

2.5 – SANITARY SEWER

(Last revised 02/2017)

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PART 1 – GENERAL

2.5.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this specification.
- B. Section 2.2 - EARTHWORK
- C. Section 2.3 - TRENCHING, BACKFILLING & COMPACTION OF UTILITIES
- D. Section 2.8 - SEEDING, SODDING AND GROUNDCOVER

2.5.2 SUMMARY

This section includes sanitary sewer piping and specialties for municipal sewer and services outside of building structures.

2.5.3 DEFINITIONS

A. GENERAL:

For the purposes of this specification, the following definitions refer to the sanitary sewer collection system that comes under the authority of the City of Fairfax, Virginia as specified within this section and other sections of this manual.

- 1) **Cleanouts:** A riser pipe off of a service line that provides access to the line for the purpose of line cleaning.
- 2) **City Engineer:** The City Engineer or his/her authorized representative.
- 3) **Easement:** An instrument that depicts/describes and conveys rights and privileges to the City of Fairfax for the placement, access to and maintenance of a utility line across and/or on the property of a second

party. Ownership of the land remains with the second party.

- 4) **Force Main:** A pressurized sanitary sewer system.
- 5) **Lift/Pump Station:** A combination wetwell/pump station and appurtenances.
- 6) **Sewer Service:** Exterior domestic sewer piping.
- 7) **Sanitary Sewer:** An exterior gravity or pressure public sanitary sewer system.

B. The following are industry abbreviations for various pipe materials:

- 1) **DIP:** Ductile Iron Pipe
- 2) **PVC:** Polyvinyl Chloride Plastic
- 3) **RCP:** Reinforced Concrete Pipe

2.5.4 PERFORMANCE

- A. **Gravity Flow, Piping Pressure Ratings:** At least equal to the system test pressure.
- B. **Force Main, Pressure Ratings:** 50% above the design operating pressure or equal to the design operating pressure plus 50 psi but no less than 150 psi, whichever is greater.

2.5.5 SUBMITTALS

- A. Submit product data and shop drawings for the following:
 - 1) Pipe and Piping Specialties.
 - 2) Precast Concrete Manhole Castings
 - 3) Frame and Covers
 - 4) For mill type steel sewer pipe, an affidavit of compliance with standard shall be required (see [paragraph 2.5.12.3](#)).
 - 5) Air & vacuum release valves and accessories
 - 6) Autodialers
 - 7) Sewage Pumps and appurtenances, operating manuals.
 - 8) Auxiliary Generators
 - 9) Alarm Devices
 - 10) Piping Paint
- B. Submit shop drawings for the following.
 - 1) Precast Concrete Vaults and wetwells, including frames and covers, ladders, drains, access hatches, wall sleeves, valve support stands, pumps, and motors.

- C. **Coordination Drawings:** Show manholes and other structures in vicinity, pipe sizes and elevations, elevations of lift station elements such as influent lines, floats, etc.
- D. **Bypass Pumping:** Contractor shall provide a detailed written plan of how the bypass pumping operation shall be performed.
- E. **Computations:**
 - 1) Buoyancy calculations for wetwells, manholes, interceptor/outfalls, and mains with shallow cover.
 - 2) Provide structural calculations for any elevated main and pier system where span of the main exceeds the joint length. Provide calculations for all aerial mains, and their supporting structures that are subject to hydrodynamic forces.
- F. **Tunneling:** The Contractor shall submit shop drawings to the City Engineer for approval prior to construction. All liner plates and ribs used in the tunnel shall be of one type.
- G. **Pipe Design Life:** The Contractor shall secure and the manufacturer shall furnish and warrant that sanitary sewer pipe is designed for a 50-year life.
- H. **Project Closeout:** Submit 3 copies of manufacturer's maintenance and operation manuals on all sewage pumps and/or package lift stations and appurtenant devices.

2.5.6 QUALITY ASSURANCE

- A. Materials and operations shall comply with the latest revision of all applicable Codes and Standards.
- B. Piping materials shall be marked clearly and legibly.
 - 1) PVC pipe shall show identification marks, at intervals not to exceed 5 feet, as follows:
 - a. Nominal pipe diameter,
 - b. PVC cell classifications,
 - c. Company, plant, shift, ASTM, SDR and date designation,
 - d. Service designation or legend.
 - 2) Ductile Iron Pipe shall show identification marks on or near bell as follows:
 - a. Weight,
 - b. Class or nominal thickness,
 - c. The letters "DI" or "Ductile,"
 - d. Manufacturer's identifying mark,
 - e. Year in which pipe was made,
 - f. Casting period.
 - 3) Steel pipe shall be marked as follows:

Each length of steel pipe and each special section shall be legibly marked by paint stenciling, die stamping or hot-roll marking to show the following:

- a. Manufacturer's name or mark,
 - b. Size and weight of the pipe or special section,
 - c. The type of steel from which the pipe or special section was made.
- 4) Reinforced Concrete Pipe shall be marked as follows:
- a. Pipe Class,
 - b. Manufacturer.
- C. "Gravity Sanitary Sewer Design and Construction, Second Edition, 2007" ASCE Manuals and Reports on Engineering Practice – NO. 60, WEF Manual of Practice NO. FD-5.
- D. AWWA C600: *AWWA Standard for Installation of Ductile Iron Mains and Their Appurtenances*.

2.5.7 STANDARD ABBREVIATIONS

AASHTO	American Association of State Highway Transportation Officials.
ANSI	American National Standards Institute
AREA	American Railway Engineers Association
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
DEQ	Virginia Department of Environmental Quality
UL	Underwriters Laboratories, Inc.
VDOT	Virginia Department of Transportation
WEF	Water Environment Federation

2.5.8 PRODUCT DELIVERY, STORAGE AND HANDLING

Materials used for the construction of gravity sewer, pressure mains and appurtenances in the City sewer collection system shall be new, free of defects, and meet the highest standards set forth. An authorized City representative must inspect, review, and approve all materials to be used for sewer main and appurtenances prior to installation. At the option of the City, any material installed without inspection will have to be sufficiently removed for inspection and review. Any additions, deletions, or changes from the City of Fairfax approved plan set must be submitted to the City Engineer for approval, prior to making changes in the field.

A. Pipe Condition/Pipe Examination:

- 1) **New Pipe Inspection:** Inspect materials thoroughly upon arrival, including the interior. Examine materials for damage and to ensure the right pipe has been delivered to the site. Remove damaged or rejected materials from site. Pipe shall be protected during handling against impact shocks and free fall. Pipe shall be kept clean at all times, and no pipe shall be used in the work that does not conform to the appropriate ASTM Specifications. Check bells and spigots closely for smoothness, roundness, and honeycombing (concrete pipe), which may be a source of infiltration. Check for cracks, chips, etc. on both ends. Reject any pipe that will not provide watertight seal or is otherwise structurally deficient.
 - 2) **Pre-Installation Inspection:** Prior to being installed, each section of the pipe shall be carefully examined for damage and conformity with these specifications. All pipe damaged or deemed not to conform to these specifications shall be rejected and removed from site. All pipe in which the spigots and bells cannot be made to fit properly, or pipe, which has chipped bells or spigots, will be rejected. The faces of all spigots ends and of all shoulders on the bells must be true. Examine bell and spigot for uniformity and smoothness of liner and barrel.
- B. Protect pipe coating during handling using methods recommended by the manufacturer. Use of bare cables, chains, hooks, metal bars, or narrow skids in contact with coated pipe is not permitted.
 - C. Prevent damage to pipe during transit. Repair abrasions, scars, and blemishes to the satisfaction of the City. If repair of satisfactory quality cannot be achieved, replace damaged material immediately.
 - D. Observe manufacturer's directions for delivery and storage of materials and accessories.
 - E. Protect stored piping from entry of water or dirt into pipe. Protect bells and flanges of special fittings from entry of moisture and dirt.
 - F. Support pipe to prevent sagging or bending. Do not store plastic pipe, structures, and fittings in direct sunlight.
 - G. Handle precast concrete manholes and other structures according to manufacturer's written rigging instructions.

2.5.9 PRODUCT SUBSTITUTIONS

The City Engineer will approve materials not specified but deemed equal, on a case-by-case basis. Submit documentation and samples of materials. New materials approved for the sewer collection system will be incorporated into these specifications after approval.

2.5.10 PROJECT CONDITIONS

2.5.10.1 SEPARATION OF WATER AND SANITARY SEWERS

Follow the **DEQ** Sewage Collection and Treatment Regulations for separation of water mains and sanitary sewers lines.

A. Parallel Installations:

- 1) **Normal Conditions** – Water lines shall be constructed at least 10 feet horizontally from a sewer or sewer manhole. The distance shall be measured edge-to-edge.
- 2) **Unusual Conditions** – When local conditions prevent a horizontal separation of at least 10 feet, the water line may be laid closer to a sewer or sanitary sewer manhole provided that:
 - a. The bottom (invert) of the water line is at least 18 inches above the top (crown) of the sewer, in which case, a minimum horizontal distance of six (6) feet will be permissible.
 - b. Where this vertical separation cannot be obtained, the sewer shall be constructed of AWWA approved Ductile Iron Pipe pressure-tested in place without leakage prior to backfilling. The sewer manhole shall be of watertight construction and tested in place.

B. Crossing:

- 1) **Normal Conditions** – water lines crossing over sewers shall be laid to provide a separation of at least 18 inches between the bottom of the water line and the top of the sewer whenever possible.
- 2) **Unusual Conditions** – when local conditions prevent a vertical separation described in Crossing, Normal Conditions, paragraph above, the following construction shall be used:
 - a. Sewers passing over or under water lines shall be constructed of the materials described in paragraph A Parallel Installation, Unusual Conditions – subparagraph 2) b, above.
 - b. Water lines passing under sewers shall, in addition, be protected by providing:
 - i) A vertical separation of at least 18 inches between the bottom of the sewer and the top of the water line.
 - ii) Adequate structural support for the sewers to prevent excessive deflection of the joints, and the settling on and breaking of the water line.
 - iii) That the length of the water line be centered at the point of the crossing so that joints shall be equal distant and as far as possible from the sewer.

C. Sewer Mains and Other Utilities

- 1) **Horizontal Separation – Preferred/Normal Condition** – Sewer lines shall be constructed to provide at least 3 feet horizontally from other utilities whenever possible. The distance shall be measured edge-to-edge.

- 2) **Vertical Separation – Preferred/Normal Condition** – Whenever it is necessary for another utility to cross a sewer main, a 12-inch vertical separation shall be maintained between the lines. When local conditions prevent a 12-inch vertical separation, the following construction shall apply:
- a. Provide adequate structural support for the utility to prevent excessive deflection of the joints, which can result in settling on and/or breaking the sewer line.
- D. **Sanitary sewers or sewer manholes** – No water mains/pipes shall pass through or come in contact with any part of a sewer or sewer manhole. Water mains shall be placed at least 10 feet away from sewer manhole. The distance shall be measured edge-to-edge of the pipes or structures.
- E. **Storm Drainage System** – No water mains or services, gravity sewer or sewer lateral shall pass through a storm drain pipe or manhole system.
- F. **New Utilities and Existing Sewer Mains** – When installing a new utility adjacent to or in close proximity to an *existing* sewer main, the new utility line shall be installed to provide the minimum horizontal and vertical clearances specified in [paragraph 2.5.10.1 C](#), *Sewer Mains and other Utilities*.
- G. **Protection of Wells** – No sewer shall pass within 50 feet of a drinking water supply well, source or structure unless special construction and pipe materials are used to obtain adequate protection. Also refer to the Sewer Design Section of this manual, paragraph 5.2.6 A 5 for *Sewer/Well Conflict*.

2.5.11 COORDINATION

- A. Valve operation/interruption of water service: Work that requires valve operation or interruption of water service must be coordinated with Fairfax Water by contacting Fairfax Water Construction Department at 703-289-6387 or 703-289-6388.
- B. Before digging in the ground for any construction, call MISS UTILITY at 1-800-552-7001 to have all underground utilities marked in order to prevent damage or disruption of services. Other utilities that may have potential conflicts are:

Utility	Company	Phone
Electricity	Dominion Virginia Power	1-888-667-3000
Gas	Washington Gas	1-800-752-7520
Phone / Cable TV	Verizon	1-800-837-4966
	Cox Communication	703-378-8422
	Comcast	1-800-266-2278

- C. A permit for installation of sanitary sewers shall be obtained from the Department of Public Works.
- D. Coordinate tie-ins to municipal sewer mains with the Department of Public Works.

