

SECTION 1016

SEWER PIPE

1016-1 GRAVITY SEWER PIPE: Contractor shall provide sewer pipes with the inside diameter shown on the Contract Documents. Diameters shown on the Drawings and listed in the pay items represent the required inside diameters, regardless of pipe material.

1016-1.1 Plastic Pipe: Pipe may be any of the following types:

1016-1.1.1 Polyvinyl Chloride (PVC) Pipe and Fittings:

- a. Polyvinyl chloride sewer pipe shall be green in color.

1016-1.1.1.1 PVC for Direct Bury Application:

- a. Solid Wall PVC
 1. Pipe shall be of solid-wall construction and be available in laying lengths not exceeding 20 feet.
 2. Pipe 15" diameter or smaller shall conform to ASTM D 3034; pipe larger than 15" diameter shall conform to ASTM F 679.
 3. Material for PVC pipe from 4" to 15" shall conform to the requirements of ASTM D 1784 for cell classifications 12454. Material for PVC pipe from 18" to 27" shall conform to the requirements of ASTM D 1784 for cell classifications 12364 or 12454. Maximum filler content shall be 10 percent.
 4. All pipe shall have an SDR of 35 and a minimum pipe stiffness of 46 psi when tested in accordance with ASTM D 2412. **Where pipe depth is greater than 12 ft., provide pipe in SDR 26 with minimum pipe stiffness of 115 psi.**
 5. Joints shall be an integral bell and spigot-type with solid cross section elastomeric or rubber gasket ring conforming to ASTM D 3212. Gaskets shall meet the requirements of ASTM F 477. Use elastomeric factory installed gaskets to make joints flexible and watertight. Lubricant for rubber-gasketed joints shall be water soluble, non-toxic, non-supporting of bacteria growth, having no deteriorating effect on PVC or rubber gaskets. The manufacturer shall test a sample from each batch conforming to the requirements of ASTM D 2444.
 6. All sewer fittings and accessories shall conform to the requirements of ASTM F 1336 and ASTM D 3034 or ASTM F 679 and shall have bell and/or spigot compatible with pipe. The stiffness of the fittings shall not be less than the stiffness of the adjoining pipe.
- b. Large Diameter Closed Profile PVC (21" – 54" only)
 1. PVC closed profile pipe shall be permitted for 21" through 54" direct bury gravity sewer pipe.
 2. The pipe shall meet the requirements of ASTM F-1803, Closed Profile, and have a smooth interior and effectively smooth exterior. Fittings shall be

fabricated from pipe meeting these standards.

3. Pipe and fittings shall be fabricated from PVC compounds meeting the minimum requirements of cell classification 12364 as defined by ASTM D-1784.
4. Joints shall have an integral bell and spigot with an elastomeric gasket and shall conform to the requirements of ASTM D-3212 and ASTM F-477. Gaskets shall be factory installed and chemically bonded to the bell end of the pipe. The use of putty, fillers, rubber or plastic inserts or wedges to form either the inner or outer wall of the pipe will not be allowed on spigots or bells. Jointing shall be accomplished in accordance with the manufacturer's recommendations.
5. PVC closed profile pipe shall be designed to provide a minimum pipe stiffness value of 60 psi for all sizes when tested in accordance with ASTM D-2412.
6. Each pipe length and fitting shall be clearly marked with the name of the manufacturer, nominal size, cell classification, ASTM designation F-1803, pipe stiffness designation "PS-60", and manufacturer's date code.
7. Handling and storage shall be in accordance with the pipe manufacturer's recommendations.

1016-1.1.1.2 Non-metallic Restrained Joint PVC:

- a. Pipe shall be manufactured only from water distribution pipe and couplings conforming to AWWA C900 (4-inch through 12-inch) and AWWA C905 (14-inch through 48-inch). The restrained pipe joint system shall meet all short and long-term pressure test requirements of AWWA C900 and AWWA C905, respectively.
- b. The compound shall qualify for a Hydrostatic Design Basis (HDB) of 4000 psi for water at 73.4 degrees F., in accordance with the requirements of ASTM D2837.
- c. Nominal outside diameters and wall thicknesses of thrust-restrained pipe shall conform to the requirements of AWWA C900 and AWWA C905. Pipe shall be furnished in standard lengths of 20 feet.
- d. PVC pipe shall be in accordance with Table 1016-1.
- e. Green or white pipe shall be supplied, unless otherwise agreed upon at time of purchase.
- f. Pipe and couplings shall be made from unplasticized PVC compounds having minimum cell classification of 12454, as defined in ASTM D1784.
- g. Pipes shall be joined using non-metallic couplings which have been designed as an integral system for maximum reliability and interchangeability. High-strength flexible thermoplastic splines shall be inserted into mating precision-machined grooves in the pipe and coupling to provide full 360-degree restraint with evenly distributed loading. No external pipe-to-pipe restraining devices, which clamp onto or otherwise damage the pipe surface as a result of point-loading, shall be permitted.
- h. Couplings shall be designed for use at the rated pressures of the pipe with which

they are utilized, and shall incorporate twin elastomeric sealing gaskets meeting the requirements of ASTM F477. Joints shall be designed to meet the leakage requirements of ASTM D3139.

