

DIVISION 33 – UTILITIES
SECTION 33 31 00 – SANITARY UTILITY SEWERAGE PIPING AND ACCESSORIES

PART 1 – GENERAL

1.01 SECTION INCLUDES

- A. Force main sanitary sewer pipe, fittings, and related appurtenances.
- B. Gravity sanitary sewer pipe, fittings, and related appurtenances.

1.02 RELATED SECTIONS

- A. Section 31 23 33 – Trenching and Backfilling for Utilities.

1.03 REFERENCES

- A. American Society for Testing and Materials:
 - 1. ASTM A126 – Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
 - 2. ASTM A312/A312M – Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
 - 3. ASTM A536 – Standard Specification for Ductile Iron Castings.
 - 4. ASTM A733 – Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples.
 - 5. ASTM B117 – Standard Practice for Operating Salt Spray (Fog) Apparatus.
 - 6. ASTM C591 – Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
 - 7. ASTM C828 – Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines.
 - 8. ASTM C 1173 – Standard Specification for Flexible Transition Couplings for Underground Piping Systems
 - 9. ASTM D714 – Standard Test Method for Evaluating Degree of Blistering of Paints.
 - 10. ASTM D1784 – Standard Specification for Rigid Poly Vinyl Chloride (PVC)

Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds.

11. ASTM D2321 – Recommended Practice for Underground Installation of Flexible Thermoplastic Sewer Pipe.
12. ASTM D2412 – Standard Test Method for Determination of External Loading Characteristics of a Plastic Pipe by Parallel- Plate Loading.
13. ASTM D2467 – Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
14. ASTM D2683-10 – Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
15. ASTM D3034 – Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
16. ASTM D3035 – Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
17. ASTM D3139 – Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
18. ASTM D3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
19. ASTM D3261-10a – Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
20. ASTM D3350 – Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
21. ASTM D 5926 – Standard Specification for Poly Vinyl Chloride (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems.
22. ASTM E96 – Standard Test Methods for Water Vapor Transmission of Materials.
23. ASTM F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
24. ASTM F714 – Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
25. ASTM F1055 – Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.
26. ASTM F1290 – Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings.
27. ASTM F2206 – Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene (PE) Plastic Pipe, Fittings, Sheet Stock, Plate Stock, or Block Stock.

28. ASTM F2620 – Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings.
 29. ASTM G95 – Standard Test Method for Cathodic Disbondment Test of Pipeline Coatings (Attached Cell Method).
- B. American Nation Standard Institute:
1. ANSI/ASME B16.50 – Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings.
 2. ANSI B18.2 – Square & Hexagon Bolts & Nuts.
- C. American Water Works Association:
1. ANSI/AWWA C104/A21.4 – Cement Mortar Lining for Ductile-Iron.
 2. ANSI/AWWA C105/A21.5-10 – Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.
 3. ANSI/AWWA C110/A21.10 – Ductile-Iron and Gray-Iron Fittings, 3 in. Through 48 in., for Water and Other Liquids.
 4. ANSI/AWWA C111/A21.11 – Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings.
 5. AWWA C115 – Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
 6. AWWA C116 – Standard for Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron.
 7. ANSI/AWWA C151/A21.51 – Ductile-Iron Pipe, Centrifugally Cast.
 8. AWWA C153 – Ductile-Iron Compact Fittings for Water Service.
 9. AWWA C213 – Standard for Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
 10. AWWA C517 – Standard for Resilient-Seated Cast-Iron Eccentric Plug Valves.
 11. ANSI/AWWA C905-10 – Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 in. through 48 in.

1.04 SYSTEM DESCRIPTION

- A. All pipe shall be installed with 4'-0" of cover.

- B. Termination of main sewer shall be in a manhole.
- C. Provide minimum of 10'-0" separation between mainlines and structures.
- D. Mainlines shall not be installed in areas with fill greater than 5 ft.

1.05 SUBMITTALS

- A. Submit under provisions of Section 01 33 00.
- B. Shop Drawings and Product Data: Furnish completely dimensioned shop drawings, catalog cut or other data as required to provide a complete description of piping, fittings and other appurtenances specified herein.
- C. For force main sanitary sewers, submit design calculations sealed by a licensed Professional Engineer in the State of Pennsylvania for concrete thrust blocks. Where mechanical joint restraints are to be used, submit restraint lengths with supporting calculations.
- D. Certificates:
 - 1. Certified records or reports of results of shop tests, such records or reports to contain a sworn statement that shop tests have been made as specified.
 - 2. Manufacturer's sworn certification that pipe will be manufactured in accordance with specified reference standards for each pipe type.

1.06 QUALITY ASSURANCE

- A. Design Criteria:
 - 1. Use only one type and class of pipe in any continuous line of sewer between structures, unless otherwise approved in writing by the Authority.
 - 2. Use pipe and fittings designed to withstand imposed trench loadings and conditions at the various locations.
 - 3. Use pipe and fittings designed to withstand project specific internal operating pressures and potential surge rises.
- B. Source Quality Control:
 - 1. Perform hydrostatic and leakage shop tests on all pipe and fittings in accordance with applicable AWWA Standards.
 - 2. Shop Tests: Each pipe manufacturer must have facilities to perform listed tests. The Authority and/or its Engineer reserves the right to require the manufacturer to perform such additional number of tests as deemed necessary to establish the

quality of the material offered for use.

3. Laboratory Tests: The Authority and/or its Engineer reserves the right to require that laboratory tests also be conducted on materials that are shop tested. Furnish without compensation, labor, materials, and equipment necessary for collecting, packaging, and identifying representative samples of materials to be tested and the shipping of such samples to the Testing Laboratory. Costs for these laboratory tests shall not be the responsibility of the Authority.
 4. Quality Management System shall be ISO 9001:2000 registered.
- C. Field Quality Control:
1. Provide qualified workman trained and experienced in the skills required for the work identified herein.
 2. Use all means necessary to protect all materials of this section before, during, and after installation and to protect all objects designated to remain. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Authority and at no additional cost to the Authority.

1.07 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver, store and handle piping and related products in accordance with Specifications, manufacturer's recommendations, and as supplemented herein.
- B. Pipe and related materials to be loaded and unloaded by lifting with hoists or skidding so as to avoid shock or damage. Under no circumstances drop or skid such material against other products already on ground.
- C. Handle pipe and related materials at all times with care to avoid damage. Keep the pipe interior free from dirt and foreign matter. All pipe and appurtenances shall be carefully lowered or raised into place, with suitable equipment in a manner that will prevent damage to material. Do not drop or dump pipe or accessories under any circumstances.
- D. Thoroughly inspect pipe, pipe linings, fittings, valves, and all related materials for defects prior to being unloaded and again prior to being installed. Repair or replace any defective, damaged, or unsound material, as determined by the Authority and/or its Engineer, at no cost to the Authority.
- E. All lumps, blisters, and excess coating shall be removed from ends of each pipe. Joints shall be wire brushed and wiped clean and shall be dry and free from oil and grease before pipe is installed.