- E. No blasting is permitted within the City Limits and within 50 feet of the City's transmission main in Fairfax and Loudoun Counties.
- F. Permits for Construction on State Highways and Streets: The Virginia Department of Transportation requires a permit for work to be performed on State Highways. Provisions for obtaining such permits are set forth in the "Manual on Permits, Virginia Department of Transportation, Richmond, Virginia," latest revision. No work will be accepted by the Department of Public Works that has not been accepted or approved as satisfactory by the Department of Transportation.
- G. Permits for Construction on City Streets: All permits as required by the City of Fairfax Department of Public Works shall be obtained, and their conditions adhered to, for all work to be performed on City Streets and Rights of Way.
- H. The Contractor shall request a pre-construction meeting and inspection by the City of Fairfax Department of Public Works (703-385-7828) 3 days prior to commencing construction of any sanitary sewers.

PART 2 – PRODUCTS

2.5.12 PIPE & FITTINGS

2.5.12.1 DUCTILE IRON PIPE

A. DUCTILE IRON PIPE

- 1) Ductile iron pipe shall be manufactured in accordance with all applicable requirements of AWWA C151/ANSI A21.51 and ASTM A746, *Standard Specification for Ductile Iron Gravity Sewer Pipe* for 4-inch and larger diameter pipe, thickness class 50 minimum with the following exceptions:
 - a. Net calculated thickness shall include standard casting tolerances plus 0.02-inch additional tolerance.
 - b. Select standard class thickness above total calculated thickness.
- 2) The thickness of Ductile Iron Pipe shall be determined by considering trench load in accordance with ANSI/AWWA C150/A21.50. Minimum laying length shall be 18 feet except for tie-in at a structure.
- 3) **Linings:** The ductile iron pipe shall be lined. Approved linings:
 - a. Hi-Alumina cement mortar: Pipe and fittings shall be lined with SewperCoat as manufactured by **Kerneos Inc.** or approved equal. SewperCoat is a calcium aluminate mortar made of fused calcium aluminate cement and fused calcium aluminate aggregates. The thickness of the lining shall be the thickness identified on AWWA C104, latest revision but no less than 0.125 inch for 6-inch through 12-inch and 0.1875 inch for 14-inch through 24-inch pipe. The lining thickness may taper to less than the specified at the ends of the pipe. Cracks, other than closed hairline cracks and/or fine crazing shall not

be acceptable. Loose areas of cement lining are not allowable. A seal coat shall be applied to the lining as identified on AWWA C104.

Epoxy (Protecto 401) is an acceptable alternative to SewperCoat calcium aluminate mortar lining.

- b. **Polyethylene:** Factory applied 40-mil thickness virgin polyethylene lining conforming to ASTM D1248, *Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable*, compounded with sufficient carbon black to resist ultraviolet rays during above ground storage of pipe.
 - c. **Coal tar epoxy:** Catalyzed coal tar epoxy having a minimum thickness of 16 mils dry film thickness, a permeability rating of 0.13 perms, direct impact rating of 11.3 N·m (100 in-lbs), an abrasion resistance of 20 liters of sand per mil, and dielectric strength of 250 volts per mil.
 - d. Others as required or approved by the City Engineer.
- 4) Outside coat shall be a minimum of 1 mil bituminous paint according to ANSI/AWWA C151/A21.21 Section 51-8.1.
 - 5) Pipe and fittings shall be polyethylene encased with 8-mil polyethylene sheeting per AWWA C105, *AWWA Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems* and ASTM A674, *Standard Practice for Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids*. Color of polyethylene encasement to be green.
 - 6) Each joint of ductile iron pipe shall be hydrostatically tested before the outside coating and inside lining are applied at the point of manufacturer to 500 psi. Testing may be performed prior to machining bell and spigot. Failure of ductile iron pipe shall be defined as any rupture or leakage of the pipe wall.
 - 7) All materials used in production of the pipe are to be tested in accordance with AWWA C151 for their adequacy within the design of the pipe, and certified test results are to be provided to the City of Fairfax upon request. All certified tests, hydrostatic and material, are to be performed by an independent testing laboratory at the expense of the pipe manufacturer.
 - 8) Push-on and mechanical joint pipe shall be as manufactured by the American Cast Iron Pipe Company, United States Pipe and Foundry Company, Griffin Pipe Products Company, or McWane Cast Iron Pipe Company.

B. DUCTILE IRON JOINTS

Pipe joints may be either push-on or mechanical joint pipe sizes 4 inches through 48 inches in diameter. Rubber Gasket Joints and Mechanical Joints shall comply with AWWA C111/ANSI A21.11, ASTM A536 *Standard Specification for Ductile Iron Castings*. Acceptable pipe joints are as follows:

- 1) **Push-on Joint** Ductile Iron Pipe shall conform to AWWA C151/ANSI A21.51 (such as "*Fastite*," "*Tyton*," or "*Bell-Tite*."). The dimensions of the bell, socket, and plain end shall be in accordance with the manufacturer's standard design dimensions and tolerances. The gasket shall be of such size and shape to provide an adequate compressive force against the plain end and socket after assembly to affect a positive seal. Gaskets shall be vulcanized natural or vulcanized synthetic rubber, and comply with AWWAC111/ANSI A21.11.
- 2) **Mechanical Joint, Ductile Iron Pipe** shall be used only at the specific locations indicated on the drawings or as approved by the City Engineer.
 - a. The mechanical joint shall consist of:
 - i) A bell cast integrally with the pipe or fitting and provided with an exterior flange having cored or drilled bolt holes and interior annular recesses for the sealing gasket and the spigot of the pipe or fitting;
 - ii) A pipe or fitting spigot;
 - iii) A sealing gasket;
 - iv) Separate ductile iron follower gland having cored or drilled bolt holes; and
 - v) Ductile iron tee head bolts and hexagon nuts.
 - b. The joint shall be designed to permit normal expansion, contraction, and deflection of the pipe or fitting while maintaining a leak proof joint connection. The mechanical joint shall conform to the requirements of AWWA C110/ANSI A21.10, AWWA C111/ANSI A21.11, and ASTM A 536 Standard Specification of Ductile Iron Castings.

C. DUCTILE IRON FITTINGS

Fittings shall be ductile iron at least class 54 thickness and shall conform to AWWA C110/ANSI A21.10 or AWWA C153/ANSI 21.53 for compact fittings. All ductile iron fittings shall have a minimum working pressure rating of 250 psi and minimum iron strength of 25,000 psi. All fittings shall be cement mortar lined and the outside shall be bituminous coated as specified in [paragraph 2.5.12.1 A 3](#) for Lining. The fittings shall be tested and the manufacturer shall provide certified test results when requested by the City. This testing shall include hydrostatic proof testing of fittings. Acceptable types of fittings include Push-On Joint and Mechanical Joint.

Fittings shall be polyethylene encased with 8-mil polyethylene sheeting

2.5.12.2 PVC PIPE

- A. **PVC PIPE FOR GRAVITY SEWER AND SEWER FORCE MAINS (4-inch through 12-inch)**

- 1) **Gravity:** C900 PVC gravity pipe, 4-inch through 12-inch, with bell end with gasket and spigot end shall comply with AWWA C900, *AWWA Standard for Polyvinyl Chloride (PVC) Pressure Pipe, 4-inch through 12-inch for Water Distribution*, Pressure Class 150, DR 25. *Push-on joints shall conform to ASTM D3139, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.* Pipe shall have a bell with an integral wall section with a factory installed, solid cross section elastomeric ring in accordance with ASTM F477, *Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.*
- 2) **Pressure:** C900 PVC pressure pipe, 4-inch through 12-inch, with bell end with gasket and spigot end shall comply with AWWA C900, *AWWA Standard for Polyvinyl Chloride (PVC) Pressure Pipe, 4-inch through 12-inch for Water Distribution*, Pressure Class 150, DR 18. *Push-on joints shall conform to ASTM D3139, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.* Pipe shall have a bell with an integral wall section with a factory installed, solid cross section elastomeric ring in accordance with ASTM F477, *Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.* C900 pipe shall be used with ductile iron fittings (restrained joint).
- 3) The minimum pipe stiffness shall be 364 psi.
- 4) In accordance with ASTM D1599, *Standard Test Method for Resistance to Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings*, a minimum pipe burst of 755 psi shall be withstood without failure.
- 5) The pipe must be able to withstand an impact of 100 foot-pounds without visible evidence of shattering or splitting as specified in ASTM D2444, *Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight).*

B. PVC PIPE FOR LARGE DIAMETER GRAVITY SEWER (14-inch through 36-inch)

- 1) C905 PVC gravity pipe, 14-inch through 36-inch, with bell end with gasket and spigot end shall comply with AWWA C905, *AWWA Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14-inch through 48-inch for Water Transmission and Distribution.* Design specification:
 - a. Earth Load computed as the prism load.
 - b. Maximum modulus of soil reaction, $E' = 300$ in soil and $E' = 2,250$ in rock.
 - c. Bedding angle equal or less than 90 degrees.
 - d. Minimum pipe stiffness of 46 psi.

Push-on joints shall conform to ASTM D3139, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals. Pipe shall have a bell with an integral wall section with a factory installed, solid cross section elastomeric ring in accordance with ASTM F477, *Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.*

C. PVC PIPE FOR SMALL SEWER FORCE MAINS (2-inch)

2-inch PVC pressure pipe, bell end with gasket and spigot end shall comply with ASTM D2241, SDR 21, Class 200.

D. PVC FITTINGS

See paragraph [2.5.12.1, C, Ductile Iron Fittings](#).

2.5.12.3 STEEL PIPE**A. Steel Pipe for Sewer Mains, Encasement, Boring Applications, and Vent Pipes** (Use of steel pipe – approved on a case-by-case basis):

Steel pipe for gravity sewer mains shall meet the requirements of AWWA C200, *AWWA Standard for mill type steel water pipe*. Nominal pipe diameter and wall thickness shall be as indicated on the drawings. All steel pipe or encasements shall be high strength steel, spiral welded or smooth-wall seamless manufactured in accordance with ASTM A139, *Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over)* and ASTM A283, *Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates*, Grade “B” steel with a minimum yield strength of 35,000 psi. The interior lining shall be a coal-tar enamel coating as specified under AWWA C203, *AWWA Standard for Coal-Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot Applied*. All encasement pipes shall meet the applicable VDOT or AREA specifications but shall be no less than 6 inches larger than the outside diameter of the carrier pipe bell. The steel pipe shall be capable of withstanding the design load. The pipe shall have welded joints and be in at least 18-foot lengths. The steel encasement pipe shall be of leak proof construction and shall include end caps.

Exposed steel pipe: No interior lining and exterior coating shall be required except that all exposed metal is to be coated with coal-tar enamel or either an epoxy or asphaltic material approved by the City Engineer.

- 1) **Steel Pipe for Gravity Sewer Mains:** Pipe shall be seamless and either furnace-welded or electrically welded pipe, Grade B. The exterior coating shall be coal-tar enamel in accordance with AWWA C203.
- 2) **Steel Encasement Pipe for Boring Applications:** Encasement pipe shall meet applicable VDOT and AREA specifications. Casing pipe shall include pipe carriers (spiders) to support carrier pipe.

The spiders necessary to support the carrier pipe inside of the steel encasement pipe shall conform to both the shape and dimensions of shown on the contract documents.

- 3) **Steel Vent Pipes for Manholes:** The vent pipe shall be made from 4-inch Schedule 40. The pipe shall be coated inside and out in accordance with AWWA C203. See **Standard Detail 4.14**.

- B. **Spiders/Skids for Encasement Pipes:** Prefabricated stainless steel pipe supports with non-conductive skids or other acceptable support system shall be provided to support the pipe. Pressure treated skids will not be permitted. Acceptable manufacturers are: Advanced Products & Systems (APS) model SSI with EPDM skids, Lafayette, LA, or approved equal. For bolted connections, bolts shall be either galvanized or stainless steel.
- C. **Steel Casing End Seals:** Casing end seals shall be 1/8" thick synthetic rubber seamless pull-on end seals with T-304 stainless steel banding with 100% non-magnetic worm gear mechanism. End seals shall permit pipe movement while maintaining a seal. Acceptable manufacturers are: Advance Products & Systems, Inc., Lafayette, LA, or equal.

