V. PRODUCTS

Unless specifically stated otherwise, all materials shall be new, free from defects, and shall be in accordance with this Section.

5.1. AGGREGATE

A. MINERAL FILLER

These specifications cover inorganic material such as lime or fly ash, usually of very fine grading, added to soil or asphalt to produce a desired effect and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 201.

B. FINE AGGREGATE

These specifications cover material for use as fine aggregate in the production of hydraulic cement concrete, mortar, asphalt concrete, and asphalt surface treatments and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 202.

C. COARSE AGGREGATE

These specifications cover material used as coarse aggregate in the production of hydraulic cement concrete, asphalt concrete, asphalt surface treatments, and in drainage and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 203.

D. SUBBASE AND AGGREGATE BASE MATERIAL

These specifications cover material used to form a foundation for base or surface pavement and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 208.

E. OPEN-GRADED SHOULDER MATERIAL

These specifications cover the requirements for open-graded material used on roadway shoulders where designated on the plans or other contract documents and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 209.

F. CRUSHER RUN AGGREGATE

These specifications cover crushed aggregate used for backfilling and bedding pipe and box culverts, maintaining traffic, and repairing and constructing all-weather private access pavements and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 205.

G. LIGHTWEIGHT AGGREGATE

These specifications cover crushed aggregate used for backfilling and bedding pipe and box culverts, maintaining traffic, and repairing and constructing all-weather private access pavements and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 206.

H. SELECT MATERIAL

These specifications cover nonplastic material obtained from roadway cuts, borrow areas, or commercial sources used as foundation for subbase, shoulder surfacing, fill, backfill, or other specific purposes and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 207.

5.2. ASPHALT MATERIALS

These specifications cover the manufacturing and material requirements for asphalt material consisting of asphalt, asphalt cement, asphalt cutback, or asphalt emulsion as defined in ASTM D8 and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 210.

5.3. CASING PIPE

A. Steel Casing Pipe

1. Steel casing pipe shall be in accordance with ASTM A53 or ASTM A139, Grade B, 35,000 psi minimum yield strength, seamless (under 26-inch diameter), with beveled joints suitable for welding.

2. The diameter shall be as indicated in the Contract Documents and shall be in accordance with the VDOT *Road and Bridge Specifications*. Wall thickness shall be in accordance with the VDOT *Road and Bridge Specifications* but in no case shall be less than 1/2-inch. If casing is to be installed under railroad tracks, the railroad owner's requirements or AREA standards shall govern.

B. Carrier Pipe

1. Carrier pipe shall be as specified in the Contract Documents.

2. Skids and casing spacers shall be in accordance with the *VDOT Road and Bridge Standards*.

5.4. CLEARING AND GRUBBING

A. Temporary and /or tree protection fencing shall be as shown in the Contract Documents and in accordance with the *Virginia Erosion and Sediment Control Handbook*, as appropriate.

B. Tree wrapping where shown in the Contract Documents shall be burlap in accordance with AASHTO M182, Class 1, and/or waterproof paper, 30-30-30 krinklecraft or its equivalent, in strips 4-inches in width. Tree wound dressing shall be antiseptic and waterproof, asphalt base.

5.5. DRAINAGE STRUCTURES - PIPE AND PIPE ARCHES

These specifications cover materials used for drainage and storm water applications only and shall meet the applicable requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 232. Specifications for materials used in water distribution and sanitary sewer collection systems (gravity and force main) are described in Sections V.5.19 (Water), V.5.11 (Sanitary Gravity Sewer), and V.5.10 (Sanitary Force Main).

5.6. HYDRAULIC CEMENT CONCRETE

These specifications cover materials, design criteria, mixing, and testing procedures for hydraulic cement concrete and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 217.

A. JOINT MATERIALS

These specifications cover resilient products made from various materials that are designed to accommodate the movement of rigid structures, such as component parts of hydraulic cement concrete, and seal the joint from intrusion of water or incompressibles and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 212.

B. HYDRAULIC CEMENT MORTAR AND GROUT

These specifications cover hydraulic cement mortar and grout used in bonding units together, filling voids, and making surface repairs and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 218.

C. CONCRETE CURING MATERIALS

These specifications cover materials used to maintain the humidity and temperature of freshly placed concrete to ensure satisfactory hydration and proper hardening of the concrete and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 220.

D. DAMP-PROOFING AND WATERPROOFING MATERIALS

These specifications cover materials, generally asphalt based, that are intended to prevent or delay the passage of water, usually through a section of hydraulic cement concrete and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 213.

E. HYDRAULIC CEMENT

These specifications cover cements that harden when mixed with water. The various types have special characteristics to be used as denoted in other parts of these specifications and on the plans or in other contract documents and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 214.

F. HYDRAULIC CEMENT CONCRETE ADMIXTURES

These specifications cover materials that are chemical or organic elements that may be added to a hydraulic cement concrete mixture, when permitted elsewhere in these specifications, to achieve some desired effect and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 215.

G. WATER FOR USE WITH CEMENT OR LIME

These specifications cover water for use in mixing with cement or lime and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 216.

H. FLOWABLE FILL

Flowable fill may be used on an Owner approved, case-by-case basis for trench backfill and pipe abandonment fill. Pipe bedding requirements will remain unchanged unless otherwise specified in the Special Provisions. Fly ash may be approved for use provided it complies with the requirements of ASTM C618, Class F or Class C. A mix design certificate shall be submitted for Owner approval prior to placement of the material. Flowable fill shall meet a minimum 50 psi mix design and a maximum 300 psi mix design

5.7. PLANTING

A. Plants

1. Plants shall be obtained from approved sources. The Owner may withdraw its approval of sources that do not consistently furnish acceptable plants.

2. The botanical and common name of plants shall be in accordance with the latest edition of Standardized Plant Names, prepared by the Editorial Committee of the American Joint Committee on Horticultural Nomenclature, in effect on the date of the Invitation for Bids.

3. Plants shall be inspected and identified in accordance with the Standardized Plant Names prepared by the Editorial Committee of the American Joint Committee on Horticultural Nomenclature. The Owner may inspect and reject plants at any time and place. Plants will be inspected immediately prior to being planted. If they are planted prior to inspection and found to be unsatisfactory, they shall be replaced with approved plants at the Contractor's expense.

4. Plants and sod shipped from geographical areas that are quarantined for fire ant infestation by the U.S. Department of Agriculture shall have their roots or container contents chemically treated to destroy and/or prevent the transmission of fire ants, their eggs, or larvae. Proper certification of this treatment shall be provided with each shipment.

5. Plants shall conform to the requirements of American National Standard for Nursery Stock, by the American Association of Nurserymen, Inc. and these specifications. Plants shall be first class representatives of their normal species and varieties; shall have well-furnished branch systems and vigorous fibrous root systems characteristic of their respective kinds; shall be nursery grown; and shall bear evidence of proper nursery care, including adequate transplanting and root pruning. Plants shall comply with state and federal laws governing inspection for plant diseases and insect infestation and shall be free from insect pests, plant diseases, disfiguring knots, stubs, sun scalds, bark abrasions, or any other form of damage or objectionable disfigurements. Where a minimum and maximum size or range is specified, an average size shall be furnished. Plants shall not be pruned before delivery or cut back from larger sizes to conform to the sizes specified. Sizes furnished shall be those specified at the time of delivery and before the usual pruning at the time of planting. Nursery-grown trees shall be free from cuts of limbs that are not healing and cuts more than 3/4-inch that have not completely callused over. Deciduous shade trees shall conform to the requirements for street trees as specified in the American National Standard for Nursery Stock. Plants from cold storage will not be accepted.

6. In addition to the requirements of the American National Standard for Nursery Stock, container-grown plants shall conform to the following:

   a. The space between the rim or top of the container and the soil line within the container shall not be more than 1 1/2-inches for the 1 gallon and 2 gallon sizes and not more than 2 1/2-inches for the 5 gallon size.

   b. Encircling roots shall not have grown in such a manner that they will cause girdling of the trunk of the trunk or stems.

   c. Roots shall not protrude through drainage holes or over the rim of the container to the extent that they will be damaged while the root ball is removed from the container.

7. Plants shall have been acclimated to outside conditions. Container grown plants may be used provided their use is approved in writing by the Owner.

8. Collected plants from wild or native stands shall not be used without the written permission of the Owner unless specified in the Contract Documents. Wild or native plants shall be clean, sound stock, and free from injury, and the quality of the plants shall be similar to that specified for nursery grown material. Stock shall have sufficient root systems to ensure successful transplanting. Balls, when specified, shall be tight and well formed.

9. Clumps shall be dug from good soil that has produced a fibrous root system typical of the nature of the plant and shall have earth and incidental vegetation adhering to roots.

B. Miscellaneous Planting Materials

1. Peat moss shall be granulated, shredded, or milled sphagnum moss, nearly free from woody materials and consisting of at least 75 % decomposed leaves and stems of sphagnum moss essentially brown in color. The texture may vary from porous to spongy fibrous. Peat moss shall be free from sticks, stones, mineral matter, or other foreign material. Peat moss shall have a pH range between 3.5 and 5.5.

2. Tree wrap shall be waterproof paper, 30-30-30 krinklecraft or its equivalent, in strips 4-inches in width.

3. Twine for wrapping trees shall be jute twine, at least two-ply.

4. Soil mixture to backfill planting pits shall consist of 1 part peat moss and 4 parts topsoil as specified herein. Prior to use, peat moss and topsoil shall be thoroughly mixed. The method of mixing and the area in which the mixing operation is performed shall be approved by the Owner.

5. Water used in watering plants shall be obtained from fresh water sources and shall be free from chemicals and other toxic substances harmful to plants. Brackish water shall not be used. The source of water will be subject to the approval of the Owner.

6. Mulch used in planting plants shall be pine bark, wood chips, or other material specified in the Contract Documents or approved by the Owner. Mulch shall not be used until it has been inspected and approved by the Owner.

5.8. STEEL REINFORCEMENT

These specifications cover steel items designed to give added flexural strength to hydraulic cement concrete or to control and reduce cracking in such applications and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 223.

5.9. STONE FOR MASONRY, RIPRAP, POROUS BACKFILL, AND GABIONS

These specifications cover aggregate materials used in the construction of masonry items and stone gabions, to protect ground slopes from erosion or wave action and to facilitate drainage, generally behind a backwall or abutment and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 204.

5.10. SANITARY FORCE MAIN SYSTEMS

A. Ductile-Iron (DI) Pipe

1. DI pipe shall be furnished in 18- or 20-foot laying lengths, with push-on joints, except where mechanical or restrained joint, or flanged pipe is shown in the Contract Documents.

2. DI pipe shall conform to the requirements of ANSI/AWWA C150/A21.50 and C151/A21.51.

3. DI pipe shall be Class 52 for all pipe diameters; or Class 350 minimum pressure classification for diameters 24-inches and smaller and, 250 psi for diameters larger than 24-inches; or the thickness classification indicated in the Contract Documents. The manufacturer's mark, country where cast, year the pipe was produced, pipe class, and the letters "DI" or "Ductile Iron" shall be cast or stamped on the pipe.

4. Joints and gaskets shall conform to AWWA/ANSI C111/A21.11 or AWWA/ANSI C115/A21.15, as applicable. The minimum acceptable pressure rating for all joints is 250 psi. All flanges and glands for pipes shall be made of ductile iron.

5. Fittings shall be manufactured in accordance with ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53, as applicable, and shall be ductile iron. Compact fittings are required and shall have a minimum acceptable pressure rating of 350 psi for pipe diameters less than 16-inch and 250 psi for diameters larger than 16-inch. Fittings shall have the same pressure rating, as a minimum, as the connecting pipe.

6. Nuts and Bolts:

   a. Mechanical and buried flanged joints – provide per AWWA C111, manufactured in accordance with ASTM 588 – High strength low-alloy structural steel, up to 50 ksi minimum yield point, with atmospheric corrosion resistance (Corten steel)

   b. Heads and dimensions per ASME B1.1.

   c. Threaded per ASME B1.1.

   d. Project ends 1/4 inches to ½ inches beyond nuts.

7. ASTM A674 – Standard Practice for Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids.

8. AWWA C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems

9. Coatings shall be provided on the exterior of all pipe, joints and fittings as required by AWWA/ANSI C110/A21.10, C111/A21.11, C115/A21.15, C116/A21.16, C151/A21.51, or C153/A21.53 as applicable. All pipes, joints, and fittings shall be examined after laying to determine if the coating was damaged during installation. Any damaged areas shall be coated with a minimum of 2 mils of an approved bituminous coating.

10. Pipe diameters 12-inches and smaller shall be gaged and delivered round and true throughout its entire length. Pipe diameters over 12-inches shall have one piece of gaged pipe delivered for each fitting and at connections to existing pipelines. Gaged pieces shall be marked on the pipe with markings indicated in the shop drawings.

11. Corrosion Resistant Linings

    a. All ductile iron pipe and fittings shall be seal coated in accordance with ANSI/AWWA C104/A21.4.

    b. Ductile iron pipe and fittings shall be lined with ceramic epoxy coating.

       The lining shall be shop applied to bare metal in strict accordance with the manufacturer's recommendations to cover the inner surface of the pipe and fittings. The lining shall be a nominal thickness of 40 mils and a minimum thickness of 35 mils. The gasket area and spigot end up to 6-inches back from the end of the spigot on the outside of the pipe shall be coated with 6 mils nominal, and 10 mils maximum.

       The lining in each joint of pipe and fitting shall pass a 2,500 volt pin hole/holiday test. The pin hole/holiday detection testing shall be conducted over 100% of all lined surfaces for the ductile iron pipe and fittings. All holidays shall be repaired in accordance with the manufacturer's instructions and tested again to ensure a pinhole free lining. Short lengths of pipe required to accommodate the pipeline geometry shall be furnished factory-lined. All outlets shall be tapped by the pipe manufacturer at the factory prior to applying the pipe lining.

       Where field touch up is required to seal cut ends and repair damaged areas, Joint Compound shall be applied by brush to ensure complete coverage in accordance with the manufacturer's recommendations. Joint Compound may be used over lined pipe and fittings, or on bare substrate. Care must be taken that the joint compound is applied smooth, without excessive buildup in the gasket seat or on the spigot ends and allowed to cure for 24 hours in accordance with the manufacturer's recommendations. At least 1-inch of overlap shall be applied to the area being repaired. Protecto 401 shall not be applied over Protecto 401 Joint Compound. Joint Compound shall not be applied over wet or frozen surfaces.

12. Each length of ductile iron pipe shall be hydrostatically tested at the point of manufacture to 500 psi for a duration of 10 seconds per AWWA C151. Testing may be performed prior to machining bell and spigot. Failure of ductile iron pipe shall be defined as any leak or rupture of the pipe wall.

13. For ductile iron pipe diameters 16-inches and greater:

    a. All pipe and fittings to be installed under this Contract may be inspected at the plant for compliance with this Section by an independent testing laboratory selected by the Owner at the Owner's expense.

    b. A manufacturer's representative shall be made available when requested by the Owner during the manufacturing furnishing, transporting, and unloading of the pipe and during installation and testing to assist in confirming that the pipe is properly fabricated, transported, unloaded, stored in the field, joined and tested.

    c. The manufacturer's representative shall be made available a minimum of 2 working days (time on site) during the project when requested by the Owner, including the first 2 Days of pipeline installation.

    d. The cost for the services of the manufacturer's representative, including expenses, shall be considered incidental to the project and will not be paid separately.

B. Polyvinyl Chloride (PVC) Pipe

1. PVC pipe shall be furnished in 20-foot laying lengths, with push-on joints. Pipe shall be restrained joint where shown in the Contract Documents.

2. PVC pipe, 4 to 12-inches in diameter, shall conform to the requirements of AWWA C900 - Class 150 (DR-18), unless otherwise indicated in the Contract Documents. PVC pipe greater than 12-inches in diameter shall be AWWA C-905 - Class 235 (DR 18) or Class 165 (DR 25), as specified in the Contract Documents.

    a. The pipe, shall be made from virgin polyvinyl chloride resin or clean rework materials generated from the manufacturer's own pipe production that equals or exceeds cell class 12454-B as defined by ASTM D 1784, and shall bear the seal of approval by the NSF. The pipe shall be unplasticized polyvinyl chloride plastic pressure pipe with integral wall bell and spigot joints.

    b. Joints shall be push-on type with a flexible factory assembled elastomeric ring in the integral bell-end. O-ring gaskets shall conform to ASTM F 477. Joint material including gaskets and lubricants shall conform to AWWA C900 and ASTM D3139.

    c. Fittings shall be manufactured in accordance with ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53, and shall be ductile iron. Compact fittings are required and shall have a minimum acceptable pressure rating of 350 psi.

3. Pipe smaller than 4-inches in diameter shall be Schedule 80 PVC, in accordance with ASTM D-1785 or ASTM D-2241 for SDR (Standard Dimension Ratio) 13.5, or as

specified in the Contract Documents. Solvent cement for non-gasketed PVC pipe shall meet the requirements of ASTM D-2564.

4. Pipe shall bear identification markings that will remain legible during normal handling, storage, and installation. The markings shall be applied in a manner that will not reduce the strength of the pipe or coupling or otherwise damage either. Pipe markings shall be applied at intervals not to exceed five (5) feet and shall include the nominal size and outside diameter (e.g. 4 CI), PVC, DR 18, AWWA Pressure Class (PC 150), manufacturer's name or trademark and production record code, and the seal of the testing agency that verified the suitability of the pipe material for potable water service.

5. The manufacturer's representative shall be made available a minimum of 2 working days (time on site) during the project when requested by the Owner, including the first 2 Days of pipeline installation.

6. The cost for the services of the manufacturer's representative, including expenses, shall be considered incidental to the project and will not be paid separately.

C. High Density Polyethylene (HDPE) Pipe

1. HDPE pipe shall be in accordance with AWWA C906-15 and shall have a nominal DIPS (Ductile Iron Pipe Size) outside diameter unless otherwise specified. The nominal size, pressure classification rating, and SDR of the pipe shall be as specified in the Contract Documents. ODs and tolerances for IPS outside diameter pipe shall be in accordance with ANSI B36.10 as illustrated in AWWA C906-15 Table 3.

2. A Pipe shall be homogeneous and uniform throughout; shall be free of injurious defects such as visible cracks, holes, foreign inclusions, voids, and blisters; and shall have uniform color and physical properties according to the provisions of AWWA C906-15.