1.08 PROJECT/SITE CONDITIONS

- A. Safety:

1. The Contractor shall be responsible at all times for carrying out all pipe laying operations in a safe and prudent manner to protect all workman and the public. Encountered field conditions shall determine any necessary sheeting and bracing. All applicable OSHA requirements apply.
- B. Access and Inspection:
1. All work included in this section is subject to Inspection by the Authority or its representative. Full access to the project shall be granted.
- C. Maintenance and Protection of Traffic:
1. Contractor shall be responsible for the maintenance and protection of traffic in accordance with the requirements of the Pennsylvania Department of Transportation (PennDOT) and any applicable Highway Occupancy Permit(s). Refer to Section 01 41 00.
- D. Environmental Requirements:
1. Keep trenches dewatered until initial bedding has been placed, pipe joints have been made, and initial bedding and concrete cradle and encasement, if any, have cured.
 2. Under no circumstances lay pipe in water or on bedding containing frost.
 3. Do not lay pipe when weather conditions are unsuitable, as determined by the Authority and/or its Engineer, for pipe laying work.
 4. The Authority reserves the right to suspend the work during inclement weather, if, in the opinion of the Authority, the safety of its field personnel is endangered or if the quality of the work itself is threatened.

PART 2 – PRODUCTS

2.01 GENERAL

- A. All specials and every length of pipe shall be marked with the manufacturer's name or trademark, size, class, and the date of manufacture. Special care in handling shall be exercised during delivery, distribution, and storage of pipe to avoid damage and unnecessary stresses. Damaged pipe will be rejected and shall be replaced at the Contractor's expense. Pipe and specials stored prior to use shall be stored in such a manner as to keep the interior free from dirt and foreign matter.
- B. Testing of pipe before installation shall be as described in the corresponding ASTM or AWWA Specifications and in the applicable standard specifications listed in the following sections. Testing after the pipe is installed shall be as specified in Paragraph 3.08.
- C. If the work affects existing piping and appurtenances, the Contractor shall excavate test pits as required of all connections and crossings which may impact the new work prior to

ordering pipe and fittings to determine sufficient information for ordering materials. The Contractor shall take whatever measurements as required to complete the work.

2.02 FORCE MAIN PIPE, FITTINGS AND APPURTENANCES

A. Force Main: PVC or Ductile Iron Pipe

1. Force Main Pipe – PVC

- a. PVC sewer force main pipe shall conform to AWWA C900 Pressure Class 165 psi (DR 25), 235 psi (DR 18), 305 psi (DR 14); for sizes 4"-12" in diameter (C905 for sizes 14"-24"). Size and pressure class shall be selected based on design conditions.
- b. PVC sewer force main pipe shall be manufactured from quality PVC resin, compounded to provide physical and mechanical properties that equal or exceed cell class 12454 as defined by ASTM D1784.
- c. All PVC sewer force main pipe shall be suitable for use as a pressure conduit. Provisions shall be made at each joint for expansions and contraction at each joint with an elastomeric gasket. Pipe shall be bell and spigot.
- d. The bell shall consist of an integral thickened wall section with a factor installed, solid cross section elastomeric seal and shall be designed to be at least as hydrostatically strong as the pipe barrel and meet the requirements of AWWA C900. The wall thickness in the bell section shall conform to the requirements of Section 6.2 of ASTM D3139
- e. Pipe shall be manufactured to cast iron outside diameters (CIOD).
- f. The seal shall meet the requirements of ASTM F477.
- g. Standard laying lengths shall be no longer than 20 feet for all sizes.
- h. All pipe shall be stored indoors after production at the manufacturing site until shipped from factory.
- i. PVC sewer force main pipe to be manufactured in green and marked "Forced Sewer".
- j. Thermoplastic pipe is not acceptable for use in areas where temperature variation is possible.

2. Force Main Pipe – Ductile Iron Pipe:

- a. Ductile iron pipe, for sanitary sewer force main, shall be centrifugally cast with push-in compression joints conforming to AWWA C111, not less than 12 feet nor more than 20 feet in length. Mechanical joints are acceptable. Ductile iron sewer pipe shall be Pressure Class 350 for

sizes 4"-12". Pressure Class for pipe sizes 14" and greater shall be as required to meet design conditions. Ductile iron pipe shall meet the requirements of ANSI A21.51 and ANSI 21.50.

- b. Fittings and specials for ductile iron pipe shall be made of cast iron in accordance with ANSI A21.10 and rated for 350-psi working pressure.
- c. Lining: Ceramic epoxy lining material shall be an amine cured novalac epoxy containing at least 20% by volume ceramic quartz pigment (Protecto 401™ or equal).
- d. Coating: For buried pipe, factory coated with bituminous material, minimum 1 mil dry thickness. Bituminous material and finished coat shall conform to seal coat requirements of ANSI A21.4 and AWWA C151.
- e. All exposed (non-buried) force main ductile iron piping and fittings, including that inside wet wells and vaults, shall have flanged joints and be primed and top coated with a minimum two coats of a hi-build polyamide epoxy. Surface preparation and application shall be in accordance with the manufacturer's requirements (Tnemec Series 66 or equal). Color shall be gray.

3. Force Main Fittings – Ductile Iron Fittings:

- a. All fittings, regardless of pipe materials, shall be made of ductile iron in accordance with ASTM D536, Grade 65-45-12 and ASTM F1336. Working pressure shall be equal to or greater than the working pressure of the pipe. Wall thickness shall meet the requirements of AWWA C153. Unless otherwise specified, gasket material shall be standard styrene butadiene copolymer (SBR) in accordance with ASTM F477.
- b. Mechanical joints: Shall conform to AWWA C111. Bolts shall be high-strength, low-alloy steel per AWWA C111. Unless otherwise specified, gasket material shall be standard styrene butadiene copolymer (SBR).
- c. Flanged Joints: Shall conform to AWWA C110 and C115, Class 125. Gaskets shall be vulcanized natural or vulcanized synthetic rubber that is free of porous areas, foreign material, and visible defects. Gasket materials shall conform to AWWA C111. Factory cut gaskets shall be used. Bolts shall be black steel machine bolts with heavy hexagon heads conforming to ANSI B18.2.1. Nuts shall conform to ANSI B18.2.2. The bolts shall be tightened uniformly to distribute the bolt stress evenly and bring the pipe into alignment.

