

## Technical Specification 020

### GRAVITY SANITARY SEWER SYSTEM

#### 1.0 General

- a) It is the intent of this specification to ensure that all gravity sewer system infrastructure constructed within the service area of Brunswick County Public Utilities meets or exceeds all local, state, and federal rules and regulations as applicable. It is also the intent of this specification to provide the technical guidance needed to the utility contractor to ensure that county gravity sewer system infrastructure is properly constructed, tested, and placed in service. Service laterals shall be installed where shown on the drawings or as directed by the county's representative. Excavation, trenching, and backfilling is covered in Brunswick County Technical Specification TS 013: Excavating, Grading, Trenching, and Backfilling.

#### 2.0 References

- a) ASTM D1784 - Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
- b) ASTM D1785 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 20.
- c) ASTM D2241 - Poly (Vinyl Chloride) (PVC) Pressure-rated pipe (SDR Series).
- d) ASTM D2152 - Test Method for Degree of Fusion of Extruded Poly (Vinyl Chloride) (PVC) Pipe and Molded Fittings by Acetone Immersion.
- e) ASTM D2321 - Underground Installation of Flexible Thermoplastic Sewer Pipe.
- f) ASTM D2412 - External Loading Properties of Plastic Pipe by Parallel-Plate Loading.
- g) ASTM D2444 - Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight).
- h) ASTM D3034 - Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
- i) ASTM D3212 - Elastomeric push-on joints for plastic pipe.
- j) AWWA C600 - Installation of Ductile - Iron water mains and appurtenances.
- k) AWWA C900 - PVC Pressure Pipe 4 inch through 60 inch.
- l) ASTM D2672 - Bell-End Poly (Vinyl Chloride) (PVC) Pipe.

- m) ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
- n) ASTM F478 - Precast Concrete Manhole Risers and Tops.
- o) ASTM C497 - Concrete Pipe, Manhole Sections, or Tile.
- p) ASTM F679 - Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
- q) ASTM A746 - Ductile Iron Gravity Sewer Pipe.
- r) ASTM F794 - Poly (Vinyl Chloride) (PVC) Ribbed Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.
- s) AWWA C600 - Standard for Installation of Ductile Iron Pipe Mains and Appurtenances
- t) ASTM A536 – Standard Specification for Ductile Iron Castings
- u) ASTM A48 – Standard Specification for Gray Iron Castings
- v) ASTM F2764 – Standard Specification for 6 to 60 in [150 to 1500 mm] Polypropylene (PP) Corrugated Double and Triple Wall Pipe and Fitting for Non-Pressure Sanitary Sewer Applications
- w) ASTM C478 – Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
- x) ASTM C1244 – Standard Test method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
- y) ASTM D3350 – Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

### **3.0 Materials and Requirements for Gravity Sewer Mains**

- a) General
  - 1) To the maximum extent possible all materials shall be manufactured in the United States. This includes all pipe, valves, fittings, hydrants, meter boxes, etc.
  - 2) All pipe material shall be marked with the manufacturer, type, class, thickness, and date of production in lettering legible to county staff.
  - 3) The engineer is responsible for reviewing all shop submittals for written approval. County staff may assist to answer any questions concerning shop submittals.

- 4) All pipes, manholes, fittings, etc., must conform to AWWA standards.
  - 5) The minimum vertical ground cover over a gravity sewer main shall be thirty-six (36) inches.
  - 6) Gravity sewer mains shall be constructed of C900 DR-18 PVC piping. Ductile iron pipe (DIP) may only be used with express written permission of Brunswick County Public Utilities or Engineering Department.
  - 7) All pipes shall be shipped with gaskets installed inside the pipe bell.
  - 8) Restraint type gaskets that provide internal restraint by means of stainless steel inserts embedded within the gasket are **not** permitted for use in Brunswick County.
  - 9) PVC sewer mains shall be factory dyed industry standard green.
- b) Polyvinyl Chloride Pipe (PVC)
- 1) Sewer mains with depth of earth cover three (3) feet to ten (10) feet:
    - a) Eight (8) inch through twelve (12) inch PVC mains shall be C900 DR-18 or better conforming to ASTM D3034. Joints shall conform to ASTM D3139 or ASTM D3212.
    - b) Fourteen (14) inch through thirty-six (36) inch PVC mains, unless specified as DIP, shall be AWWA C900 Class 235 (DR-18). Joints shall conform to ASTM D3139 or ASTM D3212.
  - 2) Sewer mains with depth of earth cover ten (10) feet to twenty (20) feet:
    - a) Eight (8) inch through twelve (12) inch PVC mains shall be C900 DR-18 or better conforming to ASTM D3034. Joints shall conform to ASTM D3139 or ASTM D3212.
    - b) Fourteen (14) inch through thirty-six (36) inch PVC mains, unless specified as DIP, shall be AWWA C900 Class 235 (DR-18). Joints shall conform to ASTM D3139 or ASTM D3212.
  - 3) Sewer mains with depth of earth cover greater than twenty (20) feet:
    - a) Pipes installed at depths greater than twenty (20) feet shall be constructed of C900 DR-18 or better per manufacturer's recommendations based on depth and soils classification. DIP may be allowed with the express written permission of Brunswick County Utilities or Engineering Department.
  - 4) All PVC mains shall be manufactured with PVC material conforming to PVC 1120.