2.5.12.4 TUNNEL LINERS AND APPURTENANCES

- A. Carrier pipe shall be mechanical joint or restrained joint ductile iron pipe class 52 DIP, minimum for pipe sizes up to 12". Greater than 12" carrier pipe shall be class 54 DIP.
- B. Grout mix for filling voids in between carrier pipe and tunnel shall consist of the following materials properly mixed in proportions by weight.
 - 1) 1.0 Part Cement,
 - 2) 3.0 Parts Fine Sand, 100 Percent Shall Pass No. 16 Sieve, and
 - 3) 0.5 to 0.6 Part Water.
- C. Tunnel lining construction shall comply with the "*Specification for Steel Tunnel Liner Plates*" in the AREA Manual for Railway Engineering. The design and shape of the liner plates shall be such that erection and assembly of the liner plate structure can be completely and readily effected from inside the tunnel. Plates shall be accurately curved to suit the tunnel cross section, and all dimensions shall be of the size and accuracy that plates of similar curvature shall be interchangeable. All plates shall be connected by bolts on both longitudinal and circumferential joints.
- D. The steel lining shall consist of plates 16, 18, or 24 inches wide. Each circumferential ring shall be composed of the number and length plates necessary to complete the required shape shown on the drawings. The nominal tunnel diameter shall be of sufficient size to install the carrier pipe.
- E. Plates shall be one-piece steel meeting the requirements of ASTM A 569, ASTM A 570, or ASTM A 611. Plates shall have an ultimate tensile strength of at least 42,000 psi and yield strength of 28,000 psi. Gage thickness shall be a minimum of 8 gage. The liner plate and bolts shall be galvanized in accordance with ASTM A153. The liner plates shall be asphalt coated to meet AREA 1-14-13. For two flange plates, the minimum thickness shall be 0.135 inches. Plates shall be manufactured by Armco Steel Corporation, Commercial Shearing, Incorporated, Republic Steel Corporation, or approved equal.

- F. Grout holes 1½ inches or 2 inches (or larger) in diameter shall be provided in each ring to permit grouting as the erection of the tunnel liner plates progresses. Grout hole screw plugs shall be provided in plates.
- G. Steel bolts shall meet requirements of ASTM A449 for plate thickness equal to or greater than 0.209 inch and ASTM A 307 for plate thickness less than 0.209 inch. The nut shall meet requirements of ASTM A 307, Grade A.

2.5.12.5 CARRIER PIPE FOR CASINGS AND TUNNELS

Carrier pipe shall be mechanical joint or restrained joint ductile iron pipe class 52, minimum for pipe sizes up to 12". Greater than 12" carrier pipe shall be class 54 DIP.

2.5.13 MISCELLANEOUS APPURTENANCES

2.5.13.1 AIR AND VACUUM RELEASE VALVES:

Combination air and vacuum release valves are to be used to bleed air during filling of force mains and to automatically vent air that collects in the force mains. The valve shall be a NPT threaded cast iron body with a stainless steel float assembly and stainless steel trim. The valve outlet is to be protected from debris entering the outlet of the valve. Plumbing valves shall be all brass. The air and vacuum release valves shall be furnished with a back flushing hose with quick disconnect and brass valve assembly. Valves shall be designed for a maximum cold water pressure of 300 psig. Combination air and vacuum release valves shall be located as shown on the drawings or as otherwise directed by the City Engineer. The valve shall be housed in a precast concrete eccentric flat top manhole. Acceptable manufacturers are Crispin as manufactured by Multiplex Manufacturing Co., Berwick, PA, APCO Williamette Valve and Primer Corporation, and Empire Specialty Co., Inc., Mars, PA.

2.5.13.2 BEDDING

See [Section 2.3 – Trenching, Backfilling, and Compaction of Utilities](#).

2.5.13.3 CONCRETE BLOCK (FOR MANHOLES)

Concrete block shall conform to the requirements of ASTM C139, *Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes*.

2.5.13.4 BRICK (Solid brick for modifications to manholes)

Brick shall be hard clay, grade SM, ASTM C 32, *Standard Specification for Sewer and Manhole Brick (Made From Clay or Shale)* and AASHTO M91.

2.5.13.5 FORMS

Forms shall be of wood or other approved materials. Forms shall be mortar-tight and sufficiently rigid to prevent displacement. Responsibility for their adequacy shall rest with the Contractor. Form surfaces shall be smooth and

free from irregularities, dents, or holes. Form removal shall be accomplished in such a manner as will prevent damage to the concrete.

2.5.13.6 IRON CASTINGS: MANHOLE FRAMES AND COVERS

- A. **General:** Manhole frames and covers shall be US made and manufactured from Class 35B gray iron, meeting the requirements of ASTM A48, *Standard Specification for Gray Iron Castings* as noted in section 3.1 of AASHTO M306. Standard manhole frames and covers shall be built to the dimensions and configurations shown on **Standard Details 4.09, 4.10, and 4.11** and shall be manufactured in the USA. Minimum inside diameter of the opening shall be 23 5/8 inches. Manholes castings are to be uncoated. The bearing surface of the frames and covers shall be machined and the cover shall seat firmly into the frame without rocking. Covers are to be embossed along the perimeter with the name "Fairfax City" and on the interior field with the words "Sewer." With the exception of watertight covers, manhole covers shall have a 1-inch vent hole and a notch pick hole in the perimeter.

Watertight Frames and Covers: Frame is to have a minimum of four 1-inch diameter holes in flange of the frame at 90 degrees to permit placement of bolts. Watertight bolt-down frames and covers shall have 4 5/8" diameter stainless steel bolts at 90 degrees and one neoprene gasket between cover and frame seat.

- B. Approved castings are:

Manufacturer	East Jordan Iron Works	Capitol Foundry	Standard Detail
Standard Model	1930	MH-210-CR	4.9
Cover Weight		160	
Frame Weight		275	
Total Weight	477	435	
Lockable Model	1935	MH-213-CR	4.10
Cover Weight		165	
Frame Weight		285	
Total Weight	364	450	
Watertight Model (Bolt-Down)	1940	MH-214-CR	4.11
Cover Weight		165	
Frame Weight		285	
Total Weight	384	450	

- C. Frame weights shall not vary more than 5%+/- from that shown on the standard details.

2.5.13.7 IRON CASTINGS: SEWER CLEANOUT BOX (in paved areas only)

General: Sewer cleanout frames and covers shall be manufactured from Class 35B gray iron, meeting the requirements of ASTM A48, *Standard Specification for Gray Iron Castings*. Standard sewer cleanout frame and covers shall be built to the dimensions and configurations shown on **Standard Details 4.12 and 4.13**. Approved casting is Capitol Foundry model VB-9 By-Pass Valve Box and the US Foundry 7610 FC.

2.5.13.8 MORTAR FOR CONCRETE BLOCK & BRICK

Mortar shall be type M, ASTM C 270, *Standard Specification for Mortar for Unit Masonry* and ASTM C-144, *Standard Specification for Aggregate for Masonry Mortar*. Mortar shall be prepared from cement in perfect condition and shall be prepared in boxes for that purpose. No mortar that has stood beyond forty-five minutes shall be used. Proportion by volume for the different types of application shall be as follows:

Brick masonry = 1 part cement to 2 parts sand

Pointing = 1 part cement to 1 part sand

2.5.13.9 MISCELLANEOUS CONCRETE

Concrete Classes (VDOT) to Design Compressive Strength at 28 days (f'c):

Class A4.5	General	4,500-psi
Class A4	General	4,000-psi
Class A3	General	3,000-psi
Class B2	Massive or Lightly Reinforced	2,200-psi

Ready mixed concrete shall comply with ASTM C94, *Standard Specification for Ready-Mixed Concrete*. All exposed concrete shall be air entrained. Concrete strength shall be as specified on standard details and drawings. Unless otherwise specified, all concrete shall be Class A3, minimum.

2.5.13.10 PORTLAND CEMENT

Type I, CSA normal, ASTM C150 *Standard Specification for Portland Cement*.

2.5.13.11 PRECAST REINFORCED CONCRETE STRUCTURES

- A. Manholes of precast reinforced concrete shall be designed and manufactured in accordance with ASTM C478, *Standard Specification for Precast Reinforced Concrete Manhole Sections*, or latest revision. Manhole diameters shall be 4-foot minimum. The wall shall be a minimum of 5 inches thick and have a 6-inch minimum base. The standard joint shall be sealed with non-shrink hydraulic cement mortar per VDOT Road and Bridge Specifications, Section 218. Either an "O" ring or Forsheda gasket shall be used in the joints. The "O" ring joint shall conform to the requirements of ASTM C443, *Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets* or latest revision. The gasketed joint shall conform to ASTM C990, *Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants* (or AASHTO M-199) or latest revision. Rubber boot and stainless steel clamps, meeting the requirements of ASTM C923, *Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals*, shall be supplied with the manhole bases to tie the pipe to the base section of the manhole. Concrete used in the construction of the manholes shall have a minimum 28-day

strength of 4000-psi air entrained (with 4 to 6 percent air) conforming to ASTM C33, *Standard Specification for Concrete Aggregates* and ASTM C94/C94M, *Standard Specification for Ready-Mixed Concrete*. Manhole units shall consist of standard modular precast riser sections, modular riser sections, and a monolithic base (except where doghouse bases are to be used when placing manholes over existing mains). Where conditions do not favorably accommodate the use of an eccentric cone, eccentric precast reinforced concrete flat tops are to be used.

Manholes shall be tested per Department standards and defective sections must be replaced; no patching will be allowed.

Unless otherwise allowed by the City Engineer, manholes will be precast reinforced concrete. Drop manholes shall be a minimum of 4 feet in diameter and shall be constructed in accordance with **Standard Detail 4.07**.

Refer to the **Standard Details 4.02, 4.03, 4.04, 4.05, 4.06, and 4.07** for boot to pipe connection detail. All manholes shall have extended bases with appropriate reinforcing.

- B. **Flexible Pipe-to-Manhole Connector:** A flexible Pipe-to-Manhole connector shall be employed in the connection of the sanitary sewer to precast manholes. The connector shall be **KOR-N-SEAL**, as manufactured by Trelleborg Pipe Seals Milford, Inc. or approved equal.

The connector shall be the sole element relied on to assure a flexible watertight seal of the pipe to the manhole. No adhesives or lubricants shall be employed in the installation of the connector into the manhole. The rubber for the connector shall comply with ASTM C923 *Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals*, and consist of EPDM and elastomers designed to be resistant to ozone, weather elements, chemicals, including acids, alkalis, animal and vegetable fats, oils and petroleum products from spills.

All stainless steel elements of the connector shall be totally non-magnetic Series 304 Stainless, excluding the worm screw for tightening the steel band around the pipe, which shall be Series 305 Stainless. The worm screw for tightening the steel band shall be torqued by a breakaway torque wrench set for 60-70 inch/lbs.

The connector shall be of a size specifically designed for the pipe material and size being utilized on the project.

C. **Manhole Steps**

Manhole steps shall be steel reinforced polypropylene. Steps shall have a footing surface at least 10 inches wide and shall protrude at least 5 inches away from the manhole wall. The step surface shall have a tread plate or other safety surface. Steps shall be provided on 15 inch centers and be located directly below the manhole cover on the eccentric cone section. Steps shall be located directly over the outlet pipe on the base.

D. **Joints at Existing Manholes (Clay Brick and Concrete Brick)**

For 12 inch and smaller pipe, a virgin PVC waterstop concrete manhole adapter (Fernco Joint Sealer Company - CMA series or equal), sized for the respective pipe, shall be placed over the pipe, centered horizontally within the manhole wall and the space between the pipe and manhole completely filled with non-shrink grout (water plug or approved equal).

For 15-inch and larger sewers, the annular space shall be complete filled with nonshrink grout. Standard brick and mortar shall then be placed completely around the pipe outside the manhole, supported on the extended base and entirely coated with at least 3/4 inch of mortar. Particular care shall be exercised in placing the bedding in order to achieve adequate and uniform support of the manhole and the pipe through the first joint outside the manhole.