- d. Lining: Ceramic epoxy lining material shall be an amine cured novalac epoxy containing at least 20% by volume ceramic quartz pigment (Protecto 401™ or equal).
- e. Fittings Coating: For buried pipe, factory coated with bituminous material, minimum 1 mil dry thickness. Bituminous material and finished coat shall conform to seal coat requirements of ANSI A21.4 and AWWA C151.
- f. All exposed (non-buried) fittings, including those inside wet wells and vaults, shall have flanged joints and be primed and top coated with a minimum two coats of a hi-build polyamide epoxy. Surface preparation and application shall be in accordance with the manufacturer's requirements (Tnemec Series 66 or equal). Color shall be gray.

B. Force Main Thrust Restraint:

- 1. Contractor has the option of any of the means specified below. Restraint shall be provided at open cut force main (non-fused) fittings, bends, tees, changes in direction, etc.
 - a. Concrete Thrust Blocks and Tie Rods: Concrete shall be as specified in PennDOT Publication 408, Section 704 for Class A Concrete - 3,000 psi compressive strength (at 28 days). Tie rods shall be constructed of suitable metal. Metal harness of tie rods shall be galvanized or otherwise rust proofed and shall be painted with bituminous coating after installation. Contractor shall submit design calculations to support
 - b. Mechanical Joint Restraint: Restraint device for nominal pipe sizes 3" through 48" shall consist of multiple gripping wedges incorporated into a follow gland meeting the applicable requirements of ANSI/AWWA C110/A21.10. The device shall have a minimum working pressure of 350 psi for sizes 3"-16" and 250 psi for sizes 18"-48", including a minimum safety factor of 2:1. Gland body, wedges and wedge actuating components shall be cast from grade 65-45-12 ductile iron material conforming to ASTM A536. Ductile iron gripping wedges shall be heat treated within a range fo 370 and 470 BHN.
 - c. Restraint Harness (PVC): Restraint for PVC pipe bell (AWWA C900) shall consist of the following: The restraint shall be manufactured of ductile iron conforming to ASTM A536. The restraint devices shall be coated with a thermoset epoxy coating. A split serrated ring shall be used behind the pipe bell. A split serrated ring shall also be used to grip the pipe, and a sufficient number of bolts shall be used to connect the bell ring and the gripping ring. The combination shall have a minimum working pressure rated to the full pressure of the pipe. The restraint shall be manufactured by EBAA Iron, Inc., or approved equal.
 - d. Restrain Harness (DI): Ductile iron pipe bell restraint shall consist of a wedge action restraint ring on the spigot joined to a split ductile iron ring behind the bell. The restraint ring shall have individually actuated wedges that increase their resistance to pull-out as pressure or external forces increase. The restraint ring and its wedging components shall be

made of minimum grade 65-45-12 ductile iron conforming to ASTM A536. The wedges shall be heat treated to a minimum hardness of 370 BHN. Torque limiting twist off nuts shall be used to insure proper actuation of the restraining wedges. The split ring shall be made of a minimum grade of 65-45-12 ductile iron conforming to ASTM A536. The restraint devices shall be coated with a thermoset epoxy. The connecting tie rods that join the two rings shall be made of low alloy steel that conforms to ANSI/AWWA C111/A21.11. The assembly shall have a rated pressure with a minimum two to one safety factor of 350 psi for sizes 4"-16" and 250 psi for sizes 18" and larger. The product shall be manufactured by EBAA Iron, Inc., or approved equal.

C. Swing Check Valves (3" and larger)

1. Check valves larger than 3-inches shall be cushioned swing check valves rated for a minimum working pressure of 200 psi.
2. Valve closure shall be controlled by an external weighted lever arm, the action of which is cushioned by a hydraulic oil or pneumatic cylinder. Counterweights and cushion cylinders shall be designed so that adjustments can be made in the field to minimize surge and to prevent backflow and hammering noises during actual service conditions. The pneumatic cushion system shall be completely self-contained.
3. Valve bodies, cover discs, levers, and disc arms shall be constructed of heavy cast iron or cast steel fully conforming to the latest revision of ASTM A-126 Class B or Class WCB, respectively. Valve ends shall be Standard American 125 pound flat-faced flanged, in accordance with ANSI B16.1. Each valve disc shall be suspended from a noncorrosive shaft which shall pass through a stuffing box and be connected on the outside of the valve to the cushion and counterweight mechanism.
4. Valve seating shall be rubber-to-metal designed for drop-tight shutoff. The body seat ring shall be made of bronze or stainless steel and the disc seat ring of 80 Durometer rubber. Body and disc seats shall be renewable.
5. With the exception of the valve body and seat, all parts in contact with water shall be manufactured from noncorrosive materials. Internal corrosive surfaces shall be shop painted with two coats of epoxy for corrosion resistance. Exterior of valves shall be manufacturer's standard finish.

D. Plug Valves:

1. Plug valves shall be non-lubricated eccentric type with flanged ends. Eccentric plug valves shall be not less than 100% port in all sizes and meet AWWA C517. Flanges to be faced and drilled ANSI 125 pound standard. Mechanical Joint valves shall fully comply with ANSI/AWWA C111/A21.11.
2. Eccentric plug valves to be provided with grease fittings in body.
3. Valve bodies of ASTM A126 Class B cast iron. Bodies in 4 inch and larger valves

furnished with 1/8 inch welded overlay seat of not less than 99 percent pure nickel. Seat area to be raised, with raised surface completely covered with weld to insure that plug face contacts only nickel. Screwed-in seats not acceptable.

4. Plugs shall be of ASTM A536 ductile iron. Plug to have cylindrical seating surface eccentrically offset from center of plug shaft. Interference between plug face and body seat, with plug in closed position, to be externally adjustable in field with valve in line under pressure. Plug resilient faced with soft rubber.
5. Valves to have sleeve type metal bearings of sintered, oil impregnated permanently lubricated type 316 Grade CF-8M or Type 317L stainless steel in 1/2 inch to 36 inch sizes. Non-metallic bearings not acceptable.
6. Valve shaft seals shall be of the U cup type in accordance with AWWA C-517, externally adjustable and repackable without removing bonnet from the valve.
7. Valve shall be designed and manufactured to shut off bubble tight at 175 psi for valves through 12" and 150 psi for valves 14" and larger. Each valve shall be given a hydrostatic and seat test.
8. Interior of valves to be fluidized bed epoxy coated. Exterior of valves shall be manufacturer's standard finish.
9. Plug valves to be manual hand-wheel actuated. Valves to open left unless otherwise required.