- 5) Fittings shall be molded PVC with joints similar to the PVC pipe. Fabricated fittings using solvent welded joints are not acceptable. Fittings may also be DIP fittings listed and documented as approved for use with PVC pipe and shall have an asphaltic coating on the exterior for corrosion resistance, and an interior lining of ceramic epoxy Protecto 401, Ceramapure PL90 (or equivalent), unless otherwise shown or specified.
  - 6) Acceptable products are Diamond Plastics Corporation, J M Eagle Manufacturing Company, National, Certainteed, North American, U.S. Composite Pipe or written approved equal.
- c) Ductile Iron Pipe (DIP)
- 1) Ductile iron pipe (DIP) may only be used with express written permission of Brunswick County Public Utilities or Engineering Department.
  - 2) If DIP is required, it shall conform to ANSI / AWWA C150 / A21.50 and ANSI / AWWA C151 / A21.51, with an exterior asphaltic coating for corrosion resistance, and an interior lining of Protecto 401 Ceramapure PL90 (or equivalent) unless otherwise shown or specified.
  - 3) All sizes of pipe shall be manufactured to a nominal laying length of 18'-0" or 20'-0", except to make adjustments for bends, tees, and other fittings.
  - 4) Joints shall be the push-on or mechanical joint type conforming to ANSI / AWWA C111 / A21.11 as modified by ANSI / AWWA C151 / A21.51.
  - 5) Rubber gaskets and lubricant shall conform to ANSI / AWWA C111 / A21.11.
  - 6) No metric sized pipe shall be permitted.
  - 7) If DIP is required, and the soils are found to be corrosive, then all DIP and fittings shall be wrapped in a polyethylene encasement per ANSI / AWWA A21.5 / C105 Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids.
  - 8) Acceptable products are American Cast Iron Pipe Company, Griffin Pipe Company, U.S. Composite Pipe, or written approved equal.
- d) Installation
- 1) Contractor shall install PVC gravity sewer mains in accordance with ASTM D2321. Ductile iron mains shall be installed in accordance with AWWA C600. Both types of material installations shall adhere to excavation, trenching, and backfilling standards as covered in Brunswick County Technical Specification TS 013: Excavating, Grading, Trenching, and Backfilling.

- 2) Pipe shall be installed starting from the lowest point and shall be laid with the spigot ends pointing in the direction of flow.
- 3) Gravity sewer trenches shall be kept free of standing water during installation by use of a pump. If deemed necessary prior to or during construction, well point systems should be used for dewatering.
- 4) All mains shall have locating tape, and shall be as follows:
  - a) Tape shall be three (3) inches wide, green in color, bearing continuous message "CAUTION SEWER LINE BURIED BELOW".
  - b) Tape shall be made of plastic or other permanent material.
  - c) Tape shall be buried continuously above the gravity sewer main at a depth of eighteen (18) inches below finished grade.
- 5) No sewer line of any type shall pass through any storm drain structure unless first approved by county staff in writing.
- 6) When a transition is required from a PVC sewer main to ductile iron pipe sewer main, mechanical joints will be used. Mechanical joints shall conform to AWWA C111. Bolts shall be high strength low alloy steel per AWWA C111.
- 7) When installing a gravity or force main above or below a water main or storm drain, all minimum separations and material requirements must be met, as defined by 15 NCAC 02T .0305 and 15A NCAC 18C .0906 (b) and (c); outlined below:
  - a) Gravity sewer mains shall be laid at least ten (10) feet horizontally from existing or proposed water mains, unless local conditions or barriers prevent a 10-foot separation, in which case;
  - b) The sewer main shall be C900 DR-18 or better and shall be laid in a separate trench, with eighteen (18) inch minimum separation between the invert of the water main and the crown of the sewer main; or the water main shall be laid in the same trench as the sewer, with the water main located at one side on a bench of undisturbed earth and with the elevation of the bottom of the water main at least eighteen (18) inches above the top of the sewer.
  - c) When a gravity sewer main crosses a water main, the sewer main will be built to water main rules (15A NCAC 18C .0906); where one full length of water pipe shall be located so that both joints will be as far from the sewer as possible.