3. Commercial virgin PE Compounds shall meet ASTM D3350 physical property requirements and shall be classified per ASTM D3350 as shown in Table 1 of AWWA C906-15. The compound shall have HDB (Hydrostatic Design Basis) ratings at 73°F (23°C) and at 140°F (60°C) and HDS (Hydrostatic Design Stress) ratings at 73°F (23°C) determined in accordance with ASTM D2837 and PPI TR-3 (Policies and Procedures for Developing Recommended Hydrostatic Design Stress for Thermoplastic Pipe Materials).

4. The PE Compound in the pipe shall contain color and ultraviolet (UV) stabilizer meeting the requirements of ASTM D3350 Codes C or E. Code C compounds shall contain 2 to 3 percent carbon black when material from the pipe is tested in accordance with Section 4.3.11 of AWWA C906-15. Code E compounds used for solid color pipe, color stripes, or color layer (shell) shall contain sufficient UV stabilizer to protect the pipe against UV degradation for at least 24 months of unprotected outdoor exposure. Color PE compounds used for stripes or color layers shall be of the same materials designation codes as the pipe material, varying only by color and UV stabilizer.

5. Clean rework materials derived from pipe production by the same manufacturer are acceptable as part of a blend with virgin PE compound meeting section 4.2.1 of

AWWA C906-15 for the production of new pipe, including sections 4.2.3.1, 4.2.3.2, 4.2.3.3 and 4.2.4.

6. PE fittings or components may be molded, thermoformed from pipe sections or fabricated. Molded fittings shall meet the requirements of AWWA C906-15 and the requirements of ASTM D2683 for socket-type fittings, or ASTM D3261 for butt-type fittings, or ASTM F1055 for electrofusion-type fittings. Thermoformed and fabricated fittings shall meet the requirements of AWWA C906-15 and ASTM F2206.

7. Pipe sections shall be joined on the job site above ground into continuous lengths by the thermal butt-fusion or electrofusion method, which shall be performed in strict accordance with the manufacturer's recommendations. The butt-fusion equipment used in the joining procedures shall be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, temperature requirements of 400 ° F, alignment, and 75 psi interfacial fusion pressure. Butt-fusion joining shall be 100% efficient and shall provide a joint weld strength equal to or greater than the tensile strength of the pipe. Socket-fusion, extrusion welding or hot gas welding of HDPE shall not be used for pressure pipe applications. Flanges, unions, grooved-couplers, transition fittings, and some mechanical couplers may be used to mechanically connect HDPE pipe without butt-fusion, if specified in the Contract Documents and approved by the manufacturer.

8. The manufacturer's representative shall be made available a minimum of 2 working days (time on site) during the project when requested by the Owner, including the first 2 Days of pipeline installation.

9. The cost for the services of the manufacturer's representative, including expenses, shall be considered incidental to the project and will not be paid separately.

10. Transition couplings from HDPE to other pipe materials shall be as indicated in the Contract Documents.

D. Fusible Polyvinylchloride (fPVC) Pipe

1. Pipe Supplier shall furnish fPVC pipe conforming to all standards and procedures, and meeting all testing and material properties as described in this specification. Pipe, 4 to 12 inches in diameter, shall conform to AWWA C900 – Class 150 (DR 18), unless otherwise indicated in the Contract Documents. Pipe greater than 12 inch shall conform to AWWA C905 – Class 235 (DR 18) or Class 150 (DR25), as specified in the Contract Documents.

2. fPVC pipe shall be tested at the extrusion facility for properties required to meet all applicable parameters as outlined in AWWA C900 or C905, as appropriate. Rework material shall be allowed per AWWA C900 and AWWA C905 standards. All piping shall be made from a PVC compound conforming to cell classification 12454 per ASTM D1784.

3. fPVC pipe shall be extruded with plain ends and shall normally be supplied in standard 40 foot lengths. 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. fPVC pipe shall be blue in color for potable water use or green for wastewater.

4. Acceptable fittings for use with fPVC pipe shall include standard ductile iron fittings conforming to AWWA/ANSI C110/A21.10 and AWWA/ANSI C153/A21.53.

5. Connections to fPVC pipe may be made using a restrained or non-restrained retainer gland product for PVC pipe, as well as for MJ or flanged fittings.

6. Bends, tees and other ductile iron fittings shall be restrained as indicated in the Contract Documents.

7. Ductile iron fittings and glands must be installed per the manufacturer's guidelines.

8. Pipe generally shall be marked per AWWA C900 or AWWA C905, and shall include as a minimum:

   a. Nominal pipe size
   b. PVC
   c. Dimension Ratio, Standard Dimension Ratio or Schedule
   d. AWWA pressure class and Standard number
   e. Extrusion production-record code
   f. Trademark or trade name
   g. Cell Classification 12454 and/or PVC material code 1120 may also be included.
   h. NSF-61 mark, if for potable water service.

9. The manufacturer's representative shall be made available a minimum of 2 working days (time on site) during the project when requested by the Owner, including the first 2 Days of pipeline installation.

10. The cost for the services of the manufacturer's representative, including expenses, shall be considered incidental to the project and will not be paid separately.

E. Valves

1. Gate Valves

   a. Resilient-seated gate valves shall be used on pipelines from 3-inches in diameter up to and including 16-inches in diameter. Valves under 16-inches shall operate in a vertical position (valves 16-inches and larger shall operate in a horizontal position). Gearing shall be provided on 16-inch and larger valves. Resilient-seated gate valves shall be in accordance with AWWA C509 or AWWA C515 and shall be supplied with an interior and exterior epoxy coating in accordance with AWWA C550. Resilient-seated gate valves shall be ductile iron body, non-rising bronze or stainless steel stem with standard 2-inch wrench nut, rubber encapsulated disc valve seat, o-ring seals, and suitable for buried service. Valve ends shall be flanged, mechanical joint, or mechanical joint by flange to suit the pipe or fittings as indicated in the Contract Documents. All gate valves for force main installations shall be drip tight with bidirectional shutoff and open counter clockwise.

      Gate valves shall be manufactured by Kennedy Valve Company, Mueller Company, or approved equal, or as specified in the Special Provisions.

b. Gate valves smaller than 3-inches in diameter shall be cast bronze, solid-wedge disc, screwed bonnet, inside screw, non-rising stem valves. Valves shall conform to Standard SP-80, Type 2, Class 150, Manufacturer's Standardization Society of the Valve and Fitting Industry, Inc.

c. Gate valves larger than 16-inches in diameter shall meet the requirements of AWWA C500, except Section 4.4.8.1.1 will not be allowed. Valves shall be rated for 150 psi working pressure and a minimum 300 psi test pressure. Valves shall be iron body, bronze-mounted, double disc, parallel seat, non-rising stem type fitted with O-Ring seals. Valves shall be capable of drip tight, bi-directional shut off and operate in the horizontal position. The operating nuts shall be 2-in square. Valves shall open counter clockwise. Seats in the body shall be replaceable without removing the valve from the pipeline. Discs shall be cast iron and bronze faced. Valves to be furnished with bronze rollers and, bronze tracks and bronze scrapers.

d. Coatings

All interior ferrous surfaces of all valves shall be coated in accordance with ANSI/AWWA C550 and shall not contain lead, coal tar resins, lampblack, carbon black or bituminous materials. The exterior surfaces shall receive a factory applied fusion bonded epoxy coating.

e. Valve Operators

Buried valves shall have a 2-inch square operating nut conforming to AWWA C509, and shall open counter-clockwise, unless otherwise noted. Valves in vaults shall have a hand wheel of cast iron conforming to ASTM A 126, Class B.

f. Valve Stem Extensions

Valve stem extensions, when allowed by the locality, shall be furnished when the distance from the operating nut to the top of the valve box frame is greater than 36-inches from finished grade. Extension stems shall have a 2-inch square wrench nut on the top end and shall be at least as strong as the valve stem. Extension stems shall be coated in accordance with Paragraph, above.

2. Ball Valves

Owner-approved ball valves smaller than 3-inches in diameter shall be:

a. Brass with threaded connections, O-ring seals, and a coated ball conforming to AWWA C800 and Standard SP-80, Type 2, Class 150 Manufacturer’s Standard Society of the Valve and Fittings Industry, Inc. Valves shall be manufactured by the Ford Meter Box Company B11, Mueller Company 300 Ball Curb Valve, B-20283, or approved equal.

b. PVC True Union Standards ball valve with steel reinforced threaded-end connectors, with a minimum pressure rating of 230 psi at 70°F, conforming to ASTM D1784, Cell Classification 12454, as manufactured by Asahi, Spears, or approved equal.

c. NSF approved.

3. Plug Valves (16-inch and larger)

Valves shall be full port size, designed for a minimum working pressure of 150 psi, conforming to AWWA C517. Valve actuators shall be sized based upon the working pressure. The valve body and plugs shall be ASTM A126 Class B cast iron. Plugs shall be one piece with a cylindrical seating surface eccentrically offset from the center of the shaft. Plug facing shall be Buna-N with a minimum hardness (Shore A) of 70 durometer. Seats shall be welded in overlay minimum 1/8 inch nickel raised surface of not less than 95% pure nickel. Bearings shall be sintered, permanently lubricated 316 stainless steel. Packing shall be multiple v-type or "U" cup type. Washers at the top and bottom of the plug journal shall be provided to keep grit and debris out of the bearings and packing. Gear cases and shafts shall be totally enclosed suitable for buried services. Valves shall have an interior and exterior epoxy coating. All exposed nuts, bolts, springs and washers shall be 316 stainless steel.

Valves shall operate in a horizontal position and have non-rising stems operated with a standard 2-inch wrench nut. Operator stems and nuts shall be provided with an enclosure that will protect the stem from being bent and provide a base and guide for the riser pipe.

Opening shall be counter clockwise. Extension stems shall not be allowed. Plug valves in the horizontal position shall be installed so that the plug rotates upward as the valves opens. Valves ends shall be mechanical joint unless otherwise specified and shall be oriented so that the plug rotates 90 degrees to the top of the pipe when open.

A bidirectional leakage test and low pressure 5 psi seat test shall be applied in accordance with the procedures in AWWA C157. Certified copies of the Proof-of-Design test reports documenting that all requirements of AWWA C-517 were successfully met shall be furnished to the Owner prior to installation.

Valves shall be manufactured by DeZurik, Inc., Milliken Valve Company, Inc., Val-Matic Valve and Manufacturing Corp., or approved equal, or as specified in the Special Provisions.

F. Appurtenances

1. Force Main Air Vent Assemblies shall be as indicated in the Standard Details. Air Vent Assemblies shall be installed where indicated in the Contract Documents and shall be as specified in the Special Provisions.

2. Brass Pipe shall be red brass pipe meeting the requirements of ASTM B 43. Pipe sizes, wall thickness and dimensions shall meet the requirements of ASTM B 251 Table I for regular pipe. Brass pipe fittings shall be screwed end malleable iron pattern meeting the requirements of ANSI B16.15. They shall be finished rough, unless otherwise specified. Unions shall be of all brass or bronze with ground joints and shall be left semi-finished. Fittings shall be rated for steam working pressures up to 125 psi. Joints shall be screwed type with threads clean cut, tapered and smooth, meeting the requirements of ANSI B2.1.

3. Service Saddle - Shall be designed and sized for the force main on which the saddle is to be installed. The service saddle shall also meet the following requirements:

   a. Stainless steel saddle bodies shall be 18-8, Type 304, stainless steel with all welds fully passivated to restore stainless steel characteristics.

   b. Ductile iron saddle bodies shall conform to ASTM A-536 and have a fusion applied epoxy coating 12-mils dry thickness (D.T.). Straps shall be stainless steel, 18-8, Type 304 fully passivated for corrosion resistance.

   c. Threads shall be AWWA C-800 CC/Taper.

   d. The saddle band shall be a minimum of 2-inches in width.

   e. The saddle shall be provided with a Buna-N rubber gasket meeting ASTM D2000 to seal the saddle and the main pipe.

   f. The nuts, washers, bands, and bolts shall be 18-8 stainless steel.

   g. Acceptable manufacturers are The Ford Meter Box Co., Inc., Model FS202/FS303/FRS202, JCM Model 406, Romac Industries Inc., Style 202N, Cascade Products Style CNS2, or approved equal.

G. Joint Restraint Devices

1. Joint restraints shall be provided where indicated in the Contract Documents.

2. The restrained joint system shall have a pressure rating equal to or greater than that of the pipe on which it is used. Restrained joint devices shall be installed in strict accordance with the manufacturer's recommendations.

3. Ductile Iron Pipe

   a. Push-on Joints

      For push–on joint type pipe, the restrained joint system shall be a manufacturer's standard restrained joint system, SnapLock (U.S.Pipe), TR Flex (U.S. Pipe), FlexRing (American Pipe), or approved equal.

   b. Mechanical Joints

      For mechanical joint type pipe, the restrained joint system shall be a manufacturer's standard restrained joint system, Series 1100 Megalug ductile iron glands (EBAA iron, Inc.), Series 1400 retainer glands (Ford Meter Box Company, Inc.), or approved equal.

4. PVC Pipe (4-inch and larger)

   a. Bell and Spigot PVC Joints

      The restraint system for bell and spigot PVC joints shall be Series 1600/2800 ductile iron retainers as manufactured by EBAA Iron, Inc, Series 1390

retainers as manufactured by Ford Meter Box Company, Inc., or approved equal.

b. PVC to Mechanical Joint Fittings

The restraint system for restraining PVC pipe to ductile iron mechanical joint fittings shall be Series 2000 PV ductile iron retainers as manufactured by EBAA Iron, Inc., Series 1500 retainers as manufactured by the Ford Meter Box Company, Inc., or approved equal.

5. Concrete Reaction Blocking

Concrete reaction blocking shall not be permitted, unless approved by the Owner.

6. Tie Rods

Tie roads shall not be used unless specifically approved by the Owner and shown in the Contract Documents. When appropriate, Tie rods, bolts, washers and nuts shall be stainless steel in accordance with ASTM A-307.

H. Tapping Valves and Sleeves

1. Tapping valves and sleeves shall be compatible for use with the pipe being tapped and as approved by the Owner. The Contractor shall verify the material and diameter of the pipe being tapped prior to ordering tapping valves and sleeves.

2. Tapping valves for ductile iron pipe shall meet the same specifications as gate valves, except they shall have a full, unobstructed opening to receive a full size shell cutter. Tapping valves shall contain a standard mechanical joint on one end and a flanged joint on the other end. The valves shall be subjected to a factory test pressure of 400 psi and be designed for a working pressure of 200 psi.

3. Tapping sleeves shall be split sleeve with mechanical joint type end seals. Cast sleeves for tapping cast iron pipe, shall be ductile iron meeting ASTM A536 Grade 65-42-12.

4. Tapping sleeves for Ductile Iron and PVC C-900 Pipe

As appropriate, tapping sleeves shall be mechanical joint, furnished complete with plain rubber gaskets, mechanical joint accessories, and approved interior and exterior coatings. The outlet flange shall be 125 pound, drilling per ANSI B16.1, with standard tapping flange counterbore per MSS SP-60. Tapping sleeves shall be in accordance with ANSI/AWWA C110/A21.10.and approved by the manufacturer for use on the type and class of pipe being tapped.

5. Tapping sleeves for PVC Pipe (Other than C-900)

Tapping sleeves shall be complete, furnished with plain rubber gaskets, have a full circumference band made of 18-8 type 304 stainless steel. The flange and all bolts and nuts shall conform to AWWA C207 Class D 150 lb. drilling, made of 18-8 type 304 stainless steel.

6. Gaskets shall conform to the applicable requirements of ANSI/AWWA C111/A21.11, and shall be clearly marked to identify the diameter range for which intended.

7. When approved by the Owner and indicated in the Contract Documents, stainless steel tapping sleeves may be used and shall be constructed of all stainless steel conforming to the following requirements:

   a. Flange - The flange shall be 18-8, type 304 stainless steel, with recess to accept the standard tapping valve according to MSS-SP60. The flange shall also conform to AWWA C207-latest revision, Class D ANSI 150 lb. drilling. The bolt hole shall be aligned to straddle the pipe centerline.

   b. Body - The body shall be 18-8, type 304 stainless steel. All welds shall be fully restored to stainless steel characteristics.

   c. Gaskets - The gaskets shall be virgin SBR compounded for water service. ASTM D2000 8M 4AA607. The gasket shall be a full 360 degree pipe coverage. The outlet gasket shall be Buna-N.

   d. Test Plug - Provide a waterworks brass 3/4-inch test plug with standard square head.

   e. Bolts and Nuts - The bolts and nuts shall be 18-8, type 304 stainless steel UNC threads. Provide heavy hex nuts and washers fluorocarbon coated to prevent galling.

   f. Manufacture - Acceptable manufacturer is the Ford Meter Box Co., Inc., Model FTSS, Smith-Blair Style 665, Romac Industries Inc., SST or JCM Industries, Inc., Model 432, or approved equal.

I. Sleeves and Couplings

1. Mechanical joint sleeves shall be solid type, long body pattern as approved by the Owner, manufactured in accordance with ANSI/AWWA C110/A21.10. Sleeves shall have a minimum pressure rating of 350 psi. Glands, gaskets, bolts, and nuts shall be in accordance with ANSI/AWWA C111/A21.11.

2. Sleeves shall not be machined in order to facilitate use with pipe of a class or type other than that for which the sleeve was manufactured.

3. The use of bolted steel couplings shall be restricted to joining pipes of different outside diameters, joining pipes of dissimilar materials, and joining sections of steel pipe. Ferrous surfaces shall be coated with a fusion bonded epoxy lining and coating with stainless steel nuts and bolts. Enamel coatings are not acceptable.

   a. Bolted steel transition couplings shall be Rockwell 413, Dresser style 162, or approved equal.

   b. Bolted steel reducing couplings shall be Rockwell 415, Dresser style 62, or approved equal.

c. Bolted steel couplings for joining pipes of the same outside diameter shall be Rockwell 411, Dresser style 38, or approved equal.

5.11. SANITARY GRAVITY SEWER SYSTEMS

A. Ductile-Iron Pipe (DI)

1. DI pipe shall be furnished in 18- or 20-foot laying lengths, with push-on joints, except where mechanical or restrained joint or flanged pipe is shown in the Contract Documents.

