SPECIAL SPECIFICATION

5893

Sanitary Sewers

1. Description. Furnish labor, materials, and equipment necessary to provide a complete sanitary sewer system in accordance and compliance with ANSI, AWWA, ASTM, ASA, SSPC, ACI, and NSF standards, the plans and specifications, and in compliance with the Department's Utility Accommodation Policy (Title 43. T.A.C., Sections 21.31-21.55).

The abbreviations ANSI, AWWA, ASTM, ASA, SSPC, ACI, and NSF in this specification refer to the following organizations:

ANSI - American National Standards Institute

AWWA - American Water Works Association

ASTM - American Society for Testing and Materials

ASA - American Standards Association

SSPC - Steel Structures Painting Council

ACI - American Concrete Institute

NSF - National Sanitation Foundation

When referring to the specifications of the above organizations, it means the latest standard or tentative standard in effect on the date of the proposal.

The size and location of utility lines shown on the plans were obtained from field surveys and from the various utility companies. The Department does not assume responsibility for the accuracy of the information presented, nor does it warrant that every utility line is shown.

2. Materials. Furnish new and unused materials for this project unless otherwise specified on the plans. Provide a manufacturer's certificate of compliance for quality control of materials unless otherwise shown on the plans, except for the inspection requirements of Item 464, "Reinforced Concrete Pipe."

A. Circular Concrete Pipe. Provide circular concrete pipe 36 in. in diameter and greater conforming to the class specified on the plans and in accordance with Item 464, "Reinforced Concrete Pipe." Circular concrete pipe less than 36 in. in diameter is not allowed. Furnish polyvinyl chloride (PVC)-lined concrete pipe interiors for corrosion protection. See Section 2.I., "Plastic Liner for Concrete Pipes," of this specification.

Upon delivery to the trenches, the pipe and specials will be inspected for transportation and handling damages incurred after acceptance at the source of manufacture. Repair the pipe if necessary. If, in the opinion of the Engineer, the repairs are sound, properly

finished and cured, and the repaired pipe conforms to the requirements of these specifications, it will be acceptable.

Unless otherwise specified on the plans, for concrete pipe, use corrosion-resistant rubber gasket joints of the "push on" type, and that meet the requirements of ASTM C443.

B. Polyvinyl Chloride (PVC) Pipe and Fittings.

1. **Gravity Sewer.** Provide plastic pipe and fittings meeting the requirements of ASTM D3034 SDR35, D2241 or D3034 SDR26, F679 SDR35, or F794.

2. **Force Mains.** Provide PVC pipe for force mains meeting or exceeding the requirements of AWWA C-900/905. Use ductile-iron (Class 52) fittings for force main pipes.

3. **Water Main Crossings.** If constructing gravity or force main sewers in the vicinity of water mains, meet the requirements of the "Rules and Regulations for Public Water Systems" adopted in 1992 by the Texas Water Commission (now the Texas Commission on Environmental Quality).

For PVC pipe, use steel casing meeting the requirements of Section 2.H., "Steel Casing Pipe," of this specification.

Use lubricant for assembly that has no detrimental effects to the gasket or pipe and is of the type recommended by the pipe manufacturer.

Furnish a manufacturer's certification that the pipe and fittings being furnished on the project meet the requirements of this specification. Ensure written approval from the Engineer in charge accompanies this certification to the project site, before installing the pipe and fittings.

Provide pipe and fittings that are free from defects which, in the judgment of the Engineer, would hinder their ability to function as planned.

C. Ductile-Iron Pipe and Fittings. Provide ductile-iron pipe that meets the requirements of ANSI A21.51 (AWWA C151) Class 53. Unless otherwise specified on the plans, determine the pipe thickness based on the depth of cover and an internal pressure of 150 psi. Furnish pipe in nominal 18 ft. or 20 ft. lengths.

Provide fittings for use with ductile-iron pipe that meet the requirements of ANSI Standard A21.10 (AWWA C110). Design the fittings for a minimum working pressure of 150 psi.

Provide joints for ductile-iron pipe of the type in accordance with the requirements of ANSI Standard A21.11 (AWWA C151) for push on or ANSI A21.15 for flanged end.

D. Line Interiors. Provide lined interiors meeting ANSI A21.4, cement lined with seal coat or ANSI A 21.16 fusion bonded epoxy coating for interior. Comply with NSF 61.

E. Sanitary Sewer and Force Main Interiors.

1. **Preparation.** Provide commercial blast cleaning conforming to SSPC-SP6.
2. **Liner thickness.** Provide a nominal liner thickness of 40 mils for the pipe barrel interior and a minimum of 6 to 10 mils at the gasket groove and outside spigot end to 6 in. back from the end.
3. **Testing.** Perform testing in accordance with ASTM G 62, Method B for voids and holidays. Provide written certification.
4. **Acceptable Lining Materials.** Provide approved virgin polyethylene conforming to ASTM D 1248, with inert fillers and carbon black to resist ultraviolet degradation during storage, heat bonded to the interior surface of pipe and fittings.

    a. **Ceramic Epoxy Protection.** For the exterior of sanitary sewers, furnish a prime coat and outside asphaltic coating conforming to ANSI A21.10, ANSI A21.15, or ANSI A21.51 for pipe and fittings in open cut excavation and in casings.

F. Gaskets. Furnish, when no contaminant is identified, plain rubber (SBR) gasket material in accordance with ANSI A21.11 or ASTM F 477 (one bolt only). For flanged joints, furnish a 1/8-in.-thick gasket in accordance with ANSI A 21.15.

G. Fiberglass Pipe and Fittings. Provide centrifugally cast fiberglass pipe in accordance with the requirements of ASTM D3262 and ASTM D3681. Ensure the actual outside diameter of the pipe is in accordance with Table 3 of ASTM D3754. The standard pipe length is approximately 20 ft. A maximum of 10% of the lengths, excluding special order pipes, may be supplied in random lengths.

Ensure the manufacturer uses only polyester resin systems with a proven history of performance in this particular application. Use only the historical data collected from applications of a composite material of similar construction and composition as the proposed product.

For the reinforcing glass fibers used to manufacture the components, use the highest quality commercial grade glass filaments with binder and sizing compatible with impregnating resins.

Silica sand or other suitable materials may be used for fillers.

If resin additives, such as pigments, dyes, and other coloring agents are used, ensure they are not detrimental to the performance of the pipe and they do not impair visual inspection of the finished product.

Provide gaskets supplied by approved gasket manufacturers, in accordance with ASTM 477, and that are suitable for the service intended.

Provide flanges, elbows, reducers, tees, and other fittings capable of withstanding operating conditions when installed. They may be contact-molded or manufactured from metered sections of pipe joined by glass fiber reinforced overlays.

Use a stiffness class of centrifugally cast fiberglass pipe that satisfies design requirements under ASTM D3262, but that is not less than 46 psi when used in direct-bury operation or 36 psi when installed in a tunnel liner.

Provide centrifugally cast fiberglass pipe with an internal liner resin suitable for service as sewer pipe and that is highly resistant to exposure to sulfuric acid in accordance with ASTM D3681.

Supply pipe manufactured by the centrifugal casting process. An acceptable manufacturer is Hobas Pipe, USA, Inc. or approved equal.

Provide a manufacturer's certification that the pipe and fittings furnished on the project meet the requirements of this specification. Written approval from the Engineer in charge must accompany this certification to the project site, before installing the pipe and fittings.

Furnish pipe and fittings that are free from defects which, in the judgment of the Engineer, would hinder their ability to function as planned.

H. Steel Casing Pipe. Provide minimum wall thicknesses in accordance with those shown in Table 1 for HS-20 live loads and depths of bury of up to 16 ft.