- d) When a gravity sewer main crosses a storm sewer or other utilities, eighteen (18) inch minimum separation must be achieved. If this separation cannot be achieved, the gravity main shall be constructed in a manner concurrent with Brunswick County standard detail S-15.
- e) When a gravity sewer main crosses a reclaimed water line, eighteen (18) inch minimum vertical (reclaimed over sewer) or two (2) feet horizontal separation must be achieved.

#### 4.0 Materials and Requirements for Sewer Services

##### a) General

- 1) Pipe and fittings for four (4) inch and six (6) inch gravity sewer services shall be constructed of SCH 40 PVC pipe conforming to ASTM D178 with solvent welded joints.
- 2) Sewer services shall be installed in accordance with county standard details.
- 3) All services shall be single services. No double services are to be installed.

##### b) Installation

- 1) All gravity sewer services are to be installed using a wye angled downstream of the main.
- 2) The service wye should be turned to the top quadrant of the gravity main – approximately (45) degrees from the top centerline of the main. In no case, shall the service laterals be stacked vertically over the gravity main.
- 3) Gravity sewer services shall be installed perpendicular to the gravity main.
- 4) Wherever possible, gravity services shall be tied into a gravity line.
- 5) Services shall be installed so that they meet minimum clearances from existing and proposed utilities, such as eighteen (18) inch minimum separation below a water main. If clearances cannot be met, then gravity sewer services shall be constructed of SCH 40 PVC pipe or better.
- 6) The minimum vertical ground cover over a gravity sewer lateral shall be twenty-four (24) inches (thirty-six (36) inches if in NCDOT right-of-way).
- 7) Sewer services shall terminate with a wye to a surface cleanout complete with square nut cap, cast iron box, and cover marked “C/O” or “SEWER”. The invert of the wye shall be capped with a watertight plug for future plumbing connection. See county standard details.

- 8) Install a 4"x4"x 6' treated timber marker at the property or easement line behind the service cleanout for location of the service. The timber shall be installed with 2' buried and 4' visible above final grade.
- 9) Services shall be installed at a minimum grade of 1/8 inch per foot. Service termination grade shall be at adequate depth for future plumbing connection.

## 5.0 Materials and Requirements for Manholes

### a) General

- 1) To the maximum extent possible all materials shall be manufactured in the United States. This includes all precast and drop manholes, frames, grates, covers, etc.
- 2) To protect against hydrogen sulfide corrosion, polypropylene and precast polymer concrete manholes are the preferred materials for gravity sewer manholes. Concrete manholes shall not be used as receiving manholes or where pressurized sewer mains enter the manhole.
- 3) Joint surfaces between bases, risers and cones shall be manufactured to the joint surface design and tolerance requirements of ASTM C76.
- 4) Flexible joint sealants shall be butyl rubber-based conforming to Federal Specification SS-S-210A, AASHTO M-198, Type B - Butyl Rubber and as follows: maximum of 1% volatile matter and suitable for application temperatures between 10- and 100-degrees F.
- 5) Pipe to manhole connectors shall conform to ASTM C923. The location of the pipe connectors shall vary from the location shown on the project plans by no more than (1/2) inch vertically and five (5) degrees horizontally. Provide for control of the pipe OD to within the tolerances of the connector on flexible pipes larger than twelve (12) inches.
- 6) Manholes shall have a minimum inside diameter of four (4) feet for sewer mains eighteen (18) inches diameter and smaller and shall be five (5) feet inside diameter for sewer mains larger than eighteen (18) inches. Larger inside diameters may be required for larger pipe sizes, more than two pipes, or when entrance/exit angles require a larger manhole.
- 7) The receiving manhole in a gravity sewer main line immediately before the lift station shall be polymer concrete and have a minimum inside diameter of five (5) feet.
- 8) Where pressurized sewer mains connect to a gravity sewer manhole structure, a minimum four (4) feet inside diameter plastic polypropylene or polymer concrete manhole structure shall be used.

