

## SECTION 13 - SANITARY SEWER SYSTEM

### 13.1 General.

- A. Work included in this Section consists of all gravity sanitary sewers, force mains, manholes, valves, air vents and all related equipment or material as indicated on the construction plans.

#### 13.1.1 Related requirements specified in other Sections of the Specifications:

- A. Section 8 - General Construction Standards
- B. Section 9 - Site Clearing
- C. Section 10 - Trenching & Backfilling
- D. Section 11 - Seeding
- E. Section 12 - Water Distribution System

#### 13.1.2 Reference Specifications are referred to by abbreviation as follows:

- A. American National Standards Institute ..... ANSI
- B. American Society for Testing and Materials .....ASTM
- C. American Water Works Association ..... AWWA
- D. American Railway Engineering and Maintenance-of-Way Association ..... AREMA
- E. American Association of State Highway and Transportation Officials ..... AASHTO
- F. Virginia Department of Transportation .....VDOT

### 13.2 Products.

- A. Submit shop drawings on all products as required by County.
- B. Provide certified test results of pipe testing.

#### 13.2.1 NOT USED

- 13.2.2 Reinforced concrete pipe in sizes 42 in. and larger shall meet requirements of ASTM C76 for the class shown on the Drawings. Pipe end shall have O-ring gasket groove provided during manufacturing process.

- A. Rubber gaskets and joints of concrete pipe shall meet requirements of ASTM C443.
- B. Pipe and joints shall be tested in accordance with ASTM C497 with test reports submitted to Engineer.
- C. Pipe shall have lining for corrosion protection.

**13.2.3** Polyvinylchloride (PVC) nonpressure pipe and fittings with elastomeric gasket seals for sanitary sewers:

- A. For pipe sized 4-inch through 15-inch, pipe shall meet requirements of ASTM D3034 type PSM SDR-35 or of ASTM F1760 DR-35 having reprocessed – recycled content. Pipe that has reprocessed – recycled content shall be as allowed in Section 14 - Approved Water and Sewer Materials.
- B. For pipe sized 18-inch through 27-inch, pipe shall meet requirements of ASTM D3212.

**13.2.4** Ductile iron pipe shall meet requirement of AWWA C151 for the pressure and thickness classes shown on the Drawings. Pipe shall have cement-mortar lining and an asphaltic seal coat. Thickness classes shall meet requirements of AWWA C150. See Section 14.4.A.1(b) for acceptable pipe manufacturers.

**13.2.5** Cast iron and ductile iron fittings shall meet requirements of AWWA C110 for the pressure ratings indicated on Drawings. Fittings shall have cement-mortar lining and an asphaltic seal coat.

**13.2.6** Mechanical joints and jointing materials shall meet requirements of AWWA C111.

- A. Mechanical joint retainer glands shall meet requirements of AWWA C111. Retainer gland shall be fitted with set screws.
- B. Metal harness shall be galvanized rods and clamps as detailed on Drawings.

**13.2.7** Push-on joint and rubber gasket shall meet requirements of AWWA C111.

**13.2.8** Flanged joints for ductile iron pipe shall meet requirements of ANSI B16.1.

**13.2.9** Flanged joint gaskets shall be full face, made of 1/16 in. thick rubber, and shall meet requirements of ANSI B16.21.

**13.2.10** Cement mortar lining with asphaltic seal coat for cast iron pipe and fittings or ductile iron pipe shall meet requirements of AWWA C104.

- A. Cement mortar lining shall be standard thickness.

**13.2.11** Exterior, asphaltic coating for cast iron and ductile fittings and ductile iron pipe shall meet requirements of AWWA C151.

**13.2.12** Reinforced concrete pipe, steel cylinder type, in sizes 42 inch and larger, not prestressed and prestressed, rubber gaskets for joints, fittings and specials shall meet requirements of AWWA C300, and AWWA C301. Design pressure as defined in these standards shall be as indicated on Drawings. Design limits of pipe shall be such that they shall not be exceeded by the combined requirements of design pressure plus 40 percent of design pressure for water hammer, plus earth dead load. Pipe shall be lined for corrosion protection.

