TECHNICAL SPECIFICATIONS

FOR

3628 WINPLACE RD. LIFT STATION
4417 RALEIGH LAGRANGE RD. LIFT STATION
5081 HILLBROOK RD. LIFT STATION
5184 PLEASANT VIEW RD. LIFT STATION
9612 GROVE RD. LIFT STATION

ISSUED FOR BID SUBMITTAL

MAY 2022

City of Memphis, Tennessee

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Black and Veatch
SARP10 and City of Memphis
Issued For Bid Specifications

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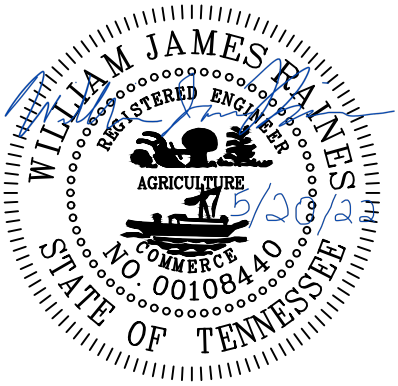
CITY OF MEMPHIS
SEWER ASSESSMENT AND REHABILITATION PROGRAM (SARP10)

CERTIFICATION AND SEAL

I hereby certify that the Contract Documents and Specifications for the following contract were prepared by me or under my direct supervision, and I am a duly registered engineer under the laws of the state in which these projects are located:

LIFT STATION DESIGN GROUP 3 C PROJECT
CONTRACT NO. 409278.61.0127



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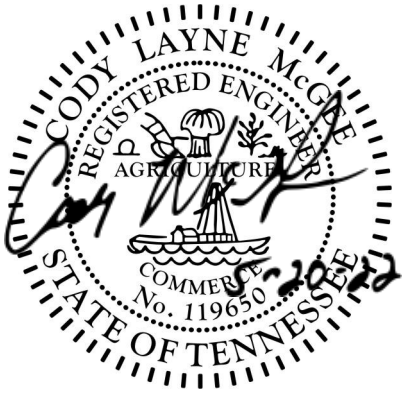
11000, 11310, 11347



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SECTION 01501
SPECIAL CONDITIONS

PART 1 GENERAL

1.01 SUBMITTALS

A. Site Contractor emergency phone numbers.

B. Schedules of work on a weekly basis that will be delivered no later than 2:00 PM on Thursday for the week following, and daily AM email updates of approximate crew locations each day.

1. Weekly schedule format shall contain the following elements:

a. Map format.

b. Sufficient streets labeled and identified at a scale to provide clarity.

c. Nature and type of crew location by map area.

2. Contractor shall fax smoke test locations to local Memphis Fire Department station by 7:00 AM on each day of smoke testing.

1.02 MEETINGS

A. The Program Team will arrange bi-weekly meetings (every other week) with the Subcontractor to discuss data management and field issues.

1.03 WASTE DISPOSAL

A. All debris removed from sanitary sewer lines shall be disposed of in a lawful manner at a landfill. The Subcontractor shall not dispose of debris at a City of Memphis Wastewater Treatment Plant. The entity responsible for disposing of the debris must have a permit for disposal at the landfill. The Program Manager will hire a consultant to facilitate the acquisition of the landfill disposal permit including taking samples of debris, laboratory analysis, and completion of the permit paperwork. The Subcontractor shall provide a full truckload of debris from which the sample will be pulled and will work with the Program Manager's consultant to acquire the permit. The Subcontractor shall be responsible for providing a location and legal means of storage for the truckload of debris to be stored until the analytical results are processed.

1.04 ACCESS ROADS

A. For interceptor assessment, the Program Manager will construct access roads in accordance with the dates specified on the maps. Road building will not be covered by this contract.

1.05 ELEVATED MANHOLE ACCESS

A. The Subcontractor will be paid a one-time payment to access each elevated manhole 4-feet or greater above grade. This item includes all equipment and labor necessary to access the manhole for both manhole and pipe inspection. Additional payment will not be made for multiple setups at one manhole.

1.06 SUCTION LIFT STATION PUMPING SYSTEM

A. The Owner considers Gorman Rupp as a candidate manufacturer capable of producing pumping equipment and/or products satisfying the requirements of the Project. The Gorman Rupp product may require modification to conform to the Project requirements. Any design aspects or modifications required for the Gorman Rupp pumping system as part of the Project will be the sole responsibility of the Contractor. Contractor's final design will be reviewed by Owner's Engineer for approval during the shop drawing process. Structural or Electrical modifications will require the seal of a licensed engineer in the State of Tennessee.
B. Measurement and payment for the Gorman Rupp equipment and/or product will be held under item number 11310-2.02.A. Contractor shall provide bid for Gorman Rupp pumping system under item number 11310-2.02.A within Bid Tab.

PART 2 PRODUCTS

2.01 This part not used.

PART 3 EXECUTION

3.01 This part not used.

PART 4 MEASUREMENT & PAYMENT

4.01 MEASUREMENT

A. Elevated Manhole Access

1. Elevated manhole access shall be measured per each manhole 4-foot or greater above grade.

4.02 PAYMENT

A. Elevated Manhole Access

1. Elevated manhole access shall be paid per each manhole 4-foot or greater above grade. Additional payment will not be made for multiple setups at one manhole.

4.03 PAYMENT WILL BE MADE UNDER

Item No.	Pay Item	Pay Unit
01501-4.02.A	ELEVATED MANHOLE ACCESS	EACH

END OF SECTION 01501

SECTION 01610
BASIC PRODUCT REQUIREMENTS

PART 1 GENERAL

1.01 SCOPE

A. All materials and permanently installed equipment (for example, traffic signalization equipment, sewer pumps, and other such items) furnished by the Subcontractor for the Work shall conform to the requirements of the Plans and Contract Documents, including the applicable City of Memphis Standard Construction Specifications and Design Standards.

B. Throughout the entire Project, all units of any one item of installed equipment shall be of the same manufacture and model unless otherwise approved by the Purchaser.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Equivalent Materials and Equipment

1. The General Conditions allows for the substitution of equivalent materials and equipment, with the written approval of the Purchaser.

2. Reference to a particular product by manufacturer, trade name, or catalog number establishes the quality standards of materials and equipment required for the Work. It is not intended to exclude products equivalent in quality and similar in design. Whenever any article, material, or equipment is identified by using the name of a manufacturer or vendor, the term “or approved equal” if not inserted shall be implied.

3. If the Subcontractor proposes to furnish materials or supplies other than those specified, he shall furnish complete descriptive data, including performance capabilities, specifications, and other data as required in the Contract General Conditions. The provisions of this substitution of materials shall not relieve the Subcontractor of the responsibility of meeting the requirements of the Plans and Contract Documents. All materials must be approved by the Purchaser before any installation will be permitted.

B. List of Major Materials an Equipment

1. The Subcontractor shall submit to the Purchaser for approval, with due promptness after award of Contract but in no case later than at the preconstruction conference, a list of major equipment and materials which he proposes to provide. The list shall include in sufficient detail to identify the materials, the name of the manufacturer’s model number of all material that is identified on the Plans or in the Contract Documents, including catalog literature for standard equipment and detailed scale drawings of any nonstandard or special equipment and of any proposed deviation from the Plans. A signed statement shall accompany this list stating that materials and equipment are in exact accordance with Project specifications. No charge shall be made to the Purchaser for any materials or equipment purchased, labor performed, or delay to the Work prior to approval of materials by the Purchaser.

C. Source of Supply

1. The source of supply for each material to be supplied by the Subcontractor shall be subject to approval by the Purchaser before delivery is started.

PART 3 EXECUTION

A. Samples and Testing

1. Representative samples of materials included for incorporation in the Work shall be submitted to the Purchaser for his examination and/or testing when so specified or requested.

2. All testing of materials shall be made in accordance with the standard methods of testing of the ASTM, AASHTO, NEMA, ITE, or other applicable standard specifications.

PART 4 MEASUREMENT AND PAYMENT

4.01 PROPOSAL QUANTITIES

A. The quantities appearing in the Proposal Sheet(s) of the Proposal are approximate and are proposed and shown for the comparison of bids and award of a Contract. The Purchaser does not guarantee or assume any responsibility that the quantities indicated on the Plans or in the Proposal will hold true and accurate in the construction of the Project. The Subcontractor shall not plead deception or misunderstanding because of variation from these quantities. Unless otherwise provided in the Contract Documents, payment to the Subcontractor will be made only for the actual quantities of Work performed and accepted, and materials and equipment furnished and placed in accordance with the Contract.

4.02 MEASUREMENT OF QUANTITIES

A. All Work completed under the Contract will be measured by the Purchaser according to United States standard measure.

B. The term “ton” will mean the short ton consisting of 2,000 pounds.

C. The determination of quantities for specific items will be made as set for the in the subsection titled “Measurement” under the applicable Sections of the Standard Construction and Material

D. Specifications hereof, or of other Specifications provided for the Work.

E. Longitudinal and transverse measurements for surface area computations will be to the exact dimensions shown in the horizontal plane on the Plans or as ordered in writing by the Purchaser.

F. Structures will be measured according to the lines and exact dimensions shown on the Plans or as altered to fit field conditions by direction to the Purchaser.

G. In all cases where measurement of materials is based on certified weights, the Subcontractor shall furnish the Purchaser certified weigh bills showing the net weight of materials received in each shipment. In no instance will the Purchaser pay for materials in excess of the amounts represented by the certified weigh bills.

H. When certified scale weights are not used for measurement, all materials which are measured or proportioned by weight shall be weighed on accurate, approved scales, by competent, qualified personnel, at locations designated by the Purchaser.

I. Trucks used to haul material being paid for by weight shall be weighed empty at such times as the Purchaser directs, and each truck shall bear a plainly legible identification mark.

J. Measurements for payment will be made to the nearest fractional units specified below, unless otherwise specified herein or in the Contract Documents for the project.

Unit of Measurement	Nearest Unit
Linear Foot	0.1 LF
Square Foot	0.1 SF
Square Yard	0.1 SY
Ton	0.1 Ton
Cubic Yard	0.01CY
1,000 SF Unit	0.1 Unit

END OF SECTION 01610

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SECTION 02530
SEWER PIPE INSTALLATION

PART 1 GENERAL

1.01 SCOPE

A. This Work shall consist of the removal of sanitary sewers, siphons, service connections, and/or the removal and replacement of existing sanitary sewers and service connections of the kinds and dimensions shown on the Drawings, stipulated in the Contract Documents, or as directed by the Purchaser. The construction shall be accomplished by these Specifications and in conformity with the lines, grades, and details shown on the Drawings or established by the Purchaser. The Subcontractor shall perform all work necessary to complete the Contract with the best modern practice. Without specifications that state the quality of any work, the Subcontractor is required to perform such items using first-quality construction. Unless otherwise provided, the Subcontractor shall furnish all material, equipment, tools, labor and incidentals necessary to complete the Work.

PART 2 PRODUCTS

2.01 MATERIALS

A. Construction Material

1. All material furnished by the Subcontractor shall be new, high quality and free from defects. Previously used material in acceptable condition may be used for bracing, forms, false work, and similar uses. Material not conforming to the requirements of the Specifications shall be considered defective and will be removed immediately from the site.

B. Higher Strength Pipe

1. The Subcontractor may substitute a higher strength pipe of the same type as that specified subject to the approval of the Purchaser.

C. Qualifications of Manufacturers

1. Pipe for sanitary sewers shall be the standard product of an established, reputable manufacturer made in a permanent plant. Suppliers for each material to be used by the Subcontractor shall be subject to approval by the Purchaser. No material shall be delivered until the manufacturer and product have been approved by the Purchaser. For any construction project, pipe and appurtenances for each pipe material shall be the product of a single manufacturer having a minimum of 10 years domestic experience producing the type of pipe supplied.

D. Material Inspection and Testing

1. Representative samples of material intended for incorporation in the work shall be submitted for examination when so specified or requested. All material to be used in the work shall be sampled, inspected, and tested by current ASTM specifications, or other standard specifications approved by the Purchaser. The Subcontractor shall furnish the Purchaser with three copies of certified reports from a reputable testing laboratory showing the results of the tests carried out on representative samples of material to be used on the Project. Each length of pipe delivered to the project shall show the laboratory's stamp. The performance or cost of all testing is the responsibility of the Subcontractor.

2. The Subcontractor shall notify the Purchaser before any deliveries of material and shall make whatever provisions are necessary to aid the Purchaser in the inspection and culling of the material before installation.

E. Storage

1. The Subcontractor shall provide and maintain storage facilities and exercise such measures to maintain the specified quality and fitness of material to be incorporated in the work. The interior and sealing surfaces of the pipe, fittings, and adapters shall be kept free from dirt and foreign matter. PVC pipe, fittings, and adapters stored outside and exposed to sunlight shall be covered with an opaque material with proper ventilation. All precautions taken to ensure safe storage of materials shall be the responsibility of the Subcontractor.

F. Polyvinyl Chloride (PVC) Gravity Pipe and Fittings (Small Diameter)

1. All PVC pipe and fittings specified herein are small diameter with solvent cemented joints.

2. All PVC pipe and fittings shall be made from high impact, rigid poly (vinyl chloride) compounds. Pipe and fittings shall be marked indicating size, type and schedule, ASTM Designation, manufacturer or trademark, and shall bear the NSF (National Sanitation Foundation) seal of approval.

3. PVC pipe and fittings shall be Schedule 40 or 80, unless otherwise specified, ASTM D1785 12454-B or ASTM D2665 Class 12454-B, with socket ends.

4. Schedule 40 socket-type fittings shall comply with ASTM D2466 with dimensions in accordance with ASTM D3311.

5. Joint cement for PVC pipe and fittings shall comply with ASTM D2564. Cement shall be heavy bodied, medium setting, and 100 percent solvent and PVC resin. Cement shall be IPS 711 Weld-On or approved equal. Primer shall be staining solvent conforming to ASTM F656 and manufactured by cement manufacturer.

G. Ductile Iron

1. All pipe system materials to be new, free from defects and conforming to ANSI/AWWA C151/A21.51 requirements and standards. Pipe thickness design shall conform to ANSI/AWWA C150/A21.50. If thickness class is not specified on the Drawings or Contract Documents, Pressure Class 350 or approved equivalent shall be used. Testing of pipe shall be in conformance with AWWA C600. Minimum wall thickness required for corporation stops and tapped outlets shall be in accordance with ANSI/AWWA C151/A21.51.

2. Flanges:

a. Mating flanges for pipe shall be of the same Standard, Class, and Series. Mating flanges at valves and equipment shall have specified rating and matching drilling pattern.

b. Flanges shall be in accordance with AWWA C115 for pipe and AWWA C110 for fittings with dimensions per ANSI/ASME B16.1-Class 125. Flanges shall have a rating of 350 psi.

c. Ductile iron backing ring flanges with the flange thicknesses specified in the table below.

Flange Size, in	Flange Thickness, minimum, in.
3	1/2

4	9/16
6 thru 10	5/8

3. Stub Ends:

   a. Wall thickness equal to or greater than pipe or fitting to which it is welded.

   b. Lap face/gasket mating surfaces clean, free of debris, with welds ground flush and surface roughness between 3.18 and 12.7 microns RMS.

4. Fittings.

   a. Restrained push-on, mechanical joint, and flanged fittings shall be ductile iron for use with ductile iron pipe as specified herein.

   b. Cast ductile iron fittings 3-inch through 24-inch shall be pressure rated at 350 psi (except flange-joint fittings shall be rated at 250 psi).

   c. Flanged fittings shall conform to ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53. Mechanical joint and push-on joint fittings shall conform to ANSI/AWWA C111/A21.11.

   d. The weight of fittings shall be as given in ANSI/AWWA C110/A21.10 and C153/A21.53.

5. Pipe Lining.

   a. Ceramic Epoxy
      i. Factory applied.
      ii. Line pipe and fittings with amine cured novolac epoxy containing at least 20 percent ceramic quartz pigment.
      iii. 40 mils minimum thickness.
      iv. Candidate Manufacturers
         (1) Protecto 401
         (2) Approved Equal

H. Pipe Coating.

   a. Asphaltic Coating for Buried Pipe:
      i. Factory applied.
      ii. Coat pipe and fittings with 1 mil DFT, minimum, of asphaltic material as specified in ANSI/AWWA C151/A21.15.

   b. Epoxy Primer:
      i. Factory or shop applied.
      ii. Coat pipe and fittings with Amide or Polyamide cured epoxy; 4 to 6 mils DFT.

   c. Epoxy Coating with Polyurethane Top-Coat for Non-Buried Pipe:
      i. Field applied in accordance with ANSI/AWWA C151/A21.15.
      ii. Clean, dry, and remove all existing paint and black coating, and sandblast with non-silica media for surface preparation in accordance with NAPF 500-3 standard.

I. Fusion-Bonded Epoxy Lining and Coating for Fittings.

   a. Factory or shop applied.

b. Fusion Bonded Epoxy lining and coating per ANSI/AWWA C116/A21.16.

J. Ductile Iron Joints and Couplings.

1. Flanged Joint:

a. Flanged ductile iron pipe shall be manufactured and conform to the requirements specified in ANSI/AWWA C151/A21.51, with provisions contained herein and shall be furnished with ANSI/ASME B16.1-Class 125 flanges, plain faced and drilled. Hollow back flanged are not acceptable. Flanges shall be ductile iron, class 70-50-5 in accordance with ANSI/AWWA C110/A21.10.
b. All joint materials for flanged pipe and fittings shall be supplied with all pipe or fittings ordered.

2. Mechanical Joint (MJ):

a. Mechanical joints shall conform to ANSI/AWWA C110/A21.10 and ANSI/AWWA C111/A21.11.

3. Restrained Mechanical Joint (RMJ):

a. Restrained by tie-rods/bolts tying the gasket gland to a second retainer/follower gland behind a welded ring on the spigot end of the joint. Fully restrained mechanical joints for above or below ground service conforming to ANSI/AWWA C110/A21.10 and ANSI/AWWA C111/A21.11.

b. Candidate manufacturers:
i. American Cast Iron Pipe Company, Mechanical Joint Coupled Joint
ii. U.S. Pipe, MJ HARNESS-LOK
iii. Approved Equal

c. Restrained joints with gripping wedges, or gripping gaskets, radial pads, or other devices that penetrate, grip, or embed in the pipe material to resist axial thrust loads may be allowed where specifically noted on the Drawings and/or as approved by the Engineer. Restrained joints 4 through 16-inch shall be rated for a pressure of 350 psi.

d. Candidate manufacturers:
i. EBAA Iron Sales, Inc., Megalug Series 1100
ii. Sigma One-Lok
iii. Ford, Uni-Flange Series 1400

4. Push-On (PO) Joint (Unrestrained).

a. Rubber ring compression gasket, push-on type joints conforming to AWWA C111.

b. 5-degree deflection at rated operating pressure for joints on 4-inch through 30-inch pipe.

c. Candidate manufacturers:
i. American Cast Iron Pipe Company Fastite
ii. U.S. Pipe Tyton Joint
iii. Approved Equal

5. Restrained Push-On (RPO) Joint:

a. Restrained, rubber ring compression gasket, push-on joints conforming to AWWA C111.

b. Restrained by the interference of metallic rings, bolts, locking segments or other interlocking components with flanges, lugs, beads, grooves or retainer rings that are integrally cast into or welded onto both ends of the joint. ADD 1, ITEM 20 and 21

c. Candidate manufacturers:
   i. American Cast Iron Pipe Company, Flex-Ring or Lok-Ring
   ii. U.S. Pipe, TR Flex or HP LOK
   iii. Approved Equal

6. Sleeve/Transition Coupling:

   a. When connecting new ductile iron piping to existing piping, field verify outside diameters of existing pipe prior to connection. See drawings for location and installation requirements.

   b. Candidate Manufacturers.
      i. Romac, "501"
      ii. JCM, "212"
      iii. Smith-Blair, "461"
      iv. Approved Equal

7. Bolts and Nuts:

   a. Bolts and nuts metallurgy as specified in ANSI/AWWA C111/A21.11.

   b. Unless otherwise specified, bolts shall be carbon steel machined bolts with hot pressed hexagon nuts.
   c. Flange assembly bolts shall be ANSI B18.2.1 standard square or hexagon head bolts with ANSI B18.2.2 standard hexagon nuts. Threads shall be ANSI B1.1, standard coarse thread series; bolts shall be Class 2A, nuts shall be Class 2B. bolt length shall conform to ANSI B16.5.
   d. Bolts and nuts for buried service shall be made of non-corrosive, high-strength- low-alloy steel having the characteristics specified in ASNI/AWWA C111/A21.11, regardless of any other protective coating. Where washers are required, they shall be of the same material as the associated bolts.
   e. Bolts and nuts for submerged service shall be made of Type 316 stainless steel in conformance with ASTM A193 Grade B8M and A194 Grade 8M.

8. Gaskets:

   a. Gaskets shall be provided in conformance with ANSI/AWWA C111/A21.11. Gasket material shall be Nitrile (Buna-N) or Neoprene (black) 70 durometer.

   b. Follower gaskets shall be of the compression wedge type. Gasket material shall be Nitrile (Buna-N) or Neoprene (black) 70 durometer.

   c. Gaskets for plain faced flanges shall be of the full-face type. Thickness shall be 1/16-inch for pipe 10-inches and smaller in diameter.

K. Adapters and Couplings:

1. At the direction of the Purchaser, a connection of sanitary sewer pipes, 8 inches through 16 inches, of dissimilar material, different sizes or for the repair of sanitary sewer pipes of similar material may be made by means of an approved compression or mechanical connector or adapter. The gaskets for compression connectors or adapters shall be

manufactured of an approved preformed elastomeric material conforming to applicable sections of ASTM Standards C 143, C 425, C 564, and D 3212. Mechanical couplings or adapters shall have tightening clamps or devices made of 300 series stainless steel with a stainless steel shear ring and stainless steel hardware, as specified in ASTM A 167. If a stainless steel shear band is not used, a concrete collar shall be required. Each connector and adapter shall bear the manufacturer's name and required markings. Installation shall be by the manufacturer's recommendations.

2. At the direction of the Purchaser, a connection of sanitary sewer pipes (18 inches in diameter and larger) of dissimilar material, different sizes or for the repair of sanitary sewer pipes of similar material may be made in accordance with this Specification. Mechanical connectors meeting the above requirements may be used at the direction of the Purchaser.

L. Plug Valves:

1. Plug valve shall be of the non-lubricated eccentric type, with resilient faced plugs, and shall be designed for a minimum cold working pressure (CWP) of 175 psi at a temperature of 125-degrees Fahrenheit for valves 3-inch through 12-inch. Plug valves to be designed in accordance with AWWA C517.

2. Plug valves shall have flanged end connections drilled and tapped to ANSI B16.1-Class 125 standard.

3. Plug valves shall be solid one-piece, standard port, providing a minimum port area of 100% of the adjacent pipe for valves 4-inches and less. Provide 80 to 85% port area of adjacent pipe for valves 6 to 24-inches. Ports shall be rectangular.

4. Plug valve body shall be Cast Iron conforming to the requirements of ASTM A126 Class B. All nuts, bolts, springs, washers, and similar component items exposed to the operating fluid shall be AISI Type 316 stainless steel.

5. Plugs shall be cast iron conforming to the requirements of ASTM A126 Class B or Ductile Iron ASTM A536 Grade 65-45-12.

6. Plug valves shall be furnished with a corrosion-resistant seat consisting of welded-in overlay of high nickel content on all surfaces contacting the plug face and shall comply with ANSI/AWWA C507.

7. Plug valves shall be furnished with replaceable, sleeve-type, permanently lubricated AISI Type 316 stainless steel bearings in the upper and lower journals and shall comply with ANSI/AWWA C507.

8. Plug valves to be furnished with multiple V-ring type adjustable packing of Buna V-Flex with a packing gland follower, designed for adjustment or complete replacement of packing without disturbing any part of the valve or actuator assembly.

9. Plug valves shall be furnished with a grit excluder constructed of PTFE or Buna-N.

10. Plug valves shall be installed with the shaft in the vertical position and valve seat located upstream.

11. Plug valves shall have stops at the fully-opened and fully-closed positions.

12. Plug valves shall be furnished with lever or handwheel operators conforming to the corresponding AWWA or MSS SP standard. Provide lever for valves 6-inches and smaller. Totally enclosed worm gears to be provided for valves larger than 6-inches.

13. Buried valves shall be provided with a AWWA 2-inch square nut. Buried valves to be installed within a valve box and cover as shown on the Drawings.

14. Exterior surfaces of exposed valves shall be factory coated. Buried valves shall be field coated with a petrolatum-based mastic or wax based wrapping tape applied with the coating system manufacturer's recommendations. Tape shall be spirally wrapped with a 55 percent overlap and sufficient tension and pressure to provide continuous adhesion without stretching the tape. Smooth contours shall have a minimum thickness of 50 mils while nuts, bolts, and sharp projections shall be 100 mils. Number and types of tape wraps shall be in accordance with the coating system manufacturer's written instructions.

15. Plug valves shall be manufactured by DeZurik, Pratt, Valmatic, or approved equal.

M. Check Valves:

1. Check valves shall be of the swing check, lever & spring type, designed for a minimum cold working pressure (CWP) of 250 psi at a temperature of 100-degrees Fahrenheit for valves 2-inch through 12-inch.

2. Check valves shall have flanged end connections drilled and tapped to ANSI B16.1-Class 125 standard.

3. Check valve body shall be Cast Iron or Ductile Iron conforming to the requirements of ASTM 126 Class B and ASTM A536 Grade 65-45-12, respectively. All nuts, bolts, springs, washers, and similar component items exposed to the operating fluid shall be AISI Type 316 stainless steel. Valve body shall permit mounting external lever and springs on either side of the valve.

4. Check valve shall be furnished with a clear opening size equal to or greater than the connecting pipe.

5. Check valve disc and disc arm shall be Ductile Iron conforming to the requirements of ASTM A536 Grade 65-45-12. Valve shall include pivot arm secured to disc with twin bolted connections or a pinned nut. Disc and lever arm shall be keyed to the shaft and retained by bushings or pins.

6. Check valve body seat shall be Type 316 stainless steel per ASTM A276 with an O-ring seal and locked into place with stainless steel screws.

7. Check valve hinge pin and shaft shall be Type 316 stainless steel and provided with a stuffing box and packing or O-ring seal at each penetration through the valve body.

8. Check valve closure control shall be lever arm and spring type with adjustable spring tension, capable of closing within 0.05 seconds of pump stoppage with fluid moving at 8 feet per second.

9. Check valves shall be factory epoxy lined and coated at 12 mil DFT.

10. Check valves shall be manufactured by DeZurik APCO Series 6000, Golden Anderson Series 340-S, or approved equal.

N. Crushed Limestone

1. Crushed limestone shall be size No. 67 Coarse Aggregate meeting the requirements of the Tennessee DOT Standard Specifications for Road and Bridge Construction and the following gradation:

Total Percent by Dry Weight
Passing Each Sieve (U.S. Standard)

Size No.	1"	3/4"	3/8"	No. 4	No. 8
67	100	90-100	20-55	0-10	0-5

O. Pit Run Gravel

1. Pit run gravel shall consist of one of the three gradations shown in the table below.

Total Percent by Dry Weight
Passing Each Sieve (U.S. Standard)

Size No.	2½"	2"	1½"	1"	3/8"	No.40	Clay *
1	100	95-100			35-65	10-30	1-12
2		100	95-100		40-65	10-30	1-12
3			100	90-100	45-65	10-35	2-12

*Clay content shall be determined by the Hydrometer Test - AASHTO T 88. Clay content up to 15 percent may be used with the approval of the Purchaser.

2. The portion passing the No. 40 sieve shall be known as the binder. The binder aggregate shall consist of hard durable particles of limestone or sound siliceous material. Shale aggregate or pipe clay binder shall not be acceptable. The percent of silt shall not exceed the percent of clay by more than 25 percent. If the binder material is insufficient to bond the aggregate a satisfactory binding material may be incorporated, as approved by the Purchaser, so that the resultant mixture shall comply with these Specifications. The mixing shall be done uniformly, and blending of material on stockpiles or in the pits by bulldozers, clamshells, draglines, or similar equipment shall not be permitted.

P. Non-Shrinking Grout

1. Grout shall be mixed in small quantities as needed and shall not be re-tempered or used after it has begun to set. Unless otherwise specified, the grout shall consist of one part Portland cement, two parts masonry sand by volume, a non-shrinking, nonmetallic admixture and sufficient water to form a grout of proper consistency. When non-shrinking or non-shrinking fast setting grout is specified it shall be formulated by the incorporation of an admixture, or a premixed grout may be used.

2.02 EQUIPMENT

A. The Subcontractor shall furnish and maintain in good condition all equipment and facilities as required for the proper execution and inspection of the Work. All equipment and facilities shall be on site and approved by the Purchaser before work will be permitted to begin.

PART 3 EXECUTION

3.01 SITE PREPARATION AND RESTORATION

A. Rights-of-Way and Easements

1. This Work shall include removing and replacing existing sanitary sewers in existing rights-of-way. To the degree that the existing sewer drawings can be provided, the existing rights-of-way and/or easements as shown on the existing City Drawings and/or rights-of-way/easement plats shall be provided by the City to the Subcontractor for construction of sanitary sewer facilities. The Subcontractor shall confine his construction activities to these areas. The Subcontractor shall be responsible for obtaining written agreements for use of private property outside City acquired rights-of-way/easements for such purposes as storage of material and equipment and access to the construction site. The Subcontractor shall immediately provide a copy of all such written agreements to the City and Purchaser upon obtaining the same.

B. Clearing of Rights-of-Way and Easements

1. The Subcontractor shall confine his clearing of rights-of-way and easements to the least area necessary for construction of facilities shown on the Drawings. The Subcontractor shall protect as many trees and shrubs within the area as possible. Where necessary for construction, the Subcontractor shall clear all live and dead vegetation and growth, pole stubs, logs, and other objectionable material. Cleared material shall be removed to within 3 inches of existing ground. This work shall be done well before excavation operations but only after erosion controls have been placed.

C. Location of Existing Obstructions

1. Locations of obstructions shown on the Drawings are approximate and are not intended as an accurate location of such obstructions. Obstructions not shown on the Drawings but encountered by the Subcontractor shall be removed and replaced in their original state or protected by the Subcontractor at no additional cost to the Purchaser.

D. Removal of Obstructions

1. The Subcontractor shall demolish and remove all structures and structure foundations, abandoned vehicles, appliances, and rubbish within the right-of-way/easement limits necessary for the performance of the work.

E. Protection of Obstructions Outside Easement Limits

1. The Subcontractor shall protect and avoid damage to all trees, shrubs, plants, fences, structures, and all other objects outside the right-of-way/easement limits shown on the Drawings and/or Plats due to construction operations. All damage shall be repaired or restored at the Subcontractor's expense. Particular attention shall be paid to avoid damage to trees, shrubs, bushes, and private property located next to rights-of-way/ easements. No trees, plants, or other objects may be removed outside such limits without written permission of the property owner.

F. Special Protection of Obstructions Inside Easement Limits

1. Wherever the underground installation of sanitary sewer facilities will go through surface improvements previously made by the City, other governmental bodies, or property owners, the Subcontractor shall be responsible for their protection and preservation. This responsibility includes the removal and storage of such improvements to allow replacement and restoration as close as possible to the undisturbed condition.

G. Disposal of Debris

1. All trees, brush, logs, snags, leaves, sawdust, bark, and refuse shall be collected and disposed of according to the City Code of Ordinances at the expense of the Subcontractor. There will be no separate pay item for disposal of debris. Debris shall be removed from the site when practical and shall not be left until the completion of the contract. Burning of debris shall not be allowed. When material is to be disposed of outside the easement, the Subcontractor shall first obtain written permission from the property owner on whose property the disposal is to be made and shall file a copy with the Purchaser. Unless otherwise provided in the Contract Documents, the Subcontractor shall arrange for disposing of such material outside the right-of-way/easement. No debris shall be deposited in wetlands.

H. Replacement of Fences

1. Any fences disturbed inside the right-of-way/easement limits shall be replaced or restored to their original or better condition. Any fences removed shall be replaced in their original location. Fences in such poor condition that they cannot be taken down and rebuilt with the same material shall be replaced with new fence material similar in original quality, size, construction, and appearance to the removed fence. Exceptions to this requirement shall be allowed if written releases are obtained from the property owners by the Subcontractor and submitted to the Purchaser.

I. Restoration of Turfed Areas

1. All areas shall be restored as nearly as practicable to their original condition. Finished lawn areas where soil has been deposited shall be cleared to the level of the existing sod and then raked and watered. Areas where sod has been damaged, destroyed, or ruts have been filled shall be re-sodded or re-seeded. After final restoration of the settled trench surfaces, trench areas and areas regraded as part of the construction shall be re-sodded or re-seeded, unless otherwise shown on the Drawings or directed by the Purchaser. Sod must be living at the time of final acceptance of the project. See Specification Section 02920 for seeding requirements.

J. Maintenance of Flow

1. Where existing sewer lines are being modified, the Subcontractor shall arrange his work so that sewage flow will be maintained during the construction period with no discharge of sewage into the open trench, and no back up of sewage in the existing line. The Subcontractor shall provide necessary bypass pumping capacity to carry flow downstream of the section to be modified.

3.02 EXCAVATION

A. All excavation performed under this Section including trench excavation, structure excavation, and channel excavation, but excluding undercut excavation, shall be considered unclassified excavation despite the nature of the material and objects excavated and shall not be measured or paid for separately except as specifically noted. Pavement removal and replacement shall be accomplished as specified in Specification Section 02950.

B. Trench Excavation

1. All trenches shall be open cut unless otherwise shown on the Drawings. Trenching practices shall comply with all applicable local, state, and federal regulations. Tunneling, boring, or jacking may be allowed by written permission of the Purchaser.

2. Trenches may be excavated by machinery to a depth that will not disturb the finished subgrade. The remaining material shall be hand excavated so that the pipe is bedded on a firm, undisturbed subgrade.

3. No more than 300 feet of trench shall be opened ahead of the completed sanitary sewer, nor will more than 100 feet be left unfilled except by written permission from the Purchaser. In special cases, the Purchaser may limit the distance to which the trench may be opened by notifying the Subcontractor in writing.

4. The width of trenches below a level 1 foot above the outside top of pipe shall be at least 6 inches but not more than 12 inches on each side of the outside of the pipe for all sizes up to and including 16 inches in diameter. A maximum trench width dimension for these pipe sizes shall be 42 inches. For 18 inch diameter pipes, the width of trenches below a level 1 foot above the outside top of pipes shall be at least 6 inches on each side of the pipe, with a maximum trench width of 42 inches. For pipe sizes more than 18 inches, the width of trenches below a level 1 foot above the outside top of the pipe shall be at least 12 inches but no more than 15 inches on each side of the outside of the pipe. If the trench width at or below 1 foot above the top of pipe exceeds the width specified, provisions shall be made at the Subcontractor's expense to compensate for the additional load upon the pipe.

5. The sides of the trench shall be as nearly vertical as possible. The bottom of the trench shall be carefully graded, formed, and aligned according to SARP10 Trench Cross Section Showing Terminology Figure, the project details, and to the satisfaction of the Purchaser before sanitary sewers are laid.