- 9) When a watertight manhole is to be used due to flood plain location, a vent pipe shall be installed for proper ventilation of the manhole. Refer to county standard details.
  - 10) All manhole covers are to be clearly marked "Sanitary Sewer".
  - 11) Manhole steps shall be provided in bases, risers, and cones and aligned vertically on center. Steps shall be cast in place or, if approved by the County, secured to the wall with a compression fit in tapered holes. Steps shall not be vibrated or driven into freshly cast concrete or grouted in place. The steps shall be Copolymer Polypropylene Plastic reinforced with a ½" diameter grade 60 bar and have serrated tread and tall end lugs. Step pullout strength shall be tested per ASTM C497.
  - 12) All manhole frames and covers shall conform to ASTM A48.
  - 13) Sanitary sewer covers shall utilize lifting bars instead of pick holes.
  - 14) Standard covers shall have up to four (4), one (1) inch diameter vent holes.
  - 15) Watertight manhole covers are required for all manholes where the rim elevation is less than two (2) feet above the 100-year flood elevation or the 500-year flood elevation, whichever is lower.
  - 16) The maximum separation between manholes shall be 400 feet, unless otherwise approved by Brunswick County in writing.
  - 17) Outside drop manholes, for new construction, shall be provided where invert separations exceed 2.5 feet (30 inches).
  - 18) Acceptable manufacturers of watertight manhole frames and covers are US Foundry, Capitol Foundry, East Jordan, or written approved equal.
- b) Plastic Polypropylene Manhole Structures
- 1) Plastic polypropylene manhole structures shall have a minimum inside diameter of four (4) feet. The installation of a plastic polypropylene manhole must be according to the manufacturer's specifications and written approval by Brunswick County.
  - 2) Plastic polypropylene manhole structures shall follow manufacturer specifications for minimum angles between adapters when connecting sewer mains.
  - 3) Four (4) feet inside diameter and larger polypropylene manhole structures shall be fabricated from triple wall pipe made from an impact modified copolymer polypropylene meeting the material requirement of ASTM F2764. The body riser shall be provided with an integrally cast into a reinforced concrete base meeting the requirements of ASTM C478.

The base and riser shall meet the performance requirements outlined in ASTM C1244. The eccentric cone reducer shall be manufactured from polyethylene material meeting ASTM D3350 cell class 213320C. Water tight connections meet the testing requirements of ASTM D3212.

- 4) All plastic polypropylene manhole installations shall conform to manufacturer specifications for maximum allowable depth and deep burial installation requirements.
- 5) All new drop manhole structures shall be outside drop.
- 6) All plastic polypropylene manhole structure frames and covers shall conform to ASTM A48, unless otherwise specified by the manufacturer.

c) Concrete Manholes

- 1) Concrete shall conform to ASTM C478 and as follows:
  - a) Compressive strength: 4000 psi minimum at 28 days.
  - b) Air Content: 4 percent minimum.
  - c) Cementitious Materials: Minimum of 564 pounds per c.y.
  - d) Coarse Aggregates: ASTM C33.
  - e) Fine Aggregates: ASTM C33. Free from organic impurities.
  - f) Chemical Admixtures: ASTM C494. Calcium Chloride or admixtures containing calcium shall not be used.
  - g) Air Entraining Admixtures: ASTM C260.
- 2) Mortar shall be Type S conforming to ASTM C270.
- 3) Brick shall be used to bring concrete manhole rings to grade or filler for forming manhole inverts only and shall conform to ASTM C62 Grade SW or ASTM C32 Grade MS.
- 4) Concrete manholes shall have an eccentric cone. Concrete manholes four (4) feet deep or less may have a flat top.
- 5) Concrete manholes shall have a minimum six (6) inch extended base.
- 6) Concrete manholes shall not be used as receiving manholes or where pressurized sewer mains enter the manhole.