- i. Every pipe and machined coupling shall pass AWWA C900/C905 hydrostatic proof test requirements.
- j. Pipe shall be legibly and permanently marked in ink with the following information:
 - 1. Manufacturer and Trade Name
 - 2. Nominal Size and DR Rating / Pressure Class
 - 3. Hydrostatic Proof Test Pressure (NSF-61)
 - 4. Manufacturing Date Code

1016-1.1.1.3 Fusible Polyvinylchloride (FPVC) Pipe:

- a. Fusible PVC pipe shall be permitted for only 4" through 16" diameter gravity sewer pipe.
- b. All piping shall be made from a PVC compound conforming to cell classification 12454 per ASTM D1784.
- c. Fusible polyvinylchloride pipe shall conform to ASTM D3034 or ASTM F679.
- d. Fusible polyvinylchloride pipe may instead conform to AWWA C900 or AWWA C905, if applicable. Testing shall be in accordance with AWWA standards for any of these pipe types. If the AWWA standards are used, pipe diameters shall be in Ductile Iron Pipe Sizes (DIPS).
- e. Rework material shall be allowed per ASTM D3034, ASTM F679, AWWA C900 or AWWA C905 standards.
- f. All pipe shall have an SDR of 35 and a minimum pipe stiffness of 46 psi when tested in accordance with ASTM D 2412. **Where pipe depth is greater than 12 ft., provide pipe in SDR 26 with minimum pipe stiffness of 115 psi.**
- g. Fusible polyvinylchloride pipe shall be extruded with plain ends. The ends shall be square to the pipe and free of any bevel or chamfer. There shall be no bell or gasket of any kind incorporated into the pipe.
- h. Fusible polyvinylchloride pipe shall be manufactured in a standard 20', 30' or 40' nominal length.
- i. Fusible polyvinylchloride pipe shall be green in color for wastewater use.
- j. Pipe generally shall be marked per AWWA C900 or AWWA C905, and shall include as a minimum:
 - 1. Nominal pipe size
 - 2. PVC

3. Dimension Ratio, Standard Dimension Ratio or Schedule (omit for ASTM D3034 or ASTM F679 pipe)
 4. Pipe legend or stiffness designation, or AWWA pressure class, or standard pressure rating for non-AWWA pipe
 5. AWWA Standard designation number or pipe type for non-AWWA pipe (omit for ASTM D3034 or ASTM F679 pipe)
 6. Extrusion production-record code
 7. Trademark or trade name
 8. Cell Classification 12454 and/or PVC material code 1120 may also be included.
- k. Pipe shall be homogeneous throughout and be free of visible cracks, holes, foreign material, blisters, or other visible deleterious faults.
- l. Unless otherwise specified, fusible polyvinylchloride pipe lengths shall be assembled in the field with butt-fused joints. The Contractor shall follow the pipe supplier's written guidelines for this procedure. All fusion joints shall be completed with the following minimum requirements:
1. Fusible polyvinylchloride pipe will be handled in a safe and non-destructive manner before, during, and after the fusion process and in accordance with this specification and pipe supplier's guidelines.
 2. Fusible polyvinylchloride pipe will be fused by qualified fusion technicians, as documented by the pipe supplier.
 3. Each fusion joint shall be recorded and logged by an electronic monitoring device (data logger) affixed to the fusion machine.
 4. Only appropriately sized and outfitted fusion machines that have been approved by the pipe supplier shall be used for the fusion process.
- m. Handling and storage shall be in accordance with the pipe manufacturer's recommendations.

1016-1.1.2 High Density Polyethylene (HDPE) Pipe and Fittings:

- a. HDPE Pipe for gravity sewers shall be as specified in Section 1016-2.2.
- b. HDPE Pipe for gravity sewers shall also have a light interior color.
- c. Electrofusion Fittings: Fittings shall be made of HDPE material in accordance with subsection 1016-2.2a. Electrofusion (EF) fittings shall have a manufacturing standard of ASTM F 1055.
 1. These fittings shall be supplied with an integral identification resistor and an ISO compliant 24-bit barcode which is recognized by fusion processors to set the proper fusion parameters.
 2. The electrofusion processor used must be capable of reading and storing the input parameters and the fusion results for later download to a record file which will be

made available to the Engineer.

3. These fittings, such as EF couplings, gasketed EF sewer saddles, and EF flex restraints, shall be for use with pipe conforming to ASTM D 2513/3035, F-714, and with butt fittings conforming to ASTM D 3216 as applicable.
4. Fittings shall have a pressure rating equal to the pipe unless otherwise specified.
5. ASTM F2620 and the pipe manufacturer's recommended procedure shall be observed for butt fusion and saddle fusion joints.
6. ASTM F1290 and the electrofusion fitting manufacturer's recommended joining procedure shall be observed for electrofusion joints.
7. Field fusion joints shall be made by qualified fusion technicians. Qualification of the fusion technician shall be demonstrated by evidence of certified training within the past year, specific to the fusion joint type and equipment to be utilized for the project.

1016-1.2 Ductile Iron Pipe: Ductile Iron Pipe for gravity sewers shall be as specified in Section 1016-2.3.

1016-1.3 Steel Pipe: Pipe less than 6" diameter shall be galvanized steel pipe conforming to ASTM A 53, Type E or S, Grade A.