E. Manhole Coating

All manholes shall have bituminous coating on the outside walls.

2.5.13.12 REINFORCEMENT

All steel reinforcement for concrete shall conform to the requirements of ASTM A615, *Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement*. All bars #4 or larger shall be grade 60. Ties and all #3 bars shall be grade 40. All welded wire fabric shall conform to ASTM A185, *Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete* using bright basic wire meeting the requirements of ASTM A82, *Standard Specification for Steel Wire, Plain, for Concrete Reinforcement*. Wire gage 11 or smaller shall be galvanized. All reinforcing shall be, when surrounding concrete is placed, entirely free from rust, scale, mud, grease, or other coating, which might destroy or reduce bond with concrete. Steel shall be stored on pallets above grade.

2.5.13.13 SERVICES

Services shall include in-line wyes on new lines. Sewer service pipe for sewer services shall be DIP or PVC DR 25 per AWWA C900, *AWWA Standard for Polyvinyl chloride (PVC) Pressure Pipe, 4-inch Through 12-inch for Water Distribution, or PVC ASTM D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120, Schedule 40 solvent cement joints*. See **Standard Detail 4.12 & 4.13**.

Service Saddles: PVC saddles and adapters shall be Romac Industries, Inc. CB-4.80 (6-inch through 12-inch) or CB-4.80LS (14-inch through 24-inch), Geneco U 40 or E40 gasketed bell to accept schedule 40 or approved equal.

2.5.13.14 WETWELL/VALVE VAULT ACCESS HATCHES

- A. **Non-Traffic Areas:** The aluminum access frames and covers are manufactured with 1/4-inch thick, one-piece aluminum extruded frame, with a continuous concrete anchor as part of the one-piece extrusion. The door panels are 1/4-inch thick aluminum diamond plates, to withstand a live load of 300 lbs. per square foot, with a safety factor of times 1.5. The doors are provided with stainless steel hinges with tamper-proof fasteners. All

hardware is stainless steel. The doors open to 90 degrees and lock automatically in that position with a stainless steel positive locking arm and a stainless steel release handle. Doors are provided with a stainless steel lifting handle, stainless steel locking bar, or stainless steel snap-lock with removable key handle. Two key handles shall be provided with each door. The doors will close flush with the top of the frame, resting on a 1/2-inch wide lip around the entire inside of the frame for added support. Provide padlock hasp for doors on wetwells and valve vaults.

- B. **Traffic Areas** (Low Density Traffic H-20 Loading – 12,000 lb. wheel load on an 8 1/2-inch x 20 1/2-inch wheel area): The aluminum access frames and covers are provided with a 1/4-inch thick structural grade aluminum channel frame with the flanges acting as a continuous concrete anchor. The inside of the frame has a continuous door support angle that must have a full bed of Class "A" concrete under both the frame and support angle. Door leaves shall be a minimum of 1/4-inch thick aluminum diamond plate with structural grade aluminum. Door reinforcing shall withstand an H-20 live load designation. The doors also have lifting aids of aluminum tubular construction with compression springs to assist in opening and closing of the doors. The doors are provided with heavy-duty stainless steel hinges with tamper-proof fasteners. All hardware is to be stainless steel. The doors open to 90 degrees and lock automatically in that position with a stainless steel positive locking arm and a stainless steel release handle. Doors are provided with a stainless steel lifting handle, stainless steel snap-lock with removable key handle. Two key handles shall be provided with each door. The door leaves extend to the outside perimeter of the frame for added support. Provide padlock hasp for doors on wetwells and valve vaults.
- C. **Guarantee and Manufacturer:** The aluminum access frames and covers shall carry a 10-year guarantee against defects in materials and workmanship. The frame and cover shall equal or exceed the units manufactured by Halliday Products, Inc. or The Bilco Company.

2.5.13.15 YARD HYDRANTS

Yard hydrants shall equal or exceed the Clayton Mark model 5451 Lever type Frostproof Yard Hydrant or the Woodford W-34 for 3/4-inch and the Woodford Y-1 for 1-inch.

PART 3 – EXECUTION

2.5.14 PIPE INSTALLATION - GENERAL

2.5.14.1 CONSTRUCTION – ALL PIPE

- A. **Trench Width:** Minimum clearance between the side of trench and the pipe shall be 12 inches on each side of pipe or minimum trench width shall be 2 feet 8 inches whichever is greater. See **Standard Detail 4.01**.
- B. **Protection of Existing Sewers:** Sewer lines under construction shall be plugged with a mechanical plug (wing nut, rim bolted type, or approved equal) at the first manhole upstream from the point of connection. Plug shall be placed in the outlet connection and secured with a steel cable. Plug shall

remain in place until acceptance of lines by the City. Water, stone, dirt, or any other debris shall not be allowed to enter the City sanitary sewer system during flushing operations or at any other time. Construction taking place in the vicinity of any existing City sewer lines or manholes shall not cause any inflow of surface water or debris to enter the City sanitary sewer system. Existing City manholes located in construction sites are to remain accessible at all times. The Owner and/or Contractor shall be responsible for any damages incurred to the City of Fairfax sanitary sewer system and any fines imposed by the State due to sewer spills or overflows.

- C. **Pipe Laying Direction:** Place piping beginning at low point and progress uphill. Place on grade, with unbroken continuity in invert, horizontally and vertically, and on alignment as indicated on plans. Place bell ends of piping facing upstream. Install gaskets, seals, sleeve, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
- D. **Directional changes in gravity lines:** Use manholes for changes in direction of gravity lines.
- E. **Stringing out Pipe:** When pipe is strung out during unloading, it shall be set on high ground and in a position to prevent silt deposits, storm water, or other matter from entering the pipe prior to its placement in the trench.
- F. **Pipe Laying:** Pipe shall be bedded per [Section 2.3 – Trenching, Backfilling and Compaction of Utilities](#). The pipe and fittings shall be laid in the trench so that its interior surface shall conform to the grade and alignment as shown on the plans. Pipe laying shall be done in such a way as to disturb as little as possible the pipe that has already been laid. The alignment and grade of the sewer main may be field adjusted whenever, in the opinion of the City Engineer, it is necessary, so long as the adjustments are within that allowed by Virginia Department of Environmental Quality based on regulations in effect at the time of the change and so long as the changes are consistent with City of Fairfax policy in effect at the time of the change. **Changes in either grade or alignment may only occur at manholes.**

Before laying, the bell and spigot will be wiped free from any dirt or other foreign matter. All surfaces of the portion of the pipe to be joined, and the factory-made jointing material, shall be clean and dry. Lubricants, primer, adhesives, etc., shall be used as recommended by the pipe or joint manufacturer's specifications. The jointing material or factory-fabricated joints shall then be placed, fitted, and adjusted in such workmanlike manner as to obtain the degrees of water tightness required.

Trenches shall be kept as dry as possible during bedding, laying and jointing and for as long a period as required until the trench is backfilled. As soon as possible after the joint is made, sufficient backfill material shall be placed along each side of the pipe to offset conditions that might tend to move the pipe off line or grade. The greatest care shall be used to secure water tightness and to prevent damage to or disturbing of the joints during the backfilling process, or at any other time.

All special fittings, such as wyes and other connections, shall be installed at the points indicated on the plans, in accordance with the standard detail

drawings. Use appropriate adaptors to tie connection pipe to wyes. Plug end of connection with appropriate plug.

After the trench foundation has been properly graded to receive the pipe, the pipe shall be carefully lowered into the trench with approved methods. Under no circumstances shall the pipe or accessories be dropped or dumped into the trench. All damaged pipe shall be replaced at the Contractor's expense.

Any defects due to settlement shall be made good by the Contractor at his own expense.

- G. **Temporary Suspension of Work:** When the trench is left for the night or if pipe laying is suspended, the upper end of the pipe shall be plugged to keep out dirt, water, animals and other foreign matter or substances. This plug shall be kept in the end of the pipe line at all times when laying is not in actual progress.
- H. **Cutting or Fitting Pipe:** Whenever a pipe requires cutting, to fit in the line or to bring it to the required location, the work shall be done in a satisfactory manner with an approved cutting tool or tools which will leave a smooth end at right angles to the axis of the pipe and not otherwise damage the pipe or liner. When the cut end is to be assembled in a *Fastite* bell, an adequately smooth (without sharp edges) bevel should be ground or filed on the cut edge to prevent damage to or dislodgement of the gasket during assembly. The method of cutting pipe shall be in accordance with manufactures recommendations. No welding, flame cutting or flame tapping will be allowed. Such cuts shall be made by the Contractor without extra compensation.
- I. **Surface Water Crossings:** Surface water crossings with pipe under streambed shall have the pipe encased in either a concrete or steel casing. Concrete or steel casing shall extend from top of stream bank to top of stream bank.
- J. **Crossing Conflicts:** All drains, gutters, culverts, and sewers for surface drainage are to be kept open or if unavoidably closed, other provisions are to be made for this drainage.

2.5.14.2 DUCTILE IRON PIPE

- A. Bury limitations shall govern as follows based on the type laying condition:

Bury Limitations on DIP		
Pipe	Maximum Bury to Invert of Pipe*	
	Type 4 Laying Condition - Equivalent to Class C Bedding (See Detail 4.01)	Type 5 Laying Condition - Equivalent to Class B Bedding (See Detail 4.01)
8-inch DIP, Class 50	34 feet	50 feet
10-inch DIP, Class 50	28 feet	45 feet
12-inch DIP, Class 50	28 feet	44 feet
14-inch DIP, Class 50	28 feet	44 feet

16-inch DIP, Class 50	28 feet	44 feet
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*Laying condition **type 4** is a 4-inch bed of stone with pipe embedded to 1/8 pipe diameter (equivalent to Class C bedding). **Type 5** laying condition is also a 4-inch bed of stone with pipe embedded to the spring line of the pipe (equivalent to a Class B).

Bury Limitations: Minimum cover shall not be less than 3 feet. Where approved by the Department of Public Works, sewers with less than 3 feet of cover shall be encased in concrete.

B. Mechanical Joint Bolt Torque

Where mechanical joint fittings are required, unless otherwise advised by the manufacturer, the minimum bolt torque shall comply with Table 2 of AWWA C600, *AWWA Standard for Installation of Ductile-Iron Water Mains and Their Appurtenances* for mechanical joints, as follows:

Bolt Size (Inches)	Torque (Ft-Lbs)
5/8	45-60
3/4	75-90
1	100-120
1 1/4	120-150

C. See also [Section 2.3 – Trenching, Backfilling, and Compaction of Utilities](#).

2.5.14.3 PVC PIPE

A. Installation shall comply with *Underground Installation of Flexible Thermoplastic Sewer Pipe*, ASTM D2321, *Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications*.

B. Bury Limitations:

Bury Limitations on all PVC		
Pipe	Bedding Class	Maximum Bury to top of pipe ^a
DR 25 PVC	Class B-1 w/ VDOT # 57 stone	18 feet

^aSewers with 18 feet or more of covers shall be DIP.

Minimum cover shall not be less than 3 feet for PVC pipe.

2.5.14.4 STEEL PIPE

A. Encasement Pipe:

Where required, steel encasement pipe shall meet the length, thickness, and diameter as shown on the plans. Boring across roads and railways shall be performed by dry boring and jacking a steel encasement pipe under the pavement or rail. The encasement shall be located in an area that is relatively free from material such as rock and stone that may hamper the

boring operation. If requested by the City Engineer, the Contractor shall submit a complete plan and schedule for pipe installation prior to the commencement of such work. The submission shall include complete details of the sheeting, shoring and bracing for the protection of the roadbed and the materials and equipment pertinent to the boring operation. The Contractor shall not proceed with the pipe installation until he has received approval of the plan and schedule from the City Engineer.

Construction shall be executed in such a manner as to prevent settlement of the ground surface above the pipeline. The installation of the pipeline shall follow the heading or tunneling excavation as closely as possible.

All operations of the contractor shall be subordinated to the free and unobstructed use of the right of way of the passage of traffic without delay or danger to life, equipment, or property. Installation shall be in accordance with Section 302.03 of the *VDOT Road and Bridge Specifications* or AREA, as applicable.

The pipe shall be beveled and prepared for field welding at the circumferential joints. Joining of steel casing pipe shall meet the requirements of AWWA C206, *Standards for Field Welding Steel Water Pipe Joints*. Casing shall be installed by jacking, boring, or open cuts as indicated on the drawings.

