

02730 – SANITARY SEWER

(Revised 3/25/2020)

SELECTED LINKS TO SECTIONS WITHIN THIS SPECIFICATION

Part 1- General	Infiltration/Exfiltration Test	Pipe Separation Req'ts
Part 2 – Products	Low Press Air Test Lines	PVC Pipe - spec
Part 3 – Execution	Manhole Frame & Cover	PVC Service Pipe - spec
DIP Fittings	Manholes Precast – Spec	Service Connections
Ductile Iron Pipe - spec	Manhole Vacuum Test	Steel Encasement Pipe
Dry Bore Encasements	Manhole Vent Pipes	Tunneling
	Pipe Laying	Tunnel Liner - Spec

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this specification.
- B. Section 01000 – GENERAL REQUIREMENTS.
- C. [Section 02220](#) – TRENCHING, BACKFILLING AND COMPACTION OF UTILITIES.

1.2 SUMMARY

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

1.3 DEFINITIONS

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 Lynchburg, Virginia as specified within this section and other sections of this manual.

- A. **Sanitary Sewer:** Exterior gravity sanitary sewer system.
- B. **Sewer Service:** Exterior domestic sewer piping.

1.4 PERFORMANCE

Gravity Flow, Piping Pressure Ratings: At least equal to the system test pressure.

1.5 SUBMITTALS

- A. Submit product data and shop drawings for the following in accordance with Section 01000 - *General Requirements*:
 - 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 2.1.4](#)).
- B. **Bypass Pumping**: Contractor shall provide submittals in accordance with Section 02770- *Sewer Flow Control*.
- C. **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.

1.6 QUALITY ASSURANCE

- A. Materials and operations shall comply with the latest revision of all applicable Codes and Standards including but not limited to DEQ regulations.
- 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) 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.

1.7 STANDARD ABBREVIATIONS

AASHTO American Association of State Highway Transportation Officials

ACI	American Concrete Institute
ACPA	American Concrete Pipe Association
ANSI	American National Standards Institute
AREA	American Railway Engineers Association
ASCE	American Society of Civil Engineers
ASSE	American Society of Sanitary Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
CRSI	Concrete Reinforcing Steel Institute
DEQ	Department of Environmental Quality
DIP	Ductile Iron Pipe
FS	Federal Specifications
MSDS	Material Safety Data Sheets
NCMA	National Concrete Masonry Association
NSF	National Sanitation Federation International
PVC	Polyvinyl Chloride Plastic
UL	Underwriters Laboratories, Inc.
VDOT	Virginia Department of Transportation
VDH	Virginia Department of Health
WEF	Water Environment Federation

1.8 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Pipe Condition/Pipe Examination

- 1) New Pipe Inspection:** Inspect materials thoroughly upon arrival. Examine materials for damage. 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 and roundness. 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.
- 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. Observe manufacturer's directions for delivery and storage of materials and accessories.
 - D. Protect stored piping from entry of water or dirt into pipe. Protect bells and flanges of special fittings from entry of moisture and dirt.
 - E. Support pipe to prevent sagging or bending. Do not store plastic pipe, structures, and fittings in direct sunlight.
 - F. Handle precast concrete manholes and other structures according to manufacturer's written rigging instructions.

1.9 PROJECT CONDITIONS

1.9.1 SEPARATION OF WATER AND SANITARY AND/OR COMBINED SEWERS

Follow the **VDH** and **DEQ** standards 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.
 - 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. **Sanitary and/or Combined 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 any part of a manhole.

1.9.2 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.

1.10 COORDINATION

- A. The contractor shall completely remove and dispose of all dirt, debris, rubbish and surplus, and unsuitable materials at the end of each work day at no additional cost to the owner.
- B. Whenever the contractor desires to use a hydrant for water supply, the contractor shall obtain the permission of the owner. All costs associated with the use of water supplied from hydrants shall not be paid for separately but shall be deemed to be included in the bid. Operation of hydrant shall be in accordance with the City Of Lynchburg Backflow Prevention Program. Use of an RPZ device or air gap is required.

- C. Coordinate tie-ins to municipal sewer mains with the City of Lynchburg Water Resources (Utilities) Engineer.

PART 2 – PRODUCTS

2.1 PIPE & FITTINGS

2.1.1 DUCTILE IRON PIPE

A. Ductile Iron Pipe

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. 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.