Supply the pipe in double random lengths, of at least 16 ft. and at most 40 ft., unless otherwise shown on the plans. Bevel the ends of the pipe for field butt welding. Provide welder qualification in accordance with AWWA C206.

Table 1
Casing Pipe

Casing Pipe Size (in.)	Outside Diameter (in.)	Min. Wall Thickness (in.)	Approx. Weight Uncoated (lb./ft.)
6	6.625	0.219	14.97
8	8.625	0.219	19.64
10	10.750	0.219	24.60
12	12.750	0.219	29.28
14	14.000	0.219	32.00
16	16.000	0.219	36.86
20	20.000	0.250	52.73
24	24.000	0.250	63.41
30	30.000	0.250	79.43
36	36.000	0.250	95.45
42	42.000	0.250	111.50
Note: It is the design Engineer's responsibility to review the design for conditions more extreme than those indicated by this specification and to design accordingly. Do not use a thickness of the pipe wall less than that defined in Table 1.			

Furnish steel casing pipe coated with coal-tar enamel externally and with polyamide epoxy internally.

I. Plastic Liner for Concrete Pipes. Furnish plastic liner sheets, joint, corner, and weld strips, manufactured from a high molecular weight thermoplastic polymer compounded to make a permanently flexible material suitable for use as a protective liner in pipe or

other structures. Ensure polyvinyl chloride resin constitutes a minimum of 99% by weight of the resin used in the formulation. Co-polymer resins are not permitted.

Any time during the manufacture or before the final acceptance of the work, the Engineer may sample specimens taken from sheets, strips, or welded joints for testing.

Changes in formulation will be permitted only after notifying the Engineer and after the manufacturer demonstrates that the new plastic liner meets or exceeds requirements for chemical resistance and physical properties.

Furnish the plastic liner as manufactured by Ameron T-Lok, Poly-Tee, Inc., or approved equal.

Provide plastic liner sheets including locking extensions, joints, corners, and welding strips, which are free of cracks, cleavages, or other defects adversely affecting the protective characteristics of the material.

Except at shop welds, ensure plastic liner sheets, joint, corner, and weld strips have the properties shown in Table 2 when tested at 77°F ± 5°F.

Table 2
Chemical Resistance Test

Property	Initial Result	After Exposure for 112 Days in Chemical Solutions
Tensile Strength, Min.	2200 psi	2100 psi
Elongation at Break, Min.	200%	200%
Shore Durometer, Type D	Within 1 sec.	± 5 (With respect to
	50-60	initial test result)
	10 sec. 35-50	± 5
Weight Change	--	± 1.5%

J. Liner for Ductile-Iron Pipe. Furnish pipe internally lined with ceramic epoxy Protecto 401 or virgin polyethylene in accordance with the requirements of ASTM D1248, compounded with inert fillers and carbon black to resist ultraviolet light degradation during storage.

Heat-bond the liner to the interior of the pipe and fittings over a blast cleaned surface as recommended by the manufacturer or SSPC-SP6.

Provide a nominal liner thickness of 40 to 50 mils with a minimum thickness of 35 mils and covering surfaces exposed to sanitary sewage.

Test for voids and holidays in accordance with ASTM G62, Method B and provide a manufacturer’s certification.

Furnish Polyline liner pipe manufactured by U.S. Pipe and Foundry Company, Polybond by American Cast Iron Pipe Company, or an approved equal.

Apply a polyamide epoxy prime coat to the exterior and ensure the outside asphaltic coating is in accordance with ANSI A21.10, ANSI A21.15, ANSI A21.51, or AWWA C-218 for pipe and fittings in open cut excavation and in casings.

Use a polyurethane coating for the exterior conforming to the requirements of the approved manufacturer, CORROPIPE II – TX, Madison Chemical Industries, Inc., for polyurethane coatings on steel or ductile-iron pipe.

K. Polyethylene Film Wrap.

1. General. Except where noted on the plans, use polyethylene film or tape as a wrap to protect ductile-iron pipe and fittings only in open ditch placements. Use polyethylene film conforming to the requirements of this specification.

2. Film. For polyethylene film, use virgin polyethylene in accordance with ASTM D1248 and AWWA C105, Type I, Class C, Category 5, Grade E-5, 2.5 to 3.0% carbon black content. Unless otherwise specified on the plans, use film 8 mils thick and with a tensile strength of 1200 to 2500 psi with elongation up to 600%. Also, ensure the dielectric strength is 800 volts per mil of thickness. Furnish the film in either in tubular form or in sheet form. Furnish film supplied in tubular form in the minimum widths shown in Table 3.

Table 3
Minimum Width of Film Tube (when laying flat)

Nominal Pipe Size (in.)	Push-On Joint Flat Tube Width (in.)
4	20
6	20
8	24
10	27
12	30
14	34
16	37
18	41
20	45
24	54

Furnish film supplied in sheet form in a width equal to twice that shown for tube widths.

3. Polyethylene Tape. For the tape used to tape film edges and overlaps, use a 3-in. wide plastic backed adhesive tape. Use Paleocene No. 900, Scotch Wrap No. 50, or approved equal.

L. Concrete. Unless otherwise shown on the plans, for concrete other than materials for pipe, use Class "A" concrete in accordance with the materials requirements of Item 420, "Concrete Structures," and Item 421, "Hydraulic Cement Concrete."

M. Cement Stabilized Sand. Use cement stabilized sand backfill containing a minimum of 7% cement, per cubic yard of material, based on the dry weight of the aggregate in accordance with Test Method TEX-120-E, of material as placed. The materials consist of aggregate, hydraulic cement, and water. Use cement and water in accordance with the materials requirements of Item 421, "Hydraulic Cement Concrete." Furnish sand, free from deleterious matter, with a maximum Plasticity Index of 6 when tested by Test Method TEX-106-E.

N. Backfill and Bedding Materials. Unless otherwise specified on the plans, furnish sand for bedding of the sanitary sewer that is free from clay lumps, organic material, and other deleterious substances. Use sand that, when tested in accordance with Test Method TEX-106-E, has a maximum Plasticity Index of 7, a maximum Liquid Limit of 25, and for which a maximum of 40% passes the No. 200 sieve.

Use earth or native soil backfill consisting of soil containing no deleterious material such as trash, wood fragments, organics, or other objectionable material. Furnish the material from either the material removed from the excavation or offsite sources. The material may consist of soil classified by the Unified Soil Classification System (USCS) as CH, CL, SC, SP, SM, SW, or GC. Use earth backfill meeting the compaction requirements of this specification and which does not cause any settlement.

O. Manholes. Use materials for manholes in accordance with the materials requirements of Item 465, "Manholes and Inlets" and as shown on the plans, except that brick is not allowed. Use fiberglass manholes if shown on the plans.

If specified, furnish prefabricated fiberglass manholes conforming to the shape, size, dimension, and details shown on the plans. Unless otherwise shown on the plans, use manhole sections in accordance with ASTM D3753. Acceptable manufacturers: fiberglass manholes manufactured by Containment Solutions Inc., L.F. Manufacturing, Inc., or an approved equal.

Stencil the date of manufacture and name or trademark of the manufacturer in 1-in. high letters on the inside of the barrel.

Unless a larger size is specified, use a 48-in. diameter barrel for fiberglass manholes. Construct wall sections of the appropriate thickness for the depth of manhole as specified in ASTM D3753, but not less than 0.48 in. thick.

Provide a fabricated reducer, bonded at the factory to form a single continuous unit at the top of the manhole barrel to accept concrete grade rings and cast-iron frame and cover. For the reducer, use an acceptable design with enough strength to safely support HS-20 loading.

For the manhole base, use a minimum 12-in. (under the invert) precast concrete base. For precast manhole bases, use an approved steel reinforced design with enough strength to withstand the imposed loads. Include an acceptable joint in the base to receive a fiberglass pipe section forming the barrel of the manhole. Coat precast concrete base sections with Thane Coat TC300 or approved equal, as recommended by the manufacturer.