C. Other Excavation

1. Undercut Excavation:

a. Undercut excavation shall consist of removing and disposing of unsatisfactory material below the grade established on the Drawings for sanitary sewers, structures, and manholes. No undercut excavation shall be done without prior authorization of the Purchaser. The limits of undercut excavation shall be determined by the Purchaser's Resident Project Representative who will be present during the undercut operations.

b. Undercut areas shall be backfilled with No. 67 limestone or other aggregate approved by the Purchaser to the grade established on the Drawings to produce a suitable foundation. The backfill shall be placed in 6 inch maximum lifts and compacted to 95 percent of maximum density at plus or minus 2 percent of optimum moisture content as determined by Laboratory Standard Proctor Test (ASTM D 698) or a minimum relative density of 0.75.

c. Unauthorized Excavation Below Subgrade or Outside Limits: Any unauthorized excavation and subsequent removal and backfilling beyond the lines and grades shown on the Drawings shall be at the Subcontractor's expense. The excess space between the undisturbed bottom and sides of the excavation and subgrade limits shown on the Drawings shall be backfilled according to this Specification.

D. Change in Location and Grade

1. If the Purchaser orders in writing that the location or grade of a proposed sanitary sewer facility be changed from that shown on the Drawings, the following provisions will apply. If the change is made before excavation work has begun and the item being constructed is covered in the Proposal Sheet(s) by pay items with appropriate depth classifications, the appropriate pay item will apply. If the facility being constructed is not covered in the Proposal Sheet(s) and if the average excavation per linear foot at the changed location or grade is within 10 percent of the original Plan quantity, there will be no change in the unit price for this work. If the average excavation per linear foot at the changed location varies more than 10 percent above or below original Plan quantities, a Contract Revision will be prepared to cover

the new work. For purposes of comparing changed quantities with Plan quantities, a 1 foot long strip will be calculated from natural ground line to invert along both the revised and original locations. These calculations will then be multiplied by the proper lengths to determine the total cost.

2. If the change is made after excavation has already begun on the original Plan location, the procedures described above shall apply to payment for work along the changed location. If abandonment of an existing excavation is required due to a change by the Purchaser, a Contract Revision shall be prepared covering the backfilling and restoration of the abandoned excavation. Backfilling and restoration of the abandoned excavation shall be accomplished according to the appropriate section of these Specifications.

3. Filling a portion of existing excavation to meet changed grades shall be accomplished in accordance with this Specification.

4. If a change in a location and/or grade is authorized in writing by the Purchaser at the written request of the Subcontractor, the Subcontractor shall not receive any additional compensation for the changed work. Backfilling and restoration of abandoned excavation work shall be accomplished totally at the Subcontractor's expense. If changes requested by the Subcontractor result in reduced lengths and/or depth of excavation, the revised quantities using Proposal unit prices or Contract Revisions as appropriate shall be used to develop payment.

E. Disposition of Excavated Material

1. Excavated material suitable for backfill shall be stored no closer than 2 feet from the edge of the excavation, unless a greater distance is required by OSHA or other applicable regulations,. Excavated material shall not obstruct crosswalks, sidewalks, driveways, street intersections, nor interfere unreasonably with travel on streets. Gutters or other surface drainage facilities shall not be obstructed. The Subcontractor must provide access to fire hydrants, mailboxes, sewer and conduit manholes, and similar utility or municipal service facility as required. Excavated material intended for backfill shall be stored in a way that minimizes loss of excavated material due to erosion. The Subcontractor shall comply with all applicable OSHA regulations and City of Memphis Storm Water Ordinances.

2. Unless otherwise directed, all excavated material that will not be used for backfilling or restoration shall be removed from the site and disposed of by the Subcontractor. If the Subcontractor proposes to store or place such excess excavated material upon any private property, written consent of the property owner or owners must be obtained by the Subcontractor in advance. A certified copy shall be given to the Purchaser. No surplus or excess material shall be deposited in any stream channel nor anywhere that would change preconstruction surface drainage.

F. Control of Water

1. The Subcontractor shall keep all excavations free of water. If the trench subgrade consists of good soil in good condition at the time of excavation, it shall be the Subcontractor's responsibility to maintain it in suitable condition. Dams, flumes, channels, sumps, or other work and equipment necessary to keep the excavation clear of water shall be provided by the Subcontractor. Dewatering of trenches shall be incidental to trench excavation. The Subcontractor shall avoid producing mud in the trench bottom by his operations. If necessary or so ordered by the Purchaser, the Subcontractor shall remove any soil that becomes unacceptable and replace it with limestone or other approved aggregate at his own expense to maintain a firm, dry base.

2. Pipe embedment, laying, jointing, and the placing of concrete or masonry shall be done in a water free trench or excavation. Trenches shall be kept clear of water until pipe joints, concrete and masonry have set and are resistant to water damage. The water shall be disposed of in a manner acceptable to the Purchaser.

3. All gutters, pipes, drains, conduits, culverts, catch basins, storm water inlets, ditches, creeks, and other storm water facilities shall be kept in operation, or their flows shall be satisfactorily diverted and provided for during construction. Any facilities disturbed during construction shall be restored to the satisfaction of the Purchaser.

4. Control of storm water and dewatering water shall conform to all TDEC and City of Memphis standards. Water from dewatering shall be pumped through a sediment bag or other suitable sediment removal device prior to discharge.

G. Excavation Around Obstructions

1. The Subcontractor shall perform all excavation by hand where excavation by machinery would endanger trees, structures, or utilities that otherwise might be saved by hand excavation.

2. The Subcontractor shall cautiously excavate test holes to find the limits of underground obstructions anticipated within the excavation. When a water pipe, gas pipe, other sanitary sewer, storm drain, or similar utility comes within the limits of the trench, such facilities shall be properly supported.

H. Excavation for Manholes and Special Structures

1. The Subcontractor shall be responsible for performing the Work according to the lines and elevations shown on the Drawings or as directed by the Purchaser. The Subcontractor shall excavate as required for all structures with foundations carried to firm, undisturbed earth at the elevation of the underside of the structure.

2. The outside dimensions of excavations for manholes and special structure shall be at least 12 inches greater than the outside of the masonry or concrete work to permit backfilling around the structure.

3. Where structures are to be built in street rights-of-way or paved areas, the excavation shall not exceed 2 feet from the outside of the masonry or concrete work. If the excavation exceeds this limit, the Subcontractor shall be required to backfill the entire space around the structure with pit run gravel compacted as specified in this Specification.

I. Special Protection

1. Treacherous Ground:

a. When running sand, quicksand, or other treacherous ground is encountered, the work shall be carried on with the utmost urgency and shall continue day and night should the Purchaser so direct.

2. Sheeting and Shoring:

a. The Subcontractor shall furnish, place, and maintain sheeting and shoring as required to support the sides of any excavation to prevent earth movement that could endanger the workers or public and to prevent damage to the excavation, adjacent utilities or property. The Subcontractor shall place this sheeting and shoring without the Purchaser’s instructions.

b. Sheeting shall extend below structure invert a sufficient depth to assure adequate support. In the installation of sheeting, the use of vibratory type pile drivers (as opposed to impact type) shall be limited to sheeting driven no greater than 5 feet below the invert. The sheeted trench width, as measured between those faces of the sheeting in contact with the earth trench wall, shall not exceed the maximum width of a trench. Walers and struts shall be designed and installed to present no obstructions to proper placement of the pipe, pipe embedment, cradle or encasement, and they shall not interfere with the satisfactory installation of the pipe.

c. Sheeting, bracing, and shoring shall be withdrawn and removed as the backfilling is being done, except where the Purchaser permits the material to be left in place. The Subcontractor shall cut off sheeting left in place at least 2 feet below the surface and shall remove the cut off material from the excavation.

d. All sheeting, bracing, and shoring which is not left in place under this provision shall be removed in a way that will not endanger the completed work or other structures, utilities, storm drains, sewers, or property. The Subcontractor shall be careful to prevent the opening of voids during the extraction process.

e. If sheeting and shoring are not specifically required on the Drawings or in the Specifications, steel drag shields or trench boxes may be used subject to the authorization of the Purchaser. Voids left by the advancement of the shield shall be carefully backfilled and compacted following trench backfill requirements.

f. Sheeting and shoring systems shall be designed by a Professional Engineer licensed in the State of Tennessee.

3. Excess Width of Trench:

a. If the Subcontractor is permitted to use equipment that results in wider trenches than specified, approved methods shall be used around the pipe to resist the additional load caused by the extra width. The dimensions of the cradle or other methods will be specified by the Purchaser. The Subcontractor shall be responsible for meeting all applicable OSHA requirements. No extra compensation will be allowed for the additional material or work. Excess width trenches for semi-rigid and flexible pipe shall be backfilled and compacted according to ASTM D 2321, and no concrete cradle shall be used.

4. Underpinning:

a. When excavations require underpinning of existing structures, the Subcontractor shall submit shop drawings of underpinning details to the Purchaser for review before commencement of excavation below the foundation of the structure. Review of underpinning details by the Purchaser shall not relieve the Subcontractor of his responsibility for protection of the structure and its contents.

b. Underpinning shall be designed by the Contractor’s structural engineer licensed in the State of Tennessee. Submit engineering calculations and drawings for reference.

J. Existing Utilities

1. It shall be the Subcontractor's responsibility to arrange for the location of existing utilities prior to excavation. The Subcontractor will also be responsible for coordinating the relocation of any existing utilities with the appropriate utility owner.

2. Protection

    a. The Subcontractor shall protect any storm drain, sewer, or utility within the limits of the construction. The Subcontractor shall proceed with caution and shall use every means to establish the exact location of underground structures and facilities before excavating in the vicinity. The Purchaser shall not be responsible for the cost of protection or repair or replacement of any structure, pipe line, conduit, service connection, or similar facility broken or damaged by the Subcontractor's operations. All water and gas pipes and other conduits near or crossing the excavation shall be properly supported and protected by the Subcontractor.

3. If the construction requires the removal and replacement of any overhead wires or poles, underground pipes, conduits, structures or other facilities, the Subcontractor shall arrange for such work with the Owner or Owners of the facilities. No additional payment will be made by the Purchaser for this work.

4. Service Connections:

    a. Sewer and utility services between mains and buildings shall be maintained and adjusted as necessary by the Subcontractor to provide as nearly a continuous operation as can be expected. This shall be accomplished in any way that the Subcontractor chooses, provided the individual service is not interrupted for more than two consecutive hours. The occupants shall be notified by the Subcontractor at least six hours before such service interruptions. When a break occurs, the Subcontractor shall notify the affected occupant(s) of the probable length of time that the service will be interrupted. New service laterals with double-sweep cleanouts will be required to be installed to the property line for each service and reconnected to the existing service if one exists. If no service exists, the Subcontractor shall cap the pipe after installing a cleanout.

5. If existing underground facilities or utilities require removal and replacement for the performance of this work, all replacements shall be made with new material conforming to the requirements of these Specifications. If not specified, the material will be as approved by the Owner.

6. The removal and replacement of water services to adapt to new construction shall be the Subcontractor's responsibility within the limits where the new service line grade blends smoothly with the existing service line grade.

7. The Subcontractor shall be responsible for any damage to the sewer house connection because of his operations. The Purchaser does not guarantee the number, size, condition, nor length of adjustment necessary to bring a service to a new grade.

3.03 SEWER PIPE INSTALLATION

A. General

1. Sewer pipe and pipe embedment shall be constructed as shown on the Drawings. It shall be the Subcontractor's responsibility to find all underground utilities before construction to ensure there are no conflicts with the proposed line and grade. The Subcontractor’s surveyor shall verify the base information on the Drawings prior to commencement of construction. Any discrepancies in the Drawings shall be reported to the Purchaser immediately. If approved by the Purchaser, minor changes in the alignment or grade will be permitted to

avoid underground facilities, if straight alignment can be maintained between manholes. If minor changes in line or grade cannot avoid a conflict with the existing utility, the Subcontractor shall arrange with the owner of said utility to have it adjusted as required to accommodate the proposed sewer at no additional expense to the Purchaser.

B. Modifications of Existing Sanitary Sewer Facilities

1. Maintenance of Flow:

   a. Where existing sewer lines are being modified, the Subcontractor shall arrange his work so that sewage flow will be maintained during the construction period with no discharge of sewage into the open trench, and no back up of sewage in the existing line. The Subcontractor shall provide necessary bypass pumping capacity to carry flow downstream of the section to be modified.

2. Abandonment of Sewer Pipe:

   a. Sewer pipe called for in the Specifications or Drawings to be abandoned shall be sealed at each end for a minimum distance of 18 inches, or one-half the diameter of the pipe, whichever is greater. Unless otherwise specified, the pipe shall be sealed with a brick bulkhead and/or acceptable cement grout to form a solid watertight plug completely bonded to the pipe.

3. The Subcontractor shall be allowed to remove pipe to be abandoned if wanted. If the Subcontractor elects the removal method, all associated costs shall be included in the cost for other Pay items.

4. Connection to Existing Manholes:

   a. The Subcontractor shall cut suitable openings into existing manholes or remove existing pipe to accommodate the sewer pipe at the proper elevation, location, and direction, as indicated on the Drawings. Care shall be used to avoid unnecessary damage to the existing manhole.

5. All loose material shall be removed from the cut surfaces that will be completely coated with non-shrinking grout before setting the pipe. Before inserting the pipe, a sufficient thickness of grout shall be placed at the bottom and sides of the opening for proper bedding of the pipe. For semi-rigid and flexible pipe installations a water stop as approved by the pipe supplier shall be installed on the pipe according to the manufacturer's recommendations. After setting, all spaces around the pipe shall be solidly filled with non-shrinking grout and neatly pointed up on the inside to present a smooth joint, flush with the inner wall surface. Any necessary revisions on the existing manhole invert shall be made to provide a smooth, plastered surface for properly channeled sewage flow from the new connection. Plaster on the exterior of brick manholes shall be repaired with non-shrinking grout. Particular care shall be given to ensure that the earth sub-base and bedding next to the manhole will provide firm solid support to the pipe.

6. Removal of Sewer Pipe:

   a. Existing pipes and manholes to be removed and their locations shall be shown on the Drawings. Existing sewer pipe and manholes that must be removed to excavate for the proposed sewer shall be included in the cost of the proposed sewer pipe and no additional compensation shall be made to the Subcontractor. The City reserves the right to retain or reject salvage of any material encountered. All remaining material becomes the property of the Subcontractor who shall be responsible for properly disposing of the same.

3.04 PIPE EMBEDMENT

A. Pipe embedment will be defined as that material supporting, surrounding and extending to 6 inches above the top of the pipe. Pipe Embedment for sewer pipe shall conform to the requirements given below. At the direction of the Purchaser or as shown on the Drawings, sewer pipe and backfill shall be encapsulated in geotextile fabric meeting the following requirements:

Physical Property	Test Method	Acceptable Test Result
Tensile Strength, wet (lbs)	ASTM D-1682	200 (min)
Elongation, wet (%)	ASTM D-1682	40 (min)
Coefficient of Water Permeability (cm/sec)	Constant Head	0.03 (min)
Puncture Strength (lbs)	ASTM D-751	100 (min)
Pore Size (EOS U.S. Standard Sieve)	Corps of Engineers CW-02215	40 (max)

B. Crushed Limestone

1. Pipe embedment material shall be Number 67 crushed limestone. Pipe 8 inches to 24 inches in diameter shall be bedded on 4-inches of Number 67 crushed limestone. Pipe 27 inches to 48 inches in diameter shall be bedded on 6-inches of bedding material. Pipe embedment for pipes larger than 48 inches in diameter shall be by design based on anticipated soil conditions. After pipe installation, crushed limestone shall then be tamped under the haunches and continued in layers not more than 6 inches in loose thickness around and above the pipe to a level 6 inches above the outside top of the pipe. The remainder of the installation shall be as outlined in this Specification's Backfill requirements.

3.05 PIPE LAYING

A. Inspection Before Laying

1. All pipe shall be inspected upon delivery. Pipe that does not conform to the requirements of these Specifications or is not suitable for use will be rejected by the Purchaser and immediately removed from the work site.

B. Preparation of Pipe Ends

1. All surfaces of the pipe to be joined shall be clean and dry. All necessary lubricants, primer, adhesives, and similar material shall be used as recommended by the pipe or joint manufacturer's specifications.

C. Care During Hoisting, Placing, And Shoving Home

1. Equipment used to handle, lay, and join pipe shall be equipped and used as to prevent damage to the pipe. All pipe and fittings shall be carefully handled and lowered into the trench. Damaged pipe or jointing material shall not be installed.

D. Direction of Work

1. The laying of pipe shall be commenced at the lowest point. The bell or grooved end shall be laid upgrade. All pipe shall be laid with ends abutting and true to line and grade. The pipe ends shall be carefully centered so that when laid they will form a sewer with a uniform invert.

E. Uniform Pipe Bearing

1. Special care shall be taken to ensure that the pipe is solidly and uniformly bedded, cradled, or encased according to the Drawings. For pipe with a bell that is larger than the barrel of the pipe, the bedding material shall be removed to a depth that will provide continuous support for the bell and barrel. No pipe shall be brought into position for joining until the preceding length has been bedded, joined, and secured in place. Where a concrete cradle is required, the pipe shall be supported at no more than two places with masonry supports of minimum size sufficient to provide the required clearance and to prevent displacement during placing of concrete.

F. Alignment and Grade

1. Each piece of pipe shall be checked for vertical and horizontal alignment immediately after being laid. All adjustments to alignment and grade must be made by scraping away or filling in under the barrel of the pipe and not by wedging or blocking up any portion of the pipe or striking the pipe to drive it down. Curved alignments shall not be allowed except as directed by the Purchaser.

G. Backfilling to Secure Pipe

1. When the joint is made, sufficient backfill material shall be simultaneously placed along each side of the pipe to prevent moving the pipe off line and grade. Particular care shall be used to prevent disturbance or damage to the pipe and the joints during backfilling.

H. Flotation and Water in the Trench

1. The Subcontractor shall take all necessary precautions to prevent flotation of the pipe in the trench. Water shall not be allowed to rise in the trench. The Subcontractor shall use well points, sump pumps, or another approved method of dewatering as required to lower the water table below the bottom of the excavation while minimizing the migration of fines from the surrounding area. The Subcontractor shall make a request to the Purchaser and receive approval prior to the use of special dewatering equipment other than well points or sump pumps. Dewatering operations are considered incidental to the work and no additional compensation will be made to the Subcontractor.

I. Open Ends

1. Whenever pipe laying is stopped for any significant length of time, such as at the end of a workday, the unfinished end shall be protected from damage and a temporary tight fitting plug or bulkhead shall be placed in the exposed ends of the pipe to keep soil or other debris from entering the pipe.

J. Concrete Cradle Section next to Manhole

1. The pipe shall be supported from the manhole wall to the limits of the manhole excavation in a normal sewer trench with a concrete cradle, structurally continuous with the manhole base slab or footing. Cost for this work is incidental to the cost of the pipe installation.

K. Cutting Pipe

1. Cutting shall be in a neat workmanlike manner at right angles to the pipe axis without damage to the pipe. The Subcontractor shall smooth the cut end by power grinding or filing to remove burrs and sharp edges.

L. Wyes and Special Fittings

1. Wyes, stubs, reducers, fittings, or other special pipes shall be installed as shown on the Drawings or where ordered by the Purchaser. The fittings and special pipes shall be made of a compatible material, type, and class and/or strength designation as the pipe and installed as required by the Drawings and Specifications. The cost for providing and installing the above items is incidental to the cost of the pipes.

3.06 PIPE JOINTS

A. General

1. Pipe shall be jointed immediately following the laying of each section. No pipe section shall be left overnight which has not been completely jointed to the preceding pipe section in conformance with these Specifications.

2. The following provisions will apply to insure tight and sound joints:

a. The joint will be placed with special care to avoid breaking joints and to leave gasket, if required, in proper position.

b. All pipe 12 inches in diameter or larger will have dead weight held by crane while being lined up and pushed home.

c. Pipe will be pushed home with a constant and even force and not jarred home by the momentum of a moving force that will place an impact load on pipe.

d. Cement and lubricant will be used as recommended by the manufacturer and designated by the Purchaser.

B. Compression Joints

1. The two ends to be joined shall be thoroughly cleaned and a compression gasket compatible with the type of pipe to be joined shall be at the position recommended by the pipe manufacturer.

2. Lubricant recommended by the gasket manufacturer shall be liberally applied to the gasket and both ends immediately before pipe ends are joined. The upstream pipe shall be positioned such that the spigot may enter the bell squarely. The pipe being laid shall be pushed home and the gasket position checked with a feeler gauge before installation of the next section. Flat, unconfined gaskets on concrete pipe shall be cemented to the spigot at the position recommended by the pipe manufacturer.

C. Mechanical Joints

1. The two ends to be joined shall be thoroughly cleaned with a wire brush and the plain end, socket end, and gasket shall be brushed with soapy water. The end shall be centered in the socket and adequate anchorage shall be provided to hold the pipe in position until the joint can be completed. When deflecting pipe from a straight line is necessary, the deflection shall be made after joint assembly and before tightening bolts. Pipe deflection shall not exceed that specified by ANSI C 600.

2. When tightening bolts, it is essential that the gland be brought up toward the pipe flange evenly, maintaining approximately the same distance between the gland and the face of the flange at all points around the socket. All bolts shall be torqued to the required range recommended by the pipe manufacturer. The Subcontractor shall avoid over stressing the bolts. Gauge lines on the spigot end shall be checked following assembly to ensure proper positioning of bell and spigot has been accomplished.

3. Any joints not properly positioned shall be disassembled, cleaned, and reassembled as previously indicated.

D. Flanged Joints

1. The two ends to be joined shall be thoroughly cleaned with a wire brush. Bolt holes on each pipe flange to be joined shall be aligned and bolts inserted. Bolts shall be torqued evenly by alternating tightening of bolts opposite one another until all bolts are torqued to the recommended pressure.

E. Restrained Joints

1. Restrained push-on joints are to be used as specified on the Drawings or by the Purchaser. These special joints shall be installed as specified by the manufacturer. The length of the pipe to be restrained will be determined by the Purchaser based on pipe size, internal pressure, depth of cover, and soil characteristics around the pipe.

3.07 SERVICE CONNECTIONS

A. The Subcontractor shall install a new lateral with cleanout for each house connection. Cleanouts should be located on the property line or easement with 6-inch PVC (SDR 26) with a minimum slope of 1 percent unless otherwise directed by the Purchaser.

B. The Subcontractor shall provide a Double Sweep PVC cleanout with a PVC screw plug cap and 4-inch PVC stack pipe. When installed, the cap shall lie 3-inches below finished grade.

C. If the existing service connection is 4-inch diameter, the Subcontractor shall provide a 6-inch to 4-inch concentric PVC reducer to connect the new 6-inch lateral to an existing 4-inch private property lateral.

D. The Subcontractor shall connect the new lateral to the PVC main with a PVC fitting in accordance with the details shown on *Typical Installation of Service Lateral*.

3.08 PIPE CAPS AND PLUGS

A. Wyes, stubs, or other fittings installed in the pipe for future connections shall be closed at the open end. For pipes 21 inches in diameter or smaller, an approved cap or plug shall be installed in the bell or socket using the same type joint or jointing material as required for the sewer. For pipes larger than 21 inches in diameter, temporary approved masonry bulkheads of the thickness required by the Drawings and Specifications to close the open end may be substituted for stoppers. Care in backfilling shall be used so that such closure and its seal will not be disturbed. This stopper shall be jointed so that it may be removed later without injury to the pipe itself. Work and material is incidental to the cost of the pipe installation.

3.09 BACKFILLING

A. General

1. After sanitary sewer facilities have been bedded and installed according to these Specifications and upon permission of the Purchaser, the backfill may be placed. Backfilling operations shall continue following as closely behind pipe installation as practical. All backfill shall be placed in uniform horizontal layers. Pushing backfill material down a ramp into excavated areas will not be permitted. No trash will be allowed to accumulate in the space to be backfilled. Particular care shall be taken to avoid allowing wood to be included in the

backfill, other than sheeting and shoring that has been approved by the Purchaser to be left in place.

2. The Subcontractor shall be responsible for the condition of the trenches and filled areas during the contract and warranty period. The Subcontractor shall maintain frequent inspection of the same. If at any time during the 12-month warranty period the trenches or filled areas settle and sunken places appear, the Subcontractor shall be required to refill these sunken places when they are discovered with suitable material and will replace all damaged curb, gutter, and sidewalk. All soft or dangerous trenches shall be marked, barricaded and caution lighted for the protection of the public.

3. Property with an existing dwelling located on it or lots within a developed subdivision or planned development are considered improved property.

B. Street Right-of-Way and Improved Property

1. Backfill Material:

a. Backfill for manhole and pipe trench excavations through pavements in street or highway right-of-way or where the Purchaser orders, shall be made with pit run gravel or other acceptable material as approved by the Purchaser. The backfill shall be from the top of the pipe embedment material or manhole foundation to the subgrade elevation of the pavement. Pea gravel or similar granular material approximately uniform in size and without bonding properties will not be used.

b. Backfill for manhole and pipe trench excavations beyond pavements in street or highway right-of-way or outside public right-of-way shall be made with select earth from the top level of the pipe embedment material or foundation to the subgrade elevation in paved area, or within 1 inch of the surface in areas to be sodded, or to the surface in all other areas.

c. Select material shall be free from debris, organic matter, perishable compressible material and will contain no stones or lumps larger than 6 inches. Rocks and lumps smaller than 6 inches will not exceed an amount that will interfere with the consolidating properties of the fill material. Care shall be taken that stones and lumps are kept separated and well distributed, and that all voids are completely filled with fine material. No rocks or lumps will come in direct contact with the pipe. The upper 3 feet of backfill in sodded or planted areas will be free of rocks or lumps larger than 1 inch in diameter.

2. Placement and Compaction:

a. Sanitary Sewer Trenches:

i. Backfill material shall be placed by hand in 6 inch loose layers and tamped to a point 2 feet above the outside top of the pipe. Backfill will be compacted with suitable mechanical tamping equipment with special care being taken not to damage the pipe or joints. Use of compaction equipment directly above semi-rigid and flexible pipe should be avoided until sufficient backfill has been placed to ensure that the equipment will not damage the pipe. A minimum of 36 inches of compacted backfill above the top of semi-rigid and flexible pipe shall be in place before wheel loading and a minimum of 48 inches of compacted backfill before use of pneumatic tampers. From these elevations to the subgrade elevation of the pavement, bottom of the sod, or to the original ground surface, suitable backfill shall be mechanically placed in9inch, maximum, loose layers. All backfill material shall be compacted to 95 percent of maximum density at plus or minus 2 percent of optimum moisture content as determined by Laboratory Standard Proctor Test (ASTM D 698).

b. Manholes and Special Structures:

i. When the masonry or concrete work has set sufficiently to withstand compaction, and the Purchaser authorizes, backfill material will be placed in 6 inch loose layers and compacted with heavy tampers or pneumatic tampers to 95 percent of maximum density at plus or minus 2 percent of optimum moisture content as determined by Laboratory Standard Proctor Test (ASTM D 698). Suitable backfill shall be placed in this manner from the foundation of the structure to the subgrade elevation of the pavement, the bottom of the sod or to the original ground surface.

C. Open Areas and Unimproved Property

1. Backfill Material:

a. Backfill of excavations on unimproved property shall be made with select material from the top level of pipe embedment material or foundation to the surface. Non-granular select material to be used for backfill will be free from debris, organic matter and perishable compressible material, and will contain no stones or lumps or rock fragments larger than 6 inches. Rocks or lumps smaller than 6 inches in diameter will not exceed an amount that will interfere with the consolidating properties of the fill material. No rocks or lumps shall come in direct contact with the pipe. Stones and lumps shall be kept separated and well distributed, and all voids shall be completely filled with fine material.

2. Placement of Backfill:

a. Backfill procedures specified in Specification Section 02530 Paragraph 3.08.B shall apply from the trench bottom to a point 2 feet above the outside of the pipe. From this point to slightly above the surrounding surface elevation, suitable backfill may be placed by bulldozer or other mechanical means.

D. Removal of Excess Material

1. After the trench or excavation has been properly backfilled, all excess dirt shall be removed from the streets, roadways and improved private property so pavements or turfed areas may be replaced and properties cleaned.

2. In open areas and unimproved property, the excess material may be used to fill low spots on property next to the right-of-way/easement. Before spreading excess soil, the Subcontractor shall obtain written permission from the property owner for the spreading of excess soil, and

a copy of the written permission shall be submitted to the Purchaser. Such spreading or filling shall not obstruct surface drainage and be to the satisfaction of the property owner. Excess material shall be disposed of by the Subcontractor.

3.10 BYPASS PUMPING

A. As required for acceptable completion of the work and/or to avoid damages due to sewer spills or overflows, the Subcontractor shall provide for sewer flow maintenance around the line segments and manholes designated for rehabilitation. The bypass shall typically be made by plugging the line at an existing upstream manhole and pumping the flow into a downstream manhole or adjacent sanitary sewer system. The pump and bypass lines shall be of adequate capacity and size to handle the anticipated flow. Bypassing of sanitary sewage into the storm water system will not be allowed. For all bypass pumping, pump noise shall be kept to a minimum to the satisfaction of the Purchaser. The Subcontractor shall be required to contact all residential and commercial customers whose service lines connect to the sewer main being bypassed and inform them that they will be temporarily out of service. The Subcontractor shall also advise those customers against water usage until the mainline is back in service. After completing the necessary work on the main line, the Subcontractor shall advise those customers that the sewer main is back in service.

B. Bypass pumping is defined as providing pumps, standby pumps, piping, elevated structural support for aerial crossings, manpower to operate, routine maintenance and repair capability, pipe plugs, fuel, route and pump site clearing and any other work necessary to provide a complete bypass pumping operation. Any structures proposed by the Subcontractor for construction over or penetration into the interceptor piping for the purpose of performing the bypass operations must be approved by the Purchaser prior to implementation. The Subcontractor shall submit design drawings and details that are signed and sealed by a professional engineer licensed in the State of Tennessee. All bypass pump schemes must be submitted to and approved by the Purchaser in advance.

C. Public advisory services shall be required to notify all parties whose service laterals will be out of service and to advise against water usage until the mainline is back in service.

D. The Subcontractor shall be required to provide businesses with temporary service, as needed, and shall be responsible for all necessary bypass pumping flows.

3.11 FINAL GRADING

A. Final grading around sanitary sewer facilities shall conform to the elevation of adjacent undisturbed ground or as shown on the Drawings. Sufficient grading shall be done to provide adequate drainage.

3.12 CLEANING

A. All necessary precautions shall be taken to prevent the entrance of mud, sand, or other obstructing material into the pipelines. As the work progresses, the interior of the sewer shall be cleaned of all dirt, jointing material and extraneous material. On small pipe where cleaning after laying may be difficult, a squeegee shall be kept in the pipeline and pulled forward past each joint immediately after its completion. Before final inspection the Subcontractor shall remove all debris and foreign material.

3.13 TRAFFIC CONTROL

A. All traffic control shall be installed and maintained in accordance with the Manual on Uniform Traffic Control Devices (MUTCD). At a minimum, the Subcontractor must have two trucks with flashing yellow lights on the work site. Traffic cones must also be placed downstream of the

construction site to divert cars into the adjacent lane(s) per MUTCD requirements. On roads with a heavy traffic volume, a flagman may also be needed to assist with traffic control. For bidding purposes, the Subcontractor shall assume that a flagman will be needed on 30 percent of the setups. At the end of each working period, the Subcontractor shall plate all open excavations to maintain traffic flow.

3.14 FALL PROTECTION

A. Subcontractor shall install and maintain all fall protection measures in accordance with the SARP10 Loss Control Manual. The Subcontractor shall construct a controlled access zone around the manhole being adjusted. At a minimum, the fall protection zone shall include traffic cones encircled with pennant tape. The controlled access zone must have one point of access with an entrance log.

3.15 PROTECTION OF DOWNSTREAM FACILITIES

A. The Subcontractor must take all steps necessary to assure that no material is allowed to fall into the line during his installation process. The Subcontractor shall bear all cost of repairs resulting from any damages to downstream facilities resulting from failure to abide by this stipulation.

3.16 WASTEWATER SPILLS

A. Should the Subcontractor spill any wastewater, such that the sewage either immediately or ultimately enters the waters of the State of Tennessee, then the Subcontractor shall be completely responsible for any fines or penalties imposed on the Purchaser or the Subcontractor by the USEPA or the State of Tennessee.

3.17 FINAL TESTING AND ACCEPTANCE

A. Visual Inspection

1. All work will be subject to visual inspection for faults or defects and any such deviation or omission will be corrected at once.

2. A PACP CCTV inspection in accordance with Section 00003 shall be submitted after pipe replacement is competed.

B. Leakage Tests

1. On sewers with no house connections, leakage tests shall be performed on the full length of all sewer lines and manholes in the presence of the Purchaser before acceptance. On all other sewers, an infiltration test shall be performed. The cost of all testing will be included in the unit price for the item being tested.

2. Air Leakage Test for 8-24 inch Diameter Pipe

a. Upon completion of construction, or earlier if the Purchaser deems advisable, the Subcontractor shall provide the necessary equipment and labor to perform low pressure air tests according to ASTM F1417. This test shall be performed in the presence of the Purchaser and shall be for all types of gravity sewer pipe. This test shall also include service lines from manholes.

b. The pressure test gauge will meet the following minimum specifications:

Size (diameter)	4 ½ inches
Pressure Range	0-15 PSI

Figure Intervals	1 PSI Increments
Minor Subdivisions	0.05 PSI
Pressure Tube	Bourdon Tube or diaphragm
Accuracy	Plus or minus 0.25% of Maximum scale reading
Dial	White coated aluminum with black lettering, 270° arc and mirror edges
Pipe Connection	Low male ½ inch NPT

c. Calibration data shall be supplied with all pressure test gauges. Certification of pressure test gauges shall be required from the gauge manufacturer. This certification and calibration data shall be available to the Purchaser whenever air tests are done.

d. Air leakage tests shall be performed on each reach of sewer pipe between manholes after completion of the installation of pipe and appurtenances and the backfill of sewer trenches. The test time shall be determined from the following table. If air tests fail to meet the following requirements, the Subcontractor shall repeat tests as necessary after all leaks and defects have been repaired. Before acceptance, the same sewer reach shall pass the low pressure air test.

e. Time Required for a 1.0 psig Pressure Drop for Size and Length of Pipe Indicated[1]

Pipe Diameter (in.)	Minimum Time (min:sec)	Test Time for Length of Sewer Tested (min)
8	7:34	1.52 X L(ft)/60
10	9:26	2.374 X L(ft)/60
12	11:20	3.418 X L(ft)/60
15	14:10	5.342 X L(ft)/60
18	17:00	7.692 X L(ft)/60
21	19:50	10.47 X L(ft)/60
24	22:40	13.674 X L(ft)/60

i. Establish the test time for the sewer length from the formula or the minimum time, whichever is greater.

3. Infiltration Test

a. Infiltration tests may be required for the complete line or any portion of it. Failure of any part of the line to pass an infiltration test shall be sufficient reason to require additional work by the Subcontractor to reduce the infiltration in such portions of the line tested. The passing of an infiltration test shall in no way relieve the Subcontractor of any responsibility to repair visible leaks found during the visual inspection.

b. Maximum allowable infiltration shall be 0 gallons per mile per inch of diameter of sewer per 24-hour day at a time. The joints shall be tight, and visible leakage in the joints of leakage greater than that specified above shall be repaired at the Subcontractor's expense by any means necessary.

C. Deflection Test – Semigrid and Flexible Pipe

1. All polyvinyl chloride (PVC) pipe and glass fiber reinforced polymer mortar pipe shall be tested for deflection. All testing shall take place after backfill has been in place at least 30 days. All lines shall be thoroughly cleaned before testing to assure accuracy.