The ductile iron pipe shall be cement mortar lined with a seal coat in accordance with ANSI/AWWA C104/21.4. Hi-Alumina or Protecto 401 shall be used at the specific locations indicated on the drawings or as required by the City Engineer. Outside coat shall be a minimum of 1 mil bituminous paint according to ANSI/AWWA C151/A21.21 Section 51-8.1.

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*," or "*Tyton*,"). 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 Federal Specification WW-P-421, AWWA C111/ANSI A21.11, and ASTM A 536 Standard Specification of Ductile Iron Castings.

C. Ductile Iron Fittings

Fittings shall be ductile iron 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 in accordance with AWWA C104/ANSI A21.4 and the outside shall be bituminous coated. 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.

D. Ductile Iron Pipe for Aerial Crossings (*without encasement and carrier pipe*):

Pipe shall meet the requirements of Section 02730, 2.1.1.A. Joints shall be restrained mechanical or flanged joints meeting the requirements of Section 02660, 2.1.1.B.3 or 4. Exposed bolts, nuts, and washers shall be 316 Stainless Steel. Details of pipe joints and structural support of aerial crossings shall be submitted to the City Engineer for approval prior to construction.

2.1.2 PVC PIPE

A. PVC Pipe and Fittings

PVC Solid Wall Sewer Gravity Pipe and Fittings, Bell and Spigot Joints shall comply with ASTM D3034, *Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings*, SDR 26 minimum (6 inches - 15 inches). For 18-, 21-, 24- and 27-inch diameter PVC, SDR 26, comply with the requirements of ASTM F679, *Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings*, or latest revision. Laying lengths shall be a minimum of 12.5 feet for pipes 15 inches or less and 11 feet for the pipes greater than 15 inches. PVC pipe strength shall be capable of withstanding stiffness, flattening, and impact test as scheduled or referenced in ASTM D3034 or ASTM F949. Smooth wall pipe shall have a Standard Dimension Ratio (SDR) of 26 or less. All PVC pipe shall have a minimum pipe stiffness of 46 psi when measured at 5 percent vertical ring deflection and tested in accordance with ASTM F477, *Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe*.

B. PVC Pipe Joints

Joints for Solid Wall PVC Sewer Gravity Pipe & Fittings and Elastomeric flexible seals (Gaskets) shall be compatible with pipe and shall meet the requirements of ASTM D3212 *Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals*. Rubber Gaskets shall be used which conform to the requirements of ASTM F477, *Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe*.

2.1.3 STEEL PIPE

Steel Pipe for Sewer Mains, Aerial Creek Crossings, Encasement, Boring Applications, and Vent Pipes:

Steel pipe for gravity sewer mains and aerial crossings 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. Pipe 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.

- 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. The interior lining shall be a coal-tar enamel coating as specified under AWWA C203 of liquid epoxy coating as specified under AWWA C210.
- 2) **Steel Pipe for Aerial Creek Crossings** (*without encasement and carrier pipe*): Minimum wall thickness shall be 0.250 inch. The outside of the pipe shall have one coat of zinc chromate primer conforming to Federal Specification TT-86-a and afterwards painted with coal tar enamel. The interior lining shall be a coal-tar enamel coating as specified under AWWA C203 or liquid epoxy as specified under AWWA C210. Pipe shall not be joined by butt welding. Pipe joints shall be restrained mechanical joint couplings. Details of pipe joints and structural support of aerial crossings shall be submitted to the City Engineer for approval prior to construction. Exposed bolts, nuts, and washers shall be 316 stainless steel.
- 3) **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 **Standard Detail 27.23**. Refer to **Standard Detail 27.23** for spider spacing. Spiders shall be of heavy-duty galvanized steel.

- 4) **Steel Vent Pipes for Manholes:** The vent pipe shall be made from 4-inch Schedule 40. The pipe shall be pipe shop galvanized on the interior or have a cement-lined interior. Exterior paint shall be per **Standard Detail 27.06**.

2.1.4 TUNNEL LINERS AND APPURTENANCES

- A. 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.
- B. 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.
- C. 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.
- D. 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.
- E. 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.
- F. 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.

2.1.5 CARRIER PIPE FOR CASINGS AND TUNNELS

Carrier pipe shall be restrained joint ductile iron pipe class 50.