Pipe 6" diameter and larger shall conform to AWWA C 200, Class 125. Fittings shall conform to AWWA C 208. Pipe and fittings shall be coal-tar lined and coated in accordance with AWWA C 203.

1016-1.4 Fiberglass Reinforced Polymer (FRP) Pipe:

- a. The pipes shall be manufactured in accordance with ASTM D3262. Pipe materials shall conform to the following:
 1. Resin Systems: The manufacturer shall use only approved polyester resin systems with a proven history of performance of in this particular application. The historical data shall have been acquired from a composite material of similar construction and composition as the proposed product.
 2. Glass Reinforcements: The reinforcing glass fibers to be used to manufacture the components shall be of the highest quality commercial grade of glass filaments suitably treated with binder and sizing compatible with impregnating resins.
 3. Silica Sand: Sand shall be minimum 98% silica with a maximum moisture content of 0.2%.
 4. Additives: Resin additives, such as curing agents, pigments, dyes, fillers, thixotropic agents, etc., when used, shall not detrimentally effect the performance of the product.
 5. Elastomeric Gaskets: Gaskets shall meet ASTM F477 and be supplied by qualified gasket manufacturers and be suitable for the service intended.
- b. The internal liner resin shall be suitable for service as sewer pipe, and shall be highly

resistant to exposure to sulfuric acid as produced by biological activity from hydrogen sulfide gases. Pipe shall meet or exceed requirements of ASTM D 3681.

- c. Minimum pipe stiffness when tested in accordance with ASTM D2412 shall normally be 46 psi.
- d. The pipe shall be field connected with glass reinforced plastic sleeve couplings that utilize elastomeric sealing gaskets as the sole means to maintain joint water tightness. The joints shall utilize elastomeric sealing gaskets and meet the performance requirements of ASTM D4161.
- e. Fittings: Flanges, elbows, reducers, tees, and other fittings shall be capable of withstanding operating conditions when installed. They may be contact molded or manufactured from mitered sections of pipe joined by glass fiber reinforced overlays.
- f. Pipe shall be supplied in nominal lengths of 20 feet. Shorter and custom lengths will be supplied as defined by the project requirements. The minimum wall thickness shall be per the manufacturer's design in accordance with ASTM D3567. Pipe ends shall be square to the pipe axis with a maximum tolerance of 1/8".

1016-1.5 Vitrified Clay Pipe (VCP) for Microtunneling and Pipe-Jacked Tunnels:

- a. Vitrified clay pipe and joints for jacking and microtunneling pipe shall conform to ASTM C 700 and ASTM C 1208.
- b. Joints: All VCP joints shall consist of watertight seat, an elastomeric sealing element, a sleeve, and a load distribution medium (compression disc).
 - 1. Elastomeric Sealing Gaskets: Gaskets shall conform to the requirements ASTM C 1208 and the test requirements of ASTM D 395, D 412, D 471 and D 573.
 - 2. All sleeves shall bridge between pipe sections. Stainless steel joint sleeves/couplings shall meet the requirements per grade 316L of ASTM A240\240M.
 - 3. Water tightness: Joints shall be fully watertight and shall develop the full strength of the pipe. Sealing elements shall be bonded to the bearing surface or shall be positively positioned in a recess. The manufacturer shall certify the joints to be watertight to exceed the maximum project design water head pursuant to ASTM C 828, Standard Test Methods for Low Pressure Air Testing of Vitrified Clay Pipe Lines.
 - 4. Load Distribution Medium: All joints shall be equipped with a load distribution medium (i.e., Plywood spacer or compression disc) which shall distribute the jacking force uniformly around the pipe's jacked bearing surface. All load distribution mediums shall prevent the jacking load from being concentrated on a specific area (i.e., Point loading) of the pipe that would result in damage or failure to the pipe. The width of the compression disc shall not exceed the maximum wall thickness of the pipe, nor shall it extend into the flow line or inhibit the installation of the sleeve onto the spigot end of the connecting pipe.
 - 5. When the pipes are assembled, the joints shall not extend beyond the pipes outside surface and shall not restrict installation during jacking.

6. Joint deflection shall be in strict accordance with manufacturer's recommendations.
- c. Clay pipes shall meet applicable standards when tested in accordance with ASTM C 301.

1016-1.6 Fiberglass Reinforced Polymer (FRP) Pipe for Micro tunneling and Pipe-Jacked Tunnels:

- a. The pipes shall be manufactured in accordance with ASTM D3262. Pipe materials shall conform to the following:
 1. Resin Systems: The manufacturer shall use only polyester resin systems with a proven history of performance in this particular application. The historical data shall have been collected from applications of a composite material of similar construction and composition as the proposed product.
 2. Glass Reinforcements: The reinforcing glass fibers used to manufacture the components shall be of highest quality commercial grade glass filaments with binder and sizing compatible with impregnating resins.
 3. Silica Sand: Sand shall be minimum 98% silica with a maximum moisture content of 0.2%.
 4. Additives: Resin additives, such as curing agents, pigments, dyes, fillers, thixotropic agents, etc., when used, shall not detrimentally effect the performance of the product.
 5. Elastomeric Gaskets: Gaskets shall meet ASTM F477 and be supplied by qualified gasket manufacturers and be suitable for the service intended.
- b. Pipe manufacturing process to result in a dense, nonporous, corrosion-resistant, consistent composite structure. Do not use stiffening ribs or rings.
- c. The internal liner resin shall be suitable for service as sewer pipe, and shall be highly resistant to exposure to sulfuric acid as produced by biological activity from hydrogen sulfide gases. Pipe shall meet or exceed requirements of ASTM D 3681.
- d. Joints: All FRP joints shall consist of watertight seat, an elastomeric sealing element, a sleeve, and a load distribution medium (compression disc). All FRP joints shall meet the performance requirements of ASTM D 4161 and conform to the following:
 1. Seat: The seat shall be formed at the time of fabrication or machined after fabrication and shall be watertight when assembled and combined with an elastomeric sealing element.
 2. Elastomeric Sealing Gaskets: Gaskets shall conform to the requirements of ASTM F 477.
 3. All sleeves shall bridge between pipe sections. Unless otherwise specified, the pipe shall be field connected with fiberglass sleeve couplings.

4. Load Distribution Medium: All joints shall be equipped with a load distribution medium (i.e., Plywood spacer or compression disc) which shall distribute the jacking force uniformly around the pipe's jacked bearing surface. All load distribution mediums shall prevent the jacking load from being concentrated on a specific area (i.e., Point loading) of the pipe that would result in damage or failure to the pipe. The width of the compression disc shall not exceed the maximum wall thickness of the pipe, nor shall it extend into the flow line or inhibit the installation of the sleeve onto the spigot end of the connecting pipe.
 5. The joint shall have the same outside diameter as the pipe so when the pipes are assembled; the joints are flush with the pipes outside surface and does not restrict the installation during jacking.
 6. Allowable joint deflection shall be in strict accordance with the manufacturer's recommendations.
- e. Fittings: Flanges, elbows, reducers, tees, and other fittings shall be capable of withstanding operating conditions when installed. They may be contact molded or manufactured from mitered sections of pipe joined by glass fiber reinforced overlays.
- f. Dimensions and Tolerances: All dimensions and sizes of pipe shall conform to the following:
1. Diameters: The actual outside diameter of the pipes shall be in accordance with Table 3 of ASTM D 3262 for gravity sewers.
 2. Lengths: The pipe standard length will be approximately 10 feet. A maximum of 10 percent of the lengths, excluding special order pipes, may be supplied in random lengths.
 3. Wall Thickness: The minimum average wall thickness shall be the stated design thickness. The minimum single point thickness shall not be less than 90 percent of the stated design thickness.
 4. End Squareness: Pipe ends shall be square to the pipe axis.
 5. Tolerance of Fittings: The tolerance of the angle of an elbow and the angle between the main and leg of a wye or tee shall be plus or minus 2 degrees. The tolerance on the laying length of a fitting shall be plus or minus 2 inches.
- g. Stiffness Classes: Stiffness class of FRP pipe shall satisfy design requirements, but shall not be less than 46 psi. Stiffness class of FRP in a pipe jacking operation shall be governed either by the ring deflection limitations or by a pipe design providing longitudinal strength required by the jacking method and shall satisfy design requirements stated below:
1. Pipe stress calculations based on jacking loads shall be performed to conform with Section 819 - Microtunneling and Pipe Jacked Tunnels.
 2. Ring deflection calculations shall be performed accordance to AWWA-M5 for fiberglass pipe in buried applications, to ensure that predicted pipe deflection will be less than 5 percent under long-term loading conditions (soil prism load) for the highest density of soil overburden and surcharge loads. Deflection on calculations shall be prepared using long-term (drained) values for soil parameters contained in the geotechnical investigation report for the Project, or other site-specific data obtained by the Contractor as approved by the Engineer.

1016-1.7 Polymer Concrete Pipe for Microtunneling and Pipe-Jacked Tunnels:

- a. Polymer Concrete Pipe (PCP) for use in microtunneling/tunneling installations for sanitary sewers shall be manufactured in accordance with ASTM D 6783-02.
 1. Minimum compression strength of 13,000 psi is required. The pipe-jacking load for the pipe shown on the Drawings shall be determined by the contractor for the geotechnical and other specific conditions of this project. Do not use stiffening ribs or rings.
- b. Wall Resin: The polyester wall resin used to bond the aggregate material shall be isophthalic, orthophthalic, or other approved resin with a minimum tensile elongation of two (2) percent. The resin content shall be no less than 9 percent by weight. The resin used shall have a proven history of performance in chemical solutions in a sanitary sewer environment ranging from pH 1.0 to pH 10.0.
- c. Aggregate: All PCP shall be comprised of aggregates that have a maximum grain size of 5/8 inch and sand that contains a maximum grain size of 0.08 inches. The filler material shall be a quartzite powder. All aggregate, sand, and filler material shall be washed and dried prior to fabrication. All aggregate and sand materials used in fabrication of the pipe shall be of like material and mined from the same source.
- d. Joints: All PCP joints shall consist of watertight seat, an elastomeric sealing element, a sleeve, and a load distribution medium (compression disc). All PCP joints shall meet the performance requirements of ASTM D 4161 and conform to the following:
 1. Seat: The seat shall be formed at the time of fabrication and shall be watertight when assembled and combined with an elastomeric sealing element. Seats shall not be ground after fabrication.
 2. Elastomeric Sealing Gaskets: Gaskets shall conform to the requirements of ASTM F 477.
 3. All sleeves shall bridge between pipe sections. Stainless steel joint sleeves/couplings shall meet the requirements of ASTM A 276.
 4. Water tightness: Joints shall be fully watertight and shall develop the full strength of the pipe. Sealing elements shall be bonded to the bearing surface.
 5. Load Distribution Medium: All joints shall be equipped with a load distribution medium (i.e., Plywood spacer or compression disc) which shall distribute the jacking force uniformly around the pipe's jacked bearing surface. All load distribution mediums shall prevent the jacking load from being concentrated on a specific area (i.e., Point loading) of the pipe that would result in damage or failure to the pipe. The width of the compression disc shall not exceed the maximum wall thickness of the pipe, nor shall it extend into the flow line or inhibit the installation of the sleeve onto the spigot end of the connecting pipe.