Encasement ends shall be enclosed.

- B. **Spiders/Skids:** Spiders shall be placed at the bell of each carrier pipe within a steel encasement as well as at each end of the steel encasement pipe. For bolted connections, bolts shall be either galvanized or stainless steel. See [paragraph 2.5.12.3, Steel Casing Pipe, paragraph B.](#)

2.5.15 TUNNELING METHOD

A. **General:**

The Contractor shall submit shop drawings to the City Engineer for approval prior to construction. All liner plates and ribs used in the tunnel shall be of one type. All material removed shall be disposed of off the site by the Contractor at his expense.

All operations of the Contractor shall be subordinated to the free and unobstructed use of the rights of way for passage of traffic without delay or danger to life, equipment, or property. The Contractor shall provide all necessary bracing, bulkheads, and shields to ensure safety to traffic at all times. The Contractor shall provide all traffic control devices as necessary and as shown on the approved traffic control plan.

B. **Tunneling (Boring Method):**

- 1) Commence boring operation from a pit, with the bottom excavated to grade, and sheeted or shored if necessary. A steel pipe shall be jacked in place as a casing pipe.

- 2) After installation of the casing pipe, pull the carrier pipe in place a joint at a time. Each section of carrier pipe shall be supported by steel spiders strapped to the carrier pipe.
- 3) Close up tunnel liner ends to protect against entrance or foreign matter. The open ends of the casing pipe or tunnel shall be closed off by an 8-inch grout or masonry block wall prior to backfilling. A steel drain line to a 1 cubic yard French drain or daylight shall be provided.

C. Tunneling (Hand Mining)

- 1) Commence tunneling operation from a pit, with the bottom excavated to grade, and sheeted or shored if necessary.
- 2) Install the steel liner plates immediately after the excavated material has been removed, and remove the material not more than 24 inches ahead of the installed liner plates.
- 3) Grout all voids between the soil and tunnel liner plates. The maximum grouting pressure shall be 30 PSI. Start grouting at the bottom of the tunnel liner plates and proceed upward progressively and simultaneously on both sides of the tunnel. Install liner plates no more than 6 feet ahead of grouted section. Prohibit traffic over ungrouted sections of tunnel unless this section is in solid rock. Thoroughly dry-mix grout ingredients before adding water. After adding water, mix the batch for 3 minutes. Batches shall be of size to allow continuous placement of freshly mixed grout. Grout not used within 30 minutes after mixing shall be discarded. Placing shall be quick and continuous. Placement shall be under pressure with a grout pump. The period between installation of the tunnel liner plate and the placing of grout shall not exceed 7 hours, without the approval of the City Engineer. Upon completion of grouting, fill grout plugs with provided grout hole plugs.
- 4) Smoothly pave the bottom of the tunnel with concrete: After installation of the tunnel liner plates, the Contractor shall pour concrete pavement on the bottom quadrant (invert) of the tunnel, the surface of the pavement being parallel to the inner plate, with screed rails embedded in it, on line and grade for the installation of pipe in the tunnel.
- 5) The periphery of the tunnel shall be trimmed smooth to fit the outside of the steel liner plate as nearly as is practical, so that the void outside the plates is a minimum.
- 6) After installation of the tunnel liner, pull the carrier pipe in place a joint at a time. Each joint of the carrier pipe shall be supported by steel spiders strapped to the carrier pipe.
- 7) Close up tunnel liner ends to protect against entrance or foreign matter. The open ends of the casing pipe or tunnel shall be closed off by an 8-inch grout or masonry block wall prior to backfilling. A steel drain line to a 1 cubic yard French drain or daylight shall be provided.

2.5.16 MANHOLE CONSTRUCTION

- A. **Standard Manholes:** Manholes shall be constructed in accordance with **Standard Details 4.02, 4.03, 4.04, and 4.05** with preformed inverts with a through-manhole fall of 0.20 feet unless shown otherwise on the plans. Manholes shall be installed plumb and on a 12-inch bed of VDOT #57 stone. Non-shrink grout shall be placed around pipe where pipe meets precast invert in manhole to provide for a smooth transition for sewage flow.

Maximum depth of 4-foot diameter manhole is 20 feet.

- B. **Grade Rings/Adjustments:** In street rehabilitation work, the combination of grade rings and/or brick shall not exceed 12 inches in heights before removal of the cone is necessary to effect adjustment. When making adjustments to manhole frames, place a ½-inch parge coat on interior of manhole from half depth of the iron casting to a depth of 2 inches below the top of the precast cone.

When applicable, during installation of manhole, if frame and cover is near or within wheel path in roadway, turn cone to place out of wheel path.

- C. **Drop Manholes:**

Invert elevations for drop connections in manhole shall be as shown on the plans.

Interior drop (**Standard Detail 4.07**) connections shall consist of schedule 40 PVC pipe with solvent cement joints. Interior drop manholes shall be installed as shown in detail. The entire stack, including elbow, vertical section of pipe and cross with an outstanding open-end tee with plug, shall be strapped to the inside wall of the manhole with stainless steel bands lagged into wall of the manhole with stainless steel expansion bolts. A minimum of 2 steel bands shall be installed at a distance of no greater than 4 feet on center. Manholes shall be cored and booted for the inlet line.

Exterior drops are not permitted without approval of the City Engineer.

- D. **Precast Concrete Doghouse Manholes:** When it is necessary to install a manhole over an existing sewer main, a precast concrete doghouse manhole shall be installed over the main. A minimum of an 8-inch thick reinforced concrete base shall be poured over a VDOT #57 stone base and the doghouse manhole risers set over the existing sewer. The joint between the precast manhole and the base shall be sealed both inside and out with grout. The annular space of the precast manhole, around the main, shall be filled with grout and a shelf formed to the springline of the existing main. The crown/top of the main shall be removed once the shelf has been formed and has set sufficiently and all upstream lines tested and approved by the City. See **Standard Detail 4.06**.

- E. **Replacement/Rehabilitation of Existing Manholes:**

The City of Fairfax reserves the right to require replacement of the existing manhole with a new manhole. When a new manhole is necessary, the old manhole must be completely removed and a new precast manhole constructed in its place. Where the old manhole is of satisfactory quality, the Contractor will make connection thereto as directed by the City Engineer at no additional cost

even if it is necessary to modify the bottom of the manhole to meet the new grade. Such extras are considered to be incidental to the manhole connection cost.

Any tie-in's performed on sanitary sewer manholes must be machine-core drilled with a neoprene flexible boot and adjustable band, except brick manholes. The core shall be the size specified with a smooth finish. If connecting to existing brick manhole, seal penetration and add "Strong-Seal" on perimeter of manhole. Coordinate with the City Engineer.

- F. **Connection to Existing Manholes:** Connection to existing sewer shall be made at manholes. Upon completion of the connection to existing sewers, existing lines no longer needed shall be sealed or plugged and the invert rebuilt to reflect the new flow patterns.
- G. **Flexible Pipe-to-Manhole Connector:** The connector shall be installed per manufacturer's recommendations.
- H. **Manhole stubs:** Where shown on the drawings or required by the Department, the Contractor shall place a stub in the wall of the manhole. The stub shall be bell and spigot piece at least 36 inches long. Provide a watertight plug or masonry bulkhead capable of withstanding manhole test requirements. All spurs will be connected with flexible Kor-N-Seal, or approved equal.
- I. **Installation of Manhole Frames and Covers** Frames and covers shall be installed on the manhole in accordance with **Standard Details 4.09, 4.10, and 4.11**. A ½ inch bed shall be placed between the cone and the frame. Frame and covers shall be installed level and to finished elevation. Adjustments shall be made as necessary to achieve finished elevation.
- J. **Manhole Steps:** Steps are to be located over the outlet pipe spaced vertically at 15 inches on centers. Steps shall be firmly anchored in the riser/cone/base sections by the precast manhole manufacturer (see **Standard Details 4.02, 4.03, 4.06, and 4.07**).
- K. **Manhole Coating:** All manholes shall have bituminous coating on the outside walls.
- L. **Watertight Manhole Frames and Covers:** Watertight manhole frames and covers are to be utilized for all manholes located outside of paved areas and, as a minimum, when frames are located below the 25-year flood level. For watertight applications, place a butyl rubber between frame and cone/flat top and bolt frame to cone. Frames shall be bolted to the cone/flat top with 4 bolts placed at 90 degrees to each other. Bolts shall be stainless steel expansion bolts as manufactured by Hilti, Rawl or Liebig. Watertight systems shall be vented at least every 1000 feet (see **Standard Detail 4.14**).
- M. **Manhole Inserts.** When shown on the drawings or directed by the City Engineer, manholes frames and covers will be provided with a watertight manhole insert. The manhole insert shall be a No Flow/Inflow insert or *Rainstopper* insert as manufactures by Southwestern Packing and Seals, Inc. or an acceptable substitute approved by the Department.

- N. **Testing of New Manholes:** Manholes are to be subjected to a vacuum test. Manholes shall be vacuum tested after installation in accordance with the [manhole vacuum testing procedures](#) outlined in paragraph [2.5.23 D. Manhole Testing](#). Service connections tied into manholes shall be tested in conjunction with the manhole. The Contractor is to perform manhole testing as well as provide the necessary testing equipment to perform the tests, as directed by the City Inspector.

2.5.17 ABANDONING SEWER LINES & MANHOLES

- A. **Sewer lines:** When an existing sewer line is designated to be abandoned in place, the low end of the line is to be plugged and lean concrete grout (flowable fill) pumped into the line until line is completely filled.
- B. **Manholes:** When an existing manhole, either partially or wholly, is designated to be abandoned and the sewer lines, either entering or exiting the manhole, have been abandoned according to the preceding paragraph, the upper portion of the manhole shall be removed to a minimum of 18 inches below the proposed finished grade, or as determined by the City Engineer, VDOT #57 stone dumped into the manhole, and the stone vibrated to consolidate the stone (Alternatively, the City Engineer may require filling with flowable fill concrete in lieu of VDOT #57 stone). The remainder of the fill between the top of the manhole and the finished subgrade is to be backfilled as follows. Where the manhole is located within a roadway right of way, backfill with VDOT # 57 Stone and consolidate. Outside roadway right of ways, filter fabric shall be placed over the stone, suitable material of a compactable nature shall be placed over the top of the manhole, and the material tamped.

2.5.18 CONNECTION TO EXISTING SEWERS

Where required or shown on the plans, connection to existing sewer shall be made in a manner, which will maintain existing sewage flow on a continuous basis. Where flow cannot be maintained, interruption of service shall be minimized such that no by-pass of sanitary sewage to any natural waterway or storm drain occurs nor shall such interruption create a public health hazard by sewage back up or overflows. Sewage by-pass pumping shall comply with the requirements of [paragraph 2.5.19. Bypass Pumping](#), below.

Connection to existing sewer mains shall be made at manholes. See paragraph [2.5.16 F. Connection to Existing Manholes](#).

2.5.19 BYPASS PUMPING

- A. The bypass system shall be of sufficient capacity to handle peak flow of the pipe. Provide the necessary labor and supervision to set up and operate the pumping and bypassing system. Contractor shall comply with local sound ordinance. If pumping is required between the hours of 8:00 PM and 6:00 AM, engines shall be equipped as specified in [paragraph E](#), below, in order to keep noise to a minimum. The equipment shall be manned continuously. During bypass pumping operations, the Contractor shall provide the necessary labor to continually monitor the operation and ensure uninterrupted and sufficient pumping at all times.

