a. PVC plastic sewer pipe and fittings shall meet the requirement of ASTM D3034 and Uni-Bell Uni-B4. The standard dimension ratio (SDR) of all pipe and fittings shall not exceed SDR 35 unless otherwise specified.
b. All joints shall be of the bell and spigot type and conform to ASTM D3212 and/or Uni-Bell Uni-B-1. All bells shall be formed integrally with the pipe and shall contain a factory installed elastomeric gasket.
c. Gaskets shall be in accordance with ASTM F477.

2.1.2.3 Polyvinyl Chloride (PVC) – SDR 21

a. PVC pipe and fittings shall be manufactured to steel pipe size (IPS) outside dimensions with DR's and tolerances in compliance with ASTM D2241 PVC plastic pipe, DR, PR.
b. Pipe and fittings shall be manufactured to steel pipe O.D.'s (IPS) or by special construction in which pipe thickness shall be maintained but pipe shall be manufactured to meet SDR 35 pipe O.D.'s. Pipe and fittings shall be joined by means of rubber ring bell joint meeting ASTM D3139 which shall be an integral and homogenous part of the pipe. Pipe and fittings shall conform to all requirements of ASTM D2241 for PVC pipe with pressure ratings of 200 PSI (DR21) for pipe barrel and bell. Ductile Iron mechanical joint fittings, if used, shall conform to Part "2.1.2.1" above and shall be used with appropriate transition gasket.

SEC. 2.2 Gravity Pipe (greater than 12" in diameter)

2.2.1 Gravity sewer pipe materials selection is to be in accordance with the following installation application.

2.2.1.1 One to three (1 - 3) feet of cover above pipe: Case-by-case approval by engineer and local authority.
2.2.1.2 3 to 10 feet of cover above pipe: **SJDIP, MJDIP, RCP, PVC-large diameter**.
2.2.1.3 10 to 20 feet of cover above pipe: **SJDIP, MJDIP, RCP**.
2.2.1.4 Greater than 20 feet of cover: Case by case approval by engineer and local authority.
2.2.1.5 Pipe placed in fill material: **MJDIP**.
2.2.1.6 Pipe placed within 10 feet slope embankment: **MJDIP**.
2.2.1.7 Pipe within steel casing: **SJDIP, MJDIP**.
2.2.1.8 Pipe within concrete encasement: **SJDIP, MJDIP**.
2.2.1.9 Pipe "meeting watermain specifications": **SJDIP, MJDIP**.
2.2.1.10 Pipe under ponds, and detention ponds: **MJDIP.**
2.2.1.11 Pipe under stream crossings and aerial sewers: **RJDIP.**

2.2.2 Sewer Pipe Materials

2.2.2.1 Ductile Iron Pipe (**SJDIP** = Slip joint, **MJDIP** = Mechanical joint; **RJDIP** = Restrained joint) Ductile Iron pipe complying with Specifications in part 2.1.2.1 above. Strength class shall be as required for pipe diameter and live load/height of cover. Assume Class "D" bedding. Use Safety Factor of 2.

2.2.2.2 Reinforced Concrete Pipe (**RCP**)

a. Reinforced concrete pipe (RCP) complying with ASTM C76. Strength class shall be as required for pipe diameter and live load/height of cover. Assume Class "D" Bedding. Use Safety Factor of 2. Engineer shall establish requirement for sacrificial concrete thickness and corresponding reinforcing combination. Pipe shall be manufactured with crushed calcareous coarse aggregate. The finished product shall have an AZ factor equal to 90 where 'A' is the Alkalinity, stated as a percent, in grams of calcium carbonate equivalent in reactivity to 1 gram of concrete and 'Z' is the internal concrete cover over reinforcement in inches. The internal diameter of the pipe shall not be reduced to increase the internal concrete cover. Pipe in sizes 18" through 30", except Class V, shall be C-wall with B-wall reinforcement placed so that there is a minimum of ¾ inch additional concrete cover on the inner circumferential reinforcement than that specified in ASTM C76 for B-wall.
b. Pipe shall be coated inside and outside with bitumastic compound equal to Tarmastic-100.
c. Rubber gaskets and joints of concrete pipe shall meet requirements of ASTM C361.
d. Pipe and joints shall be testes in accordance with Section 9 of ASTM C76 and ASTM C443 with test report submitted to Engineer.

