

Section 02530**GRAVITY SANITARY SEWERS****1.0 GENERAL****1.01 SECTION INCLUDES**

- A. Gravity sanitary sewers and appurtenances, including cleanouts, stacks, service connections, and reconnections.
- B. References to Technical Specifications:
 - 1. Section 02415 – Augering Pipe or Casing for Sewers
 - 2. Section 01200 – Measurement and Payment Procedures
 - 3. Section 01350 – Submittals
 - 4. Section 01450 – Testing Laboratory Services
 - 5. Section 01500 – Temporary Facilities and Controls
 - 6. Section 01570 – Trench Safety System
 - 7. Section 02318 – Excavation and Backfill for Utilities
 - 8. Section 01564 – Control of Ground Water and Surface Water
 - 9. Section 02220 – Site Demolition
 - 10. Section 01140 - Contractor’s Use of Premises
- C. Reference Standards:
 - 1. American Society for Testing and Materials (ASTM)
 - a. ASTM D 1784, “Standard Specification for Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds”
 - b. ASTM F 477, “Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe”
 - c. ASTM D 3034, “Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings”
 - d. ASTM F 679, “Standard Specification for Poly Vinyl Chloride (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings”
 - e. ASTM F 949, “Standard Specification for Poly Vinyl Chloride (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings”
 - f. ASTM D 794, “Standard Specification for Poly Vinyl Chloride (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter”
 - g. ASTM D 2241, “Standard Specification for Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series)”
 - h. ASTM D 3212, “Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals”

- i. ASTM D 3139, “Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals”
 - j. ASTM D 2444, “Standard Test Method for Determination for the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)”
 - k. ASTM F 714, “Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter”
 - l. ASTM D 2657, “Standard Practice for Heat Fusion Joining and Polyolefin Pipe and Fittings”
 - m. ASTM D 1248, “Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable”
 - n. ASTM D 3350, “Standard Specification for Polyethylene Plastic Pipe and Fittings Materials”
 - o. ASTM D 3681, “Standard Test Method for Chemical Resistance of Fiberglass (Glass-Fiber Reinforced Thermosetting-Resin) Pipe in a Deflected Condition”
 - p. ASTM D 4161, “Standard Specification for Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals”
 - q. ASTM D 3262, “Standard Specification for Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe”
 - r. ASTM D 3754, “Standard Specification for Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer and Industrial Pressure Pipe”
 - s. ASTM D 618, “Standard Practice for Conditioning Plastics for Testing”
 - t. ASTM C 828, “Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines”
 - u. ASTM C 924, “Standard Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method”
 - v. ASTM F 1417, “Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air”
2. American Water Works Association (AWWA)
 - a. AWWA C 900 Polyvinyl Chloride (PVC) Pressure Pipe, 4” – 12” for Water Distribution
 - b. AWWA C 905 Polyvinyl Chloride (PVC) Water Transmission Pipe, Nominal Diameters, 14in. Through 36 in.
 3. Plastic Pipe Institute (PPI)
 - a. PPI TR3, “Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe”
 4. Texas Commission on Environmental Quality (TCEQ)

5. Texas Administrative Code (TAC)

1.02 MEASUREMENT AND PAYMENT

- A. Measurement of pipe installed at depths 8-feet and less by open cut method is on a linear foot basis, measured and complete in place. Measurement will be taken along the center line of the pipe from center line to center line of manholes, except for pipe in casing or augered installation.
- B. Payment includes sewer pipe, excavation, bedding, backfill and special backfill, shoring, earthwork, connections to existing manholes and pipe, stacks, cleanouts, accessories, inspection and testing. Depths beyond 8' will be paid by 2 vertical feet increments.
- C. Refer to Section 02415 – Augering Pipe or Casing for Sewers for measurement and payment of augered sewer pipe.
- D. Refer to Section 01200 – Measurement and Payment Procedures.

1.03 SUBMITTALS

- A. Make Submittals required by this Section under the provisions of Section 01350 – Submittals.
- B. Submit inspection reports, testing reports, and video tape of television inspections as directed by Engineer.
- C. Submit proposed methods, equipment, materials and sequence of operations for Gravity Sanitary Sewer construction. Plan operations to minimize disruption of utilities to occupied facilities or adjacent property.

1.04 QUALITY ASSURANCE

- A. Qualifications. Gravity Sanitary Sewer shall be watertight both in pipe-to-pipe joints and in pipe-to-manhole connections. Perform testing in accordance with this Section and Section 01450 – Testing Laboratory Services.
- B. Regulatory Requirements.
 1. Install Gravity Sanitary Sewer to meet the minimum separation distance from any potable water line, as scheduled below. The separation distance is defined as the distance between the outside of the water pipe and the outside of the sewer pipe. When possible, install new Gravity Sanitary Sewers no closer to water lines than 9 feet in all directions. Where this separation distance cannot

be achieved, new Gravity Sanitary Sewers shall be installed as specified in this Section.

2. Make notification to the Engineer if water lines are uncovered during Gravity Sanitary Sewer installation where the minimum separation distance cannot be maintained.
3. Lay Gravity Sanitary Sewers lines in straight alignment and grade.