- B. Contractor shall provide all materials and labor as necessary to maintain flows in the existing sewer interceptor and all collector and lateral lines at all times and under all weather conditions. Interruption of flows will not be permitted. Overflows from bypass operations will not be permitted to enter into any streams or bodies of water. **The Contractor will be solely responsible for any legal actions taken by the state regulatory agencies if such overflows occur during construction.**
- C. Bypass pumping equipment shall include pumps, conduits, engines, and related equipment necessary to divert the flow or sewage around the section in which work is to be performed. In addition, the contractor shall maintain at the same location and in operable condition, duplicate equipment to be used in case there is equipment failure. In this event, the Contractor shall promptly repair or replace the failed equipment to the satisfaction of the City Engineer.
- D. The new sewer line may be used by the Contractor to carry the sanitary flows after the new pipe has passed inspection and testing. Any “temporary” connections to the new sewer line shall be approved by the City Engineer.
- E. Engine driven equipment for bypass pumping equipment shall have “critical grade mufflers.” If equipment is operated between the hours of 8:00 PM and 6:00 AM, this equipment shall also be provided with sound attenuation enclosure consisting of a three sided enclosure with roof constructed of 2 x 4 frame with ½-inch plywood sheathing and 2-inch Styrofoam panels attached to the inside of the entire enclosure. The enclosure shall be portable in order to allow the enclosure to be moved when bypass pumping equipment is moved.
- F. **Plan Requirements:** The plan should include, but is not necessarily limited to, the following details:
- 1) Staging areas for the pumps.
 - 2) Sewer plug method and type of plugs or gates to be used.
 - 3) Number, size, material, locations, and method of installation of suction piping.
 - 4) Bypass pump sizes, capacity, number of each size to be on site, and power requirements.
 - 5) Calculations of static lift, friction loss, and flow velocity.
 - 6) Stand-by power.
 - 7) Downstream discharge plan.
 - 8) Method of noise control for each pump.
 - 9) Temporary pipe supports and anchoring required.
 - 10) Heavy equipment needed for installation of pumps and piping.
 - 11) Stand-by/back-up pumpset for the bypass application.
 - 12) Detail plan for 24-hour monitoring.
 - 13) Fueling of pumpsets on demand.
- G. **Sewer Overflows – Penalties:** The Contractor shall make every effort to avoid causing sewer overflows. All sewer overflows shall result in appropriate disciplinary actions. For all sewer overflows, the Contractor shall be responsible, and shall reimburse the City, for any damages, operational costs, fines, or other effects.

- 1) **Unplanned Service Outages:** The Contractor shall make every effort to avoid causing unplanned service outages. All Contractor-caused service outages shall be investigated by the City Engineer. If the investigation determines that the service outage could have been avoided by the Contractor, then the outage shall result in disciplinary action as shown above.

2.5.20 SERVICE CONNECTIONS

- A. Unless otherwise permitted by the City Engineer, all sewer services shall be Schedule 40 PVC with solvent cement joints (see **Standard Detail 4.12**). However, DIP may be used if desired and is required in bore applications (see **Standard Detail 4.13**). Where laterals are bored, the entire sewer service from main to property line shall be ductile iron pipe. The face of the bore cut shall be a minimum distance of five feet from the edge of the pavement on either side unless either the City Engineer gives approval to the contrary.
- B. During service installation or line rehabilitation on existing mains, the Contractor shall be responsible for the maintenance of all house sewer connections and the proper treatment and/or by-pass of effluent sewer around work areas.
- C. Any services or utilities damaged by the Contractor shall be properly repaired at Contractor's expense.
- D. 4-inch and 6-inch sewer laterals shall be connected to the main by means of an in-line monolithic wye (see **Standard Detail 4.12, sheet 2**) or, if on an existing line with a tap and saddle installed over a hole cut in the top quadrant of the main at an angle of forty-five degrees, with respect to flow direction.
- E. **Service Saddles:** The hole shall be cut with a mechanical circular type saw cutter designed for the particular use and rendering a smooth uniform cut with no damage to the main and is one which retrieves the plug. Saddle service "coupon" shall be given to the City's inspector for review and approval. Service saddles shall be constructed using Romac Industries, Inc. or Geneco sewer service saddles (see paragraph [2.5.13.13, Services](#)) placed in the top quadrant of the pipe main. Backfill under and around saddle with VDOT #57 stone. The cost for such cut-ins shall be included in the cost of the lateral.
- F. **Cleanouts:** A combination wye and cleanout shall be installed at the terminal end of the service connection and located at the right of way or easement line on the City side of the line and constructed as shown on **Standard Detail 4.12**. The cleanout shall be installed to surface grade and both the cleanout and the service material shall be capped or plugged to exclude entry of water or earth. Brass plugs shall be required for all above ground piping. All laterals are to be left exposed until the inspectors can verify the installation of each service.

Service connections shall not be located in driveways unless the cleanout is enclosed in a cast iron box with the letter "S" on the lid. The cleanout is to be set 4 to 6 inches from the top of the box. Cleanouts shall not be relocated outside of a driveway once installed.

- G. Trench support, bedding, and backfill for laterals shall conform to the same specifications as those for sewer mains. All wyes, saddles, laterals, and cleanout assemblies shall be embedded in VDOT #57 stone. See **Standard Detail 4.12** for bedding requirements of sewer laterals.

- H. **Service Connection to Manholes:** Unless approved otherwise by the City Engineer, services connections to manholes shall be made at dead end lines only. Service connections must be near the bottom of the manhole whenever possible. If not practical, services may be located above the bottom but may not enter the cone or it's joint. Service connections in manholes shall also be core bored and booted and shall be separated by a minimum of 2 times the pipe OD (either vertically or horizontally) from other services or mains. When connections are made at deep manholes, a standard drop connection shall be provided. The invert of manhole service connections shall be located such that a pipe half-diameter channel is formed through in the bench shall be required.
- I. **Deep Sewer Service Connections:** For service connection to deep sewer with confined trenches, the service shall extend from the connection upward at a 45 degree angle to a point near the trench wall, shall bend 45 degrees up to a riser which shall parallel the vertical trench wall to a point no less than 30 inches below finished grade and shall turn using 2 consecutive 45 degree bends to provide a lateral service to match the grade and slope of the building sewer. For all other service connections, the service shall extend from the connection upward at 45 degrees to a point where it shall bend 45 degrees to match the grade and slope of the building sewer. Vertical stacks or standpipe services are not allowed.
- J. **Cleanout Spacing:** Unless otherwise shown on the plans, cleanout spacing on 4 or 6 inch on long service lines shall not exceed 75 feet on center and shall also be provided at all horizontal or vertical changes in direction.
- K. **Grade:** Minimum grade for services shall be ¼-inch per foot for 4-inch services. Minimum grade for 6-inch services are to be laid preferably at a 1/8-inch per foot but no less than 0.6%.
- L. During service installation or line rehabilitation on existing mains, the Contractor shall be responsible for the maintenance of all sewer house connections and the proper treatment and/or by-pass of effluent sewer around work areas.
- M. Any services or utilities damaged by the Contractor shall be properly repaired.
- N. Deviations of branch connections from the design drawings (i.e. station number from nearest downstream manhole, and by direct reference to the property boundaries) shall be recorded on the as-built drawings.
- O. Sewer lines shall be air tested (low-pressure air test) after the complete installation of all sewer services. Laterals shall be tested with the main line. However, branch outlets for building sewers may be installed in sewer line while under construction provided:
- 1) Branch is plugged and blocked with a plug and joint capable of sustaining without failure or leakage an internal water pressure of 10 feet (4.3 psi).
 - 2) Branch connections may be installed after public sewer has been completed and tested as required by the City of Fairfax Code Enforcement Division.

2.5.21 CONCRETE ENCASEMENTS

All concrete encasements shown on the plans shall be constructed per the details on the Contract Drawings.

The earth may be used for side and bottom forms provided such sides can be excavated uniformly smooth and to the size and shape specified. Care must be taken during the pouring operation to ensure that the pipe does not float or move from the buoyant affects of the concrete. The trench must be dewatered before placing concrete. Misalignments of the crossings shall be cause for total removal and replacement of the encasement and pipe at the Contractor's expense.

Concrete cradles and arches, where required, shall be Class B2 concrete as specified in [paragraph 2.5.13.9 Miscellaneous Concrete](#). Once the concrete is set, measures shall be taken to cure the concrete by covering it with plastic. Backfill shall not be placed over concrete cradle or arch until 24 hours after pouring unless otherwise authorized. Water shall not be allowed to run over the concrete for at least 48 hours.

Forms will be required if the subgrade and sides are not firm, or will not hold shape.

See **Standard Detail 4.01** for concrete encasement.

2.5.22 SLOPE ANCHORS

All lines with slopes greater than 20 percent shall have concrete anchors placed on the bell end of the sewer line. Lines are to be constructed of DIP. The anchors shall be spaced and constructed to the dimensions shown on the plans.

2.5.23 TESTING

A. Testing and Inspection

The following tests shall apply for the respective pipe materials and manholes as required by the following specifications.

Material	Air Test	Mandrel	Vacuum Test	Infiltration	Visual	TV Inspection
DIP	X			X	X	X
PVC	X	X		X	X	X
Force Mains	X				X	
Manholes			X		X	

- B. **Preparation for Testing:** Unless otherwise specified, all sanitary sewer pipe shall be tested after backfilling has been completed and before final acceptance by the City. Testing and inspection shall promptly follow installation of sewer pipe including services. Testing intervals and sequences shall be as determined by the City Engineer.

The Contractor shall provide all equipment, material, water, labor, etc. needed to perform any and all tests in accordance with the procedures listed herein. All equipment, materials, etc. used shall be checked and approved by the City Engineer prior to its use. Provide lights and mirrors; furnish all pumps, gauges, instruments, test equipment, and personnel required for inspections and testing operations.

Upon completion of entire pipe installation, the City Engineer may inspect the work in part or as a whole and make such tests as necessary to verify that every portion of the contract has been faithfully carried out.

If, in the opinion of the City Engineer, a defect exists in the pipeline or its appurtenances, in some place not accessible except by uncovering, the City Engineer may order the line to be uncovered. If it is found that after the pipe has been uncovered at the order of the City Engineer, no defect exists or that the defects were not the fault of the Contractor, then the expense so incurred by the Contractor shall be borne by the City.

All manholes shall be of the specified size, shape, and material, and shall have their tops set to the grade as furnished by the design engineer. Frame and covers shall be tested with manhole tests.

It shall be the responsibility of the Contractor to ensure pipe to be tested is clean before any tests are made. Flush all sand, dirt, and debris from lines prior to inspection. If during any of the inspections sewer lines and manholes are found to contain mud and other debris, the contractor shall be required to flush or clean this material from the system by whatever means necessary. **Mud and other debris shall not be allowed to enter the existing sanitary sewer system.** The contractor shall be responsible for the cost of water used to flush the system. The City will charge for multiple inspections due to unclean lines.

Clean and pretest all pipe and manholes prior to notifying the City and arranging for inspections and tests.

All final testing and inspections shall be performed in the presence of the City Engineer or his/her representative. All final testing and retesting results shall be recorded on copies of test data sheets by the City. Final tests and acceptance shall be based only upon a test after backfill is complete.

Inspect the system for conformance with line and grades shown on the plans and provide record drawings measurements on Record Drawings.

Backfill Testing: Testing of backfill shall be performed in accordance with the requirements of [Section 2.3 – Trenching, Backfilling, and Compaction of Utilities](#). Additional tests are the responsibility of the Contractor, if they are required to determine the extent of unacceptable compaction..

C. Line Testing

1) Visual Inspection (Mirrors and TV Camera):

All sewer lines and manholes shall be visually inspected by the City of Fairfax from every manhole by use of mirrors and television cameras.

- a. **Mirror:** The lines shall exhibit a fully circular pattern when viewed from one manhole to the next. Lines, which do not exhibit a true and correct line and grade, have obstruction or structural defects, shall be corrected to meet these specifications and the sewer barrel left clean for its entire length.

- b. **TV Inspection:** The Department of Public Works shall inspect sanitary sewers by camera after lines are put into service. Any and all defects detected shall be corrected by the Contractor at no expense to the City.

2) **Primary Test Method - Low Pressure Air Test:**

Low-pressure air test shall be the primary method of testing for pipe diameters 24 inches or less and shall comply with ASTM F1417, *Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air*.

Before tests are made, all wyes, tees, or end of side stubs shall be plugged with flexible joint caps, or acceptable alternate, securely fastened to withstand the internal pressures. Such plugs or caps shall be readily removable, and their removal shall provide a socket suitable for making a flexible-jointed lateral connection or extension.

The portion of the line being tested shall be accepted if the portion under the test meets or exceeds the requirements of ASTM F1417 *Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air*. This requirement shall be accomplished by performing the test as follows: the time required in minutes for the pressure to decrease from 3.5 to 2.5 psig greater than the average back pressure of any groundwater that may be over the pipe shall not be less than the time shown for the given diameters in [Table 1 Line Pressure Air Test Table](#). If the system does not meet the foregoing requirements, the contractor will be required to locate and repair the leaks at no cost to the City and repeat the tests until the allowable leakage is obtained.