6. The joint shall have the same outside diameter as the pipe so when the pipes are assembled, the joints are flush with the pipes outside surface and does not restrict the installation during jacking.
 7. No joint deflection of any amount shall be allowed.
- e. Dimensions and Tolerances: All dimensions and sizes of pipe shall conform to the following:
1. Length: The typical pipe lengths shall have nominal dimensions of 3 feet, 6 feet or a maximum length of 10 feet.
 2. Minimum wall thickness: The minimum wall thickness shall be as needed to support the anticipated jacking forces with a factor of safety of 3.0 at the joints.
 3. Out of straight: Pipes shall not deviate from straight by more than 0.06 inch per linear foot. Measurement shall be taken by measuring the gaps between the pipe wall and a straightedge placed along any longitudinal line on the pipe's exterior surface.
 4. Out of round: The inside and outside diameters shall not vary from a true circle by more than 1.0 percent of its designed diameter. The out-of-round dimensions are the difference between the maximum and minimum diameters measured at any one location along the barrel. The compression disk shall be installed in the bell end of the pipe at the factory as part of the manufacturing process.
 5. Out of square: The ends of the pipe shall be perpendicular to the straight long axis with a tolerance of 0.125 degrees.
 6. Diameter: All diameters for PCP pipe shall be in accordance with tolerances specified by Table 2 in ASTM D 6783-02.

1016-2 FORCE MAIN SEWER PIPE:

- a. Contractor shall provide sewer force main pipes with Ductile Iron Pipe (DIPS) diameters shown on the Contract Documents. Diameters shown on the Drawings and listed in the pay items represent the required DIPS diameters, regardless of pipe material, unless otherwise noted.

1016-2.1 Polyvinylchloride (PVC) Pipe and Fittings:

- a. PVC pressure pipe (4-inch through 12-inch) and large PVC pressure pipe (14-inch through 48-inch) shall conform to the applicable requirements of AWWA C900 and AWWA C905, respectively, and the additional requirements herein.
- b. The pipe shall be of the diameter and pressure class indicated, shall be furnished complete with rubber gaskets, shall be provided as required in the Contract Documents.

- c. Materials used in manufacture of the pipe shall be tested in accordance with the requirements of this Section and the applicable ASTM and AWWA standards.
- d. Joints for the buried PVC pipe shall be an integral bell manufactured on the pipe employing a rubber ring joint. The bell shall be the same thickness as of the pipe barrel, or greater thickness. Where indicated, restrained joint pipe shall be ductile iron pipe or PVC pipe with approved Mechanical Joint (MJ) restrainer glands.
- e. Joint deflection at the joint shall not exceed 75 percent of the maximum deflection recommended by the manufacturer. No deflection of the joint shall be allowed for joints that are over-belled or not belled to the stop mark.
- f. PVC pipe shall be in accordance with the following table:

**TABLE 1016-1
PVC PRESSURE PIPE DATA**

WALL CONSTRUCTION	MANUFACTURER	AWWA DESIGNATION	SDR (MAX)	DIAMETER SIZE RANGE
Solid	See QPL	AWWA C900 (235 psi)	DR 18	4" to 12"
		AWWA C905 (165 psi)	DR 25	14" to 36"

- g. Fittings shall be ductile iron conforming to the requirements of AWWA C153 or AWWA C110 and shall have a minimum pressure rating of 250 psi. Bends, tees and other ductile iron fittings shall be restrained with the use of an approved Mechanical Joint restrainer gland or other means as indicated in the Contract Documents. Ductile iron fittings and glands must be installed per the manufacturer's guidelines.
- h. All ductile iron fittings shall be lined and coated with Ceramic Epoxy: Protecto-401 by Induron Protective Coatings, Series 431 PermaShield by TNEMEC, Permax-CTF by Permite, or approved equal.
- i. Each fitting shall be clearly labeled to identify its size and pressure class.
- j. Gaskets shall meet the requirements of ASTM F477. Use elastomeric factory-installed gaskets to make joints flexible and watertight. Lubricant for rubber-gasketed joints shall be water soluble, non-toxic, non-supporting of bacteria growth, having no deteriorating effect on PVC or rubber gaskets.
- k. Polyvinyl chloride sewer force main pipe shall be green in color.