1.05 PROTECTION OF PEOPLE AND PROPERTY

- A. Contractor shall conduct all construction operations under this Contract in conformance with the practices described in Section 01500 – Temporary Facilities and Controls.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Inspect pipe and fittings upon arrival of materials at the Project Site.
- B. Handle and store pipe materials and fittings to protect them from damage due to impact, shock, shear, or free fall. Do not drag pipe and fittings along the ground. Do not roll pipe unrestrained from delivery trucks.
- C. Use mechanical means to move or handle pipe. Employ acceptable clamps, rope or slings around the outside barrel of pipe and fittings. Do not use hooks, bars, or other devices in contact with the interior surface of the pipe to lift or move lined pipe

2.0 PRODUCTS

2.01 GASKET MATERIAL FOR USE IN POTENTIALLY CONTAMINATED AREAS

- A. Gravity Sanitary Sewer pipes to be installed in potentially contaminated areas, especially where free product is found near the elevation of the proposed sewer, shall have the following Gasket Material for the noted contaminants:

CONTAMINANT	GASKET MATERIAL REQUIRED
Petroleum (diesel, gasoline)	Nitrile Rubber
Other contaminants	As recommended by the pipe manufacturer

2.02 POLYVINYL CHLORIDE (PVC) PIPE

- A. Use PVC compounds in the manufacture of pipe that contain no ingredient in an amount that has been demonstrated to migrate into water in quantities considered to be toxic.
- B. Furnish PVC pressure pipe manufactured from Class 12454-A or Class 12454-B virgin PVC compounds as defined in ASTM D 1784. Use compounds qualifying for a rating of 4000 psi for water at 73.4° F per requirements of PPI TR3. Provide pipe which is homogeneous throughout, free of voids, cracks, inclusions, and other defects, uniform as commercially practical in color, density, and other physical properties. Deliver pipe with surfaces free from nicks and scratches with joining surfaces of spigots and joints free from gouges and imperfections which could cause leakage. All pipe used for gravity sanitary sewer shall be green.
- C. Gaskets:
 - 1. Gaskets shall meet the requirements of ASTM F477. When no contaminant is identified, use elastomeric factory-installed gaskets to make joints flexible and watertight.
- D. Lubricant for rubber-gasketed joints: Water soluble, non-toxic, non-objectionable in taste and odor imparted to fluid, non-supporting of bacteria growth, having no deteriorating effect on PVC or rubber gaskets.
- E. PVC Gravity Sanitary Sewer pipe shall be green in color and shall be in accordance with the provisions in the following table:

WALL TYPE	MANUFACTURER	PRODUCT OPTIONS	ASTM DESIGNATION	SDR (MAX.)/ STIFFNESS (MIN.)	DIAMETER SIZE RANGE
	J - M P i p e C e r t a i n T e e d C a n - T e x C a r l o n D i a m o n d		D 3034	SDR 26 / PS 115	6" to 15"
			F 679	SDR 26 / PS 115	18" to 48"
			AWWA C900	DR 18 / N/A***	4" to 12"
			AWWA C905	DR 18 / N/A***	14" to 36"

	C o n t e c h			
	A - 2 0 0 0 * *		F 949	N/A / 50 psi 12" to 36"
	E T I U l t r a - R i b		F 794	N/A / 46 psi 12" to 48"
	L a m s o n V y l o n		F 794	N/A / 46 psi 21" to 48"

* Allowed to be used where there are no service taps.

** Allowed to be used to a maximum depth of 10' only.

***For water-sewer separation requirements unless specifically noted in Bid Schedule.

- F. When solid wall PVC pipe 18 inches to 27 inches in diameter is required in SDR 26, provide pipe conforming to ASTM F 679, except provide wall thickness as required for SDR 26 and pipe strength of 115 psi.
- G. For Gravity Sanitary Sewers up to 12 inch diameter crossing over waterlines, or crossing under waterlines with less than 2 feet separation, provide minimum 150 psi pressure-rated pipe conforming to ASTM D 2241 with suitable PVC adapter couplings.
- H. Joints: Spigot and integral wall section bell with solid cross section elastometric or rubber ring gasket conforming to requirements of ASTM D 3212 and ASTM F 477, or ASTM D 3139 and ASTM F 477, shall be provided. Gaskets shall be factory-assembled and securely bonded in place to prevent displacement. The manufacturer shall test a sample from each batch conforming to requirements ASTM D 2444.
- I. Fittings: Provide PVC gravity sanitary sewer bends, tee, or wye fittings for new sanitary sewer construction. PVC pipe fittings shall be full-bodied, either injection molded or factory fabricated. Saddle-type tees, wye fittings, or solvent welds are not acceptable.