**13.2.13** Steel casing pipe for boring or jacking under highways and railroads shall meet the requirements of ASTM A139, Grade B. Nominal pipe diameter and wall thickness shall be as indicated on the Drawings. No protective coating or lining will be required.

**13.2.14** Casing pipe laid in open cut shall be ductile iron pipe, steel pipe, or pipe meeting following requirements:

- A. Reinforced concrete casing pipe and fittings shall meet requirements of ASTM C76.
  - (1) Class of casing pipe shall be as indicated on the Drawings.
- B. Nonreinforced concrete casing pipe and fittings shall meet requirements of ASTM C14.
  - (1) Class of concrete casing pipe shall be as indicated on drawings.
- C. Rubber gaskets for concrete casing pipe joints shall meet requirements of ASTM C361.

**13.2.15** Manholes

- A. Precast reinforced concrete manholes shall be constructed in accordance with DPU Standard Drawings for the type and size of manhole indicated on the Drawings.
- B. Manhole joint types shall comply with the following:
  - (1) Provide joint for placement rubber gasket in accordance with the requirements of ASTM C443; or,
  - (2) Provide paper backed Butyl Rubber Rope and Butyl Rubber Sheet joint sealant system in accordance with the requirements of ASTM C990.
  - (3) Joint gasket or sealant shall provide the sole element in sealing the joint from either internal or external hydrostatic pressure.
- C. Liners for acid-resistant manholes shall be of fiberglass reinforced polyester (FRP), polyvinylchloride (PVC) or high-density polyethylene (HDPE) construction. The

liner shall be installed to protect the precast manhole sections from the inside base of the manhole to the base of the manhole frame. The connection of the pipe to the manhole shall be sealed with the liner in a manner to eliminate any exposed concrete surfaces that could be subject to damage by corrosive gases.

- (1) FRP liners shall consist of a 3/16 in. thick fiberglass reinforced polyester with a 15 mil gel coat interior surface. The polyester resin shall be similar to that as allowed in Section 14 - Approved Water and Sewer Materials. Joints between sections of the liner shall be sealed with joint sealant.
  - (2) PVC liners shall consist of polyvinylchloride plates, not less than 0.060 in. thick, with integral bonding ribs and shall be as allowed in Section 14 - Approved Water and Sewer Materials. Joints between sections of liner shall be welded in accordance with the manufacturer's instructions.
  - (3) HDPE liners shall be as allowed in Section 14 - Approved Water and Sewer Materials. Joints between sections of the liner shall be welded in accordance with the manufacturer's instructions.
- D. Manhole steps shall be corrosion-resistant and shall be one inch square cast iron, rubber-covered steel or aluminum. The steps shall conform to the dimensions shown in Section 7 - Standard Drawings. Manhole steps shall be aligned to minimize conflicts with future connections to manhole. For sewers up to 15 inches in diameter, steps should be placed on the downstream side of the manhole.
- E. Manhole Frames and Covers.
- (1) All manhole frames and covers shall be in accordance with the standard drawings and as listed in Section 14, Approved Water and Sewer Materials. Suppliers/manufacturers of standard manhole frames and covers, and vandalproof/watertight frames and covers located in areas subject to traffic shall be listed on the Virginia Department of Transportation (VDOT) list of approved suppliers/manufacturers. If at any time a particular supplier/,manufacturer is no longer listed as approved by VDOT, they will no longer be approved for use in the County.
  - (2) Standard manhole frames and covers shall have a 24-inch clear opening, in accordance with Standard Drawing D-150. Gray iron frames and covers shall conform to AASHTO M306 and AASHTO M105 Grade 35B.. Ductile iron frames and covers shall conform to AASHTO M306. Standard manhole frames and covers shall be load tested to 40,000 pounds as required by AASHTO M306. Standard manhole frames and covers shall not be painted or coated.
  - (3) Vandalproof and watertight manhole frames and covers shall have a 24-inch clear opening, in accordance with standard drawing D-155, if located in areas subject to vehicular traffic. Vandalproof and watertight frames and covers for use in easements not subject to vehicular traffic shall be made of ductile iron and shall be one-man operable, and shall be as shown in standard drawing D-160. All vandalproof/watertight manhole frames and covers shall be as listed in Section 14, Approved Water and Sewer Materials.