- 7) New concrete drop manholes shall be outside drop, unless otherwise approved by Brunswick County in writing. Where approved, inside drop manholes shall have a minimum inside diameter of five (5) feet.
- 8) Acceptable manufacturers of standard manhole frames and covers are US Foundry, Capitol Foundry, East Jordan, General Foundries, or written approved equal.
- 9) Each concrete manhole shall be equipped with an insert of high-density polymer meeting the requirements of ASTM 124. Concrete manholes located in traffic areas shall have stainless steel sewer guards.
- 10) Concrete manhole interiors shall be factory coated with a minimum twenty (20) mils coal tar epoxy or other County written approved coating, except where polymer concrete is used.
- 11) Where pressurized sewer mains connect to an existing gravity sewer manhole, the manhole shall be polymer concrete or plastic polypropylene to protect against hydrogen sulfide corrosion. Where pressurized sewer mains connect to a gravity sewer manhole, the inside diameter of the manhole shall be four (4) feet minimum.

It may be required to replace the existing manhole with a plastic polypropylene manhole structure, or precast polymer concrete manhole.

- 12) All damage to pre-cast concrete sections shall be thoroughly repaired. Repair and patching of minor breaks shall be done by chipping and scarifying the defective area before application of grout. Pre-cast sections shall be subject to rejection on account of failure to conform to any of the specification requirements. In addition, individual sections of manhole sections may be rejected because of fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint; defects that indicate imperfect proportioning, mixing, and molding; surface defects indicating honey-combed or open texture; damaged or cracked end, where such damage would prevent making a satisfactory joint; and/or any continuous crack having a surface which width of 0.01 inches or more and extending for a length of twelve (12) inches or more, regardless of position in the section wall.
- 13) For concrete manholes, all joints, cracks, lifting nooks inside the manhole are to be grouted to prevent infiltration. All interior grouting shall be covered in a field coat of coal tar epoxy. All exterior joints are to be wrapped with flat butyl rubber tape.

d) Installation

1) Setting:

- a) The contractor is responsible for getting the manhole tops to proper grade. The top of the pre-cast manhole may be brought to proper grade for receiving manhole frames by using precast riser rings, unless otherwise approved for masonry in writing. Masonry construction shall be performed by experienced and qualified workmen. All work shall be laid plumb, straight, level, square, and true. Total extensions may not be made greater than six (6) inches – limited to three (3) courses. If needed, manhole riser sections with precast steps shall be used.
- b) Manholes shall be set on a minimum of eight (8) inches of #57 crushed stone on a level undisturbed or well compacted subgrade.
- c) Manhole structures are to be level upon completion.
- d) Butyl rubber sealing shall be placed between each manhole riser section. Backing tape shall be removed prior to application and a sufficient amount of sealant shall be used to completely seal the joint.
- e) Four (4) feet inside diameter polypropylene manhole structures shall be installed using conventional flexible pipe backfill materials and procedures. The backfill material and installation guidelines shall be specified by the manufacturer on the standard installation detail and may vary based on local conditions. Bedding material shall be well placed and uniformly compacted. The maximum standard burial depth of the four (4) feet polypropylene manhole structure is sixteen (16) feet.

2) Connections:

- a) All in place penetrations into manholes must be by core boring methods including main line and service drops. Properly sized elastomeric boots shall be set in penetrations. The boot and the pipe must be fully mortared on the inside and the outside of the manhole.
- b) The invert channels shall be  $(3/4)$  the depth of the largest pipe and shall be smooth and semicircular in shape conforming to the inside of the adjacent sewer section. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. Changes in size and grade of channels shall be made gradually and evenly. The invert channels shall be formed directly in the concrete of the manhole base or shall be built up with solid brick and Type S mortar.

- c) All main or service connections made above the shelf, not exceeding thirty (30) inches, shall have a slide constructed with brick and type S mortar. Slide shall be formed at the connection in a semicircular fashion conforming to the inside of the connected pipe. The slide shall be gradually angled toward the downstream invert of the gravity main for smooth flow. Connections made above thirty (30) inches will require a drop. Refer to Brunswick County standard details.
  - d) All plastic polypropylene manhole structures shall be outside drop. Concrete drop manholes shall be outside drop unless otherwise approved by county staff in writing. All hardware used to anchor the drop pipe shall be Type 316 stainless steel. Refer to county standard details.
- 3) Frames and Covers:
- a) For four (4) feet inside diameter polypropylene manhole structures in H-20 traffic load rated applications, a concrete load ring shall be poured in place around the grate and frame. The concrete slab must be designed taking into consideration local soil conditions, traffic volume, and other applicable design factors. For other considerations such as deep burials, ground water, and soft foundations refer to the manufacturer.
  - b) Four (4) feet inside diameter plastic polypropylene manhole structures shall have ductile iron covers and iron castings that fit the structures so that they become an integral component of the structure when installed and are supplied by Nyloplast ®.
  - c) Covers for four (4) feet inside diameter plastic polypropylene manhole structures shall be capable of supporting various wheel loads as specified by the manufacturer. Ductile iron used on the manufacture of the castings shall conform to ASTM A536 grade 70-50-05, and Nyloplast ® standard drawing 7001-110-222 Rev D, or written approved equal. Manhole covers shall be provided painted black.
  - d) For concrete and polymer concrete manholes, standard frames are to be centered over the precast opening of the manhole, sealed with butyl rubber sealant, and mortared into place inside and out. Mortar inside shall be coated with field coat of coal tar epoxy along with all other grouted surfaces.
  - e) For concrete and polymer concrete manholes, standard frames and covers shall have high density copolymer inserts in non-traffic areas, and stainless-steel inserts in traffic areas.