2. DI pipe shall conform to the requirements of ANSI/AWWA C151/A21.51.

3. DI pipe for gravity sewer systems shall be minimum pressure class 350 psi, for diameters 24-inches and smaller and, 250 psi for diameters larger than 24-inches, unless otherwise indicated in the Contract Documents. The manufacturer's mark, country where cast, year the pipe was produced, and the letters "DI" or "Ductile Iron" shall be cast or stamped on the pipe.

4. Joints and gaskets shall conform to ANSI/AWWA C111/A21.11 or ANSI/AWWA C115/A21.15 as applicable. The minimum acceptable pressure rating for all joints is 250 psi. All flanges and glands for pipes shall be made of ductile iron.

5. Fittings shall be manufactured in accordance with ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53, and shall be ductile iron. Compact fittings are required and shall have a minimum acceptable pressure rating of 350 psi.

6. Coatings shall be provided on the exterior of all pipe, joints and fittings as required by ANSI/AWWA C110/A21.10, C111/A21.11, C115/A21.15, C116/A21.16, C151/A21.51, or C153/A21.53 as applicable. All pipes, joints, and fittings shall be examined after laying to determine if the coating was damaged during installation. Any damaged areas shall be coated with a minimum of 2 mil of an approved bituminous coating.

7. Corrosion Resistant Linings

   a. All ductile iron pipe and fittings shall be cement lined and seal coated in accordance with ANSI/AWWA C104/A21.4.

   b. Where corrosion resistant linings are identified in the Contract Documents for ductile iron pipe and fittings, linings shall be ceramic epoxy.

      If ceramic epoxy is specified, the lining shall be shop applied to bare metal in strict accordance with the manufacturer's recommendations to cover the inner surface of the pipe and fittings. The lining shall be a nominal thickness of 40 mils and a minimum thickness of 35 mils. The gasket area and spigot end up to 6-inches back from the end of the spigot on the outside of the pipe shall be coated with 6 mils nominal, and 10 mils maximum.

      The lining in each joint of pipe and fitting shall pass a 2,500 volt pin hole/holiday test. The pin hole/holiday detection testing shall be conducted over 100% of all lined surfaces for the ductile iron pipe and fittings. All

holidays shall be repaired in accordance with the manufacturer's instructions and tested again to ensure a pinhole free lining. Short lengths of pipe required to accommodate the pipeline geometry shall be furnished factory-lined.

Where field touch up is required to seal cut ends and repair damaged areas, Joint Compound shall be applied by brush to ensure complete coverage in accordance with the manufacturer's recommendations. Joint Compound may be used over lined pipe and fittings, or on bare substrate. Care must be taken that the joint compound is applied smooth, without excessive buildup in the gasket seat or on the spigot ends and allowed to cure for 24 hours in accordance with the manufacturer's recommendations. At least 1-inch of overlap shall be applied to the area being repaired. Protecto 401 shall not be applied over Protecto 401 Joint Compound. Joint Compound shall not be applied over wet or frozen surfaces.

8. Pipe inside diameters 12-inches and smaller shall be gaged and delivered round and true throughout its entire length. Pipe inside diameters greater than 12" inside shall have one piece of gaged pipe delivered for each fitting. Gaged pieces shall be marked as such on the pipe and shall be accompanied by the manufacturer's certification. Manufacturer's certification of inspection and testing shall accompany each delivery.

B. Polyvinyl Chloride (PVC) Non-Pressure Pipe

1. PVC pipe shall be integral bell and shall be furnished in 20-foot laying lengths with gasketed joints, except where specified otherwise in the Contract Documents.

2. Pipe and fittings shall be manufactured from approved PVC compound conforming to ASTM D1784.

3. PVC pipe sizes 4-inches through 15-inches in diameter shall conform to ASTM D3034 SDR 21 or SDR 26, as indicated in the Contract Documents

4. PVC pipe sizes 18-inch through 27-inch in diameter shall conform to ASTM F679.

5. Joints shall meet all requirements of ASTM D3034, Section 6 and shall conform to the performance requirements of ASTM D3212. Restrained joints shall be provided where shown in the Contract Documents.

6. Rubber gaskets shall meet physical requirements specified in ASTM F477 and ASTM D1869.

C. Polyvinyl Chloride (PVC) Pressure Pipe

1. PVC pipe shall be furnished in 20-foot laying lengths with push-on joints.

2. PVC pipe 6 to 12 inches in diameter shall conform to the requirements of AWWA C-900 – DR-18, unless otherwise indicated in the Contract Documents. PVC pipe greater than 12-inches in diameter shall conform to the requirements of AWWA C-905 – DR 25, unless otherwise indicated in the Contract Documents.

3. PVC pipe shall be plasticized polyvinyl chloride plastic pressure pipe with integral wall bell and spigot joints and shall bear the seal of approval by the National Sanitation

Foundation (NSF).

4. Joints shall be push-on type with a factory assembled elastomeric ring in the integral bell-end. O-ring gaskets shall conform to ASTM F477. Joint material including gaskets and lubricants shall conform to AWWA C-900/C-905 and ASTM D3139.

5. Pipe shall bear identification markings that will remain legible during normal handling, storage, and installation. The markings shall be applied in a manner that will not reduce the strength of the pipe or otherwise damage. Pipe markings shall be applied at intervals not to exceed five (5) feet and shall include the nominal size and outside diameter, DR, manufacturer's name or trademark and production code, and the seal of the testing agency that verified suitability of the pipe material for potable water service.

D. A DFW/HPI non-shear coupling, Mission Flex Seal ARC Coupling, Fernco R/C Strong Back, or approved equal shall be used between transitions of pipe materials and connections to existing pipe.

E. Manholes

1. Precast concrete manholes shall be manufactured in accordance with ASTM C478 and shall conform to the Standard Details.

2. Lifting devices shall be used in lieu of thru-wall lifting holes, unless approved by the Owner. Lift voids shall be filled with non-shrink grout upon installation. Grout to be in accordance with of Paragraph V.5.6.A.1 and of Paragraph V.5.6.F.

3. Manhole joints shall be sealed with profile gasket (Type 4G manufactured by Press Seal Corp. or equal), or butyl resin sealants, or equal. Joints shall be watertight. Gaskets and sealants for section joints shall meet the requirements of ASTM C443 or ASTM C990.

4. The manhole frame and cover shall conform to ASTM A48. Frame and covers are to be even grained and free from unsightly defects, and shall be machined to insure a uniform bearing in all positions. The frame and cover; including dust cover, locking cover, and watertight assemblies, where required, shall conform to the Standard Details. Casting shall be finished with a minimum of one coat (2 mils) of bituminous asphaltic coatings, or in accordance with manhole coating procedures, described below.

5. When required, manhole steps shall be corrosion-resistant and shall be one-half inch grade 60 steel reinforcing rod encapsulated in a copolymer polypropylene. The steps shall conform with ASTM C478 and to the dimensions shown on the Standard Details.

6. Pipe connections shall be flexible rubber pipe-to-manhole connections of the locked-in factory assembled rubber ring type utilizing a stainless steel band as manufactured by NPC, Inc. (Kor-N-Seal), International Precast Supply Flexible Pipe, or Press-Seal Gasket Corp. (PSX or Press Boot) gasket adjustable ring. The resilient flexible manhole connector shall conform to ASTM C443 and ASTM C923 and the stainless steel band shall be totally non-magnetic Series 304 Stainless. Other flexible connectors must be approved by the Owner.

7. Manhole inverts shall be built up of brickwork and cement mortar to match the inside diameters of the connecting sewers (bricks shall be surfaced with cement mortar, ½-inch thick and shall be trowel finished). Invert channels and manhole bottoms shall be shaped and smoothed with sand-cement grout or as otherwise approved by the Owner. Inverts shall have a positive slope as indicated on the Standard Details. When benching and channel shaping is performed prior to manhole field installation, adequate clear space must be provided to allow adjacent piping to be properly inserted in the manhole and "brought home" at the pipe joint.

8. To enhance the bonding capacity between the manhole or structure and a coating system, a Concrete Surface Profile (CSP), as defined by the International Concrete Repair Institute's (ICRI) Guideline No. 03732 dated January 1997, and as specified by the coating Manufacturer's requirements, shall be provided on all interior surfaces of manholes or structures designated to receive protective coatings.

9. Sections are to be assembled so as to provide a plumb structure with uniform bearing at all joints, and at the base slab.

10. Polymer Concrete Manholes shall comply with the requirements of items 1 through 7 and 9 of this section (200.5.11) and the following:

    a. Shall be acid resistant polymer manhole sections, base sections and related components conforming to ASTM D 6783, ASTM C 857, and ASTM C 478.

    b. Base riser section shall have integral floors, unless otherwise shown.

    c. Polymer mixture shall consist solely of thermosetting resin san and aggregate with no cementitious materials. Polymer concrete shall have a minimum unconfined compressive strength of 9,000 psi when measured in accordance with ASTM C 497.

    d. Manholes wall thickness shall be designed to resist hydrostatic pressures with a minimum safety factor of 2.0 for full depth conditions from grade to invert. Wall thickness for all members shall be stated by the polymer manhole manufacturer based on loading conditions and material properties. The wall thickness of risers and conical tops shall not be less than that prescribed by the manufacturer's design by more than 5%. In no cases shall the wall thickness be less than 3 inches.

    e. Manholes shall be designed with sufficient bottom anchorage and side friction to resist buoyancy.

    f. Round manhole components shall be connected with an elastomeric sealing gasket as the sole means to maintain joint water tightness and both the gasket material and the manhole joint shall meet the requirements of ASTM C443. Round manholes shall utilize spigot and bell type joints incorporating either a confined O-ring or single step profile joint. Square and rectangular structures shall utilize a shiplap joint and be sealed with a butyl rope sealant per ASTM C990 as recommended by the structure manufacturer.

    g. Thermosetting resin shall have a minimum deflection temperature of 158 °F when tested at 264 psi following ASTM Test Method D 648. The resin shall

not be less than 7% of the weight of the sample as determined by ASTM test method D 2584. Resin selection shall be suitable for applications in the corrosive conditions to which the structures will be exposed.

h. Polymer bench and channel:

(i) Polymer bench and channels are to be constructed with all resin aggregate material containing no alternative fill material. Invert channels shall provide a smooth flow transition waterway with no disruption of flow at pipe-manhole connections. Invert slopes shall be as indicated in the Contract Documents.

(ii) If brick benching is indicated in the Contract Documents, brick shall be sewer grade brick SS in accordance with ASTM C32-05. Mortar shall be furan resin-based brick mortar. Mortar shall be 100% carbon filled and have the following physical properties and minimum values per referenced test method:

(1) Compression Strength, 14,500 psi, ASTM C579

(2) Tensile Strength, 1,400 psi, ASTM C307

(3) Flexural Strength, 3,900 psi, ASTM C580

(4) Bond Strength to Bricks, 750 psi, Pull Blocks

(5) Water Absorption, 0.15%, ASTM C413

(iii) Concrete surfaces that have a furan resin mortar placed against them shall be coated with the furan resin mortar manufacturer's recommended primer and prepared in accordance with the furan resin mortar manufacturer's recommendations.

(iv) The bench and channel brick mortar components shall be free of cracks, holes, delaminations, foreign inclusions, blisters, or other defects that result in a variation of inside diameter of more than 1/8 inch from that obtained on the adjacent unaffected portions of the surface or defects that would, due to their nature, degree, or extent, have a deleterious effect on the manhole performance as determined by the Owner.

(v) Mortar manufacturer shall be Furalac Green Panel Mortar by Henkel, or Owner approved equal.

i. All materials needed for grouting and patching shall be a polyester mortar compound provided by the manufacturer or an Owner approved equal.

11. Stainless Steel Manhole Inserts

The manhole insert body shall be manufactured of 304 stainless steel with a minimum thickness of 18 gauge. The insert shall have a straight side design to allow a loose fit into the ring for easy removal. The insert manufacturer shall submit a load test

verification showing a load test failure in excess of 3,000 pounds. Inserts shall have a closed cell neoprene gasket with pressure sensitive adhesive backing installed by the manufacturer on one side. Gaskets shall have a minimum thickness of 1/8 inch. The insert shall have one handle made of 3/16 inch plastic coated 304 stainless steel cable. The handle shall be attached with a # 6 high grade stainless steel rivet or with bolts, flat washers and locking nuts, all made of 304 stainless steel. The handle shall be capable of withstanding a pull force of at least 500 pounds before it fails or separates from the insert. The gas relief valve shall be designed using one valve capable of releasing gas at a pressure of 0.5 to 1.5 psi and have a water leak down rate no greater than 5 gallons per 24 hours. The valve shall be installed by means of a hole tapped in the insert by the manufacturer. The valve shall be made of nitrile or similar material for the prevention of corrosion from the contact with hydrogen sulfide, dilute sulfuric acid and other gases associated with wastewater collection systems. The insert shall be custom made to fit the manhole frame, outside diameter (cover), and inside diameter.

F. Manhole /Structure Coatings

Sanitary sewer manholes are often exposed to environments with various degrees of aggressiveness thereby degrading the concrete and reinforcing, and shortening the useful life of the structures. A number of measures have been used to maintain manhole structural integrity and component life, including epoxy coatings, concrete additives, embedded liners, etc. Choosing the appropriate protective measure should be determined during the design of the project. Any protective system must be applied in strict accordance with the protective system Manufacturer's recommendations. The manhole coating specifications presented in this document are intended to be used by experienced Engineers and are not meant to be inclusive of all available protective measures. Because of their current widespread usage in the Hampton Roads area, only epoxy coating systems are addressed herein. Other protective measures may be used if approved by the Owner. See also the Special Provisions for Owner-specified manufacturers, alternative coating systems, and specific coating thickness.

1. Products are to be stored and handled according to their material safety data sheets and the manufacturer's instructions.

2. Coatings are to be applied to manholes/structures in strict accordance with the coating manufacturer's requirements.

3. Manhole Coatings shall be 100% solids, solvent-free, epoxy resin systems.

4. Manhole Coatings are defined as:

   a. Type A Coating (40 to 50 mils thickness)

   b. Type B Coating (80 to 125 mils thickness), as specified

G. Clean-Out Assemblies

Clean-out assemblies include Fernco Strong Back RC Series coupling or Non-Shear DFW-HPI (if required), mainline or wye, riser pipe, end caps, and clean-out box as indicated on the Standard Details.

5.12. SEEDING

A. Seed

1. Seeds shall comply with applicable state and federal seed laws and the Contract Documents. Seed shall be accompanied by the Form of Affidavit provided in VDOT *Road and Bridge Specifications* Section 244.

2. Seed shall be subject to inspection by the Virginia State Seed Regulatory Inspectors of the Virginia Department of Agriculture and Consumer Services.

3. Seed test shall be completed within the twelve-month period prior to the time the seed is to be used.

4. Seed shall not be, or have been, stored in an enclosure where herbicides, kerosene, or other material detrimental to seed germination is stored.

5. Noxious weed seeds, as defined by the rules and regulations adopted for enforcement of the Virginia Seed Law, will not be permitted. The number of restricted noxious weed seeds shall be not more than the number per ounce or per pound of noxious weed seeds specified in the rules and regulations.

Schedule of Grass Seed Mixture:

Mix	Proportion by Weight	Common Name	Botanical	Min. % Germ.	Min. % Pure Seed	Max. % Weed Seed
Permanent	100%	Fescue	Festuca arundinacea	85	98	0.25
Temporary	100%	Annual Rye Grass	Lolium multiflorum	90	95	0.15

B. Fertilizer

1. Fertilizer shall be uniform in composition, free flowing, and suitable for application with approved equipment.

2. Urea formaldehyde shall be slow-release fertilizer material containing 38 % nitrogen. The material shall have an activity index of 40 to 50 % as determined by tests in accordance with the Association of Official Agricultural Chemists.

3. Fertilizer for general seeding shall be Grade 15-30-15 fertilizer, uniform in composition, free flowing, and suitable for application with approved equipment, and shall be applied at the rate of 600 lb/acre (unless specified otherwise by soil tests).

4. Fertilizer for planting plants shall have an analysis of approximately 10-30-6. Approximately 75 % of the nitrogen shall be slow release nitrogen from methylene ureas, also termed urea formaldehydes, which become slowly available for plants through nitrogen breakdown by soil microbes. Urea nitrogen shall not be used except as specified hereinafter. The phosphate fraction shall be triple superphosphate. Fertilizers to be mixed shall be delivered to the project or another approved location in separate bags bearing the manufacturer's label and shall be thoroughly mixed in the presence of the Owner on the job or other approved location in the following amounts:

20 pounds of urea-formaldehyde as specified herein (38%N), 5 pounds of ureas (45%N), 65 pounds of triple superphosphate (46%P_20_5), and 10 pounds of muirate of potash (60%K_2O).

5. Fertilizer shall be accompanied by the Form of Affidavit provided in VDOT *Road and Bridge Specifications* Section 244.

6. The analysis and rate of application shall be verified by soil testing. The Contractor shall have the soil tests performed by a state or approved laboratory at no additional cost to the Owner. Analysis and application rates shall be adjusted as recommended by the laboratory.

C. Lime

1. Lime shall be agricultural grade ground limestone. Agricultural grade pulverized limestone may be used at no additional cost to the Owner.

2. The material source shall be registered with and approved by the Virginia Department of Agriculture and Consumer Services in accordance with the Virginia Agricultural Lime Law and shall conform to the following requirements:

3. Ground limestone shall be of such fineness that at least 86 % will pass a No. 20 mesh screen, at least 47 % will pass a No. 60 mesh screen, and at least 28 % will pass a No. 100 mesh screen. Material shall have a calcium carbonate equivalent of at least 85 %.

4. Pulverized limestone shall be of such fineness that at least 90 % will pass a No. 20 mesh screen and at least 66 % will pass a No. 100 mesh screen. Material shall have a calcium carbonate equivalent of at least 85 %.

D. Mulch for Seeding or Erosion Control

Mulches for Seeding or Erosion Control shall be in accordance with the following based on functional longevity, slope length; and slope gradient as detailed herein.

1. Dry Straw or Hay

Dry straw or hay shall be used to facilitate vegetative establishment on slopes of 4:1 or less gradient designed to be functional for up to thirty (30) days. The dry straw or hay shall be free from noxious weeds, reasonably bright in color, and not be musty, moldy, caked, decayed, or dusty. Straw or hay shall be applied by tacking with a Hydraulic Erosion Control Product **(**HECP), Type 1, at the rate of 1000 pounds per acre and applied as recommended by the manufacturer by punching or disking into the soil or by other Engineer-approved methods.