E. Restraint Couplings

1. Joint Restraint to prevent axial separation shall be incorporated into the design of the sleeve or coupling used to connect two plain pipe ends. The restraint mechanism shall consist of a plurality of individually actuated gripping surfaces to maximize restraint capability. Torque limiting twist off nuts shall be used to insure proper actuating of the restraint devices. The restraint devices shall be coated with a thermoset epoxy. Ductile Iron components shall be of a minimum of 65-45-12 ductile iron meeting the requirements of ASTM A536 of the latest revision and shall be tested in accordance with the stated standard. The restrained joining system shall meet the applicable requirements of AWWA C219, ANSI/AWWA C111/A21.11, and ASTM D2000. The restrained joining system shall be manufactured by EBAA Iron, or approved equal.

F. Flanged Coupling Adapters

1. Restrained flange adapters shall be used in lieu of threaded, or welded, flanged spool pieces. Flange adapters shall be made of ductile iron conforming to ASTM A536 and have flange bolt circles that are compatible with ANSI/AWWA C110/A21.10.
2. Restraint for the flange adapter shall consist of a plurality of individual actuated gripping wedges to maximize restraint capability. Torque limiting actuating screws shall be used to insure proper initial set of gripping wedges.

3. Pressure and service shall be the same as connected piping.
 4. The flange adapter shall be capable of deflection during assembly, or permit lengths of pipe to be field cut, to allow a minimum of 0.6" gap between the end of the pipe and the mating flange without affecting the integrity of the seal.
 5. Flanged adapters shall be provided with manufacturer's standard finished coat.
 6. Bolts and nuts shall be stainless steel.
 7. For ductile iron pipe, the flange adapter shall have a safety factor of 2:1 minimum.
- G. Combination Valves (2" through 6")
1. Combination air valves shall be heavy-duty "Universal" style single body units incorporating the functions of an air and vacuum valve with an air release valve in a single housing.
 2. Combination air valves shall release accumulations of air at high points within a pipeline by exhausting large volumes of air as the pipeline is being filled, and then by releasing accumulated pockets of air while the pipeline is in operation and under pressure. Combination air valves shall also be designed to permit large volumes of air to enter the pipe-line during pipeline drainage. Valves shall be sized and located in accordance with manufacturer's recommendations.
 3. The valve body and cover flange shall be cast or fabricated 316 stainless steel and shall incorporate a "sanitary clamp" to attach the flange to the body at the outlet. Valves that use traditional bolting to attach the cover flange to the body are not acceptable. The flange clamp must be located at the outlet of the body for ease of cleaning and maintenance.
 4. All non-sealing internal metal components shall be 316 stainless steel.
 5. The valve shall incorporate an Air Release orifice of 3/16" for use at 200 psig. This orifice shall be located in the outlet of the valve and shall be drilled in a 316 stainless steel orifice plate that seals against a Buna-N rubber seat.
 6. Unit may have a maximum height of 14 inches and a maximum weight of 28 lbs.

2.03 GRAVITY SEWER PIPE AND FITTINGS

- A. PVC SDR-35 Pipe and Fittings:
1. Polyvinyl chloride (PVC) pipe, used for gravity sewer construction, shall meet or exceed the requirements of ASTM D3034 for sizes 6"-15" and ASTM F679 for sizes 18"-48". The pipe shall be colored green for in-ground identification as sewer pipe. All pipe shall be manufactured from quality PVC resin, compounded to provide physical and mechanical properties that equal or exceed cell class 12454 or 12364 as defined by ASTM D1784. The PVC sewer pipe shall have a minimum standard dimension ratio (SDR) of 35 and the minimum pipe stiffness, as tested in accordance with ASTM D2412, shall be 46 psi when measured at 5

percent deflection at 738 F. Pipe shall be manufactured with integral wall bell and spigot joints in standard lengths of 14 and/or 20 feet.

2. All pipe shall be suitable for use as a gravity sewer conduit. Provisions must be made for expansion and contraction at each joint with an elastomeric gasket. The bell shall consist of an integral wall section with a solid cross section elastomeric gasket which meets the requirements of ASTM F477. Gaskets shall be factory assembled and securely locked in place to prevent displacement during assembly. The joint design shall meet requirements of ASTM D3212 under both pressure and 22 in. Hg vacuum. All polyvinyl chloride (PVC) pipe and fittings except lateral riser cleanout stacks shall utilize elastomeric O-ring gasketed joints assembled in accordance with the manufacturer's recommendations. Provide elastomeric gaskets that have been tested as suitable for continuous contact with domestic sewage.
3. All lateral riser components shall utilize solvent welded joints and be assembled with the manufacturer's recommendations. Solvent Weld Sewer Fittings SDR 35 (3" -12") 3 through 12 injection molded solvent weld SDR 35 sewer fittings shall be manufactured in accordance with ASTM D3034. They shall be molded from virgin PVC compound having a minimum cell classification of 12454-B in accordance with, and certified by the National Sanitation Foundation (NSF), to meet ASTM D 1784. Solvent weld SDR 35 sewer fittings shall be certified by the National Sanitation Foundation (NSF) to meet ASTM D 3034.4.
4. Polyvinyl chloride wye branches, repair couplings, tees, pipe stoppers, and other fittings shall be manufactured in accordance with the same specifications and shall have the same thickness, depth of socket, and annular space as the pipe. PVC sewer fittings shall conform to ASTM D3034 specifications with a minimum wall thickness of SDR 35. PVC material shall have a cell classification of 12454 or 12364 as defined in ASTM D1784.

B. Ductile Iron (DI):

1. Ductile Iron gravity sewer pipe shall be centrifugally cast with push-on joints conforming to ASTM A746. Pipe and fittings shall have push-on joints with gaskets all conforming to AWWA C111/A21.11. Pipe and fittings shall have cement-mortar lining conforming to AWWA 104/A21.4, standard thickness.

2.04 LATERAL SEWER PIPE

- A. Lateral sewer pipes (4" or 6') that extend from the property line to the structure, in a gravity application, shall be constructed with Schedule 40 solid wall PVC pipe. All PVC Schedule 40 pipe shall be manufactured from a Type I, Grade I PVC compound with a Cell Classification of 12454 per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM D1785 and D2665, consistently meeting and/or exceeding the Quality Assurance test requirements of these standards with regard to material, workmanship, burst pressure, flattening, and extrusion quality. All pipe shall be stored indoors after production at the manufacturing site until shipped from factory.