2.2 MISCELLANEOUS APPURTENANCES

2.2.1 BEDDING

See Section 02220, *Trenching, Backfilling, and Compaction of Utilities*.

2.2.2 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*.

2.2.3 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.

2.2.4 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

2.2.5 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.

2.2.6 PORTLAND CEMENT

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

2.2.7 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. A rubber gasket joint seal shall be used and 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.

Manhole steps are not permitted.

Unless otherwise allowed by the City Engineer, manholes will be precast reinforced concrete. Drop manholes shall be constructed in accordance with **Standard Details 27.04 and 27.05**. Interior and exterior drops are permitted on both existing and new manholes. Utilities Engineer approval is required for exterior drop manhole use. All drop manholes shall have a minimum diameter of 4 feet, with the exception of interior drops on new construction which shall have a 5-foot minimum diameter. Refer to the **Standard Details 27.02, 27.03, 27.04, & 27.05** for boot to pipe connection detail. Manholes over 12 feet in depth, as measured from top of casting to effluent invert, 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 NPC, Inc., Milford, New Hampshire, 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 Scour Protection:** Scour protection coating shall be fiberglass reinforced polyamine epoxy or elastomeric polyurethane as manufactured by

Tnemec, Inc., Kansas City, MO; Carboline Company, Saint Louis, MO; or approved equal.

- D. **Manhole External Wrap:** Wrap shall be made of a stretchable, self-shrinking, intra-curing halogenated based rubber with a minimum thickness of 30 mils. The wrap shall have a non-hardening butyl adhesive backing used to attach the wrap to the structure. Product shall be Gator Wrap as manufactured by Infi-Shield or approved equal.
- E. **Grade/Riser Ring External Sealant:** The sealing system shall be a Uni-Band sealing system as manufactured by Sealing Systems, Inc. (800-478-2054) or approved equal. The seal shall be a continuous seamless band made of high quality EPDM (Ethylene Propylene Diene Monomer) rubber with a minimum thickness of 65 mils.

2.2.8 MANHOLE FRAMES AND COVERS

- A. **Standard Frames and Covers:** Manhole frames and covers shall be manufactured from Class 30 gray iron, meeting the requirements of ASTM A48, *Standard Specification for Gray Iron Castings*. Standard manhole frames and covers shall be manufactured to the dimensions and configurations shown on **Standard Details 27.10 and 27.11** and shall have 4 or 6 1-inch diameter holes in the flange of the frame, as applicable. Minimum inside diameter of the opening shall be 24 inches. Manholes castings may be either bituminous coated or plain. 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 words "Sanitary Sewer." Approved castings are the US Foundry 710 ring and DP cover, East Jordan Iron Works 2027 frame and cover, Capitol Foundry or approved equal. (See **Standard Details 27.10 & 27.11**).

A Vulcan V-1883 is to be used with flat top manholes unless the top of the manhole is less than 1-foot above the 100-year base flood elevation. In that case, a waterproof frame and cover shall be used.

- B. **Waterproof Frames and Covers:** Waterproof bolt-down frames and covers shall have 4 stainless steel bolts at 90 degrees and one polyvinyl gasket between cover and frame seat. Frame is to have a minimum of four 1-inch diameter holes in flange of the frame. Bolt down frames and covers are to be utilized whenever manhole top is set lower than 1-foot above the 100-year base flood elevation. Covers are to be embossed along the perimeter with the words "Sanitary Sewer." Frame and covers shall be manufactured by US Foundry, East Jordan Iron Works, Capitol Foundry or approved equal. Frame and cover shall be equipped with rubber gasket. See **Standard Detail 27.11**.
- C. **Frame to Manhole Bolts:** Bolts shall be stainless steel expansion bolts manufactured by Hilti, Rawl or Liebig. See **Standard Detail 27.02**. This requirement shall apply for waterproof frames and covers.

2.2.9 SERVICES

PVC sewer service pipe for sewer services shall be Schedule 40 PVC, ASTM D1785, *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe*,

Schedules 40, 80, and 120, solvent cement joints (type SC) including the clean-out stack. See **Standard Detail 27.15**.

Service Saddles: PVC sewer pipe, saddles and adapters shall conform to the requirements of ASTM D3034, *Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings*.