Procedure:

It is imperative that proper plugs be installed on the laterals at the cleanout stack. All plugs should be properly installed to withstand the test pressures without requiring external bracing or blocking. Before tests are made, all wyes, tees, or end of side sewer stubs shall be plugged with flexible-joint caps, or acceptable alternate, securely fastened to withstand the internal test pressures. Such plugs or caps shall be readily removable, and their removal shall provide a socket suitable for making a flexible-jointed lateral connection or extension.

Air leakage testing of installed system shall be performed with a continuous monitoring gauge no less than 4 inches in diameter with minimum divisions of 0.10 psi and an accuracy of plus or minus 0.04 psi. All air used shall pass through a single, above ground control panel visible to the City's representative.

Pressurize the system to 3.5 psi and measure the time interval for the pressure to drop 1.0 psi.

All air used shall pass through a single control panel. Individual air hoses shall be used from control panel to pneumatic plugs, from control panel to sealed line for introducing low pressure air, and from sealed line to control panel for continually monitoring the air pressure rise in the sealed line. After all pipes are cleaned, air shall be slowly supplied to the plugged pipe

installation until the internal air pressure reaches 4.0 psig (greater than average groundwater backpressure that may submerge the pipe). Throttle the air supply to maintain that constant pressure for at least 2 minutes. The air pressure supply shall then be disconnected from the system or shut-off. Do not enter manhole during test. Do not exceed 9.0 psig in the system.

Observe the continuous monitoring gauge while decreasing the pressure to no less than 3.5 psig (greater than groundwater pressure). At a reading of 3.5 (adjusted), or any convenient observed pressure reading between 3.5 and 4.0 psig (adjusted), timing shall commence with a stopwatch or other timing device that is at least 99.8% accurate. Regulate the pressure for at least 2 minutes to permit the air/ground temperature to reach equilibrium before commencing test.

Measure the time interval for pressure to drop 1.0 psig.

If the time, shown in Table I for the designated line size and length, elapses before the air pressure drops 1.0 psig; the section undergoing the test may be discontinued once the prescribed time has elapsed even though the 1.0-psig drop has not occurred. Record all readings.

If the pressure drops 1.0 psig before the appropriate time shown in Table I has elapsed, the air loss rate shall be considered excessive, and the section of pipe has failed the test. Record all readings.

If service lateral sewers are included in the test section, their lengths may be ignored for computing the required test times. The test will be slightly more severe. In the event a test section, having a total surface area less than 625 square feet, fails to pass the air test when lateral sewers have been ignored, the test time shall be recomputed to include all laterals.

If the sections fail the air test, the Contractor shall determine the source or sources of leakage and shall repair or replace all defective material and workmanship.

No sealant shall be used in the newly installed sewers to correct the leaks.

The extent and type of repair that may be allowed shall be subject to the approval of the City Engineer.

The repaired pipe installation shall be retested and required to meet the requirements of this test.

Determining Groundwater Elevation: If the pipe to be tested is submerged in groundwater, the test pressure shall be increased 1.0 psi for every 2.31 feet the groundwater level is above the invert of the sewer. To determine groundwater level, the Contractor shall install a 4-inch PVC pipe on the outside of the manhole from the base of the manhole to above ground level. The bottom of this pipe shall be laid in a minimum of 18 inches of pipe bedding material to allow groundwater to enter the bottom of the pipe. Immediately prior to the line test, the groundwater elevation shall be determined by measuring down to the surface of the water in the PVC pipe from ground level. The PVC pipe shall be cut off below grade and capped or filled after an acceptable test has been obtained.

Other methods of determining groundwater level may be used subject to approval of the City Engineer.

Safety Note: The air pressure test may be dangerous if, because of ignorance or carelessness, a line is improperly prepared. It is extremely important that the various plugs be installed and braced in such a way as to prevent blowouts. A force of 250 lbs is exerted on an 8-inch plug by an internal pressure of 5 psi. It should therefore be realized that sudden expulsion of a poorly installed plug, or a plug that is partially deflated before the pressure is released, can be dangerous. As a safety precaution, pressurizing equipment should include a pressure regulator set at, for example, 10 psi to avoid over-pressurizing and damaging an otherwise acceptable line. **No one shall be permitted in the manholes during testing.**

3) Infiltration/Exfiltration:

Allowable leakage of pipe using Infiltration tests shall be limited to 100 gallons per day per inch diameter per mile or 2,400 gallons per day, whichever is less. If groundwater is 4 feet above top of pipe, use infiltration test. If groundwater is less than 4 feet above top of pipe, fill pipe and upstream manhole to produce a minimum 4-foot head over the top of pipe, let stand for 12 hours, refill manhole to original level, and conduct Exfiltration test for 1 hour.

4) Pipe Deflection Test:

Deflection testing shall be performed for all semi-rigid and flexible pipe 8 inches or larger. Deflection shall not exceed 5% (95% of the ASTM base inside diameter). Testing shall be conducted in the presence of the City Engineer or his representative and shall utilize a mandrel go/no-go gauge complete with proving ring. Mandrel shall be approved by the City Engineer for this test. Arm mandrels shall have a minimum of 9 arms.

The mandrel device shall be cylindrical in shape and constructed with a minimum of nine evenly spaced arms or prongs. Mandrels with less than nine arms will not be approved for use. The "D" mandrel dimension shall carry a tolerance of plus or minus 0.01 inch. Allowance for piping wall thickness tolerances or ovality (from heat, shipping, poor production, etc.) shall not be deducted from the "D" dimension but shall be counted in as a part of the 5% or lesser deflection allowance.

The mandrel shall be hand pulled through by the Contractor in the presence of the City Engineer or his representative. Any sections of the sewer not passing the mandrel shall be uncovered and the Contractor shall re-round or replace the sewer to the satisfaction of the City Engineer. The repaired section shall be retested.

The inspection shall be conducted no earlier than 30 days after reaching final trench backfill grade.

Contact length shall be measured between points of contact of the mandrel arm.

The inspector shall be responsible for approving the mandrel. Proving rings may be used to assist in this. Drawings of the mandrel with complete dimensions shall be furnished by the Contractor to the City Engineer for each diameter and specification of pipe.

5) Force mains Testing

- a. **Order of Operations:** The installation of sewer force mains shall be set forth on the plans and shall meet the requirements set forth in the specifications. Fill the system with water at a velocity of approximately 1 foot per second while necessary measures are taken to eliminate all air. Do not leave fill line connected to sewer line unless an RPZ backflow preventer is placed between the potable water supply and the line being filled.
- b. **Pressure Tests & Leakage:** The Contractor shall test completed sections of line, including fittings, with water. This testing, however, does not relieve the contractor of his responsibility to repair or replace any cracked or defective pipe. All work necessary to secure a tight line shall be done performed by the Contractor. Testing shall be performed in the presence of a City representative and the Contractor. Cost for testing shall be incidental to line construction.

Pressure Test: The newly laid piping or any valved section of piping shall, unless otherwise specified, be subjected to a minimum pressure of at least 50% above the design operating pressure for at least 30 minutes. Raise the pressure by pump to either 150% of design operating pressure, or test pressure as shown on the drawings, whichever is greater. Measure the pressure at the low point on the system compensating for gauge elevation. Maintain this pressure (+ or – 5 psi) for 30 minutes. If pressure cannot be maintained using reasonable pumping rate, determine cause, repair, and repeat the test until successful. The allowable leakage shall be no greater than the amount given by the formula contained in Section 5.2, of AWWA C 600-93, *AWWA Standard for Installation of Ductile Iron Water Mains and Their Appurtenances*. The Contractor shall be responsible for all costs, labor, materials, and equipment to perform the testing. All visible leaks, broken or cracked pipe, valves, etc. shall be repaired.

i) Prerequisite conditions for testing shall be as follows:

- All pipe has been laid and the trench backfilled.
- Valves shall be properly located, operable and at correct elevation.
- All reaction anchors have had sufficient set of 3 days. High early strength concrete, 4500 psi or greater, may be used to reduce number of days.
- Lines shall be properly vented where entrapped air is a consideration.

- **All construction activities on the project, that requires trenching or excavation within the limits of the line location, shall be completed prior to pressure testing of line.**

D. Manhole Testing

Manholes shall be vacuum tested as indicated below unless otherwise allowed by the City Engineer. Vacuum testing shall meet ASTM C1244 *Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test*, or latest revision. Only new manholes are to be vacuum tested. Vacuum testing of existing manholes is not required.

The test shall be made using an inflatable compression band, vacuum pump, and appurtenances specifically designed for vacuum testing manholes. Vacuum Equipment shall be approved by the City Engineer prior to its use. The Contractor shall be responsible for furnishing all equipment and labor for the vacuum test at no additional cost to the City.

Manholes may be tested by vacuum test immediately after assembly of the manhole, frames and connecting pipes and before any backfill is placed around the manholes. However, the final test and acceptance shall be based only upon a test after the manhole is backfilled and the cover frame castings are set to grade and grouted in place. Manholes shall be tested from the top of the casting, including the casting-to-cone joint (adjusting ring). Testing devices shall be installed on the metal manhole frame.

All lift holes shall be plugged with nonshrink grout and all pipes shall be plugged, taking care to securely brace the plugs and pipe. Stubouts, manhole boots and pipe plugs shall be secured to prevent movement while the vacuum is drawn.

Installation and operation of vacuum equipment and indicating devices shall be in accordance with manufacturer's recommendations.

After the testing equipment is in place, a measured vacuum of 10 inches of mercury (Hg) shall be established in the manhole. The time for the vacuum to drop to 9 inches of mercury shall be recorded.

Acceptance standards for leakage shall be established from the elapsed time for a negative pressure change from 10 inches to 9 inches of mercury. See Table II for allowable leakage rate.

If the manhole fails the test, the Contractor shall locate the leakage, make the proper repairs, and the vacuum test shall be repeated until the manhole passes the test. After the manholes have been backfilled and the cover frame casting sealed in place, and prior to final acceptance of the project, any signs of leaks or weeping visible from the inside of the manhole shall be repaired and the manhole made watertight and tested. The extent and type of repairs that may be allowed shall be subject to the approval of the Public Works Director. Leaks shall be repaired on the outside of the manhole unless approved otherwise by the Public Works Director.

If a manhole joint mastic material is completely pulled out during the vacuum test, the manhole shall be disassembled and the mastic replaced.