2.05 LOW PRESSURE SEWER PIPE PIPE AND FITTINGS

- A. High Density Polyethylene - HDPE (3" and smaller):
1. Polyethylene pipe shall be made from a HDPE material having a material designation code of PE 3408/3608. The material shall meet the requirements of ASTM D3350 and shall have a minimum cell classification of PE345464C for PE 3408/3608.
 2. HDPE pipe shall be rated for use at a pressure class of 160 psi. The outside diameter of the pipe shall be based upon the IPS sizing system.
 3. IPS HDPE Butt and Socket Fusion Fittings:
 - a. Fittings shall be made of HDPE material with a minimum material designation code of PE 3408/3608 and with a minimum Cell Classification as noted in paragraph 2.02.A.4.a above. Butt Fusion Fittings shall meet the requirements of ASTM D3261. Socket fittings shall meet ASTM D2683. Molded and fabricated fittings shall have a pressure rating equal to the pipe unless otherwise specified on the Contract Drawings.
 - b. Markings for molded fittings shall comply with the requirements of ASTM D3261. Fabricated fittings shall be marked in accordance with ASTM F2206.
 4. Electrofusion Fittings: Fittings shall be made of HDPE material with a material designation code of PE 3408/3608 and with a minimum Cell Classification as noted in 2.02.A.4.a above. Electrofusion Fittings shall have a manufacturing standard of ASTM F1055. Fittings shall have a pressure rating equal to the pipe unless otherwise specified on the plans. All electrofusion fittings shall be suitable for use as pressure conduits, and have nominal burst values of four times the Working Pressure Rating (WPR) of the fitting. Markings shall be according to ASTM F1055.
 5. IPS Polypropylene (PP) compression fittings:
 - a. Compression fittings shall be suitable for connecting HDPE pipe, rated for a minimum working pressure of 160 psi, and manufactured in accordance with the latest revisions of ASTM D3035 and ASTM F714.
- B. PVC – SDR 21
1. PVC pipe with integral bell and spigot joints for low pressure sewer application shall be minimum SDR 21 iron pipe size (IPS) meeting or exceeding the requirements of ASTM D1784 cell class 12454. Gaskets shall conform to ASTM F477.

2. The bell shall consist of an integral wall section with a factory installed, solid cross section elastomeric gasket conforming to the requirements of ASTM F477. The bell section shall be designed to be at least as hydrostatically strong as the pipe barrel and meet the requirements of ASTM D2241. The joint design shall meet the requirements of ASTM D3139, under both pressure and 22 in. Hg vacuum.
 3. PVC-SDR 21 shall have a pressure rating of 200 psi and a minimum burst pressure of 630 psi at 73°F.
 4. All fittings for IPS pipe shall be manufactured in one piece of injection molded PVC compound meeting ASTM D1784. Fittings shall conform to requirements of DR 21. Fittings shall be designed to withstand a minimum of 630 psi quick burst pressure at 73°F., tested in accordance with ASTM D1599. Bell shall be gasketed joint conforming to ASTM D3139 with gaskets conforming to ASTM F477.
- C. Low Pressure Thrust Restraint:
1. Contractor has the option of any of the means specified. Restraint shall be provided for all open cut (non-fused) fittings, bends, tees, changes in direction, etc.
 - a. Concrete Thrust Blocks and Tie Rods: Concrete shall be as specified in PennDOT Publication 408, Section 704 for Class A Concrete - 3,000 psi compressive strength (at 28 days). Tie rods shall be constructed of suitable metal. Metal harness of tie rods shall be galvanized or otherwise rust proofed and shall be painted with bituminous coating after installation.

2.06 PIPELINE DETECTION AND MARKING

- A. Pipeline Detection Tape for Gravity (including laterals), and Forcemain Pipe
1. Underground Warning Tape shall be installed 18-24 inches below final grade and directly above all buried piping. Tape shall be capable of being detected with inductive methods.
 2. Detectable warning tap shall consist of a nominal 4.5 mil (0.0045") overall thickness, with a solid aluminum foil core. The imprinted warning message shall be encased to prevent ink rub-off and shall be impervious to acids, alkalis and other destructive soil elements.
 3. Minimum width of 3"
 4. Color shall be Green
 5. Tape shall be clearly and permanently labeled "CAUTION: BURIED SEWER PIPELINE BELOW".

- B. Sewer Markers for Forcemain Pipe
 - 1. Reclaimed Waterline markers shall be provided at 500 ft intervals and at all points of access to the reclaimed waterline (valves, flush mounted tracer wire posts, etc.).
 - 2. Markers shall be highly visible 100% recyclable triangular fiberglass composite posts with 360 degree visibility. Posts shall be capable of withstanding repeated vehicle impacts up to 55 mph and snap back to the original position. Markers shall be UV stable and fade resistant.
 - 3. Marker shall be 66 inches in total length and extend a minimum of 48 inches above finished grade after installation.
 - 4. Markers shall be green, and be clearly and permanently labeled "WARNING FORCE MAIN SEWER PIPELINE"
 - 5. Marker shall be installed directly above all buried piping. Install markers in accordance with the manufacturers' instructions.

- C. Test/Tracer Wire and Stations
 - 1. Test/Tracer Wire and Stations shall be installed on all non-conductive forcemains.
 - 2. AWG No. 12 stranded copper wire with high molecular weight polyethylene (HMW/PE) insulation specifically designed for direct burial in corrosive soil or water. Polyethylene insulation shall conform to ASTM D 1248, Type 1, Class C.
 - 3. Terminate test/tracer wire in a flush mounted or above ground (pedestal) test station at 500 ft intervals. The Authority will identify the required station based on force main location. Where the flush mount station is required, install a Marker Post at each station. Station shall come standard with integral internal tracer wire access points. Tube material shall be of high grade ABS, or equivalent rigid plastic that meets or exceeds ASTM D-1788, Type 1 requirements. Lid material shall be of cast iron or ductile iron. Tensile strength or ductility of such material shall be equal or superior to hi-tensile cast iron ASTM A-126-B requirements. Lid-locking bolt material shall be made of aluminum material equal or superior to ASTM B-253. Lid-locking mechanism material shall be made of plastic to meet or exceed ASTM A-126-B requirements.
 - 4. Test Stations shall be marked for sanitary sewer and contain a green insignia or be entirely green.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Carefully examine each section of pipe and each pipe fitting before laying on conformance with the inspection requirements of the appropriate referenced standard.

- B. Remove rejected pipe from the Project.

3.02 PREPARATION

- A. Clean piping interior and mating surfaces of bell, spigot and gasket before laying. Maintain clean until completed work is accepted.
- B. Perform trenching for sewer pipe and place pipe bedding as specified in Section 31 23 33 "Trenching and Backfilling for Utilities."
- C. Dig bell holes sufficiently large to permit proper joint making and to insure pipe is firmly bedded full length of its barrel.