- (4) Where vandalproof or watertight manhole frames and covers are subject to vehicular traffic loading, they shall be from a manufacturer/supplier listed on the VDOT list of approved manufacturers/suppliers, and they shall meet the requirements of AASHTO M306 if ductile iron, and AASHTO M306 and AASHTO M105 Class 35B if constructed of gray iron, and shall be as listed in Section 14, Approved Water and Sewer Materials. If at any time a manufacturer/supplier is no longer listed as approved by VDOT, they will no longer be approved for use in the County. In addition, vandalproof/watertight frames and covers subject to vehicular loading shall not be painted or coated, and shall meet the 40,000 pound load test in accordance with AASHTO M306.
  
- F. Manholes shall be supplied with flexible connectors to allow connection of sewer pipes to the manholes. The manholes shall be cored at the factory and supplied with the appropriate flexible connectors. The connector shall be as allowed in Section 14 - Approved Water and Sewer Materials.
  
- G. A maximum of 12" adjustment may be done utilizing precast riser rings to raise frame and cover. For additional height adjustment, new precast manhole riser sections, cone, and frame and cover must be installed. Decreasing manhole depth must be done by removal and replacement of precast manhole riser sections. Repaver rings shall not be used to adjust new or reconstructed manholes to grade.

**13.2.16** Plug valves shall be the nonlubricated eccentric type with resilient faced plugs. Port area shall be at least 80 percent of the full pipe area. Bodies shall be cast iron with welded nickel, raised seats. Valves shall have permanently lubricated corrosion resistant bearings in the bonnet and body.

- A. Packing and packing glands shall be accessible without having to disassemble valves. Packing shall be adjustable.
  
- B. Valves shall have resilient plug facings suitable for the service intended and shall provide dead-tight shutoff. Opening the valve shall cause the plug to be raised off the seat without scraping the seat or body walls.
  
- C. Plug valves shall be gear operated unless otherwise shown or specified, and shall open counter-clockwise.
  
- D. Plug valves located inside the pumping station shall be provided with handwheel actuators complete with valve position indicators.
  
- E. The maximum pull requirement on manual operators shall be 40 pounds.
  
- F. Plug valves for direct burial service shall be provided with right angle worm gear operators. Buried valves shall be provided with adjustable cast-iron valve boxes and extension stems to grade.

- G. A tee wrench shall be provided for operation of the buried valve.
- H. Inside iron or steel surfaces of valves and exterior surfaces of valves which are to be buried in the ground shall be given two coats of asphalt varnish meeting the requirements of Fed. Spec. TT-V-51a. Exterior iron or steel surfaces of other valves shall be painted as specified for the pipelines in which they are installed.
- I. Plug valves shall as allowed in Section 14 - Approved Water and Sewer Materials.

**13.2.17** Install passive electronic markers (ball type) on all sewer pipe in accordance with these Standards and in accordance with approved plans.

### **13.3 Execution.**

**13.3.1** Take all precautions necessary to insure that pipe, valves, fittings, and related items are not damaged in unloading, handling and placing in trench. Examine each piece of material just prior to installation to determine that no damage has occurred. Remove any damaged material from the site and replace with undamaged material.

- A. Keep pipe clean. Exercise care to keep foreign material and dirt from entering pipe during storage, handling and placing in trench. Close ends of in-place pipe at the end of any work period to prevent entry of animals and foreign material.
- B. Bed pipe as specified in Section 10 - Trenching and Backfilling.
- C. Do not lay pipe when weather or trench conditions are unsuitable.
- D. Separation of sanitary sewer lines and water lines shall be in accordance with Virginia Department of Health Regulations.
- E. A plug shall be installed in existing manholes to prevent debris and construction run-off from entering the County sewer system. The plug shall be installed at the start of construction and only be removed after approval of the Construction Division Director.

**13.3.2** Lay gravity sewers so as to maintain a true alignment and grade as indicated on Drawings. After completion, the pipe shall exhibit a full circle of light when lighted at one manhole and viewed from the next.