2.03 HIGH DENSITY POLYETHYLENE (HDPE) SOLID AND PROFILE WALL PIPE

- A. Provide HDPE pipe as follows and only when listed as a Bid Item:

WALL TYPE	MANUFACTURER	PRODUCT OPTIONS	ASTM DESIGNATION	PIPE STIFFNESS (MIN)	DIAMETER RANGE (INCHES)
Solid Wall	Drisco 1000 Drisco 8600 Quail Pipe Poly Pipe Plexco	Approved	F 714	115 psi	8 to 10

- B. Solid wall pipe shall be produced with plain end construction for heat-joining (butt fusion) conforming to ASTM D 2657. Utilize controlled temperatures and pressures for joining to produce a fused leak-free joint.
- C. Pipe and Fittings: High density, high molecular weight polyethylene pipe material meeting the requirements of Type III, Class C, Category 5, Grade P34, as defined in ASTM D1248. Material meeting the requirements of cell classification in accordance with ASTM D 3350 are also suitable for making pipe products under these specifications.
- D. Gaskets:
 - 1. Use gaskets meeting requirement of ASTM F 477. Use gasket molded into a circular form or extruded to the proper section and then spliced into circular form. When no contaminant is identified, use gaskets of a properly cured,

high-grade elastomeric compound. The basic polymer shall be natural rubber, synthetic elastomer, or a blend of both.

- E. Lubricant. Use a lubricant for assembly of gasketed joints which has no detrimental effect on the gasket or on the pipe, in accordance with manufacturer's recommendations.
- F. Furnish pipe and fittings that are homogeneous throughout and free from visible cracks, holes, foreign inclusions, or other injurious defects. Provide pipe as uniform as commercially practical in color, opacity, density, and other physical properties.

2.04 CENTRIFUGALLY CAST FIBERGLASS PIPE

- A. Manufacturers.
 - 1. Pre-approved manufacturer for centrifugally cast fiberglass pipe is Hobas Pipe USA, Inc.
- B. Materials:
 - 1. Resin Systems: The manufacturer shall use only polyester resin systems with a proven history of performance in this particular application. The historical data shall have been collected from applications of a composite material of similar construction and composition as the proposed product.
 - 2. Glass Reinforcements: The reinforcing glass fibers used to manufacture the components shall be of highest quality commercial grade glass filaments with binder and sizing compatible with impregnating resins.
 - 3. Fillers: Silica sand or other suitable materials may be used.
 - 4. Additives: Resin additives, such as pigments, dyes, and other coloring agents, if used, shall in no way be detrimental to the performance of the product nor shall they impair visual inspection of the finished products.
 - 5. Rubber Gaskets: Supply from an approved gasket manufacturer in accordance with ASTM F 477, when no contaminant is identified and suitable for the service intended. Gaskets shall either be affixed to the pipe by means of a suitable adhesive or shall be installed in such a manner so as to prevent the gasket from rolling out of the pre-cut groove in the pipe or sleeve coupling.
 - 6. The internal liner resin shall be suitable for service as sewer pipe, and shall be highly resistant to exposure to sulfuric acid as produced by biological activity from hydrogen sulfide gases. Pipe shall meet or exceed requirements of ASTM D 3681.

- C. Pipes:
1. Furnish pipes in the diameters specified and within the tolerances specified below.
 2. Manufacture pipe by the centrifugal casting process to result in a dense, nonporous, corrosion-resistant, consistent composite structure to meet the operating conditions as shown on the Plans.
 3. Do not use stiffening ribs or rings.
- D. Couplings: Unless otherwise specified, the pipe shall be field connected with fiberglass sleeve couplings that utilize elastomeric sealing gaskets as the sole means to maintain joint watertightness. The joints must meet the performance requirements of ASTM D 4161.
- E. Fittings: Flanges, elbows, reducers, tees, and other fittings shall be capable of withstanding operating conditions when installed. They may be contact molded or manufactured from mitered sections of pipe joined by glass fiber reinforced overlays.
- F. Manhole Connections: Provide a water stop flange (wall pipe) for connection to a cast-in-place manhole base or other structure.
- G. Grout Ports: Provide grout ports in the wall of pipe when required. Provide plugs of 316 stainless steel or other corrosion-resistant material compatible with the pipe. Grout port plugs shall be designed and installed to meet the test pressure of the pipe.
- H. Dimensions:
1. Diameters: The actual outside diameter of the pipes shall be in accordance with Table 3 of ASTM D 3262 for Gravity Sanitary Sewers, or ASTM D 3754 for force mains.
 2. Lengths: The pipe standard length will be approximately 20 feet. A maximum of 10 percent of the lengths, excluding special order pipes, may be supplied in random lengths.
 3. Wall Thickness: The minimum average wall thickness shall be the stated design thickness. The minimum single point thickness shall not be less than 90 percent of the stated design thickness.
 4. End Squareness: Pipe ends shall be square to the pipe axis.
 5. Tolerance of Fittings: The tolerance of the angle of an elbow and the angle between the main and leg of a wye or tee shall be plus or minus 2 degrees. The tolerance on the laying length of a fitting shall be plus or minus 2 inches.