2.2.2.3 PVC – Large Diameter

a. Polyvinyl Chloride (PVC) closed profile wall plastic gravity sewer pipe 24" through 30" with an integral bell and elastomeric seal joints shall meet requirements of ASTM F794. The following requirements shall also be met:

PVC Homopolymer meeting ASTM D1784; Impact Strength of 1.5 inch-pounds minimum, ASTM D256; Tensile Strength of 5,000 PSI (cell class minimum), ASTM D638; Tensile Modulus of Elasticity at 450,000 PSI, ASTM D638; Pipe Stiffness of 46 PSI, ASTM D2412; Pipe Flattening at 60% Deflection minimum without cracking, ASTM F794; Impact Strength of 220 foot-pounds (30 lbs. TUP B 72 F), ASTM D2444; Rubber gasket material shall conform to ASTM F477; Joint Tightness shall be such that no leakage occurs at 11.8 PSI (22" of Hg Vacuum), ASTM D3212.

SEC. 2.3 Sanitary Sewer Lateral

2.3.1 Allowable materials for use in sanitary sewer service laterals shall be limited to the following:

2.3.1.1 Pipe and Fittings within the Public Right-of-Way or Easement

a. PVC SDR 21 with elastometric gaskets conforming to specifications set forth for sewer main in excess of ten (10) feet of cover. **PVC SDR 35 will NOT be permitted**. Fittings shall include:
   45° Gasket SDR 21
   SDR 35 Spigot x 4" Gasket – SDR 21 Adapter
   SDR 21 Repair Coupling Gasket
   Special Longsweep Tee-Wye for SDR 21 Gasket by HARCO
   SDR 21 Push Plug
b. Cast Iron Soil Pipe in conformance with CISPI 301.
c. Ductile Iron as specified for sanitary sewer main.

2.3.1.2 Pipe and Fittings on Private Property Beyond the Right-of-Way or Easement Limits.
a. All materials listed in Part A above.
b. PVC SDR 35 pipe conforming to specifications for sanitary sewer main with cover greater than three (3) feet or less than ten (10) feet.
c. PVC Schedule 40 or 80 pipe conforming to ASTM D1785. Fittings and couplings shall be solvent weld conforming to ASTM D2466 or ASTM D2467. Joints and solvent cements shall conform to ASTM D2564.

2.3.1.3 Cleanout Plug: Panella Cleanout PA4XHCSK 4-inch XH with countersunk plug. Plastic plugs are NOT permitted.

2.3.1.4 Saddles
a. PVC SDR 21 Pipe – Romac CB 4.215 saddle with adapter fitting.
b. PVC Schedule 40 Pipe – Romac CB 4.215 saddle with adapter fitting.
c. Cast Iron Soil Pipe – Romac CB 4.38 saddle.

2.3.2 Pipe bedding, haunching and initial backfill VDOT aggregate material #68.

SEC. 2.4 Force Main Pressure Pipe

FORCE MAIN
CONNECTION @ MANHOLE

12-VAC 5-581-500:

Connection:

2.4.1 Force mains shall normally enter a gravity sewer system at a point no more than one (1) foot above the flow line of the receiving manhole with a curved section to prevent air from traveling up into the force main.
The force main should enter the receiving manhole with its center-line horizontal, and shall have an invert elevation which ensures a smooth flow transition to the gravity flow section. Special attention shall be paid to the design of the termination in order to prevent turbulence at this point.

2.4.2 PVC (POLYVINYL CHLORIDE) PIPE AND FITINGS

Unless shown otherwise on the approved plans, the Contractor/Developer may use any of the following types of PVC pipe:

2.4.2.1 **PVC** pipe meeting the requirements of AWWA C 900, Standard Specifications for PVC Pressure Pipe, four (4) inches through 12 inches. The minimum pressure class allowance should be class 150 (DR18). PVC pipe meeting the requirements of AWWA C 900, Standard Specifications for PVC Water Transmission Pipe,. Nominal Diameters 14 inch through 36 inch, pressure rated 165 psi (DR25). The minimum pressure class allowed shall be Class 150 (Dr18). Joints shall be gasket, bell and spigot, push-on types that meet the requirements of AWWA C 900. Gaskets shall meet the requirements of ASTM F 477, Standard Specifications for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

2.4.2.2 **PVC** pipe meeting the requirements of ASTM D 1785, Standard Specifications for PVC Plastic Pipe, Schedule 40, 80, or 120. The minimum pressure rating allowed shall be 150 psi.