2. Hydraulic Erosion Control Products (HECP)

Hydraulic Erosion Control Products shall be dyed green or contain a green dye in the package that will provide a color to facilitate visual inspection of the uniformly spread slurry. Mulch, including dye and tackifiers, shall not contain germination-inhibiting or growth-inhibiting factors. The mulch shall be manufactured and processed so that it will remain in uniform suspension in water under agitation and will blend with seed, fertilizer, and other additives to form a homogenous slurry. The mulch shall form a blotter-like

ground cover on application having moisture absorption and percolation properties. It shall cover and hold grass seed in direct contact with the soil, promoting the germination and growth of grass seedlings.

The manufacturer shall provide certification that all components are pre-packaged by the manufacturer to assure material performance and compliance with the minimum requirements of Table 200-5.12-1. Under no circumstances will field mixing of HECP additives or HECP components be allowed. Mulch shall be delivered in packages of uniform weight bearing the name of the manufacturer, the net weight, and an additional statement of the net dry weight content.

When polyacrylamide is used as part of a hydroseeding mix, only an anionic polymer formulation with free acrylamide monomer residual content of less than 0.05% is allowed. Cationic polyacrylamide shall not be used in any concentration. The Contractor shall ensure polyacrylamide-containing mixtures are not sprayed onto pavement. Polyacrylamide-containing mixtures may include tackifiers, flocculants, or moisture-holding compounds.

In addition to making field performance determinations, the Owner may sample and perform such other tests on mulch as it deems warranted to ensure that the mulch conforms to these specifications. Only those materials that have been evaluated by the VDOT and are deemed acceptable will appear on the *VDOT Materials Division Approved Products List*. Mulch types shall contain a tackifier or additive as detailed below that, upon drying, becomes insoluble and non-dispersible, to eliminate direct raindrop impact on soil. Typically, all HECP products shall be applied when the soil is dry and rain is not expected within at least 48 hours after application.

HECP types are as follows:

a. HECP, Type 1 shall be used to facilitate vegetative establishment on slopes of 1V:4H or flatter gradient. Products shall be functional for up to two (2) months after application and shall be composed of non-toxic fibers consisting of a minimum of 70% specially prepared wood fiber, paper fiber, or a mixture of shredded wood fiber and paper fiber.

b. HECP, Type 2 shall be used to facilitate vegetative establishment on slopes of 1V:3H or flatter gradient. Products shall be functional for up to three (3) months after application and shall consist of a hydraulically applied matrix composed of a minimum of 70% of non-toxic defibrated organic fibers with, at a minimum, one of the following non-toxic tackifiers or additives:

    (1) Soil tackifiers,

    (2) Soil flocculants,

    (3) Soil polymers,

    (4) Cross-linked hydro-colloidal polymers, or

    (5) Cross-linked tackifiers.

    HECP, Type 2 products shall not contain materials composed of paper, cellulose

fiber, or any mixture containing paper or cellulose.

c. HECP, Type 3 shall be used to facilitate vegetative establishment on slopes of 1V:2H or flatter gradient. Products shall be functional for up to six (6) months after application and shall consist of a hydraulically applied matrix composed of a minimum of 70% of non-toxic long-strand organic fibers heated to a minimum temperature of 212° Fahrenheit for sterilization purposes with, at a minimum, one or more of the following non-toxic additives that, upon drying, become insoluble and non-dispersible to eliminate direct raindrop impact on soil:

(1) Soil tackifiers,

(2) Soil flocculants,

(3) Soil polymers,

(4) Cross-linked hydro-colloidal polymers, or

(5) Cross-linked tackifiers.

HECP, Type 3 products shall not contain materials composed of paper, cellulose fiber, or any mixture containing paper or cellulose.

d. HECP, Type 4 shall be used to facilitate vegetative establishment on slopes of 1V:1H or flatter gradient. The product shall be functional for up to twelve (12) months after application. HECP, Type 4 shall be applied when the soil is dry, when the site requires immediate erosion protection or when there is a risk of impending adverse weather. HECP Type 4 shall consist of a hydraulically applied matrix composed of a minimum of 70% thermally refined wood fibers, cross-linked hydro-colloidal tackifiers (10% by weight), and crimped man-made fibers.

TABLE 200-5.12-1
Minimum HECP Performance and Physical Requirements

HECP Property	Test Method[1]	HECP Type 1	HECP Type 2	HECP Type 3	HECP Type 4
Physical	**Requirement**				
Color	Visually Observed	Colored to provide contrast upon application, shall be stable and not stain concrete or painted surfaces.			
Organic Matter	ASTM D2974	90% minimum			
Water Holding Capacity	ASTM D7367	400% minimum	500% minimum	600% minimum	700% minimum

Acute Toxicity	ASTM 7101 EPA 2021.0-1	Non Toxic			
Endurance	**Requirement**				
Functional Longevity	VDOT approved Testing Methods[4]	Up to 2 Months	Up to 3 Months	Up to 6 Months	Up to 12 Months
Performance	**Requirement**				
Maximum Slope Application	Observed	4.0 H:1V	3.0 H:1V	2.0 H:1V	1.0 H:1V
Rainfall Event (R-Factor)	ASTM D6459 [2,3]	N/A	75 < R	140 < R	175 < R
Cover Factor	ASTM D6459 [2,3]	C ≤ 0.50	C ≤ 0.10	C ≤ 0.05	C ≤ 0.01
Vegetation Establishment	ASTM D7322 [2]	200% minimum	300% minimum	400% minimum	500% minimum

[1] All products must meet the requirements of this Specification to be listed on VDOT's Materials Division Approved List for HECPs.

[2] ASTM test methods developed for Rolled Erosion Control Products (RECPs) that have been modified to accommodate Hydraulic Erosion Control Products (HECPs).

[3] Utah State Protocol of 2.5:1 slope with rainfall simulated at 5 inches per hour for a 60 minute duration, or TTI Protocol of 2:1 slope with rainfall simulated at 3.5 inches per hour with 3 successive test durations of 30 minutes for each test in 24-hour intervals may be substituted for ASTM D6459.

[4] Functional Longevity performed at a VDOT test facility or test facility approved by VDOT.

3. Compost Blanket

Compost blankets shall be used to facilitate vegetative establishment on slopes with gradients of 1V:2H or flatter. The compost shall meet the requirements listed in *VDOT Road and Bridge Specifications* Section 244.02 (j) with the exception of particle size as stated below:

Percentage (%) by Dry Weight Passing Sieve Size			
3"	1"	¾ "	¼ "
100	90-100	65-100	0-75

Compost used as a compost blanket shall be uniformly applied to the depth specified in the Contract Documents. Compost may be manually spread, or distributed by the use of a pneumatic (blower) or slinger type spreader unit. Compost shall be projected directly at the soil surface, thereby preventing water from moving between the soil\compost interface. The Contractor shall apply the compost layer approximately 3 feet beyond the top of the slope or overlap it into or underneath existing vegetation.

5.13. SODDING

A. Sod

1. Sod shall be cultivated material conforming to the requirements of the State Board of Agriculture for state-approved sod or the State Sod Certification Agency for state certified sod.

2. Root development shall be such that standard size pads will support their own weight and retain their size and shape when suspended vertically from a firm grasp on the uppermost ten (10) % of the area.

3. The top growth of sod shall be mowed so that the height of the grass will be 2 to 3 inches at the time of the stripping operation.

4. Sod may be furnished in any standard pad width and length provided the dimensions do not vary from the average by more than five (5) %.

5. Sod shall be machine stripped at a uniform soil thickness of at least 1-inch.

6. Broken, torn, or irregularly shaped pads will be rejected.

B. Fertilizer

1. Fertilizer shall be uniform in composition, free flowing, and suitable for application with approved equipment.

2. Urea formaldehyde shall be slow-release fertilizer material containing 38 % nitrogen. The material shall have an activity index of 40 to 55 % as determined by tests in accordance with the Association of Official Agricultural Chemists.

3. Fertilizer shall be accompanied by the Form of Affidavit provided in VDOT *Road and Bridge Specifications* Section 244.

4. The analysis and rate of application shall be verified by soil testing. The Contractor shall have the soil tests performed by a state or approved laboratory at no additional cost to the Owner. Analysis and application rates shall be adjusted as recommended by the laboratory.

C. Lime

1. Lime shall be agricultural grade ground limestone. Agricultural grade pulverized limestone may be used at no additional cost to the Owner.

2. The material source shall be registered with and approved by the Virginia Department of Agriculture and Consumer Services in accordance with the Virginia Agricultural Lime Law and shall conform to the following requirements:

3. Ground limestone shall be of such fineness that at least 86 % will pass a No. 20 mesh screen, at least 47 % will pass a No. 60 mesh screen, and at least 28 % will pass a No. 100 mesh screen. Material shall have a calcium carbonate equivalent of at least 85 %.

4. Pulverized limestone shall be of such fineness that at least 90 % will pass a No. 20 mesh screen and at least 66 % will pass a No. 100 mesh screen. Material shall have a calcium carbonate equivalent of at least 85 %.

5.14. SIDEWALKS, STEPS, AND HANDRAILS

A. Concrete shall be Class A3 conforming to the requirements of Paragraph V.5.6.

B. Aggregate for exposed aggregate concrete shall be approved by the Owner.

C. Asphalt concrete shall conform to the requirements of Paragraphs V.5.2, V.5.22 and V.5.23.

D. Preformed joint filler shall conform to the requirements of Paragraph V.5.6.B. Material shall be approximately ½ inch in thickness and shall have a width and depth equal to those of the incidental structure.

E. Curing materials shall conform to the requirements of Paragraph V.5.6.C.

F. Reinforcing steel shall conform to the requirements of Paragraph V.5.8.

G. Rails and posts shall conform to the requirements of VDOT *Road and Bridge Specifications* Section 232.02(c)4.b. Rails shall be of standard weight and posts shall be extra strong pipe.

H. Geotextile drainage fabric shall conform to the requirements of Paragraph V.5.26.

I. Detectable warning surface panels shall conform to the requirements of Paragraph V.5.24.

5.15. SOIL RETENTION COVERINGS

A. Jute mesh shall be a uniform, open, plain weave of undyed and unbleached single jute yarn. The yarn shall be loosely twisted and shall not vary in thickness by more than its normal diameter. Jute mesh shall be new, and its length shall be marked on each roll.

B. Openings: Between strands lengthwise, openings shall be 0.60 inch + 25 %. Between strands crosswise, openings shall be 0.90 inch + 25 %. Jute mesh shall weigh 0.9 pound per square yard + 5 %.

C. Soil retention mats shall consist of a machine-produced mat of wood fibers, wood excelsior, or manmade fiber that shall intertwine or interlock.

D. Matting shall be nontoxic to vegetation and germination of seed and shall not be injurious to the unprotected skin of the human body.

E. Mats shall be of consistent thickness, with fiber evenly distributed over its entire area, and covered on the top and bottom side with netting having a high web strength or covered on the top side with netting having a high web strength and machine sewn on 2-inch centers along the longitudinal axis of the material. Netting shall be entwined with the mat for maximum strength and ease of handling.

5.16. SUBGRADE AND SHOULDERS

A. Materials may consist of material in place, treated material in place, or imported material. Imported material may be borrow material, select material, or other material as shown in the

Contract Documents.

B. Materials other than regular excavation or borrow material that are shown in the Contract Documents shall conform to the applicable requirements of this Section.

5.17. TOPSOIL

A. Class A topsoil shall be stockpiled topsoil that has been salvaged in accordance with the requirements of Section 303. It shall be free from refuse or any material toxic to plant growth and reasonably free from subsoil, stumps, roots, brush, stones, clay lumps, or similar objects larger than 1-inch in their greatest dimension.

B. Class B topsoil shall be topsoil furnished from sources outside the project limits and shall be the original top layer of a soil profile formed under natural conditions, technically defined as the "A" horizon by the Soil Society of America. It shall consist of natural, friable, loamy soil without admixtures of subsoil or other foreign materials and shall be reasonably free from stumps, roots, hard lumps, stiff clays, stones, noxious weeds, brush, or other litter. It shall have demonstrated by evidence of healthy vegetation growing or having grown on it prior to stripping that it is reasonably well drained and does not contain substances toxic to plants.

C. Topsoil for planting plants shall have a pH in the range of 6.0 to 7.0 prior to mixing with organic matter. If the pH is not within this range, the pH shall be corrected at the Contractor's expense or a different source of supply shall be selected. Topsoil shall be subject to inspection by the Owner at the source of supply and immediately prior to use in planting and shall be mixed with organic matter as specified in the Contract Documents.

5.18. UNDERDRAINS

A. Unless specifically stated otherwise, all materials shall be new, free from defects, and shall be in accordance with this Section.

B. Pipe shall conform to the requirements of VDOT *Road and Bridge Specifications* Section 232.

C. Aggregate shall conform to the requirement of Paragraph V.5.1.

D. Geotextile drainage fabric shall conform to the requirements of Paragraph V.5.26.

5.19. WATER DISTRIBUTION SYSTEMS

A. Ductile-Iron (DI) Pipe

1. DI pipe shall be furnished in 18- or 20-foot laying lengths, with push-on joints, except where mechanical or restrained joint or flanged pipe is shown in the Contract Documents.

2. DI pipe shall conform to the requirements of ANSI/AWWA C151/A21.51.

3. DI pipe shall be Class 52 for all pipe diameters; or, Class 350 minimum pressure classification for diameters 24-inch and smaller and 250 psi for diameters larger than 24-inches; or, the thickness classification indicated in the Contract Documents. The manufacturer’s mark, country where cast, year the pipe was produced, and the letters “DI” or “Ductile Iron” shall be cast or stamped on the pipe.

4. Joints and gaskets shall conform to ANSI/AWWA C111/A21.11 or ANSI/AWWA C115/A21.15 as applicable. The minimum acceptable pressure rating for all joints is 250 psi. All flanges and glands for pipes shall be made of ductile iron.

5. Fittings shall be manufactured in accordance with ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53, as applicable, and shall be ductile iron. Compact fittings are required, and shall have a minimum acceptable pressure rating of 350 psi for 24-inch and smaller piping and 250 psi for larger than 24-inch piping. Fittings shall have the same pressure rating, as a minimum, of the connecting pipe.

6. Coatings shall be provided on the exterior of all pipe, joints and fittings as required by ANSI/AWWA C110/A21.10, C111/A21.11, C115/A21.15, C151/A21.51, C116/A21.16, or C153/A21.53 as applicable. All pipes, joints, and fittings shall be examined after laying to determine if the coating was damaged during installation. Any damaged areas shall be coated with a minimum of 2 mil of an approved bituminous coating.

7. All ductile iron pipe and fittings shall be double thickness cement lined and seal coated in accordance with ANSI/AWWA C104/A21.4.

8. Pipe diameters 12-inch and smaller shall be gaged and delivered round and true throughout its entire length. Pipe over 12-inches in diameter shall have one piece of gaged pipe delivered for each fitting. Gaged pieces shall be marked as such on the pipe and shall be accompanied by the manufacturer's certification. Manufacturer's certification of inspection and testing shall accompany each delivery.

9. ASTM A242 – Standard Specification for High-Strength Low-Alloy Structural Steel

10. ASTM A307 – Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

11. ASTM A674 – Standard Practice for Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids.

12. AWWA C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.

13. For pipe diameters 16-inches and greater:

    a. Each length of ductile iron pipe shall be hydrostatically tested at the point of manufacture to 500 psi for a duration of 10 seconds per AWWA C151. Testing may be performed prior to machining bell and spigot. Failure of ductile iron pipe shall be defined as any leak or rupture of the pipe wall.

    b. All pipe and fittings to be installed under this Contract may be inspected at the plant for compliance with this Section by an independent testing laboratory selected by the Owner at the Owner's expense.

    c. A manufacturer's representative shall be made available to the Owner during the manufacturing furnishing, transporting, and unloading of the pipe during installation and testing of the pipe to assist in insuring that the pipe is properly fabricated, transported, unloaded, stored in the field, joined and tested. Manufacturer's responsibilities relate only to the proper care and treatment of

the pipe during these procedures and not the techniques or procedures used during installation and testing.

d. The manufacturer's representative shall be made available a minimum of 2 working days (time on site) during the project when requested by the Owner, including the first 2 Days of pipeline installation.

e. The cost for the services of the manufacturer's representative, including expenses, shall be considered incidental to the project and will not be paid separately.

B. Polyvinyl Chloride (PVC) Pipe

1. PVC pipe shall be furnished in 20-foot laying lengths, with push-on joints. Restrained joints shall be provided where shown in the Contract Documents.

2. PVC pipe, 4- to 12-inches in diameter, shall conform to the requirements of AWWA C900 - Class 150 (DR-18), unless otherwise indicated in the Contract Documents. PVC pipe greater than 12-inches in diameter shall be AWWA C-905 - Class 235 (DR 18) or Class 165 (DR 25), as specified in the Contract Documents.

3. The pipe, shall be made from virgin polyvinyl chloride resin or clean rework materials generated from the manufacturer's own pipe production that equals or exceeds cell class 12454-B as defined by ASTM D 1784, and shall bear the seal of approval by the NSF. The pipe shall be unplasticized polyvinyl chloride plastic pressure pipe with integral wall bell and spigot joints.

4. Joints shall be push-on type with a flexible factory assembled elastomeric ring in the integral bell-end. Joint material including gaskets and lubricants shall conform to AWWA C900.

5. Fittings shall be manufactured in accordance with ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53, and shall be ductile iron. The minimum acceptable pressure rating shall be 250 psi. Compact fittings are required and shall have a minimum acceptable pressure rating of 350 psi.

6. Pipe smaller than 4-inches in diameter shall be Schedule 80 PVC, in accordance with ASTM D-1785 or ASTM D-2241 for SDR (Standard Dimension Ratio) 13.5, or as specified in the Contract Documents. Solvent cement for non-gasketed PVC pipe shall meet the requirement of ASTM D-2564.

7. Pipe shall bear identification markings that will remain legible during normal handling, storage, and installation. The markings shall be applied in a manner that will not reduce the strength of the pipe or coupling or otherwise damage either. Pipe markings shall be applied at intervals not to exceed five (5) feet and shall include the nominal size and outside diameter (e.g. 4 CI), PVC, DR 18, AWWA Pressure Class (PC 150), manufacturer's name or trademark and production record code, and the seal of the testing agency that verified the suitability of the pipe material for potable water service.