- I. Stiffness Classes:
1. Stiffness class of FRP pipe shall satisfy design requirements, but shall not be less than 46 psi, when used in direct bury operation; 36 psi, when installed within a primary tunnel liner.
 2. Stiffness class of FRP in a pipe jacking operation shall be governed either by the ring deflection limitations or by a pipe design providing longitudinal strength required by the jacking method and shall satisfy design requirements stated below. Submit design calculations as required in Paragraph 1.05, Submittals.
 - a. Pipe stress calculations based on jacking loads shall be provided by the pipe supplier.
 - b. Ring deflection calculations shall conform to design requirements of 30 TAC Chapter 317.20 pertaining to flexible pipe used in Gravity Sanitary Sewers. The pipe deflection calculations shall ensure that predicted deflection will be less than 5 percent under long-term loading conditions (soil prism load) for the highest density of soil overburden and surcharge loads. Deflection on calculations shall be prepared using long-term (drained) values for soil parameters contained in the geotechnical investigation report for the Project, or other site-specific data obtained by the Contractor as approved by the Engineer.
- J. Testing:
1. Pipes shall be tested in accordance with ASTM D 3262 or ASTM D 3754, as applicable, except that the factory hydrostatic pressure testing is not required.
 2. Joints: Coupling joints shall be qualified per the tests of Section 7 of ASTM D 4161.
- K. Packaging, Handling, and Shipping:
1. Packing, handling, and shipping should be done in accordance with the manufacturer's recommendations.
- L. Installation:
1. Install pipe and fittings in accordance with requirements of this Section.
 2. The manufacturer must supply a suitable qualified field service representative to be present periodically during the installation of pipe.
 3. Pipe Bedding: Conform to requirements of Section 02318 – Excavation and Backfill for Utilities.

4. Pipe Handling: Use textile slings.
5. Jointing:
 - a. Clean ends of pipe and coupling components.
 - b. Check pipe ends and couplings for damage. Correct any damage found.
 - c. Coupling grooves must be completely free of dirt.
 - d. Apply joint lubricant to pipe ends and rubber seals of coupling. Use only lubricants approved by the pipe manufacturer.
 - e. Use suitable auxiliary equipment, such as a wire rope puller, to pull joints together.
 - f. Do not exceed forces recommended by the manufacturer for coupling pipe. If excessive force is required, remove coupling, determine source of problem, and correct it.
 - g. In the process of jointing the pipe, do not allow the deflection angle to exceed the deflection permitted by the manufacturer.
6. If pressure grouting of the pipe is conducted as part of a pipe-jacked tunnel installation, seal the grout holes with liner resin to a thickness equal to the pipe liner thickness, or with a threaded plug for that purpose.
7. Tests: Conform to requirements of this Section.

2.05 INSPECTIONS

- A. The Engineer reserves the right to inspect pipes or witness pipe manufacturing. Such inspection shall in no way relieve the manufacturer of the responsibilities to provide products that comply with the applicable standards and these Specifications.
- B. Manufacturer's Notification to Customer. Should the Engineer wish to witness the manufacture of specific pipes, the manufacturer shall provide the Engineer with adequate advance notice of when and where the production of those specific pipes will take place.
- C. Failure to Inspect. Approval of the products or tests is not implied by the Engineer's decision not to inspect the manufacturing, testing, or finished pipes.

2.06 TEST METHODS

- A. Conditioning. Conditioning of samples prior to and during tests are subject to approval by the Engineer. When referee tests are required, condition the specimens in accordance with Procedure A in ASTM D 618 at 73.4 degrees F plus or minus 3.6 degrees F (23 degrees C plus or minus 2 degrees C) and 50 percent relative humidity plus or minus 5 percent relative humidity for not less than 40 hours prior to test. Conduct tests under the same conditions of temperature and humidity unless otherwise specified.
- B. Flattening. Flatten three specimens of pipe, prepared in accordance with Paragraph 2.05A, in a suitable press until the internal diameter has been reduced to 40 percent of the original inside diameter of the pipe. The rate of loading shall be uniform and at 2-inches per minute. The test specimens, when examined under normal light and with the unaided eye, shall show no evidence of splitting, cracking, breaking, or separation of the pipe walls or bracing profiles.
- C. Joint Tightness. Test for joint tightness in accordance with ASTM D 3212, except replace the shear load transfer bars and supports with 6 inch wide support blocks that can be either flat or contoured to conform to the pipe's outer contour.
- D. Purpose of Tests. The flattening and the joint tightness tests are not intended to be routine quality control tests, but rather to qualify pipe to a specified level of performance.

2.07 MARKING

- A. Mark each standard and random length of pipe in compliance with these Specifications with the following information:
 - 1. Pipe size
 - 2. Pipe class
 - 3. Production code
 - 4. Material designation

3.0 EXECUTION**3.01 PREPARATION**

- A. Employ a Trench Safety Plan as specified in Section 01570 – Trench Safety Systems.
- B. Install and operate dewatering and surface water control measures in accordance with Section 01564 - Control of Ground Water and Surface Water.
- C. Remove existing pavements and structures, including sidewalks and driveways, in conformance with requirements of Section 02220 – Site Demolition, as applicable.