1016-2.1.1 Fusible Polyvinylchloride (FPVC) Pipe:

- a. Fusible polyvinylchloride pipe shall be permitted for only 4" through 16" diameter sewer force main pipe.
- b. Fusible polyvinylchloride pipe shall conform to AWWA C900 or AWWA C905.

- c. Rework material shall be allowed per AWWA C900 and AWWA C905 standards.
- d. Fusible polyvinylchloride pipe shall be extruded with plain ends. The ends shall be square to the pipe and free of any bevel or chamfer. There shall be no bell or gasket of any kind incorporated into the pipe.
- e. Fusible polyvinylchloride pipe shall be manufactured in a standard 20', 30' or 40' nominal length.
- f. PVC pipe shall be in accordance with Table 1016-1.
- g. Fusible polyvinylchloride pipe shall be green in color for wastewater use.
- h. Pipe generally shall be marked per AWWA C900 or AWWA C905, and shall include as a minimum:
 - 1. Nominal pipe size
 - 2. PVC
 - 3. Dimension Ratio, Standard Dimension Ratio or Schedule
 - 4. AWWA pressure class
 - 5. AWWA Standard designation number
 - 6. Extrusion production-record code
 - 7. Trademark or trade name
 - 8. Cell Classification 12454 and/or PVC material code 1120 may also be included.
- i. Pipe shall be homogeneous throughout and be free of visible cracks, holes, foreign material, blisters, or other visible deleterious faults.
- j. Connections and Fittings:
 - 1. Connections shall be defined in conjunction with the coupling of project piping, as well as the tie-ins to other piping systems.
 - 2. Ductile Iron Fittings:
 - i. Fittings shall be ductile iron conforming to the requirements of AWWA C153 or AWWA C110 and shall have a minimum pressure rating of 250 psi. Bends, tees and other ductile iron fittings shall be restrained with the use of an approved Mechanical Joint restrainer gland or other means as indicated in the Contract Documents. Ductile iron fittings and glands must be installed per the manufacturer's guidelines.
 - ii. All ductile iron fittings shall be lined and coated with Ceramic Epoxy: Protecto-401 by Induron Protective Coatings, Series 431 PermaShield by TNEMEC, Permax-CTF by Permitem, or approved equal.

- iii. Each fitting shall be clearly labeled to identify its size and pressure class.
3. Fusible Polyvinyl Chloride Sweeps or Bends:
- i. Fusible polyvinyl chloride sweeps or bends shall conform to the same sizing convention, diameter, dimensional tolerances and pressure class of the pipe that they are joining together.
 - ii. Fusible polyvinyl chloride sweeps or bends shall be manufactured from the same fusible polyvinyl chloride pipe being used for the installation, and shall have at least 2 feet of straight section on either end of the sweep or bend to allow for fusion of the sweep to the pipe installation.
 - iii. Standard fusible polyvinyl chloride sweep or bend angles shall not be greater than 22.5 degrees, and shall be used in nominal diameters ranging from 4 inch through 16 inch.
- k. Unless otherwise specified, fusible polyvinylchloride pipe lengths shall be assembled in the field with butt-fused joints. The Contractor shall follow the pipe supplier's written guidelines for this procedure. All fusion joints shall be completed with the following minimum requirements:
- 1. Fusible polyvinylchloride pipe will be handled in a safe and non-destructive manner before, during, and after the fusion process and in accordance with this specification and pipe supplier's guidelines.
 - 2. Fusible polyvinylchloride pipe will be fused by qualified fusion technicians, as documented by the pipe supplier.
 - 3. Each fusion joint shall be recorded and logged by an electronic monitoring device (data logger) affixed to the fusion machine.
 - 4. Only appropriately sized and outfitted fusion machines that have been approved by the pipe supplier shall be used for the fusion process.
- l. Unless otherwise specified, fusible polyvinylchloride pipe lengths shall be assembled in the field with butt-fused joints. The Contractor shall follow the pipe supplier's written guidelines for this procedure. All fusion joints shall be completed with the following minimum requirements:
- 1. Fusible polyvinylchloride pipe will be handled in a safe and non-destructive manner before, during, and after the fusion process and in accordance with this specification and pipe supplier's guidelines.
 - 2. Fusible polyvinylchloride pipe will be fused by qualified fusion technicians, as documented by the pipe supplier.
 - 3. Each fusion joint shall be recorded and logged by an electronic monitoring device (data logger) affixed to the fusion machine.
 - 4. Only appropriately sized and outfitted fusion machines that have been approved by the pipe supplier shall be used for the fusion process.

- m. Handling and storage of the pipe shall be in accordance with the pipe manufacturer's recommendations.