3.03 LAYING PIPE

- A. General Requirements for Open Cut Pipe Installation:
 - 1. Lay pipe with a minimum of 4'-0" cover.
 - 2. Lay pipe proceeding upgrade true to line and grades given. Lay bell and spigot pipe with bell end upgrade unless otherwise directed by the Authority. Lay all pressure piping with the bell end toward pump discharge.
 - 3. The Contractor shall use care in setting lasers or the other means that he plans to utilize for construction of the sewers. If not constructed at the required grade, the Authority shall have the option of directing the Contractor to relay the pipe to the required grade at no cost to the Authority.
 - 4. Exercise care to insure that each length abuts against the next in such a manner that no shoulder or unevenness of any kind occurs along inside bottom half of pipeline.
 - 5. Center spigot end in bell or socket end of previously laid pipe, shove tight and secure.
 - 6. No wedging or blocking permitted in laying pipe unless by written order of Engineer.
 - 7. Before joints are made, bed each section of pipe full length of barrel with recesses excavated so pipe invert forms continuous grade with invert of pipe previously laid. Do not bring succeeding pipe into position until the preceding length is embedded and securely in place.
 - 8. Walking or working on completed pipe line, except as necessary in tamping and backfilling, not permitted until trench is backfilled one-foot deep over top of pipes.
 - 9. Take up and relay pipe that is out of alignment or grade, or pipe having disturbed joints after laying.
 - 10. Take up and replace with new, such in-place pipe sections found to be defective.

Replace at Contractor's expense.

11. Take necessary precautions to prevent newly laid pipe from floating as a result of water accumulation in the trench; or the collapse of the pipe line from any cause. Restore or replace pipe as necessary at Contractor's expense.
12. Bed pipe using materials specified in Section 31 23 33.
13. At the close of each day's work, and at such other times when pipe is not being laid, protect open end of pipe with a close fitting stopper.
14. Cut pipe using only equipment specifically designed for that purpose such as an abrasive wheel, rotary wheel cutter, a guillotine pipe saw or a milling wheel saw. The use of chisels or hand saws will not be permitted. Grind smooth cut ends and rough edges. Bevel slightly, cut end for push-on connections.
15. Where cutting of pipe is necessary, minimum laying length shall be five (5) feet.

B. Specific Requirements:

1. Install plastic pipe and fittings, and assemble joints according to ASTM D2321 for Class 1 bedding material.
2. Ductile Iron Pipe and Fittings – Install per AWWA 600. Pipe cutting, where necessary to field cut pipe use an approved pipe cutter, milling cutter or abrasive wheel. Pipe sections must have a minimum laying length of five (5) feet.
3. Refer to Section 31 23 33 – Trenching and Backfilling for Utilities, for backfilling requirements.
4. Pipeline detectable tape shall be installed continuously along all gravity and forcemain sewer lines. The tape shall be installed directly above each pipeline and two (2) feet from the ground surface. Tracer wire shall be installed continuously along all force main sewer lines.

C. Joints:

1. Make pipe and fittings joints according to pipe manufacturer's specifications and to specifications previously specified for pipe.
2. Make joints watertight. Immediately repair detected leaks and defects. Methods of repair subject to Engineer's approval.

D. Alignment and Grade:

1. Lay and maintain all pipe at the required lines and grades as shown on the Contract Drawings. Place fittings and valves at the required locations with joints centered, spigots forced home, and all valve stems plumb. Do not deviate from the required line and grade, except with the approval of the Engineer.
2. Deflect pipe joints where indicated on the drawings. Deflections shall not exceed

pipe manufacturer's recommended maximum allowable deflection.

3. Do not change grade or alignment without Engineer's approval.

E. Drop Connections:

1. Make drop connections only as required, where drop in invert is two feet or more or as required by the Authority. Construct drop connection in accordance with the Authority's detail.

3.04 LATERALS

A. Service Connection Fittings:

1. Make connections to sewer using fittings of same material and joint configuration as the sewer at the planned point of branch connection.
2. Use commercially manufactured wye fittings and one-eighth bends.
3. Set wye branches at proper vertical angles as required to bring service connections to the proper depth.
4. Fitting locations shall be determined in the field by the Authority.

B. Deep Cut Laterals

1. Where elevations of main sewers and service connections are such that lateral trenching is required to be in excess of seven (7) feet, a riser connection off of the main shall be made.
2. Riser assemblies consist of a wye fitting inserted in the main sewer with an elbow for plumb. Place a six (6) inch diameter riser pipe of a length terminating at a height allowing for shallow lateral trenching. Place an elbow on the riser pipe and extend the lateral to two (2) feet inside the property line and cap.
3. Where appropriate, place a wye on top of the riser pipe and extend to the surface and properly cap for use as a clean-out. Comply with cleanout requirements
4. Bed sewer main and riser pipe to height of elbow or wye with bedding, minimum of 6" thick.

C. Cleanouts

1. Cleanouts shall consist of a wye, 45 degree elbow, and riser pipe placed along a sewer lateral or at the end of a main for maintenance and observation.
2. Cleanouts placed in sewer laterals shall be at minimum intervals of fifty feet for 4" diameter pipe and one hundred feet for 6" diameter pipe.
3. Riser pipes shall extend to meet finished grade, capped with an adaptor for a

threaded flush plug.

4. Protect cleanout and plug as required by the Applicable detail. Refer to standard details.
5. Cleanout riser shall be of the same size and material as the lateral pipe.

D. Building/House Connection

1. Shall comply with all requirements of these specifications, including material, trenching, backfill, and compaction.
2. The house sewer shall be installed in a trench separate from the water service line with a minimum separation of ten (10) feet.
3. Where passing through the building wall or under a footer, the service lateral shall be cased in a steel conduit one pipe diameter larger than the lateral. The annular space between the later and the casing shall be sealed with a modular seal.

3.05 BORING AND JACKING

- A. Refer to Section 33 05 23 – Utility Pipe Boring and Jacking, for trenchless installation of pipe.

3.06 THRUST RESTRAINTS

- A. Temporary Thrust Restraint: Provide temporary thrust restraint at temporary caps or plugs. Submit details of temporary restraint to the Engineer for review.
- B. Permanent Thrust Restraint: Provide as specified.

3.07 FIELD QUALITY CONTROL

- A. General Requirements: Conduct tests specified herein so that each pipe line installed in the Project is tested to the Authority's satisfaction.
 1. Provide tools, materials (including water), apparatus and instruments necessary for pipe line testing.
 2. Conduct tests in the presence of and to the satisfaction of the Engineer.
- B. Alignment: After the gravity mains have been laid and backfilled, a light will be flashed between manholes or manhole locations to determine whether the alignment of the sewer is true and whether any pipe has been displaced, broken or otherwise damaged subsequent to laying. This test will again be conducted before final acceptance of the sewer.