3.02 DIVERSION PUMPING

- A. Install and operate required bulkheads, plugs, piping, and diversion pumping equipment to maintain sewage flow and to prevent backup or overflow. Obtain approval for diversion pumping equipment and procedures from the Engineer.
- B. Design piping, joints and accessories to withstand twice the maximum system pressure or 50 psi, whichever is greater.
- C. No sewage shall be diverted into any area outside of the sanitary sewer.
- D. In the event of accidental spill or overflow, immediately stop the overflow and take action to clean up and disinfect spillage. Promptly notify the Engineer so that required reporting can be made to the TCEQ and the Environmental Protection Agency by the Engineer.

3.03 INSPECTION AND TESTING

- A. Acceptance testing of sanitary sewers including:
 - 1. Visual inspection of sewer pipes
 - 2. Mandrel testing for flexible sewer pipes.
 - 3. Leakage testing of sewer pipes.
 - 4. Leakage testing of manholes.
- B. Performance Requirements:
 - 1. Gravity sanitary sewers are required to have a straight alignment and uniform grade between manholes.
 - 2. Flexible pipe, including “semi-rigid” pipe, is required to show no more than 5 percent deflection. Test pipe no sooner than 30 days after backfilling of a line segment but prior to final acceptance using a standard mandrel to verify that installed pipe is within specified deflection tolerances.
 - 3. Maximum allowable leakage for Infiltration or Exfiltration.
 - a. The total exfiltration, as determined by a hydrostatic head test, shall not exceed 50 gallons per inch diameter per mile of pipe per 24 hours at a minimum test head of 2 feet above the crown of the pipe at the upstream manhole or 2 feet above the groundwater elevation, whichever is greater.
 - b. When pipes are installed more than 2 feet below the groundwater level, an infiltration test shall be used in lieu of the exfiltration test. The total infiltration shall not exceed 50 gallons per inch diameter per mile of

pipe per 24 hours. Groundwater elevation must be at least 2 feet above the crown of the pipe at the upstream manhole.

- c. Refer to Table 2530-1, Water Test Allowable Leakage, at the end of the Section, for measuring leakage in sewers. Perform leakage testing to verify that leakage criteria are met.
4. Perform air testing in accordance with requirements of this Section and the Texas Natural Resources Conservation Commission requirements. Refer to Table 02530-2, Time Allowed For Pressure Loss From 3.5 psig to 2.5 psig, Table 02530-3, Minimum Testing Times for Low Pressure Air Test, and Table 02530-4, Vacuum Test Time Table, at the end of this Section.
- C. Gravity Sanitary Sewer Quality Assurance:
1. Repair, correct, and retest manholes or sections of pipe which fail to meet specified requirements when tested.
 2. Provide testing reports and video tape of television inspection as directed by Engineer.
 3. Upon completion of tape reviews by Engineer, Contractor will be notified regarding final acceptance of the sewer segment.
- D. Sequencing and Scheduling:
1. Perform testing as work progresses. Schedule testing so that no more than 1000 linear feet of installed sewer remains untested at any one time.
 2. Coordinate testing schedules with Engineer. Perform testing under observation of Engineer.
- E. Deflection Mandrel:
1. Mandrel Sizing. The rigid mandrel shall have an outside diameter (O.D.) equal to 95 percent of the inside diameter (I.D.) of the pipe. The inside diameter of the pipe, for the purpose of determining the outside diameter of the mandrel, shall be the average outside diameter minus two minimum wall thicknesses for O.D. controlled pipe and the average inside diameter for I.D. controlled pipe, dimensions shall be per appropriate standard. Statistical or other "tolerance packages" shall not be considered in mandrel sizing.
 2. Mandrel Design. The rigid mandrel shall be constructed of a metal or a rigid plastic material that can withstand 200 psi without being deformed. The mandrel shall have nine or more "runners" or "legs" as long as the total number of legs is an odd number. The barrel section of the mandrel shall have a length of at least 75 percent of the inside diameter of the pipe. The rigid mandrel shall not have adjustable or collapsible legs which would allow a reduction in

mandrel diameter during testing. A proving ring shall be provided and used for modifying each size mandrel.

3. Proving Ring. Furnish a "proving ring" with each mandrel. Fabricate the ring of 1/2 inch thick, 3-inch-wide bar steel to a diameter 0.02 inches larger than approved mandrel diameter.
4. Mandrel Dimensions (5 percent allowance). Average inside diameter and minimum mandrel diameter are specified in Table 02530-5, Pipe vs. Mandrel Diameter, at the end of this Section. Mandrels for higher strength, thicker wall pipe or other pipe not listed in the table may be used when approved by the Engineer.

F. Exfiltration Test:

1. Water Meter: Obtain a transient water meter from the City for use when water for testing will be taken from the City system. Conform to City requirements for water meter use.
2. Test Equipment:
 - a. Pipe plugs.
 - b. Pipe risers where the manhole cone is less than 2 feet above highest point in pipe or service lead.