1016-2.2 High Density Polyethylene (HDPE) Pipe and Fittings:

- a. Polyethylene pipe shall be made from HDPE material having a material code of PE3408 or higher. The material shall meet the requirements of ASTM D 3350 and shall have a minimum cell classification of PE345464C (345464E for gray HDPE pipe).
- b. Pipe and Fittings: The pipe shall meet the requirements of AWWA C906. Pipe shall be in ductile iron pipe sizes (DIPS). The pressure rating shall be 160 psi with a maximum dimension ratio (DR) of 11. Laying lengths shall be 40-ft standard.
- c. Pipe and fittings shall be marked as prescribed by AWWA C906. Pipe markings shall include nominal size, OD base (ie: 12-inch ductile iron pipe sizing, DIPS), dimension ratio, pressure class, AWWA C906, manufacturer's name, manufacturer's production code including day, month, and year extruded, and manufacturer's plant and extrusion line.
- d. Workmanship: Furnish pipe and fittings that are homogeneous throughout and free from visible defects such as foreign inclusions, concentrated ridges, discoloration, pitting, varying wall thickness, cracks, holes, foreign material, blisters, and other deformities. Pipe with gashes, nicks, abrasions, or any such physical damage which may have occurred during storage and/or handling, which are larger/deeper than 10% of the wall thickness shall not be used and shall be removed from the construction site. Provide pipe as uniform as commercially practical in color, opacity, density, and other physical properties.
- e. HDPE sewer force main pipe shall have a green colored stripe on along the exterior length of the pipe.
- f. Connections and Fittings:
 - 1. Connections shall be defined in conjunction with the coupling of project piping, as well as the tie-ins to other piping systems.
 - 2. MJ (Mechanical Joint) Adapters are to be used when connecting HDPE pipe to Ductile Iron Fitting. MJ Adapters are manufactured in standards IPS and DIPS sizes for connecting IPS sized or DIPS sized polyethylene pipe to mechanical joint fittings and appurtenances that meet AWWA C111.
 - 3. Ductile Iron Fittings:
 - i. Fittings shall be ductile iron conforming to the requirements of AWWA C153 or AWWA C110 and shall have a minimum pressure rating of 250 psi. Bends, tees and other ductile iron fittings shall be restrained with the use of an approved Mechanical Joint restrainer gland or other means as indicated in the Contract Documents. Ductile iron fittings and glands must be installed per the manufacturer's guidelines.
 - ii. All ductile iron fittings shall be lined and coated in accordance with Section 1016-2.3.

- iii. Each fitting shall be clearly labeled to identify its size and pressure class.
- iv. Gaskets shall meet the requirements of ASTM F477. Use elastomeric factory-installed gaskets to make joints flexible and watertight. Lubricant for rubber-gasketed joints shall be water soluble, non-toxic, non-supporting of bacteria growth, having no deteriorating effect on PVC or rubber gaskets.

1016-2.3 Ductile Iron Pipe and Fittings:

- a. Lined and polyethylene-wrapped ductile iron pipe shall conform to AWWA C150 and C151, subject to the supplemental requirements in this Section. The pipe shall be of the diameter and class indicated, and shall be provided complete with rubber gaskets, specials, and fittings as required under the Contract Documents. Nominal pipe laying lengths shall be 20 feet.
- b. Fittings shall be ductile iron conforming to the requirements of AWWA C153 or AWWA C110 and shall have a minimum pressure rating of 250 psi.
- c. All pipe shall have a minimum pressure rating as indicated in Table 1016-2, or higher ratings as indicated in the Contract Documents.

**TABLE 1016-2
MINIMUM PRESSURE CLASS**

PIPE SIZES (inch)	PRESSURE CLASS (psi)
4-12	350
14-20	250
24	200
30-64	150

- d. The Contractor shall legibly mark specials 24-inches in diameter and larger in accordance with the laying schedule and marking diagram. Each fitting shall be marked at each end with top field centerline.
- e. Closures and correction pieces shall be provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing on the Contract Drawings. The locations of correction pieces and closure assemblies are shown on the Contract Drawings. Any change in location or number of said items shall only be as accepted by the Engineer.
- f. Interior Linings:
 - 1. Preparation: Brush-off blast cleaning conforming to SSPC-SP7.
 - 2. Liner thickness: Minimum 40 mils, for pipe barrel interior.
 - 3. Testing: ASTM G 62, Method B for voids and holidays; provide written certification.

4. Acceptable Lining Materials shall be Ceramic Epoxy: Protecto-401 by Induron Protective Coatings, Series 431 PermaShield by TNEMEC, Permox-CTF by Permite, or approved equal. Interior lining shall be applied in accordance with the manufacturer's recommendations.
 5. Contractor shall seal cut ends, touch-up, or repair interior lignin in accordance with manufacturer's recommendations.
- g. Exterior Coating: Exterior pipe coating shall be in accordance with Section 822.
 - h. Buried Piping: –Provide polyethylene encasement unless otherwise specified or shown. Polyethylene sleeves or bags shall conform to the requirements of AWWA C105 and these specifications.
 - i. All buried piping, fittings, steel lugs, rods, brackets, clamps and other metal components shall be polyethylene encased in accordance with subsection 1016-2.3.1.
 - j. The pipe shall be designed, manufactured, tested, inspected, and marked according to AWWA C150 and C151 except where modified by this Section. The pipe and fittings shall be of the diameter and class indicated.
 - k. Ductile iron pipe and fittings shall be furnished with mechanical joints, push-on joints, flanged joints, or restrained joints as required. Mechanical and push-on joints including accessories shall conform to AWWA C111.
 - l. Flanged joints shall conform to AWWA C115. Flanged joints shall not be used in underground installations except within structures. Where threaded flanges are provided, the pipe wall thickness under the cut threads shall not be less than the calculated net thickness required for the pressure class of the pipe. All flanged piping shall be a thickness Class 53, per AWWA C115. All flanged joints shall be furnished with a minimum 1/8-inch, thick red rubber or styrene butadiene rubber gasket. The bolts and nuts shall be teflon coated high strength low alloy steel per AWWA C111 with head and nut dimensions as specified in ANSI B18.2. For bolts of 1-3/4-inches in diameter and larger, bolt studs with a nut on each end are recommended.
 - m. Restrained joints shall be commercially available units provided by American Ductile Iron Pipe, U.S. Pipe, or approved equal. Joint restraining devices that impart point loads and/or wedging action on the pipe wall as a means of joint restraint shall not be allowed unless there are no other options for joint restraint available. Under such circumstances, the Contractor may propose such devices provided the following conditions are met and the request is made as a substitution:
 1. A statement from the pipe manufacturer is provided accepting the use of the retaining devices and indicating that the use of such devices will in no way affect the warranty of the pipe and/or the performance of the pipe.
 2. The manufacturer of the device and the pipe manufacturer jointly provide instruction on the proper installation of the device to the personnel installing the units and provide certification to the Owner that the installers are adequately trained in the installation of the units and that all warranties are in full affect for the project.
 3. The devices shall be MegaLug Model 1100 as manufactured by EBAA Iron or approved equal.