8. The manufacturer's representative shall be made available a minimum of 2 working days (time on site) during the project when requested by the Owner, including the first

2 Days of pipeline installation.

9. The cost for the services of the manufacturer's representative, including expenses, shall be considered incidental to the project and will not be paid separately.

C. High Density Polyethylene (HDPE) Pipe

1. HDPE pipe and fittings shall meet the requirements for potable water and have ANSI/NSF No. 61 certification.

2. HDPE pipe 3-inches or less in diameter shall comply with AWWA C901 and shall have a nominal DIPS (Ductile Iron Pipe Size) outside diameter unless otherwise specified. The nominal size and SDR of the pipe shall be as specified in the Contract Documents. HDPE pipe greater than 3-inches in diameter shall be in accordance with AWWA C906-15 and shall have a nominal DIPS (Ductile Iron Pipe Size) outside diameter unless otherwise specified. The nominal size, pressure classification rating, and SDR of the pipe shall be as specified in the Contract Documents. ODs and tolerances for IPS outside diameter pipe shall be in accordance with ANSI B36.10 as illustrated in AWWA C906-15 Table 3.A Pipe shall be homogeneous and uniform throughout; shall be free of injurious defects such as visible cracks, holes, foreign inclusions, voids, and blisters; and shall have uniform color and physical properties according to the provisions of AWWA C906-15.

3. Commercial virgin PE Compounds shall meet ASTM D3350 physical property requirements and shall be classified per ASTM D3350 as shown in Table 1 of AWWA C906-15. The compound shall have HDB (Hydrostatic Design Basis) ratings at 73°F (23°C) and at 140°F (60°C) and HDS (Hydrostatic Design Stress) ratings at 73°F (23°C) determined in accordance with ASTM D2837 and PPI TR-3 (Policies and Procedures for Developing Recommended Hydrostatic Design Stress for Thermoplastic Pipe Materials).

4. The PE Compound in the pipe shall contain color and ultraviolet (UV) stabilizer meeting the requirements of ASTM D3350 Codes C or E. Code C compounds shall contain 2 to 3 percent carbon black when material from the pipe is tested in accordance with Section 4.3.11 of AWWA C906-15. Code E compounds used for solid color pipe, color stripes, or color layer (shell) shall contain sufficient UV stabilizer to protect the pipe against UV degradation for at least 24 months of unprotected outdoor exposure. Color PE compounds used for stripes or color layers shall be of the same materials designation codes as the pipe material, varying only by color and UV stabilizer.

5. Clean rework materials derived from pipe production by the same manufacturer are acceptable as part of a blend with Virginia PE compound meeting section 4.2.1 of AWWA C906-15 for the production of new pipe, including sections 4.2.3.1, 4.2.3.2, 4.2.3.3 and 4.2.4.

6. PE fittings or components may be molded, thermoformed from pipe sections or fabricated. Molded fittings shall meet the requirements of AWWA C906-15 and the requirements of ASTM D2683 for socket-type fittings, or ASTM D3261 for butt-type fittings, or ASTM F1055 for electrofusion-type fittings. Thermoformed and fabricated fittings shall meet the requirements of AWWA C906-15 and ASTM F2206.

7. Pipe sections shall be joined on the job site above ground into continuous lengths by the thermal butt-fusion or electrofusion method, which shall be performed in strict accordance with the manufacturer's recommendations. The butt-fusion equipment used in the joining procedures shall be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, temperature requirements of 400 °F, alignment, and 75 psi interfacial fusion pressure. Butt-fusion joining shall be 100% efficient and shall provide a joint weld strength equal to or greater than the tensile strength of the pipe. Socket-fusion, extrusion welding or hot gas welding of HDPE shall not be used for pressure pipe applications. Flanges, unions, grooved-couplers, transition fittings, and some mechanical couplers may be used to mechanically connect HDPE pipe without butt-fusion, if specified in the Contract Documents and approved by the manufacturer.

8. The manufacturer's representative shall be made available a minimum of 2 working days (time on site) during the project when requested by the Owner, including the first 2 Days of pipeline installation.

9. The cost for the services of the manufacturer's representative, including expenses, shall be considered incidental to the project and will not be paid separately.

10. Transition couplings from HDPE to other pipe materials, shall be as indicated in the Contract Documents.

D. Copper Water Pipe

Pipe shall be seamless copper tubing conforming to ASTM B 88, Type K, Temper 060, and shall be of the coiled type. Fittings shall be wrought copper solder-joint pressure fittings conforming to ASME B16.22. Copper tube and fittings shall be rated for a working pressure of 150 psi. Joints shall be compression style.

E. Valves

1. Gate Valves

a. Resilient-seated gate valves shall be used on pipelines 3-inches in diameter up to and including 12-inches in diameter. Resilient-seated gate valves shall be in accordance with AWWA C509 or AWWA C515 and shall be supplied with an interior epoxy coating in accordance with AWWA C550. Resilient-seated gate valves shall be iron body, non-rising bronze or stainless steel stem, rubber encapsulated iron disc, o-ring seals, and suitable for buried service. Valve ends shall be flanged, mechanical joint, or mechanical joint by flange to suit the pipe or fittings as indicated in the Contract Documents.

Gate valves shall be manufactured by Kennedy Valve Company, Mueller Company, or approved equal, or as specified in the Special Provisions.

b. Gate valves smaller than 3-inches in diameter shall be cast bronze, solid-wedge disc, screwed bonnet, inside screw, non-rising stem valves with threaded connections. Valves shall conform to Standard SP-80, Type 2, Class 150, Manufacturer's Standardization Society of the Valve and Fitting Industry, Inc.

c. Gate valves larger than 16-inches in diameter shall meet the requirements of AWWA C500, except Section 4.4.8.1.1 will not be allowed. Valves shall be rated for 150 psi working pressure and a minimum 300 psi test pressure. Valves shall be iron body, bronze-mounted, double disc, parallel seat, non-rising stem type fitted with O-Ring seals. Valves shall be capable of drip tight, bi-directional shut off and operate in the horizontal position. The operating nuts shall be 2-in square. Valves shall open counter clockwise. Seats in the body shall be replaceable without removing the valve from the pipeline. Discs shall be cast iron and bronze faced and shall be free to revolve 360 degrees. Valves to be furnished with bronze rollers, bronze tracks and bronze scrapers.

d. Valve Operators

Buried valves shall have a 2-inch square operating nut conforming to AWWA C509, and shall open in a counterclockwise direction, unless otherwise noted. A valve key wrench of adequate length and of each type required shall be provided for each buried valve; however, not more than three of each type are required for each project. Valves in vaults shall have a hand wheel of cast iron conforming to ASTM A126, Class B.

2. Ball Valves

Owner-approved ball valves smaller than 3-inches in diameter shall be:

a. Brass with threaded connections, O-ring seals, and a coated ball conforming to AWWA C800 and Standard SP-80, Type 2, Class 150 Manufacturer's Standard Society of the Valve and Fittings Industry, Inc. Valves shall be manufactured by the Ford Meter Box Company B11, Mueller Company 300 Ball Curb Valve, B-20283, or approved equal.

b. PVC True Union Standards ball valve with steel reinforced threaded-end connectors, with a minimum pressure rating of 230 psi at 70°F, conforming to ASTM D1784, Cell Classification 12454, as manufactured by Asahi, Spears, or approved equal.

c. NSF approved.

3. Butterfly Valves

a. Butterfly valves may be used on pipelines 16-inches in diameter and larger and shall be Pressure Class 150B in accordance with the latest revision of AWWA C504. Butterfly valves and operators shall be suitable for buried service. Valve seats shall be of synthetic rubber compound and tested in accordance with ASTM D-429. The valve shall be operable with a maximum input of 150 foot-pounds on the operating nut, and be able to withstand an overload input torque of 150 foot-pounds at full open and full closed positions without damage to the operator nut. Actuator components shall be designed to withstand, without damage, a rim pull of 200 pounds for the hand wheel, and an input torque of 300 Ft-Lbs for wrench nuts, in accordance with AWWA C504.The disc shall be capable of holding in any intermediate position without creep or flutter.

b. Butterfly valve operators may be side-mounted, shall meet the requirements of AWWA C504, pressure class 150B, shall be capable of seating and unseating the discs against the full design pressure and velocity, and shall transmit sufficient torque to the valve to accomplish this. Buried valves shall contain permanently lubricated operators. Valve operators shall be suitable for a minimum of 10,000 cycles of operations at its rated torque.

4. Coatings

All interior ferrous surfaces of all valves shall be coated in accordance with ANSI/AWWA C550 using a coating approved by the Virginia Department of Health for contact with potable water and shall not contain lead, coal tar resins, lampblack, carbon black or bituminous materials. The exterior surfaces shall receive a factory applied fusion bonded epoxy coating.

5. Valve Stem Extensions

Valve stem extensions, when allowed by the locality, shall be furnished when the distance from the operating nut to the top of the valve box frame is greater than 36-inches. Extension stems shall have a 2-inch square wrench nut on the top end and shall be at least as strong as the valve stem. Extension stems shall be coated in accordance with above.

6. Valve Markings

Valve markings shall be cast on the bonnet or body of each valve and shall show the manufacturer's name or mark, the year the valve casting was made, the size of the valve, and the designation of working pressure.

F. Valve Boxes

Valve boxes shall be as indicated in the Standard Details.

G. Fire Hydrants

1. Fire hydrants shall be of the dry-barrel type and shall conform to AWWA C502.

2. The hydrant base shall have a 6-inch mechanical joint bell, designed for connection to a horizontal 6-inch ductile iron hydrant branch with retainer glands. The traffic coupling shall allow for 360-degree adjustment of the upper standpipe. The fire hydrant shall be painted with a high gloss, alkyd industrial enamel (colors shall be selected by the Owner). Extension spools shall be available from 6-inches to at least 48-inches, in 6-inch increments. Normal bury depth shall be 3.5 feet.

3. The flow rate shall be a minimum of 1000 gallons per minute with not more than 5-psi pressure drop through the steamer nozzle, per AWWA C502.

4. The internal valve shall be no smaller than 4½-inches in diameter and have bronze-to-bronze seating.

5. Hydrants shall include two (2) 2 1/2-inch hose nozzles placed 180 degrees apart; National Standard (American) fire hose coupling screw threads; and one steamer

nozzle with 4 1/2-inch National Standard (American) fire hose coupling screw threads (unless specified otherwise by the Owner).

6. Fire Hydrants shall conform to Mueller Super Centurion 250 Model A421 or A-423, Kennedy Guardian K-81D, or Owner-approved equal.

H. Appurtenances

1. Air Vent and Blow Off Assemblies

a. Air Vent and Blow Off Assemblies shall be as indicated in the Standard Details.

b. Brass Pipe shall be red brass pipe meeting the requirements of ASTM B 43. Pipe sizes, wall thickness and dimensions shall meet the requirements of ASTM B 251, Table I for regular pipe. Brass pipe fittings shall be screwed end malleable iron pattern meeting the requirements of ANSI B16.15. They shall be finished rough, unless otherwise specified. Unions shall be of all brass or bronze with ground joints and shall be left semi-finished. Fittings shall be rated for steam working pressures up to 125 psi. Joints shall be screwed type with threads clean cut, tapered and smooth, meeting the requirements of ANSI B2.1.

2. Water Sampling Stations

Water sampling stations shall conform to Eclipse Model 88 as manufactured by the Kupferle Corporation, or approved equal, in accordance with the Special Provisions. Housing shall be either aluminum or plastic as approved by the Owner. If aluminum, housing shall be painted in a color approved by the Owner. If housing is plastic, the color shall be impregnated in the plastic and approved by the Owner.

3. Corporation Stops

Corporation Stops shall be manufactured to meet or exceed the AWWA C-800 latest revision. The corporation stops shall also meet the following requirements:

a. The valve shall be of the ball type construction. A plug valve is not approved.

b. The corporation stops shall be designed to withstand working pressures up to 300 psi.

c. The corporation stops shall be manufactured with AWWA/CC tapered threads.

d. Corporation stops joining to copper and plastic tubing shall have pack joint compression couplings.

e. Corporation stops joining to existing galvanized piping shall have female iron pipe threads.

f. Acceptable manufacturers of corporation stops are:

(1) The Ford Meter Box Co. Inc, Model FB 1000 for joining copper and plastic tubing. For joining to galvanized piping use Model FB 1600.

(2) A.Y. McDonald Mfg., Co., Model 4701B-22 for joining copper and plastic tubing. For joining to galvanized piping use Model 3148B.

(3) Or, approved equal.

4. Service Saddle

Service Saddle shall be designed and sized for the water main on which the saddle is to be installed. The service saddle shall also meet the following requirements:

a. Stainless steel saddle bodies shall be 18-8, Type 304, stainless steel with all welds fully passivated to restore stainless steel characteristics.

b. Ductile iron saddle bodies shall conform to ASTM A-536 and have a fusion applied epoxy coating 12-mils dry thickness (D.T.). Straps shall be stainless steel, 18-8, Type 304 fully passivated for corrosion resistance.

c. Threads shall be AWWA C-800 CC/Taper.

d. The saddle band shall be a minimum of 2-inches in width.

e. The saddle shall be provided with a Buna-N rubber gasket meeting ASTM D2000 to seal the saddle and the main pipe.

f. The nuts, washers, bands, and bolts shall be 18-8 stainless steel.

g. Acceptable manufacturers are The Ford Meter Box Co., Inc., Model FS202/FS303/FRS202, JCM Model 406, Romac Industries Inc., Style 202N, Cascade Products Style CNS2, or approved equal.

J. Water Meters

Meter settings shall include meter setter, meter box, water meter, and all appurtenances necessary for providing customer water service at the location designated in the Contract Documents. See the Special Provisions for additional information.

K. Joint Restraint Devices

1. Joint restraints shall be provided where indicated in the Contract Documents.

2. Ductile Iron Pipe

The restrained joint system shall have a pressure rating equal to or greater than that of the pipe on which it is used. Restrained joint devices shall be installed in strict accordance with the manufacturer's recommendations.

a. Push-On Joints

For push–on joint type pipe, the restrained joint system shall be a manufacturer's standard restrained joint system, SnapLock (U.S.Pipe), TR Flex (U.S. Pipe), FlexRing (American Pipe), Series 3000 Stargrip wedge

action restraint (Star Pipe Products), or approved equal.

b. Mechanical Joints

For mechanical joint type pipe, the restrained joint system shall be a manufacturer's standard restrained joint system, Series 1100 Megalug ductile iron glands (EBBA iron, Inc.), Series 1400 retainer glands (Ford Meter Box Company, Inc.), Series 3000 Stargrip wedge action restraint (Star Pipe Products), or approved equal.

3. PVC Pipe (4-inch and larger)

The restrained joint system shall have a pressure rating equal to or greater than that of the pipe on which it is used. Restrained joint devices shall be installed in strict accordance with the manufacturer's recommendations.

a. Bell and Spigot PVC Joints

The restraint system for bell and spigot PVC joints shall be Series 1600/2800 ductile iron retainers as manufactured by EBAA Iron, Inc, Series 1390 retainers as manufactured by Ford Meter Box Company, Inc., or approved equal.

b. PVC to Mechanical Joint Fittings

The restraint system for restraining PVC pipe to ductile iron mechanical joint fittings shall be Series 2000 PV ductile iron retainers as manufactured by EBAA Iron, Inc., Series 1500 retainers as manufactured by the Ford Meter Box Company, Inc., Series 4000 Stargrip wedge action restraint (Star Pipe Products),or approved equal.

4. Concrete Reaction Blocking

Concrete reaction blocking shall not be permitted, unless approved by the Owner.

5. Tie Rods

Tie rods shall not be used unless specifically approved by the Owner and only where shown in the Contract Documents. When appropriate, tie rods, bolts, washers, and nuts shall be stainless steel in accordance with ASTM A-307.

L. Tapping Valves and Sleeves

1. Tapping valves and sleeves shall be compatible for use with the pipe being tapped and as approved by the Owner. The Contractor shall verify the material and diameter of the pipe being tapped prior to ordering tapping valves and sleeves.

2. Tapping valves for ductile iron pipe shall meet the same specifications as gate valves, except they shall have a full, unobstructed opening to receive a full size shell cutter. Tapping valves shall contain a standard mechanical joint on one end and a flanged joint on the other end. The valves shall be subjected to a factory test pressure of 400 psi and be designed for a working pressure of 200 psi.

3. Tapping sleeves shall be split sleeve with mechanical joint type end seals. Cast sleeves for tapping cast iron pipe, shall be ductile iron meeting ASTM A536 Grade 65-42-12.

   a. Tapping sleeves for Ductile Iron and PVC C-900 Pipe

      As appropriate, tapping sleeves shall be mechanical joint, furnished complete with plain rubber gaskets, mechanical joint accessories, and approved interior and exterior coatings. The outlet flange shall be 125 pound, drilling per ANSI B16.1, with standard tapping flange counterbore per MSS SP-60. Tapping sleeves shall be in accordance with ANSI/AWWA C110/A21.10.and approved by the manufacturer for use on the type and class of pipe being tapped.

   b. PVC Pipe (Other than C-900)

      Tapping sleeves shall be complete, furnished with plain rubber gaskets, have a full circumference band made of 18-8 type 304 stainless steel. The flange and all bolts and nuts shall conform to AWWA C207 Class D 150 lb. drilling, made of 18-8 type 304 stainless steel.

      Gaskets shall conform to the applicable requirements of ANSI/AWWA C111/A21.11, and shall be clearly marked to identify the diameter range for which intended.

4. When approved by the Owner and indicated in the Contract Documents, stainless steel tapping sleeves may be used and shall be constructed of all stainless steel conforming to the following requirements:

   a. Flange - The flange shall be 18-8, type 304 stainless steel, with recess to accept the standard tapping valve according to MSS-SP60. The flange shall also conform to AWWA C207-latest revision, Class D ANSI 150 lb. drilling. The bolt hole shall be aligned to straddle the pipe center line.

   b. Body - The body shall be 18-8, type 304 stainless steel. All welds shall be fully restored to stainless steel characteristics.

   c. Gaskets - The gaskets shall be virgin SBR compounded for water service. ASTM D2000 8M 4AA607. The gasket shall be a full 360 degree pipe coverage. The outlet gasket shall be Buna-N.

   d. Test Plug - Provide a waterworks brass 3/4-inch test plug with standard square head.

   e. Bolts and Nuts - The bolts and nuts shall be 18-8, type 304 stainless steel UNC threads. Provide heavy hex nuts and washers fluorocarbon coated to prevent galling.

   f. Manufacturer - Acceptable manufacturer is the Ford Meter Box Co., Inc., Model FTSS, Smith-Blair Style 665, Romac Industries Inc., SST or JCM Industries, Inc., Model 432, or approved equal.