Joints can be solvent-cement joints on pipes less than (4) four inch and shall meet the requirements of ASTM D 2855, Standard Specifications for making Solvent-Cement Joints with PVC Pipe Fittings. The solvent-cement shall meet the requirements of ASTM D 2564, Standard Specifications for Solvent-Cement PVC Plastic Pipe and Fittings.

2.4.2.3 **PVC** pipe meeting the requirements of ASTM D 2241, Standard Specifications for PVC Pressure-Rated Pipe (SDR Series). The minimum pressure rating shall be 150 psi.

Joints shall be gasket, bell and spigot, push-on types which meet the requirements of ASTM D 3139, Standard Specifications for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals. Gaskets shall meet the requirements of ASTM F 477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

2.4.2.4 **PVC** pipe shall be "traced" by installing metallic ribbon; wire etc. to aid in location after pipe is buried.

SEC. 2.5 Manholes

2.5.1 Units shall be pre-cast concrete conforming to 4000 PSI minimum strength with manhole conforming to ASTM specifications C478. Sections shall have O-rings meeting ASTM C-361. All reinforcing shall meet ASTM C-361. All reinforcing shall meet ASTM C361.

2.5.2 Protective coating for concrete manhole section exterior shall be two coats of coal tar solutions such as Porter Paint Company "Tarmastic 100".

2.5.3 Manhole steps shall be cast iron meeting requirements of ASTM A48 for Class 30 Gray iron. Steps shall be coated with coal tar pitch varnish. Manhole steps may also be aluminum meeting requirements of Alloy 6005-T5 or Alloy 6061-T6. Manhole step surfaces in contact with concrete shall be coated with coal tar pitch varnish.

2.5.4 Manhole frames and covers shall be roadway type with deep socket covers. Machine frames and covers to prevent rattling. Castings shall be of Gray iron meeting requirements of ASTM A-48, Class 30, and have 24 inch diameter openings. Each cover shall have cast or embossed on it in letters not less than 1 inch high "Sanitary Sewer". The frame and cover shall weigh at least 310 pounds.

Approved models for Pavement/Concrete:	Dewey Bros. RCR-2001
Approved models for Other Areas:	Dewey Bros. RCR-2001
	Capitol Foundry MH-2001
	Neenah Foundry R-2001 with Type C cover

Watertight Lids required when top of manhole elevation is lower than the 100-Year Flood Elevation

2.5.5 Pipe to manhole connection shall be sealed with a flexible boot, gasket, sleeve, or as detailed on drawings. When the boot is used, the port shall be cored to the size, shape, surface finish, and location required and not cast in the manhole. Angular adjustments through 20 degrees shall be allowed. The flexible boot shall be a 3/8-inch thick neoprene compound meeting ASTM C443 specifications. The boot shall be secured to the port with an internal aluminum expanding band and to the pipe with a nonmagnetic corrosion resistant steel external band. Boot seal shall be "Kor-n-Seal" as manufactured by National Pollution Control Systems, Inc. When a gasket is used, the gasket shall be a rubber pressed wedge gasket cast into the manhole with a maximum deflection of 15 degrees as manufactured by Press-Seal Gasket Corporation. When a sleeve is used, the sleeve shall be a flexible rubber sleeve cast into the manhole complete with stainless steel strap as manufactured by Interpace Corp. Connection for 24-inch diameter and larger pipe to manhole shall be made with "Contour-Seal" manufactured by NPC, Inc. Installation of "Contour-Seal" gasket shall be in accordance with the manufacturer's recommended procedures. Use of grouted connections must be approved by the Director and shall require a joint within 24" of the manhole.