2. Tests shall be run using a rigid ball or nine arm mandrel having a diameter of 95% of the inside diameter of the pipe for PVC and 96% of the inside diameter of the pipe for glass fiber

reinforced polymer mortar pipe. The mandrel will be pulled freely by hand through the pipe from manhole to manhole. No pipe deflection will exceed 5% for PVC and 4% for glass fiber reinforced polymer mortar pipe. Any section failing the test shall be repaired by re-bedding or pipe replacement and retested to the satisfaction of the Purchaser.

3. The cost of this service shall be included in the unit price bid for the pipe.

D. Final Acceptance

1. When all work required by the Contract has been completed, the Subcontractor shall submit to the Purchaser written certification from a registered land surveyor that the centerline of each structure is within 2.0 feet of the centerline of the sewer easement or the location designated on the Drawings. After receiving the surveyor's certification from the Subcontractor, the Purchaser will make a final inspection of the Work, including any tests for operation. After completion of this inspection, the Purchaser will, if all things are satisfactory to him, issue to the Subcontractor a Certificate of Completion certifying that the Work required by the Contract has been completed according to the Contract Drawings and Specifications. However, the Certificate will not operate to release the Subcontractor or his sureties from any guarantees under the Contract or the Performance Bond. Upon receipt of the Certificate of Completion the Subcontractor will clean the premises and see that they are in an orderly condition.

PART 4 MEASUREMENT & PAYMENT

4.01 MEASUREMENT

A. Sewage Force Main

1. Sewage force main shall be measured per linear foot.

B. Forcemain Bypass Connection Assembly

1. Forcemain bypass connection assembly shall be measured per each.

C. Combination Air Valve Assembly (NOT USED)

D. Valves

1. Valves shall be measured per each.

E. Bypass Pumping

1. Bypass pumping will be measured as a lump sum item.

F. Traffic Control

1. Traffic control will be paid per each sewer pipe installation. Traffic control does not apply to segments being replaced in alleys or other locations where traffic is not impacted.

G. Wet Well Piping Replacement

1. Wet well piping replacement will be measured as a lump sum item.

H. Dry Pit Piping Replacement

1. Dry pit piping replacement will be measured as a lump sum item.

I. Excavation

All work for excavation, blasting, drainage of trenches and dewatering, backfilling of excavation, compaction, grading, protection of existing utilities, disposal of excess material, and all other similar items included in this section of the Specifications but not covered by a Pay Item herein will be considered obligations of the Subcontractor under other Pay Items of the Contract.

J. Site Preparation and Restoration

1. This work will be required within the construction limits and will not be paid for directly buy will be considered as a subsidiary obligation of the Subcontractor under the contract items.

4.02 PAYMENT

A. Sewage Force Main

1. The accepted quantities of swage force main will be paid for at the contract unit price per linear foot furnished and laid for the various sizes, types, classes, or wall thicknesses, which will be full compensation for material and material testing, excavation, special protection, protection of existing utilities, bedding, laying, jointing, fittings, shut-off valves, relief valves, valve pits and boxes, thrust blocks, cleaning and inspection, conducting acceptance tests, , connection to existing sewer manholes or structures, adapters and couplings, and removal and/or abandonment of existing pipe.

B. Forcemain Bypass Connection Assembly

1. Forcemain bypass connection assembly will be paid for at the contract unit price per each. This item will include but not limited to all work and materials necessary to install the bypass tee assembly as shown on the Drawings including all piping between and including the solid sleeves/couplings, fittings, valves, Bauer connection fitting, precast concrete vault with drain line and access hatch, crushed stone, excavation, and backfill.

C. Combination Air Valve Assembly (NOT USED)

D. Valves

1. Valves will be paid for at the contract unit price per each per type and size. This item will include but not be limited to all work and materials necessary to install the valve as shown on the Drawings.

E. Bypass Pumping

1. Bypass pumping will be paid as lump sum. This item includes all materials and labor necessary to properly comply with the bypass pumping requirements listed in the specification.

F. Traffic Control

1. Traffic Control will be paid per each sewer pipe installation including all appurtenances required to comply with MUTCD Standards. Traffic control does not apply to segments being replaced in alleys or other locations where traffic is not impacted.

G. Wet Well Piping Replacement

1. Wet well piping replacement will be paid at the appropriate contract lump sum price. This item includes all materials and labor necessary to replace the piping as shown on the Drawings including couplings, pipe and fittings, and sealing of existing pipe penetrations.

H. Dry Pit Piping Replacement

1. Dry pit piping replacement will be paid at the appropriate contract lump sum price. This item includes all materials and labor necessary to replace the suction and discharge piping within the dry pit area as shown on the Drawings including couplings, and pipe and fittings.

4.03 PAYMENT WILL BE MADE UNDER:

Item No.	Pay Item	Pay Unit
02530-4.02.A	SEWAGE FORCEMAIN	LINEAR FOOT
02530-4.02.B	FORCEMAIN BYPASS CONNECTION ASSEMBLY	EACH
~~02530-4.02.C~~	~~COMBINATION AIR VALVE ASSEMBLY~~	~~EACH~~
02530-4.02.D	VALVES	EACH
02530-4.02.E	BYPASS PUMPING	LUMP SUM
02530-4.02.F	TRAFFIC CONTROL	EACH
02530-4.02.G	WET WELL PIPING REPLACEMENT	LUMP SUM
02530-4.02.H	DRY PIT PIPING REPLACEMENT	LUMP SUM

END OF SECTION 02530

SECTION 02537
REHABILITATION OF INTERCEPTOR MANHOLES AND WET WELLS

PART 1 GENERAL

1.01 SCOPE

A. This work consists of the rehabilitation and lining of interceptor manholes and/or wet wells for sanitary sewers and/or pump stations as shown on the Drawings, stipulated in the Contract Documents, or as directed by the Purchaser. The construction will be accomplished by these Specifications and in conformity with the details shown on the Plans or established by the Purchaser. The Subcontractor shall perform all work necessary to complete the Contract with the best modern practice. Unless otherwise provided, the Subcontractor is required to furnish all labor, materials, equipment, and incidentals required to rehabilitate or repair manholes or wet wells as noted on the Drawings or directed by the Purchaser.

1. Accurately field measure and size each individual manhole and wet well. Each existing sewer manhole and wet well designated to be rehabilitated may have a different configuration and varying field dimensions.

2. Each manhole or wet well to be rehabilitated shall be thoroughly cleaned and all loose or missing bricks, loose mortar, holes, etc. shall be repaired. All leaks shall be plugged prior to rehabilitation or recoating.

3. The presence or absence of leakage through manhole or wet well walls noted on the manhole inspection reports or pump station condition assessments and as seen in the Subcontractor's independent manhole or wet well inspections prior to bidding or construction depend on the groundwater levels and conditions at the time of the inspections. High groundwater levels in the project area typically occur in the dormant season (December through May), but will vary with rainfall in any given year and sewer location. Be advised the groundwater currently entering the leaking sewer mains and laterals may migrate to the manholes after the sewer mains and laterals are rehabilitated or replaced. Reflect assumptions and judgments on leakage through manhole walls based on this information in the unit prices bid for lining manholes. All leakage shall be stopped prior to lining manholes or wet wells. No additional payment will be made for repairing leaks not visible prior to bidding or sewer rehabilitation.

4. Where existing manholes or wet wells are being rehabilitated, the Subcontractor will arrange his work so that sewage flow will be maintained during the construction period with no discharge of sewage into the open trench, and no backup of sewage into the existing line. The subcontractor will provide necessary bypass pumping capacity to carry flow downstream of the manhole or wet well to be rehabilitated.

B. References:

1. ASTM D-638: Test Method for Tensile Properties of Plastics.

2. ASTM D-695: Test Method for Compressive Properties of Rigid Plastics.

3. ASTM D-790: Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

4. ASTM D-4541: Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
5. ASTM D-412: Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

6. ASTM D-2240: Standard Test Method for Rubber Property Durometer Hardness

7. ASTM D-522: Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings

8. ICRI 03732: Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

C. Quality Assurance

1. Furnish materials of quality required by the American Society for Testing and Materials (ASTM) standards and industry approved standards and specifications. Provide guarantee against defective materials and workmanship in accordance with the requirements of these specifications.

D. Sequencing:

1. All required interruptions of flow through manholes or any other portion of the sanitary sewer system shall be coordinated with the Owner, and approval must be received from the Owner prior to the interruption.

2. When rehabilitating manholes or wet wells, the material for stopping active leaks and repairing nonleaking holes, cracks, etc. in concrete and masonry manholes shall be compatible with the lining/ coating system used for rehabilitation.

3. When applicable, the manhole or wet well lining/coating system shall not be installed until all main sewer lining and other manhole rehabilitation work is complete, as applicable.

E. Substitutions:

1. Should the Subcontractor wish to use any brand or type of material other than as specified herein, he shall so state in writing to the Purchaser naming the proposed substitution and manufacturer. This statement shall be accompanied by a certificate of compliance from an approved independent testing laboratory that the proposed substitute meets or exceeds the specified requirements and has been tested in accordance with the specified test standards. The statement shall also include documented proof that the proposed brand or type of material has a proven record of performance when used in the intended application as confirmed by actual field test or successful installations.

1.02 SUBMITTALS

A. Unless otherwise specified all sample submittals shall be delivered to the Purchaser within two weeks of the NTP.

B. Site Subcontractor emergency phone numbers.

C. Schedules of work on a weekly basis that will be delivered no later than 2:00 PM on Thursday for the week following with daily AM email updates of approximate crew locations each day. Weekly schedule format shall contain a map, with sufficient streets labeled and identified at a scale to provide clarity, along with the nature and type of crew located by map area.

D. Product Data on the following:

1. Crack and hole repair products.

2. Cementitious plug and/or repair material.

3. Active Leak-Stop Material

4. Frame and cover seals.

5. Corrosion resistant lining/ coating system including surface preparation, application requirements, and chemical resistance data.

6. Gasket Polymer Properties

E. Manufacturer's Certificate of Compliance for each type of product that product furnished meets requirements of this Section.

F. Manufacturer's written recommendations for product handling and installation.

G. Confined space entry plans.

H. Plan for diversion of flow during installation.

I. Subcontractor shall submit to the Purchaser (when requested) evidence indicating that the proposed applicators are fully qualified to perform the work, and any proposed applicator found to be not qualified shall (at the written request of the Purchaser) be removed forthwith by the Subcontractor.

J. The lining/ coatings manufacturer shall warranty the entire project to include any and all aspects of the surface preparation, base material installation and protective coating applications for a period of TEN (10) YEARS from the date of acceptance by the Purchaser. The warranty shall make no distinction between installation practices and material performance and shall not be prorated with respect to elapsed time for the entire warranty period. Manufacturer shall, within a reasonable period of time after receipt of written notice thereof by the Purchaser, period not to exceed sixty (60) calendar days, repair defects in materials or workmanship during said TEN (10) year period, and any damage to other work caused by such defects or repairing of same at his own expense and without cost to the Purchaser.

1.03 DELIVERABLES

A. Provide post-rehabilitation MACP inspection for each manhole and inspections report for each wet well.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. The Subcontractor will furnish and maintain in good condition all equipment and facilities as required for the proper execution and inspection of the Work. All equipment and facilities will be on site and approved by the Purchaser before work will be permitted to begin.

2.02 MATERIALS

A. Manhole and Wet Well Lining/Coating System

1. The Subcontractor shall apply the manhole or wet well lining/coating system material on a sample area not less than four square feet (4 ft^2) in size. When approved, the sample area shall serve as a standard of acceptance for all further work.

2. All manholes or wet wells shall be lined/coated either in their entirety or to the water level as indicated on the maps and Drawings.

3. Spray applied or centrifugally cast manhole or wet well lining/ coating system:

   a. The material applied onto the surface of brick or concrete manholes or concrete wet wells shall be a lining/ coating system consisting of a base coat and/or top coat to provide corrosion resistance within a sanitary sewer environment. The thickness of the base coat and top coat shall meet the manufacturer's recommendation. Where applicable, the lining/ coating shall be applied to the roof, fillets, hatch frames, and underside of hatch surfaces. Subcontractor can request to not use a base coat but must provide to the Owner and Purchaser evidence of successful installations of the product without using a base coat and its capability to properly adhere to the manhole wall and form a smooth finish on the wall, bench, and invert. In cases where the base coat is not used, the thickness of the top coating will be increased by the base coat thickness listed above.

   b. The top coat applied shall be an approved polymer based polyurethane, a geopolymer, or a high-build solvent free epoxy product in conjunction with a high-strength cementitious repair/patch/base coat. The following products are acceptable and approved: CCI Spectrum, LLC "Spectrashield Liner System", OBIC "Armor 1000", Vortex Companies "Structure Guard", Quadex "GeoKrete Geopolymer Mortar Lining System", or Inland Pipe Rehabilitation (IPR) "EcoCast Lining System".

   c. The installer shall warrant and save harmless the Owner and his Purchaser against all claims for patent infringement and any loss thereof. The Subcontractor shall handle and store all material and shall dispose of all wastes in accordance with applicable regulations.

   d. Each system shall be designed for application over damp (but not active running water) surfaces without degradation of the final product and the bond between the product and the manhole surfaces. Active leaks shall be stopped using a premixed fast-setting, volume-stable waterproof cement plug consisting of hydraulic cement, graded silica aggregates, special plasticizing and accelerating agents or urethane injection. It shall not contain chlorides, gypsum, plasters, iron particles, aluminum powder or gas-forming agents, or promote corrosion of steel it may come in contact with. Set time shall be approximately 1 minute. Ten-minute compressive strength shall be approximately 500 PSI.

   e. Where specified on the Drawings, all invert channels shall be coated with the protective top coat only to prevent infiltration and to build up the invert channel to the new sewer main invert elevations; to fill all voids, cracks, holes, etc.; and to form a smooth flow channel. The entire channel/ wet well bottom shall be coated where specified. The coating thickness shall be in accordance with manufacturer's recommendations.

B. Mortar

1. Mortar shall be composed of one part Portland cement and two parts sand (volumetric measure) thoroughly mixed in a tight box, with water added gradually and mixed continually until mortar has attained the proper consistency for use in brick masonry; prepared only in such quantities as needed for immediate use; mortar mixed for more than 30 minutes, retempered, or previously set will not be allowed.

PART 3 EXECUTION

3.01 PRELIMINARY AND GENERAL ITEMS

A. Notify all property owners who discharge sewage directly to the manhole being surfaced that their service will be discontinued while the lining/ coating is being placed, cured, and active pipe and service connections reopened. The Subcontractor shall notify individual property owners at least 72 hours in advance, giving the date, start time, and estimated completion time for the work being conducted. This notification shall be coordinated with the door hanger distribution.

3.02 INSPECTION

A. Traffic Control

1. All traffic control shall be installed and maintained in accordance with the Manual on Uniform Traffic Control Devices (MUTCD). At a minimum, the Subcontractor must have two trucks with flashing yellow lights on the work site. Traffic cones must also be placed downstream of the construction site to divert cars into the adjacent lane(s) per MUTCD requirements. On roads with heavy traffic volume, a flagman may also be needed to assist with traffic control.

B. Fall Protection

1. Subcontractor shall install and maintain all fall protection measures in accordance with the SARP10 Loss Control Manual. The Subcontractor shall construct a controlled access zone around the manhole or wet well being adjusted. At a minimum, the fall protection zone shall include traffic cones encircled with pennant tape. The controlled access zone must have one point of access with an entrance log.

C. Cleaning/Surface Prep

1. All manholes or wet wells to be rehabilitated shall be thoroughly cleaned before rehabilitation. All grease, oil, laitance, coatings, loose bricks, mortar, unsound concrete and other foreign materials shall be completely removed. Debris resulting from cleaning shall be removed from the manhole or wet well and not allowed to be carried downstream.

D. Flow Control

1. The Subcontractor shall be responsible for plugging or diverting the flow of sewage as needed for repair and lining/coating of manhole inverts and benches or interior of wet well.

E. Bypass of Flow

1. As required for acceptable completion of the work and/or to avoid damages due to sewer spills or overflows, the Subcontractor shall provide for sewer flow maintenance around the manholes or wet wells designated for rehabilitation. The bypass shall typically be made by plugging the line at an existing upstream manhole and pumping the flow into a downstream manhole or adjacent sanitary sewer system. The pump and bypass lines shall be of adequate capacity and size to handle the anticipated flow. Bypassing of sanitary sewage into the storm water system will not be allowed. For all bypass pumping, pump noise shall be kept to a minimum to the satisfaction of the Purchaser. The Subcontractor shall be required to contact all residential and commercial customers whose service lines connect to the sewer main being bypassed and inform them that they

will be temporarily out of service. The Subcontractor shall also advise those customers against water usage until the mainline is back in service. After completing the necessary work on the main line, the Subcontractor shall advise those customers that the sewer main is back in service.

2. Bypass pumping is defined as providing pumps, standby pumps, piping, elevated structural support for aerial crossings, manpower to operate, routine maintenance and repair capability, pipe plugs, fuel, route and pump site clearing and any other work necessary to provide a complete bypass pumping operation. Any structures proposed by the Subcontractor for construction over or penetration into the interceptor piping for the purpose of performing the bypass operations must be approved by the Purchaser prior to implementation. The Subcontractor shall submit design drawings and details that are signed and sealed by a professional engineer licensed in the State of Tennessee. All bypass pump schemes must be submitted to and approved by the Purchaser in advance.

3. Public advisory services will be required to notify all parties whose service laterals will be out of service and to advise against water usage until the mainline is back in service.

4. The Subcontractor will be required to provide businesses with temporary service, as needed, and will be responsible for all necessary bypass pumping flows.

F. Wastewater Spills

1. Should the Subcontractor spill any wastewater, such that the sewage either immediately or ultimately enters the waters of the State of Tennessee, then the Subcontractor will be completely responsible for any fines or penalties imposed on the Purchaser or the Subcontractor by the USEPA or the State of Tennessee.

G. Manhole Modification for CIPP Installation

1. If the Subcontractor deems it necessary to temporarily modify a manhole for CIPP installation, he shall submit a drawing detailing the modification. The drawing must be stamped by a licensed Professional Engineer in the State of Tennessee and approved by the Purchaser prior to modification.

H. Safety

1. The Subcontractor shall carry out his operations in strict accordance with all applicable OSHA and SARP10 standards. Particular attention is drawn to those safety requirements involving work on an elevated platform and entry into a confined space.

3.03 MANHOLE AND WET WELL REHABILITATION

A. Protective Lining/Coating System

1. The surface prior to spraying shall be damp without noticeable water droplets or running water. Materials shall be spray applied to a minimum uniform thickness to ensure that all cracks, crevices, and voids are filled and a smooth surface remains after light troweling. Perform light troweling to compact the material into voids and to set the bond. All manhole steps shall be removed prior to the lining/ coating being applied.

2. Application procedures shall conform to the recommendations of the protective lining/ coating manufacturer, including handling, thickness, mixing, environmental controls during application, safety, and spray equipment.

3. The equipment shall be specifically designed to accurately ratio and apply the base coat and top coat materials and shall be well maintained and in proper working order for the duration of the Work.

4. The lining/coating must be applied by a “Certified Applicator” of the protective lining/ coating manufacturer.

5. Specified surfaces shall be coated by moisture tolerant, solvent-free, protective lining/ coating system exhibiting properties described in these specifications.

6. Equipment approved by the lining/ coating manufacturer shall be used to apply each coat of the protective lining/ coating.

7. If necessary, subsequent top-coating or additional coats of the protective lining/ coating shall occur as soon as the base coat becomes tack-free, ideally within twelve (12) hours but not later than the recoat window for the specified products. Additional surface preparation procedures shall be required if the recoat window is exceeded.

8. The bench covers used to catch debris shall be removed and the bench and invert sprayed such that a gradual slope is produced from the walls to the invert. The wall-bench intersection shall be rounded to a uniform radius the full circumference of the intersection.

9. No application shall be made to frozen surfaces or if freezing is expected to occur within the manhole for 24 hours after application. If ambient temperatures are in excess of 95°F, precautions shall be taken to keep the mix temperature at time of application below 90°F, using ice if necessary.

10. The final application shall have a minimum of four (4) hours cure time before subjected to actual flow.

3.04 MANHOLE AND WET WELL REHABILITATION ACCEPTANCE

A. After the manhole or wet well rehabilitation work has been completed, the manhole or wet well shall be visually inspected by the Subcontractor in the presence of the Purchaser’s Representative and the work shall be accepted if found satisfactory to the Purchaser’s Representative. The finished surface shall be free of blisters, “runs” or “sags” or other indications of uneven coating thickness. No evidence of visible leaks shall be allowed.

B. After the protective lining/coating has set hard to the touch, it shall be inspected with high-voltage holiday detection equipment. The surface shall first be dried, an induced holiday shall then be made onto the lined/ coated concrete surface and shall serve to determine the minimum/maximum voltage to be used to test the lining/ coating for holidays at that particular area. The spark tester shall be initially set at 100 volts per 1 mil (25 microns) of film thickness applied but may be adjusted as necessary to detect the induced holiday. All detected holidays shall be marked and repaired by abrading the lining/ coating surface with grit disk paper or other hand tooling method. After abrading and cleaning, additional protective lining/ coating material can be hand applied to the repair area. All touch-up/repair procedures shall follow the protective lining/ coating manufacturer’s recommendations.

C. The Purchaser reserves the right to reject any and all manholes that do not pass holiday testing requirements, and replacement shall be at the Subcontractor’s expense. A significant number of leaks on a single manhole or significant number of manholes leaking shall be considered as a basis for rejection and replacement of manholes.

3.05 WARRANTY AND GUARANTEE FOR REHABILITATED MANHOLES AND WET WELLS

A. The Subcontractor shall guarantee the rehabilitated manholes or wet wells for ten (10) years after acceptance by the Purchaser to the extent that he will repair any leaks that may appear in them during this period because of faulty workmanship or materials furnished by him at no additional expense to the Owner.

PART 4 MEASUREMENTS & PAYMENTS

4.01 MEASUREMENTS

A. Standard Manhole and Wet Well Lining/Coating

1. A protective lining/coating system consisting of a base coat and top coat with thicknesses in accordance with manufacturer's recommendations shall be measured per vertical foot of manhole from the downstream invert or water level up to the bottom of the frame casting or interior of wet well where specified on the maps and Drawings.

B. Additional Leak-Stop Grouting

1. Additional continuous leak-stop grouting beyond four hours per manhole or wet well structure shall be measured per hour.

C. Traffic Control

1. Traffic control will be measured per each manhole or wet well rehabilitated.

D. Dewatering

1. Dewatering is considered to be an incidental to sewer manhole or wet well rehabilitation.

E. Bypass Pumping

1. Bypass pumping shall be measured as a lump sum item.

4.02 PAYMENT

A. Standard Manhole and Wet Well Lining/Coating

1. A standard manhole lining/ coating shall be paid for per vertical foot and shall include consist of surface preparation, up to four hours of continuous leak-stop grouting, sprayed on lining/ coating, removal and disposal of manhole steps, and holiday testing.

B. Additional Leak-Stop Grouting

1. Additional continuous leak-stop grouting beyond four hours per manhole structure shall be paid for per hour. This item includes all materials and labor necessary to complete the grouting.

C. Traffic Control

1. Traffic control will be paid per each manhole or wet well rehabilitated including all

appurtenances required to comply with MUTCD standards.

D. Bypass Pumping

1. Bypass pumping will be paid as a lump sum item. This item includes all materials and labor necessary to properly comply with the bypass pumping requirements listed in the specification.

4.03 PAYMENT WILL BE MADE UNDER:

Item No.	Pay Item	Pay Unit
02537-4.02.A	STANDARD MANHOLE AND WET WELL LINING/COATING	VF
02537-4.02.B	ADDITIONAL LEAK-STOP GROUTING	HOUR
02537-4.02.C	TRAFFIC CONTROL	EACH
02537-4.02.D	BYPASS PUMPING	LUMP SUM

END OF SECTION 02537

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SECTION 02630
SITE PREPARATION AND RESTORATION

PART 1 GENERAL

1.01 SCOPE

A. This Work shall consist of the removal of brush, rubbish, fences, structures, abandoned appliances, building foundations, all trees, shrubs and plants not to be protected, and all other obstacles within the right-of-way / easement limits shown on the Plans and/or in the Special Instructions; the disposal of debris; and the restoration and/or protection of trees, shrubs, plants, fences, turfed areas, and structures after construction of drainage facilities is completed.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. All equipment for the satisfactory performance of the work shall be on the project and approved before the work will be permitted to begin.

PART 3 EXECUTION

3.01 RIGHT-OF-WAY AND EASEMENT

A. The Subcontractor shall confine his construction activities within the rights-of-way and/or easements as shown on the Plans and easement/rights-of-way plats provided by the owner. The Subcontractor shall be responsible for obtaining written agreements for use of private property outside of City of Memphis acquired rights-of-way/easements for such purposes as storage of material and equipment and access to the construction site. The Subcontractor shall provide a copy of all such written agreements to the Purchaser immediately upon obtaining the necessary documentation.

3.02 EXISTING OBSTRUCTIONS

A. Where applicable, locations of obstructions shown on the Plans are approximate and are shown only for information purposes and are not intended as an accurate location of such obstructions. Obstructions not shown on the Plans but encountered by the Subcontractor shall be removed as necessary and, if directed by the Owner, replaced in their original state or protected by the Subcontractor at no additional cost to the Purchaser.

3.03 REMOVAL OF VEGETATION

A. The rights-of-way/permanent easements shown on the Plans and right-of-way/easement plats shall be cleared of all dead trees, living trees, stumps, brush, projecting roots, hedge, weeds, pole stubs, logs, and other objectionable material, vegetation and growth. This work shall include the removal of all trees, shrubs, and plants not suitable for moving and replanting as determined by the Owner. All trees, stumps, roots, pole stubs, brush, hedge, and other protruding obstructions within the rights-of-way/easements shall be removed to within 3 inches of existing ground. This work shall be done well in advance of excavation operations. Trees and shrubs to be replanted shall be extracted with an ample ball of earth around roots so that transplanting may be successful. The root ball shall be wrapped in burlap. Vegetation stored for replanting shall be watered sufficiently to protect the root system from dehydration.

B. Low hanging branches and unsound branches on trees or shrubs designated to remain, shall be removed. All trimming shall be done by skilled workmen and in accordance with good tree surgery practices.

3.04 REMOVAL OF OBSTRUCTIONS

A. Existing fence material and posts within the rights-of-way/easement limits shown on the Plans and right-of-way/easement plats shall be moved from the construction area and stored in such a manner as to protect them against damage. The Subcontractor shall be responsible for the condition of the removed fence material and posts. The Subcontractor shall demolish and remove all structures and structure foundations within the rights-of-way/easement limits unless otherwise instructed by the Purchaser. Such structures and foundations shall be removed to 12 inches below the subgrade elevation or as directed by the Purchaser. If permitted by the Purchaser, the Subcontractor shall backfill basements, cisterns, and the like in an approved manner. The Subcontractor shall remove all abandoned vehicles, appliances and rubbish within the rights-of-way/easement limits.

3.05 PROTECTION OF OBSTRUCTIONS OUTSIDE RIGHT-OF-WAY/EASEMENT LIMITS

A. The Subcontractor shall protect and avoid damage to all trees, shrubs, plants, fences, turfed areas, structures, and all other objects outside of the right-of-way/easement limits shown on the Plans and right-of-way/easement plats from damage due to construction operations. Damage caused by the Subcontractor shall be repaired or restored at no cost to the Purchaser. Particular care shall be used to avoid damage to trees, shrubs, bushes, turfed areas, and private property located adjacent to rights-of-way/easements on private property. No trees, plants, turfed areas, or other objects outside such limits shall be disturbed or damaged without the written permission of the property owner.

3.06 SPECIAL PROTECTION OF OBSTRUCTIONS INSIDE EASEMENT LIMITS

A. Wherever the underground installation of drainage facilities conflicts with other improvements previously made by the Purchaser, other governmental bodies, or adjacent property owners, the Contractor shall be responsible for their protection and preservation, including necessary removal and storage of such improvements, and subsequent replacement to obtain, to the fullest extent possible, the undisturbed condition.

3.07 DISPOSAL OF DEBRIS

A. All trees, brush, logs, snags, leaves, sawdust, bark, construction debris, and refuse shall be collected and disposed of in accordance with all applicable City codes and ordinances. Debris shall be removed from the site as soon as practical and shall not be left until the completion of the contract. If burning of debris is allowed by the Purchaser, the Subcontractor must obtain and pay for a permit from the City of Memphis Department of Fire Prevention and all precautions necessary shall be exercised to prevent the spread of fire and such burning shall be in accordance with Division 1, “General Requirements” of these Specifications. Burning shall be done only at approved locations and in conformity with the laws, ordinances, and requirements of agencies and officials having jurisdiction. When materials are to be disposed of, the Subcontractor shall obtain written permission before hand from the property owner on whose property the disposal is to be made and shall file a copy of such permit with the Purchaser. Unless otherwise provided in the Contract Documents, the Subcontractor shall make his own arrangements for disposing of such materials off site.

3.08 REPLACEMENT OF VEGETATION

A. As soon as backfill operations permit, the Contractor shall replace transplanted trees, shrubs, and plants. The Contractor shall properly water the transplanted vegetation immediately upon

replanting and at suitable intervals thereafter. If shrubs, plants, or trees die after transplanting and before final acceptance of the Work, the Contractor shall, at his expense, replace same with equal shrubbery, plants, or trees.

3.09 REPLACEMENT OF FENCES

A. Any fences disturbed within the rights-of-way/easement limits shall be replaced to the satisfaction of the Purchaser. Fences in such poor condition that they cannot be removed and replaced shall be replaced with new fence material similar in original quality, size, and appearance to the removed fence or a written release shall be obtained from the property owners. For chain link fence, new fence materials and construction methods shall conform to the requirements of Specification Section 02820. For box culvert or pipe construction, any fences removed shall be replaced in their original location. Any fence damaged during construction shall be restored to original or better condition. For channel lining construction, removal of fences shall be performed with care and the fence rolled up or stacked and stored on the owner's property. All side yard fences within the easement shall be replaced or extended to the new channel with in-kind fence material.

3.10 ESTABLISHMENT OF TURFED AREAS

A. After final restoration of settled trench surfaces, all areas within the right-of-way or permanent easement limits which were established turfed areas prior to construction will be seeded in accordance with Specification Section 02920 All cut or fill slopes constructed for new drainage facilities will be seeded in accordance with Specification Section 02920 and in conformity with City cross-sections.

3.11 RESTORATION OF OTHER TURFED AREAS

A. All areas outside the right-of-way, permanent easement, or cut and fill slopes shall be restored as nearly as practical to their original condition at the Contractor's expense. Finished lawn areas upon which earth has been deposited shall be cleared to the level of the existing sod and then raked and watered. Areas where sod has been damaged, destroyed, or ruts have been filled in shall be reseeded. Areas where sod is only slightly damaged may be lightly reseeded, if so permitted by the Purchaser. Seeding materials and construction methods shall conform to the requirements of Specification Section 02920.

PART 4 MEASUREMENT & PAYMENT

4.01 MEASUREMENT

A. Site Prep and Restoration

1. No measurement of area will be made. When changes in the Contract Documents affect the rights-of-way/easement area, a proportionate adjustment for the increased or decreased area will be made.

2. This work will be required within the construction limits and will not be paid for directly but will be considered as a subsidiary obligation of the Subcontractor under other contract items.

END OF SECTION 02630

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SECTION 02631
EARTHWORK

PART 1 GENERAL

1.01 SCOPE

A. This Work shall consist of all types of excavation, special protection, protection of existing utilities, backfilling, and grading for all types of drainage facilities including such labor, material and equipment, and all other items as may be necessary to complete the earthwork as shown on the Plans, stipulated in the Contract Documents, or directed by the Owner.

PART 2 PRODUCTS

2.01 MATERIAL

A. Lumber. Lumber to be used for bracing trenches shall be no less than 2 inch thick rough cut oak.

B. Pit Run Gravel. Pit run gravel shall consist of one of the three gradations shown in the table below.

1. Total Percent, by Dry Weight, Passing Each Sieve (U.S. Standard)

Size No.	2 ½ "	2"	1 ½ "	1"	3/8"	No. 40	Clay*
1	100	95-100			35-65	10-30	1-12
2		100	95-100		40-65	10-30	1-12
3			100	90-100	45-65	10-35	2-12

* Clay content shall be determined by the Hydrometer Test – AASHTO T 88. Clay content up to 15 percent may be used with the approval of the Owner.

2. That portion passing the No. 40 sieve shall be known as the binder. The binder aggregate shall consist of hard durable particles of limestone or a sound silicious material. Shale aggregate or pipe clay binder will not be acceptable, and in no case shall the percent of silt exceed the percent of clay by more than 25 percent.

3. If the binder material is insufficient to properly bond the aggregate, a satisfactory binding material may be incorporated, as approved by the Owner, so that the resultant mixture will comply with these Specifications. The mixing shall be done uniformly, and blending of materials on stockpiles or in the pits by bulldozers, clamshells, draglines, or similar equipment will not be permitted.

C. Backfill Material. Material for backfill shall be fine compactible soil selected from site excavation if approved by the owner as being suitable. Additional material needed shall be obtained from borrow excavation.

2.02 EQUIPMENT

A. All equipment necessary for the satisfactory performance of this work shall be on the Project and approved before work will be permitted to begin.

PART 3 EXECUTION

3.01 EXCAVATION

A. General. All excavation performed under this Section including trench excavation, structure excavation, and channel excavation but excluding undercut will be considered unclassified excavation regardless of the nature of the material and objects excavated and will not be measured or paid for separately except as specifically noted herein. Pavement removal and replacement shall be accomplished as specified in Specification Section 02950.

1. Undercut Excavation.

   a. Undercut excavation shall consist of removing and disposing of soft, spongy earth, muck, mud, unconsolidated fill, organic matter, and any other unsatisfactory materials below the grade established on the Plans for storm drains, structures, and channels where determined necessary by the Owner. No undercut excavation shall be performed without prior authorization of the Owner in writing. The limits of undercut excavation will be determined by the Owner, who will be present during the undercut operations.

   b. Undercut areas shall be backfilled with suitable material to the grade established on the Plans. The backfill shall be placed in 6 inch maximum lifts and compacted by use of a roller or vibratory compactor.

2. Unauthorized Excavation Below Subgrade or Outside of Limits. All unauthorized excavation carried beyond or below the lines and grades given by the Plans or Contract Documents, together with the removal of such excess excavated materials, and the cost of refilling the space of such over dig or unauthorized excavation, shall be at the Contractor's expense. The excess space between the undisturbed bottom and sides of the excavation and subgrade limits shown on the Plans for storm drain pipe shall be refilled with suitable material and compacted per Specification Section 02631, Paragraph 3.01.A.1b unless otherwise directed by the Owner. The excess space between the undisturbed bottom of the excavation and subgrade elevations shown on the Plans for box culverts and concrete channel lining shall be refilled with suitable material and compacted per Specification Section 02631, Paragraph 3.01.A.1b. The unauthorized excavation outside of side excavation limits shall be backfilled with select material unless otherwise directed by the Owner. The backfill shall be compacted in accordance with Specification Section 02631, Paragraph 3.01.A.1b.