1. Horizontal Alignment: Each section (manhole to manhole) of sewer shall show no less than a three-quarter (3/4) light circle throughout its length and any and all defects shall be corrected by the Contractor, to the satisfaction of the Engineer, before the work shall proceed and before acceptance of and/or payment shall be made.
2. Vertical Alignment: No vertical displacement or misalignment will be accepted. The Contractor, to the satisfaction of the Engineer, shall correct all defects before the work shall proceed and before acceptance of and/or payment shall be made.

C. Initial Section Test:

To demonstrate acceptability of installed pipe materials and workmanship, construct and air test one sewer section from manhole to manhole using the pipe provided in the Contract. Pre-testing such section prior to actual Initial Section Test not permitted.

1. Conduct Initial Section Test in same manner as Line Acceptance Test specified in a following paragraph.
2. Conduct said Initial Section Test for each size and type pipe material used in the Project prior to continued installation of same pipe.
3. Provide pipe manufacturer's representation during laying, backfilling and testing of Initial Sections Tests.
4. Failure of an Initial Section Test will be sufficient cause for the Engineer to reject manufacturer and supplier of pipe regardless of cause of failure.
5. Sewer sections successfully tested as Initial Section Test will be retested under Line Acceptance Test.
6. Include costs for above stated tests in unit or lump sum price or prices bid for the Work as no separate payment will be allowed for Initial Section Test.

D. Line Acceptance Test for Gravity Lines: (Leakage tests)

1. After a section of sewer is constructed between adjacent manholes, backfilled and successfully cleaned, perform a low pressure air Line Acceptance Test in accordance with ASTM C828 and the following:
 - a. Seal and brace sewer piping at upstream and downstream manholes and at all laterals. Test plug seal before actual use by testing plugs outside the trench in one length of pipe pressurized to maximum anticipated testing pressure. Plugs shall hold without bracing and show no movement. After plug is placed in pipe and sealed, brace or protect as insurance against blow out. Protect workers from potential of plug blow out.
 - b. Introduce low pressure air slowly into sealed sewer section until the internal air pressure is four psig greater than the average ground water pressure acting on the pipe, but in no case higher than 10 psig.

- c. To determine the internal air pressure for the test, add 3.5 psig to the height in feet of the ground water above the invert of the pipe divided by 2.3. However, the test pressure should not exceed 10 psig.
For example, if ground water height is 6.9': $3.5 + (6.9/2.3) = 6.5$ psig
- d. Allow no less than 3 minutes for air temperature and pressure to stabilize. Add air only to maintain required test pressure.
- e. After the stabilization period, adjust the test pressure to the required test pressure, and disconnect the air supply. Then measure the time that is required to achieve a 1.0 psig pressure drop.
- f. The line passes if the time required for a 1-psig pressure drop exceeds the value listed in Table 1 included at the end of this Section. Interpolate values for intermediate distances from those shown. If the time for 1 psig pressure loss is less than that reported in the table, then the line fails and shall be repaired prior to re-test.
- g. For conditions not reflected in the Table, utilize the following equation:

$$T=0.085 * (D^k)/Q$$

Where: T=shortest time, in seconds, allowed for the air pressure to drop 1.0 psig.

$K=0.000419D*L$, but not less than 1.0

$Q=0.0015$ cubic feet/minute/square feet of internal surface

D=nominal pipe diameter in inches

L=Length of pipe being tested in feet

- 2. After laterals are installed, re-test line in accordance with the above procedure if line is initially tested before the installation of laterals.
- 3. Where lines are live and carry flow, perform Joint Acceptance Test by testing one joint at a time as described in paragraph E, below.

E. Joint Acceptance Test for Gravity Lines (Leakage Tests)

- 1. Joint Testing Equipment Control Test: A two-part control test shall be performed to insure the accuracy, integrity, and performance capabilities of the testing equipment; testing as follows:
 - a. Demonstration Test: Prior to starting the air testing work, perform a demonstration test in the presence of the Engineer using a test cylinder, furnished by the Contractor, constructed so that a leak can be simulated. The demonstration test shall use the procedures specified in this Section.

- 1) The purpose of the demonstration test is to establish that the air testing system is capable of meeting the specified test criteria.
 - 2) If this test cannot be performed successfully, the Contractor shall repair or otherwise modify his equipment and repeat the test until the results are satisfactory to the Engineer.
 - 3) The Engineer may require that this test be repeated at any time during the joint testing work when, in the Engineer's opinion, the testing results are suspect.
- b. Readiness Test: Prior to commencing joint testing in each section of sewer main piping, perform a readiness test in the presence of the Engineer. Position the air testing packer on a section of sound sewer pipe between pipe joints and perform a test as specified in Paragraph 3.03 of this Section.
- 1) The purpose of the test is to check that the piping is properly cleaned for air testing and the air testing equipment system is operating in accordance with the requirements of the Specifications.
 - 2) If this test cannot be performed successfully, the Contractor shall remove the air testing packer from the sewer section and repair or otherwise modify his equipment and repeat the test until the results are satisfactory to the Engineer.
2. Air Testing Equipment: Provide a complete air testing system specifically designed and constructed for internal air pressure tightness integrity testing of sewer piping joints. The equipment shall be constructed in such a way as to provide means for introducing air, under pressure, into the void area created by the expanded ends of the joint-testing packer and a means for continuously measuring the actual static pressure of the air within the void area only. The system shall include, but not be limited to, the following items and features:
- a. Closed Circuit Television System per requirements of Section 33 01 31.
 - b. Packer: Open end, cylindrical casing of a size less than the pipe diameter, remote controlled for forward and backward movement within the sewer mains.
 - 1) Air-inflatable sleeves (or diaphragms) mounted at each end of the casing exterior with the ends of sleeves fastened to the casing. Devices that have sleeves which may require extreme pressures to "seat" against the inside periphery of the sewer main pipe are not permitted.
 - 2) Regulate expansion of air-inflatable sleeves by precise pressure gauges and controls. Under no conditions will hydraulically or mechanically expanded devices be allowed.