M. Sleeves and Couplings

1. Diameters greater than 2-inch

a. Mechanical joint sleeves shall be solid type, long or short body pattern as approved by the Owner, manufactured in accordance with ANSI/AWWA C110/A21.10. Sleeves shall have a minimum pressure rating of 350 psi. Glands, gaskets, bolts, and nuts shall be in accordance with ANSI/AWWA C111/A21.11.

b. Sleeves shall not be machined in order to facilitate use with pipe of a class or type other than that for which the sleeve was manufactured.

c. The use of bolted steel couplings shall be restricted to joining pipes of different outside diameters, joining pipes of dissimilar materials, and joining sections of steel pipe. Ferrous surfaces shall be coated with an epoxy coating; enamel coatings are not acceptable.

d. Bolted steel transition couplings shall be Rockwell 413, Dresser style 162, or approved equal.

e. Bolted steel reducing couplings shall be Rockwell 415, Dresser style 62, or approved equal.

f. Bolted steel couplings for joining pipes of the same outside diameter shall be Rockwell 411, Dresser style 38, or approved equal.

2. Diameters 2 inches and less:

a. Service couplings or unions shall conform to the requirements of AWWA C800-05 with the exception that any brass part of a fitting or coupling or valve in contact with potable water shall be made of copper alloy CDA No. C89520 or "no-lead brass" complying with ASTM B30 and B584. This "no-lead brass" alloy shall contain no more than ¼ of 1 percent (0.25%) total lead content by weight.

b. An ANSI accredited test lab per ANSI/NSF 61, Drinking Water Components-Health Effects Section 8, shall be used to certify the lead content for all "no-lead brass" fittings and valves. Proof of certification is required.

c. All brass fittings and couplings and valves shall have the manufacturers name or trademark integrally stamped as well.

d. Service couplings or unions shall be Mueller type H-15400, McDonald 4602, Cambridge 202, or approved equal.

5.20. MISCELLANEOUS ITEMS

A. Copper Tracer Wire - Shall be 10 Gauge, solid wire with plastic coating.

B. Subsurface Utility Warning Tape - Shall be of a durable, metalized, plastic film, similar to Terra Tape D for identification of water and force mains. Bright blue tape imprinted with the

legend "Caution - Waterline Below" and bright green tape imprinted with the legend "Caution - Sewer Below" shall be used as appropriate. The utility warning tape shall have a width of 6-inches and shall be manufactured by Reef Industries, or approved equal.

5.21. SANITARY SEWER REHABILITATION

The sanitary sewer rehabilitation specifications presented here and in Section 800 are meant as a guideline for the educated and experienced designer and practitioner of gravity sanitary sewer rehabilitation. Because most of the gravity sanitary sewers in Hampton Roads range in size from 6 to 18 inches, these specifications focus on technologies that are well understood in this geographic area and can be supported with competent contractors. These specifications are not meant to be inclusive of all rehabilitation technologies available today.

A. DVDs

1. All television surveys shall be digitally recorded and supplied to the Owner on DVD disks. DVDs shall be submitted to the Owner and will become the property of the Owner.

2. Two labels are required for DVDs. One label shall be placed on the plastic storage case for the CD/DVD and the other on the face of the DVD. Permanently label each DVD and case with the following information:

Plastic case of DVD

Owner Name: _____ Contractor's Name: _____
Tape No.: _____ Date Televised: _____ Date Submitted: _____
Project Name: _____
Branch Name:_____ Street Name:_____

Face of DVD

Manhole No. From	Manhole No. To	Pipe Diameter	Pipe Length	Street
_____	_____	_____	_____	
_____	_____	_____	_____	
_____	_____	_____	_____	
_____	_____	_____	_____	
_____	_____	_____	_____	

B. Pipe Rehabilitation by Cured-In-Place Pipe Method

1. The product proposed for the cured-in-place rehabilitation of sewers must have been in use in the United States for at least three years with a minimum of 50,000 linear feet of the product installed to date in this country.

2. The liner shall generally consist of corrosion resistant polyester, vinyl ester, or epoxy thermosetting resin, or approved equal, impregnated flexible polyester felt or fiberglass fiber. The liner may also consist of glass reinforced pipe (GRP).

3. The wall color of the interior pipe surface of the cured-in-place pipe after installation shall be a light reflective color so that a clear detail examination with closed circuit television inspection equipment may be made.

4. Design inputs generally considered to be the same from site to site for a particular project, are provided in Table 200-5.21.1.

TABLE 200-5.21.1

Common Design Parameters

Safety Factor	2.0
Soil Modulus (1)	1000 psi
Soil Density (2)	120 pcf

Notes:
(1) In the absence of site-specific information, assume a soil modulus of 1000 psi.
(2) In the absence of site-specific information, assume a soil density of 120 lb/ft3 (pcf).

The information listed in Table 200-5.21.2 is specific to each manhole to manhole run of pipe. The Contractor shall use for design the information provided by the Owner and information the Contractor collects during site visits for each manhole to manhole run.

TABLE 200-5.21.2
Site-Specific Design Parameters

Ovality	Notes 1, 2
Ground Water Depth Above Invert	Notes 1, 3
Soil Depth Above Crown	Note 1
Live Load	Notes 1, 4
Design Condition (Fully Deteriorated)	Notes 1, 5
CIPP Thickness	Notes 1, 6, 7

Notes:
(1) Design thickness and complete site-specific designs, in accordance with ASTM F 1216 (Appendix XI) or ASTM F 2019
(2) The Contractor shall estimate the ovality by viewing the videotapes and other information provided by the Owner. If tapes are not available, the Contractor shall assume an ovality of 2%. In cases where the ovality exceeds 10%, the Contractor may consider employing alternative design methods (such as beam design methods) to determine the pipe thickness.
(3) In the absence of accurate water table information or high water elevation observed during the site visit (stream, ponds, etc.), the Contractor shall assume a seasonal groundwater elevation variation of 3 feet below the ground surface.
(4) CIPP is subjected to traffic live loads as calculated by AASHTO Standard Specifications for Highway Bridges, HS-20-44 Highway Loading.
(5) The Contractor shall assume the pipe segments are fully deteriorated.
(6) Thicknesses specified (designed by the Contractor and approved by the Owner) are the final, in-ground thickness required. Measured sample thicknesses will not include polyurethane or polyethylene coatings, any layer of the tube not fully and verifiably impregnated with resin, or any portion of the tube not deemed by the Owner to be a structural component of the composite.
(7) The Contractor must consider any factors necessary to ensure the final, cured-in-place pipe thickness

is not less than specified above. These factors include any stress applied to the material during transportation, handling, installation and cure; the host pipe's material type, condition, and configuration; weather (including ambient temperature conditions); and any other factors which are reasonably expected to be found in existing combined or sanitary sewer systems.

5. The corrosion resistance of the resin system shall be tested by the resin manufacturer in accordance with ASTM D 543. The result of exposure to the chemical solutions listed in Table 200-5.21.3 shall produce loss of not more than 20% of the initial physical properties when tested in accordance with ASTM D 543 for a period of not less than 1 year at a temperature of 73.4°F plus or minus 3.6°F. For applications other than municipal wastewater, conduct chemical resistance tests with actual samples of the fluid to be transported in the pipe and in accordance with procedures approved by the Owner.

TABLE 200-5.21.3
Concentrations of Chemical Solutions for Chemical Resistance Test

Chemical Solution	Concentration, %
Tap Water (pH 6-9)	100
Nitric Acid	5
Phosphoric Acid	10
Sulfuric Acid	10
Petroleum Hydrocarbon Based Fuels (e.g. Gasoline, diesel, etc.)	100
Vegetable Oil[1]	100
Detergent[2]	0.1
Soap[2]	0.1
Domestic Sewage	100

1 Cotton seed, corn, or mineral oil
2 As per ASTM D 543

6. Manufacturer's Information

a. It shall be necessary for the Contractor to obtain the Owner's prior approval for all materials or processes and the Owner shall have the power at any time to order the Contractor to modify or discontinue any practice. All such orders shall be given in writing.

b. All fabricating and Contractor testing shall be carried out under cover and no materials shall be exposed to the weather until they are ready to be inserted. All materials should be protected from the weather and exposure to ultra-violet light as practicable during the manufacture and installation process.

c. Each liner shall be accompanied by suitable documentation indicating time

and date of manufacture, felt thickness, number of layers, length of liner, resin types, resin content, catalyst, relevant batch numbers, etc.

7. Non-Reinforced Thermoset Cured In Place Pipe Liners (Water or Steam Cured)

a. The liner shall meet the requirements of ASTM F 1216 and shall be constructed to withstand inversion pressures, have sufficient strength to bridge missing pipe, stretch to fit irregular pipe sections, and shall invert smoothly around bends. The liner shall fit tightly to the internal circumference of the existing pipe, and a membrane integrally bonded to the internal circumference of the felt, thus forming a smooth, chemically inert internal flow surface. The membrane shall be a minimum of 0.25 mm +5% and shall not be considered to impart any structural strength of the liner. The liner shall be fabricated to a size that when installed will neatly fit the internal circumference of the pipe to be lined. Allowance for longitudinal and circumferential stretching of the liner during installation shall be made by the Contractor.

b. The CIPP liner shall be composed of tubing material consisting of one or more layers of a flexible non-woven polyester felt with or without additives such as woven fiberglass or other fibers and meet the requirements of ASTM F 1216, ASTM F 1743, and ASTM D 5813. The felt content of the CIPP liner shall not exceed 25 percent of the total impregnated liner volume. The fabric tube shall be capable of absorbing and carrying resins, constructed to withstand installation pressures and curing temperatures and have sufficient strength to bridge missing pipe segments, and stretch to fit irregular pipe sections.

c. The CIPP liner tube may be made of single or multiple layer construction, with any layer not less than 1.5 mm thick. The wet-out fabric tube shall have a uniform thickness and excess resin distribution that when compressed at installation pressures will meet or exceed the design thickness after cure.

d. The exterior of the manufactured tube shall have distance markings along its length at regular intervals not to exceed 5 feet. Contractor shall use these marks as a gauge to measure elongation during insertion. Should the overall elongation of a reach exceed 5 percent, the liner tube shall be rejected and replaced. The Contractor shall identify the wet-out facility where all CIPP liner under this Contract will be manufactured. All CIPP liner shall be manufactured from this designated wet-out facility throughout the entire Contract unless specifically approved otherwise by the Owner in writing. Multiple wet-out facilities shall not be allowed. The application of the resin to the felt tubing (wet-out) shall be conducted under factory conditions and the materials shall be fully protected against UV light, excessive heat and contamination at all times.

e. The resin volume shall be adjusted by adding 5 to 10% excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe. The resin used shall not contain fillers, except those required for viscosity control, fire retardance, or as required to obtain the necessary pot life. Thixotropic agents which will not interfere with visual inspection may be added for viscosity control. Resins may contain pigments, dyes or colors that will not interfere with visual

inspection of the cured liner. However, the types and quantities of fillers and pigments added shall have prior approval of the Owner. The resin content of the liner shall be 10-15% by volume greater than the volume of felt in the liner bag. The felt resin tubing shall be vacuum impregnated with a thermosetting polyester resin and catalyst, vinyl ester resin and catalyst, or epoxy resin and hardener.

f. The Contractor shall deliver the uncured resin impregnated liner bag to the site. The bag may not be impregnated at the site unless approved by the Owner. The liner bag shall be impregnated with resin not more than 80 hours before the proposed time of installation and stored out of direct sunlight at a temperature of less than 30 °F.

Certain design inputs vary by manufacturer, process design, or installation technique. These variables are listed in Table 200-5.21.4 with explanatory notes below.

TABLE 200-5.21.4
Product-Specific Design Parameters

Minimum Enhancement Factor, K(1)	K = 7
Minimum Initial Flexural Strength (ASTM D 790)(2)	σ_s = 4500 psi
Minimum Initial Flexural Modulus of Elasticity (ASTM D 790)(2)	E_s = 350,000 psi
Minimum Retention of Properties to Account for Long-Term Effects (3)	50%
Maximum Long-Term Flexural Modulus of Elasticity (3)	E_L = 175,000 psi

Notes:

(1) Enhancement factor (K) is the additional buckling or load resistance of the rehabilitation product due to the restraining action of the host pipe. The tighter the fit of the product within the host pipe, the greater the value of K. Third party testing of external hydrostatic loading capacity of restrained pipe samples shall be conducted to verify the enhancement factor, K. The minimum values provided are based on the "Long-Term Structural Behavior of Pipeline Rehabilitation Systems," Trenchless Technology Center, 1994.

(2) Initial values are defined in ASTM D 790. The Owner may, at any time prior to installation, direct the Contractor to make cured samples (according to ASTM F 1216 93) and test them in accordance with the listed ASTM standards to verify initial values of physical properties. In such tests the Contractor's samples must achieve a 95% pass-rate.

(3) The initial flexural modulus is multiplied by the creep factor (or percentage retention) to obtain the long-term values used for design. Long-term values shall be verified by long-term external pressure testing of circular lengths of the pipe material by third-party labs prior to bid (e.g. Trenchless Technology Center - TTC). It is understood that the material's modulus of elasticity will not change over time; however, by convention the modulus is reduced for design purposes for all plastic pipe sections to account for the reduced ability of plastic pipe to carry loads due to the changes in pipe geometry resulting from the effects of creep over time.

8. Glass Reinforced Pipe (GRP) Liners

The materials used for GRP liners shall have the following additional properties:

a. The fiberglass within the liner shall be non-corrosion material and shall be free from tears, holes, cuts, foreign materials and other surface defects. Its

glass fibers must extend in a longitudinal direction to insure no longitudinal stretching during the installation process. The tube shall consist of a seamless, flexible, glass fiber with no longitudinal seams.

b. Interior and exterior plastics shall be styrene resistant to protect and contain the resin used in the liner.

c. The exterior plastic shall be UV light resistant, when applicable, and translucent to allow visual inspection of the impregnation of the resin within the glass fibers.

d. The resin shall be a chemically resistant, isophthalic polyester resin or vinyl ester resin. When cured the resin/liner system shall meet the structural and chemical resistance requirements of ASTM F 2019.

Certain design inputs vary by manufacturer, process design, or installation technique. These variables are listed in Table 200-5.21.5 with explanatory notes below.

TABLE 200-5.21.5
Product-Specific Design Parameters

Minimum Enhancement Factor, K(1)	K = 7
Minimum Initial Flexural Strength (ASTM D 790)(2)	σ_s = 4500 psi
Minimum Initial Flexural Modulus of Elasticity (ASTM D 790)(2)	E_s = 725,000 psi
Minimum Retention of Properties to Account for Long-Term Effects (3)	50%
Maximum Long-Term Flexural Modulus of Elasticity (4)	E_L = 362,500 psi

Notes:
(1) Enhancement factor (K) is the additional buckling or load resistance of the rehabilitation product due to the restraining action of the host pipe. The tighter the fit of the product within the host pipe, the greater the value of K. Third party testing of external hydrostatic loading capacity of restrained pipe samples shall be conducted to verify the enhancement factor, K. The minimum values provided are based on the "Long-Term Structural Behavior of Pipeline Rehabilitation Systems," Trenchless Technology Center, 1994.
(2) Initial values are defined in ASTM D 790. The Owner may, at any time prior to installation, direct the Contractor to make cured samples (according to ASTM F 1216 93) and test them in accordance with the listed ASTM standards to verify initial values of physical properties. In such tests the Contractor's samples must achieve a 95% pass-rate.
(3) The initial flexural modulus is multiplied by the creep factor (or percentage retention) to obtain the long-term values used for design. Long-term values shall be verified by long-term external pressure testing of circular lengths of the pipe material by third-party labs prior to bid (e.g. Trenchless Technology Center - TTC). It is understood that the material's modulus of elasticity will not change over time; however, by convention the modulus is reduced for design purposes for all plastic pipe sections to account for the reduced ability of plastic pipe to carry loads due to the changes in pipe geometry resulting from the effects of creep over time.
(4) E_L based on ASTM F 2019.

9. Liner Wall Thickness

a. Liner thicknesses shall be submitted for all pipe sections for Owner approval.

b. The required structural CIPP wall thickness shall be designed in accordance

with the guidelines in Appendix X1 of ASTM F 1216 - or ASTM F2019. In cases where ovality exceeds 10%, or where pipes are egg or oval shaped, alternative methods of design may be considered by the Owner. The categories of design parameters noted in Tables 200-5.21.1, 200-5.21.2, 200-5.21.3, 200-5.21.4 and/or 200-5.21.5 shall be used, as appropriate, unless otherwise directed by the Owner.

c. Liner thicknesses may be modified with the Owner's approval of supporting calculations by the Contractor's Professional Engineer. The Owner reserves the right to change specified thickness based on new information. The Bid prices will be adjusted to increase or decrease unit price as liners are thickened or thinned at the Owner's direction.

d. Maintenance of flow capacity of existing pipes is essential. Rehabilitated pipe shall have minimum or no change in capacity. An increase in flow capacity following rehabilitation is preferred, and in no case shall the flow capacity of rehabilitated pipes be reduced.

e. Verify that installed thickness of the CIPP is within minus 5 % and plus 10 % of the specified thickness. The Contractor shall collect samples per Section 813.2.6 Testing. The results of the liner thickness measurements and structural analysis shall be submitted to the Owner within 14 Days and prior to payment.

f. Minimum liner thicknesses for water or steam cured polyester thermoset CIPP and GRP liners shall be:

Pipe Diameter (In.)	Polyester Thermoset CIPP (mm)	GRP (mm)
6	4.5	3.0
8	6.0	4.5
10	6.0	4.5
12	6.0	4.5
15	7.5	6.0
18	9.0	7.5

10. The length of the liner shall be that which is deemed necessary by the Contractor to effectively carry out the insertion and seal the liner at the inlet and outlet of the manhole. Individual inversion runs may be made over one or more manhole to manhole sections as determined.

11. The Contractor shall provide a liner exhibiting the previously described properties. Prior approval of Shop Drawings related to any or all materials or methods of installation shall not relieve the Contractor of this responsibility.