3. Change in Excavation Location or Grade. If the Owner orders in writing that the location or grade of a proposed drainage facility be changed from that shown on the Plans, the following provisions will apply.

   a. If the change is made before excavation work has begun and the facility being constructed is covered in the Proposal Sheet(s) by pay items with appropriate depth classifications (pipes, manholes, and similar items), the appropriate pay item will apply to the new depth measurements along the changed centerline. If the changed location or grade introduces a new depth classification not included in the Proposal Sheet(s), a Change Order or Construction Change Order will be prepared in accordance with Specification Section 00710 Article 9 "Changes". If the facility being constructed is not covered in the Proposal Sheet(s) by pay items with depths classifications (box culverts, concrete channel lining, unlined channel, inlets, junction structures, etc.) and if the average depth of excavation per linear foot at the changed location or grade is within 10 percent of the original Plan quantity, there will be no change in the unit price for this work and no additional compensation (or reduced compensation) will be allowed for the change. If the average depth of excavation per linear foot at the changed location is more than 10 percent above or below original

Plan quantities, a new unit price for the actual excavation depth will be established. For purposes of comparing changed quantities to Plan quantities, a 1 foot wide strip will be assumed from natural ground line to invert along both the revised and original locations; quantities will then be calculated for the 1 foot wide strip along both conditions and then divided by the proper lengths.

b. If the change is made after excavation has already begun on the original Plan location, the procedures described above will apply to payment for work along the changed location. If abandonment of an existing excavation or a portion of an existing excavation is required due to a change by the Owner, the Contractor will be compensated for the backfilling and restoration of the abandoned excavation. Backfilling and restoration of the abandoned excavation will be accomplished in accordance with the appropriate section of these Specifications.

c. Filling a portion of existing excavation to meet changed grades will be accomplished in accordance with Specification Section 02631 Paragraph 3.01.A.1b.

d. If a change in location and/or grade is authorized in writing by the Owner at the written request of the Contractor; whether before or after excavation work has begun; the Contractor will not receive and additional compensation whatsoever for the changed work even though lengths and/or depth of excavation may be greater than original Plan quantities. Backfilling and restoration of abandoned excavation work will be accomplished totally at the Contractor's expense. If changes requested by the Contractor result in reduced lengths and/or depth of excavation, the revised quantities using Proposal unit prices or Change Orders/Construction Change Orders as appropriate will be used to develop payment.

4. Disposition of Excavated Material.

a. Excavated materials suitable for backfill shall be stored no closer than 2 feet from the edge of the excavation, unless a greater distance is required by OSHA or other applicable regulations, to allow free passage of the Owner and permit the Owner to perform his work in an expeditious and safe manner. Excavated material shall not obstruct crosswalks, sidewalks, street intersections, nor interfere unreasonably with travel on streets by occupants of adjoining property. Gutters or other surface drainage facilities shall not be obstructed. When clear access to fire hydrants, mail boxes, sewer and conduit manholes, and similar utility or municipal service facilities is required, the Contractor must provide such access. Excavated material intended for backfill shall be stored in such a manner as to minimize loss of excavated material due to erosion.

b. All materials excavated, disturbed, damaged, or removed by the Contractor and not to be used for refilling trenches, channels, or structure excavations or to be used in restoration of subsurface or surface facilities or conditions, shall be removed from the site and disposed of by the Contractor, unless otherwise directed. The City reserves the right to retain excess excavation material and direct the Contractor to deliver it to a site specified by the Owner at the Contractor's expense. If the Contractor proposes to store or place such excess excavated material upon any property, written consent of the property owner or owners must be secured in advance and a certified copy thereof be filed with the Owner. No surplus or excess materials shall be deposited in any stream channel nor in any place where preconstruction surface drainage would be changed, without written permission of the Owner.

5. Control of Storm Water.

a. The Contractor shall keep all excavations free of water. He shall provide all dams, flumes, channels, sumps, or other works necessary to keep the excavation entirely clear of water and shall provide and operate pumps or other suitable equipment of adequate capacity for dewatering the excavations. He shall avoid producing mud in the trench or channel bottom by his operations. If necessary or so ordered by the Owner, the Contractor shall place pit run gravel at his own expense to maintain a firm, dry excavation bottom and base. Pipe bedding, laying, jointing, and the placing of concrete or masonry shall be done in a water free trench or excavation, which shall be kept clear of water until pipe joints, concrete and masonry have set and are resistant to water damage. The water shall be disposed of at the Contractor's expense.

b. All gutters, pipes, drains, conduits, culverts, catch basins, inlets, ditches, creeks, and other storm water facilities shall be kept in operation, or their flows shall be satisfactorily diverted and provided for during construction. Any facilities disturbed during construction shall be restored to the satisfaction of the Owner.

c. Control of storm water and dewatering water shall conform to all TDEC and City of Memphis standards. Water from dewatering shall be pumped through a sediment bag or other suitable sediment removal device prior to discharge.

6. Excavation Around Obstructions.

a. The Contractor shall perform all excavation by hand where excavation by machinery would endanger trees, structures, or utilities which otherwise might be saved by the use of hand excavation.

b. The Contractor shall cautiously excavate test holes to locate the limits of underground obstructions anticipated within the excavation. When a water pipe, gas pipe, sewer, or similar utility comes within the limits of the trench, such facilities shall be properly supported.

B. Trench Excavation.

1. All trenches shall be open cut unless otherwise shown on the Plans. Trenching practices shall comply with all applicable local, state, and federal regulations. Tunneling, boring, or jacking will be allowed only on permission of the Owner, unless otherwise shown on the Plans, and a complete record thereof shall be kept in the Contractor's project diary.

2. The Contractor shall be responsible for prosecuting the work in accordance with the grades and lines shown on the Plans or as directed by the Owner. Trenches may be excavated by machinery to a depth that will not disturb the finished subgrade. The remaining material shall be hand excavated so that the pipe may be laid on a firm, undisturbed subgrade.

3. No more than 300 feet of trench shall be opened at any time in advance of the completed storm drain, nor shall more than 100 feet be left unfilled except by written permission from the Owner. In special cases the Owner may limit the distance to which the trench may be opened by notifying the Contractor in writing.

4. The width of trenches below a level 1 foot above the outside top of pipe shall be such as to leave not less than 6 inches on each side of the outside of the pipe for all sizes up to and including 15 inch diameter pipe. Maximum trench width dimension for these pipe sizes shall be 36 inches. For 18 inch diameter pipe, the width of trenches below a level 1 foot above the outside top of pipes shall be such as to allow not less than 6 inches on

each side of the pipe, with a maximum trench width of 42 inches. For pipes sizes over 18 inches, the width of trenches below a level 1 foot above the outside top of the pipe shall be such as to allow not less than 12 nor more than 15 inches on each side of the outside top of the pipe. If the trench width at or below that level 1 foot above the outside top of pipe exceeds the widths specified, provision shall be made for the additional load upon the pipe at the Contractor's expense. For pipes other than circular, trench width shall be adjusted to provide for the additional pipe width along the along the horizontal axis.

5. The sides of the trench shall be as nearly vertical as possible. The bottom of the trench shall be carefully graded, formed, and aligned according to the Plans and to the satisfaction of the Owner before pipes are laid thereon.

6. The bottom of the trench shall be excavated at each joint of bell and spigot pipe to allow the body of the pipe a uniform contact and support throughout its entire length. When mortar joints are specified, bell holes shall be excavated at each joint in the pipeline to provide space underneath the pipe in which to properly build up mortar joints.

C. Excavation For Drainage Structures.

1. The Contractor shall be responsible for prosecuting the Work in accordance with the lines and elevations shown on the Plans or as directed by the Owner. The Contractor shall excavate as required for all structures with foundations carried to firm, undisturbed earth at the elevation of the underside of the structure.

2. The outside dimensions of all manholes, inlets, box culverts, channel lining, and other drainage structure excavations shall be at least 12 inches greater than the outside of the masonry or concrete work to permit backfilling around structure.

3. Where structures are to be built in street right-of-way or paved areas, the excavation shall not exceed 2 feet from the outside of the masonry or concrete work. In the event that the excavation exceeds this limit, the Contractor will be required, at his expense, to backfill the entire space around the structure with suitable material compacted as specified in Specification Section 02631 Paragraph 4.0.

4. For drainage facilities to be constructed in fill areas, the fill shall first be placed and compacted in accordance with these Specifications. The excavation for the drainage facilities shall then commence following the placement of fill.

D. Unlined Channel Excavation. The Contractor shall be responsible for prosecuting the Work in accordance with the grades and lines shown on the Plans or as directed by the Owner. The sides and bottom of the channel shall be excavated and shaped so as to conform with the cross-sections shown on the Plans or as directed by the Owner.

3.02 SPECIAL PROTECTION

A. Treacherous Ground. When running sand, quicksand, or other treacherous ground is encountered, the work shall be carried on with the utmost vigor and shall be prosecuted day and night should the Owner so direct.

B. Sheeting and Shoring.

1. The Contractor shall furnish, place, and maintain such sheeting and shoring as may be required to support the sides of any excavation to prevent earth movement that could endanger the work or workmen; or to prevent any earth movement which might in any way delay the Work, change the required width of the excavation, or endanger adjacent pavement, utilities, sewers, buildings, or other structures above or below the ground

surface; or to contain the construction within a specified area such as an easement or street right-of-way. The Contractor shall place this sheeting and shoring for such protective purposes without the Owner's instructions.

2. During the extraction of sheeting, care shall be exercised to prevent damage due to settlement or movement of new drainage facilities. The sheeted trench width, as measured between those faces of the sheeting in contact with the earth trench wall, shall not exceed the maximum width of trench specified in Specification Section 02631 paragraph 3.01.B. below an elevation 1 foot above the top of the pipe. Walers and struts shall be designed and installed to present no obstructions to proper placement of the pipe, bedding, cradle or encasement, nor shall they interfere with the satisfactory laying and jointing of the pipe.

3. Sheeting, bracing, and shoring shall be withdrawn and removed as the backfilling is being done, except where and to such extent as the Owner shall order that sheeting, bracing, and shoring be left in place, or where the Owner will permit the same to be left in place at the Contractor's request. The Contractor shall cut off any such sheeting at least 2 feet below the surface and shall remove the cutoff material from the excavation.

4. All sheeting, bracing, and shoring which is not left in place under the foregoing provisions shall be removed in a manner which will not endanger the completed work or other structures, utilities, sewers, or property whether public or private. The Contractor shall exercise care to prevent the opening of voids during the extraction process.

4. Steel drag shields or trench boxes may be used in lieu of sheeting, shoring, and bracing unless the Owner directs otherwise.

5. Sheeting and shoring systems shall be designed by a Professional Engineer licensed in the State of Tennessee.

C. Excess Width Of Trench. If the Contractor is permitted to use equipment that results in wider trenches than hereinbefore specified, concrete cradle or additional concrete cradle shall be used around pipe if required to resist the additional load caused by the extra width. The dimensions of this cradle will be specified by the Owner, and no extra compensation will be allowed for the additional material or work.

D. Blasting.

1. Blasting shall be under taken only after the Contractor has received written authorization from the Owner. With respect to the use of explosives in blasting, the Contractor shall apply for and receive all necessary permits and comply with all federal and state laws, rules, ordinances and regulations and requirements of the insurer governing the keeping, storage, use, manufacture, sale, handling, transportation, or other disposition of explosives. The Contractor shall provide additional liability insurance to the City, with limits and coverages as specified by the Owner, covering blasting operations in advance of any blasting. All operations involving the handling, storage, and use of explosives shall be conducted with every precaution under the supervision of a properly licensed individual. The Contractor shall take special precautions for the proper use of explosives both at or near the top of the excavation and in the excavation in order to prevent harm to human life and damage to surface structures, utilities, sewers, or other subsurface structures. The Contractor shall advise the Owner in advance when charges are to be set off. Blasts shall not be fired until all persons in the vicinity have had ample notice and have reached positions of safety.

2. Storm drains shall be carefully protected from all blasts, and all excavations requiring blasting shall be fully completed at least 30 feet in advance of the laying of the pipe. In

all cases, the mouth of the pipe shall be provided with a board or other stopper carefully fitted to the pipe to prevent all earth or other substances from entering.

3. After a blast is fired, the Contractor shall thoroughly scale the excavation. All loose shattered rock or other loose material which may be dangerous to the workmen, pipe, or structure shall be removed and the excavation made safe before proceeding with the Work. The fact that the removal of loose, shattered rock or other loose material may enlarge the excavation beyond the required width will not relieve the Contractor from making such removal and filling the extra space. The Contractor shall not be entitled to extra compensation therefore.

E. Wellpoints. The Contractor shall use wellpoints, sump pumps, or any other method of dewatering as required to lower the water table below the bottom of the excavation. He shall make a request to the Owner and receive approval of the use of special dewatering equipment other than well points or sump pumps. Dewatering operations are considered incidental to the Work and no additional compensation shall be made to the Contractor.

F. Underpinning. When excavations require underpinning of existing structures, the Contractor shall submit shop drawings of underpinning details to the Owner prior to commencement of excavation below the foundation of the structure. Review of underpinning details by the Owner shall not relieve the Contractor of his responsibility for protection of the structure and its contents.

3.03 EXISTING UTILITIES

A. Location.
The Plans indicate the available records of location of existing structures and facilities, both above and below the ground, but the City assumes no responsibility for the accuracy or completeness of this information. Utility service connections are not shown on the Plans, but can be encountered at any location on the Project. If it is necessary to adjust or relocate any utility, it shall be the Contractor's responsibility to coordinate the work with the appropriate utility. Any cost or delays incurred by the Contractor in this activity shall be incidental and no additional compensation will be made.

B. Protection.

1. If the construction of the storm drains, structures, or channel requires the removal and replacement or protection of any overhead wires or poles, the Contractor shall make satisfactory arrangements for such work with the owner or owners of such wires and poles and no additional payment will be made by the City.

5. The Contractor shall protect any sewer or utility within the limits of the construction. The Contractor shall proceed with caution in any excavation and shall use every means to determine the exact location of underground structures, pipe lines, conduits, and similar obstructions prior to excavation in the vicinity thereof. The City will not be responsible for the cost of protection or repair or replacement of any structure, pipe line, conduit, service connection, or similar facility above and below ground which may be broken or otherwise damaged by the Contractor's operations. All water and gas pipes and other conduits adjacent to or crossing the excavation shall be properly supported and protected by the Contractor.

6. The Contractor will be responsible for all permits and permissions for crossing other utilities.

C. Service Connections.

1. Sewer and utility services between mains and buildings shall be maintained and adjusted as necessary by the Contractor so as to provide as nearly a continuous operation as reasonably can be expected. This shall be accomplished in any way that the Contractor may desire, provided that the individual service not be inoperative more than two consecutive hours. The occupants shall be notified by the Contractor at least six hours in advance of such service interruptions. When a break occurs, the Contractor shall notify the affected occupant(s) of the probable length of time that the service will be interrupted.

2. If existing underground facilities or utilities require removal and replacement for the prosecution of this Work, all replacements of such underground construction or parts thereof shall be made with new materials conforming to the requirements of these Specifications or, if not specified, as approved by the Owner.

3. The removal and replacement of water services to accommodate new construction shall be the Contractor's responsibility within the limits where the new service line grade blends smoothly with the existing service line grade. This work will be incidental to the construction of the drainage facility and no additional compensation will be made.

4. The removal and replacement of sewer services to accommodate new construction shall be the Contractor's responsibility from the sewer main to a point where the new grade and existing grade can be matched. Payment will be made in accordance with Specification Section 02631 Paragraph 5.05.

5. The Contractor shall be responsible for any damage to the service as a result of his operations. The City does not guarantee the number, size, condition, nor length of adjustment necessary to bring a service to a new grade.

3.04 BACKFILLING

A. General.

1. Bedding for drainage facilities shall be constructed in accordance with the following specifications for the various type facilities:
   a. Storm Drain Pipe: Specification Section 02632 Paragraph 3.02.B
   b. Manholes, Inlets and Special Structures: Specification Section 02640 Paragraph 3.02
   c. Reinforced Concrete Box Culverts: Specification Section 02641 Paragraphs 3.02.B and 3.01.B
   d. Applicable details on the Contract Drawings.

   After drainage facilities have been bedded and installed in accordance with appropriate specifications and upon permission of the Owner, the backfill may be placed. No trash will be allowed to accumulate in the space to be backfilled. Particular care shall be taken to avoid allowing wood to be included in the backfill, other than sheeting and shoring that has been approved to be left in place.

2. The Contractor shall at all times be responsible for the condition of the trenches and filled areas. He shall maintain frequent inspection of same and at any time before the final acceptance of the work by the City the trenches or filled areas settle and sunken places appear, he shall be required to refill these sunken places with suitable material as soon as they are discovered. All trenches shall be barricaded and caution lighted at all times for the protection of the public.

3. Backfilling shall be accomplished as soon as practicable after underground work is completed and inspected. Backfilling operations shall proceed in an orderly fashion following as closely behind construction operations as practical.

4. All backfill shall be placed in uniform horizontal layer. "Ramping," that is pushing backfill material down a ramp into excavated areas, will not be permitted unless authorized in writing by the Owner.

B. Backfill in Street Right-Of-Way and Improved Property

1. Backfill Material in Pavement Areas. Backfill in excavations through pavement in street right-of-way or wherever prevention of backfill settlement is considered essential such as driveways and paved parking areas on private property, and where the Plans require or the Owner orders, shall be made with pit run gravel or other acceptable material from the top of the bedding material or foundation to the subgrade elevation of the pavement. Pea gravel, sand or similar granular materials approximately uniform in size and without bonding properties shall not be used.

2. Backfill Material Outside of Pavement Areas.

a. Backfill in excavations outside of pavement in street right-of-way or outside of public right-of-way shall be made with select, job-excavated earth from the top level of the bedding material or foundation to the subgrade elevation in paved area, or to within 1 inch of the surface in areas to be sodded, or to the surface in all other areas.

b. Nongranular, job-excavated material shall be free from debris, organic matter, perishable compressible materials, and shall contain no stones or lumps or rock fragments larger than 6 inches in dimension, nor be in such amount that will interfere with the consolidating properties of the fill material. Care shall be taken that stones and lumps are kept separated and will distributed, and that all voids are completely filled with fine materials. The upper 3 feet of backfill in sodded or planted areas shall be free of such rocks or lumps larger than 1 inch in diameter.

3. Placement and Compaction.

a. Pipe Trenches. As soon as the pipe has been bedded, laid, jointed, and inspected by the Owner, backfilling shall continue in the following manner. Backfill shall be placed by hand in 6 inch loose layers above the bedding and tamped with heavy tampers or pneumatic tampers, special care being taken not to damage the pipe or joints, to a point 2 feet above the outside top of the pipe. From this point to the subgrade elevation of the pavement, or to the bottom of the sod, or to the original ground surface in all other areas, suitable backfill shall be placed in 12 inch loose layers and compacted to 95 percent of maximum density at plus or minus 2 percent of optimum moisture content as determined by Laboratory Standard Proctor Test (ASTM D 698).

b. Structure and Box Culvert Excavations. As soon as the masonry or concrete work has set sufficiently to withstand compaction, and the Owner has inspected it, suitable backfill shall be placed in 6 inch loose layers concurrently and uniformly on all sides and compacted with heavy tampers or pneumatic tampers to 95 percent of maximum density at plus or minus 2 percent of optimum moisture content as determined by Laboratory Standard Proctor Test (ASTM D 698). Suitable backfill shall be placed in this manner concurrently on all sides from the foundation of the structure or culvert to the subgrade elevation of the pavement, or to the bottom of the sod or to the original ground surface in all other areas.

c. Concrete Channel Lining Excavations. As soon as concrete work has set sufficiently to withstand backfilling and has been inspected by the Owner, select backfill material shall be placed by methods other than ramping and compacted by

jetting or flooding from the foundation of the channel lining to 3 inches above the top of the wall. Backfill will be rounded slightly adjacent to the top of wall to an elevation 1 inch above the top of the wall to assure positive surface drainage over the top of the wall. Backfill operations shall be coordinated with placement of the weep hole drainage system behind the channel lining wall. Special care shall be exercised during backfilling operations to prevent settlement behind channel lining walls.

C. Backfill in Open Areas and Unimproved Property

1. Backfill Material. Backfill for pipe excavations in open areas and unimproved property shall be made with select earth material from the top level of the bedding material or foundation to the surface. Backfilling for structures, box culverts, and concrete channel lining excavations in open areas and unimproved property shall be performed in accordance with Specification Section 02631 Paragraph 3.04.B. Nongranular, job-excavated material to be used for backfill shall be free from debris, organic matter and perishable compressible materials, and shall contain no stones or lumps or rock fragments larger than 6 inches in dimension or in such amount that will interfere with the consolidating properties of the fill material. Stones and lumps shall be kept separated and well distributed, and all voids shall be completely filled with fine materials.

2. Placement of Backfill. Backfill procedures specified for improved areas shall apply from the trench bottom to a point 2 feet above the outside of the pipe. From this point to slightly above the surrounding surface elevation, suitable backfill may be placed by bulldozer or other mechanical means.

D. Drainage Facilities Placed on Fill

1. Fill material placed in areas over which drainage facilities will be constructed shall be select earth material from the elevation of suitable subgrade to the bottom elevation for bedding or foundation of the drainage facility.

2. Placement and Compaction. If drainage facilities are constructed on filled areas, the fill material shall be placed in 6 inch loose layers and compacted to 95 percent of maximum density at plus or minus 2 percent of optimum moisture content as determined by Laboratory Standard Proctor Test (ASTM D 698) up to a point at least 2 feet above the outside top of the pipe or to the foundation of manholes, inlets, special structures, box culverts, concrete channel lining and concrete ditch paving. If compaction standards for pipe exceed that of the adjoining fill, the width of compaction for the storm drain shall be not less than the outside diameter of pipe plus 10 feet. If compaction standards for the manhole, inlets, special structure, box culverts, concrete channel lining and concrete ditch paving exceed that of adjoining fill, the limits of compaction for the facility shall be not less than 5 feet outside of the facility base slab.

3.05 FINAL GRADING

A. Final grading around and above drainage facilities shall be shaped to the slope of adjacent undisturbed ground. Sufficient grading operations shall be performed to provide natural surface drainage from adjacent properties into drainage facilities.

B. Grading above the top of concrete channel lining walls shall be accomplished in accordance with proposed cross-sections supplied by the City at the preconstruction conference or as directed by the Owner. Grading shall provide adequate drainage over the top of channel walls. Side slopes shall be graded to provide a minimum slope of ½ inch per foot beginning 3 inches above the top of channel walls. Side slopes shall be rounded off near the channel wall to an elevation of 1 inch above the top of wall. The addition of sod will provide a final side slope elevation 2 inches above the top of wall.

PART 4 MEASUREMENT

4.01 UNDERCUT BACKFILL

A. Undercut backfill will be measured by the ton of suitable material.

4.02 SHEETING AND SHORING DIRECTED TO REMAIN IN PLACE

A. Sheeting and shoring directed to remain in place will be measured by the 1,000 board feet, in place prior to being cut off below grade. Sheeting and shoring placed and removed by the Contractor will not be measured for payment.

4.03 PAVEMENT BACKFILL

A. Pit run gravel or other suitable materials used for backfill as determined by Specification Section 02631 Paragraph 3.04.B will be measured by the ton.

4.04 UNLINED CHANNEL

A. Unlined channel will be measured per linear foot along the centerline for various channel cross-sections, complete in place.

4.05 SEWER BUILDING (HOUSE) CONNECTION REMOVAL AND REPLACEMENT

A. Sewer building connection removal and replacement for construction of drainage facilities shall be measured per each, complete in place. Sewer building connections damaged by the Contractor which do not require removal and replacement for construction of drainage facilities will not be measured for payment.

4.06 COMPACTION TESTING

A. Soil test as required by the Owner will be paid for by the test as performed by a testing agency which meets the approval of the Owner.

4.07 GENERAL

A. All work for excavation, blasting, drainage of trench and dewatering, backfilling of excavation, compaction, grading, protection of existing utilities, water service connection adjustments, disposal of excess materials, and all other similar items included in this section of the Specifications but not covered by a Pay Item herein will be considered as a subsidiary obligation of the Contractor under other Pay Items of the Contract.

PART 5 PAYMENT

5.01 UNDERCUT BACKFILL

A. Accepted quantities of undercut backfill will be paid for at the contract unit price per ton of backfill material furnished and placed, which price will be full compensation for undercut excavation, special protection, protection of existing utilities, and backfilling to bottom of facility subgrade elevations, complete in place.

5.02 SHEETING AND SHORING DIRECTED TO REMAIN IN PLACE

A. Accepted quantities of sheeting and shoring directed by the Owner to remain in place will be paid for at the contract unit price per 1,000 board feet in place prior to being cut off below

grade, which will be full compensation for material only. The cost of placing sheeting and shoring to remain in place shall be incidental to the work. No payment will be made for sheeting and shoring placed and removed by the Contractor.

5.03 PAVEMENT BACKFILL

A. Pavement backfill will be paid for at the contract unit price per ton furnished and placed, which price will be full compensation for furnishing, placing and compacting the selected fill.

5.04 UNLINED CHANNEL

A. Accepted quantities of unlined channel will be paid for at the contract unit price per linear foot for various channel cross-sections, which price will be full compensation for excavation, removal, and disposal of excavated material and grading, complete in place.

5.05 SEWER BUILDING (HOUSE) CONNECTION REMOVAL AND REPLACEMENT

A. Accepted quantities of sanitary sewer building connections removed and replaced will be paid for at the contract unit price per each connection, which price will be full compensation for excavation, removal of old connection line and appurtenances, materials and construction of new connection, joining to existing connection line, and backfilling, complete in place.

5.06 COMPACTION TESTING

A. Accepted quantities of compaction tests as required by the Owner will be paid for at the contract unit price per test.

5.07 PAYMENT WILL BE MADE UNDER:

Item No.	Pay Item	Pay Unit
02631-5.01	Undercut Backfill	Ton
02631-5.02	Sheeting and Shoring Directed to Remain In Place	1,000 Board Feet
02631-5.03	Pavement Backfill	Ton
02631-5.04	Unlined Channel	Linear Foot
02631-5.05	Sewer Building (House) Connection Removal and Replacement	Each
02631-5.06	Soil Compaction Test	Each

END OF SECTION 02631

SECTION 02820
CHAIN LINK FENCE

PART 1 GENERAL

1.01 SCOPE

A. This work shall consist of the construction of chain link fences and gates in accordance with these Specifications and at the locations and in conformity with the lines, grades, and dimensions shown on the Plans or as directed by the Owner. Chain link fence may be located atop concrete channel lining walls, retaining wall or similar structure, or may be located independently of structures.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials used throughout the project shall be of constant design and manufacture in respect to individual items or parts, excepting where the proposed fence will be an extension of an existing fence, in which case the new fence shall be constructed of materials similar in appearance to those in the existing fence and continued until broken by cross street, railroad, fence ditch, or other physical feature. Unless otherwise directed, new materials shall be as described hereinafter.

B. Fabric

1. The fabric shall be zinc coated steel chain link type meeting the requirements of AASHTO M 181 for Type I, Class B fabric (zinc coating = 2 oz/ft^2). All chain link fabric shall be manufactured of No. 9 gauge wire pickets, forming a uniform 2 inch mesh, and shall be of the height shown on the Plans or specified in the Contract Documents. Fabric up to and including 60 inches high shall be knuckled at the top and bottom selvage and fabric over 60 inches high shall be twisted on the top selvage and knuckled on the bottom selvage.

C. Line Posts

1. Line posts shall be zinc coated steel pipe or H-sections of the following dimensions and of the lengths shown on the Plans or specified herein:

H - Section

Fence Height	Nominal Size (inch)	Outside Diameter (inch)	Weight Per Foot (Pounds)	Dimension (inches)	Weight Per Foot (pounds)
6 feet or less	1 ½	1.9	2.72	1.875 x 1.625	2.70
6 feet to 8 feet	2	2.375	3.65	2.25 x 1.95	4.10

2. Steel pipe shall conform to ASTM A 120 or AASHTO M181-85I Grade 2 and H-Sections shall be produced from ASTM A 570 and ASTM A 572, Grade 45. The weight of zinc coating shall be a minimum of 1.8 oz/square foot. The weight of zinc coating and weight per foot for steel post meeting the requirements of AASHTO M181-85I grade 2 may vary from the above noted valves.

D. End Posts, Corner And Pull Posts, And Braces.

E. End posts, corner posts, and pull posts shall be zinc coated steel pipe or square sections of the following dimensions and of the lengths shown on the Plans or specified herein:

	Steel Pipe			Square Section	
Fence Height	Nominal Size (inch)	Outside Diameter (inch)	Weight Per Foot (Pounds)	Outside Dimension (inches)	Weight Per Foot (pounds)
6 feet or less	2	2.375	3.65	2.0	3.60
6 feet to 8 feet	2 ½	2.875	5.79	2.5	5.70

1. Diagonal braces shall be 1 ¼ inch (1.660 inch O.D.) galvanized steel pipe, weighing 2.27 pounds per foot. Steel pipe and square sections shall conform to ASTM A 120 or AASHTO M181-85I Grade 2. The weight of zinc coating and weight of pipe per foot for steel post meeting the requirements of the AASHTO M181-85I grade 2 may vary from the above noted valves.

F. Top Rail

1. Top rail shall be used when specified on the Plans in lieu of top tension wire. The top rail shall be 1 ¼ inch (1.660 inch O.D.) galvanized steel pipe, weighing 2.27 pounds per foot, meeting the requirements of ASTM A 120 or AASHTO M181-85I Grade 2. Top rails in random lengths shall be fitted with expansion sleeves for connecting lengths into a continuous run or shall have a 3 inch swagged end. Suitable fittings shall be provided for securing top rail to each gate, corner, and end post.

G. Barbed Wire

1. Barbed wire shall consist of two No. 12 ½ gauge, twisted steel strands with No. 14 gauge four-point barbs spaced not more than 5 inches apart. The galvanized strands shall meet the requirements of ASTM A 121, Class II coating.

H. Miscellaneous Fittings And Hardware

1. Zinc coated miscellaneous fittings and hardware shall be commercial grade steel or better quality, pressed, wrought, or cast as appropriate to the article, and sufficient in strength to provide a balanced design when used in conjunction with fabric, posts, and wires of the quality specified herein. All steel fittings and hardware shall be galvanized in accordance with AASHTO M 111.

I. Barbed Wire Support Arms

1. Barbed wire support arms shall be single arms for carrying 3 barbed wire strands. Barbed wire support arms for line posts shall be at an angle of 45 degrees (plus or minus 5 degrees) and shall be fitted with clips or other suitable means for attaching three lines of barbed wire, with the top strand of barbed wire 12 inches (plus or minus 1 inch) above and horizontally from the fence line, and the remaining two strands of barbed wire spaced uniformly between the top of the fence fabric and top strand of barbed wire. Support arms shall be capable of withstanding a load of 250 pounds when the base is clamped securely and the vertical load applied from where the outer strand of barbed wire passes over the arm.

J. Wire Ties

1. Wire ties shall be No. 9 gauge and shall be either zinc coated steel, aluminum coated steel or aluminum alloy and sufficient in strength and other properties to provide a balanced design when used in conjunction with fabric, posts, and wire of the qualities specified herein. When tension wire is used, wire ties and clips for fastening fabric to tension wire shall be No. 11 gauge.

K. Tension Wire

1. Tension wire shall be used at the bottom of fencing fabric when not otherwise secured and used at the top unless a top rail is specified. Tension wire shall be No. 6 gauge, spring rolled, aluminized steel wire.

L. Truss Rods and Turnbuckle

1. Truss rods shall be 3/8 inch diameter steel rods and shall be equipped with a turnbuckle having a take-up of not less than four inches and shall be galvanized in accordance with AASHTO M 111.

M. Fence Gates

1. Fence gates shall be of the kinds and sizes shown on the Plans or specified in the Contract Documents. They shall be of the swing type, complete with latches, stops, keepers, hinges, and fabric. The latch shall have provision for fastening with a padlock. The gates shall be covered with fabric matching the fence. The hinges shall be of adequate strength to support the gate and shall not twist or turn under action of the gate. The gates, gate posts, and braces shall be of the same material and finish as the adjoining fence. All gate posts and rails shall be furnished complete with ball caps and rail ends.

2. Posts, braces, and framing members for chain link fence gates shall be zinc coated steel pipe meeting the requirements of Specification Section 02820 Paragraph 2.01.C. Gate post shall be 2 ½ inch (2.875 inch O.D.) pipe weighing 5.79 pounds per foot for gate widths of 5 feet or less; and 3 ½ inch (4.0 inch O.D.) pipe weighing 9.10 pounds per foot for gate widths between 5 feet and 13 feet.

3. Framing members and interior bracing shall be of the following minimum dimensions:

Framing and Bracing

Fence Height	Nominal Size	Outside Diameter	Weight Per Foot
6 feet or less	1 ¼	1.66	2.27
6 feet to 8 feet	1 ½	1.90	2.72

a. Gate frames shall be welded at all corners or assembled with corner fittings. When corner fittings are used, gates shall have truss rods as specified in Specification Section 02820 Paragraph 2.01.J to prevent sag or twist. All welded joints shall receive a shop applied zinc coating equivalent in thickness to that of the members being joined.

4. Fabric shall meet the requirements of Specification Section 02820 Paragraph 2.01.A.

5. Barbed wire shall meet the requirements of Specification Section 02820 Paragraph 2.01.E.

6. Miscellaneous fittings and accessories shall meet the applicable requirements of Specification Section 02820 Paragraphs 2.01 F, G, H, and J. The hinges shall be of such design to allow the gate to swing back 180 degrees, parallel with the fence line.

N. Concrete

1. Concrete for post footings shall be Class A as specified in Specification Section 03050.

O. General

1. Posts shall be fitted with ornamental tops or extension arms as stipulated in the Plans or in the Contract Documents. Caps or ornamental tops for tubular posts shall have a base fitting into the post with a flange extending over the top of the posts to protect against moisture. When a top rail is provided, all posts shall be provided with caps having a ring or hole suitable for the through passage of the top rail. Rail and brace ends, or other suitable means of connection, shall be provided when top rail or braces are required.

2. Fabrication of all materials shall be in conformity to the sizes, shapes, and other factors set out in these Specifications or shown on the Plans, and shall show careful, finished craftsmanship in all respects.

3. The weights specified for steel posts, braces, and rails are nominal weights, and a plus or minus tolerance of 5 percent will be permitted. All posts located on the top of concrete channel lining walls or similar structure shall be of sufficient length to be set fully 12 inches into the wall or structure.

4. All line posts located on the ground shall be of sufficient length to be set fully 24 inches deep into concrete footings, and all end, corner, and pull posts shall be of sufficient length to be set 30 inches deep into concrete footings.

2.02 EQUIPMENT

A. All equipment necessary for the satisfactory performance of the work shall be on hand and inspected by the Owner before construction work will be permitted to begin.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Fencing shall be placed atop concrete structures, such as concrete channel linings, in accordance with Plans and Design Standards. Fence post inserts will normally have been set into the concrete walls prior to fence construction activities. Inserts shall be 12 inch ling solid wall PVC pipe conforming to ASTM D2241, thin wall metal conduit conforming to ANSI C 80.3 and sealed at one end or other material approved by the Owner. Cans, bottles and the like shall not be used as inserts. Alternatively, posts may be sect directly into the structure concrete as the concrete is poured, making sure that all posts are plumbed and held securely in the proper position until the concrete has set.

B. The inside diameter of the inserts shall be sufficient to provide a minimum of ¼ inch clear space between the outside surface of the post and the inside surface of the insert. Inside of inserts shall be cleaned of debris and other foreign matter, insert space filled full of nonshrinking grout, the posts set into place in the insert and plumbed, and the post held plumb until the grout has set. All excess grout shall be removed before it sets. Where inserts have not been provided in

the concrete structure, post holes of the same diameter and depth as required for inserts shall be cored in the concrete. Posts shall be set in cored holes in the same manner as posts set in inserts.