- 3) Pass conduits leading from the surface though one end of the packer casing adapted to supply air, under pressure, to the space at the center of the casing.
 - c. Compressed Air System: compressed air system shall include compressed air source, piping, valves and pressure gauges to control the rate of air flow to the packer sleeves and test section.
 - 1) To prevent loading the test section with the full pressure of the compressor, the test equipment shall be provided with an approved pressure regulating device.
 - d. Test Monitoring Equipment: Provide test monitoring equipment to transmit the value of the void air pressure to a remote test pressure monitoring gauge or readout.
 - 1) Test pressure monitoring gauge or readout shall be located to allow for simultaneous and continuous observation of the television monitor and test monitoring equipment by the Engineer.
3. Use internal televising to observe each joint and fault and to accurately position air testing equipment in sewer piping. Televising conducted in conjunction with air testing will be considered a part of the work of air testing.
 4. The air testing packer end elements shall be expanded so as to isolate the joint from the remainder of the line and create a void area between the packer end elements and the pipe joint. The ends of the testing device shall be expanded against the pipe with sufficient inflation pressure to contain the air within the void without leakage past the expanded ends.
 5. Contractor shall then introduce pressurized air into the isolated void created by testing device. Pressure shall be applied until it is determined that the pressure cannot be built in the void or until the test pressure of $\frac{1}{2}$ psi per foot of depth plus four (4) psi to a maximum of 10 psi is reached as recorded by the void pressure monitor. When either of these conditions is reached, Contractor shall shut off the air supply.
 6. If the required pressure cannot be developed, joint shall have failed the test. If the required test pressure in the void was increased to $\frac{1}{2}$ psi per foot of depth plus four (4) psi, rate of decay of this pressure shall not exceed one (1) psi in 30 seconds. The joint being tested will also have failed if the pressure drops more than one (1) psi in 30 seconds. The line shall then be repaired prior to the retest.
 7. Test Records:
 - a. During joint acceptance testing, records shall be kept which include identification of the sewer section tested, test pressure used, location (footage) of each joint tested, a statement indicating test results (passed or failed) for each joint tested, test pressure achieved and maintained for each joint passing air test, weekly equipment pressure test results, sewer section barrel test results, and air temperature at time of testing joints.

F. Hydrostatic Testing for Pressure Lines (Force Main and Low Pressure Sewers):

1. Leakage Test Requirements

- a. After the pipe has been installed as specified, all newly laid pipe, or any valved section thereof, shall be subjected to a pressure of 150 pounds per square inch, or 50% in excess of the normal working pressure. Engineer will provide working pressures.
- b. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or any valved section thereof, necessary to maintain the specified leakage test pressure after the pipe has been filled with water and the air expelled.
- c. All piping inside chambers, valve pits, etc. shall show no leakage.
- d. Leakage in PVC and DIP pipelines shall be acceptable when the leakage is less than the number of gallons per hour as determined by the formula,

$$L = \frac{ND \times P^{1/2}}{7400}$$

in which "L" equals the allowable leakage in gallons per hour; "N" is the number of joints in the length of pipelines tested; "D" is the nominal diameter of the pipe, in inches, and "P" is the average test pressure during the leakage test, in pounds per square inch gauge. (the allowable leakage according to the formula is equivalent to 11.6 gallons per 24 hours per mile of pipe per inch nominal diameter, for pipe in 18' lengths evaluated on a pressure basis of 150 psi.).

- e. Duration of Test: The duration of the test under pressure shall be two hours.
- f. Procedure: Each valved section shall be slowly filled with water and the specified test pressure, based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe in a manner satisfactory to Engineer. The pump, pipe connections, and all necessary apparatus, including gauges, shall be furnished by Contractor and approved by Engineer. Contractor will make all taps into the pipe, and furnish all necessary assistance for conducting the tests.
- g. Expelling Air Before Test: Before applying the specified test pressure, all air shall be expelled from the pipe. If hydrants or blowoffs are not available at high places, Contractor shall make the necessary taps at points of highest elevation before the test is made and insert the plugs after the test has been completed, at no additional cost to Owner.
- h. Should any test of pipe laid disclose leakage greater than that specified above, Contractor shall, at his own expense, locate, repair and replace the defective joints, pipe or fittings until the leakage is within the specified

allowance.

G. Time for Making Test:

1. Where any section of a main is provided with concrete reaction backing, the hydrostatic pressure test shall not be made until at least five days have elapsed after the concrete reaction backing was installed. If high early strength cement is used in the concrete reaction backing, the hydrostatic pressure test shall not be made until at least two days have elapsed.
2. Engineer shall be present during the operating of valves required to fill mains for pressure and leakage test.
3. Contractor shall advise Engineer of any pressure test and leakage test at least 48 hours in advance. No testing will be authorized unless ambient air temperature is 35 \pm F or higher.
4. The pressure and leakage tests shall be witnessed by Engineer.
5. Contractor shall furnish laboratory calibrated test gauges and measuring devices for the leakage test.
6. The section under test shall be brought back to test pressure at one-half hour intervals during the testing. Engineer will record both the makeup water amount and pressure at each one-half hour re-pressurization.

H. Alignment Test for Pressure Lines:

1. Prior to backfilling of pressure lines, the joint alignment shall be inspected to assure the maximum deflection present in each joint does not exceed the manufacturer's recommendations.
2. Pressure lines that are a portion of a pump discharge system shall be inspected to assure the line is installed at a constant or increasing grade so as to eliminate the possibility for air accumulation at an intermediate high point.
3. Contractor shall correct any and all defects at no additional cost to Authority and to the satisfaction of Engineer prior to backfilling. This shall be completed before the work shall proceed and before acceptance of and/or payment shall be made.

I. Acceptance: Observation of successful testing of manholes, gravity sewers, force mains, or low pressure piping by the Authority does not constitute acceptance of the system or any portion thereof. Only upon final televisual inspection by the Authority, and upon written acceptance for same, will the system or portion thereof be considered substantially completed. Upon such acceptance, the warranty period as specified for the manholes, sewers or force main will commence.

1. If, during this final inspection, any irregularities are observed, the condition must be corrected at the Contractor's expense prior to acceptance.

TABLE 1

**MINIMUM SPECIFIED TIME REQUIRED FOR A 1.0 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q = 0.0015**

1 Pipe Diameter (in.)	2 Minimum Time (min: sec)	3 Length for Minimum Time (ft)	4 Time for Longer Length (sec)	SPECIFICATION TIME FOR LENGTH (L) SHOWN (MIN:SEC)								
				100 ft.	150 ft.	200 ft.	250 ft.	300 ft.	350 ft.	400 ft.	450 ft.	
4	3:46	597	.380 L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6	5:40	398	.854 L	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.520 L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24	
10	9:26	239	2.374 L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48	
12	11:20	199	3.418 L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38	
15	14:10	159	5.342 L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04	
18	17:00	133	7.692 L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41	
21	19:50	114	10.470 L	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31	
24	22:40	99	13.674 L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33	
27	25:30	88	17.306 L	28:51	43:16	57:41	72:07	86:32	100:57	115:22	129:48	
30	28:20	80	21.366 L	35:37	53:25	71:13	89:02	106:50	124:38	142:26	160:15	
33	31:10	72	25.852 L	43:05	64:38	86:10	107:43	129:16	150:43	172:21	193:53	
36	34:00	66	30.768 L	51:17	76:55	102:34	128:12	153:50	179:29	205:07	230:46	

END OF SECTION