PART 3 – EXECUTION

3.1 PIPE INSTALLATION - GENERAL

3.1.1 CONSTRUCTION – ALL PIPE

- A. **Trench Width:** Trench width shall be per **Standard Detail 27.01**.
- B. **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.
- C. **Directional Changes in Gravity Lines:** Use manholes for changes in direction of gravity lines.
- D. **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.
- E. **Pipe Laying:** Pipe shall be bedded and metallic tape installed per Section 02220 – *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 Health based on regulations in affect at the time of the change and so long as the changes are consistent with City of Lynchburg policy in affect 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. See **Standard Details 27.13, 27.14, 27.15, and 27.16**. 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.

At least 4 joints shall be left exposed for inspection purposes during the working day and a suitable ladder affording easy and safe access for such inspection shall be furnished.

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

- F. **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.
- G. **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.
- H. **Surface Water Crossings:** Surface water crossings with pipe under streambed shall have the pipe encased in concrete as detailed by **Standard Detail 27.19** (*Sewer Line Crossing Beneath Stream Bed*).
- I. **Ravine Crossings:** Surface water crossings with pipe above the water shall be adequately supported by pipe support piers as shown on **Standard Detail 27.17** and **27.18**. Kraft paper shall be placed between pipe and all points of contact with concrete and steel straps.

3.1.2 DUCTILE IRON PIPE

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

Pipe	Maximum Bury to Invert of Pipe*	
	Type 4 Laying Condition - Equivalent to Class C Bedding (See Detail 27.01)	Type 5 Laying Condition - Equivalent to Class B Bedding (See Detail 27.01)
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

*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).

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 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. Aerial Pipe

Where required, ductile iron aerial pipe shall meet the length, thickness, and diameter shown on the plans.

Pipe is to be joined by flanged or restrained mechanical joint.

Pipe support piers shall be constructed in accordance with **Standard Detail 27.17** or **27.18**, as applicable. One support shall be placed at each length of pipe, immediately behind the pipe bell where possible otherwise within 2 feet of each joint.

3.1.3 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

Table 27.2		
Bury Limitations on all PVC		
Pipe	Bedding Class	Maximum Bury to top of pipe ^a
SDR 26 PVC	Class B-1 w/ VDOT # 57 stone	22 feet

^aBury is based on SDR 26 pipe, E'=1000 psi (dumped crushed rock), H20 loading, earth load = 120 pcf, D_L=1.0, E=400,000 psi (PVC pipe), K=0.1, and a maximum long term deflection not exceeding 5%, Modified Iowa Equation.

Minimum cover shall not be less than 4 feet.

3.1.4 STEEL PIPE

A. Aerial Pipe

Where required, steel aerial pipe shall meet the length, thickness, and diameter shown on the plans.

Pipe is to be joined by welded lap joints, flanged joints, or restrained mechanical joints. Joining of steel pipe shall meet the requirements of AWWA C206, *Standards for Field Welding Steel Water Pipe Joints*. Pipe shall not be joined by butt welding. Field welding shall not damage the interior coating.

Pipe support piers shall be constructed in accordance with **Standard Detail 27.17** or **27.18**, as applicable. A pier shall be installed at each joint, where possible otherwise within 2 feet of each joint. Kraft paper shall be placed between pipe and all points of contact with concrete and steel straps. Upon completion of installation, paint the exterior of the pipe with coal tar enamel.

B. Encasement Pipe

Where required, steel encasement pipe shall meet the length as shown on the plans and the thickness and diameter as shown on **Standard Detail 27.23**. The Contractor shall submit to the City Engineer 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.

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 as shown on **Standard Detail 27.23**.

Manufactured Spiders: Refer to **Standard Detail 27.23** for spider spacing.

3.2 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.

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.

3.3 MANHOLE CONSTRUCTION

- A. **Standard Manholes:** Manholes shall be constructed in accordance with **Standard Details 27.02** and **27.03**. Manholes shall be vacuum tested after installation of all mains and services according to paragraph 3.9 C.

Manholes shall be installed plumb.

All lift holes shall be plugged with nonshrink grout.

- B. Each manhole shall be sealed with an external rubber wrap. The back side of each unit shall be coated with butyl adhesive. The seal shall stretch around the manhole then overlap creating a fused bond between the rubber and butyl adhesive. The application shall form a continuous rubber seal that applies inward pressure on the protected area for the life of the application. The wrap shall be installed per manufacturer's recommendations.
- C. **Grade Rings/Adjustments:** The Contractor shall exercise care in the ordering of manholes so that the use of grade rings for leveling and adjustments can be minimized. In street rehabilitation work, the combination of grade rings shall not exceed 12 inches before removal of the cone is necessary to effect adjustment.