P. Rings and Covers. Use materials for rings and covers in accordance with the material requirements of Item 471, "Frames, Grates, Rings, and Covers." Use covers and rings conforming to the shapes and dimensions shown on the plans and marked with the wording and logos shown on the plans.

Q. Reinforcing Steel. Furnish and place reinforcing steel in accordance with the material requirements of Item 440, "Reinforcing Steel."

R. Mortar. Furnish mortar composed of one part cement, two parts finely graded clean sand, and enough water to make the mixture plastic. When required by the Engineer, add a latex adhesive to the mortar. Use latex adhesive in accordance with the requirements of Departmental Material Specifications DMS-8110. Hydrated lime ASTM C207, Type S or lime putty may be added to the mix up to a maximum of 10% by weight of the total dry mix.

S. Adjusting Manholes. Furnish materials for adjusting manholes in accordance with the materials requirements of Item 479, "Adjusting Manholes and Inlets," and as shown on the plans.

T. Nonmetallic Pipe Detection. If installing nonmetallic pipe longitudinally underground, a method of detecting the location of the nonmetallic pipe is required. The specific method used is shown on the plans or as approved. This system may involve installing some components in the trench around the pipe which are detectable by a metal detector. Alternately, the system may involve some locating equipment capable of creating a non-destructive pressure wave which can be detected above ground using a portable detection device with both audible and visual indicators. Ensure either system of detection is capable of accurately locating to a maximum depth of 3 ft. over the areas shown on the plans.

Ensure the selected system is capable of locating lines under earth, concrete, and asphalt surfaces. Use equipment, materials, and installation as specified by the manufacturer.

U. Air Release and Vacuum Relief Valves. Provide combination air valves designed to fulfill the functions of air release, permitting escape of air accumulated in the line at high points of elevation while the line is under pressure and vacuum relief. Paint the valve exterior with an epoxy shop-applied primer.

1. Air Release Valves. Provide air release valves in combination with inlet, outlet connections, and orifice as specified on the plans. For valve materials, use: ASTM 48, Class 30, cast iron; float and leverage mechanism with body and cover, ASTM A 240 or ASTM A 276 stainless steel; orifice and seat, stainless steel against Buna-N or Viton mechanically retained with hex head nut and bolt. For other valve internals, use stainless steel or bronze.

2. Air Release and Vacuum Valves. Provide single-body standard combination or duplex-body custom combination valves as shown on the plans.

a. 2-in. and 3-in. Single-Body Valves. Provide inlet and outlet sizes as shown on the plans and an orifice sized for a 100 psi working pressure. Valve materials: for the body, cover, and baffle, use ASTM A48, Class 35, or ASTM A126, Grade B cast iron; for the plug or poppet, use ASTM A276 stainless steel; for the float, use ASTM A240 stainless steel; for the seat, use Buna-N; and for other valve internals, use stainless steel.

b. 3-in. and Larger Duplex-Body Valves. Provide air release valves as shown on the plans. Valve materials: for the body and cover, use ASTM A48, Class 35, cast iron; for the float, use ASTM A240 stainless steel; for the seat, use Type-304, stainless steel and Buna-N; and for other valve internals, use

stainless steel or bronze. Construct air release valves as specified in Section 2.U.1, “Air Release Valves.”

3. **Vacuum Release Valves.** Provide air inlet vacuum relief valves with flanged inlets and outlet connections as shown on the plans. Valve materials: for the valve body, use ASTM B 584 bronze, copper alloy 836; for the spring, use ASTM A 313, Type 304, stainless steel; for the bushing, use ASTM B 584 bronze, copper alloy 932; for the retaining screw, use ASTM A 276, Type 304, stainless steel. Set the valves to open under a pressure differential of 0.25 psi (maximum).

3. Construction.

A. Excavating and Backfilling. Excavate and backfill as required to complete the work as outlined in this specification, in accordance with construction requirements of Item 400, “Excavation and Backfill for Structures,” and as shown on the plans.

Construct sewer lines in open cut trenches with vertical sides, except in those locations where the pipe is to be jacked, bored, tunneled, or augered. Construct the trench in accordance with the dimensions shown in the Excavation and Backfill Diagram.

Sheath and brace trenches to the extent necessary to maintain the sides of the trench in a vertical position throughout the construction period. Protect excavation greater than 5 ft. in depth as required in accordance with Item 402, “Trench Excavation Protection” or Item 403, “Temporary Special Shoring.”

Always open and excavate the trench to the finished grade for a minimum distance of 50 ft. in advance of the previously placed joint of pipe. To allow for possible adjustment of alignment and grade, positively locate existing sewer lines which will connect to the sewer under construction, well in advance of making those connections.

Construct sanitary sewers in dry trenches. Perform additional work as necessary, such as dewatering or well-pointing, placing additional sheathing, or placing a concrete seal in the bottom of the trench, to accomplish this objective. This work, if necessary, is subsidiary to the pertinent bid items.

If it is necessary to excavate trenches adjacent to improved property, take precautions necessary to prevent damaging or impairing that property. If it is necessary to disturb grass, shrubs, driveways, etc., restore such improvements to their original condition.

1. **Existing Streets.** Unless otherwise shown on the plans, open cut existing streets.

   If sanitary sewer construction requires cutting through existing streets outside the limits of new street construction, replace them in kind in conformance with the pertinent specifications in the proposal and as directed.

   Cut-back the existing pavement a minimum of 1 ft. on each side of the sanitary sewer trench before replacing concrete and asphalt paving. Additional trench width may be required for unstable conditions. If this repaired area is to remain after final construction, then the repair area is to be full lane width from expansion joint to expansion joint for concrete pavement or the length of the repair for asphalt pavement.

If, in the opinion of the Engineer, a single lane closure is insufficient to maintain traffic across a trench, construct temporary access as necessary to safely maintain the traffic flow.

If the proposed sanitary sewer parallels the edge of an existing permanent pavement (i.e., concrete pavement, concrete base with asphalt surface, etc.) and is 3 ft. or less from the edge of that pavement, protect the trench with timber sheathing and bracing. Leave the bracing in place at intervals of 5 ft. maximum, for the duration of the excavation.

Keep the street surface adjacent to the trench free of surplus spoil. Place construction materials at locations that will minimize interference with the traveling public.

A maximum of 2 street intersections may be closed at any time, unless otherwise authorized by the Engineer in writing.

2. **Cutting and Restoring Pavement.** If installing sewers in streets or other paved areas, the work includes saw cutting the pavement and asphalt stabilized base (if any), removing the foundation base to neat lines, and replacing these materials after sewer excavation and backfill are complete. The type and thickness of replacement materials is shown on the plans. Performing work on or making repairs to damaged base and pavement within the project limits will be measured and paid for under the applicable specifications.

   If excavating in streets or highways, maintain traffic and provide traffic control in accordance with the plans.

   When allowed by the construction sequence shown on the plans or when directed, use a "temporary concrete cap" of the depth and class of concrete shown on the plans, or as otherwise directed, instead of a permanent repair.

B. Bedding. Before laying the pipe, shape the bedding material to conform to the outside diameter of the pipe as shown on the plans. Carefully prepare bell holes to fit the bell where using bell and spigot pipe.

C. Laying Pipe.

1. **General.** Lay sewers in a straight line, so that a light can be seen from one manhole to the other, even for the smaller size sewers. Accurately lay the pipe to line and grade, with the spigot end downstream entering the bell of the next joint of pipe. Fit pipes and fittings together and match them so they form a sewer with a smooth, watertight, and uniform invert. Take measures to provide uniform bearing for the entire length of the pipe.