- f) For watertight concrete manholes, frames are to be centered over the precast opening of the manhole, sealed with butyl rubber sealant, bolted down, and mortared into place inside and out. Mortar inside shall be coated with field coat of coal tar epoxy along with all other grouted surfaces.
- g) Watertight frames and covers do not require an insert.

## 6.0 Requirements for Connections to Existing Gravity Sewer Systems

### a) Connections to Existing Mains

- 1) Connection of a new gravity sewer collection main to an existing gravity sewer collection main shall be made by installation of a new “doghouse” manhole at the connection point. Refer to Brunswick County standard details.
- 2) Connection of a new gravity sewer service to an existing gravity sewer main shall be made by use of a tapping saddle in accordance with county standard details.
- 3) Where two or more mains of different diameters enter a sanitary sewer manhole, it is required to match the crown elevations of the different size pipes.

## 7.0 Requirements for Testing and Completion

### a) Preparation

- 1) All personnel and materials needed for satisfactory testing of gravity systems are to be supplied by the contractor. All procedures will be performed by the contractor except where otherwise indicated.
- 2) Upon completion of construction of the new gravity collection system, all main lines and manholes are to be cleaned of any silt and debris.
- 3) All newly constructed gravity systems must be allowed a settling period of thirty (30) days from the date of completion of the system prior to any testing. In lieu of a settling period, contractor may opt to backfill trenches in one (1) foot compacted lifts upon written approval from Brunswick County. Intention must be made known at the time of the preconstruction meeting.
- 4) It is the contractor’s responsibility to schedule all testing a minimum of (48) hours in advance. The contractor shall have all testing equipment on site and in place prior to the scheduled start time of the respective test. All lines used to pull the mandrel must be in place prior to the start of testing so that personnel are not waiting for set up to take place before testing can commence.

b) Deflection Test

- 1) Deflection testing shall be performed on all sections of flexible pipe.
- 2) The maximum allowable deflection at any point shall be five (5) percent.
- 3) Deflection will be measured by a pin-type mandrel “GO/No GO” gauge outfitted for the proper pipe material and diameter.
- 4) The mandrel shall be pulled through the pipe by means of a strong cord or cable. Mandrel shall be pulled by hand.
- 5) Any section not meeting the five (5) percent deflection requirement shall be excavated, backfilled, re-compacted in one (1) foot lifts, and retested.

c) Air Test

- 1) Each segment of line shall prove airtight.
- 2) Test pressure shall be five (5) psi. No pressure loss will be allowed.
- 3) Testing time, in minutes, shall be calculated as  $[0.625 \times \text{Nominal pipe diameter (in inches)}]$ . Minimum air test time is five (5) minutes.

d) Displacement Test

- 1) Sewer mains will be checked by county personnel to determine whether displacement has occurred.
- 2) Displacement will be checked by shining light from manhole to manhole by means of flashlight or reflected sunlight. The line shall be visually inspected directly or with the aid of a mirror. A “full moon” shall be visible.
- 3) If any displacement is visible, the section of pipe displaced shall be excavated, backfilled, re-compacted in one (1) foot lifts, and retested for airtightness and displacement.

e) Other Testing

- 1) At the discretion of county staff, the following tests may also be required, at the expense of the contractor, prior to acceptance:
  - a) Manhole Vacuum Test
    - 1) Vacuum testing shall be performed in accordance with the requirements outlined in ASTM C1244.

b) Soil Compaction Test

- 1) All trenches suspected of not meeting compaction requirements shall be tested for conformance by a written approved facility for the locations and depths specified by county staff. The facility written approval shall be by county staff.