3.02 FENCING SET INDEPENDENTLY OF STRUCTURES

A. Before beginning construction or placing of fences, all necessary work for clearing and grubbing, removal of structures and obstructions, and site preparation shall be performed in accordance with the applicable Sections of these Specifications. Clearing for fence construction shall not extend beyond the construction easements without written approval of the property owner. Living trees and shrubs one foot or more each side of the fence line shall remain undisturbed unless otherwise directed by the Owner. Any rock protruding above the ground surface and in the line of the fence shall be removed to ground surface.

B. Posts for chain link fence shall be set at intervals not to exceed 10 feet. The interval between posts shall be measured parallel to the bottom of the fabric of the proposed fence and in line of fence from center to center of post.

C. All line posts located on the ground shall be set fully 24 inches deep in concrete footings; end, corner and pull post shall be set 30 inches deep in concrete footings. Diameters of footing shall be : for line post not less than 8 inches; for end, corner or pull post not less than 10 inches. Footings for gate post shall be designed to support the cantilever load of the gate. Concrete for embedment of posts and for anchors shall be Class A and shall be crowned to shed water. Concrete shall be cured a minimum of 3 days prior to installation of fabric.

3.03 ERECTING FENCE

A. For fence heights less than 6 feet a top and bottom tension wire shall be installed, unless specified otherwise. For fence heights 6 feet or greater a top rail and bottom tension wire shall be installed. When a top rail is specified, the top rail shall be connected with expansion sleeves to form a continuous rail.

B. Bracing assemblies consisting of the specified bracing pipe as the compression member and specified truss rod as the tension member shall be installed and securely tightened prior to installation of fabric. One brace assembly shall be provided for end post and two brace assemblies for corner and pull posts. When fence alignment changes abruptly by more than 30^0 a corner brace assembly shall be installed. When the internal angle of a curved fence alignment exceeds 30^0 one brace assembly shall be installed at each point of curvature. Pull post shall be installed at abrupt changes in grade or at the midpoint of a straight fence alignment exceeding 500 feet in length.

C. The fabric shall be placed on the side of the post as directed by the Owner and 2” above ground or concrete structure. Fabric shall be secured at one end and sufficient tension applied to remove all slack before making attachment elsewhere. The fabric shall be fastened to the posts with wire ties at intervals not exceeding 14 inches. Fabric shall be fastened to the tension sire or rail with wire ties at intervals not exceeding 24 inches. When specified, barbed wire shall be installed and pulled taut before being permanently attached to a post or arm. Fence gates shall be constructed in accordance with the Plans, Specifications and manufacturer’s standards and instructions, or as directed by the Owner.

3.04 TEST

A. Before any fencing is installed, manufacturer’s certificates stating that the fabric, post, rails, braces, barbed wire, tension wire, ties and hardware are made in accordance with applicable standards as specified herein shall be filed with the Owner. At the option of the Owner, test samples of any materials to be furnished shall be furnished at the job site before work

commences.

PART 4 PAYMENT

4.01 MEASUREMENT

A. Chain Link Fence

1. Fences will be measured for payment by the linear foot along the bottom of the fabric and from end to end of fence, complete and in place, deducting the width of gates and openings, for each type and height of fence provided.

B. Fence Gates

1. Gates will be measured for payment by the unit, per each, complete and in place, for the kinds and dimensions as shown on the Plans.

4.02 PAYMENT

A. Chain Link Fence

1. The accepted quantities of chain link fence will be paid for at the contract unit price per linear foot, complete and in place, for each type and height of fence, which price will be full compensation for fabric, posts, rails, tension wire, miscellaneous hardware, post hole excavation, concrete footings, concrete coring and grouting.

B. Fence Gates

1. The accepted quantities of gates will be paid for at the contract unit price per each, complete and in place, for the kinds and dimensions of gates stipulated or shown on the Plans.

4.03 Payment will be made under:

Item No.	Pay Item	Pay Unit
02820-4.02.A	CHAIN LINK FENCE HEIGHT x DESCRIPTION	LINEAR FOOT
02820-4.02.B	FENCE GATES HEIGHT x WIDTH OF OPENING	EACH

END OF SECTION 02820

SECTION 02920
SEEDING

PART 1 GENERAL

1.01 SCOPE

A. This work shall consist of furnishing and placing seed, commercial fertilizer, agricultural limestone, erosion control fabric, and mulch material when specified, and of caring for such areas until acceptance, all in accordance with these specifications, on all newly graded earthen areas that are not to be paved, stabilized, or sodded, unless otherwise indicated on the plans or directed by the owner.

PART 2 PRODUCTS

2.01 MATERIALS

A. Grass Seed

1. The seed shall meet the requirements of the Tennessee Department of Agriculture and no "Below Standard" seed will be accepted. Grass seed furnished under these Specifications shall be packed in new bags or bags that are sound and not mended.

2. The Contractor shall furnish the Owner a certified laboratory report from an accredited commercial seed laboratory or from a State seed laboratory showing the analysis of the seed to be furnished and approving the seed for purity and germination. The report from an accredited commercial seed laboratory shall be signed by a Senior Member of the Society of Commercial Seed Technologists. At the discretion of the Owner, samples of the seed may be taken for a check against the certified laboratory report. Sampling and testing will be in accordance with the requirements of the Tennessee Department of Agriculture.

3. When a seed group is used, the percentages forming the group shall be as set out below, unless otherwise specified.

Name	Quantity, Percent by Weight
Group A	
Lespedeza (Common or Korean)	20
Sericea Lespedeza	15
Ky. 31 Fescue	40
English Rye	15
White Dutch Clover	5
Weeping Love Grass	5
Group B	
Ky. 31 Fescue	55
Redtop	15
English Rye	20
White Dutch Clover	5
Weeping Love Grass	5

Group C

Sericea Lespedeza	50
Ky. 31 Fescue	30
English Rye	15
White Dutch Clover	5

4. In mixing or forming “Groups” of seed, they shall be uniformly mixed. “Group” seed shall not be mixed until after each type seed that is used to form the “Group” has been tested and inspected separately and approved for purity and germination. Seed mixed before tests and inspection are made will not be accepted.

B. Fertilizer

1. Manufactured fertilizer shall be a standard commercial fertilizer containing the specified percentages by weight of nitrogen (N), phosphoric acid (P_2O_5) and potash (K_2O). The fertilizer shall be furnished in standard containers with the name, weight, and guaranteed analysis of the contents clearly marked. The containers shall insure proper protection in handling and transporting the fertilizer. All commercial fertilizer shall comply with local, state, and federal fertilizer laws.

C. Agricultural Limestone

1. Agricultural limestone shall contain not less than eighty-five (85%) of calcium carbonate and magnesium carbonate combined and shall be crushed so that at least 85 percent will pass the No. 10 mesh sieve and 100 percent will pass the 3/8 inch sieve.

D. Mulch Material

1. All mulch material shall be air dried and virtually free of noxious weeds and weed seeds or other materials detrimental to plant growth on the work site or on adjacent agricultural lands. Hay shall be stalks of approved grasses, sedges, or legumes seasoned before baling or loading. Straw shall be stalks of rye, oats, wheat, or other approved grain crops. Both hay and straw shall be suitable for spreading with standard mulch blower equipment. Biodegradable fabric as specified in this section may be used as an alternate to mulch material at the Contractor’s option.

E. Inoculants for Legumes

1. Inoculants for treating legume seed shall be standard cultures of nitrogen fixing bacteria that are adapted to the particular kind of seed to be treated. The inoculant shall be supplied in convenient containers of a size sufficient to treat the amount of seed to be planted. The label on the container shall indicate the specified legume seed to be inoculated and the date period to be used.

F. Mulch Binder

1. Cut back asphalt, Grade RC-70 or RC-250 conforming to AASHTO Specifications shall be used.

G. Water

1. Water shall be free from any harmful or objectionable qualities or organisms.

H. Biodegradable Fabric

1. Biodegradable fabric shall consist of a knitted or bonded construction of yarn with uniform openings interwoven with strips of biodegradable paper. The fabric shall be degradable by exposure to ultraviolet light. The fabric shall be "Hold/Gro" as manufactured by Gulf States Paper Corporation of Tuscaloosa, Alabama, or equal. The fabric shall be furnished in rolls and shall conform to the following requirements:

    a. Roll Widths: 5 feet minimum and 10 feet maximum.

    b. Roll Length: Approximately 360 feet.

    c. Weight: Approximately 0.2 pounds per square yard of fabric.

2. Fabric shall be secured in a place with wood pegs or other biodegradable materials.

3. The manufacturer shall provide moisture proof bags comparable to 4 to 6 mil opaque polyethylene bags for protection of the fabric prior to installation.

2.02 EQUIPMENT

A. All equipment necessary for the satisfactory performance of this construction shall be on the project and inspected before work will be permitted to begin.

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor shall notify the Owner at least 48 hours in advance of the time he intends to begin sowing seed and shall not proceed with such work until permission to do so has been granted by the Owner. Before starting seeding operations on any area, final dressing and the placing of topsoil shall have been completed in accordance with the project requirements. All seeding and related operations shall be continuous operations.

3.02 PREPARING THE SEEDBED

A. Each area to be seeded shall be scarified, disked, harrowed, raked, or otherwise worked until it has been loosened and pulverized to a depth of not less than one inch. This operation shall be performed only when the soil is in a tillable and workable condition. Fertilizer, at the rate of not less than 23 pounds of Grade 6-12-12 or equivalent, per 1,000 square feet, and agricultural limestone, at the rate of not less than 100 pounds per 1,000 square feet, shall be distributed evenly over the seedbed, unless otherwise specified on the plans or in the Contract Documents. The limestone and fertilizer shall be lightly harrowed, raked, or otherwise incorporated into the soil as specified above when mixed with seed in water and applied with power sprayer equipment.

3.03 TIME OF SEEDING

A. Group "A" seed shall be used for seeding from February 1 to August 1, and Group "B" seed shall be used from August 1 to December 1, except that either Group "A" or "B" may be used during the month of August. Group "C" seed shall be used from February 1 to December 1 and only when specified on the Plans or in the Contract Documents. Seeding shall be performed only

when the soil is in a tillable and workable condition, and no seeding shall be performed between December 1 and February 1, unless otherwise permitted.

3.04 SEEDING

A. Seed of the specified group shall be sown as soon as preparation of the seedbed has been completed and thoroughly watered after seeding. Care shall be exercised to not wash seeding by over watering. Seed shall be sown uniformly by means of a rotary seeder, wheelbarrow seeders, hydraulic equipment, or other satisfactory means, and unless otherwise specified on the Plans or in the Contract Documents, at the rate of 1 ½ pounds per 1,000 square feet. Group "C" seed and seeds of legumes when sown alone shall be inoculated before sowing in accordance with the recommendations of the manufacturer of the inoculant and as directed by the Owner. No seeding shall be done during windy weather, or when the ground surface is frozen, wet, or otherwise nontillable.

3.05 BIODEGRADABLE FABRIC

A. When biodegradable fabric is specified, the fabric shall be loosely draped over the seeded area. The seed bed to be covered shall be prepared, fertilized, limed, seeded, and watered prior to installation of the fabric. If the slope is greater than 3 to 1, fabric shall be applied vertically with paper strips oriented parallel to the slope.

B. The Contractor shall dig a 4 inch deep check ditch 1 foot back from the slope crown, then fold, place and peg fabric every 9 inches in the check ditch, and cover with soil. An identical check ditch shall be provided 1 foot away from the bottom of the slope. When 2 or more lengths of fabric are required to be installed side by side to cover an area, they shall overlap 4 inches minimum. Fabric installed end to end shall overlap 4 inches minimum with the upgrade section on top of the lower grade section. End to end overlaps of adjacent rows of fabric shall be staggered a minimum of 5 feet. Each length of fabric shall be pegged in 3 rows, each edge and the center, with pegs placed on 3 foot centers maximum. Overlapped ends shall be pegged on 9 inch centers across the fabric overlap. Pegs shall be driven flush with the ground. The Contractor shall strictly adhere to the installation directions provided by the manufacturer of the fabric.

C. The Contractor shall maintain and protect the biodegradable fabric until Final Acceptance or until the Owner has determined that the fabric has served its useful life, whichever occurs first. Maintenance shall consist of watering as required, repairs made necessary by erosion, wind, fire, or any other cause until Final Acceptance. Following the restoration of damaged areas under plant establishment requirements for applicable underlying items, the fabric shall be repaired or replaced to meet the original requirements and maintained until Final Acceptance of the Project.

3.06 MULCHING

A. When seeding with mulch is specified, the mulch material shall be spread evenly over the seeded areas at an approximate rate of 75 pounds per 1,000 square feet immediately following the seeding operations. This rate may be varied by the Owner, depending on the texture and condition of the mulch material and the characteristics of the area seeded. All portions of the seeded areas shall be covered with a uniform layer of mulch, so that approximately 25 percent of the ground is visible. The mulch shall be held in place by the use of an approved mulch binder. Cutback asphalt or emulsified asphalt shall be applied at the approximate rate of 4 gallons per 1,000 square feet as required to hold the mulch in place. Mulch in medians and other areas affected by traffic shall be held in place by applying asphalt binder at the approximate rate of 11 gallons per unit. The Contractor shall cover exposed structures, guardrails, signs, and

appurtenances, if the mulch binder is applied in such a way that it would come in contact with or discolor the structures.

3.07 MAINTENANCE AND REPAIR

A. All seeded areas shall be cared for and maintained properly to the Owner's satisfaction until Final Acceptance of the Work and for the duration of the warranty period. Such care shall include, but not be limited to watering as necessary, fertilizing, and mowing the seeded areas when required by the Owner. When mowing is required, mower blades shall be set at sufficient height to protect the vitality of the growth. Areas which have been previously seeded and mulched in accordance with this Specification Section but which have been eroded, damaged or failed to successfully establish a stand of grasses or legumes shall be repaired as directed by the Owner. All material and labor required to maintain and repair seeded areas shall be furnished by the Contractor at no cost to the City. If the Owner directs the Contractor to place additional fertilizer on the area to be reseeded, and additional 4 pounds of agricultural limestone will be required for each additional pound of fertilizer.

PART 4 MEASUREMENT

The furnishing of seeding as specified herein may be incidental to the work of the Contract, or may be measured and payment made under the Pay Items described herein, as defined by the Pay Items in the Proposal Sheet(s) and/or as included in the Plans and Contract Documents. If payment is made separately, measurement for the work of this Specification will be as described below.

4.01 SEEDING (WITH MULCH)

A. The area of seeding (with mulch) to measured for payment will be the number of seeding units, with mulch, in accordance with these Specifications. Each unit will consist of 1,000 square feet measured along the surface.

4.02 SEEDING (WITHOUT MULCH)

A. The area of seeding (without mulch) to be measured for payment will be the number of seeding units in accordance with these Specifications. Each unit will consist of 1,000 square feet measured along the surface.

4.03 BIODEGRADABLE FABRIC

A. Biodegradable fabric to be measured for payment will be the number of 1,000 square foot units for which biodegradable fabric has been applied over seeded areas. Measurement will be along the surface.

4.04 GENERAL

A. All work and materials for seed bed preparation, application of fertilizer and limestone, application of mulch binder, watering and maintenance and repair of work, and all other similar items included in this section of the Specifications but not covered by a Pay Item herein will be considered as a subsidiary obligation of the Contractor under other items of the Contract.

PART 5 PAYMENT

5.01 SEEDING (WITH MULCH)

A. Seeding (with mulch) will be paid for at the contract unit price per unit (1,000 square feet), for the accepted quantities, which price will be full payment for preparing the seedbed, and for furnishing and placing all materials including fertilizer, water, agricultural limestone, seed, mulch materials, mulch binder and inoculant, complete in place; and for maintenance and repair of the seeded and grassed area.

5.02 SEEDING (WITHOUT MULCH)

A. Seeding (without mulch) will be paid for at the contract unit price per unit (1,000 square feet) for the accepted quantities, which price will be full payment for preparing the seedbed, and for furnishing and placing all materials including fertilizer, water, agricultural limestone, seed, and inoculant, complete in place; and for maintenance and repair of the seeded and grassed areas.

5.03 BIODEGRADABLE FABRIC

A. Biodegradable fabric will be paid for at the contract unit price per unit (1,000 square feet) for furnishing, installing, maintaining, and protecting the fabric, which price will be full payment for accomplishing the above.

5.04 PAYMENT WILL BE MADE UNDER:

Item No.	Pay Item	Pay Unit
02920-5.01	SEEDING (WITH MULCH)	Unit of 1,000 SF
02920-5.02	SEEDING (WITHOUT MULCH)	Unit of 1,000 SF
02920-5.03	BIODEGRADABLE FABRIC	Unit of 1,000 SF

END OF SECTION 02920

SECTION 02950
REMOVAL AND REPLACEMENT OF PAVEMENTS AND INCIDENTALS

PART 1 GENERAL

1.01 SCOPE

A. This Work shall consist of the removal and replacement of pavements, sidewalks, driveway aprons, curbs and gutters, driveways, paved areas, and curbs made necessary by the improvement of sanitary sewer infrastructure, and other items of construction that require temporary cuts. Such replacement shall be to a condition at least equal to the condition existing prior to removal and of in-kind material and shall be compliance with the Drawings, these Specifications, or as directed by the Purchaser. The Work which will be included in the Subcontract and for which the Subcontractor shall be compensated therefore is limited to that area within the rights-of-way and construction easements for the Project. The Subcontractor will not be compensated for the removal and replacement of facilities outside the rights-of-way, easements, and limits of construction of the Project.

PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete:

1. Portland cement concrete shall be in accordance with Section 03050 Portland Cement Concrete.

B. Asphaltic Concrete Pavement:

1. Asphaltic concrete surface courses shall meet the requirements of Mix No. 1 and bases courses shall meet the requirements of Mix No. 2 as described below.

2. The composition of the mixes shall be as follows:

Total Percent Passing by Weight

Sieve Size	Mix No. 1	Mix No. 2
2”	100	100
1-1/2”	100	100
3/4”	100	100
3/8”	76-96	65-95
No. 4	51-76	45-70
No. 8	36-60	25-50
No. 30	16-40	12-30
No. 100	3-12	2-12
No. 200	2-8	1-6

3. The proportions of the total mixture, in percent by weight, shall be as follows:

Courses	Combined Mineral Aggregate	Asphalt Cement
Mix No. 1, Surface	92.0 – 96.0	4.0 – 8.0
Mix No. 2, Binder	93.0 – 97.5	2.5 – 7.0

4. It is the intent of this Section of the Specifications that the above described mixes shall conform to the following mixtures specified in the Tennessee Department of Transportation Standard Specifications for Road and Bridge construction.

   a. Mix No. 1 – Section 411, Asphaltic Concrete Surface (Hot Mix), Grading E.

   b. Mix No. 2 – Section 307, Bituminous Plant Mix Base (Hot Mix), Aggregate Grading C.

5. For multiple layer construction, succeeding layers shall not be laid until the previous layer has cooled sufficiently to support the construction equipment

6. When Mix No. 1 is to be used as a surface for traffic lanes, the mineral aggregate shall be composed of not less than 50 percent nor more than 55 percent crushed limestone and not more than 50 percent nor less than 45 percent natural sand. When Mix No. 1 is used for surfacing of shoulders or other non-traffic lane construction, the mineral aggregate may be composed entirely of limestone, including screening and manufactured sand, but in no case shall the mineral aggregate for this construction consist of less than 50 percent limestone. The natural sand shall be so graded that not more than 5 percent will be retained on the No. 4 sieve.

C. Temporary Cold Patch Asphalt

1. Temporary cold patch asphalt shall meet the requirements of TDOT Standard Specifications for Road and Bridge Construction Section 410.

D. Expansion Joint Filler:

1. Preformed expansion joint filler shall be of the bituminous type, shall conform to the requirements of AASHTO M 213 and shall not be more than 1 inch or less than 1/2 inch in thickness. The filler shall be cut to the full depth of pavement, curb and gutter, sidewalk, or driveway being replaced.

E. Gravel Pavement or Base:

1. Crushed limestone with such material as manufactured sand or other fine materials naturally contained or added thereto as needed to match existing conditions and conform to the gradations shown below:

Grading Table for Graded Aggregate Base Course
Total Percent, by Dry Weight, Passing Each Sieve (U.S. Standard)

Size No.	2 ½ “	2”	1 ½”	1”	3/8”	No. 40
1	100	95-100			35-65	10-30

2.02 EQUIPMENT

A. Equipment and tools necessary for cutting, removal, and hauling of existing items; handling and placement of new material; and all equipment necessary to perform all parts of the Work shall be at the job site sufficiently ahead of the start of construction operations to be examined and approved by the Purchaser.

B. When saws are used to cut pavement, the Subcontractor shall provide sawing equipment adequate in power to complete the sawing to a minimum of 1-1/2 inches below the pavement

surface in one pass. An ample supply of saw blades shall be maintained at the site of the Work at all times during sawing operations.

C. Other types of pavement cutting equipment shall be capable of cutting the pavement to a neat straight line of 1-1/2 inch minimum depth below the pavement surface in one pass.

D. The Subcontractor shall provide equipment capable of removal of pavements, sidewalks, driveway aprons, curbs and gutters, driveways, paved areas, and curbs without disturbance of adjacent items to remain in place.

PART 3 EXECUTION

3.01 REMOVAL OF ASPHALT PAVEMENT

A. Asphalt pavement shall be removed to a clean straight line as shown on the drawing details. Pavement shall be cut by saw or other equipment approved by the Purchaser in advance. Edges of existing asphalt pavement adjacent to trenches, where damaged, shall be recut in a clean straight line within the limits of damaged pavement only. Such recuts shall be parallel to the original cuts and perpendicular to the pavement surface.

3.02 REMOVAL OF CONCRETE PAVEMENT

A. Concrete pavement shall be removed to a neat straight line as shown on the drawing details. Care shall be used to avoid damage to pavements and to the pavement base remaining in place.

3.03 REMOVAL OF CONCRETE SIDEWALK, CURB AND GUTTER, AND DRIVEWAY

A. Concrete sidewalks, curbs and gutters, and driveways shall be removed to the nearest contraction or expansion joint. Care shall be used to avoid damage to sidewalks, curbs and gutters, and driveways remaining in place.

3.04 REMOVAL OF GRAVEL PAVEMENT

A. Gravel surfaces encountered in construction shall be removed as needed to allow for the adjustment of the manhole frame and cover.

3.05 REPLACEMENT OF PAVEMENT

A. Asphalt Pavements

1. Replace asphalt paving courses to match existing thickness. The minimum surface course thickness shall be 2 inches. Asphalt pavement and base replacement shall be constructed for the entire cross-section of pavement removal area including all areas where pavement was re-cut subsequent to the initial pavement removal.

B. Concrete Pavements

1. Concrete pavement shall be replaced with Class A concrete pavement equal in thickness to the pavement removed but not less than 4 inches thick. Concrete pavement and base replacement shall be constructed for the entire cross-section of pavement removal area including all areas where pavement was re-cut subsequent to the initial pavement removal.

2. Reasonable efforts shall be made to avoid contrast in the color and texture of existing and restored surfaces.

C. Placing, Curing, and Protection of Concrete

1. After the backfill in the trench has been brought to the appropriate subgrade elevation shown on the Plans, compacted to the specified density, and permission has been given by the Purchaser, a concrete slab of the appropriate thickness shall be placed within the entire disturbed area.

2. Any loose or disturbed pavement or base shall be removed prior to placement of the concrete. Concrete shall be placed only on a moist subgrade and shall not be placed unless the ambient temperature is 35^{o} F and rising. In no case shall concrete be placed on a frozen or frosty subgrade. After the concrete is placed, it shall be struck off in an approved manner to the appropriate grade as shown on the Plans and shall be finished with floats and straight edges until the required surface texture has been obtained.

3. No vehicles or loads shall be permitted on any concrete until the Purchaser has determined that the concrete has obtained sufficient strength for such loads. The Subcontractor shall construct and place such barricades and protection devices as are necessary to protect the concrete.

D. Installation and Replacement of Temporary Cold Patch Paving

1. With the approval of the Purchaser, during times when permanent hot mix asphalt is not available, pavement surfaces shall be restored with temporary cold patch asphalt. Once the permanent asphalt is available, the Subcontractor shall remove and replace the temporary cold patch asphalt with permanent asphalt in accordance with Section 3.05.A Asphalt Pavements.

3.06 REPLACEMENT OF SIDEWALKS, DRIVEWAY APRONS, CURBS AND GUTTERS, DRIVEWAYS AND OTHER PAVED AREAS, AND CURBS

A. Concrete sidewalks and driveway aprons shall be replaced in accordance with the City of Memphis Standard Construction Specifications.

B. Unless otherwise directed, curb and gutter shall be replaced with new concrete curb and gutter of the same cross-section and at the same top of curb elevation and flow line as that removed. Where curb and gutter of a different type than existing is to be used for replacement, the replacement flow line shall match existing and a transitions section provided between the existing and replacement cross-sections. Curb heights shall be transitioned at a rate of 1 inch in 5 feet. Granite curb shall be replaced with new concrete curb whose height matches existing adjacent curb top elevations. Any expansion joint material removed shall be replaced at the original locations. Existing concrete edges shall be cleaned prior to placement of concrete. The finished curb and gutter cross-section, elevations, texture, and color shall conform to the adjacent concrete surfaces.

C. Replacement of paved areas other than street pavement; concrete, asphalt, or gravel driveways; and asphalt or concrete curb within the right-of-way or construction easement limits shall be in kind for those cross-sections removed, unless directed otherwise by the Purchaser.

3.07 DAMAGE DUE TO SETTLEMENT

A. The Subcontractor shall be responsible for any damage caused by settlement of backfill placed beneath pavements, sidewalks, driveway aprons, curbs, curbs and gutters, driveways, paved areas other than street pavement, and asphalt or concrete curb within the right-of-way or construction easement limits. This includes any damage which may occur at any time prior

to, and during a period of one year from the date of Final Completion of the Work covered by the Subcontract.

B. During such period, the Subcontractor shall at his own cost and expense refill all excavations where settlement damage has occurred and replace damaged pavements, sidewalks, driveway aprons, curbs, curbs and gutters, paved areas, driveways, and all other damaged items to the satisfaction of the Purchaser. Should the Subcontractor fail to repair settlement damage which may occur as described above within 5 days after being given notice thereof, the Purchaser shall have the right to repair such settlement and charge the cost of such repairs to the Subcontractor.

3.08 DAMAGE OUTSIDE CONSTRUCTION EASEMENT LIMITS

A. The Subcontractor will be held responsible for all damage to roads, highways, shoulders, curbs and gutters, ditches, embankments, bridges, culverts, and other property, caused by him or any of this Sub-subcontractors in hauling or otherwise transporting materials to and from the several sites of Work, regardless of the location of such damage. The Subcontractor shall make arrangements relative to the payment for, or repair or replacement of, such damage or damaged surfaces or structures which are satisfactory and acceptable to the Purchaser, at the Subcontractor's cost and expense.

PART 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Pavement Removal and Replacement

1. Pavement removal and replacement shall be measured for payment by the square yard, complete in place.

B. Concrete Sidewalk Removal and Replacement

1. Sidewalk removal and replacement shall be measured for payment by the square foot, complete in place.

C. Concrete Curb and Gutter Removal and Replacement

1. Curb and gutter removal and replacement shall be measured for payment by the linear foot, complete in place.

D. Gravel Driveway and Gravel Area Removal and Replacement

1. Gravel driveways and gravel area removal and replacement shall be measured for payment by the ton of crushed limestone, complete in place.

4.02 PAYMENT

A. Pavement Removal and Replacement

1. The accepted quantities of pavement removal and replacement shall be paid for at the Subcontract unit price per square yard for the type specified, which price will be full compensation for cutting and recutting pavement; removal and disposal of pavement and base; preparing the subgrade; placing, finishing, curing, and protection of concrete; and placing and compacting asphaltic concrete wearing surfaces, complete in place.

2. The accepted quantities of temporary pavement removal and replacement shall be paid for at the Subcontract unit price per square yard for the type specified, which price will be full compensation for installation; maintenance; removal and disposal of pavement; preparing the subgrade; and placing and compacting temporary asphaltic concrete wearing surfaces, complete in place.

B. Concrete Sidewalk Removal and Replacement

1. The accepted quantities of sidewalk removal and replacement shall be paid for at the contract unit price per square foot, which price will be full compensation for removal and disposal of sidewalk; preparing the subgrade; and placing, finishing, curing and protection of concrete, complete in place.

C. Concrete Curb and Gutter Removal and Replacement

1. The accepted quantities of curb and gutter removal and replacement shall be paid for at the Subcontract unit price per linear foot for the type specified, which price will be full compensation for removal and disposal of curb and gutter; preparing the subgrade; and placing, finishing, curing and protection of concrete, complete in place.

D. Gravel Driveway and Gravel Area Removal and Replacement

1. The accepted quantities of gravel driveway and gravel area removal and replacement shall be paid for at the Subcontract unit price per ton of crushed limestone, which price will be full compensation for preparing the subgrade and replacing the gravel, complete in place.

4.03 PAYMENT WILL BE MADE UNDER:

Item No.	Pay Item	Pay Unit
02950-4.02.A.1	ASPHALTIC CONCRETE PAVEMENT REMOVAL AND REPLACEMENT	SQUARE YARD
02950-4.02.A.2	CONCRETE PAVEMENT REMOVAL AND REPLACEMENT	SQUARE YARD
02950-4.02.A.3	TEMPORARY ASPHALT REMOVAL AND REPLACEMENT	SQUARE YARD
02950-4.02.B	CONCRETE SIDEWALK REMOVAL AND REPLACEMENT	SQUARE FOOT
02950-4.02.C	CONCRETE CURB AND GUTTER REMOVAL AND REPLACEMENT	LINEAR FOOT
02950-4.02.D	GRAVEL DRIVEWAY AND GRAVEL AREA REMOVAL AND REPLACEMENT WITH CRUSHED STONE	TON

END OF SECTION 02950

SECTION 03050
PORTLAND CEMENT CONCRETE

PART 1 GENERAL

1.01 SCOPE

A. This specification covers the classification, materials, proportioning of materials, equipment, mixing requirements, and testing for portland cement concrete to be used for construction of miscellaneous structures and facilities.

PART 2 PRODUCTS

2.01 CONCRETE CLASSIFICATION

A. Portland cement concrete used for construction of the various items covered in Division 2 of these Specifications shall be classified by usage as follows:

1. Class A

   a. Class A concrete shall be used as specified for such items as concrete curb, curb and gutter, sidewalks, drainage and sewer structures other than box culverts, ditch paving, and similar uses.

2. Class C

   a. Class C concrete shall be used as specified for such items as concrete fillets, cradles, encasements, embankment slope paving at bridge abutments, and other low strength applications.

2.02 MATERIALS

A. Materials used in the production of portland cement concrete of the various classifications specified herein shall meet the following requirements.

2.03 PORTLAND CEMENT

A. Portland cement shall be Type I cement conforming to the requirements of AASHTO M 85, except that for high-early-strength concrete, Type III cement may be used.

2.04 FINE AGGREGATE

A. Fine aggregate shall consist of natural sand, clean and free from any surface film or coating and graded from fine to coarse. Fine aggregate shall conform to the requirements of ASTM C 33 and the specifications included herein. The amount of deleterious substance shall not exceed the following percentage by weight:

1. Removed by decantation…… 3 percent
2. Coal or lignite…… 1 percent
3. Clay lumps…….. 1 percent
4. Other local deleterious substances (such as shale, alkali, Mica, coated grains, soft and flaky particles)…… 1 percent

5. Total coal, clay lumps, shale, soft fragments and other local deleterious substances …….. 5 percent

B. All fine aggregate shall be free from amounts of organic impurities that would be detrimental to concrete strength and durability. Aggregate shall be subjected to the colorimetric test made in the field as follows:

1. Fill a 12 oz. graduated bottle to the 4 ½ oz. mark with the sand to be tested. Add a 3% solution of sodium hydroxide until the volume, after shaking, amounts to 7 ounces. Shake thoroughly and let stand for 24 hours. The sample shall then show a practically colorless solution, or at least, a solution not darker than straw color.

C. Fine aggregate shall be well graded from coarse to fine and, when tested by means of laboratory sieves, shall conform to the following requirements:

Passing	Percent
3/8 in. Sieve……	100
No. 4 Sieve……	95 to 100
No. 16 Sieve……..	50 to 90
No. 50 Sieve……..	10 to 30
No. 100 Sieve……	0 to 10
No. 200 Sieve……	0 to 3

a. Note: Not more than 45% should be retained between any two consecutive sieves.

D. Fine aggregate shall be of such quality that mortar composed one (1) part portland cement and three (3) parts fine aggregate, by weight when made into briquets or cylinders, shall show a tensile or compressive strength at seven (7) and twenty-eight (28) days at least equal to the strength of briquets or cylinders composed of one (1) part of the same cement and three (3) parts standard Ottawa sand by weight. The percentage of water used in making the test specimens of cement and fine aggregate shall be such as to produce a mortar of the same consistency as that of the Ottawa sand test specimens of standard consistency.

2.04 COARSE AGGREGATE

A. Coarse aggregate for any class of portland cement concrete shall consist of crushed stone or crushed or uncrushed gravel unless otherwise specified.

B. Coarse aggregate for Class A or Class C concrete shall be furnished in two sizes: Size No. 4 and Size No. 67 as shown hereinafter in Table 03050.1, Coarse Aggregate Gradation Table. The two sizes shall be manufactured, within the specified limits, to produce Size No. 467 when combined in the proper proportions at the batching plant. If the supplier provides a proper stockpile to prevent segregation, then a combined Size No. 467 can be used in lieu of blending Size No. 4 and Size No. 67.

C. Coarse aggregate for concrete curbing placed by machine extrusion methods shall be Size No. 57 or Size No. 67.

D. The coarse aggregates shall otherwise conform to the requirements of AASHTO M 80 and ASTM C 33 with the following exceptions and stipulations:

1. Deleterious Substances.

The amount of deleterious substances shall not exceed the following limits:

	Maximum Percent by Weight
a. Soft or nondurable fragments (fragments which are structurally weak such as shale, soft sandstone, limonite concretions, gypsum, weathered schist or cemented gravel) ……..	3.0
b. Coal and lignite ……	1.0
c. Clay lumps ……	0.25
d. Material passing the No. 200 sieve ……..	1.00
e. Thin or elongated pieces (length greater than 5 times average thickness)	10.00
f. Other local deleterious substances……..……..……	1.00

i. Notes:

(1) In the case of crushed aggregate, if all the material finer than the 200 mesh sieve consists of the dust of fracture essentially free of clay or shale, Item 4, Maximum Per Cent by Weight, may be increased to 1.5.

(2) The sum of the percentages of Items No. a, b, c, d, and f shall not exceed 5.0.

(3) When the coarse aggregate is subjected to five alternations of the sodium sulfate soundness test, the weighted percentage of loss shall be not more than nine.

(4) Alternate freeze/thaw tests for soundness will not be performed.

(5) The percentage of wear as determined by AASHTO T 96 shall not exceed 40.

COARSE AGGREGATE GRADATION TABLE
Table 03 05 00.1

Size	Amounts Finer Than Each Lab, Sieve (Sq. Openings), % By Weight							
Number	2”	1-1/2”	1”	3/4”	1/2”	3/8”	No. 4	No.8
4	100	90-100	20-55	0-15	----	0-5	----	----
467	100	95-100	----	35-70	----	10-30	0-5	----
57	----	100	95-100	----	25-60	----	0-10	0-5
67	----	----	100	90-100	----	20-55	0-10	0-5

2.05 WATER

A. The water used in mixing concrete shall be clean, free from oil, acid, strong alkalis, organic or vegetable matter.

2.06 AIR-ENTRAINING ADMIXTURES

A. Air-Entraining Admixtures shall conform to the requirements of AASHTO M 154, except that the tests for bleeding, bond strength and volume change will not be required.