   Install sewer lines meeting the minimum separation distance from any potable water line, as required by the Design Criteria for Sewage Systems, Texas Administrative Code - Chapter 317.13, Appendix E., of the Texas Commission on Environmental Quality Regulations.

Lay pipe to the lines and grades shown on the plans. To ensure proper placement, use adequate surveying methods, equipment, and employ personnel competent in the use of this equipment. Unless otherwise approved, the maximum allowable deviation of the pipe from the horizontal and vertical alignment indicated on the plans is 0.10 ft. Measure and record the “as-built” horizontal alignment and vertical grade at a maximum of every 50 ft. on the on-site recorded plans.

Submit a mylar set of plans with this “as-built” information to the Engineer for final acceptance.

During pipe laying operations, always keep pipe trenches free of water which might impair pipe laying operations. Ensure holes for bells are of ample size to prevent bells from contacting the subgrade. Carefully grade the pipe trenches to provide uniform support along the bottom of the pipe.

Do not lay more than 50 ft. of pipe in the trench ahead of backfilling operations. If the pipe laying operations are interrupted for more than 48 hours, cover the pipe laid in the trench simultaneously on each side of the pipe to avoid lateral displacement of the pipe and damage to the joints. If adjustment of the position of a length of pipe is required after it has been laid, remove and re-lay it in accordance with these specifications at no expense to the Department. After completing pipe laying and joining operations, clean the inside of the pipe and remove any debris.

Use caution to prevent damage to the coating or polyethylene film wrap when placing backfill. Place backfill in accordance with this specification.

Do not place, more than 1,000 ft. of pipe on publicly used streets ahead of the trench excavating machine. Obtain permission, in writing, from the owner or the owner’s agent before placing materials or equipment on private property.

Regardless of the type of pipe being used, place sand bedding in the bottom of the trench and compact it to a depth of 6 in. Carefully grade the bedding and excavate bell holes.

Lay pipe with bell ends facing in the direction of laying, unless otherwise directed.

Adjust the pipe and fittings to be at their proper locations and prepare each joint as specified on the plans and by the Engineer. While laying each joint of pipe in the trench, center the spigot end in the bell of the previously laid pipe. Force the pipe home and bring it to correct line and grade. Ensure each length of pipe rests on the bottom of the trench throughout its entire length.

If laying of pipe is discontinued for the day or for an indefinite period, tightly place a cap or plug in the end of the last pipe laid to prevent the intrusion of water. When water is excluded from the interior of polyvinyl chloride pipe, place enough backfill on the pipe to prevent floating. Schedule the work to prevent the possibility of floatation. Remove pipe that has floated from the trench and re-lay it as directed.

When PVC pipe is assembled on top of the trench, allow it to cool to ground temperature before backfilling to prevent pull out due to thermal contraction.

2. **PVC Pipe and Fittings.** Splicing is not allowed unless the required length of a straight section of pipe exceeds 30 ft. The Engineer may waive this requirement to meet special conditions.

   Use devices required for attaching the pipe to portions of structures or to other types of pipe that are shown on the plans or as approved. Install a water stop gasket and clamp at each PVC connection to a manhole.

   After installing, clean and paint pipe and fittings which are exposed to view in the completed structure, as shown on the plans.

3. **Ductile-Iron Pipe and Fittings.** Provide and operate proper and suitable tools and appliances for safely and conveniently handling the pipe and fittings. Use caution to prevent damaging the pipe coating. Examine pipe for defects and do not lay pipe that is known to be defective. If any defective pipe is discovered after being laid, remove and replace it with sound pipe at no expense to the Department. If the pipe requires cutting, perform it in conformance with the manufacturer's recommendations for pipe 12 in. in diameter and smaller. Use approved cutting methods for larger pipes. Ensure each cut is smooth and at right angles to the axis of the pipe.

4. **Thrust Restraint.** Unless otherwise shown on the plans, provide Portland cement concrete thrust blocking for force mains up to 12-in. in diameter, to prevent movement of buried lines under pressure at bends, tees, caps, valves, and hydrants. Place concrete in accordance with details on the plans. Place thrust blocks between undisturbed ground and fittings. Anchor the fittings to the thrust blocks so that the pipe and fitting joints are accessible for repairs. Extend the concrete from 6 in. below the pipe or fitting to 12 in. above.

   For force mains larger than 12 in. in diameter, and where indicated on the plans, provide restrained joints conforming to the requirements of the force main pipe material specifications. Install restrained joints for the length of pipe on both sides of each bend or fitting for the full length shown on the plans.

   Horizontal and vertical bends between zero and 10 degrees deflection angle will not require thrust blocks or harnessed or restrained joints.

   For horizontal and vertical bends between 10 degrees and 90 degrees deflection angle, provide thrust restraint as shown on the plans.

   Provide thrust restraint at tees, plugs, blowoff drains, valves, and caps, as indicated.

   Reinforced concrete encasement of force main pipe and fittings may be used in lieu of manufactured joint restraint systems. Provide alternate joint restraint systems using reinforced concrete encasement that conform to following design requirements:

   - Ensure design calculations are performed and sealed by Professional Engineer licensed in the State of Texas.
   - Base design calculations upon soil parameters quantified in a geotechnical report for the site where alternative thrust restraint system will be installed.

When data is not available for the site, use parameters recommended by a geotechnical engineer.

- The design system pressure is the specified test pressure.
- Utilize the following safety factors in sizing the restraint system:
  - Apply a factor of safety equal to 1.5 for passive soil resistance.
  - Apply a factor of safety equal to 2.0 for soil friction.
- Contain the encasement entirely within the standard trench width and terminate it on both ends at the pipe bell or coupling.
- Design the concrete encasement reinforcement steel for all loads, including internal pressure and longitudinal forces. Design the concrete in accordance with ACI 318.

Install piping and fittings true to alignment with rigid support. Provide anchorage where required. Repair any damage to linings before the pipe is installed. Clean out each length of pipe before installation. Adhere to the pipe manufacturer's recommendations.

Ensure the deflection at joints does not exceed that recommended by the pipe manufacturer. Provide fittings, in addition to those shown on the plans, if required, in areas where conflict exists with existing facilities.

Fabricate flanged joints using gaskets, bolts, bolt studs with a nut on each end, or studs with nuts where the flange is tapped. Use the number and size of bolts that conform to the same ANSI standard as the flanges.

- Tighten bolts in flanged joints or mechanical joints alternately and evenly.

5. Fiberglass Pipe. Do not use stiffening ribs or rings. Provide a water stop flange (wall pipe) for connection to existing cast-in-place manholes.

If the pipe is cut in the field or the interior lining is disturbed, re-coat the interior with a similar quantity of the liner resin in accordance with this specification.

Do not exceed forces recommended by the manufacturer for coupling pipes. If excessive force is required, remove the coupling, determine the source of the problem and correct it.

When jointing the pipe, do not exceed the deflection angle, measured by mandrel, permitted by the manufacturer, unless otherwise directed.

Either affix gaskets to the pipe by means of a suitable adhesive or install them in such a manner to prevent the gasket from rolling out of the pipe's pre-cut groove.

D. Manholes. Construct manholes in accordance with Item 465, "Manholes and Inlets" and with the details shown on the plans.

E. Adjusting Manholes. Adjust manholes in accordance with the construction requirements of Item 479, "Adjusting Manholes and Inlets" and as shown on the plans.

Elevations of manholes may be raised by using precast concrete rings. Elevations of manholes may be lowered by removing existing cast-in-place walls, adjusting rings, or the top section of the barrel below the new elevation and then rebuilding or raising the elevation to the proper height.

Salvage and reuse cast-iron frames and covers. Protect or block off manhole or inlet bottoms by using wood forms shaped to fit so that no debris or soil falls to the bottom during adjustment.