On all manholes, a mastic joint material shall be placed between the frame and cover and the cone or grade ring.

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.

Grade/Riser Rings shall be sealed sufficiently to prevent leakage of water into the manhole through the frame joint and/or the adjustment ring. The casting shall be sealed to the structure with a specified sealing system in accordance with manufacturer's recommendations.

D. Drop Manholes

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

Interior drop (**Standard Detail 27.04**) connections for new 5-foot and larger diameter manholes shall consist of either entirely schedule 40 PVC pipe with solvent cement joints or a combination of a Reliner or PREDEL low profile inside drop or approved equal and 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 tee 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.

Interior drop (**Standard Detail 27.04**) connections for existing 4-foot diameter manholes shall consist of a Reliner or PREDEL low profile inside drop bowl, or approved equal. Interior drop manholes shall be installed as shown in detail. Manholes shall be cored and booted for the inlet line.

Exterior drop connections (**Standard Detail 27.05**) shall consist of DIP and mechanical joint fittings. Exterior drop manhole shall be installed per detail. Manholes shall be cored and booted for the inlet line. Exterior drop manholes will only be allowed upon the approval of the Utilities Engineer.

E. Replacement/Rehabilitation of Existing Manholes

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.

See Specification Section 02790- *Manhole Rehabilitation* for specifications on rehabilitation of existing manholes.

F. **Flexible Pipe-to-Manhole Connector:** The connector shall be installed per manufacturer's recommendations.

G. **Precast Concrete Doghouse Manholes:** Precast Concrete Doghouse manholes shall be installed per **Standard Detail 27.07**.

- H. **Installation of Manhole Frames and Covers:** Frames and covers shall be installed to manhole with bolts in accordance with **Standard Details 27.02** and **27.03**. Butyl sealant shall be installed between the cone or adjusting ring and the frame and cover. Frame and covers shall be installed to elevation shown on plans. Adjustments shall be made as necessary to achieve design elevation.
- I. **Manholes with influent pipes exceeding 10 percent slope:** Where influent pipes exceed 10 percent entering a manhole, a means to reduce the velocity entering the manhole shall be provided by one of the following methods:
- 1) Installation of an interior drop connection for influent pipe as per **Standard Detail 27.04**.
 - 2) Installation of sacrificial concrete on the walls and floor of the manhole as directed by and to the satisfaction of the City Engineer.
 - 3) Installation of erosion resistant (scour protection) coating on the walls and floor of the manhole. Coatings shall be applied in accordance with the manufacturer's recommendations.

3.4 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 Construction Coordinator, VDOT #57 stone dumped into the manhole, and the stone vibrated to consolidate the 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.

3.5 BYPASS PUMPING

Bypass pumping shall be performed in accordance with Section 02770- *Sewer Flow Control*.

3.6 SERVICE CONNECTIONS

- A. Unless otherwise approved by the City Engineer, sewer services shall be Schedule 40 PVC with solvent cement joints or DIP. Where laterals are bored or placed in non-buried conditions, 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 otherwise approved by the City Engineer.

- 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 27.14**) 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 (see **Standard Detail 27.16**). 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. The cost for such cut-ins shall be included in the cost of the lateral.
- E. A combination wye is to be provided at the cleanout set at the property line. All laterals are to be left exposed until the Construction Coordinators can verify the installation of each service.
- F. 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 Details 27.14, 27.15, and 27.16** for bedding requirements of sewer laterals.
- G. Vertical stacks or standpipe services are not allowed.
- H. The cleanout shall be located at the right of way or easement line on the City side of the line and constructed as shown on **Standard Detail 27.15**, unless otherwise directed or approved by the City Engineer.
- I. Minimum grade for services shall be 1/4-inch per foot.
- J. 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 unless otherwise directed by the City Engineer.

3.7 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. Misalignments of the crossings shall be cause for total removal and replacement of the encasement and pipe at the Contractor's expense.

Once the concrete is set, measures shall be taken to cure the concrete by covering it with plastic. 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 27.19** for application of concrete encasement.

3.8 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 as shown on the plans and constructed to the dimensions shown on **Standard Detail 27.21**.