- A. Commence laying gravity sewers at the lowest point on a section of line and lay pipe with the bell ends uphill.
- B. Pipe Joint. Preparatory to making pipe joints on gravity sewer lines, clean and dry all surfaces of joint pipe and jointing material. Use lubricants, primers, adhesives and similar materials as recommended by the manufacturer. Place, fit, join and adjust the jointing materials or factory fabricated joints as recommended by the

manufacturer to obtain the degree of watertightness required. As soon as possible after the joint is made, place sufficient backfill material, as specified under Section 10 - Trenching & Backfilling, along each side of the pipe to resist forces that might tend to move the pipe off line and grade.

- C. Complete backfilling as specified under Section 10 - Trenching & Backfilling. Place backfill over the pipe immediately after the pipe has been laid. Provide ductile iron pipe where cover over main line sewer pipe is less than 5.5 ft. in public roads or other paved areas and 3.5 ft. in easements.

**13.3.3** Install force main with a minimum depth of cover of 42 in. over the top of the pipe, where no grades are shown on the Drawings.

- A. Where grades on the force main conflict with existing pipes or structures, lay force main to additional depth with a uniform vertical curve to provide proper clearance without the use of fittings. No additional payment will be allowed for additional excavation. Provide allowance for expansion as directed by Engineer.
- B. Lay force main pipe with bell ends facing the direction of laying. Where grade is 10 percent or greater, pipe shall be laid uphill with bell ends up grade.

**13.3.4** Joining Pipe

- A. Join mechanical joint pipe as follows:

- (1) Thoroughly clean inside of the bell and 8 inches of the outside of the spigot end of the joining pipe to remove oil, grit, excess coating and other foreign matter from the joint. Paint the bell and spigot with soap solution (half cup granulated soap dissolved in 1 gallon water). Slip cast-iron gland on spigot end with lip extension of gland toward end of pipe. Paint rubber gasket with or dip into the soap solution and place on the spigot end with thick edge toward the gland.
- (2) Push the spigot end forward to seat in the bell. Then carefully press the gasket into the bell so that it is located evenly around the joint. The gland is moved into position, bolts inserted and nuts screwed up finger tight, then tighten all nuts to torque listed below:

Bolt Size – (Inches)	Torque - (Ft. – Lbs)
5/8	40 - 60
¾	60 - 90
1	70 - 100
1 ¼	90 - 120

- (3) Tighten nuts on alternate sides of the gland until pressure on the gland is equally distributed.
- (4) Permissible deflection in mechanical joint pipe shall not be greater than

listed in AWWA C600.

B. Join push-on joint pipe as follows:

- (1) Thoroughly clean inside of the bell and 8 inches of the outside of the spigot end of the joining pipe to remove oil, grit, excess coating, and other foreign matter. Flex rubber gasket and insert in the gasket recess of the bell socket. Apply a thin film of gasket lubricant supplied by pipe manufacturer, to either the gasket or the spigot end of the joining pipe.
- (2) Start spigot end of pipe into socket with care. The joint shall then be completed by forcing the plain end to the bottom of the socket with a forked tool or jack type device. Field cut pipe shall have the end filed to match the manufactured spigot end.
- (3) Permissible deflection in push-on joint pipe shall not be greater than 2/3 of that listed in AWWA C600.

C. Join reinforced concrete pipe with rubber gaskets installed as recommended by the manufacturer.

**13.3.5** Provide reaction anchors of concrete blocking, metal harness or retainer gland type at all changes in direction of pressure pipelines and as shown on Drawings.

A. Concrete reaction anchors shall bear against undisturbed earth and shall be of the size and shape indicated on Drawings.

B. Use metal harness restraints as indicated on Drawings.

**13.3.6** Encase sewer pipe lines crossing under highways and railways in a larger pipe or conduit called a casing pipe. The casing pipe shall be of the diameter and wall thickness indicated on Drawings. Steel casing pipe shall be joined in accordance with AWWA C206. Install casing pipe by jacking, boring or open cut if permitted.

A. The installation shall meet AREMA requirements for installation of pipe lines carrying nonflammable substances under railway tracks. Brick up casing pipe ends so as to protect against foreign matter but do not tightly seal. Prior to beginning work, notify the Railway Company or Highway Department.

**13.3.7** Construct service connections from sewer main to property line as follows:

A. Place a tee fitting of the required size in accordance with Paragraph 2.2.07.G in the sewer where service connection is to be constructed. Lay pipe from the tee to the property line on a grade of not less than 1/4 in. per foot. Close service connection at the property line with a water-tight plug. If a conflict or unusual condition is encountered, the Construction Division Director may approve installation of ductile iron or PVC on a grade of not less than 1/8 inch per foot.