Install a cast-in-place slab at the top of the manhole barrel to receive the cast-iron frame and cover. Form concrete slabs a minimum of 6 in. thick. Set the cast-iron frame for the manhole cover in a full mortar bed and adjust it to the established elevation. If placing in streets, adjust covers to be flush with the top of the pavement.

The following requirements apply for fiberglass manhole adjustments: install concrete grade rings for height adjustment, as required. Construct the chimney on the flat shoulder. Do not load the manhole except on the load bearing shoulder of the manhole. The maximum adjustment height is 18 in.

Use a cut length of approved Fiberglass Reinforced Pipe (FRP) to create a finished liner inside the adjustment rings. Cut the pipe to fit between the casting and the top of the fiberglass manhole reducer. Completely seal the liner pipe to the casting and to the manhole reducer section with sealant as recommended by the manufacturer.

Set the cast-iron frame on top of the cone or adjustment rings using approved sealant materials and adjust the elevation of the casting cover to match the pavement surface. For manholes in unpaved areas, set the top of the frame a minimum of 6 in. above the existing ground line unless otherwise shown on the plans.

F. Service Connections. If existing service connections are tied into existing sewers which will be abandoned, reconnect such connections to the proposed sewers as shown on the plans or as directed.

If sewers are more than 6 ft. in depth from the finished grade to the top of the pipe, construct service connections by placing stacks on the sewer line.

Construct sewer stacks in a manner approved by the Engineer and in accordance with the details shown on the plans. If stacks are to be adjusted, make the adjustment in a manner as directed by the Engineer.

If sewers are 6 ft. or less in depth from the finished grade to the top of the pipe, construct service connections by placing wyes or tees in the sewer line at each location and using 1/4 or 1/8 bends where necessary to tie into the existing house sewer lead.

For stub outs, use PVC sewer pipe, 6-in. through 10-in. diameters, in accordance with ASTM D1784 and ASTM 3034 with a cell classification of 12454-B. Use a SDR (ratio of diameter to wall thickness) of 26 for pipe 12-in. in diameter or less and a SDR of 35 for larger pipe.

Use gasket-jointed PVC pipe with the gasket in accordance with ASTM D3212.

Select the service connection pipe diameter to match the existing service diameter, but use a minimum diameter of 6-in.

Furnish a one-piece prefabricated saddle, made either of polyethylene or PVC, with a neoprene gasket for connection to HDPE. Use full body fittings for new PVC installation.

For connection between a stub out and existing service, use a minimum 6-in. diameter flexible PVC coupling, Fernco Adapter, or an approved equal as needed.

Use 1/2-in. stainless steel bands to secure saddles to the liner pipe and the couplings to the service line.

Reconnect service connections, including those to unoccupied or abandoned buildings or to vacant lots, unless otherwise directed.

Include reconnected services on the as-built plans. Record the exact distance from each service connection to the nearest downstream manhole.

Test the service connection before backfilling. Backfill in accordance with this specification and details as shown on the plans.

G. Jacking, Boring, or Tunneling Pipe.

1. General. Perform jacking, boring, or tunneling for sanitary sewers at the locations shown on the plans and at other locations specifically designated.

Unless otherwise shown on the plans, provide casing pipe in accordance with the requirements of Section 2.H., “Steel Casing Pipe,” of this specification.

2. Jacking. Perform jacking in accordance with the requirements of Section 476.3.A., “Jacking,” of Item 476, “Jacking, Boring, or Tunneling Pipe or Box.”

3. Boring. Perform boring in accordance with the requirements of Section 476.3.B., “Boring,” of Item 476, “Jacking, Boring, or Tunneling Pipe or Box.”

If sewer lines cross underneath driveways (16 ft. wide or less) and sidewalks, install pipe in tight-fitting augered holes.

If the centerline of the proposed sanitary sewer is 10 ft. or less from the centerline of an 8-in. diameter or larger growing tree, place the pipe in a tight-fitting augered hole. Extend the bored hole at least 4 ft. beyond each side of the tree.

4. Tunneling. Perform tunneling in accordance with the requirements of Section 476.3.C., “Tunneling,” of Item 476, “Jacking, Boring, or Tunneling Pipe or Box.”

H. Handling of Pipe and Accessories.

1. General. Unload pipe, fittings, and accessories at the point of delivery and haul them to the project site. Distribute the material opposite or near to the place where it will be laid in the trench. Do not drop the materials. Do not skid or roll pipe handled on skid ways against pipe already on the ground.

Load, transport, unload, and otherwise handle pipe and fittings in a manner and by methods which will prevent damage to them. Handle and transport pipe with equipment designed, constructed, and arranged to prevent damage to the pipe, lining, and coating. Bare chains, hooks, metal bars, or narrow skids or cradles are not permitted to come in contact with the coatings. Ensure spiders are installed by the manufacturer at joint ends of fittings.

Hoist pipe from the trench side into the trench by using a sling of smooth steel cable, canvas, leather, nylon, or similar material.

During pipe construction operations, always use caution to prevent injury to the pipe, protective linings, and coatings.

If stacking pipe, package it on timbers. Place protective pads under the banding straps at the time of packaging.

If fork trucks are used to relocate pipe, pad the forks using carpet or some other suitable type of material. When relocating pipe using a crane or backhoe, use nylon straps, not chains or cables around the pipe for lifting.

Do not lift pipe using hooks at each end of the pipe.

Repair or replace any damage done to the pipe or the protective lining and coating, from any cause, during the installation of the pipeline and before final acceptance by the purchaser, at the expense of the laying Contractor, and in conformance with the applicable standards and as directed.

2. **Cleaning of Pipe and Accessories.** Remove lumps, blisters, and excess coating from the bell and spigot ends of ductile-iron pipe and fittings. Wire brush the outside of the spigot and the inside of the bell and wipe clean, dry, and free from oil and grease before laying the pipe.

   Remove foreign matter or dirt from the interior of sanitary sewer pipe and accessories and from the mating surfaces of the joints before lowering the material into the trench. During and after laying by approved means, keep the pipe and accessories clean.

   Use cleaning solutions, detergents, solvents, etc. with caution when cleaning PVC pipe.

I. Abandoning Sanitary Sewers. Where plans call for abandoning sanitary sewers, adhere to the following general procedure:

After the replacement main is constructed, tested, and released, and after services are transferred to the replacement line, locate the line to be abandoned and trace it back to the feeder line and at this point cut, plug, and abandon it. Grout the pipe if required by the plans.

J. Removing Sanitary Sewers, Casing, Force Main, and Manholes. Remove sanitary sewers, casing, force mains, and manholes in accordance with Item 100, “Preparing Right of Way” or as shown on the plans. This work includes removing and disposing of

the pipe and appurtenances as shown on the plans or as directed. Excavation and backfill, as required, are subsidiary to this Item.

K. Joining Pipe and Accessories.

1. General. After thoroughly cleaning the inside of the bell and the outside of the spigot, install members in conformance with the manufacturer's recommendation.

Mark pipe and accessories that are not furnished with a depth mark before assembling to assure that the spigot end is inserted to the full depth of the joint.

2. Polyvinyl Chloride Pipe and Accessories. Join plastic pipe in conformance with the instructions furnished by the manufacturer. Do not handle or install pipe joined using solvent cementing techniques, in the trench until after the joints are sufficiently "cured" to prevent weakening the joint.

Use lubrication for rubber-jacketed joints that is water soluble, non-toxic, non-supporting of bacteria growth, and has no deteriorating effect on PVC or the rubber gaskets.

3. Ductile-Iron Pipe. Except as noted on the plans, wrap ductile-iron pipe (including fittings and other appurtenances) with a polyethylene film wrap material.