G. Infiltration Test:

1. Test Equipment:
 - a. Calibrated 90 degree V-notch weir.
 - b. Pipe plugs.

H. Low Pressure Air Test:

1. Minimum Requirement for Equipment:
 - a. Control panel.
 - b. Low-pressure air supply connected to control panel.
 - c. Pneumatic plugs: Acceptable size for diameter of pipe to be tested; capable of withstanding internal test pressure without leaking or requiring external bracing.
 - d. Air hoses from control panel to:
 - 1) Air supply.
 - 2) Pneumatic plugs.
 - 3) Sealed line for pressuring.
 - 4) Sealed line for monitoring internal pressure.
2. Testing Pneumatic Plugs: Place a pneumatic plug in each end of a length of pipe on the ground. Pressurize plugs to 25 psig; then pressurize sealed pipe to 5 psig. Plugs are acceptable if they remain in place against the test pressure without external aids.

- I. Ground Water Determination:
 1. Equipment: Pipe probe or small diameter casing for ground water elevation determination.
- J. Visual Inspection:
 1. Check pipe alignment visually by flashing a light between structures. Verify if alignment is true and no pipes are misplaced. In case of misalignment or damaged pipe, remove and re-lay or replace pipe segment.
- K. Mandrel Testing:
 1. Perform deflection testing on flexible and semi-rigid pipe to confirm pipe has no more than 5 percent deflection. Mandrel testing shall conform to ASTM D 3034. Perform testing no sooner than 30 days after backfilling of line segment, but prior to final acceptance testing of the line segment.
 2. Pull the approved mandrel by hand through sewer sections. Replace any section of sewer not passing the mandrel. Mandrel testing is not required for stubs.
 3. Retest repaired or replaced sewer sections.
- L. Leakage Testing:
 1. Test Options:
 - a. Test Gravity Sanitary Sewer pipes for leakage by either exfiltration or infiltration methods, as appropriate, or with low pressure air testing.
 - b. Test new or rehabilitated sanitary sewer manholes with water or low pressure air. Manholes tested with low pressure air shall undergo a physical inspection prior to testing.
 - c. Leakage testing shall be performed after backfilling of a line segment, and prior to tie-in of service connections.
 - d. If no installed piezometer is within 500 feet of the sewer segment, Contractor shall provide a temporary piezometer for this purpose.
 2. Compensating for Ground Water Pressure:
 - a. Where ground water exists, install a pipe nipple at the same time sewer line is placed. Use a 1/2-inch capped pipe nipple approximately 10 inches long. Make the installation through manhole wall on top of the sewer line where line enters manhole.

- b. Immediately before performing line acceptance test, remove cap, clear pipe nipple with air pressure, and connect a clear plastic tube to nipple. Support tube vertically and allow water to rise in the tube. After water stops rising, measure height in feet of water over invert of the pipe. Divide this height by 2.3 feet/psi to determine the ground water pressure to be used in line testing.
 3. Exfiltration test:
 - a. Determine ground water elevation.
 - b. Plug sewer in downstream manhole.
 - c. Plug incoming pipes in upstream manhole.
 - d. Install riser pipe in outgoing pipe of upstream manhole if highest point in service lead (house service) is less than 2 feet below bottom of manhole cone.
 - e. Fill sewer pipe and manhole or pipe riser, if used, with water to a point 2-1/2 feet above highest point in sewer pipe, house lead, or ground water table, whichever is highest.
 - f. Allow water to stabilize for one to two hours. Take water level reading to determine drop of water surface, in inches, over a one-hour period, and calculate water loss (1 inch of water in 4 feet diameter manhole equals 8.22 gallons) or measure the quantity of water required to keep water at same level. Loss shall not exceed that calculated from allowable leakage according to Table 02530-1 at the end of this Section.
 4. Infiltration test: Ground water elevation must be not less than 2.0 feet above highest point of sewer pipe or service lead (house service).
 - a. Determine ground water elevation.
 - b. Plug incoming pipes in upstream manhole.
 - c. Insert calibrated 90 degree V-notch weir in pipe on downstream manhole.
 - d. Allow water to rise and flow over weir until it stabilizes.
 - e. Take five readings of accumulated volume over a period of 2 hours and use average for infiltration. The average must not exceed that calculated for 2 hours from allowable leakage according to the Table 02530-1 at the end of this Section.

5. Low Air Pressure Test: When using this test conform to ASTM C 828, ASTM C 924, or ASTM F 1417, as applicable, with holding time not less than that listed in Table 02530-2.
 - a. Air testing for sections of pipe shall be limited to lines less than 36-inch average inside diameter.
 - b. Lines 36-inch average inside diameter and larger shall be tested at each joint. The minimum time allowable for the pressure to drop from 3.5 pounds per square inch gauge to 2.5 pounds per square inch during a joint test shall be 10 seconds, regardless of pipe size.
 - c. For pipe sections less than 36-inch average inside diameter:
 - 1) Determine ground water level.
 - 2) Plug both ends of pipe. For concrete pipe, flood pipe and allow 2 hours to saturate concrete. Then drain and plug concrete pipe.
 - 3) After a manhole-to-manhole section of sanitary sewer main has been sliplined and prior to any service lines being connected to new liner, plug liner at each manhole with pneumatic plugs.
 - 4) Pressurize pipe to 4.0 psig. Increase pressure 1.0 psi for each 2.3 feet of ground water over highest point in system. Allow pressure to stabilize for 2 to 4 minutes. Adjust pressure to start at 3.5 psig (plus adjustment for ground water table). Refer to Table 02530-2 at the end of this Section.
 - 5) To determine air loss, measure the time interval for pressure to drop to 2.5 psig. The time must exceed that listed in the Table 02530-2 at the end of this Section for pipe diameter and length. For sliplining, use diameter of carrier pipe.
6. Retest: Any section of pipe which fails to meet requirements shall be repaired and retested.