B. The Purchaser will maintain a list of qualified products. The Subcontractor shall be required to furnish a material that appears on this list.

C. A product may become approved by furnishing test data from a recognized laboratory showing that the air-entraining admixture proposed for use conforms to the requirements of these Specifications. A recognized laboratory is defined as one of the following: A State Transportation Department Laboratory; a Federal Highway Administration Laboratory; or other laboratories which are approved by the Purchaser.

2.07 CHEMICAL ADDITIVES

A. For Portland cement concrete mixtures, these additives shall conform to the requirements of AASHTO M 194 covering the following five types:

1. Type A – Water reducing admixtures

2. Type B – Retarding admixtures

3. Type C – Accelerating admixtures

4. Type D – Water reducing and retarding admixtures

5. Type E – Water reducing and accelerating admixtures

B. Additionally, admixtures for increasing the flowable characteristics of concrete (super plasticizers) may be used, subject to the approval of the Purchaser for each class and intended use of the concrete. Such admixtures shall meet the applicable requirements of ASTM C 494. The use of a plasticizer shall not change the maximum water requirements for the approved design mix. When approved for use, the admixture shall be introduced into the mix in the manner and quantities recommended by the manufacturer.

C. Additives listed in items A through E above and super plasticizers may only be used with the written approval of the Purchaser. Before any admixture is approved, the manufacturer of the admixture or the Subcontractor shall furnish the Purchaser documentary evidence that the material proposed for use has been tested in accordance with the methods of test specified in AASHTO M 194 (or ASTM C 494 for super plasticizers) and meets the requirements of the Specification. Documentary evidence for all additives shall be the results of tests conducted by a testing laboratory inspected at regular intervals by the National Bureau of Standards. The Purchaser may require a notarized certification from the manufacturer of any additives used stating that the material is identical with that originally approved and has in no way been changed or altered. Even through additives have been approved by the Purchaser, the Subcontractor shall be responsible for the successful use of the additives. No reduction in the cement content of the concrete as designed without chemical additives will be made when additives are permitted.

D. Calcium chloride additives will not be permitted.

2.08 CURING MATERIALS

A. Curing materials shall be as specified in the various Specification Sections of Division 2 and as specified below:

B. Water

1. Water used in curing portland cement concrete shall be free from any substance which may be injurious to concrete when applied on the surface as a curing agent.

C. Burlap

1. Burlap shall conform to AASHTO M 182, Class 3 or Class 4. If Class 1 or Class 2 burlap is permitted, at least two layers shall be use.

D. Liquid Membrane-Forming Compounds.

1. These compounds shall conform to AASHTO M 148. Where applied texture finish is specified, a Type 1-D, Class B, membrane which is compatible with the texture finish shall be used. Type 2 (white pigmented) membrane shall be used in all other applications, unless otherwise specified.

E. White Polyethylene Sheeting.

1. This material shall conform to AASHTO M 171.

2.09 FLY ASH

A. Class C fly ash conforming to the requirements of ASTM C 618-84 may be used as a replacement for portland cement if approved in writing by the Purchaser. The maximum amount of cement being replaced by fly ash shall not exceed 15 percent. Before any fly ash will be approved for use, the Subcontractor shall furnish the Purchaser documentary evidence that the fly ash proposed for use has been tested in accordance with ASTM C 311-7 and meets the requirements of that specification. Documentary evidence shall be the results of tests conducted by a testing laboratory inspected at regular intervals by the National Bureau of Standards. Even though the fly ash has been approved by the Purchaser, the Subcontractor shall be responsible for its successful use. When a specific air content has been required and fly ash is being used, the air content shall be tested on each truck load of concrete at the batch plant and the tested value shall be indicated on the ticket.

2.10 EQUIPMENT

A. General

1. Equipment and tools necessary for handling materials and performing all parts of the Work shall be subject to the approval of the Purchaser. The equipment shall be at the job site sufficiently ahead of the start of construction operations to be examined thoroughly and approved. The equipment and organization shall be of sufficient capacity to accomplish the maximum continuous concrete placement, as governed by the construction joints shown on the Plans and Design Standards or as directed by the Purchaser.

2.11 BATCHING PLANT AND EQUIPMENT

A. General

1. The batching plant shall include bins, weighing hoppers, and scales. If cement is used in bulk, a bin, hopper, and separate scale for cement shall be included. The Subcontractor shall provide adequate means for cement cut off checks. The weighing hoppers shall be properly sealed and vented to preclude dusting during operation. The bulk cement storage bin or hopper shall be provided with adequate means for sampling the cement in storage.

B. Bins and Hoppers

1. Bins with adequate separate compartments for fine aggregates, each size of coarse aggregate, and cement shall be provided in the batching plant. Each compartment shall discharge efficiently and freely into the weighing hopper. Means of control shall be provided so that as the quantity desired in the weighing hopper is being approached, the material may be added slowly and shut off with precision. A port or other opening shall be provided for removing an overload of any one of the several materials from the hopper. Weighing hoppers shall be constructed so as to eliminate accumulations of tare materials and to discharge fully without jarring the scales. Partitions between compartments, both in bins and in hoppers, shall be ample to prevent spilling under any working conditions.

C. Scales

1. The scales for weighing aggregates and cement shall be of either the beam type or the springless-dial type. They shall be accurate within 0.5 percent throughout the range of use. The value of the minimum graduation on the scale for weighing cement shall not be greater than 5 pounds. The value of the minimum graduation on the scale for weighing amounts of aggregates up to 10,000 pounds or more shall be not greater than 10 pounds. The value of the minimum graduation of scales used in weighing amounts of aggregate 10,000 pounds or more shall be not greater than 0.1 per cent of the nominal capacity of the scales but shall not exceed 50 pounds. When beam type scales are used, provision, such as a “tell-tale” dial, shall be made for indicating to the operator that the required load in the weighing hopper is being approached. The “tell-tale” device on weighing beams shall indicate critical position clearly. Poises shall be designed so that they cannot be easily removed from the beam and can be held firmly in place. The weigh beams and “tell-tale” device shall be in full view of the operator while charging the hopper, and he shall have convenient access to all controls.

2. Scales shall be tested no less than once monthly by a certified scale testing company. Testing shall meet the requirements of applicable City ordinances and State law. The Subcontractor shall have available not less than 10 standard 50 pound weights meeting the requirements of the U.S. Bureau of Standards for calibrating and testing weighing equipment. The person dispensing weighed material shall certify that the amounts of materials used is in accordance with quantities shown on the delivery ticket.

D. Batch Plant Equipment

1. The requirements for batching plants shall be as prescribed above, except that when approved by the Purchaser, the requirement for storage compartments in addition to weigh bins, for fine and coarse aggregates may be waived, provided the batching tolerances are maintained.

2. Ample and satisfactory equipment for conveying concrete from the mixer to final position in the forms shall be provided. Closed chutes or pipes shall be used when concrete is to be dumped or dropped for a distance greater than 5 feet. Where steep slopes are required, the chutes shall be equipped with baffle boards or shall be in short lengths that will enable the direction of movement to be reversed. Tremies for placing seal concrete under water shall consist of a water tight tube 10 inches to 14 inches in diameter. It shall be constructed so that the bottom can be sealed and opened after it is in place and fully charged with concrete. It shall be supported so that it can be easily moved horizontally to cover all the work area and vertically to control the concrete flow.

2.12 MIXERS

A. General

1. Concrete may be mixed at a central point or wholly or in part in truck mixers. Each mixer shall have attached in a prominent place a manufacturer's plate showing the capacity of the drum, in terms of mixing and agitating capacity, and the speed of rotation of the mixing drum or blades for both mixing and agitation.

2. Mixers shall be capable of combining the aggregates, cement, additives when specified, and water into a thoroughly mixed and uniform mass within the specified mixing period. They shall have a minimum capacity sufficient to comply with minimum production requirements.

3. Mixers shall be equipped with an approved device for accurately measuring water within a range of error of not more than one percent. The amount of water used in each batch shall be shown by an indicator which is accurately calibrated and easily read.

4. Central plant mixers shall be equipped with an approved batch meter and timing device which will automatically lock the discharge lever during the full time of mixing and release it at the end of the mixing period. This device shall be equipped with a bell or other suitable warning device that will give a clearly audible signal each time the lock is released. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, providing the Subcontractor furnishes a satisfactory means of determining the mixing time.

B. Mixers at Site of Construction

1. Mixers at the site of construction will not be permitted, unless permitted by the Purchaser.

C. Truck Mixers and Truck Agitators

1. Truck mixers used for mixing and hauling concrete and truck agitators used for hauling central-mixed concrete shall meet all the applicable requirements under Paragraph A above, and in addition, the manufacturer's plate shall indicate the various uses for which the equipment is designed, the gross volume of the drum, and the minimum and maximum speed of rotation of the drum or blades for charging, mixing and agitating. Trucks equipped for mixing shall be equipped with an approved device for recording the number of revolutions of the drum or blades. Mixers or agitators used to mix and transport paving concrete shall be of the hydraulic drum lift type or other especially designed types which will discharge low slump concrete (1 – 2 ½ inch) at a satisfactory rate without segregation.

D. Non-agitator Trucks

1. Bodies of non-agitator hauling equipment for concrete shall be smooth, mortar tight, metal containers, and shall be capable of discharging the concrete at a satisfactorily controlled rate without segregation. Covers shall be provided when needed for protection of the concrete. Nonagitator trucks may be used only with approval of the Purchaser.

E. Admixture Induction

1. A satisfactory method and equipment for setting the dosage for admixtures must be furnished and if admixtures other than air entraining agents are used, they shall be added in the manner and in the dosage recommended by the manufacturer.

F. Vibrators

1. Vibrators shall be of an approved type and design, and shall operate under load at the rate as recommended by the manufacturer and approved by the Purchaser. For concrete structures, all concrete to be vibrated shall be compacted by means of approved high

frequency internal vibrators or other approved types of vibrators immediately after being deposited in the forms. At least two vibrators in good operating condition and tow sources of power shall be available at the site where more than 25 cubic yards of concrete are to be poured. The use of external vibrators for compacting concrete will be permitted where the concrete is inaccessible for adequate compaction, provided the forms are sufficiently rigid to prevent displacement or damage from external vibration and approved by the Purchaser. For concrete pavement, the frequency of surface vibrators shall not be less than 3,500 impulses per minute and the frequency of the internal type shall not be less than 5,000 impulses per minute for tube vibrators and not less than 7,000 impulses per minute for spud vibrators. When spud type internal vibrators, either hand operated or attached to spreader or finishing machines, are used adjacent to forms, they shall have a frequency not less than 7,000 impulses per minute. For prestressed concrete, all concrete shall be thoroughly compacted with approved high frequency vibrators operating at a minimum of 7,000 vibrations per minute.

PART 3 EXECUTION

3.01 HANDLING, BATCHING AND MIXING

A. Stockpiling Aggregates

1. Sites for aggregate stockpiles shall be grubbed and cleaned prior to storing aggregates, and the ground shall be firm and smooth and well drained. A cover of at least three inches of aggregate shall be maintained in order to avoid the inclusion of soil or foreign material. The stockpiles shall be built in layers not exceeding four feet in height, and each layer shall be completely in place before the next layer is started so as to prevent segregation. The material shall be deposited in such manner as to prevent coning, except in the case of aggregate composed essentially of material finer than the No. 4 sieve and base material.

2. Dumping, casting or pushing over sides of stockpiles will be prohibited, except in the case of aggregate for base material and fine aggregate materials.

3. Unless otherwise authorized, aggregates from different sources, different gradings or differing in specific gravity by more than 0.03 shall not be stockpiled together. Stockpiles of different types or sizes of aggregates shall be spaced far enough apart, or separated by suitable walls or partitions, to prevent the mixing of the aggregates.

4. When it is necessary to operate trucks or other equipment on a stockpile in the process of building the stockpiles, it shall be done in a manner approved by the Purchaser. Any method of stockpiling aggregate which allows the stockpile to become contaminated with foreign matter or causes excessive degradation of the aggregate will not be permitted. Excessive degradation will be determined by sieve tests of samples taken from any portion of the stockpile over which equipment has operated, and failure of such samples to meet all grading requirements for the aggregate shall be considered cause for discontinuance of such stockpiling procedure.

5. Stockpiles shall be maintained in a saturated surface dry condition to the extent possible.

3.02 HANDLING, MEASURING AND BATCHING MATERIAL

A. General

1. The batch plant site, layout, equipment and provisions for transporting material shall be such as to assure a continuous supply of material to the Work.

2. Aggregates shall be handled from stockpiles or other sources to the batching plant in such manner as to maintain a uniform grading of the material. Aggregates that have become segregated, or mixed with earth or foreign material, shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipment requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage. In case the aggregates contain high or non-uniform moisture content, storage or stockpile periods in excess of 12 hours may be required by the Purchaser. The Purchaser may require sprinkling of aggregate that has dried to the extent that it absorbs mixing water.

3. The fine aggregate and each size of coarse aggregate shall be separately weighed into the hopper or hoppers in the respective amounts set by the Subcontractor and approved by the Purchaser. Cement shall be measured by the sack or weight. Separate scales and hoppers shall be used for weighing the cement. The scales shall be equipped with a device to indicate positively the complete discharge of the batch of cement into the batch box or container. Ninety-four pounds of bulk cement shall be considered one sack. Batches involving fractional sacks will not be allowed except when bulk cement is used.

4. Batching plants equipped to proportion aggregates and bulk cement by weight by means of automatic and interlocked proportioning devices of approved type may be used.

5. Batching shall be so conducted as to result in the required weights of each material being within a tolerance of 1.0 percent for cement and 1.5 percent for aggregates.

6. Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within a range of error of not over 1.0 percent. Unless otherwise permitted, calibrated tanks for measuring water shall include an auxiliary tank from which the measuring tank shall be filled. The measuring tank shall be equipped with an outside tap and valve to provide for checking the setting unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

7. The use of chemical additives shall be as prescribed under Paragraph 3.06 of this Specification and they shall be added to the mix using the methods and at the time and in the manner recommended by the manufacturer of the additive, subject to approval by the Purchaser.

8. Unless specifically provided in the contract, the furnishing and use of approved additives or admixtures and the other precautions necessary to provide satisfactory concrete and concrete products shall be considered subsidiary to the furnishing and placement of the concrete and any and all additional costs related thereto and risks resulting there from shall be borne by the Subcontractor.

9. Different types of cement shall not be mixed, nor shall they be used alternately. Where it is necessary for the color of the concrete to be uniform, only those cements which will produce similar color in concrete may be used alternately. The Purchaser shall designate which cements may be used alternately.

10. Air entraining agents shall be added to the mix by an approved procedure and by the use of an approved dispenser to assure an accurate proportioning of the agent.

11. All admixtures shall be measured with an accuracy of plus or minus 3.0 percent.

B. Limitations on Concrete Operations

1. Mixing of concrete shall be discontinued in time to allow finishing to be completed in daylight hours, unless an adequate and approved artificial lighting system is provided and operated.

2. When concrete is being placed during hot weather, appropriate measures shall be taken to reduce the hazards of increased rate of cement hydration and high concrete temperatures. The temperature of the concrete at point of discharge shall not exceed 90^0 F. The Purchaser may require any or all, but not limited to, the following precautions to reduce the temperature of the concrete:

   a. Sprinkle coarse aggregate stockpiles in a manner so as to distribute the water evenly and to prevent a variation of moisture within the stockpile.

   b. Use crushed or chipped ice as a portion of the mixing water, or use water cooled by refrigeration or other means. If ice is used, it shall be substituted on a pound for pound basis for water and completely melted before the concrete is discharged from the mixer.

   c. The Subcontractor may employ other means which he may have at his disposal if approved by the Purchaser. In order to minimize the number and extent of precautions as indicated during the production and use of concrete during hot weather, the Subcontractor may use approved chemical admixtures for set-retarding purposes, with the Purchaser's approval. However, the use of such approved set-retarding admixtures shall not relieve the Subcontractor of the necessity for other precautions deemed necessary to minimize variability of the physical characteristics, strength, and other requirements of the green concrete.

   d. Unless authorized in writing by the Purchaser, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 40^0F (if the temperature is expected to reach 35^0F or below), and not resumed until an ascending air temperature in the shade and away from artificial heat reaches 35^0F.

   e. When concreting at temperatures above 35^0F, the aggregates or water shall be heated or cooled if necessary prior to being placed in the mixer so that the temperature of the resultant mixture will be not less than 50^0F nor more than 90^0F at the time of placement. If heating is required, the apparatus used shall heat the mass uniformly and shall be so arranged as to preclude the possible occurrence of overheated areas which might injure the concrete.

   f. When concreting is authorized at temperatures 35^0F or less, the Purchaser will require the water or the aggregates or both to be heated to not less than 70^0F nor more than 150^0F. The temperature of the mixed, heated concrete shall be not less than 50^0F nor more than 100^0F at the time of placement. No concrete shall be placed on frozen grade nor shall frozen aggregates be used in the concrete.

   g. When it is expected that the ambient temperature will drop below 35^0F, the Subcontractor shall provide sufficient canvas and framework, other types of housing, or to enclose and protect the concrete in such a way that the air surrounding the fresh concrete can be maintained at a temperature of not less than 45^0F and the temperature of the concrete shall not exceed 80^0F. The above conditions shall be maintained for a period of 120 hours after the concrete is placed. The Subcontractor shall be responsible for the quality of concrete placed during cold weather, and any concrete injured by frost action or freezing shall be removed and replaced at the Subcontractor's expense. When impending weather conditions indicate the possibility of the need for such temperature protection, all necessary heating and covering material shall be on hand ready for use before the Purchaser's permission is granted to begin placement.

3.03 MIXING CONCRETE

A. General

1. The concrete may be mixed in a central mix plant or in truck mixers. The mixer shall be of an approved type and capacity, and shall comply with the applicable requirements of Paragraph 4.03 of this Specification Section. Mixers shall be cleaned at suitable intervals. Equipment having components made of aluminum or magnesium alloys which would have contact with plastic concrete during mixing, transporting or pumping of Portland cement concrete, shall not be used.

2. The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. Mixing time shall be measured from the time all materials except water are in the drum. The flow of water shall be uniform, and all water shall be in the drum buy the end of the first 15 seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the flow of materials into the drum.

3. When mixed in a central mixing plant, the mixing time shall not be less than 60 seconds nor more than 90 seconds. Mixing time ends when the discharge chute opens. Transfer time in multiple drum mixers shall be included in the mixing time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein.

4. The mixer shall be operated at the drum speed recommended by the manufacturer. Any concrete mixed less than the specified time shall be discarded and disposed of by the Subcontractor at his expense. Mixers for central mix plants shall not be operated at a capacity greater than the manufacturer's guaranteed mixing capacity.

5. Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators or nonagitating trucks having special bodies. The time elapsing from the time water is added to the mix until the concrete is deposited in place at the site of the Work shall not exceed 30 minutes when the concrete is hauled in nonagitating trucks, nor 60 minutes when hauled in truck mixers or truck agitators. When high early strength concrete is used, agitator trucks only shall be used and the concrete shall be deposited in place at the site of the Work within 30 minutes from the time water is added to the mix, regardless of the method of transportation, unless otherwise approved by the Purchaser.

6. Truck mixers and truck agitators used to transport concrete from a central mixing plant and truck mixers used to mix concrete in transit from a central batching plant shall meet all applicable requirements of Paragraph 4.03 of the Specification Section, and in addition, the mixing speed and agitating speed shall be those recommended by the manufacturer of the mixer and the total revolutions at mixing speed shall not be less than 70 nor more than 100. Truck mixers and truck agitators shall be operated within the capacity recommended by the manufacturer.

7. Retempering concrete by adding water or by other means will not be permitted. Concrete that is not within the specified slump limits at time of placement shall not be used. Admixtures for increasing the workability or for accelerating the set will be used only when provided for in the Contract, or permitted by the Purchaser. The addition of admixtures to the mix shall be in accordance with the provisions of Paragraph 5.02.A of this Specification Section.

8. Tests for air content shall be made on samples of fresh concrete when and as directed. The air content shall be that specified under Part 6 of this Specification Section and shall be determined in accordance with AASHTO T 152, T 196 or T 199.

B. Ready Mixed Concrete.

1. Ready mixed concrete shall fully comply with ASTM C 94 for Ready Mixed Concrete and to the requirements of these Specifications. Ready mixed concrete shall be discharged from the mixer within 1 hour after the introduction of water, provided the air temperature or the concrete temperature does not exceed 70^0F. When the air temperature or concrete temperature exceeds 70^0F, the elapsed time between the addition of water to the mix and discharge shall not exceed 30 minutes. The 30 minute time limit for temperatures exceeding 70^0F may be extended to 1 hour, provided an approved admixture is used. The admixture shall be a water reducing and retarding agent meeting the requirements of Paragraph 3.06, Type D of this Specification Section and shall be used in accordance with the provisions of Paragraph 5.02.A of this Specification Section. The ready-mix plant furnishing the concrete shall have been inspected and approved for use as provided for in Part 4 of this Specification Section.

2. The delivery ticket accompanying each load of concrete shall show the class and quantity of concrete, the quantity of cement, aggregates, water, and additive used in the batch, and the time of batching. Materials used in the concrete shall be tested and approved.

3.04 MIX DESIGN AND PROPORTIONING

A. General

1. A Concrete Classification Table, Table 03 05 00.2 is provided hereinafter to indicate to the Subcontractor the two classes of concrete to be use. The table contains certain criteria to be met in the design of job mixes for the different classifications of concrete. Data included are the minimum 28 day compressive strength of the concrete, the range of slump allowed, the minimum cement content of the concrete, and the maximum water allowed. The Subcontractor shall be responsible for design of the concrete mix to be used for each classification of concrete within the limits of Table 03050.2, and for providing concrete to the Purchaser in accordance with the approved design mixes.

2. Unless otherwise specified in the Contract Documents all concrete shall contain an air entraining admixture. The concrete shall contain between 5 percent and 8 percent entrained air. Other admixtures may be used if specifically approved by the Purchaser. The use of calcium chloride will not be allowed.

3. The Purchaser may specify differing compressive strengths for the several classifications by notation on the Plans or in the Special Provisions, and those values shall govern over the values of these Specifications.

CONCRETE CLASSIFICATION TABLE

Table 03 05 00.2

Minimum			Min. Cement Factor-Sacks/CY		Min. Cement Factor-#/CY		Net Water Max. Gals./CY		Net Water Max- #/CY	
Class of Concrete	28-Day Compressive Strength (psi)	Min. Slump in Inches	Gravel Coarse Aggregate	Limestone Coarse Aggregate	Gravel Coarse Aggregate	Limestone Coarse Aggregate	Gravel Coarse Aggregate	Limestone Coarse Aggregate	Gravel Coarse Aggregate	Limestone Coarse Aggregate
A	4,000	3-5	6.0	5.5	564	517	36	33	300	275
C	3,000 (1)	2-4	5.0	4.5	470	423	34	30.6	283	255

(1) Tabulated valves are for Type I cement conforming to the requirements of AASHTO M 85 only.

3.05 MIX DESIGN

A. Prior to mixing any concrete for the project, the Subcontractor shall submit his proposed design mix and reports of tests for each classification of concrete to the Purchaser for approval. The design mix shall be submitted on a form that indicates the supplier and type of the concrete and materials to be used as well as the amounts of materials per cubic yard for at least the following items and units (based upon saturated surface dry aggregate):

1. Cement-Pounds
2. Coarse Aggregate-Pounds
3. Fine Aggregate-Pounds
4. Air Entraining Admixture – Ounces
5. Other Admixtures (if allowed) – Ounces
6. Water – Pounds
7. Fly Ash (if allowed) – Pounds

3.06 PROPORTIONING

A. Each class of concrete shall be manufactured by combining the several materials prescribed in the design mix in the proportions necessary to obtain the specified compressive strength for each class. Proportioning shall be based upon the specified cement content, and the amount of water for each class of concrete shall not exceed the quantity shown in Table 03050.2. Below this limit, the quantity of water shall be adjusted to meet the slump requirements. Aggregate weights shown in the Subcontractor's mix design(s) shall be based on saturated surface dry aggregate; batch weights shall be corrected to compensate for surface moisture on the aggregate in order to determine the amount of water to be added at the mixer.

3.07 CHANGES IN MIX

A. When approved by the Purchaser, the ration of coarse and fine aggregate may be adjusted in order to assure better workability or to accommodate placement by pumping. However, in no case shall the fine aggregate exceed 44 percent of the total aggregate.

B. If during the progress of the Work, the specific gravity of one or both of the aggregates change more than plus or minus 0.03 from those shown on the concrete design, the design weights shall be adjusted by a design change to conform to the new specific gravity.

3.08 HIGH-EARLY-STRENGTH CONCRETE

A. High-early-strength concrete may be required in the Plans and Specifications or substituted at the request of the Subcontractor, subject to the approval of the Purchaser. When high-early-strength cement concrete is authorized, it shall conform to the requirements of Table 03050.2 except that the 28 day strength shall be obtained in 7 days. The use of Type I or Type III cement for high-early-strength concrete in lieu of using Type III cement. When type I cement is used, the concrete shall have a minimum of 7.6 sacks (714 pounds) of cement per cubic yard of concrete. If admixtures are used to obtain high-early-strength concrete, such admixtures may only be used if previously approved by the Tennessee Department of Transportation for similar uses of the concrete and if specifically approved for the project by the Purchaser.

B. The gradation of fine and coarse aggregates shall be the same as that approved for the concrete for which the high-early-strength concrete is substituted. All materials entering into the high-early-strength concrete shall be of the same kind and class as the materials entering into the other part or parts of the facility constructed of the class of concrete for which high-early-strength is being substituted.

C. No additional compensation will be made if the Subcontractor elects to substitute high-early-strength concrete for any class of concrete. The unit price for the class for which the substitution is made shall be full compensation for the concrete.

3.08 TESTING

A. Test Samples

1. The Purchaser shall provide for all test cylinders. All samples shall be cast, cured and tested by the Purchaser at its expense. The Subcontractor will be required to assist the Purchaser in securing necessary materials for casting the required number of cylinders. Testing ages will be 7 days and 28 days unless otherwise determined by the Purchaser. Laboratory cylinders shall be used to determine the quality of concrete produced. The number of cylinders to be cast daily for any quantity of concrete and laboratory tested, shall be specified by the Purchaser. With prior consent of the Purchaser, the Subcontractor may prepare field cylinders. These cylinders may be used as a gauge for early safe removal of forms where the Subcontractor requests earlier removal than set out in the Specifications.

B. Cement Testing

1. All cement used in the Work shall be pre-tested before use. Cement may be used upon completion of a satisfactory 3 day physical test made in accordance with current ASTM Specifications. Cement shall be tested by an approved commercial testing laboratory at the Subcontractor's expense.

C. Core Samples

1. If the Purchaser's testing of cylinders indicates compressive strength less than required in Table 03050.2 for the class of concrete specified, the Subcontractor may, at his option, elect to drill core samples from the actual concrete placed. If the Subcontractor elects to drill (or is instructed by the Purchaser to drill) core samples from the hardened concrete, the costs of obtaining the cores and of repairing the core holes with nonshrinking grout shall be borne by the Subcontractor.

2. The cores shall be drilled as directed by the Purchaser, at the same approximate locations from which the test cylinder concrete was obtained. The locations of the drilled cores shall be selected so that the remaining structure will not be impaired or sustain permanent damage after the holes are repaired by the Subcontractor. The drilled samples shall be tested for compressive strength by the Purchaser, and the equivalent 28 day strength of the concrete placed and represented by the drilled core samples shall be determined. The Purchaser shall use the test results of the drilled cores to determine the acceptability of the concrete.

3.09 METHODS OF SAMPLING AND TESTING

A. Test cylinders cast to determine acceptability for minimum AASHTO strength requirements shall be made and cured in accordance with AASHTO T 23 and tested in accordance with AASHTO T 22. Test cylinders cast to determine when a precast unit or a structure may be put into service or to determine when a tensioning load may be transferred shall be cured by methods identical to those used in curing the concrete member, and tested in accordance with AASHTO T 22.

B. Drilled core samples shall be taken and tested in accordance with AASHTO T 24. Due to possible fracturing effect of the coring operation, drilled core samples having a compressive strength of 85 per cent or more of specified strength will be considered acceptable.

C. Slump shall be determined in accordance with AASHTO T 119 on the job site during each placement.

D. The amount of air entrained shall be determined by pressure or volumetric meters of approved design and in accordance with AASHTO Method T 152 or AASHTO Method T 196, except that AASHTO Method T 199 may be used after the accuracy of the Chace Air Indicator has been determined by comparison tests.

3.10 CONCRETE FAILING TO MEET STRENGTH REQUIREMENTS

A. Concrete which has been mixed and placed in accordance with these Specifications, and which fails to meet the minimum 28 day strength requirements shall be removed and disposed of by the Subcontractor, at his expense, unless specifically authorized by the Purchaser, in writing, to remain in place. The removal shall be in such manner as will not cause damage to the remaining concrete or to other structural units or other facilities and property.

B. The Purchaser may, at his discretion, allow concrete which fails to meet the minimum strength requirement to remain in place. Payment for this concrete will be at a reduced price, to compensate the Purchaser for loss of durability. The amount of the reduction shall be determined by the Purchaser and shall be based on the particular circumstances.

3.11 MISCELLANEOUS

A. Concrete Mixed and/or Batched Off Project Site

1. Concrete may be mixed and/or batched off the immediate project site, subject to specific approval of the Purchaser and under the direct supervision of the Subcontractor. A delivery ticket (certified by the batch plant) showing mix, quantity of cement, quantity of fine and coarse aggregate, moisture content, total water and gallons per cubic yard of concrete shall be furnished to the Purchaser with each delivery of concrete and the Subcontractor shall show to the satisfaction of the Purchaser that the plant is so located and equipped as to produce and deliver concrete fully meeting the specification requirements.

PART 4 MEASUREMENT AND PAYMENT

A. The methods of measurement and payment for concrete shall be as specified in Divisions 2 and 3 of these Specifications for each particular item constructed by the Subcontractor.

END OF SECTION 03050

SECTION 03310
CONCRETE STRUCTURES

PART 1 GENERAL

1.01 SCOPE

A. This work shall consist of the construction of structures, or parts of structures, composed of Portland cement concrete, reinforced. Concrete structures shall be constructed of minimum Class A Concrete. They shall be constructed on prepared foundations, at the locations indicated or directed in conformity with the dimensions, lines and grades shown on the Plans or as directed by the Purchaser and in accordance with these Specifications.

B. Work of this Section includes precast concrete vaults and similar.

PART 2 PRODUCTS

2.01 MATERIALS

A. Materials used in this construction shall meet the requirements of the applicable Sections or Paragraphs of Specification Section 03050, “Portland Cement Concrete” and the following:

B. Waterstops

1. Waterstops shall be of the type, shape, and dimension shown on the Plans or manufacturer’s standard as required to provide for watertight construction.

2. Material:

a. Waterstops manufactured from either natural rubber, synthetic rubber, or polyvinylchloride (PVC) at the option of the Subcontractor. Waterstops shall be produced by such a process that, as supplied for use, they will be dense, homogeneous, and free from holes and other imperfections. The cross-section of the waterstop shall be uniform along its length and transversely symmetrical so that the thickness at any given distance from either edge of the waterstop will be uniform.

b. Rubber Waterstop:

i. The waterstop shall be fabricated from a high-grade thread-type compound. The basic polymer shall be natural rubber or a copolymer of butadiene and styrene, or a blend of both. The compound shall contain no less than 70 percent by volume of the basic polymer, and remainder shall consist of reinforcing carbon black, zinc oxide, accelerators, antioxidants, vulcanizing agents and plasticizers, but shall contain no factice.

ii. Samples taken from the finished waterstop shall meet the following requirements when tested in accordance with the current specified ASTM method of test.

Title	Requirement	ASTM Method of Test
Tensile Strength (Die “C”)	2500 psi. min.	D 412
Ultimate Elongation (Die “C”)	450 percent, min.	D 412

Shore Durometer Hardness	60-70	D 2240
Specific Gravity	1.15 + 0.03	D 297 (Sec. 17)
Water Absorption (% by Wt.)	5 percent, max	D 570
Tensile Strength after accelerated Aging, oxygen-pressure method	80 percent, min.	D 572

c. Polyvinylchloride Waterstop

i. Extruded from an elastomeric plastic material. The basic resin of which shall be polyvinylchloride. The compound shall contain additional resins, plasticizers, stabilizers, or other materials needed to ensure that when the material is compounded it will meet the performance requirements of this Specification as listed below. No reclaimed polyvinylchloride shall be used.

Title	Requirement	ASTM Method of Test
Tensile Strength (Die “C”)		
Sheet Material	2,000 psi	D 412
Finished Waterstop	1,700 psi	D 412
Ultimate Elongation (Die “C”)		
Sheet Material	350% Min.	D 412
Finished Waterstop	300% Min.	D 412
Stiffness in Flexure	750 psi Min.	D 747
Accelerated Extraction		CRD C 572
Tensile Strength (Die “C”)	1,750 psi	D 412
Elongation (Die “C”)	300%	D 412
Effect of Alkali (After 7 Days)		
Change in Weight	-0.1 to +0.25%	
Change in Hardness, Shore Durometer	+ or – 5%	
Low Temperature Brittleness	-35^{o}	D 746
Specific Gravity	1.3	D 792

ii. For polyvinylchloride waterstops, the supplier shall submit a certificate stating that all of the performance requirements specified for the sheet material under Polyvinylchloride Waterstops have been complied with. Field splices for Polyvinylchloride waterstops shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer’s recommendations. Waterstops shall be manufactured with an integral cross-section which shall be uniform within plus or minus 1/8 inch in width, and the web thickness or bulb diameter within plus 1/16 inch and minus 1/32 inch.

iii. The Subcontractor shall furnish the Purchaser at this request and at no cost to the Purchaser a certified test report from an approved laboratory covering each

lot or unit of finished waterstops. These test reports shall contain the numerical laboratory test data of the required test.

C. Epoxy Resin Systems

1. Two Component epoxy resin systems shall conform to the requirements of the appropriate class designation of AASHTO M235. The appropriate class designation is determined by the proposed use of the material.

2. Requirements for Specific Uses:

a. Bonding fresh concrete to cured concrete.
The material shall meet the compositional specification of AASHTO M235, Class I and applicable requirements of the Class III performance specification.

b. Bonding cured concrete to cured concrete.
The material shall meet the compositional specification of AASHTO M235, Class II and the applicable requirements of the Class III performance specification.

c. Binder in epoxy resin concrete and mortar for repairing spalls and other defects in concrete.
The material shall meet the compositional specification of AASHTO M235, Class II and the applicable requirements of the Class III performance specification.

C. Reinforcement

1. Steel reinforcement for concrete shall be billet steel bars conforming to ASTM A 615.

D. Dowel Bars

1. Dowel bars shall be plain and shall conform to ASTM A 306, Grade 55, 60, 65, or 70.

E. Welded Wire Fabric

1. Fabric for reinforcement shall conform to ASTM A 185,, and shall be supplied in mats of the size, design and weight shown on the Plans or required by Manufacturer’s design.

1.02 EQUIPMENT

A. Equipment and tools necessary for handling materials and performing all parts of the Work shall be subject to approval by the Purchaser as to design, capacity, and mechanical condition. Equipment shall be on hand sufficiently ahead of the start of construction operations to be examined and approved. The equipment and organization shall be of sufficient capacity to accomplish the maximum continuous concrete placement, as governed by the construction joints shown on the Plans or as directed by the Purchaser.