4. Fiberglass Pipe. Unless otherwise shown on the plans, field connect pipe with fiberglass sleeve couplings that use elastomeric sealing gaskets as the sole means to maintain joint water tightness. Ensure the joints meet the performance requirements of ASTM D4161.

5. Diversion Pumping. Provide continuous sanitary sewer service to users of the sewer system during construction and maintenance operations, by diverting the flow around such areas. Maintain sewer flow to prevent backup or overflow onto streets, yards, and unpaved areas or into buildings, adjacent ditches, storm sewers, and waterways. Do not divert sewage outside of the sanitary sewer system. During pump operation, provide an experienced operator on site to monitor operation, adjust pumps, perform minor repairs to the system, and report problems.

L. Installing the Nonmetallic Pipe Detection System. Install the nonmetallic pipe detection system concurrently with placing the proposed pipe. Install this system as specified by the manufacturer and as approved. Install a complete, operational system that is satisfactory to the owner of the utility.

M. Air Release and Vacuum Valves. Inspect valves in open and closed positions to verify they are in satisfactory working condition. Install valves in conformance with the manufacturer's recommendation. Set manholes and vaults plumb as shown on the details and center manholes on valves. Provide above-ground vents for manholes and vaults as shown on the plans.

4. Testing Sanitary Sewers for Leakage.

A. Basic Requirements. Ensure sewers, when tested in accordance with this specification, do not show leakage of more than 50 gallons per 24 hours per inch of inside diameter, per mile of sewer.

B. General. Conduct testing under the supervision of the Engineer. It is the Engineer's option to conduct tests by either the infiltration method or the exfiltration method. On sewers larger than 24 in. in diameter, the tests may consist of visual inspection inside the sewer to locate leaks. The visual inspection method will be used for monolithic sewers. Where the section of sewer to be tested is entirely below the ground water table that will provide the required test head, the test will ordinarily be made by the infiltration method.

Test the first section of each size or type of sewer laid on the job that is 300 ft. or greater in length, installed by each crew, to determine the adequacy of the materials and methods used and the proficiency of the crew. Backfill this section to a minimum of 18 in. above the top of the pipe and test it without undue delay. If this initial section fails to meet the requirements of the test, make changes in methods, materials, and crew as necessary to correct the deficiency. It is the Engineer's option to require the Contractor to test any or all of the remaining sections of the sewer.

Completely backfill sewers, other than the first section described above, except at the stacks, before testing. It is the Contractor's option to make preliminary tests with a minimum of 18 in. of backfill over the pipe to determine if any need for repairs in the sewer is indicated. Such preliminary tests are entirely for the Contractor's information and will not be accepted instead of final tests.

Unless notified that the test will be made by the infiltration method, leave the tops of the stacks exposed and unplugged until after performing the leak test. Temporarily extend upward, stacks which may terminate below the test level by installing an additional length of pipe in the top.

Notify the Engineer a minimum of 24 hours in advance of performing the tests.

If the bottom of the trench is below the ground water level, provide suitable means at each manhole for readily determining the ground water level until testing is completed or waived by the Engineer. This may, as an example, consist of a pipe not less than 3 in. in diameter, plugged at the bottom and perforated for at least the lower 3 ft., with the perforations wrapped with at least two thicknesses of burlap, set in the trench before backfilling. Remove such pipes or cut them off at least 2 ft. below the ground after testing is completed or waived by the Engineer. Before removing, protect the pipes against damage and exclude earth or other material from them.

It is the Engineer's option, to vary the procedures described below under "infiltration test" and "exfiltration test" provided the methods used give an accurate measurement of the leakage occurring at the water levels specified.

C. Testing Procedures (Gravity System).

1. **Infiltration Test.** This test may be used where the ground water level rises to a plane that provides a test head not less than that specified for exfiltration tests. Stop all pumps and allow the ground water to return to its normal level (at least the elevation as indicated above) and allow it to remain so for at least 24 hours (the pipe will be filled with water to the overflow depth) and ensure leakage flows at a uniform rate through the opening in the plug in the downstream end of the section of sewer being tested before starting the test. Determine leakage by measuring the flow through the opening in the downstream plug during a given time. Perform 5 separate measurements over a 2-hour period. Use the average of the measurements, discarding any 1 of the 5 measurements, except the last, that varies by more than 50% from the average of the other 4. If the results of the test are otherwise satisfactory, but the last of the 5 measurements shows leakage in excess of that permitted, continue the tests to determine if additional leaks have developed during testing.

2. **Exfiltration Test.** It is the Contractor's option to keep the pipe full of water for 24 hours before the test to permit absorption by the pipe. If the Contractor wishes to fill the pipe, notify the Engineer by the time backfill is completed. The Engineer will then give notice at least 48 hours before the test will be made to allow time for filling and soaking the pipe.

   Supply plugs for this purpose. At least 2 hours before the test starts, bleed off the water to below the level of the top of the pipe at its lower end and allow it to remain so until the water level remains static at this level or continues to fall. Perform the test in the following manner:

   Insert a watertight plug equipped with a pipe riser and brace it in the inlet opening of the downstream manhole. Insert and brace a similar plug, equipped with a suitable vent pipe that will permit the air to escape in the pipe at its upper end, in the outlet opening of the upstream manhole.

   Fill the sewer and risers with water up to a level that is either 2-1/2 ft. above the highest point in the sewer pipe, service connection, or groundwater table, whichever is highest, plus the vertical distance from the invert of the sewer at its lower end up to the level of the ground water, where such ground water exists above the invert of the sewer.

   Fill the sewer with water as a continuous operation as rapidly as the supply will permit. Complete this filling in a minimum of 2 hours for sewers 12 in. in diameter or smaller, 3 hours for sewers 15 in. through 24 in. in diameter, and 4 hours for larger sewers. Over a one-hour period, measure the leakage during the test period by adding measured quantities of water to maintain the water level in the test structure. The quantity of water added to maintain the initial water level is the amount of leakage.

Test criteria and allowable leakage for exfiltration and infiltration tests are shown in Table 5.

Table 5
Test Criteria Tables for Exfiltration and Infiltration Water Tests

Diameter of Riser or Stack [1] (in.)	Volume per Inch of Depth (cu. in.)	(gal.)	Allowable Leakage [2] Pipe Size in Inches	Gallons/Minute Per 100 ft.
1	0.7854	0.0034	6	0.0039
2	3.1416	0.0136	8	0.0053
2.5	4.9087	0.0212	10	0.0066
3	7.0686	0.0306	12	0.0079
4	12.5664	0.0306	15	0.0099
5	19.6350	0.0544	18	0.0118
6	28.2743	0.1224	21	0.0138
8	50.2655	0.2176	24	0.0158
			27	0.0177
			30	0.0197
			36	0.0237
			42	0.0276
1. For other diameters, multiply the square of diameter, by the value for 1 in. diameter.			2. Equivalent to 50 gallons per inch of inside diameter per mile in 24 hours.	

3. Low Pressure Air Test. For sanitary sewers of less than 36-in. average inside diameters, conduct testing in sections less than 300 ft. long. For shorter runs, conduct the low pressure air test from manhole to manhole. Test 36-in. and larger sewer mains, every two runs of pipe with one pipe joint connection in between.

Perform the low pressure air test in accordance with ASTM C828 and ASTM C924, using holding times not less than those listed in Tables 6, 7, and 8.

Low Pressure Air Test:

Note 1: Tables are based on the following equation:

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

Where:

T = Time for pressure to drop 1.0 pound per square inch gauge (psig), in seconds

K = 0.000419(D)(L), but not less than 1.0

D = Average inside diameter, in inches

L = Length of line of the same pipe size being tested, in feet

Q = Rate of loss = 0.0015 Cubic feet/min./sq. ft. of internal surface area

Note 2: Add 1.0 psig for each 2.3 ft. of water above the highest point in the sewer.