M. Test Criteria Tables

1. Exfiltration and Infiltration Water Tests: Refer to Table 02530-1, Water Test Allowable Leakage, at the end of this Section.
2. Low Pressure Air Test:

- a. Times in Table 02530-2, Time Allowed For Pressure Loss From 3.5 psig to 2.5 psig, at the end of this Section, are based on the equation from TCEQ Design Criteria for Sewerage Systems: 317.2(a)(4)(B).

$$T = 0.0850(D)(K)/(Q)$$

Where:

- T = Time for pressure to drop 1.0 pounds per square inch gauge in seconds
- K = 0.000419 DL, but not less than 1.0
- D = Average inside diameter in inches
- L = Length of line of same pipe size in feet
- Q = Rate of loss, 0.0015 ft³/min./sq. ft. internal surface
- b. Since a K value of less than 1.0 shall not be used, there are minimum testing times for each pipe diameter as given in Table 02732-3, Minimum Testing Times for Low Pressure Air Test.

- Notes:
1. When two sizes of pipe are involved, the time shall be computed by the ratio of lengths involved.
 2. Line with a 27-inch average inside diameter and larger may be air tested at each joint.
 3. Lines with an average inside diameter greater than 36 inches must be air tested for leakage at each joint
 4. If the joint test is used, a visual inspection of the joint shall be performed immediately after testing.
 5. For joint test, the pipe is to be pressurized to 3.5 psi greater than the pressure exerted by groundwater above the pipe. Once the pressure has stabilized, the minimum times allowable for the pressure to drop from 3.5 pounds per square inch gauge to 2.5 pounds per square inch gauge shall be 10 seconds.

N. Leakage Testing for Manholes.

1. After completion of manhole construction, wall sealing, or rehabilitation, but prior to backfilling, test manholes for water tightness using hydrostatic or vacuum testing procedures.
2. Plug influent and effluent lines, including service lines, with suitably-sized pneumatic or mechanical plugs. Ensure plugs are properly rated for pressures required for test; follow manufacturer's safety and installation recommendations. Place plugs a minimum of 6 inches outside of manhole

walls. Brace inverts to prevent lines from being dislodged if lines entering manhole have not been backfilled.

3. Vacuum testing:
 - a. Install vacuum tester head assembly at top access point of manhole and adjust for proper seal on straight top section of manhole structure. Following manufacturer's instructions and safety precautions, inflate sealing element to the recommended maximum inflation pressure; do not over-inflate.
 - b. Evacuate manhole with vacuum pump to 10 inches mercury (Hg), disconnect pump, and monitor vacuum for the time period specified in Table 02530-4, Vacuum Test Time Table.
 - c. If the drop in vacuum exceeds 1 inch Hg over the specified time period tabulated above, locate leaks, complete repairs necessary to seal manhole and repeat test procedure until satisfactory results are obtained.
4. Hydrostatic exfiltration testing shall be performed as follows:
 - a. Seal wastewater lines coming into the manhole with an internal pipe plug. Then fill the manhole with water and maintain it full for at least one hour.
 - b. The maximum leakage for hydrostatic testing shall be 0.025 gallons per foot diameter per foot of manhole depth per hour.
 - c. If water loss exceeds amount tabulated above, locate leaks, complete repairs necessary to seal manhole and repeat test procedure until satisfactory results are obtained.

3.04 BACKFILL

- A. Backfill and compact soil in accordance with Section 02318 – Excavation and Backfill for Utilities.
- B. Backfill the trench in specified lifts only after pipe installation is approved by the Engineer.

3.05 CLEAN UP AND RESTORATION

- A. Perform clean up and restoration in and around construction zone in accordance with Section 01140 - Contractor's Use of Premises.

3.06 PROTECTION OF THE WORK

- A. Maintain gravity sanitary sewer installations in good condition until completion of the work.

**TABLE 02530-1
WATER TEST ALLOWABLE LEAKAGE**

DIAMETER OF RISER OR STACK IN INCHES	VOLUME PER INCH OF DEPTH		ALLOWANCE LEAKAGE*	
	INCH	GALLONS	PIPE SIZE IN INCHES	GALLONS/MINUTE PER 100 FT.
1	0.7854	.0034	6	0.0039
2	3.1416	.0136	8	0.0053
2.5	4.9087	.0212	10	0.0066
3	7.0686	.0306	12	0.0079
4	12.5664	.0306	15	0.0099
5	19.6350	.0544	18	0.0118
6	28.2743	.1224	21	0.0138
8	50.2655	.2176	24	0.0518
			27	0.0177
			30	0.0197
			36	0.0237
			42	0.0276
For other diameters, multiply square of diameters by value for 1" diameter			Equivalent to 50 gallons per inch inside diameter per mile per 24 hours	

- * Allowable leakage rate shall be reduced to 10 gallons per inch of inside diameter per mile per 24 hours, when sewer is identified as located within the 25-year flood plain.