C. Pipe Rehabilitation using the Sliplining Method

1. Fiberglass (GRP) pipe shall be centrifugally cast, or mandrel produced, with glass fiber reinforcement in a cured thermosetting resin manufactured in accordance with ASTM D3262, cell classification Type 1, Liner 1, Grade 1. Pipe stiffness shall meet the design requirements in ASTM D3262. Fiberglass pipe shall be shown by tests to be resistant to long-term corrosion. Testing shall be performed in accordance with

ASTM D3681 using 1.0N sulfuric acid for sanitary sewage, and ASTM C581 for industrial sewage. Fiberglass pipe shall have a gasket that has been affixed, via environmentally safe adhesive, to the pipe within the groove for the tongue and groove application. A coupling device with the gasket affixed similarly will suffice also. Loose gaskets affixed without adhesive will not be permitted.

2. PVC pipe shall have a minimum cell classification of 12364 B or C as defined in ASTM D1784. Pipe shall be closed profile per ASTM F 1803 with a tongue and groove gasketed joint. The joint shall be designed so that neither the outside diameter of the pipe is increased, nor the internal diameter of the pipe is decreased at the joint. The joint shall meet the requirements of ASTM D3212. PVC liner pipe shall have a minimum pipe stiffness of 46 psi when tested in accordance with ASTM D2412. Gaskets shall meet the requirements of ASTM F 477.

3. Fusible Polyvinylchloride (fPVC) Pipe

   a. Pipe Supplier shall furnish fPVC pipe conforming to all standards and procedures, and meeting all testing and material properties as described in this specification. Pipe, 4 to 12 inches in diameter, shall conform to AWWA C900 – Class 150 (DR 18), unless otherwise indicated in the Contract Documents. Pipe greater than 12 inch shall conform to AWWA C905 – Class 235 (DR 18) or Class 150 (DR25), as specified in the Contract Documents.

   b. fPVC pipe shall be tested at the extrusion facility for properties required to meet all applicable parameters as outlined in AWWA C900 or C905, as appropriate. Rework material shall be allowed per AWWA C900 and AWWA C905 standards. All piping shall be made from a PVC compound conforming to cell classification 12454 per ASTM D1784.

   c. fPVC pipe shall be extruded with plain ends and shall normally be supplied in standard 40 foot lengths. 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. fPVC pipe shall be blue in color for potable water use or green for wastewater.

   d. 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 and Standard number
      (5) Extrusion production-record code
      (6) Trademark or trade name
      (7) Cell Classification 12454 and/or PVC material code 1120 may also be included.
      (8) NSF-61 mark, if for potable water service.

4. Polyethylene pipe and fittings shall be manufactured from high density compounds in accordance with ASTM D3350. All HDPE pipe shall be closed profile and have a minimum SDR rating of 32.5 and a minimum pipe stiffness of 46 psi.

5. All pipe shall be provided with joints designed so that neither the outside diameter of the pipe is increased nor the internal diameter of the pipe is decreased at the joint.

6. Cellular concrete grout for annular space provided under this Specification shall have the following characteristics:

   a. 300 psi, 28-day compressive strength; 100 psi, 24-hour compressive strength, minimum.
   b. Foam concentrate: ASTM C869.
   c. Cement: ASTM C150.
   d. Fly ash: ASTM C618, Class F, except loss of ignition shall not exceed 5%.
   e. Water: Potable.
   f. Admixtures: Only as approved by foam concentrate manufacturer and Owner.

7. All connectors provided for reinstatement of laterals shall be as follows:

   All connectors shall be composed of synthetic rubber based compounds formulated to resist acids, alkalis, solvents, and greases encountered in sanitary and storm sewer and shall contain no reclaimed rubber. Contractor shall submit evidence of satisfactory testing in accordance with ASTM D543 with no weight loss in 1.0N sulfuric acid, 1.0N hydrochloric acid or 1.0N nitric acid. Materials shall show no etching, blistering, distortion or other evidence of chemical attack. Ultimate tensile strength shall exceed 750 psi at 80 degrees F and elongation shall exceed 150%. Water absorption shall not exceed 4% when tested in accordance with ASTM D570 and hardness shall not exceed 55 in a 5 second reading interval when tested in accordance with ASTM D2240, Type A Hardness.

8. All compression bands shall be Series 316 Stainless Steel. All nuts and bolts shall be Series 305 Stainless Steel.

9. The completed joint shall comply with ASTM C425 for resilient sewer pipe joints.

D. Pipe Saddle Lateral Connection for Rehabilitated Pipes

1. Use pipe saddles only on rehabilitated sanitary sewer mains.

2. Supply one-piece prefabricated saddle, either polyethylene or PVC, with neoprene gasket.

3. Use 1/2 inch stainless steel bands for securing saddles to liner pipe. Bands shall be resistant to corrosion for a minimum service life of 50 years.

E. Inserta Tee Lateral Connection for Rehabilitated Pipes

1. Use pipe Inserta tees only on rehabilitated sanitary sewer mains.

2. The Inserta Tee is comprised of three parts; PVC hub, stainless steel band and rubber boot as manufactured by Fowler Manufacturing Co., Inc.

3. PVC hub and rubber boot shall be engineered to accept the wall thickness and internal radius of the pipe. The PVC hub and rubber boot shall not protrude more than ½inchinto the sewer pipe.

4. The PVC hub shall be in accordance with ASTM D 3034.

5. The rubber boot shall be in accordance with ASTM C 443.

F. Manhole Rehabilitation using Cementitious Products

1. Contractor may use the following products in conjunction with the liner material to facilitate manhole rehabilitation. Material compatibility of the products must be demonstrated prior to commencement of Work.

a. Mix to be applied according to manufacturer's recommendations and shall have the following minimum requirements.

Compressive Strength	ASTM C 109	6 hr 1,400 psi
Shrinkage	ASTM C 596	0% at 90% relative humidity
Bond	ASTM C 321	28 day 150 psi
Cement	Sulfate resistant	
Density, when applied		105 ±5 pcf

b. Infiltration Control Mix: A rapid-setting cementitious product specifically formulated for leak control shall be used to stop minor water infiltration and shall be mixed and applied according to manufacturer's recommendations and shall have the following minimum requirements.

Compressive Strength	ASTM C 109	1 hr	600 psi
Compressive Strength	ASTM C 579 B	24hr	1,000 psi
Bond	ASTM C 321	1 hr	30 psi
Bond	ASTM C 321	24 hr	80 psi.

c. Grouting Mix

(1) A cementitious grout shall be used for stopping very active infiltration and filling voids and shall be mixed and applied according to manufacturer's recommendations. The cementitious grout shall be volume stable and have a minimum 28 day compressive strength of 250 psi and a 1 day strength of 50 psi.

(2) Chemical grouts may be used for stopping very active infiltration and shall be mixed and applied per manufacturer's recommendations.

d. Liner Mix

(1) Standard

The cementitious liner shall be used to form a structural/structurally enhanced monolithic liner covering all interior manhole surfaces. The material shall be applied at a minimum ½-inch thickness; but application must be at a thickness to ensure a structurally stable manhole, while forming an infiltration barrier to water and gases. The material shall meet the following minimum requirements at 28 days.

Compressive Strength	ASTM C 495	3,000 psi
Flexural Strength	ASTM C 293	600 psi
Shrinkage	ASTM C 596	0% at 90% relative humidity
Tensile Strength	ASTM C 496	500 psi
Sulfate Resistance	ASTM C 267	No visible at pH of 2.

(2) High Performance

The liner mix shall be a cement-based, fiber-reinforced calcium aluminate mortar specifically designed to prevent infiltration and restore structural integrity. The material shall be premixed and specifically formulated to withstand hydrogen sulfide bacterial corrosion and abrasion in municipal sanitary sewer systems. The material shall meet the following minimum requirements at 28 days.

Compressive Strength	ASTM C 109	9,000 psi
Flexural Strength	ASTM C 293	1,200 psi
Shrinkage	ASTM C 596	0% at 90% relative humidity
Tensile Strength	ASTM C 496	>800 psi
Sulfate Resistance	ASTM C 267	No visible at pH of 2 or less

G. Manhole Rehabilitation using Cured-In-Place Fiberglass Insert Liner

1. Cured-In-Place fiberglass insert liner shall contain 68 ounces per square yard of pre-saturated fabrics. The liner shall contain a felt impregnated non-porous membrane bonded between the layers of structural fiberglass. The cured-in-place fiberglass insert shall have a ten-year labor and materials, non-prorated warranty to stop infiltration and further deterioration of the structure.

2. Cured-In-Place fiberglass insert liner shall meet the minimum applicable requirements:

Test	Property	Results
ASTM-D-790	Flexural Strength	22,000 psi
ASTM-D-695	Compressive Strength, Yield	10,500 psi
ASTM-D-638	Tensile Strength	9,500 psi
ASTM-D-638	% Elongation @ Max Load	1.53%
ASTM-D-2240	Hardness, Shore D	80
ASTM-D-4541	Bond Strength	900 psi

3. Chemical Resistance: The corrosion resistance of the fiberglass liner insert shall be tested by the manufacturer in accordance with requirements noted in 5.21.G.4.

4. The manufacturer shall warrant that the products are produced in conformity with its standard specifications or formulations within recognized tolerances, free of adulteration or contamination, and that the product will perform in accordance with representations in the manufacturer's literature and technical data sheets when properly applied in strict conformance with the printed instructions on container and prescribed in technical data instructions and when applied to a properly prepared surface.

H. Manhole Rehabilitation using Epoxy Coating

1. The monolithic high-build epoxy coating shall consist of a 100% solids epoxy formulated with exceptionally high physical strengths and broad range chemical resistance. The coating system coverage shall be a minimum of 100 mils and shall be determined by the manufacturer. The manufacturer shall provide documentation for the recommended thickness.

2. The epoxy coating shall have a one-year labor and materials, non-prorated warranty to stop infiltration and further deterioration of the structure.

3. The epoxy coating shall have the following minimum requirements:

Test	Property	Results
ASTM-D-790	Flexural Strength	12,443 psi
ASTM-D-695	Compressive Strength, Yield	12,870 psi
ASTM-D-638	Tensile Strength	6,640 psi
ASTM-D-638	% Elongation @ Max Load	1.53%
ASTM-D-2240	Hardness, Shore D	80
ASTM-D-256	Impact, IZOD	0.345 ft. lb/in of notch

4. The epoxy coating shall have the following minimum requirements after seven day curing:

Test	Property	Results
ASTM-D2240-75	Hardness	82 Shore D
ASTM-638	Ultimate Elongation	6%

5. Chemical Resistance: The corrosion resistance of the epoxy coating shall be tested by the coating manufacturer in accordance with ASTM D543. The result of exposure to the chemical solutions listed below shall produce loss of not more than 20 % of the initial physical properties when tested in accordance with ASTM D543 for a period of not less than 1 year at a temperature of 73.4 ºF plus or minus 3.6 ºF. For applications other than municipal wastewater, conduct chemical resistance tests with actual samples of the fluid to be transported through the manhole and in accordance with procedures approved by the Owner.

CONCENTRATIONS OF CHEMICAL SOLUTIONS FOR CHEMICAL RESISTANCE TEST

Chemical Solution	Concentration, (%)
Tap Water (pH 6-9)	100
Nitric Acid	5
Phosphoric Acid	10
Sulfuric Acid	10
Petroleum Hydrocarbon Based Fuels (e.g. Gasoline, diesel, etc.)	100
Vegetable Oil[1]	100
Detergent[2]	0.1
Soap[2]	0.1

Domestic Sewage 100

[1] Cotton seed, corn, or mineral oil

[2] As per ASTM D543

6. Other Materials: No other material shall be used with the above mixes without prior approval or recommendation from the manufacturer.

7. The manufacturer shall warrant that the products are produced in conformity with its standard specifications or formulations within recognized tolerances, free of adulteration or contamination, and that the product will perform in accordance with representations in the manufacturer's literature and technical data sheets when properly applied in strict conformance with the printed instructions on container and prescribed in technical data instructions and when applied to a properly prepared surface.

I. Cured in Place Manhole Liners

1. The liner design and selection of materials shall be suitable for all the specified design conditions and shall meet the minimum requirements outlined in Table 200-5.21.6. Thicker liners may be required based on design conditions. The liner shall be custom-designed to fit each manhole and the basis of design shall be submitted to the Owner in accordance with Section 822.1.2. It is the Contractor's responsibility to supply a CIPM liner that is most suitable for the existing conditions and that meets the requirements of this specification. Contractor shall assume groundwater at grade for all sites for the purposes of liner thickness design unless otherwise instructed by the Owner.

2. The cured in place liner shall provide a minimum service life of 25 years.

TABLE 200-5.21.6
Minimum Liner Physical Properties

Manhole Depth (grade to invert)	Minimum Liner Thickness(1) (inch) ASTM D5813	Minimum Pre-Saturated Fabric Weight (ounces)	Minimum Flexural Modulus of Elasticity (psi) ASTM D790	Minimum Compressive Strength (psi) ASTM D695	Chemical Resistance Testing in accordance with ASTM F1216 Appendix X2
0 to 10 ft	0.117	56	1,000,000	11,000	PASS
10.1 to 15 ft	0.117	56	1,000,000	11,000	PASS
15.1 to 20 ft	0.158	68	1,000,000	11,000	PASS
(1) Minimum liner thickness includes only the strength portion of the liner. Non-structural layers are not included in minimum thickness requirements.					

J. Calcium Aluminate Cementitious Manhole Liner

1. The calcium aluminate cementitious liner shall be made with calcium aluminate cement and shall be used according to manufacturer's recommendations in applications where there is mild sulfide conditions (substrate surface of pH 2.0 or higher).

2. The calcium aluminate cementitious liner product shall be used to form a structural monolithic liner covering all interior substrate surfaces and shall have the following

minimum requirements:

Minimum Requirements			
Compressive Strength	ASTM C109	28 days	>9000 psi
Tensile Strength	ASTM C496	28 days	>800 psi
Flexural Strength	ASTM C293	28 days	>1500 psi
Shrinkage @90% relative humidity	ASTM C596	28 days	0%
Bond	ASTM C882	28 days	>2000 psi
Density, When Applied	-		134 ± 5lbs/ft3
Freeze/Thaw	ASTM C666	N/A	300 cycles no visible damage

3. The liner product shall be reinforced with alkaline resistant fiberglass rods or other similar fibers not less than 1/2 inch in length. The material shall meet or exceed industry standards and shall not have any basic ingredient that exceeds EPA maximum allowable limits for any heavy metals. Water used to mix product shall be clean and free from contaminants. Questionable water shall be tested by a laboratory per ASTM C-94 procedure. Potable water need not be tested.

4. When cured, the monolithic cementitious lining shall form a continuous, tight-fitting, hard, impermeable surfacing which is suitable for sewer system service and chemically resistant to any chemicals or vapors normally found in domestic sewage.

K. Manhole Frame Seals

1. Manhole frame seals shall be composed of flexible, pleated, high quality rubber gland with stainless steel expansion bands, and shall be designed to conform to the inside shape of the chimney area of the manhole frames.

   a. The rubber gland material compound shall conform to the applicable requirements of ASTM C 923, with a minimum tensile strength of 1,500 psi, a maximum compression set of 18%, and a durometer hardness of 48 (plus/minus 5).

   b. The manhole frame seals shall be contained in-place on the inside of the manhole frame chimney area through the use of stainless steel expansion bands designed to expand to form a compression seal between the rubber gland and the manhole chimney area surface.

   c. The bands shall be fabricated of 16 gauge Type 304 stainless steel conforming to ASTM A 240, and shall be equipped with a positive locking, worm-screw type mechanism. Screw hardware shall be Type 304 stainless steel conforming to ASTM F 593 and ASTM F 594.

2. Frame seals shall only be installed with the cementitious lining and epoxy coating systems. Frame seals are not required with the installation of fiberglass insert liner.

3. Acceptable Manufacturer: Cretex or equal.

L. Manhole Frame Sealants

Internal manhole frame sealant shall be Flex-Seal, or equal, and shall be composed of a corrosion resistant aromatic flexible urethane resin coating to be applied to the internal or external wall of the adjustment ring area.

1. The Aromatic Urethane Resin Liner Primer shall have the following minimum requirements:

Test	Property	Results
ASTM-D-1004	Tear Resistance	210 lb. l/in
ASTM-D-903	Adhesive Strength	400 lb. l/in
ASTM-D-412	Tensile Strength	3,200 psi
ASTM-D-442	Elongation	400%
ASTM-D-2240	Hardness	85

2. The Aromatic Urethane Resin Liner Final Coat shall have the following minimum requirements:

Test	Property	Results
ASTM-D-1004	Tear Resistance	155 lb. l/in
ASTM-D-903	Adhesive Strength	175 lb. l/in
ASTM-D-412	Tensile Strength	1,150 psi
ASTM-D-442	Elongation	800%
ASTM-D-2240	Hardness	75

M. Pipe Joint Rehabilitation using Chemical Grouting

1. Chemical joint sealing materials used on this project shall be an acrylamide joint-sealing gel grout plus activators, initiators and inhibitors recommended by the manufacturer.

2. In those lines that had root removal performed, a chemical root inhibitor shall be added to the grout prior to sealing the joints. Contractor shall submit the chemical to be used for Owner's approval prior to utilization.

3. In those lines where the grouting material may be exposed to a freeze-thaw cycle (cover depths of less than 3 feet), ethylene glycol or other Owner approved additive shall be used to prevent chemical grout cracking once set.

4. Acceptable Product and Manufacturer: AV-100 manufactured by Avanti International, Houston, Texas, or equal.

N. Insitu Point Repairs using Cured-In-Place Liner

1. The finished liner shall be in accordance with Section 5.21.B. The cured-in-place sectional pipelining shall be the New Life System as manufactured by Stephen's Technologies, Inc. or equal.

2. The liner shall be fabricated to a size that when installed will neatly fit the internal circumference of the conduit to be repaired as specified by the Owner.

3. The length and number of liners shall be that deemed necessary by the Owner to effectively carry out the repairs. The Contractor shall verify the lengths in the field before cutting liner to length. In general, the length shall vary between 3 and 8 feet.

4. Acceptable Product and Manufacturer: New Life System manufactured by Stephen's Technologies, or equal.

O. Insitu Point Repairs using Grouted Structural Sleeve

1. Sleeve: Type 316 stainless steel with a wall thickness sufficient to support the external loading of the host pipe system. The grouting sleeve material shall be of materials resistant to raw domestic sewage and corrosion caused by hydrogen sulfide gas or its derivatives.