Note 3: When two sizes of pipe are involved, compute the time by using the ratio of the lengths involved. For example, using 400 ft. of 10-in. pipe and 200 ft. of 6-in. pipe:

$$\text{Time} = \frac{\text{Length}_1 \times \text{Time}_1 + \text{Length}_2 \times \text{Time}_2}{\text{Length}_1 + \text{Length}_2}$$

$$= \frac{400 \times 15{:}50 + 200 \times 5{:}40}{400 + 200} = \frac{400 \times 950 + 200 \times 340}{400 + 200}$$

$$= 747 \text{ Seconds} = 12{:}27 \text{ min:sec}$$

Acceptance Testing for Sanitary Sewers

Table 6
Time Allowed for Pressure Loss from 3.5 psig to 2.5 psig

Pipe Diameter (in.)	Minimum Time (min:sec)	Length for Minimum Time (ft.)	Time for Longer Length (sec)	Specification Time for Length (L) Shown in (min:sec)				
				100 ft.	150 ft.	200 ft.	250 ft.	300 ft.
6	5:40	398	0.8548	5:40	5:40	5:40	5:40	5:40
8	7:33	298	1.5196	7:33	7:33	7:33	7:33	7:36
10	9:27	239	2.3743	9:27	9:27	9:27	9:54	11:52
12	11:20	199	3.4190	11:20	11:20	11:20	14:15	17:06
15	14:10	159	5.3423	14:10	14:10	17:48	22:16	26:43
18	17:00	133	7.6928	17:00	19:14	25:39	32:03	38:28
21	19:50	114	10.4708	19:50	26:11	34:54	43:38	52:21
24	22:40	99	13.6762	22:48	34:11	45:35	56:59	68:23
27	25:30	88	17.3089	28:51	43:16	57:42	72:07	68:33
30	28:20	80	21.3690	35:37	53:25	71:14	89:02	106:51
33	31:10	72	25.8565	43:06	64:38	86:11	107:44	129:17

Table 7
Time Allowed for Pressure Loss from 3.5 psig to 2.5 psig

Pipe Diameter (in.)	Minimum Time (min:sec)	Length for Minimum Time (ft.)	Time for Longer Length (sec)	Specification Time for Length (L) Shown in (min:sec)			
				350 ft.	400 ft.	450 ft.	500 ft.
6	5:40	398	0.8548	5:40	5:42	6:25	7:07
8	7:33	298	1.5196	8:52	10:08	11:24	12:40
10	9:27	239	2.3743	13:51	15:50	17:48	19:47
12	11:20	199	3.4190	19:57	22:48	25:39	28:30
15	14:10	159	5.3423	31:10	35:37	40:04	44:31
18	17:00	133	7.6928	44:52	51:17	57:42	64:06
21	19:50	114	10.4708	61:05	69:48	78:32	87:15
24	22:40	99	13.6762	79:47	91:10	102:34	113:58
27	25:30	88	17.3089	100:58	115:24	129:49	144:14
30	28:20	80	21.3690	124:39	142:28	160:16	178:05
33	31:10	72	25.8565	150:50	172:23	193:55	215:28

Table 8
Time Allowed for Pressure Loss from 3.5 psig to 2.5 psig

Pipe Diameter (in.)	Minimum Time (min:sec)	Length for Minimum Time (ft.)	Time for Longer Length (sec)	Specification Time for Length (L) Shown in (min:sec)	
				550 ft.	600 ft.
6	5:40	398	0.8548	7:50	8:33
8	7:33	298	1.5196	13:56	15:12
10	9:27	239	2.3743	21:46	23:45
12	11:20	199	3.4190	31:20	34:11
15	14:10	159	5.3423	48:58	53:25
18	17:00	133	7.6928	70:31	76:56
21	19:50	114	10.4708	95:59	104:42
24	22:40	99	13.6762	125:22	136:46
27	25:30	88	17.3089	158:40	173:05
30	28:20	80	21.3690	195:53	213:41
33	31:10	72	25.8565	237:01	258:34

4. Leakage Testing for Manholes. After completing manhole construction, wall sealing, or rehabilitation, but before backfilling, test manholes for water tightness using hydrostatic or vacuum testing procedures as described below.

Plug influent and effluent lines, including service lines, with suitably-sized pneumatic or mechanical plugs. Use plugs that are properly rated for the pressures required for the test. Adhere to the manufacturer's safety and installation recommendations. Place plugs a minimum of 6 in. outside of manhole walls. Brace the inverts to prevent lines from dislodging if lines entering the manhole have not been backfilled.

a. Vacuum Testing. Install the vacuum tester head assembly at the top access point of the manhole and adjust it for a proper seal on the straight top section of the manhole structure. Following the manufacturer's instructions and safety precautions, inflate the sealing element to the recommended maximum inflation pressure. Do not over-inflate the sealing element.

Evacuate the manhole with a vacuum pump to 10 in. of mercury (Hg) then disconnect the pump and monitor the vacuum for the time period specified in the Table 9.

Table 9
Vacuum Test Time Table

Depth in Feet	Time in Seconds, by Pipe Diameter		
	48 in.	60 in.	72 in.
4	10	13	16
8	20	26	32
12	30	39	48
16	40	52	64
20	50	65	80
24	60	78	96
See Note	5.0	6.5	8.0

Note: Add T times for each additional 2-ft. depth. (The values listed above have been extrapolated from ASTM C924-85)

If the drop in vacuum exceeds 1 in. of mercury (Hg) over the specified time period tabulated above, locate the leaks, complete repairs necessary to seal the manhole, and repeat the test procedure until satisfactory results are obtained.

b. Hydrostatic Exfiltration Testing. Perform hydrostatic exfiltration testing as follows: seal the wastewater lines entering the manhole with an internal pipe plug, then fill the manhole with water, and maintain it full for a minimum of one hour. The maximum leakage allowed for hydrostatic testing is 0.025 gallons per foot diameter per foot of manhole depth per hour.

If the water loss exceeds the amount tabulated above, locate the leaks, complete repairs necessary to seal the manhole, and repeat the test procedure until satisfactory results are obtained.

D. Testing Procedures (Pressure or Force Main System). After each section of force main is completed and can be isolated so high pressure cannot force test water into the operating system, hydrostatically test it. Perform such testing in accordance with Section 4 of AWWA C-600-77, as modified below:

- First, flush the test section with open bleeds with the flow controlled at the feed from the operating system so that the flushing pressure is always well below that of the operating system.
- Momentarily pressurize the pipe to 160 psi as a “burst” test. Conduct the leak test at a pressure of 140 psi.
- Pipe installations exceeding the leakage determined by the following formula will not be accepted:

$$L = \frac{(S)\,(D)\,(P)^{0.5}}{133{,}200}$$

in which (L) is the allowable leakage, in gallons per hour; (S) is the length of pipe in feet; (D) is the nominal inside diameter of the pipe in inches; and (P) is the average test pressure during the leakage test, in pounds per square inch gauge.

- After removing temporary inserts installed for hydrostatic testing, and before backfilling, leave the replacement piping exposed for visual inspection for leakage under normal pressure (after disinfection).

E. Deflection Test of Thermoplastic Pipe (PVC, etc.). Thirty days after backfilling, test flexible pipe (PVC, etc.) lines for deflection by pulling a mandrel or an approved deflectometer through the line. Perform mandrel testing in accordance with ASTM D3034 or F794. Remove and reinstall sections indicating 5% deflection or more, then retest for leakage and deflection. Mandrel testing is not required for stubs.