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, 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 sewer pipe shall be laid and maintained to lines and grades established by the plans for the project. Fittings, manholes, and lateral connections 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 odstruction 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 sewer pipe. 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.* Sewer lines or sewer manhole shall be laid at least ten (10) feet horizontally from a water main. The distance shall be measured edge-to-edge.

4.1.4.2 *Unusual conditions.* When local conditions prevent a horizontal seperation of ten (10) feet, the sewer line or sewer manhole may be laid closer to a water line 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 sewer (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 sewer and water pipelines cross.

4.1.6.1 *Normal conditions.* Sewers crossing water lines shall be laid to provide a separation of at least eighteen (18) inches between the bottom of the water line 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 and pressure tested in place without leakage prior to backfill.

ii. Sewer lines passing over water lines 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 sewer pipe installation shall be three (3) 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, 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 dimensions of pavement removed shall not exceed the dimensions of the opening required for installation of pipe, 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, 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 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, 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 within the utility easement area.

4.2.8.2 Temporary support, adequate protection, and maintenance of all underground and surface structures, drains, water lines, 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 pipes 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 sewer pipe. Under no circumstances shall sewer pipe 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, 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.

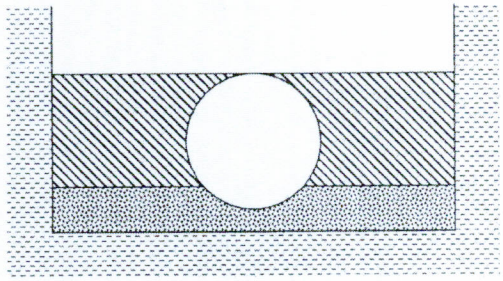
4.3.5 *Direction of bells.* Pipe is to be installed with the bells facing the up-gradient direction.

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.



Type 4 Standard Pipe Laying Condition

Pipe bedded in sand, gravel, or crushed stone to depth of 1/8 pipe diameter. 4-in. minimum.
Backfill compacted to top of pipe (Approximately 80% Standard Proctor, AASHTO T-99)
E' = 500 psi, Bedding Angle = 90 degrees, $K_b = 0.157$, $K_x = 0.096$

Figure 1

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. 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 2 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

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

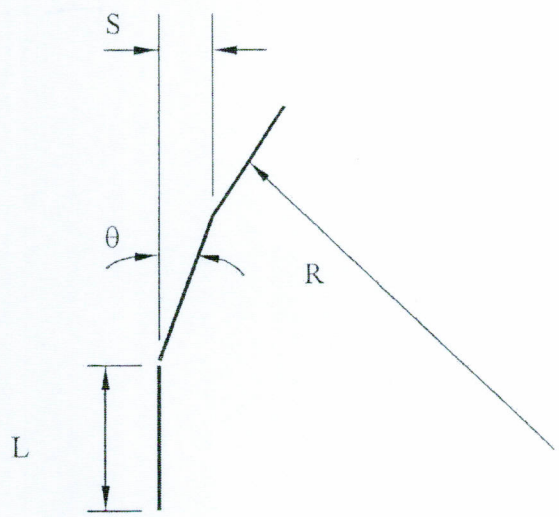


Figure 2 Pipeline curve geometry

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 Initial backfill must exclude stones greater then 1 inch in any dimension, extend to a minimum depth of 12 inches over the pipe, and be placed in lifts of no more than 6 inches. Final backfill must exclude stones greater than 5 inches in any dimension and be placed in lifts of no more than 2 feet.

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.

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: **TESTING GRAVITY SEWER LINES AND MANHOLES**

Sec. 8.1 Gravity Sewer Lines

8.1.1 Sanitary sewer lines 24 in. diameter and smaller shall be tested after backfill using a low-pressure air test in accordance with ASTM C828. Sewer lines larger than 24 in. diameter and manholes shall be tested by infiltration or exfiltration as hereinafter detailed. All sewer lines and manholes shall also be tested for final acceptance, using either the infiltration or exfiltration method as directed by and in the presence of the Engineer. Tests shall be conducted on short sections of sewer line, i.e.,

between manholes, or at the end of each day's work. Provide all labor, materials, tools, and equipment necessary to make the tests. All equipment and methods used shall be acceptable to the Engineer. All monitoring gages shall be subject to calibration, if deemed necessary.