**TABLE 02530-2
ACCEPTANCE TESTING FOR SANITARY SEWERS**

TIME ALLOWED FOR PRESSURE LOSS FROM 3.5 PSIG TO 2.5 PSIG														
Pipe Diam (in)	Min. Time (min:sec)	Length for Min. Time (ft)	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	500 ft	550 ft	600 ft
6	5:40	398	0.8548	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:25	7:07	7:50	8:33
8	7:33	298	1.5196	7:33	7:33	7:33	7:33	7:36	8:52	10:08	11:24	12:40	13:36	15:12
10	9:27	239	2.3743	9:27	9:27	9:27	9:54	11:52	13:51	15:50	17:48	19:47	21:46	23:45
12	11:20	199	3.4190	11:20	11:20	11:20	14:15	17:06	19:57	22:48	25:39	28:30	31:20	34:11
15	14:10	159	5.3423	14:10	14:10	17:48	22:16	26:43	31:10	35:37	40:04	44:31	48:58	53:25
18	17:00	133	7.6928	17:00	19:14	25:39	32:03	38:28	44:52	51:17	57:42	64:06	70:31	76:56
21	19:50	114	10.4708	19:50	26:11	34:54	43:38	52:21	61:05	69:48	78:32	87:15	95:59	104:42
24	22:40	99	13.6762	22:48	34:11	45:35	56:59	68:23	79:47	91:10	102:34	113:58	125:22	136:46
27	25:30	88	17.3089	28:51	43:16	57:42	72:07	86:33	100:58	115:24	129:49	144:14	158:40	173:05
30	28:20	80	21.3690	35:37	53:37	71:14	89:02	106:51	124:39	142:28	160:16	178:05	195:53	213:41
33	31:10	72	25.8565	43:06	64:38	86:11	107:44	129:17	150:50	172:23	193:55	215:28	237:01	258:34

**TABLE 02530-3
MINIMUM TESTING TIMES FOR LOW PRESSURE AIR TEST**

PIPE DIAMETER (INCHES)	MINIMUM TIME (SECONDS)	LENGTH FOR MINIMUM TIME (FEET)	TIME FOR LONGER LENGTH (SECONDS)
6	340	398	0.855 (L)
8	454	298	1.520 (L)
10	567	239	2.374 (L)
12	680	199	3.419 (L)
15	850	159	5.342 (L)
18	1020	133	7.693 (L)
21	1190	114	10.471 (L)
24	1360	100	13.676 (L)
27	1530	88	17.309 (L)
30	1700	80	21.369 (L)
33	1870	72	25.856 (L)

**TABLE 02530-4
VACUUM TEST TIME TABLE**

DEPTH IN FEET	TIME IN SECONDS BY PIPE DIAMETER		
	48"	60"	72"
4	10	13	16
8	20	26	32
12	30	39	48
16	40	52	64
20	50	65	80
24	60	78	96
*	5.0	6.5	8.0

*Add T times for each additional 2-foot depth.

(The values listed above have been extrapolated from ASTM C 924-85)

**TABLE 02530-5
PIPE VS. MANDREL DIAMETER**

MATERIAL AND WALL CONSTRUCTION	NOMINAL SIZE (INCHES)	AVERAGE I.D. (INCHES)	MINIMUM MANDREL DIAMETER (INCHES)
PVC-Solid (SDR 26)	6	5.764	5.476
	8	7.715	7.329
	10	9.646	9.162
PVC-Solid (SDR 35)	12	11.737	11.150
	15	14.374	13.655
	18	17.629	16.748
	21	20.783	19.744
	24	23.381	22.120
	27	26.351	25.033
PVC-Profile (ASTM F 794)	12	11.740	11.153
	15	14.370	13.652
	18	17.650	16.768
	21	20.750	19.713
	24	23.500	22.325
	27	26.500	25.175
	30	29.500	28.025
	36	35.500	33.725
	42	41.500	39.425
HDPE-Profile	18	18.000	17.100
	21	21.000	19.950
	24	24.000	22.800
	27	27.000	25.650
	30	30.000	28.500
	36	36.000	34.200
	42	42.000	39.900
	48	48.000	45.600
	54	54.000	51.300
Fiberglass-Centrifugally Cast (Class SN 46)	12	12.85	11.822
	18	18.66	17.727
	20	20.68	19.646
	24	24.72	23.484
	30	30.68	29.146
	36	36.74	34.903
	42	42.70	40.565
	48	48.76	46.322
	54	54.82	52.079
60	60.38	57.361	

END OF SECTION