B. The requirements for batching plant and mixers shall be as prescribed in Specification Section 03050.

C. Ample and satisfactory equipment for conveying concrete from the mixer to final position in the forms shall be provided. Closed chutes or pipes shall be used when concrete is to be dumped or dropped for a distance greater than 5 feet. Where steep slopes are required, the chutes shall be equipped with baffle boards or shall be in short lengths that will enable the direction of movement to be reversed.

D. Vibrators shall be of an approved type and design and shall operate under load at a rate as recommended by the manufacturer and approved by the Purchaser.

PART 2 SUBMITTALS

2.02 Shop Drawings

A. Provide detailed shop drawings of all vaults and structures. Shop drawings shall be sealed and signed by the manufacturer's licensed engineer who is registered in the State of Tennessee.

B. Under separate cover, provide sealed and signed design calculations, for record, by the manufacturer's licensed engineer who is registered in the state of Tennessee. Calculations are kept as record copy and will not be reviewed or returned to Contractor. All dead loads, live loads, floatation, erection, temperature, and anchorage stresses shall be considered in the design. Vaults shall be designed to support H-20 loading as well as a surcharge from H-20 loading. Vaults shall be design to prevent floatation by assuming ground water is at grade and provide for a 25 percent factor of safety against floatation.

PART 3 EXECUTION

3.01 FORMS

A. Construction

1. Forms shall be mortar-tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other stresses incidental to the construction operations, including vibration. Forms shall be so constructed and maintained as to prevent the opening of joints due to shrinkage of the lumber.

2. The forms shall be built true to line and grade and shall be held in place by means of studs or uprights, and waling, which shall be sufficiently and substantially braced and tied.

3. All forms and studding shall be cut off and capped with not less than a 2 inch by 4 inch piece so that the top of the cap will be at the elevation of the finished exposed surface of the concrete.

4. All edges shall be chamfered with ¾ inch material, unless otherwise specified. All chamfer strips shall be straight, of uniform width, and dressed.

5. Wood devices of any kind used to separate forms shall be removed before placing concrete within 4 inches of such devices.

B. Form Lumber

1. Form lumber for all exposed concrete surfaces shall be dressed at least on one side and two edges and shall be so constructed as to produce mortar-tight joints and smooth, even concrete surfaces.

2. Plywood forms, or forms face-lined with plywood, masonite, or other approved similar material may be used, provided the plywood forms and form linings are substantial, of uniform thickness, and are mortar-tight when in position.

C. Metal Ties

1. Metal ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least one inch from the face without injury to the concrete. In case wire ties are permitted, the wires shall be cut back at leas ¼ inch from the surface of the concrete, and the surface left sound, smooth, even, and uniform in color.
2. Thru-wall ties shall have waterstops to prevent leakage.

D. Walls

1. Sufficient openings shall be provided at intervals along the bottom of wall forms to permit thorough cleaning prior to concrete placement. Such openings shall be closed before placing concrete in the forms.

E. Surface Treatment

1. Prior to placing reinforcement, all forms shall be treated to prevent the adherence of concrete. Forms not provided with a special treatment shall be treated with an approved oil. Any material that will adhere to or discolor the concrete shall not be used.

F. Metal Forms

1. The specifications for forms, as regards design, mortar tightness, filleted corner, beveled projections, bracing, alignment, removal, and reuse and oiling apply to metal forms. The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and revet heads shall be countersunk on the face forming the concrete surface. Clamps, pins, or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or do not line up properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease, or other foreign matter.

3.02 FALSEWORK

A. The falsework used to support the forms and concrete for concrete structures shall be supported on sills resting on rigid foundations. Where required by the geotechnical report, foundations shall include piles driven until the bearing capacity of each pile is sufficient to support the load to which it will be subjected, or earth-borne footings as hereinafter provided.

B. Earth-borne footings will be permitted only when, in the opinion of the Purchaser, the soil can adequately support the superimposed loads and the following conditions are met:

1. Spread footings will only be permitted on stable ground, capable of supporting the superimposed load.

2. The site is graded and so maintained to prohibit ponding of water or erosion of soil in the proximity of the spread footings.

3. The falsework system shall be designed and constructed to preclude exceeding the bearing capacity of the soil but in no case shall exceed 3,000 pounds per square foot.

4. The footings shall be designed and constructed to carry the superimposed loads.

5. All footings shall be constructed on a level plane.

C. The falsework shall be designed and constructed to support the required loading without distortion or settlement of the forms.

D. The Subcontractor shall place “tell-tales” for observation of the amount of falsework settlement at locations designated by the Purchaser.

E. The Purchaser may require the Subcontractor to submit detailed falsework plans, together with a soils report, design calculations or any other information necessary for a thorough review. The Subcontractor is totally responsible for the design and construction of the falsework system and shall repair, or remove and replace, as directed and at his expense, any concrete, other material or portions of the structure which are damaged or destroyed due to failure of the falsework.

3.03 REINFORCEMENT

A. All reinforcement shall consist of deformed steel bars, unless otherwise indicated or directed. Deformed steel bars shall have a net area at all sections equivalent to that of plain round or square bars of the corresponding nominal size.

B. Structural steel shapes shall conform strictly to the shapes indicated or required.

C. Steel wire fabric may be furnished in sheets.

D. Reinforcing steel shall be stored above the ground surface upon platforms, skids or other supports located without the scope of the active construction operations and shall be protected at all times from injury and damage. All brush and weeds shall be removed from the area immediately prior to storing reinforcing steel thereon.

E. Reinforcing steel, where indicated, shall be accurately bent, without heating, to the forms and dimensions indicated on the Plans. Minimum bend diameters shall be in accordance with the requirements of the American Concrete Institute. Unless otherwise indicated, all bends shall be in one plane. Bars of ¾ inch or less which have only hooks or a single bend may be bent in the field, provided satisfactory equipment for proper and accurate work is used and provided the bending is accomplished true to form and dimensions without damage to the bars. All other bending shall be done in the shop before shipment.

F. Substitution of bars of different sizes from those indicated on the Plans may only be made with the written permission of the Purchaser. If substitution is permitted, the following shall apply:

1. The total area of steel in any one linear foot in each direction shall not be reduced.

2. For cast-in-place concrete the clear distance between parallel bars in a layer shall not be less than 1.5 bar diameters, 1.5 times the maximum size of the coarse aggregate, nor 1-1/2 inches.

3. Where positive or negative reinforcement is placed in two or more layers, bars in the upper layers shall be placed directly above those in the bottom layer with the clear distance between layers not less than 1 inch.

4. Clear distance limitation between bars shall also apply to the clear distance between a contact lap splice and adjacent splices or bars.

5. Groups of parallel reinforcing bars bundled in contact to act as a unit shall be limited to 4 in any one bundle. Bars larger than #11 shall be limited to two in any one bundle in beams. Bundled bars shall be located within stirrups or ties. Individual bars in a bundle cut off within the span of a member shall terminate at different points with at least 40 bar diameters stagger. Where spacing limitations are based on bar diameter, a unit of

bundled bars shall be treated as a single bar of a diameter derived from the equivalent total area.

6. In walls and slabs, the primary flexural reinforcement shall be spaced not farther apart than 1.5 times the wall or slab thickness, nor 18 inches.

G. All reinforcement shall be furnished in the full lengths shown on the Plans, unless otherwise approved in writing by the Purchaser. No splices shall be made unless indicated on the Plans or authorized by the Purchaser. Splices shall be so arranged and manipulated as to provide a minimum of 2 inches net clearance between the splices and the surface of the complete concrete work, unless otherwise indicated or directed. Splices of tension reinforcement at points of maximum stress shall be avoided. The members at all splices shall be rigidly clamped by means of at least two approved metal clips located approximately 3 inches from the ends of the bars and bolted around them or securely wired in a manner satisfactory to the Purchaser.

H. Steel shapes shall be spliced only as indicated on the Plans.

I. Steel fabric shall be spliced by overlapping of the sheets by not less than 12 inches; by matching at least three transverse member; and by securely wiring the overlapped sections in a manner satisfactory to the Purchaser.

J. All reinforcing steel before being placed shall be thoroughly cleaned of mill scale, rust, dirt, paint, oil, or other foreign substances or coating of any character that will reduce the bond. If reinforcement which has been placed becomes dirty, rusty, or spattered with mortar which dries before concrete is placed around it, such reinforcement, or part affected, shall be thoroughly cleaned before being covered with concrete.

K. Reinforcement shall be accurately placed and firmly held in position as indicated on the Plans. Steel bars shall be securely fastened together with metal clips or wire at each intersection, except where spacing is less than on 1 foot in each direction then alternate intersections shall be fastened. All reinforcing steel shall be securely spaced from the forms and between adjacent reinforcement by means of precast mortar blocks, metal spacers or other approved devices or methods, and where possible, all spacer devices shall be so arranged that their use cannot be detected in the completed structure. Spacer blocks shall be cast of mortar mixed in the same proportions as that in the concrete mixture and shall not have a length or width greater than the depth required for proper spacing from the forms or between adjacent reinforcement. The use of gravel, concrete, brick, or wooden blocks is prohibited.

L. All the reinforcing steel necessary for a section of a concrete structure shall be accurately and securely placed and the placement approved by the Purchaser before any concrete is deposited in the section, and care shall be observed not to disturb it during the placing of the concrete.

M. Dimensions relating to reinforcing bars are to the centers of the bars.

N. Tolerances for bending and cutting during fabrication shall be in accordance with the “Manual of Standard Practice” published by the Concrete Reinforcing Steel Institute.

3.04 DRAINAGE AND WEEP HOLES

A. Drainage openings and weep holes shall be constructed using materials in the manner and at the locations shown on the Plans or established by the Purchaser. Ports or vents for equalizing hydrostatic pressure, when required, shall be placed as directed.

3.05 PLACING PIPES, CONDUITS, ANCHORS, CASTING, AND OTHER APPURTENANCES

A. Pipes, conduits, anchors, castings, bolts, plates, grillage, and other appurtenances which are necessary or desirable to be placed in the concrete of a structure, whether indicated on the Plans or not, shall be placed by the Subcontractor during construction, as directed.

B. No compensation will be allowed for placing such pipes, conduits, and other appurtenances, except that no deductions will be made for the volume of concrete displaced by those items.

3.06 EXPANSION JOINTS

A. Expansion devices shall be as indicated on the Plans. The devices shall be securely anchored in correct position. All sliding surfaces shall be true and smooth and shall form complete contact throughout. Movement shall not be impeded by the concrete in which they are embedded.

B. Unless otherwise provided, where portions of concrete bridge superstructure rest on the substructure, the contact area shall be separated by at least two layers of three-ply bituminous-saturated paper.

C. Open joints shall be constructed using forms which will permit removal without injury to the concrete. After removal of the forms, the joints shall be cleaned thoroughly. Filled joints shall be constructed with pre-molded filler, unless otherwise indicated. Joints requiring a sealant shall be thoroughly cleaned and sealed with one of the specified joint sealing materials before the structure is opened to traffic. Edges of open and filled joints shall be chamfered or edged, as directed. Mortised joints shall be constructed as shown on the Plans or as directed.

3.07 PLACING CONCRETE

A. General

1. Concrete shall not be placed until forms and reinforcing steel have been checked and approved. The forms shall be clean of all debris and kept wet immediately before concrete is placed. The method and sequence of placing concrete shall be approved by the Purchaser. Unless otherwise permitted, all concrete shall be placed in daylight, and the placing of concrete in any portion of the structure shall not be started unless it can be entirely completed in daylight. When the placing of concrete is permitted during other than daylight hours, an adequate and approved artificial lighting system shall be provided and operated.

2. All concrete shall be thoroughly worked during the placing by means of tools of approved type. The working shall be such as to force all coarse aggregate from the surface and to bring mortar against the forms to produce a smooth finish, substantially free from water and air pockets or honeycomb.

3. If the forms show bulging or settlement while concrete is being placed, the placing shall be stopped until correction has been made.

4. T-beam girders, slabs, arch rings, and all horizontal sections of bridges except curbs and sidewalks shall be constructed monolithically and continuously, unless otherwise permitted. Curbs and sidewalks shall be constructed after the bridge deck is completed, unless otherwise indicated on the Plans.

5. After initial set and prior to final set of the concrete, the forms shall not be jarred, and no strain shall be placed on the ends of the projecting reinforcement. Piles shall not be

driven closer than 20 feet to footings less than 7 days old nor to foundations supporting concrete less than 7 days old.

B. Railings and Curbing

1. When constructing curb, careful attention shall be given to the installation of railing steel or anchoring devices.

2. Concrete railings shall not be constructed on any structure until the falsework has been struck.

C. Chutes and Troughs

1. Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement.

2. All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. The water used for flushing shall be discharged clear of the concrete already in place.

3. Care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred, and no strain shall be placed on the ends of projecting reinforcement.

D. Vibrating

1. Concrete shall be compacted with suitable mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate compaction.

2. Vibrators shall be so manipulated as to work the concrete thoroughly around the reinforcement and embedded fixtures and into corners and angles of the forms. Vibrators shall not be used as a means to cause concrete to flow or run into position in lieu of placing. The vibration at any point shall be of sufficient duration to accomplish compaction but shall not be prolonged to the point where segregation occurs.

3. At least one additional standby vibrating unit shall be available for all individual pours.

E. Joints

1. Feather-edge construction joints will not be permitted. Transverse or longitudinal joints through spans will not be permitted, except where specified.

2. In no case shall the concreting of any section or layer be stopped or temporarily discontinued within 18 inches of any finished surface, unless the details of the structure provide for a coping having a thickness of less than 18 inches, in which case, at the option of the Purchaser, the construction joint may be made at the underside of the coping.

3. Layers completing a day’s work or placed just prior to temporarily discontinuing operations shall be cleaned of all laitance or other objectionable material as soon as the surface has become sufficiently firm to retain its form.

3.08 BONDING CONSTRUCTION JOINTS

A. Where dowels, reinforcing bars, or other adequate ties are not indicated on the Plans, keys of a directed size shall be made by constructing projections above the concrete and monolithically with the concrete.

B. In resuming work, the forms shall be drawn tightly against the face of the concrete. The entire surface of the concrete to be bonded shall be cleaned thoroughly and roughened with a steel tool. In addition, if directed, the surface to be bonded shall be cleaned and roughened by sandblasting. The surface shall then be soaked with clean water, after which concreting may proceed.

3.09 REMOVAL OF FORMS AND FALSEWORK

A. Forms for ornamental work, railings, parapets, columns, and vertical surfaces that do not carry loads shall be removed in from 12 to 48 hours, unless otherwise directed by the Purchaser. In cold, damp, or freezing weather, all vertical forms shall remain in place until the concrete has set sufficiently to withstand damage when the forms are removed. In removing forms, care shall be exercised not to mar the surface of the concrete nor to subject it to any undue pressure.

B. Projecting wires or other metal devices used for holding forms in place and which pass through the body of the concrete shall be removed or cut as specified in Specification Section 03310 Paragraph 3.01.A, and the holes or depressions thus made and all other holes, depressions, and small voids which show upon the removal of the forms shall be filled with cement mortar mixed in the same proportions as that which was used in the body of the concrete which is being repaired.

C. Falsework and supports under slab or girder spans, any length, may be released and removed when representative specimens of the concrete in the spans, cured by the methods and in the manner the concrete which the test specimens represent is cured, attain a compressive strength of 3,000 pounds per square inch. In addition to the above requirement, the concrete shall have been placed a minimum of 10 days, not counting the days of 24 hours each in which the temperature falls below 40^{o} F., or 21 calendar days, whichever occurs first.

D. For continuous concrete girder or slab units, any length, the falsework and supports shall not be released or removed from any span in the continuous unit until the concrete in all spans in the unit has been placed a sufficient length of time to meet all requirements for the removal of falsework and supports as set forth above.

E. Forms supporting bridge decks between girders and outside curb overhangs may be removed after seven days.

3.10 DEFECTIVE CONCRETE

A. Any defective concrete discovered after the forms have been removed shall be removed immediately and replaced. If the surface of the concrete is bulged, uneven, or shows honeycombing which cannot be repaired satisfactorily, the entire section shall be removed and replaced.

B. Concrete having a 28-day strength of less than the minimum specified shall be removed and disposed of by the Subcontractor, at his expense, unless specifically authorized by the Purchaser, in writing, to remain in place. The removal shall be in such a manner as will not

cause damage to the remaining concrete or to other structural units or other facilities and property.

3.11 FINISHING CONCRETE SURFACES

A. Surface of the concrete shall be finished immediately after form removal.

B. All concrete surfaces shall be given a Class 1 finish. The following surfaces of all structures shall be given a Class 2 Finish: roadway face and top of curb, vertical outside face of curb overhang or sidewalk slab, bottom surface of slab overhang, bridge railings, barrier railings, all vertical surfaces of the superstructure of dual bridges exposed to view from either structure, and all surfaces of retaining walls, wingwalls, and end walls which are visible from passing vehicles.

1. Class 1, Ordinary Surface Finish

   a. Immediately following the removal of the forms, all fins and irregular projections shall be removed from all surfaces which are to be exposed or waterproofed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges, and other defects, shall be thoroughly cleaned, saturated with water, and carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the Class of the concrete being finished. Mortar used in pointing shall not be more than 30 minutes old. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

   b. All surfaces which cannot be repaired to the satisfaction of the Purchaser shall be “rubbed” as specified for a Class 2 finish.

2. Class 2, Rubbed Finish.

   a. After removal of forms, the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing to thoroughly set. Surfaces to be finished shall be rubbed with a wetted wooden block or a medium coarse carborundum stone. The carborundum stone shall not be used until the concrete has hardened to the state where the sand will grind, rather than ravel or roll. Rubbing shall be continued until all form marks, projections, and irregularities have been removed; all voids filled; and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place. A brush finish or painting with grout will not be permitted.

   b. After all concrete above the surface being finished has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform color.

   c. After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder, and objectionable marks.

3. Class 3, Float Finish

   a. This finish, for unformed surfaces, except slab surfaces for pavements or bases, shall be achieved by placing an excess of material in the form and removing or striking off

the excess with a template, forcing the coarse aggregate below the mortar surface. Creation of concave surfaces shall be avoided after the concrete has been struck off, the surface shall be thoroughly worked and floated with a suitable floating tool of wood, canvas, or cork. Before the finish has set, the surface cement film shall be removed with a fine brush in order to have a fine-grained, smooth but sanded texture.

3.12 FINISHING SLAB SURFACES FOR PAVEMENTS OR BASES

A. Top slabs of structures shall be finished either by hand methods or approved mechanical finishing machines.

B. When the hand method is used, floors or slabs shall be struck off with a screed which is parallel to the centerline, resting on bulkheads or screed strips cut or set to the required cross-section. This screed shall be so constructed as to have sufficient strength to retain its shape and that the cutting edge may be adjusted to conform to the required profile. Screeds shall be of sufficient length to finish the full length of spans 40 feet or less in length. Spans over 40 feet in length shall be finished in two or more sections, but no section shall be less than 20 feet in length. Screed strips or headers shall be accurately set to the specified grades, checked, and adjusted as necessary prior to the final screeding operation. The screed shall be worked back and forth over the surface until the proper profile and cross-section is obtained.

C. When mechanical finishing machines are used, they shall be approved power driven machines, traveling on rails adjusted to conform to the required profile. The machines shall be equipped with oscillating or vibrating transverse or longitudinal screeds that may be adjusted to conform to the profile. The screeds shall have sufficient strength to retain their shape after adjustment. The finishing machine shall go over each area as many times as is required to obtain the required profile and cross-section.

D. After finishing as described above, the surface shall be checked with a 12 foot straightedge and shall show no deviation is excess of 1/8 inch from the testing edge of the straightedge when placed parallel to the centerline. Deviations in excess of this requirement shall be corrected before the concrete sets.

E. Broom Finish: The surface shall be finished by dragging a seamless strip of damp burlap over the full width of the surface. The burlap drag shall consist of sufficient layers of burlap to slightly groove the surface and shall be moved forward with minimum bow of the lead edge. The drag shall be kept damp, clean, and free of particles of hardened concrete. A light broom or brush herring bone finish that leaves a texture similar to that obtained by the burlap drag may be used when permitted by the Purchaser. For bases, the surface shall be finished by grooving lightly with a wire broom at an angle of 60^{o} with the centerline. All strokes shall begin at the center and end at the edge. After the slab has been finished by the burlap drag, surfaces which will become traffic lanes shall be textured by the formation of transverse grooves. The grooves shall be formed in the surface at an appropriate time during the stiffening of the concrete, so that in the hardened concrete the grooves will be between 0.09 inch and 0.13 inch in width; between 0.12 inch to 0.19 inch in depth; and spaced at random intervals between 0.3 inch and 1.0 inch. The grooves shall terminate approximately 18 inches from curbs, parapets, barrier walls, and other vertical walls. The grooves shall be relatively smooth and uniform; shall be formed without tearing the surface and without bringing pieces of coarse aggregate to the top of the surface; and shall be formed to drain transversely. All areas which do not conform to these requirements shall be corrected at the Subcontractor’s expense by approved methods.

F. As soon as the surface has set sufficiently to withstand damage when walking on it and not later than the morning following the placing of the concrete, it shall be straightedged with the 12 foot straightedge and all variations exceeding 1/8 inch shall be plainly marked. The

Subcontractor shall correct a seal such variations in the same manner as specified for Portland Cement Concrete Pavement.

3.13 CURING CONCRETE

A. All concrete surfaces, except those surfaces protected by forms that remain tightly in-place seven days or longer as required under the provisions of Specification Section 03310 “Removal of Forms and Falsework”, shall be cured as specified below. Curing shall begin as soon as the concrete has hardened sufficiently to withstand surface damage to unformed surfaces and immediately after the forms have been removed from formed surfaces.

B. When the temperature is expected to fall below 35^{O} F., the concrete shall be protected in accordance with the provisions of Specification Section 03310.

C. The initial curing period for concrete surfaces shall be by the “Water Method” for a period of not less than 24 hours, or until the concrete surfaces have been prepared for the application of curing compound, in accordance with the provisions under B below. During the initial curing period, the concrete shall be protected from the sun by burlap mats or other approved materials and kept completely and continuously moist.

D. The “Water Method” and membrane-forming compound method of curing will be required for all bridge decks, and on all concrete slabs when the temperature exceeds 90^{O} F during placement.

1. Water Method

   a. All concrete slabs shall be covered immediately with material suitable for use with the water cure and kept thoroughly wet for at least 120 hours from the beginning of the initial curing period. All surfaces other than slabs shall be protected from the sun and shall be kept wet for a period of at least 72 hours from the beginning of the initial curing period. Curbs, walls, handrails, and other surfaces requiring a Class 2 finish may have the covering temporarily removed for finishing, but the covering shall be restored as soon as possible.

2. Membrane-Forming Compound Method

   a. All surfaces shall be given the required surface finish prior to application of the curing compound. Prior to the application of curing compound, the surface shall be kept moist.

   b. The rate of application of curing compound shall be as recommended by the manufacturer but shall not be less than one gallon for 150 square feet of concrete surface. The curing compound shall be applied, under pressure, immediately after completion of the initial curing period or acceptance of the concrete finish. If the surface is dry, the concrete shall be thoroughly wet with water and the curing compound applied just as the surface film of water disappears. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. If the application of the compound results in a streaked or blotchy appearance, the method shall be stopped and water curing, as set out above, applied until the cause of the defective appearance is corrected. The coating shall be protected against marring for a period of seven days from date of application. Any coating marred or otherwise disturbed within the seven day period shall be replaced.

3.14 PROTECTION OF CONCRETE IN COLD WEATHER

A. Concrete shall be protected in cold weather a specified in Specification Section 03050.

3.15 WATERPROOFING AND WATERSTOPS

A. A Waterproofing coating shall be applied around the entire precast vault. Dampproofing coating material is not acceptable.

B. Waterstops shall be installed in accordance with the details shown on the Plans and in conformity with the requirements of these Specifications.

C. Waterstops shall be installed in continuous strips without splices, except that splices will be permitted at changes in direction when necessary to avoid buckling or distortion of the web or flange. All splices shall be performed in accordance with the manufacturer's recommendations and in the case of polyvinylchloride waterstops, the heat used shall be sufficient to melt but not char the plastic.

D. Adequate provisions shall be made to support the waterstops during the progress of work and to insure their proper embedment in the concrete. The concrete shall be thoroughly worked in the vicinity of the joints to insure maximum density and imperviousness. Forms shall be so designed that they can be removed without damaging the waterstops. Suitable guards shall be provided to protect exposed projecting edges and ends of partially embedded waterstops from mechanical damage.

PART 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. All concrete will be measured for payment as stipulated under the Specification Section specifying each individual type of construction, unless specified otherwise herein.

B. No allowance will be made for furnishing the material and the construction of drainage openings and weep holes as indicated or as directed, provided such openings are 6 inches in diameter or less, except that no deduction will be made for such openings in the computation of concrete quantities. Allowance will be made for other openings as indicated.

C. No allowance will be made for additional cement used in depositing concrete underwater; for use of calcium chloride or chemical additives; for fillers, sealer, and tar paper used in expansion joints; for dowels or other materials used in bonding construction joints; for waterstops; and for painting metals.

D. No allowance will be made for concrete placed below the foundation elevation shown on the Drawings or as directed by the Purchaser.

E. No additional compensation will be made for high-early-strength concrete.

F. Concrete Base/Pads:

1. Concrete base/pads will be measured for payment at the contract unit price per square foot; preparing the subgrade, and placing, finishing, curing and protection of concrete, complete in place.

4.02 PAYMENT

A. All concrete will be paid for as stipulated under the Specification Section specifying each individual type of construction, unless otherwise specified herein.

B. Concrete base/pads will be paid at the contract unit price per square foot including preparing the subgrade, and placing, finishing, curing and protection of concrete, complete in place.

4.03 PAYMENT WILL BE MADE UNDER:

Item No.	Pay Item	Pay Unit
03310-4.02.B	CONCRETE BASE/PADS	SQUARE FOOT

END OF SECTION 03310

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SECTION 11000

GENERAL REQUIREMENTS FOR EQUIPMENT

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. This section specifies general requirements which are applicable to all mechanical equipment. The Contractor is responsible for ensuring that all mechanical equipment meets the requirements of this section in addition to the specific requirements of each individual equipment specification section.

1.02 QUALITY ASSURANCE

A. Arrangement:

1. The arrangement of equipment shown on the drawings is based upon information available to the Owner at the time of design and is not intended to show exact dimensions conforming to a specific manufacturer. The drawings are, in part, diagrammatic, and some features of the illustrated equipment installation may require revision to meet actual submitted equipment installation requirements; these may vary significantly from manufacturer to manufacturer. The contractor shall, in determining the cost of installation, include these differences as part of his bid proposal. Structural supports, foundations, connected piping, valves, and electrical conduit specified may have to be altered to accommodate the equipment actually provided. No additional payment shall be made for such revisions and alterations.

B. References:

1. This section contains references to the documents listed below. They are a part of this section as specified and modified. Where a referenced document cites other standards, such standards are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, has been discontinued or has been replaced.

Reference	Title
ABMA Std 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA Std 11	Load Ratings and Fatigue Life for Roller Bearings
ANSI B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI B1.20.1	Pipe Threads, General Purpose (Inch)
ANSI B16.1	Gray Iron Pipe Flanges and Flanged Fittings, (Classes 25, 125, and 250)

ANSI B18.2.1	Square and Hex Bolts and Screws (Inch Series)
ANSI B18.2.2	Square and Hex Nuts (Inch Series)
ANSI S2.19	Mechanical Vibration – Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Unbalance, Including Marine Applications

C. Unit Responsibility:

1. The Contractor shall cause equipment assemblies made up of two or more components to be provided as a working unit by the unit responsibility manufacturer, where specified. The unit responsibility manufacturer shall coordinate selection, coordinate design, and shall provide all mechanical equipment assembly components such that all equipment components furnished under the specification for the equipment assembly, and all equipment components specified elsewhere but referenced in the equipment assembly specification, is compatible and operates reliably and properly to achieve the specified performance requirements. Unless otherwise specified, the unit responsibility manufacturer shall be the manufacturer of the driven component equipment in the equipment assembly. The unit responsibility manufacturer is designated in the individual equipment specifications found elsewhere in this project manual. Agents, representatives or other entities that are not a direct division of the driven equipment manufacturing corporation shall not be accepted as a substitute for the driven equipment manufacturer in meeting this requirement. The requirement for unit responsibility shall in no way relieve the Contractor of his responsibility to the Owner for performance of all systems as provided in the General Conditions of the Contract Documents.

D. The Contractor shall ensure that all equipment assemblies provided for the project are products for which unit responsibility has been accepted by the unit responsibility manufacturer(s), where specified. Unit responsibility for related components in a mechanical equipment assembly does not require or obligate the unit responsibility manufacturer to warranty the workmanship or quality of component products not manufactured by them. Where an individual specification requires the Contractor to furnish a certificate from a unit responsibility manufacturer, such certificate shall conform to the content, form and style of Form 11000-C attached at the end of this section, shall be signed by an officer of the unit responsibility manufacturer's corporation and shall be notarized. No other submittal material will be processed until a Certificate of Unit Responsibility has been received and has been found to be satisfactory. Failure to provide acceptable proof that the unit responsibility requirement has been satisfied will result in withholding approval of progress payments for the subject equipment even though the equipment may have been installed in the work.

E. Balance:

1. Unless specified otherwise, for all machines 10 HP and greater, all rotating elements in motors, pumps, blowers and centrifugal compressors shall be fully assembled, including coupling hubs, before being statically and dynamically balanced. All rotating elements shall be balanced to the following criteria:

   a. $U_{per} = 6.015 \frac{GW}{N}$

   b. Where:

      1) U_{per} = permissible imbalance, ounce-inches, maximum

2) *G* = Balance quality grade, millimeters per second
3) *W* = Weight of the balanced assembly, pounds mass
4) *N* = Maximum operational speed, rpm

2. Where specified, balancing reports, demonstrating compliance with this requirement, shall be submitted as product data. Equipment balance quality grade shall be *G* 2.5 (*G* = 2.5 mm/sec) or better in accordance with ANSI S2.19.

PART 2 PRODUCTS

2.01 FLANGES AND PIPE THREADS

A. Flanges on equipment and appurtenances provided under this section shall conform in dimensions and drilling to ANSI B16.1, Class 125. Pipe threads shall conform in dimension and limits of size to ANSI B1.1, coarse thread series, Class 2 fit.

B. Threaded flanges shall have a standard taper pipe thread conforming to ANSI B1.20.1. Unless otherwise specified, flanges shall be flat faced.

C. Flange assembly bolts shall be heavy pattern, hexagonal head, carbon steel machine bolts with heavy pattern, hot pressed, hexagonal nuts conforming to ANSI B18.2.1 and B18.2.2. Threads shall be Unified Screw Threads, Standard Coarse Thread Series, Class 2A and 2B, ANSI B1.1.

2.02 BEARINGS

A. Unless otherwise specified, equipment bearings shall be oil or grease lubricated, ball or roller type, designed to withstand the stresses of the service specified. Each bearing shall be rated in accordance with the latest revisions of ABMA Methods of Evaluating Load Ratings of Ball and Roller Bearings. Unless otherwise specified, equipment bearings shall have a minimum L-10 rating life of 50,000 hours. The rating life shall be determined using the maximum equipment operating speed.

B. Grease lubricated bearings, except those specified to be factory sealed and lubricated, shall be fitted with easily accessible grease supply, flush, drain and relief fittings. Extension tubes shall be used when necessary. Grease supply fittings shall be standard hydraulic alemite type.

C. Oil lubricated bearings shall be equipped with either a pressure lubricating system or a separate oil reservoir type system. Each oil lubrication system shall be of sufficient size to safely absorb the heat energy normally generated in the bearing under a maximum ambient temperature of 60 degrees C and shall be equipped with a filler pipe and an external level indicator gage.

D. All bearings accessible to touch, and located within 7 feet measured vertically from floor or working level or within 15 inches measured horizontally from stairways, ramps, fixed ladders or other access structures, shall either incorporate bearing housings with sufficient cooling to maintain surface temperature at 65 degrees C or less for continuous operation at bearing rated load and a 50 degrees C ambient temperature or shall be provided with appropriate shielding shall be provided that will prevent inadvertent human contact.

2.03 V-BELT ASSEMBLIES (NOT USED)

2.04 PUMP SHAFT SEALS

A. General:

1. Seals for water and wastewater pump shafts shall be either stuffing box or mechanical seals. For industrial wastewater service, or for fluids other than water or municipal wastewater, the recommendations of the seal manufacturer shall be followed for selection of appropriate seals. Unless specified otherwise, stuffing boxes and mechanical seals shall conform to the requirements set forth in this paragraph.

B. Mechanical Seals:

1. Unless otherwise specified in the detailed pump specifications, mechanical seals shall be split mechanical seals requiring no field assembly, other than assembly around the shaft and insertion into the pump. They shall be self-aligning, and self-centering, single seals. They shall be of a nondestructive (nonfretting) type requiring no wearing sleeve for the shaft. Shafts for pumps specified with mechanical seals shall be furnished with no reduction in size through the seal area (no shaft sleeve). Where the detailed specifications call for cartridge instead of split seals, all other requirements of this paragraph apply.
2. Metal parts shall be Type 316 or 316L stainless steel. Springs shall be Hastelloy C, Elgiloy, or other Duplex SS selected for resistance to chloride attack. Rotary faces shall be silicon carbide or chrome oxide. Stationary faces shall be silicon carbide for solids bearing fluid service and carbon for clean water service. Elastomers shall be ethylene propylene or fluorocarbon. Mechanical seals shall be suitable for operation between full vacuum (0 psia) up to 200 percent of the maximum specified operating pressure, but in any event not less than 200 psig.
3. Seal chambers shall be provided with vented solids removal restriction bushings except for enclosed line shaft pumps where the seal barrier fluid is used for line shaft bearing lubrication. The bushing shall both control the amount of flushing water flow and restrict solids and gas accumulation from the seal face area.
4. Candidate seals include:
    a. Chesterton 442 seals provided with Chesterton/SpiralTrac solids removal restriction bushings Version N or D, as recommended by EnviroSeal Engineering Products, Ltd, Nova Scotia, Canada.
    b. AESSEAL RDSX seals with restriction bushing.
    c. John Crane 3710 seals with Type 24SL bushing.
5. Seals on pumps for contaminated water service (sludge, grit, wastewater, scum, reclaimed water, etc.) shall be drilled and tapped for connection of a clean water flushing supply.
6. Seals for all vertical pumps (whether column or volute type) shall be provided with a second flush connection. Vertical pumps shall have a vent valve attached to the mechanical seal to eliminate air from the seal chamber prior to pump start; start-up procedures shall include venting instructions; and for remotely started pumps, the vent system shall be automated. Where specified in the detailed specifications, permissive confirmation automatic vent systems shall be provided.