8.1.2 **Low-pressure air test**

8.1.2.1 *Summary of Method*: Plug the section of the sewer line to be tested. Introduce low-pressure air into the plugged line. Use the quantity and rate of air loss to determine the acceptability of the section being tested.

8.1.2.2 *Preparation of the sewer line*: Flush and clean the sewer line prior to testing, thus serving to wet the pipe surface as well as clean out any debris. A wetted interior pipe surface will produce more consistent results. Plug all pipe outlets using approved pneumatic plugs with a sealing length equal to or greater than the diameter of the line being tested to resist the test pressure. Give special attention to laterals.

8.1.2.3 *Ground Water Determination*: Install a ½ inch capped, galvanized pipe nipple, approximately 12 inches long, through the manhole on top of the lowest sewer line in the manhole. Immediately prior to the line acceptance test, the ground water elevation shall be determined by removing the pipe cap and blowing air through the pip nipple into the ground so as to clear it, and then connecting a clear plastic hose to the pipe nipple. The hose shall be held vertically and a measurement of the height in feet of water over the invert of the pipe shall be taken after the water has stopped rising in the plastic hose.

8.1.2.4 *Procedures*: Determine the test duration for the sewer pipe section under test by using table 5. The pressure-holding time is based on an average holding pressure of 3 psi gage or a drop from 3.5 psi to 3.0 psi gage.

Table 5 Gravity Sewer Minimum Holding Time (Air Test)

Minimum Holding Time in Minutes Required for Pressure Drop from 3.5 to 3.0 psi.

Length of Pipe	Pipe Diameter												
ft	4	6	8	10	12	15	18	21	24	27	30	33	36
25	2.8	4.2	5.7	7.1	8.5	10.6	12.7	14.8	17.0	19.2	21.2	23.3	25.5
50												23.3	25.5
75										19.2	21.2	24.3	28.8
100								14.8	17.0	21.6	26.8	32.2	38.5
125							12.7	16.3	21.2	27.0	33.3	40.1	48.2
150						10.6	14.3	19.6	25.5	32.6	40.1	48.3	57.6
175						11.6	16.7	22.8	29.7	37.9	46.7	56.2	67.3
200					8.5	13.2	19.1	26.1	34.0	43.3	53.5	64.4	77.0
225				7.1	9.5	15.0	21.5	29.4	38.2	48.7	60.1	72.3	86.7
250				7.4	10.6	16.7	24.0	32.6	42.5	54.0	66.9	80.5	96.1
275				8.1	11.7	18.3	26.3	35.9	46.7	59.6	73.5	88.4	105.8
300			5.7	8.9	12.7	20.0	28.7	39.1	51.0	65.0	80.3	96.6	115.5
350			6.6	10.4	14.9	23.4	33.4	45.7	59.5	75.7	93.7	112.7	134.6
400		4.2	7.6	11.9	17.0	26.7	38.2	52.2	68.0	86.6	107.1	128.8	154.0
450		4.8	8.5	13.4	19.1	30.0	43.0	58.7	76.5	97.4	120.5	144.9	173.1
500	2.8	5.3	9.5	14.9	21.2	33.3	47.8	65.3	85.0	108.3	133.9	161.0	192.5

a. Add air until the internal air pressure of the sewer line is raised to approximately 4.0 psi gage, adjusted for ground water. After an internal pressure of approximately 4.0 psig is obtained, allow time for the air pressure to stabilize. The pressure will normally show some drop until the temperature of the air in the test section stabilizes.
b. When the pressure has stabilized and is at or above the starting test pressure of 3.5 psi gage, commence the test. Before starting the test, the pressure may be allowed to drop to 3.5 psig. Record the drop in pressure for the test period. If the pressure has dropped more than 1.0 psi gage during the test period, the line shall be presumed to have failed. The test may be discontinued when the prescribed test time has been completed even though the 1.0 psig drop has not occurred.
c. The test procedure may be used as a presumptive test which enables the installer to determine the acceptability of the line prior to backfill and subsequent construction activities.
d. If the pipe to be tested is submerged in ground water, then ground water adjustment shall be made in accordance with table 6 shown below. Table 6 is based on 1.0 V.FT. of water equal to 0.4335 psi. The appropriate psi allowance for average vertical foot of ground water shall be added to the base starting pressure of 4.0 psi, but in NO CASE shall the resulting pressure be more than 9.0 psi. For example, the height of ground water above the pipe invert is 3 feet; the psi required to maintain 4 psi pressure = 5.30 psi (4 psi + 1.30 psi = 5.30 psi). Interpolation is needed for fractions of a foot of water.