2. Sealing Material: Water-cured polyurethane grout that complies with ANSI/NSF Standard 61.

3. Acceptable Manufacturer: Link-Pipe, Inc. or equal.

5.22. NOT USED

5.23. ASPHALT CONCRETE

Asphalt concrete shall consist of a combination of mineral aggregate and asphalt material mixed mechanically in a plant specifically designed for such purpose. Mix types shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 211.

5.24. COMPOSITE DETECTABLE WARNING SURFACE PANELS

A. Materials

Detectable Warning Surface shall be "tiles" made of homogeneous glass and carbon, reinforced composite material or vitrified polymer composite (VPC) material with ultraviolet stabilized coating, to minimize color wear, and a "non-slip" surface, incorporating "truncated domes," made of same material. The nominal thickness of the detectable warning tile shall be 1/8-foot exclusive of the height of the truncated domes. The tiles shall be in compliance with applicable Americans with Disabilities Act Accessibility Guidelines (ADAAG) and American with Disabilities Act (ADA) regulations with regard to detectable warning surfaces.

B. Types

Detectable warning surface shall be classified as follows:

1. Cast-in-Place tile shall be installed in the concrete in accordance with manufacturer's specifications. The cast-in-place tile shall be used for new construction.

2. Surface Mounted tile shall be secured to the concrete with a structural adhesive system and fasteners that anchors into the concrete. The surface mounted tile shall be installed to existing or proposed smooth finished concrete ramps.

C. Detail Requirements

Requirements for the detectable warning surface tiles shall meet the following:

1. Compressive Strength: 18,000 PSI minimum when tested by ASTM D695.

2. Tensile Strength: 10,000 PSI minimum when tested by ASTM D638-91.

3. Flexural Strength: 24,000 PSI minimum when tested by ASTM C293-94 or ASTM D790.

4. Water Absorption: 0.35% maximum when tested by ASTM D570.

5. Slip Resistance: 0.9 minimum for the combined wet/dry static co-efficient of friction when tested by ASTM C 1028.

6. Chemical and Stain Resistance: No deterioration, discoloration or staining when tested by ASTM D543-87 or ASTM 1308.

7. Fire Resistance: 25 minimum when tested to ASTM E84.

8. Accelerated Weathering: No deterioration, fading or chalking of surface after 2000 hours minimum exposure when tested by ASTM G26-95.

9. Salt and Spray Performance: No deterioration or other detects after 100 hours minimum exposure when tested by ASTM B117.

10. Accelerated Aging and Freeze Thaw: No disintegration, cracking, delamination, warpage, blistering, color change or other defects when tested by ASTM D037 or ASTM C1026.

D. Pattern/Dimension

Pattern and dimensions of the detectable warning surface tile shall incorporate an “in-line” dome pattern of truncated domes 0.2-inches in height, 0.9-inches diameter at the base and 0.4-inches diameter at top of dome. Domes should be spaced no greater than 2 1/4-inches from center to center. The field area of the detectable warning surface should consist of raised points no greater than 0.045-inches, to create a non-slip surface for wheelchair safety. Surface mounted detectable warning surface tiles shall have countersunk fastening holes and perimeter beveled edges.

Overall dimension of the detectable warning surface tiles shall be in accordance with this specification and the Contract Documents.

E. Color

Unless otherwise called out in the Contract Documents, the detectable warning surface tiles shall be “Brick Red”, Federal Color No. 31136, or Federal Color No. 11302, for applications on standard concrete curb ramps and “Light Gray”, Federal Color No. 26280 for applications on red brick paver or red brick concrete paver ramps, or as approved by Owner. The color shall be integral with the detectable warning device tiles and shall not be surface applied. Paints or other surface coatings shall not be used. Product samples with proposed color shall be submitted to Owner for approval prior to installation.

F. Fasteners

Fasteners shall be flat-head drive anchors made of a corrosion-resistant material ¼-inch in diameter x 1 3/4-inches long.

G. Adhesives

Adhesive shall be a urethane elastomeric adhesive material, as required by the manufacturer's specifications.

H. Sealants shall be a gray epoxy, two-component sealant, as required by the manufacturer's specifications.

5.25. FENCE

These specifications cover material requirements for fence components used in the construction of chain link, pedestrian, barbed wire, woven wire, and lawn fences and material specifications for temporary silt fences, geotextile fabric silt barriers, and filter barriers used for erosion and sediment control and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications* 242.

5.26. GEOSYNTHETICS

These specifications cover artificial fiber textile products to be used in transportation construction work, and low permeability liners for stormwater management facilities and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications* 245.

5.27. PAVERS

A. Concrete Pavers for Crosswalks and Sidewalks

1. Description

This section applies to concrete pavers used in sidewalks, crosswalks, driveways, roadways. This section also applies to concrete truncated dome pavers.

2. Pavers shall meet or exceed ASTM C936 specifications for Solid Concrete Interlocking Paving Units:

Average Compressive Strength (psi)	
Average of 5	8,000
Individual	7,000
Maximum Cold Water Absorption (%)	
5	5
Individual	7
Freeze/Thaw Resistance	
Resistant to 50 freeze/thaw cycles with no greater than 1% loss of material	
Freeze-thaw testing requirements shall be waived for applications not exposed to freezing conditions.	
Abrasion Resistance	
Maximum Volume Loss (%)	15 $cm^3/50cm^2$
Maximum Average Thickness Loss	3mm

a. Where 3 1/8-inch thick pavers are specified, their compressive strength test results per ASTM C 140 shall be adjusted by multiplying by 1.18 to equate the results to that from 2 3/8-inch thick pavers.

b. Detectable warning pavers shall meet the latest truncated dome requirements of the American Disabilities Act (ADA).

c. Color Pigments

(1) Color pigments for integrally colored concrete pavers shall meet or exceed ASTM C979 Standards. Products meeting this specification are concrete color pigments by the manufacturers indicated or approved equivalent if manufacturer is indicated. Integrally colored concrete pavers are defined as an acceptable color throughout the paver block as accepted by the Owner.

(2) Face-mix pavers are acceptable provided the pigment loading in the base mix is a minimum of 50% of the pigment loading in the face mix based on pigment loading being defined as 1 lb. pigment per 100 lbs. cement.

(3) The Owner shall approve the color.

d. Concrete pavers may have spacer bars on each unit. Verify with manufacturers that overall dimensions do not include spacer bars.

3. Bedding and Joint Sand

Bedding and joint sand shall conform to the following:

a. Washed, clean, non-plastic, free from deleterious or foreign matter, symmetrically shaped, natural or manufactured from crushed rock.

b. Where concrete pavers are subject to vehicular traffic, utilize sands that are as hard as practically available.

c. Bedding Sand Material Requirements

Bedding sand material shall conform to the grading requirements of ASTM C 33 with modifications as shown in Table 200-5.27.1.

TABLE 200-5.27.1
GRADING REQUIREMENTS FOR BEDDING SAND
FOR CONCRETE PAVERS
(ASTM C 33 MODIFIED)

Sand Sieve Size	% Passing
3/8 in.(9.5 mm)	100
No. 4 (4.75 mm)	95 to 100
No. 8 (2.36 mm)	85 to 100
No. 16 (1.18 mm)	50 to 85

No. 30 (0.600 mm)	25 to 60
No. 50 (0.300 mm)	10 to 30
No. 100 (0.150 mm)	2 to 10
No. 200 (0.075 mm)	0 to 1

(1) Mason sand or sand conforming to ASTM C 144 shall not be used for bedding sand.

(2) Limestone screenings or stone dust shall not be used for bedding sand.

d. Joint Sand Material Requirements

(1) Joint sand material shall conform to the grading requirements of ASTM C 144 as shown with modifications in Table 200-5.27.2 below:

TABLE 200-5.27.2
GRADING REQUIREMENTS FOR JOINT SAND
FOR CONCRETE PAVERS
(ASTM C 144 MODIFIED)

Sieve Size	ASTM C 144 Natural Sand % Passing	ASTM C 144 Manufactured Sand % Passing
No. 4 (4.75 mm)	100	100
No. 8 (2.36 mm)	95 to 100	95 to 100
No. 16 (1.18 mm)	70 to 100	70 to 100
No. 30 (0.600 mm)	40 to 75	40 to 100
No. 50 (0.300 mm)	10 to 35	20 to 40
No. 100 (0.150 mm)	2 to 15	10 to 25
No. 200 (0.075 mm)	0 to 1	0 to 10

(2) Coarser sand than that specified above may be used for joint sand including ASTM C 33 material as shown in Table 200-5.27.1. Use material where the largest sieve size easily enters the smallest joints. For example, if the smallest paver joints are 2 mm wide, use sand 2 mm and smaller in particle size. If ASTM C 33 sand is used for joint sand, extra effort may be required in sweeping material and compacting the pavers in order to completely fill the joints.

(3) Sieve according to ASTM C 136.

B. Clay Brick Pavers for Heavy Duty Traffic Loading Conditions

1. Description: This section applies to pavers used in crosswalks in roadways, higher traffic volume driveways, roadways and other applications where heavy vehicle loading or frequent vehicular traffic is anticipated. See Paragraph V.5.27.C for applications involving sidewalks, driveways and other applications where heavy or frequent vehicle loading is not anticipated.

2. Brick pavers shall conform to ASTM C 1272, Specification for Heavy Vehicular Paving Brick.

a. Durability

Paver Type	Type F (Pavers placed on sand base)	Type R (Pavers placed on asphalt or mortar base)
Average Compressive Strength (psi)		
Average of 5	8,000	10,000
Individual	7,000	8,800
Maximum Cold Water Absorption (%)		
Average of 5	6	6
Individual	7	7
Freeze/Thaw Resistance		
Resistant to 50 freeze/thaw cycles with no greater than 1% loss of material		
Freeze-thaw testing requirements shall be waived for applications not exposed to freezing conditions.		
Minimum Breaking Load (lb/in.)		
Average of 5	None	475
Individual	None	333
Abrasion Resistance		
Maximum Abrasion Index	.011	0.11
Maximum Volume Abrasion Loss	1.7 cm^3/cm^2	1.7 cm^3/cm^2

b. Dimensions

(1) Minimum Thickness: Brick pavers used in a heavy vehicular pavement shall have a minimum thickness of 2 5/8-inches. This thickness is exclusive of any chamfers.

(2) Dimensions: Pavers shall be commonly available sizes of pavers for flexible pavements. Length shall not be more than 4 times the thickness.

(3) Dimensional tolerances for pavers shall be 3/32-inch.

c. Brick pavers shall conform to Application PX as defined in ASTM C902.

C. Clay Brick Pavers for Pedestrian Areas and Light Duty Traffic Loading Conditions

1. Description: This section applies to pavers used in sidewalks, driveways and other applications where heavy or frequent vehicle loading is not anticipated. See Paragraph V.5.27.B for applications involving crosswalks in roadways, higher traffic volume driveways, roadways and other applications where heavy vehicle loading or frequent vehicular traffic is anticipated.

2. Brick pavers shall conform to ASTM C 902, Type SX.

a. Properties

Paver Type	Wire Cut	Molded

	Brick	Brick
Average Compressive Strength (psi)		
Average of 5	8,000	4,000
Individual	7,000	3,500
Maximum Cold Water Absorption (%)		
Average of 5	8	16
Individual	11	18
Freeze/Thaw Resistance		
Resistant to 50 freeze/thaw cycles with no greater than 1% loss of material		
Freeze-thaw testing requirements shall be waived for applications not exposed to freezing conditions.		
Maximum Saturation Coefficient		
Average of 5	0.78	0.78
Individual	0.80	0.80
Abrasion Resistance		
Maximum Abrasion Index	.011	0.11
Maximum Volume Abrasion Loss	1.7 cm^3/cm^2	1.7 cm^3/cm^2

b. Dimensions

(1) Minimum Thickness: Brick pavers used in a heavy vehicular pavement shall have a minimum thickness of 2 1/4-inches. This thickness is exclusive of any chamfers.

(2) Dimensions: Pavers shall be commonly available sizes of pavers for flexible pavements. Length shall not be more than 4 times the thickness.

(3) Dimensional tolerances for pavers shall be 3/32-inch.

c. Pavers shall conform to Application PX as defined in ASTM C902.

D. Setting Beds

1. Sand Setting Bed

a. Sand shall conform to ASTM C 33. Sand shall be washed, well-graded sand. The amount of material passing the 75 µm (No. 200) sieve shall be no more than 3 %. The sand particles shall be sub-angular. Only naturally occurring, washed silica sand with no silt content shall be used.

b. Mason's sand, limestone screenings, or stone dust shall not be used.

c. Cement shall not be added to the sand.

2. Sand /Cement Setting Bed

a. Sand shall conform to ASTM C 33. Sand shall be a washed, well-graded sand. The amount of material passing the 75 µm (No. 200) sieve shall be no more than 3 %. The sand particles shall be sub-angular. Only naturally occurring, washed silica sand with no silt content shall be used.

b. Mason's sand, limestone screenings, or stone dust shall not be used.

c. Sand/cement mixture shall be 3 parts sand, 1 part cement. Submit each sample for approval.

3. Mortar Setting Bed

a. Mortar shall be nonshrink.

b. Mortar shall conform to Paragraph 5.6.F.2.

4. Bituminous Setting Bed

a. Tack coat shall be SS-1 or SS-1h asphalt emulsion complying with ASTM D 977 Specification for Emulsified Asphalt.

b. The asphalt cement for the bituminous setting bed shall be the same grade as that specified for the adjacent surface course construction. The type of asphalt cement will govern the mixing and rolling temperatures. The fine aggregate for the bituminous setting bed shall be natural or manufactured sand that complies with ASTM D 1073 Specification for fine Aggregate for Asphaltic Paving Mixtures, grading No. 2, or similar material used as fine aggregate at the asphalt plant. All particles shall pass the No. 4 sieve.

c. The proportions shall be 6-8% of asphalt cement with 94-92% of fine aggregate or approximately 1 gallon of asphalt cement to 110 lbs of fine aggregate. The exact proportions shall be verified before supplying material for the project.

d. The adhesive shall be a neoprene modified asphalt product specifically developed for setting pavers. It shall consist of rubberized asphalt with inorganic fibers.

E. Jointing Sand

1. Sand Setting Bed Applications

a. Heavy Duty Traffic Loading Conditions: The sand particles shall be sub-angular. Bedding sand conforming to ASTM C 33 shall be used.

b. Pedestrian Areas and Light Duty Traffic Loading Conditions: The sand particles shall be sub-angular. Bedding sand conforming to ASTM C 33 or Mason Sand conforming to ASTM C 144 shall be used.

2. Bituminous Setting Bed Applications: Stabilized joint sand shall be provided. Stabilizers shall conform to the brick paver manufacturer's recommendations. The stabilizers shall bind the sand in the top 1/2 inch of the joint.

F. Surface Coatings

1. Colorless coatings (i.e. water repellents) shall not be used.

2. Coatings that prevent erosion of the jointing sand shall be of a type that has a high vapor transmission rate and will not affect the slip/skid resistance of the paver. The stabilizer shall be water based.

G. Miscellaneous

1. Edge Restraints shall conform to the type specified in the Contract Documents or Special Provisions. Manufactured edge restraints (other than cast-in-place concrete) shall be certified by the manufacturer to be appropriate for the type of application.

2. Mortar shall conform to ANSI 118.3

3. Grout

a. Grout shall conform to ANSI 118.3.

b. Grout colors shall be approved by the Owner from the manufacturer's complete color range.

c. Grout products shall be approved the by paver manufacturer.

4. Water that has been approved for drinking purposes is acceptable provided it is free from minerals or other materials that are detrimental to mortar and grout mixes.

5. Primer shall be as recommended by the mortar material manufacturer.

6. Sealant and backing materials shall conform to ASTM C 920.

7. Mixes - Prepare pre-mix materials in accordance with manufacturer's written instructions.

8. Geotextiles shall conform to Paragraph V.5.26, Geosynthetics. Geotextile fabric materials shall also be certified by the paver manufacturer to be appropriate for the type of application.

9. Cleaners, sealers, and joint sand stabilizers shall be certified by the paver manufacturer to be appropriate for the type of application.

5.28. GUARDRAIL

These specifications cover material requirements for components of guardrail systems and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 221.

5.29. MASONRY UNITS

These specifications cover masonry units manufactured of regular or lightweight concrete or brick made from clay or shale in a plant specifically designed for such a purpose and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 222.

5.30. STRUCTURAL STEEL

These specifications cover steel structural shapes furnished to specific dimensions and associated hardware and fasteners and shall meet the requirements of the latest edition of the *VDOT Road and Bridge*

Specifications, Section 226.

5.31. ALUMINUM ALLOY

These specifications cover aluminum alloy products designed in shapes and compositions to serve a specific purpose, such as a sign panel, post, or conduit, including necessary fasteners and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 229.

5.32. ROADWAY CONSTRUCTION PAINT

These specifications cover a mixture of pigment in a liquid vehicle that, when applied, will dry to an opaque solid film. Use of paint in these specifications refers to the requirements for highway construction and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 231. Paint materials not specified herein shall be as specified by the manufacturer and recommended specifically for or compatible with the intended application

5.33. GLASS BEADS FOR REFLECTORIZING TRAFFIC MARKINGS

This specification covers glass beads applied on the surface or incorporated into traffic-marking materials so as to produce a retroreflective surface and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 234.

5.34. RETROREFLECTORS

This specification includes retroreflectors for delineators and pavement markers and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 235.

5.35. WOOD PRODUCTS

These specifications cover the uses and requirements for roadway-related structural timber and lumber, miscellaneous wood products, and preservative treatments for such wood products where specified and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 236.Intended uses include fence post, guardrail post, signs and signalization applications.

5.36. ELECTRICAL AND SIGNAL COMPONENTS

These specifications cover roadway-related conduits, conductors, junction boxes, traffic signal components, and necessary fittings to complete a described electrical or traffic signal system and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications*, Section 238.

5.37. LIME

These specifications cover lime to be used as a stabilizer or soil conditioner and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications* 240.

5.38. PAVEMENT MARKING

These specifications cover material for use in various retroreflective pavement-marking applications and shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications* 246.

5.39. REFLECTIVE SHEETING

This specification covers reflective sheeting used on traffic control devices to provide a retroreflective

surface or shall meet the requirements of the latest edition of the *VDOT Road and Bridge Specifications* 247. The color of the reflective sheeting shall be as specified in the Contract Documents.

End of Section