B. Install service connections on existing sewer mains with a compression type cast



iron saddle as indicated in Section 14, Approved Water and Sewer Materials. Secure saddle to the pipe with a 24 gage stainless steel strap and two nickel-bronze T bolts. Make connections of this type by machine tapping or cutting the pipe. Use O-ring type gasket to insure a water-tight connection.

- C. Service connections from manholes shall be ductile iron or PVC pipe.
- D. Determine the depth of service connections by the deepest of the following:
  - (1) Provide 5 feet of cover at the edge of the road paving or 15 feet from the center line of the street.
  - (2) Provide 12 inches of cover at the bottom of highway ditches.
  - (3) Provide 5 feet of cover at the property line when property is above the street.
  - (4) Provide depth necessary for a 1 percent grade if required to provide service to a property.
- E. Place a 2 in. x 4 in. solid piece of lumber at the end of each service connection. The 2 in. x 4 in. marker shall be set vertically and extend from invert to 6 in. above grade.
- F. Provide ductile iron pipe where cover over service connections is less than 5.5 ft. in public right-of-way or 3.5 ft. in easements.
- G. All connections to reinforced concrete pipe shall be by use of Kor-N-Tee or as indicated in Section 14, Approved Water and Sewer Materials.

**13.3.8 Existing Manhole Tie-In:** A flexible pipe-to-manhole connector shall be used in the connection of the sewer pipe to precast manholes, where stubs or bricked-up openings (B.U.O.) do not exist.

- A. The connector shall be installed by coring the manhole wall. Manufacturers of connectors specified in Paragraph 13.2.15F shall be as allowed in Section 14 - Approved Water and Sewer Materials. Connectors are to be installed in strict accordance with the manufacturer's recommendations.
- B. The connection shall be installed in the manhole wall by activating the expanding mechanism in strict accordance with the recommendation of the connection manufacturer.
- C. The connector shall be of a size specifically designed for the pipe material and size being utilized on the project.
- D. This provision shall apply to both main line and service connections.
- E. Coring of manhole wall for new connections shall only be performed in the presence of a DPU construction inspector.

### 13.3.9 Installation and Acceptance of Electronic Markers

- A. Passive electronic markers (ball type) shall be installed on all water mains, sewer gravity mains and sewer force mains in accordance with the following:
- (1) Ball type electronic markers shall be passive type as manufactured by 3M or Omni.
    - a. Sewer line markers shall be rated and color coded for sewer.
    - b. Water main markers shall be rated and color coded for water.
  - (2) Locations for electronic markers shall be as shown on Standard Drawings titled Electronic Marker Placement Detail for Gravity Sewer and Electronic Marker Placement Detail for Water Mains and Sewer Force Mains.
    - a. Minimum distance between markers shall be 6 feet.
    - b. Markers shall be a minimum of 4 inches above the pipe.
    - c. Markers shall have a maximum of 3 feet of cover.
    - d. When pipe joints are deflected, place markers at the pipe joint beginning and ending the deflection and at intermediate joints for every 1 foot (maximum) of deflection.
    - e. Locations for markers on gravity sewer lines shall be in accordance with the following:
      1. Service Tee at the main
      2. Casing ends
      3. Maximum 100 feet on metallic pipe and 50 feet for non-metallic pipe
      4. All points where sewer crosses over or under other utilities
    - f. Locations for markers on sewer force mains shall be in accordance with the following:
      1. Valves
      2. Bends
      3. Deflections (begin, end, max of each 1 foot of deflection)
      4. Pipe vertical adjustments (beginning and end)
      5. Casing ends
      4. Maximum 100 feet on metallic pipe and 50 feet for non-metallic pipe
      5. All points where sewer crosses over or under other utilities
- B. Electronic Marker Balls shall be rated for sewer (green) and for water (blue) and shall be installed in accordance with manufacturer's recommendations and the following to ensure that marker is installed over centerline of pipe.
- (1) The locations for Electronic Marker Balls shall be as described in Paragraph A, above.
  - (2) Hand place at least 6 inches of backfill material over marker ball to ensure that it stays in place.
  - (3) Locations for marker balls on gravity sewers shall be as shown on standard drawings titled Electronic Marker Placement Detail for Gravity Sewer.