Table 6 Ground Water psi Correction for Sewer Air Testing

Height of Ground Water above Pipe (ft)	Equivalent (psi)
1	0.43
2	0.87
3	1.30
4	1.73
5	2.17
6	2.60
7	3.03
8	3.47
9	3.90
10	4.34
11	4.77
11.5	4.98
> 11.5	5.00

8.1.2.5 *Safety*: The air test may be dangerous if, because of lack of understanding or carelessness, a line is improperly prepared.

a. It is extremely important that the various plugs be installed and braced in such a way as to prevent blowouts. In as much as a force of 250 lb./f. is exerted on an 8 inch plug by an internal pipe pressure of 5 psi, it should be realized that sudden expulsion of a poorly installed plug that is partially deflated before the pipe pressure is released can be dangerous.

b. As a safety precaution, pressurized equipment shall include a regulator or relief valve set at perhaps 10 psi to avoid over-pressurizing and damaging an otherwise acceptable line. No one shall be allowed in the manholes during testing.

SEC. 8.2 MANHOLES

8.2.1 **Manhole Exfiltration Test**: All pipes leading to and from a manhole shall be plugged. Plugs shall be inserted into the pipes a distance greater than the length of the plugs used to air test each respective section of sewer line, so as to insure the manhole and sewer line tests overlap. Plugs shall be secured to the manhole structure. The manholes shall be filled with water to the top of frame and allowed to soak for a minimum of 12 hours to permit the manhole to absorb water. The cover shall be on the manhole during the soaking period. At the end of the soaking period, water shall be added until the manhole overflows. No loss of water will be permitted over a 4-hour period. Upon completion of the test, the water shall be removed from the manhole.

8.2.2 **Manhole Negative Air Pressure (Vacuum) Test**: As an alternative to the Manhole Exfiltration Test, the Vacuum Test shall be in accordance with ASTM C1244.

8.2.2.1 All lift holes and any pipes entering the manhole are to be plugged. A vacuum will be drawn, and the vacuum drop over a specified time period is used to determine the acceptability of the manhole.

8.2.2.2 This is not a routine test. The values recorded are applicable only to the manhole being tested and at the time of testing.

8.2.2.3 *Preparation of the Manhole*.

a. All lift holes shall be plugged.

b. All pipes entering the manhole shall be temporarily plugged, taking care to securely brace the pipes and plugs to prevent them from being drawn into the manhole.

8.2.2.4 *Procedure*.

a. The test head shall be placed at the top of the manhole in accordance with the manufacturer's recommendations.

b. A vacuum of 10 in. of mercury shall be drawn on the manhole, the valve on the vacuum line of the test head closed, and the vacuum pump shut off. The time shall be measured for the vacuum to drop to 9 in. of mercury.

c. The manhole shall pass if the time for the vacuum reading to drop from 10 in. of mercury to 9 in. of mercury meets or exceeds the values indicated in Table 7 below.

d. If the manhole fails the initial test, necessary repairs shall be made by an approved method. The manhole shall then be retested until a satisfactory test is obtained.

Table 7 Minimum Test Times for Various Diameter Manholes			
Manhole Depth ft	Manhole Diameter (in.) 48	60	72
8	20	26	33
10	25	33	41
12	30	39	49
14	35	46	57
16	40	52	67
18	45	59	73
20	50	65	81
22	55	72	89
24	59	78	97

9.2.2.5 For manholes less than 8 ft. in depth the minimum value listed shall be used. For other manhole diameters or greater depths, refer to ASTM C1244.

SECTION 9 - SEWER FORCE MAIN LEAKAGE TEST

SCOPE OF WORK:

Provide all labor, materials, equipment and services required for sewer force main leakage testing specified herein.