- n. For bell-and-spigot ends with rubber gaskets, the clearance between the bells and spigots shall be such that when combined with the gasket groove configuration and the gasket itself, will provide watertight joints under all operating conditions when properly installed. The Contractor shall require the pipe manufacturer to submit details complete with significant dimensions and tolerances and also to submit performance data indicating that the proposed joint has performed satisfactorily under similar conditions. In the absence of a history of field performance, the results of a test program shall be submitted.

1016-2.3.1 Polyethylene Encasement:

- a. Submittals:

1. Product Data: Submit product data for proposed film and tape for approval. Product shall be manufactured from virgin polyethylene, shall not be recycled and shall be purchased new for the project, clean, sound and without defects. Product shall comply with ANSI/AWWA C105/A21.5 – Polyethylene Encasement for Ductile-Iron Pipe Systems.
2. Quality Assurance Plan: Submit quality assurance plans for film manufacturing and field application.
 - i. Film Manufacturing: The manufacturer of polyethylene film for corrosion protection encasement of ductile iron pipe shall have a verifiable quality control system to assure that film is produced from only virgin polyethylene and that it complies with all requirements of this specification. Documentation of Quality Control procedures and test results shall be submitted and shall be made available for inspection for at least one year. A current ISO certificate may be used in lieu of other quality control documentation.
 - ii. Field Application: The contractor shall develop, and submit for approval, a comprehensive Quality Assurance Plan for installation of polyethylene encasement. Address all aspects of material and pipe handling, bedding, preparation of pipe surface, film installation and anchoring, service taps and backfill. Include written procedures to be used by installers.
 - iii. Manufacturer's Certification: Submit polyethylene film manufacturer's certification of compliance with this subsection. The polyethylene film manufacturer shall provide a notarized statement from an officer of the company that the film meets the inspection and all applicable material specifications of this specification. The manufacturer's statement of compliance must be verifiable. Statements from distributors or contractors shall not be accepted in lieu of a statement from the original manufacturer of the polyethylene film.
 - iv. Installer Qualifications: Polyethylene encasement shall only be installed by qualified persons who have been trained in the proper installation and handling procedures. Qualified persons shall be those that have had training and experience in the installation of polyethylene encasement for corrosion protection of ductile iron pipe. Such persons may be qualified by the Ductile Iron Pipe Research Association, ductile iron pipe manufacturers or engineering/inspection firms who offer training courses in the proper method(s) of installation. Proof of qualifications shall be submitted with the

shop drawings and shall be provided to project inspectors upon request.

b. Materials:

1. V-Bio Enhanced Polyethylene Encasement:

- i. Polyethylene encasement shall meet all the requirements for ANSI/AWWA C105/A21.5, Polyethylene Encasement for Ductile Iron Pipe Systems.
- ii. Polyethylene encasement shall consist of three (3) layers of co-extruded linear low density polyethylene (LLDPE), fused into a single thickness of not less than eight (8) mils (0.008 in.).
- iii. The inside surface of the polyethylene wrap to be in contact with the ductile pipe exterior shall be infused with a blend of anti-microbial biocide to mitigate microbiologically influenced corrosion (MIC) and a volatile corrosion inhibitor to control galvanic corrosion.

2. Polyethylene Tape: Provide 1½-inch wide, plastic-backed, adhesive tape for fitting and anchoring the encasement. Acceptable tapes are Fulton No. 355, Polyken No. 900, Scotchwrap No. 50, or other approved tape. Fulton Tie Strips are an approved alternative to tape. For patching or repairing the polyethylene film, use only polyethylene tape.

c. Installation:

1. Polyethylene encasement for corrosion protection of ductile iron pipe shall be installed in accordance with ANSI/AWWA C105/A21.5 and as required by the Contract Documents.
2. The wrap shall be overlapped one (1) foot in each direction at the joints and secured in place around the pipe with approved polyethylene tape.
3. All installations shall be carried out by personnel trained and equipped to meet these various requirements.