- (4) The locations of electronic marker balls for sewage force mains shall be as shown on standard drawing titled Electronic Marker Placement Detail for Water Mains and Sewer Force Mains.

C. Acceptance of Electronic Marker Ball Installation

- (1) Contractor shall certify in writing that all electronic markers are in place prior to paving.
- (2) Prior to Substantial Completion, contractor shall demonstrate to Construction Division that all markers are installed as required and are working properly. Any missing or non-functioning Electronic Marker Balls shall be replaced by the contractor prior to substantial completion.
- (3) The locations of all markers shall be shown on as-built drawings.

**13.3.10** Testing gravity sewer lines and manholes:

- A. 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.
- B. Low-pressure air test:
  - (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.
  - (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.
  - (3) Ground Water Determination: Install a 1/2 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 pipe 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.

- (4) Procedures:
  - a. Determine the test duration for the section under test by computation from the applicable formulas shown in ASTM C828. The pressure-holding time is based on an average holding pressure of 3 psi gage or a drop from 3.5 psi to 2.5 psi gage. Add air until the internal air pressure of the sewer line is raised to approximately 4.0 psi gage. 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. After 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, the test pressure shall be increased by 1.0 psi for every 2.31 feet the ground water level is above the invert of the sewer.
- (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. Since a force of 250 lb./f. will be 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 or of a 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.
- (6) Table: The air test table attached has been prepared utilizing applicable formulas from ASTM C828-76T. It is based on an allowable air loss of 0.0015 cu. ft./min. per square foot of internal pipe surface, a maximum air loss per test section of 3.5 cu. ft./min. and a minimum significant air loss per test section of 1.0 cu. ft./min. It applies when testing one pipe diameter only and for convenience ignores 4 inch and 6 inch lateral sewers, which in most instances create only insignificant differences in test time.

TABLE 1																													
Based on Formulas from ASTM C 828																													
SPECIFICATION TIME (Min:Sec) REQUIRED FOR PRESSURE DROP FROM 3 1/2 TO 2 1/2 PSIG																													
WHEN TESTING ONE PIPE DIAMETER ONLY																													
PIPE DIAMETER (INCHES)																													
		4		6		8		10		12		15		18		21		24		27		30		33		36			
Minutes / 100'		0.3		0.7		1.2		1.5		1.8		2.1		2.4		3.0		3.6		4.2		4.8		5.4		6.0			
		min	sec	min	sec	min	sec	min	sec	min	sec	min	sec	min	sec	min	sec	min	sec	min	sec	min	sec	min	sec	min	sec	min	sec
LENGTH OF PIPE (FT)	25	0	5	0	11	0	18	0	23	0	27	0	32	0	36	0	45	0	54	1	3	1	12	1	21	1	30		
	50	0	9	0	21	0	36	0	45	0	54	1	3	1	12	1	30	1	48	2	6	2	24	2	42	3	0		
	75	0	14	0	32	0	54	1	8	1	21	1	35	1	48	2	15	2	42	3	9	3	36	4	3	4	30		
	100	0	18	0	42	1	12	1	30	1	48	2	6	2	24	3	0	3	36	4	12	4	48	5	24	6	0		
	125	0	23	0	53	1	30	1	53	2	15	2	38	3	0	3	45	4	30	5	15	6	0	6	45	7	30		
	150	0	27	1	3	1	48	2	15	2	42	3	9	3	36	4	30	5	24	6	18	7	12	8	6	9	0		
	175	0	32	1	14	2	6	2	38	3	9	3	41	4	12	5	15	6	18	7	21	8	24	9	27	10	30		
	200	0	36	1	24	2	24	3	0	3	36	4	12	4	48	6	0	7	12	8	24	9	36	10	48	12	0		
	225	0	41	1	35	2	42	3	23	4	3	4	44	5	24	6	45	8	6	9	27	10	48	12	9	13	30		
	250	0	45	1	45	3	0	3	45	4	30	5	15	6	0	7	30	9	0	10	30	12	0	13	30	15	0		
	275	0	50	1	56	3	18	4	8	4	57	5	47	6	36	8	15	9	54	11	33	13	12	14	51	16	30		
	300	0	54	2	6	3	36	4	30	5	24	6	18	7	12	9	0	10	48	12	36	14	24	16	12	18	0		
	350	1	3	2	27	4	12	5	15	6	18	7	21	8	24	10	30	12	36	14	42	16	48	18	54	21	0		
	400	1	12	2	48	4	48	6	0	7	12	8	24	9	36	12	0	14	24	16	48	19	12	21	36	24	0		
	450	1	21	3	9	5	24	6	45	8	6	9	27	10	48	13	30	16	12	18	54	21	36	24	18	27	0		
500	1	30	3	30	6	0	7	30	9	0	10	30	12	0	15	0	18	0	21	0	24	0	27	0	30	0			