F. Defective Sewers. Remove sections of the sewer that show leakage exceeding that which is permitted by these specifications and re-lay them or otherwise make good by repairing using approved methods and materials. Perform permanent type repairs. Repair individual leaks that may appear whether or not the overall section meets the leakage requirements. Individual leaks will ordinarily be revealed by looking through the sewer with a light when the ground water level is over the sewer, or immediately after water from exfiltration tests is emptied from the sewer. Settlement in the backfill during exfiltration tests will be taken as an indication of leakage in the sewer.

G. Retests. After completing repairs, retest for leakage those sewers which failed to meet the requirements of the leak test.

H. Responsibility of the Department. The Engineer will observe the sanitary sewer construction and other contributing work. He or she will monitor the testing of this system for compliance with the plans and specifications.

I. Responsibilities of the Contractor. Conduct tests and supply labor, materials, and equipment required to perform the tests described in this specification.

5. Measurement. This Item will be measured as follows:

A. Sanitary Sewers will be measured by the foot, of the various sizes, types, and wall thickness (if applicable), of sanitary sewer specified, complete in place, tested, and accepted by the Engineer. Sanitary sewer will be measured longitudinally along the centerline of the sewer between the inside faces of the manholes.

If the installation involves a connection to an existing sewer line, the measurement will be made from the end of the existing sewer line to the inside face of the manhole on the work being measured.

Sanitary sewer pipe will be measured as described above and classified as sanitary sewers for the purposes of payment.

Wyes, tees, and bends are subsidiary to this Item. Include them in the measurement for payment of pipe sewer main in which they are installed. Plugs are subsidiary to the pertinent bid items.

B. Steel Casing will be measured by the foot of the various sizes installed by the open cut method complete in place and accepted by the Engineer. Steel casing will be measured longitudinally along the centerline of the casing pipe. The conditions, etc., regarding the

measurement of sanitary sewers stated under Section 5.A. above also apply to casing pipe.

C. Manholes will be measured by each manhole, of the various types specified, complete in place.

D. Adjusting Manholes will be measured by each manhole adjusted.

E. Jacking, Boring, or Tunneling for sanitary sewers and steel casing will be measured by the foot of the various sizes, types, and wall thickness (if applicable) specified of sanitary sewer or steel casing jacked, bored, or tunneled.

F. Service Connections will be measured by each complete disconnection (abandoned connection) or reconnection of the material, type, diameter, and depth range (0 to 10 ft., 10-15 ft., or greater than 15 ft.) specified for each sanitary sewer service. The depth will be measured from the natural ground level to the flow line of the sanitary sewer main at the point of reconnection, for the Contractor's information only. One or more connections discharging into a common point will be considered as one service connection.

G. Abandoning Sanitary Sewers will be measured by each sewer abandoned of the sizes specified.

H. Cutting and Restoring Pavement will be measured by the square yard, of the depths specified.

I. Air Release and Vacuum Relief Valves will be measured by each valve assembly installed of the various sizes and types specified.

6. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit prices bid for the items described below. These prices are full compensation for furnishing materials and their preparation; for excavation and backfill; for preparation, shaping, and fine grading the bottom of the trench; for cutting and restoring existing pavement; for hauling, placing, and joining of pipes, valves, and fittings; for constructing bollards, vent piping, stacks, and manholes; and for necessary appurtenances and other items of materials, labor, equipment, tools, and incidentals.

A. Sanitary Sewers. Payment for sanitary sewers will be made at the unit price bid for "Sanitary Sewers" of the various sizes, types, and wall thickness (if applicable) specified, complete in place. Plastic liner is required for concrete pipe interior surfaces and is subsidiary to this bid Item. An internal liner resin is required for centrifugally cast fiberglass pipe and is subsidiary to this bid Item.

Unless otherwise specified on the plans or this specification, excavation, disposing of unsuitable excavated material, backfilling, and the material used for backfill for the complete installation of the sanitary sewer system are subsidiary to and included in the unit price bid for the pipe and any structure for which payment is required.

Fittings, including necessary concrete blocking, pipe clamps, nipples, pipe coatings, lubricants, etc., are subsidiary to the sanitary sewer mains in which they are installed. If

additional fittings are required due to plan changes or alterations in line or grade, they will be subsidiary to the sanitary sewer lines in which they are installed.

B. Steel Casing. Payment for steel casing will be made at the unit price bid for "Casing (Steel)(Sanitary Sewer)" of the various sizes specified, installed by the open cut method, complete in place.

C. Manholes. Payment for manholes will be made at the unit price bid for "Manholes (Sanitary Sewer)" of the various types specified, complete in place. Rings, covers, and steps are subsidiary to this bid Item.

D. Adjusting Manholes. Payment for each manhole adjusted will be made at the unit price bid for "Adjusting Manholes (Sanitary Sewer)." The excavation and backfill required are subsidiary to this bid Item.

E. Jacking, Boring, or Tunneling. Payment for jacking, boring, or tunneling of sanitary sewer will be made at the unit price bid for "Jacking, Boring, or Tunneling (Sanitary Sewer)" of the various sizes, types, and wall thicknesses (if applicable) specified. This price includes furnishing the pipe.

Payment for jacking, boring, or tunneling steel casing will be made at the unit price bid for "Jacking, Boring, or Tunneling Casing (Steel)(Sanitary Sewer)" of the various sizes and wall thickness specified (applicable only if exceeding minimum thickness shown in Section 2.H., "Steel Casing Pipe," of this specification). This price includes the steel casing.

Sanitary sewer placed in casing will be paid for at the unit price bid for "Sanitary Sewers" as described above.

Excavating, backfilling, backfill material, and disposing of the unsuitable excavated material caused by jacking, boring, or tunneling pipe or casing, are subsidiary to and included in the unit price bid for the pipe or casing jacked, bored, or tunneled.

F. Service Connections. Payment for service connections will be made at the unit price bid for "Service Connections (Sanitary Sewer)." This payment includes any sewer stacks required. Excavation and backfill associated with disconnection or reconnection are subsidiary to this bid Item.

No separate payment will be made for an abandoned service connection if the service to be abandoned is within 4 ft. of an active connection. Payment for only one abandoned service connection will be allowed when a second abandoned connection is within 4 ft. of the first.

G. Abandoning Sanitary Sewers. Payment for abandoning sanitary sewer will be made at the unit price bid for "Abandoning Sanitary Sewer" of the sizes specified. Excavation and backfill required to abandon the sanitary sewer are subsidiary to this bid Item. Where grout is required, as shown on the plans, it is subsidiary to this bid Item.

H. Cutting and Restoring Pavement. Payment for cutting and restoring pavement will be made at the unit price bid for "Cutting and Restoring Pavement" of the depths specified. Excavation below the pavement and base is subsidiary to this bid Item.

I. Air Release and Vacuum Relief Valves. Payment for Air Release and Vacuum Relief Valves will be made at the unit price bid for "Air Release Valve," "Air Release and Vacuum Relief Valve," or "Vacuum Relief Valve" of the various sizes specified. This price is full compensation for valves, fittings, vent piping, bollards, necessary appurtenances, and incidentals.

Trench excavation protection or temporary special shoring required for trenches which are greater than 5 ft. in depth, and sloping the sides of those trenches to preclude collapse, will be measured and paid for as required by Item 402, "Trench Excavation Protection" or Item 403, "Temporary Special Shoring."

Furnishing and placing bedding material is subsidiary to the pertinent bid items.

Furnishing and installing a complete, operational nonmetallic pipe detection system, and the materials necessary for this system are subsidiary to the pertinent bid items.

Unless otherwise specified on the plans, repair curbs, pavement, base material, concrete riprap, and sidewalks damaged by construction operations at no expense to the Department, if such damaged items are not part of the Contract.

Testing sanitary sewers for leakage, including labor, materials, and equipment necessary to perform the tests, is subsidiary to the pertinent bid items.