2.5.24 PUMP STATIONS AND FORCE MAINS

- A. **Pump Stations:** Pump stations and force mains will be allowed only with the permission of the Public Works Director. Pump stations shall be self-priming pumps and designed in accordance with the requirements of the Virginia Department of Environmental Quality. Lift stations shall include the following as a minimum:
- 1) Service head, meter base, service connection, disconnect, and area light with switch.
 - 2) Audible and visual high water alarm and alarm silence. High water alarm circuitry. Provide dual high water alarm floats. The first (lowest) high water alarm float is to activate the telemetry only (not the alarm and light) to allow maintenance personnel time to arrive at site and attempt to fix the problem. The second (higher) high water alarm float shall activate the alarm horn and light.
 - 3) Auto-dialer (minimum 8 numbers, 4 channels). The automatic telephone dialer shall be a solid-state component capable of dialing up to 8 phone numbers, each up to 24 digits in length. The dialer shall have solid-state voice message recording and playback, all implemented with permanent nonvolatile solid-state circuitry with no mechanical tape mechanism.
 - 4) Automatic air release valves, as applicable.
 - 5) For self-priming pumps, provide air bubbler type control system with hand-off-automatic (H-O-A) switches and an automatic alternator.
 - 6) 3-phase voltage monitor, if applicable. Indication of 3-phase power fail.
 - 7) Suction and/or discharge gauges, as applicable.
 - 8) Elapsed time indicators.
 - 9) High pump temperature protection.
 - 10) Pump run lights.
 - 11) Motor overload resetter.
 - 12) Surge suppressor.
 - 13) Duplex service receptacles on GFCI installed external to the NEMA 4X enclosure.
 - 14) Surge relief valve and return piping to wetwell.
 - 15) Start-up assistance and certification, including operational/witness/drawdown test. Certified pump curves shall be provided as part of the project closeout documents.
 - 16) Dual power supply auto switch-over, etc.
 - 17) Non-Freeze Yard Hydrant (Clayton Mark model 5451 Lever type frost proof yard hydrant).
 - 18) For self priming pump stations, provide heaters and fluorescent lighting.
 - 19) Non-Freeze shower w/ eye wash and concrete pad.
 - 20) 10 ft x 10 ft x 8-inch concrete pad for water tank with drain and valve.
 - 21) Emergency pump connection w/ blind flange and gate valve.
 - 22) The lift station is to include back-up alarm system that operates off a 12-volt battery connection in the event of power failure. The battery system is to include a trickle charger to ensure battery integrity.
 - 23) Provide auxiliary propane, natural gas or diesel fired automatically activated stand-by power generator source with automatic reset, placed on site. Pump manufacturer to provide power demand/ratings to contractor before ordering pump and the power demand appropriately marked on the pump shop drawings. Generator shall have the capacity sufficient to sequentially start and run all pumps in the pump station. The contractor shall provide a complete engine driven generator set. The generator set shall consist of

four-cycle, radiator-cooled, engine direct connected to an alternating current generator, a unit-mounted control panel, all mounted on a common sub-base. The control panel shall be complete with engine controls and instruments, safety controls and panel lights including the following:

- a. The generation unit shall be capable of powering the pump motors starting current, electrical systems, instrumentation/controls and alarm systems, and other auxiliary equipment as may be necessary to provide for the safe and effective operation of the pump station. The generation unit shall have the appropriate power rating to start and continuously operate under all connected loads.
- b. The generation unit shall be provided with special sequencing controls to delay lead and lag pump starts unless the generating unit has the capacity to start all pumps simultaneously while the auxiliary equipment is operating.
- c. The generation unit shall be capable of shutting down and activating the audible and visual alarms and telemetry if a damaging operating condition develops.
- d. The generation unit shall be protected from damage when restoration of power supply occurs.
- e. The generator shall be equipped with an automatic transfer switch to start generator and transfer load to emergency in case of utility undervoltage, overvoltage, power loss, phase reversal, or phase loss.
- f. The control panel shall be complete with run-stop-remote switch; remote start-stop terminals; cranking limit; battery charge rate ammeter, oil pressure gauge, temperature gauge; low oil pressure shutdown; high engine temperature shutdown; over speed shutdown; AC voltmeter; voltage adjustment; frequency meter; and running time meter. The controls must indicate engine run, common engine fail, transfer switch position, low fuel level, and fuel tank leak for remote telemetry purposes. The generator shall be equipped with an automatic transfer switch to start generator and transfer load to emergency in case of utility under voltage, over voltage, power loss, phase reversal, or phase loss.
- g. Circuit breakers shall be provided with a built in control panel.
- h. The manufacturer of the unit shall completely assemble and test the unit before shipment. He shall be one who is regularly engaged in the production of such equipment, and who has spare parts and service facilities. He must also provide 1 complete set of filters.
- i. The controls must indicate engine run, common engine fail, transfer switch position, low fuel level, and fuel tank leak for remote telemetry purposes.
- j. The automatic transfer switches must have a disconnect on the utility service main side.
- k. The generator shall comply with the following minimum requirements:
 - i) Engine: Four-cycle, 4 cylinder, radiator cooled, at 1800 RPM. Starting shall be from batteries, with capability to start the unit at 32 degrees temperature.
 - ii) Generator: Rating shall be continuous standby service at 0.8 power factor, at 1800 RPM.
 - iii) Voltage: Three-phase, 208. KW rating to match facility needs.
 - iv) Engine shall be equipped with an isochronous governor as manufactured by Woodall.

- v) Frequency regulation shall be less than 3-cycles from no-load to full load.
 - l. All accessories needed for the proper installation of the system shall be furnished. Included should be batteries, battery cables, exhaust piping, mufflers, vibration mounting, and three bound sets of detailed operation and maintenance manuals with parts list. Batteries should be lead acid.
 - m. The generator set shall be enclosed with a factory-installed weather-protective housing (sound abating enclosure to 68db @ 23 ft.) Housing shall provide easy access to the engine-generator and instrument panel. Muffler to be designed so exhaust is not blown or sucked across the set by cooling air.
 - n. Included with the generator shall be a complete fuel system consisting of a fuel tank, fuel gauge, fuel lines, fuel pumps, valves and any and all other items incidental to a first-quality installation.
 - o. Provide integral sub-base double-walled diesel tank. The tank is to be Underwriters Laboratories (UL) approved closed-top dike type. The tank shall also be fitted with a leak sensor device. The tank must have a capacity to run the generator for a minimum of 48 hours at 100% load.
 - p. Fuel tank shall consist of the fuel tank separate and contained within the frame. No generator weight is to be supported by the tank. Provide a drain plug at one end of the rupture basin. Provide vibration isolators between generator set and tank assembly. Provide fuel low-level alarm remote mounted.
 - q. Generator shall be equipped with an elapsed time indicator.
 - r. Provide manufacturer's recommended anti-freeze and engine block heater, per manufacturer's recommendations, with thermostatic controls to maintain engine coolant at proper temperature to fulfill start-up requirements, adjustable if possible. Provide suitable trickle battery charger. All accessories shall be engine-mounted and within the weatherproof sound attenuated housing.
 - s. Provide annunciator panels with visual and audible alarms to monitor and warn of emergency operation conditions affecting line and generator power sources.
 - t. Provide stainless steel super critical grade type exhaust silencer mounted inside of the generator enclosure for corrosion protection.
 - u. Provide amp meter, voltmeter, and frequency meters with phase switches.
 - v. Provide fuses or circuit breakers for battery charger and engine.
 - w. Provide an automatic battery charger, static type, magnetic amplifier control with DC voltmeter, DC ammeter, and potentiometer for voltage adjustment. The charger is to be completely automatic and rated for the type of battery use. The charging rate is to be determined by the state of the battery and reducing to milliamp current on fully charged battery. The charger shall be 120 V., single-phase, 60 cycle, AC input with 6-amp maximum output.
 - x. Operation and Maintenance instructions. The contractor shall provide a minimum of 4 continuous hours of operation and maintenance instructions for the Owner's personnel.
 - y. The City must be furnished with one complete set of air, oil and fuel filters.
- B. Pump Certification:** Contractor to provide a certified shop test of pump from pump manufacturer. Manufacture's representative shall be present at pump

start-up. See *Pump Station Operational/Witness Test/Start-up* requirements, below.

- C. **Wetwell Coating:** Wetwell interiors shall be coated with a two component elastomeric, hydrophobic, corrosion resistant polyurea coating where the primer can be applied to damp or dry surfaces. Primer coat film thickness shall be 1.5 to 3 mils. The top coat film range shall be from 8 to 12 mils. Shore hardness D shall be minimum 75. Contractor to follow all applicable safety measures for handling and application as recommended by the Manufacturer of the coating. Comply with applicable confined space safety requirements.
- D. **Wetwell/Valve Vault Hatches:** Provide access frames and covers meeting paragraph [2.5.13.14, Wetwell/Valve Vault Access Hatches](#) of this specification with padlocked hasps.
- E. **Force mains:** Force mains shall be ductile iron or PVC C900. PVC Force mains must be approved by the Public Works Director. Pipe joints shall be push on or mechanical joint type. Fittings shall be mechanical joint with appropriate blocking and/or rodding. Force mains shall be constructed in accordance with the plans and in accordance with the requirements applicable to sewer main construction.
- F. **Manuals/Parts:** The City must be furnished with 3 copies of the Operation and Maintenance and Parts Manuals for the pumps/motors and/or station, pump controls, the generator unit and the automatic transfer switch. Also, provide a spare impeller, key, nut, washer, and mechanical seal for each pump.
- G. **Safety Placards:** Provide safety placards as required for structure (e.g. confined access entry) and equipment as required by OSHA readily shall be posted and readily visible.
- H. **Pump Station Operational/Witness Test/Start-up**

- 1) **Witnessed Testing:** Witnessed testing shall be performed in the presence of the Public Works Director or his representative and the results of the testing maintained as part of the construction record documentation. Witnessed testing shall include start-up assistance by a qualified factory representative and certification. Prior to acceptance by the City, an operational test of all pumps, drive, and control systems shall be conducted to determine if the installed equipment meets the purpose and intent of the specifications. Tests shall demonstrate that all equipment is electrically, mechanically, structurally, and otherwise acceptable; it is safe and in optimum working condition; and conforms to the specified operating characteristics.

After construction debris and foreign material has been removed from the wet well, the contractor shall supply an adequate amount of clear water volume to operate station through several pumping cycles. Observe and record operation of pumps, suction (if applicable) and discharge gage readings, ampere draw, pump controls, and liquid level controls. Check calibration of all instrumentation equipment, test manual control devices, and automatic control systems. Be alert to any undue noise, vibration, or other operational problems.

- 2) **Drawdown test:** The contractor shall conduct a drawdown test to confirm that the pump is operating at or near the required design operating point and to determine the actual pumping rate of each pump. This test shall be conducted in the presence of the Public Works Director or his representative, the contractor and a representative of the pump manufacturer. The rate shall be determined by subtracting the starting static surface elevation of the water in the wetwell from the “off” elevation and multiplying the difference by the volume per vertical foot of wetwell. That number shall then be divided by the number of minutes of pump run time to affect the drop measured. This test shall be performed for each pump and the rates recorded for each pump and included as part of the record in the certified pump test.
- 3) **Manufacturers Start-up Services:** The manufacture’s representative shall be present at pump start up. Co-ordinate station start-up with manufacturer’s technical representative. The representative or factory service technician shall inspect the completed installation. He shall calibrate and adjust instrumentation, correct or supervise correction of defects or malfunctions, and instruct operating personnel in proper operation and maintenance procedures.

2.5.25 PIPE DESIGN LIFE

In addition to the above noted specifications, the Contractor shall secure and the manufacturer shall warrant that sanitary sewer pipe is designed for a 50-year life.

2.5.26 CLEANUP AND RESTORATION OF SITE:

After the backfill is completed, the contractor shall dispose of all surplus material, dirt and rubbish from the site, and shall keep the site free of mud and dust to the satisfaction of the City Engineer. Prior to completion of project, all dewatering “stingers” shall be removed and the void filled with either flowable fill concrete or VDOT #67 stone. The Contractor may be required to flush or sprinkle the street to prevent dust nuisance. It is important that clean up and restoration of the site follows the work closely. The contractor shall dispose of surplus material and clean the street at the end of each day for the portion of work completed that day unless additional cleaning is required. The Contractor is to ensure that all materials, vehicles, and equipment are not stored overnight within the City streets. After all work is completed, the contractor shall remove all tools and other equipment, leaving the site free, clean, and in good condition.

END OF SECTION 2.5

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TABLE I
Line Pressure Air Test Using Low-Pressure Air
SPECIFICATION TIME REQUIRED FOR A 1.0 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q = 0.0015
 (Excerpted from ASTM F1417)

1 Pipe Diameter (in.)	2 Minimum Time (min:sec)	3 Length For Minimum Time (ft.)	4 Time For Longer Length (sec.)	Specification Time for Length (L) Shown (min:sec)							
				100 ft.	150 ft.	200 ft.	250 ft.	300 ft.	350 ft.	400 ft.	450 ft.
4	3:46	597	.380 L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6	5:40	398	.854 L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.520 L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374 L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	199	3.418 L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	159	5.342 L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	17:00	133	7.692 L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
24	22:40	99	13.674 L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33

TABLE II					
VACUUM TEST TABLE FOR MANHOLES					
BASED ON ASTM C 1244					
MINIMUM TEST TIMES FOR VARIOUS manhole DIAMETERS FOR PRESSURE DROP FROM 10 INCHES TO 9 INCHES HG.					
DIAMETER, INCHES					
Depth (FT)	48	54	60	66	72
TIME, SECONDS					
6	15				
8	20	23	26	29	33
10	25	29	33	36	41
12	30	35	39	43	49
14	35	41	46	51	57
16	40	46	52	58	67
18	45	52	59	65	73
20	50	53	65	72	81
22	55	64	72	79	89
24	59	64	78	87	97
26	64	75	85	94	105
28	69	81	91	101	113
30	74	87	98	108	121