C. Manhole Exfiltration Test: All pipes leading to and from 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.

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

- (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.
- (2) This is not a routine test. The values recorded are applicable only to the manhole being tested and at the time of testing.
- (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.
- (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 2.
  - 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.
- (5) Minimum Test Times for Various Diameter Manholes.

<b>TABLE 2</b>			
<b>MINIMUM VACUUM TEST TIME (SEC.) FOR VARIOUS DIAMETER MANHOLES</b>			
<b>Manhole Depth (FT.)</b>	<b>48" Diameter</b>	<b>60" Diameter</b>	<b>72" Diameter</b>
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

- (6) 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.
- E. Test for leakage of gravity sewers using either the infiltration or exfiltration test. Allowable leakage shall be 100 gallons per inch of pipe diameter per mile per 24 hours up to a maximum of 2,400 gallon per day per mile per 24 hours.
- (1) Use infiltration test when ground water is at least 4 feet above pipe crown along entire length of line to be tested. Plug the pipe at the upper manhole. Install suitable measuring device at the next lowest manhole. Measure the amount of water flowing through the outlet after flow has been stabilized.
  - (2) Ground water determination: Use same procedure as "low pressure air test" above.
  - (3) Use exfiltration test when ground water is less than 4 feet above the pipe crown. Plug the pipe at the lower manhole. Fill the line and manhole to 4 feet above pipe crown or top of manhole whichever is less. Let the water stand until pipe has reached maximum absorption and until all trapped air has escaped, 4 hour minimum. When maximum absorption is reached, refill manhole to original level. After 30 minutes, record difference in level and convert to gallons. Subtract manhole loss to obtain pipe line loss. Manhole loss is found by plugging inlet and outlet and filling manhole with water to 4 feet above pipe crown or top of manhole, whichever is less. Let

water stand one hour to reach maximum absorption. Refill to original level. After 30 minutes, check difference in level and convert to gallons. Manhole leakage shall not exceed 1/2 gallon per hour.

**13.3.11** Force Main tests shall be as follows:

- A. Supply the pumps, water, calibrated gages and meters, and all the necessary apparatus. Notify the Owner and Engineer at least 48 hours in advance of the test date and perform tests in presence of Engineer.
- B. Hydrostatic pressure test. After the line has been backfilled and at least seven days after the last concrete anchor block was poured, a hydrostatic pressure test shall be performed. Carefully fill the system with water at a velocity of approximately 1 ft. per second while necessary measures are taken to eliminate all air. After the system has been filled, raise the pressure by pump to 50 psi above working pressure indicated on Drawings. Measure pressure at lowest point in system with gage compensated for elevation. Maintain this pressure for at least two hours. If pressure cannot be maintained determine the cause, repair and repeat the test until successful.
- C. A leakage test shall be conducted concurrently with the pressure test. Leakage shall be determined with a calibrated test meter, furnished by the Contractor. Leakage is defined as the quantity of water required to maintain a pressure within 5 psi of the specified test pressure, after air has been expelled and the pipe filled with water. Leakage shall not exceed 10 gallons per day per mile per inch of diameter. If leakage exceeds that specified, find and repair the leaks and repeat the test until successful.
- D. All visible leaks shall be repaired regardless of the amount of leakage.

**13.3.12** No leakage will be allowed for welded steel pipe. If leaks are revealed by test, make repair by rewelding. Peening of leaks will not be allowed.