3.9 TESTING

A. General Requirements

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

Material	Air Test	Vacuum Test	Visual	Infiltration/Exfiltration
DIP	X		X	
PVC	X		X	
Manholes		X	X	
Pipe greater than 24 inches			X	X

Upon completion of entire pipe installation, the City Engineer may inspect the work in part or as a whole and make such tests as will satisfy himself/herself 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.

Testing and inspection shall be completed within 90 days of installation and backfilling of sewer pipe including services. Testing intervals and sequences shall be as determined by the Construction Coordinator.

Furnish all pumps, gauges, instruments, test equipment, and personnel required for inspections and testing operations.

Flush all sand, dirt, and debris from lines prior to inspection. Provide lights and mirrors and inspect lines in presence of the Construction Coordinator.

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

All final testing and inspections shall be performed in the presence of the Construction Coordinator. All final testing and retesting results shall be recorded

on copies of test data sheets by the Construction Coordinator. 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.

Visual Inspection: All sewer lines and manholes shall be visually inspected by the contractor/developer in the presence of the City Construction Coordinator from every manhole by use of mirrors and television cameras and in accordance with Section 02760 - *Television Inspection of Sewer Lines*. The lines shall exhibit a fully circular pattern when viewed from one manhole to the next. Lines that 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. Line Testing

1) Low-Pressure Air Tests

Low-pressure air test shall be the primary method of testing for pipe diameters 24 inches or less. Tests for PVC pipe shall comply with ASTM F1417. Tests for DIP shall conform to ASTM F1417 or appropriate ASTM DIP low-pressure air test for gravity sewers.

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.

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 of Lynchburg's Construction Coordinator.

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

If the time, shown in **Table I, Line Pressure Air Test Table** (appendix) for ASTM F1417 tests and **Table III, Minimum Test Time for Various Pipe Sizes** (appendix) for ASTM C924 tests for the designated line size and length, elapses before the air pressure drops 1 psi, the section undergoing the test may be discontinued once the prescribed time has elapsed even though the 1.0 psi drop has not occurred. The section of line has passed. Record all readings.

If the pressure drops 1.0 psi before the appropriate time shown in **Table I, Line Pressure Air Test Table** (appendix) for ASTM F1417 tests and **Table III, Minimum Test Time for Various Pipe Sizes** (appendix) for ASTM C924 tests has elapsed, the air loss rate shall be considered excessive and that section of pipe has failed. Record all readings.

If any sections of pipe fail the air test, the Contractor shall determine, at their own expense, the source or sources of leakage and shall repair or replace all defective material and workmanship. 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 re-tested and required to meet the requirements of this test.

If the pipe to be tested crosses under a stream, the allowable pressure drop shall be 0 psi over the test period shown in Table 1 as tested from manhole to manhole.

Note: 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.

2) Infiltration/Exfiltration Test

Infiltration/Exfiltration tests shall be used for pipe diameters greater than 24 inches.

Allowable leakage of pipe using Infiltration/Exfiltration 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.

C. Manhole Testing

Manholes shall be vacuum tested as indicated below unless otherwise allowed by the Engineer. Vacuum testing shall meet ASTM C1244 *Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test*, or latest revision.

The test shall be made using an inflatable compression band, vacuum pump, and appurtenances specifically designed for vacuum testing manholes. Equipment to be manufactured by Peter A Glazier & Associates, Worchester, MA or approved equal.

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 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. The maximum allowable leakage rate for manholes shall be in accordance with Table II at the end of this section.

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 City Engineer. Leaks shall be repaired on the outside of the manhole unless approved otherwise by the City Engineer. If a manhole joint mastic material is completely pulled out during the vacuum test, the manhole shall be disassembled and the mastic replaced.

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 F 1417)

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	3:46
6	5:40	398	.854 L	5:40	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	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	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	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	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	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	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

TABLE III
Line Pressure Air Test Using Low-Pressure Air
SPECIFICATION TIME REQUIRED FOR A 1.0
PSIG PRESSURE DROP
 (Excerpted from ASTM C 924)

1 Pipe Diameter (in.)	2 T (time), (min:100 ft)
4	0.3
6	0.7
8	1.2
10	1.5
12	1.8
15	2.1
18	2.4
21	3.0
24	22:40

END OF SECTION 02730

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