9.1 FORCE MAIN LEAKAGE TESTING:

As a minimum, all sewer force mains shall be tested in accordance with the Hydrostatic Testing Requirements of AWWA C600.

9.1.1. All force mains shall be given a hydrostatic test of at least 1.5 times the shutoff head of the connected pumps or 150 psi, whichever is greater. Loss of water pressure during test shall not exceed 5 psi in a 2 hour period.

9.1.2 Where practicable, pipelines shall be tested between line valves or plugs in lengths of not

more than 1500 feet.

9.1.3. The pipe shall be slowly filled with water and the specified test pressure shall be applied by means of a pump connected to the pipe in a manner satisfactory to the ENGINEER. The pump, pipe connection, and all necessary apparatus except the gauges shall be furnished by the CONTRACTOR. The ENGINEER will furnish the gauges for the test, but the CONTRACTOR shall furnish all necessary assistance for conducting the test. Before applying the specified test pressure, all air shall be expelled from the pipe. If permanent air vents are not located at all high points, the CONTRACTOR shall install corporation cocks at such points so 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.

9.1.4. Duration of test shall not be less than two hours.

9.1.5. The test pressure shall not exceed the rated pressure of the valves in the pipeline.

9.1.6. Where leaks are visible at exposed joints and/or evident on the surface where joints are covered, the CONTRACTOR shall repair the joints, retighten the bolts, relay the pipe, or replace the pipe until the leak is eliminated--regardless of total leakage as shown by the hydrostatic test. Polyethylene encasement damaged from repairs must also be properly repaired or replaced to the satisfaction of the ENGINEER.

9.1.7. All pipe, fittings and other materials found to be defective under test shall be removed and replaced at the Contractor's expense.

9.1.8. Lines which fail to meet test shall be repaired and retested as necessary until test requirements are complied with.

9.1.9. The OWNER/or CONTRACTOR may provide water for testing the force mains; however, the CONTRACTOR will be responsible for piping or hauling the water if necessary. If water is to be used from fire hydrants, the CONTRACTOR shall contact the local utility with regards to withdrawing water from a fire hydrant.

9.1.10. No pipe installation will be accepted if the leakage is greater than that determined by the formula:

$$L = \frac{SD\,(P)^{1/2}}{133{,}200}$$

in which:

L is the allowable leakage, in gallons per hour;
S is the length of pipeline tested, in feet;
D is the nominal diameter of the pipe, in inches; and
P is the average test pressure during the leakage test, in pounds per square inch gauge. Allowable leakage at various pressures and pipe sizes are shown in the Table below (from AWWA C600 - Table 6A):

Allowable Leakage Per 1,000 Feet of Pipeline* - gph

Avg. Test Pressure psi	3	4	6	8	10	12	14	16
250	0.36	0.47	0.71	0.95	1.19	1.42	1.66	1.90
225	0.34	0.45	0.68	0.90	1.13	1.35	1.58	1.80
200	0.32	0.43	0.64	0.85	1.06	1.28	1.48	1.70
175	0.30	0.40	0.59	0.80	0.99	1.19	1.39	1.59
150	0.28	0.37	0.55	0.74	0.92	1.10	1.29	1.47
125	0.25	0.34	0.50	0.67	0.84	1.01	1.18	1.34
100	0.23	0.30	0.45	0.60	0.75	0.90	1.05	1.20
Avg. Test Pressure psi	**18**	**20**	**24**	**30**	**36**	**42**	**48**	**54**
250	2.14	2.37	2.85	3.56	4.27	4.99	5.70	6.41
225	2.03	2.25	2.70	3.38	4.05	4.73	5.41	6.03
200	1.91	2.12	2.55	3.19	3.82	4.46	5.09	5.73
175	1.79	1.98	2.38	2.98	3.58	4.17	4.77	5.36
150	1.66	1.84	2.21	2.76	3.31	3.86	4.41	4.97
125	1.51	1.68	2.01	2.52	3.02	3.53	4.03	4.53
100	1.35	1.50	1.80	2.25	2.70	3.15	3.60	4.05

*If the pipeline under test contains sections of various diameters, the allowable leakage will be the sum of the computed leakage for each size.