C. Shaft Packing:

1. Where shaft packing is specified, stuffing boxes shall be tapped to permit introduction of seal liquid and shall hold a minimum of five rows of packing. Stuffing boxes shall be face attached. Stuffing box and shaft shall be suitable for field installation, without machining or other modifications, of the mechanical seal specified in paragraph 2.04.B Mechanical Seals for the applicable pump and operating conditions.
2. Unless otherwise specified, lantern rings shall be bronze or Teflon, packing shall be die-molded packing rings of non-asbestos material suitable for the intended service and as recommended by the manufacturer, and glands shall be bronze, two piece split construction. Lantern rings shall be of two-piece construction and shall be provided with tapped holes to facilitate removal. Lantern rings shall be drilled and tapped 1/4 NC-20. The impeller end of the packing on all but line shaft pumps with external source water lubricated bearings shall be fitted with a SpiralTrac, Version P packing protection system as manufactured by EnviroSeal Engineering Products, Ltd, Nova Scotia, Canada.
3. The section of each shaft or impeller hub that extends through or into the stuffing box shall be fitted with a replaceable stainless steel sleeve with a Brinell hardness of not less than 500. The sleeve shall be held to the shaft to prevent rotation and shall be gasketed to prevent leakage between the shaft and the sleeve. Minimum shaft sleeve thickness shall be 3/8 inch.

2.05 COUPLINGS

A. Unless otherwise specified in the particular equipment sections, equipment with a driver greater than 1/2 HP, and where the input shaft of a driven unit is directly connected to the output shaft of the driver, shall have its two shafts connected by a flexible coupling which can accommodate angular misalignment, parallel misalignment and end float, and which cushions shock loads and dampens torsional vibrations. The flexible member shall consist of a tire with synthetic tension members bonded together in rubber. The flexible member shall be attached to flanges by means of clamping rings and cap screws, and the flanges shall be attached to the stub shaft by means of taper lock bushings which shall give the equivalent of a shrunk-on fit. There shall be no metal-to-metal contact between the driver and the driven unit. Each coupling shall be sized and provided as recommended by the coupling manufacturer for the specific application, considering horsepower, speed of rotation, and type of service.

B. Where torque or horsepower capacities of couplings of the foregoing type is exceeded, Thomas-Rex, Falk Steel Flex, or equal, couplings will be acceptable provided they are sized in accordance with the equipment manufacturer's recommendations and sizing data are submitted. They shall be installed in conformance to the coupling manufacturer's instructions.

2.06 GUARDS

A. Exposed moving parts shall be provided with guards which meet all applicable OSHA requirements. Guards shall be fabricated of 14-gage steel, 1/2-13-15 expanded metal screen to provide visual inspection of moving parts without removal of the guard. Guards shall be galvanized after fabrication and shall be designed to be readily removable to facilitate maintenance of moving parts. Reinforced holes shall be provided. Lube fittings shall be extended through guards.

2.07 CAUTION SIGNS

A. Equipment with guarded moving parts which operates automatically or by remote control shall be identified by signs reading "Caution - Automatic Equipment May Start At Any Time". Signs shall be constructed of fiberglass material, minimum 1/8 inch thick, rigid, suitable for post mounting. Letters shall be white on a red background. The sign size and pattern shall be as shown on the drawings. Signs shall be installed near guarded moving parts.

2.08 GAGE TAPS, TEST PLUGS AND GAGES

A. Gage taps shall be provided on the suction and discharge sides of pumps, blowers and compressors. Pressure and vacuum gages shall be provided where specified.

2.09 NAMEPLATES

A. Nameplates shall be provided on each item of equipment and shall contain the specified equipment name or abbreviation and equipment number. Equipment nameplates shall be engraved or stamped stainless steel and fastened to the equipment in an accessible and visible location with stainless steel screws or drive pins.

2.10 LUBRICANTS

A. The Contractor shall provide for each item of mechanical equipment a supply of the required lubricant adequate to last through the specified commissioning period. Lubricants shall be of the type recommended by the equipment manufacturer and shall be products of the Owner's current lubricant supplier. The Contractor shall limit the various types of lubricants by consolidating them, with the equipment manufacturer's approval, into the least number of different types. Not less than 90 days before the date shown in his construction schedule for starting, testing and adjusting equipment, the Contractor shall provide the Owner with three copies of a list showing the required lubricants, after consolidation, for each item of mechanical equipment. The list shall show estimated quantity of lubricant needed for a full year's operation, assuming the equipment will be operating continuously.

2.11 ANCHOR BOLTS

A. Anchor bolts shall be designed for lateral forces for both pullout and shear in accordance with the provisions of the Section.
   1. Anchor bolts for equipment shall be designed by the equipment manufacturer to include equipment operational loads combined with seismic and wind forces when applicable.

B. Unless otherwise stated in the individual equipment specifications, anchor bolt materials shall conform to the following table.

Material	Specification
Stainless Steel Anchor Bolts	ASTM A193 or A320, Type 316
Stainless Steel Threaded Rods	ASTM F593, Type 316
Stainless Steel Nuts	ASTM A194 Heavy Hex Nuts, Type 316 ASTM F594 Heavy Hex Nuts at Adhesive Anchors, Type 316 ASTM A194 Heavy Hex Nuts Grade 8S (Nitronic 60)

Material	Specification
Stainless Steel Washers	Type 316 to match bolt material
Carbon Steel Anchor Bolts	ASTM F1554, Grade 36, Hot Dip Galvanized
High-Strength Carbon Steel Anchor Bolts	ASTM F1554, Grade 55, Weldable per Supplementary Requirement S1, Hot Dip Galvanized
Carbon Steel Nuts and Washers	ASTM A563 and F844, Heavy Hex, Hot-Dip Galvanized
Concrete Adhesive Anchors	Hilti “HIT-RE 500v3”, Simpson Strong-Tie “SET-XP”, or approved equal, with Type 316 Stainless Steel threaded rods
Concrete Masonry Adhesive Anchors	Hilti "HIT-HY 70", Simpson Strong-Tie “SET-XP”, or approved equal, with Type 316 Stainless Steel threaded rods

2.12 SPARE PARTS

A. Spare parts, wherever required by detailed specification sections, shall be stored in accordance with the provisions of this paragraph. Spare parts shall be tagged by project equipment number and identified by part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration, such as ferrous metal items and electrical components, shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high, or 3 feet in length shall be stored in a wooden box with a hinged wooden cover and locking hasp. Hinges shall be strap type. The box shall be painted and identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts." A neatly typed inventory of spare parts shall be taped to the underside of the cover.

PART 3 EXECUTION

3.01 GENERAL

1. Installation of equipment accessories included in this section shall be as recommended by the equipment manufacturer unless otherwise specified in the individual equipment specification section.

END OF SECTION

11000-C. UNIT RESPONSIBILITY CERTIFICATION FORM

LIFT STATION DESIGN GROUP 3 C

CERTIFICATE OF UNIT RESPONSIBILITY

FOR SPECIFICATION SECTION _____

_____

[SECTION TITLE]

In accordance with Section 11000-1.02 Unit Responsibility of the contract documents, the undersigned manufacturer of driven equipment ("manufacturer") accepts unit responsibility for all components of equipment furnished to the Project under specification Section_____ , and for related equipment manufactured under sections**_____, _____, and _____ .**

We have reviewed the requirements for section 11000 (where applicable) and all sections referencing this (these) section(s), including but not limited to drivers, supports for driving and driven equipment and all other specified appurtenances to be furnished to the Project by manufacturer. And, we have further reviewed, and modified as necessary, the requirements for associated variable speed drives and motor control centers. We hereby certify that all specified components are compatible and comprise a functional unit suitable for the specified performance and design requirements whether or not the equipment was furnished by us. We will make no claim nor establish any condition that problems in operation for the product provided under this specification Section _____ are due to incompatibility of any components covered by this Certificate of Unit Responsibility. Nor will we condition or void any warranty for the performance of the product of this specification Section _____ due to incompatibility of any components covered under this Certificate of Unit Responsibility.

Our signature on this Certificate of Unit Responsibility does not obligate us to take responsibility for, nor to warrant the workmanship, quality, or performance of related equipment provided by others under specification sections _____, _____, and _____. Our obligation to warranty all equipment provided by us shall remain unaffected.

Notary Public	Name of Corporation
Commission Expiration Date	Address
Seal:	By:
	Duly Authorized Official
	Legal Title of Official
	Date

SECTION 11310

WET WELL MOUNTED DUPLEX PUMPING STATION

1.01 GENERAL

A. The contractor shall furnish and install one factory-built, automatic pumping station as manufactured by Smith & Loveless, Inc., or approved equal. The station shall be complete with all needed equipment, factory-installed on a welded steel base with a hinged fiberglass cover.

B. The principal items of equipment shall include two vertical, close-coupled, motor driven, vacuum primed, non-clog pumps; valves; internal piping; central control panel with circuit breakers; motor starters and automatic pumping level controls; heater; ventilating blower; priming pumps with pump prime detection system and appurtenances; and all internal wiring.

1.02 OPERATING CONDITIONS

A. See Appendix A for operating conditions for each of the four (4) Smith and Loveless lift stations.

B. Each pump shall be capable of delivering the flowrate of raw water or wastewater against a total dynamic head as indicated in Appendix. The actual static suction lift, measured from the station baseplate to the “off” level in the wet well shall be as shown in the construction drawings. The pumps shall be capable of meeting or exceeding this value, at the specified altitude.

C. All openings and passages shall be large enough to permit the passage of a sphere 3” (75 mm) in diameter and the pump shall have a flanged suction and discharge connection no smaller than 4” (100 mm). The pump motors shall not be overloaded beyond their nameplate rating at the design conditions nor at any head in the operating range.

1.03 CONSTRUCTION

A. The station shall be constructed in one complete, factory-built assembly. It shall be sized to rest on the top of the wet well as detailed in the construction drawings.

B. The baseplate of the pump station structure shall be fabricated of manufacturers standard material suitable for application as indicated in the Contract Documents. Stainless steel material is not acceptable.

C. All stainless steel surfaces shall be dry abrasive blast cleaned to remove rust, mill scale, weld slag, etc. Cleanliness shall be to SSPC-SP16. The nominal surface profile shall be 0.75 mils. All blasted surfaces, including welds and cut edges, shall be coated completely with an environmentally friendly passivation solution and then thoroughly rinsed to provide a uniform finish, and to add a transparent oxide film to protect the surface from future contamination.

D. The pump station shall be enclosed by a hinged fiberglass cover made of molded reinforced orthophthalic polyester resins with a minimum of 30% glass fibers with a minimum average length of 1-1/4" (32mm). The outside of the enclosure shall be coated with a polyester protective in-mold coating for superior resistance to weathering, ultraviolet radiation, yellowing and chalking. The completed fiberglass enclosure shall be resistant to mold, mildew, fungus and corrosive liquids and gasses normally found in pump station environments. The dimensions of the enclosure shown on the drawings shall be considered a minimum, for internal component clearances and accessibility, and nothing smaller will be acceptable. The cover shall have a suitable drip-lip around the edge and shall be provided with a hasp and staple connection to the floor plate to allow the pump chamber to be locked with a padlock.

E. The cover shall be attached with a multi segment stainless steel hinge, constructed of 7 gauge (4.6 mm) (minimum) type 304 stainless steel with a 3/8" (9.5 mm) diameter stainless steel pin and supporting at least 75% of the width of one end. Stainless steel bolts with tamperproof heads and a full width 3/8" (9.5 mm) thick anodized aluminum backing plate shall anchor the hinge to the fiberglass cover.

F. Dual high-pressure gas struts shall be provided to counteract the dead weight of the cover assembly and limit the maximum lifting force required for opening to less than 20 pounds (9 kg). The cover shall be self-latching upon opening, with a manually operated release for closing. Duplex heavy gauge safety chains shall be provided to prevent over-extension. All hardware and components of the cover assembly that are exposed to the weather shall be constructed of corrosion-resistant materials.

G. Heavy extruded aluminum, adjustable ventilating louvers shall be provided on each end of the fiberglass cover, which are capable of being closed during cold weather operation.

H. An aluminum manway cover fabricated of 1/4" (6.3 mm) treadplate, located exterior to the fiberglass pump chamber shall be provided, complete with padlocking provisions. The manway shall be an integral part of the station floor plate and provide access to the wet well. The minimum open area of the manway access into the wet well shall be at least 4.2 square feet (0.39 m^2).

I. The manway cover shall have a three color 7" x 10" (178 mm x 254 mm) (minimum) corrosion-resistant sign permanently affixed to it, reading "DANGER – Before Entering, Test For Explosive Gases. Test For Oxygen Deficiency. Supply Fresh Air To Work Area".

J. Enclosures utilized to house the valve train and/or controls, which are defined under OSHA Article 29CFR, Parts 1910 as a Confined Space shall not be acceptable.

K. To allow on-site maintenance of the pumps, a stanchion with lifting arm shall be provided to lift each pump. The lifting arm shall have a hook over the center of the motor to support a hoist (provided by others) for removal of the motors, impellers and pumps from the station.

L. The pump casings and discharge piping shall be mounted in relation to the floor plate as detailed in the construction drawings. The suction and discharge connections, where they pass through the floor shall be sealed by gaskets, rather than being welded, to allow adjustment and replacement.

1.04 WELDING

A. All steel structural members shall be joined by electric arc welding with welds of adequate section for the joint involved. Structural welding shall be performed in accordance with AWS standards and procedures.

1.05 PROTECTION AGAINST CORROSION

A. All structural steel and cast iron surfaces shall be factory blasted with steel grit, in an environmentally controlled booth, to remove rust, mill scale, weld slag, etc. All weld spatter and surface roughness shall be removed by grinding. Surface preparation and cleanliness shall comply with SSPC-SP6 specifications. The surface profile shall be 2.0 mils (0.05 mm). Sandblasting is specifically prohibited. After blast cleaning, all surface contaminants, such as grease or oil, shall be removed before coating.

B. Immediately following cleaning, a single 6 mil (0.15 mm) minimum dry film thickness coating of VERSAPOX®, or approved equal, a self-priming Cycloaliphatic Amine Epoxy shall be factory applied to the cleaned components. After curing, a 2.5 mil (0.06 mm) minimum DFT top coating of semi-gloss XTRATHANE™, or approved equal, a moisture-cured Aliphatic Polyurethane protective finish, for abrasion resistance and weather protection, shall be applied to the exterior areas, including the pumps and piping and the top and sides of the base. These coatings shall be specifically for this type of application and service.

C. Stainless steel, aluminum and other corrosion-resistant surfaces shall not be coated. Carbon steel surfaces not otherwise protected shall be coated with a suitable non-hardening rust preventative compound. Auxiliary components shall be furnished with the original manufacturer's coating.

D. Finish coating shall be accomplished prior to shipment of the equipment from the factory and shall comply fully with the intent of these specifications. A touch-up kit shall be provided by the pump station manufacturer for repair of any mars or scratches occurring during shipping and installation. This kit shall contain detailed instructions for use.

1.06 MAIN PUMPS

A. The pumps shall be 4" (100 mm) vertical, centrifugal non-clog type of heavy cast-iron construction, especially designed for the use of mechanical seals and vacuum priming. In order to minimize seal wear caused by linear movement of the shaft, the shaft bearing nearest the pump impeller shall be locked in place so that endplay is limited to the clearance within the bearing. To minimize seal wear resulting from shaft deflection caused by the radial thrust of the pump, the shaft from the top of the impeller to the lower bearing supporting the impeller shall have a minimum diameter of 1-7/8" (48 mm) for motor frame sizes 213 through 286; 2-1/8" (54 mm) for motor frame sizes 324 and 326; and 3" (76 mm) for frame 364 and larger. The dimension from the lowest bearing to the top of the impeller shall not exceed 6" (152 mm). The motor shaft shall be directly connected to the impeller without the use of drive belts or couplings, which require alignment and maintenance, and which increase power consumption due to their inherent energy losses.

B. Pumps with less than a standard 4" (100 mm) suction or 4" (100 mm) discharge connection, or with less than a 3" (76 mm) spherical solids handling capacity will be rejected for this application.

C. The oversized shaft incorporating oversized bearings and heavier bearing frame construction provides for extended mechanical seal, bearing and overall pump/motor life. Since the larger shaft with the specified minimum overhang is the key to heavier, more rigid construction throughout, no deviation from the specified shaft diameter or tolerances will be allowed.

D. The bearing nearest the impeller shall be designed for the combined thrust and radial load. The upper bearing shall be free to move in a linear direction with the thermal expansion of the shaft and shall carry only radial loads.

E. The shaft shall be solid stainless steel through the mechanical seal to eliminate corrosion and abrasive rust particles. Removable shaft sleeves will not be acceptable if the shaft under the sleeve does not meet the specified minimum diameter.

F. The pump shall have an integral adapter providing a large water reservoir above the impeller to provide for positive exclusion of air from the impeller. The seal shall be inside this area to assure lubrication. Pumps which do not use hollow priming adapters for positive lubrication of the seal will not be acceptable. Self-priming pumps are specifically unacceptable due to the need for suction check valves, air vent piping and the possibility of overheating and damaging the pump or producing steam or high temperatures in the pump, which may be a hazard to the operator, when the pump is run dry.

G. The pump controls must be set so that the main pumps cannot be turned on unless they are filled with liquid, and the pump is completely primed.

H. The pump shall be constructed so as to permit priming from the lower pressure area behind the impeller. Priming from high- pressure connections, which tends to cause solids to enter and clog the priming system, will not be acceptable. The priming bowl shall be transparent, enabling the operator to monitor the priming level.

I. The pump shall be arranged so that the rotating element can easily be removed from the casing without disconnecting the electrical wiring or disassembling the motor, impeller, backhead or seal, so that any foreign object may be removed from the pump or suction line. Enclosed impellers must be used to avoid the necessity of wear plates and the associated costs of replacement and maintenance of wear plate clearances with semi-open impellers.

J. The pump shaft shall be sealed against leakage by a single mechanical seal constructed so as to be automatically drained and primed each time the pump is drained and primed. Water, which lubricates the mechanical seal, shall be automatically drained from around the seal if the pump loses prime in order to allow both the pump and the seal to be drained, thereby preventing freezing and breakage of the seal during power outages in sub-freezing temperatures.

K. The seal shall be of carbon and ceramic materials with the mating surfaces lapped to a flatness tolerance of one light band. The rotating ceramic shall be held in mating position with the stationary carbon by a stainless steel spring. The entire seal assembly shall be held in place by a bronze seal housing to prevent excessive heat buildup. Use of

cast-iron or other ferrous material for the seal housing which will rust and damage the seal, shortening its life, will not be acceptable.

L. The pump volute shall be furnished with mounting lugs and bolted to the station floor plate, forming a gas-tight seal.

M. Pump Type

1. NON-CLOG TWO-PORT IMPELLER (4" & 6" PUMP OPTION)
    a. The pump impeller shall be of the enclosed two-port type made of close-grained cast-iron and shall be in dynamic balance when pumping wastewater. The dynamic balance shall be obtained without the use of balance weights or liquid filled chambers. The eye of the impeller as well as the port shall be large enough to permit the passage of a sphere 3" (76 mm) in diameter in accordance with nationally recognized codes. The impeller shall be keyed with a stainless steel key and secured to the motor shaft by a stainless steel capscrew equipped with a Nylock or other suitable self-locking device.
    b. The impeller shall not be screwed or pinned to the motor pump shaft and shall be readily removable without the use of special tools. To prevent the buildup of stringy materials, grit and other foreign particles around the pump shaft, all impellers less than full diameter shall be trimmed inside the impeller shrouds.
    c. The shrouds shall remain full diameter so that close minimum clearance from shrouds to volute is maintained. Both the end of the shaft and the bore of the impeller shall be tapered to permit easy removal of the impeller from the shaft.

1.07 MOTORS

A. The pump motors shall be vertical, solid shaft, NEMA P-base, squirrel-cage induction type. See Appendix A for electrical service requirements for each of the four (4) Smith and Loveless lift stations.

B. They shall have Class F insulation. Insulation temperature shall, however, be limited to Class B. The motors shall have normal starting torque and low-starting current, as specified by NEMA Design B characteristics. They shall be open drip-proof design with forced air circulation by integral fan. Openings for ventilation shall be uniformly spaced around the motor frame. Leads shall be terminated in a cast connection box and shall be clearly identified.

C. The motors shall have 1.15 service factor. The service factor shall be reserved for the owner's protection. The motors shall not be overloaded beyond their nameplate rating, at the design conditions, nor at any head in the operating range as specified under Operating Conditions.

D. The motor-pump shaft shall be centered, in relation to the motor base, within .005" (0.127 mm). The shaft runout shall not exceed .003" (0.076 mm).

E. The motor shaft shall equal or exceed the diameter specified under Main Pumps at all points from immediately below the top bearing to the top of the impeller hub.

F. A bearing cap shall be provided to hold the bottom motor bearing in a fixed position. Bearing housings shall be provided with fittings for lubrication as well as purging old lubricant.

G. The motor shall be fitted with heavy lifting eyes or lugs, each capable of supporting the entire weight of the pump and motor.

H. The pump motors shall be Premium Efficiency type, per NEMA MG-1 table 12-12, Inverter Ready per NEMA Part 31.4.4.2, with cast-iron frames, and be UL Recognized and CSA Approved. The motor windings shall be 200 C Inverter Spike-Resistant magnet wire and the rotors shall have an epoxy coating for corrosion protection.

1.08 CONTROLS

A. The control equipment shall be mounted in a NEMA Type 4x steel enclosure with 2 hinged access doors.

B. A grounding-type convenience outlet shall be provided on the side of the cabinet for operation of 120-volt AC devices.

C. Thermal magnetic air circuit breakers shall be provided for branch disconnect service and short circuit protection of all motor control and auxiliary circuits.

D. Magnetic across-the-line starters with under-voltage release and overload coils for each phase shall be provided for each pump motor to give positive protection. Each single-phase auxiliary motor shall be equipped with an over-current protection device in addition to the branch circuit breaker, or shall be impedance protected.

E. All wiring shall be labeled with thermal transfer self-laminating labels and a coded wiring diagram shall be provided.

1.09 FLOAT SWITCH LEVEL CONTROLS

A. To control the operation of the pumps with variations of liquid level in the wet well, a minimum of three (3) displacement switches shall be provided. A 30' (9 m) cord shall be provided with each switch. The cord shall have a corrosion-resistant vinyl jacket and be multi-stranded in order to prevent fatigue.

B. The displacement switch cords shall enter the wet well through cord grip seals mounted to a removable, gasketed floor plate. The floor plate shall allow the displacement switches to be adjusted or removed and replaced without having to enter or reach into the wet well.

C. An automatic alternator with manual switch shall be provided to change the sequence of operation of the pumps every eight hours. Alternating the pumps at less than eight-hour intervals will not be acceptable.

D. Provisions shall also be made for the pumps to operate in parallel should the level in the wet well continue to rise above the starting level for the low level pump.

1.10 HIGH WET WELL LEVEL ALARM

A. An adjustable displacement switch shall be provided to sense a high water level condition. The switch shall hang into the wet well and shall activate a contact to indicate the high water condition.

1.11 RUNNING TIME METER

A. A running time meter shall be supplied for each pump to show the number of hours of operation. The meter shall be enclosed in a dust and moisture-proof molded plastic case. The flush-mounted dial shall register in hours and tenths of hours up to 99,999.9 hours before repeating. The meter shall be suitable for operation from a 115-volt, 60 (50)-cycle supply.

1.12 PUMP FAILURE TO PRIME OR FAILURE TO PUMP ALARM (CHECK VALVE SWITCH TYPE)

A. To sense failure to deliver normal flow for any reason, including failure to prime, each pump shall be provided with a sealed sensor switch mounted in a protective ABS enclosure. The enclosure shall be mounted with an adjustable universal mounting bracket to the external arm of each discharge check valve. The mounting bracket shall allow the adjustment of the sensor switch with a single locking pivot adjustment. A red LED indicating light shall be provided on each switch unit to facilitate accurate setting of the switch for proper operation. The sensor switch shall monitor the movement of the check valve arm and thereby detect failure of the pump to deliver normal operating flow when called on to run. An auxiliary time delay relay shall be provided to prevent an alarm signal during the pump priming and startup period.

1.13 VACUUM-PRIMING SYSTEM

A. A vacuum priming system shall be furnished to prime the main pumps. The system shall be as shown on the vacuum priming schematic and shall include two vacuum pumps, providing 100 percent standby. Vacuum pumps shall have corrosion-resistant internal components. The vacuum priming system shall be complete with large port vacuum control solenoid valves, prime level sensor, float-operated check valves to protect the vacuum pumps, and all necessary shut-off valves as shown on the piping schematic. The float-operated check valves shall have a transparent body for visual inspection. All hoses and tubing used in the priming system shall be at least 3/8” (9.5 mm) nominal diameter.

B. The solenoid valves used in the vacuum priming system shall be of the high flow, direct acting brass body type, with threaded ports, NBR seals and 300 Series stainless steel plunger, rod, plate and springs.

C. The minimum orifice diameter shall be 5/16” (8 mm). The solenoid valves shall be UL Listed, with Class F coil rating and of suitable voltage and thermal capacity for the application.

D. Liquid level in the pump priming chamber shall be monitored by a liquid level sensing probe incorporating frequency spectrum technology to evaluate the media with which it is in contact at several measurement points. At each measurement point the sensor shall take readings. Using a multi-variable sensing technology, collected over a spectrum sweep, the sensor shall create an outline of the medium, its residue and absence of

medium. From these reference points the sensor shall be able to accurately determine the presence or absence of liquid, unaffected by foam, residue or deposits. The liquid level sensor algorithm shall provide prime status in less than 100 milliseconds.

E. Systems utilizing an electrode, mechanical means such as a float or protrusions into the pump, which may become fouled due to bridging or wrapping, or that require any type of electrical or moving parts inside the priming chamber, which may accumulate debris, short out, bind or fail will not be acceptable. Single or double medium sensing probes will be unacceptable.

F. The probe shall be provided with light emitting diodes. This diagnostic tool shall indicate connectivity, prime status or a fault condition. The probe shall be complete sealed and have a 316L stainless steel housing for corrosion resistance. It shall be provided with a wiring connector of molded thermoplastic for impact and chemical resistance. The probe shall have a threaded electrical connector to facilitate easy removal.

G. The priming system shall automatically provide positive lubrication of the mechanical seal each time a main pump is primed. To prevent excessive stoppage due to grease accumulation, no passageway in the priming system through which the pumped liquid must pass shall be smaller than the equivalent of a 2-1/2" (64 mm) opening.

H. The vacuum priming system shall have two field selectable modes of operation. In the "On-Demand" mode, the priming system will operate only after a pump is called on to run, and if it is not primed. Once primed, the pump will be allowed to run. In the "Constant Prime" mode, both pumps are kept primed continuously, and ready to start immediately when called for.

1.14 ENVIRONMENTAL EQUIPMENT

A. A ventilating blower capable of delivering 245 CFM at 0.1" (116 l/s at 2.5 mm) static water pressure shall be provided in order to remove the heat generated by continuous motor operation. The ventilating blower shall be turned on and off automatically by a preset thermostat. A heavy extruded aluminum louvered grille with adjustable openings shall cover the discharge of the blower. A similar grille shall be provided in the other end of the station enclosure for air intake. A 500-watt electric heater controlled by a preset thermostat shall be furnished. The heater shall be rigidly mounted in the station to prevent removal.

1.15 SINGLE-PHASE 120-VOLT POWER TRANSFORMER PACKAGE

Suction Pipe Size	Aux. Heater	Min. Transformer Size
4"	No	3 KVA 208v
4"	No	2 KVA 230/460v
~~4"~~	~~Yes~~	~~3 KVA 208/230/460v~~
~~6" or 8"~~	~~No~~	~~*5 KVA 208/230/460v~~
~~6" or 8"~~	~~Yes~~	~~*5 KVA 208/230/460v~~

*[5 KVA NOT AVAILABLE WITH 4*2* PUMPS WITH 4" PIPING. USE 3 KVA]

A. A (2) (3) (5) KVA insulating-type transformer shall be provided to supply power for lights, controls and auxiliary devices. The transformer shall have 240/480 volt primary, 120/240 volt secondary, Class F insulation, with temperature rise not to exceed 115°C

above 40°C ambient. The core and coil assembly shall be given a double dip and bake. The coil shall be protected by a metal housing to prevent damage. The transformer shall be protected by a separate circuit breaker on the supply side.

1.16 MAIN PIPING

A. The pump suction connections shall be drilled and tapped for a 125-pound American Standard flange for easy attachment of the suction risers. The discharge line from each pump shall be fitted with a clapper-type check valve and eccentric plug valve. Size, location and quantity of check valves and plug valves shall be as shown on the construction drawing.

B. The check valve shall be of the spring-loaded type with external lever arm and an easily replaced resilient seat for added assurance against vacuum leaks. Check valves shall have stainless steel shaft with replaceable bronze shaft bushings. Ball-type check valves are specifically unacceptable for this application. An operating wrench shall be provided for the plug valves. All station piping and fittings shall be capable of passing a 3" (76 mm) spherical solid.

1.17 RAPID-JACK™ CHECK VALVE

A. The cast iron check valve body shall be designed so that the upper portion may be easily removed, without disturbing the end flange seals to adjacent piping, to service the shaft, arm and clapper or to remove any material which may be causing clogging. Provide one spare body gasket for each valve.

B. Protrusions through the station floor shall be sealed where necessary to effect sealing between the equipment chamber and the wet well. The suction and discharge connections, where they pass through the floor, shall be sealed by gaskets in order to prevent corrosive, noxious fumes from entering the station. Welded joints that do not allow adjustment or replacement will not be considered for this application. The pump station manufacturer shall extend the suction and discharge connections below the floor at the factory so that field connections can be made without disturbing the gas-tight seals.

C. Once the station is installed, however, it shall be possible to remove the entire 4" or 6" (100 or 150 mm) suction pipes through the station floor without having to enter the wet well to unbolt them.

D. The manufacturer of the pump station shall provide a compression-type sleeve coupling for installation on the common discharge pipe. A minimum of two anchoring points shall be provided on the bottom of the station baseplate for attachment of coupling joint restraints, which shall be provided by the installing contractor.

1.18 SUCTION PIPE SUPPORT

A. To restrain and support the two 4" diameter suction pipes in the 5'-0" inside diameter wet well, a 6" 304L stainless steel horizontal support channel with 304L stainless steel adjustable end brackets and 316 stainless steel "U" bolts and mounting hardware, shall be provided for field installation by the Installing Contractor. It shall be anchored to the wet well wall by the Contractor, using the provided 316 stainless steel 5/8" wedge anchors, and adjusted to hold the suction pipes securely in a vertical position and

minimize strain on the piping. The support shall be located 4' to 10' above the bottom of the vertical piping, as shown on the drawings.

1.19 PROTECTED LIQUID FILLED COMPOUND PRESSURE GAUGES

A. A four-inch (4") (100 mm) Bourdon tube-type compound vacuum/pressure gauge with 3-1/2" (89 mm) dial, fitted with a brass stop valve and a manual air relief valve shall be provided for each pump. The gauges shall be mounted apart from the pumps, on a bracket attached to the control panel support structure, and connected to the pump discharge taps by flexible tubing to minimize vibration. The range of each gauge shall be selected to place the normal operating discharge pressure reading in the middle one-third of the scale and the gauge shall also be capable of measuring up to 30" HG (1.0 bar) of vacuum. The dial shall be white with black markings and the gauge itself shall have an accuracy of 1% of scale. The gauge shall be American made, with a Zytel Nylon case with 1/2" (13 mm) blow-out plug, stainless steel bezel, acrylic lens and phosphorus bronze tube with brass socket. Temperature compensation shall be provided by an internal compensating diaphragm. Gauges shall be protected from the service fluid by a Buna-N elastomer "boot" diaphragm within the stem, and the Bourdon tube and the space between the Bourdon tube and the internal isolating diaphragm shall be filled with low temperature instrument oil, completely isolating the gauge components from the fluid being measured.

1.20 ONYX PRESSURE GAUGE

A. Provide a glycerin filled gauge mounted on the common discharge tee for the purpose of measuring static head.

1.21 CHECKLIST

A. The pump and pump station specifications and the following checklist must be met in total. There are many reasons for incorporating a good pump specification. For example, the stainless steel shaft with tapered impeller attachment is provided to minimize corrosion, extend seal life, and provide ease of impeller removal and seal replacement without use of a wheel puller. All items specified are for long life, durability and maintainability of the pumping equipment. Deviations from the pump specification will not be allowed.

B. The checklist is also provided to insure that the proper pumping system is provided to the owner.

1.22 FACTORY TESTS

A. All components of the pump station shall be given an operational test at the pump station manufacturer's facility to check for excessive vibration or leaks in the piping or seals, and to correct operation of the automatic control and vacuum priming systems and all auxiliary equipment. Installed pumps shall take suction from a deep wet well, simulating actual service conditions. The control panel shall undergo both a dry logic test and a full operational test with all systems operating.

B. Factory test instrumentation must include flow measuring with indicator; compound suction gauge; Bourdon tube-type discharge pressure gauge; electrical meters to

measure amperes, volts, kilowatts and power factor; speed indicator; and a Vibrometer capable of measuring both amplitude and frequency.

1.23 SPARE PARTS

A. A complete replacement pump shaft seal assembly shall be furnished with each pump station. The spare seal shall be packed in a suitable container and shall include complete installation instructions. A spare volute gasket and seal gasket shall be provided.

B. An instructional video presentation on the pump mechanical seal system in DVD format shall be included. The DVD shall contain a presentation on the following subjects: purpose and location of the mechanical seal, signs of a defective mechanical seal, how to remove the mechanical seal, troubleshooting seal failure causes, seal components, required tools, how to reinstall the seal and how to place the pump back into service. The video shall include footage of an actual seal replacement.

1.24 INSTALLATION AND OPERATING INSTRUCTIONS

A. Installation of the pump chamber shall be done in accordance with the written instructions provided by the manufacturer.

B. Operation and maintenance manuals shall be furnished which will include parts lists of components and complete service procedures and troubleshooting guide.

1.25 STARTUP

A. The Manufacturer shall provide the services of a factory-trained representative for a maximum period of one day on-site to perform initial startup of the pump station and to instruct the owners operating personnel in the operation and maintenance of the equipment.

1.26 WARRANTY

A. The manufacturer of the station shall warrant for one (1) year from date of start-up, not to exceed eighteen (18) months from date of shipment, that the structure and all equipment he provides will be free from defects in material and workmanship. Warranties and guarantees of the suppliers of various components in lieu of a single-source responsibility by the Manufacturer will not be accepted. The Manufacturer shall assume prime responsibility for the warranty of the station and all components provided by them. Equipment supplied by others and incorporated into the station is not covered by this warranty.

B. In the event a component fails to perform as specified or is proven defective in service during the warranty period, the Manufacturer shall repair or replace, at his discretion, such defective part.

C. He shall further provide, without cost, such labor as may be required to replace, repair or modify the steel structure. After start-up service has been performed, the labor to replace accessory items, such as the blower, priming pumps, alternator, etc., shall be the responsibility of others.

D. It is not intended that the Manufacturer assume responsibility for contingent liabilities or consequential damages of any nature resulting from defects in design, material, workmanship or delays in delivery, replacement or otherwise.

E. The motor adapter, volute, impeller, fiberglass enclosure and steel base shall be covered by a 10-year pro-rated warranty. The fiberglass enclosure shall be warranted against failure of the fiberglass components. The steel base shall be warranted against structural failure and perforation due to corrosion. If applicable, the microprocessor controller, panel display unit and submersible level transducer shall be covered by a 5-year pro-rated warranty.

F. The pro-rated warranties shall be computed on a monthly basis starting at shipment and shall cover replacement parts only.

G. The repair or replacement of those items normally consumed in service, such as pump seals, grease, light bulbs, etc., shall be considered as part of routine maintenance and upkeep.

H. This warranty is valid only when installation, operation and maintenance has been done in accordance with the manufacturer's recommendations. A start-up report filed by an authorized representative of the manufacturer must be received by the manufacturer after the unit is placed in service.

I. The manufacturer shall provide a warranty certificate covering specific details.

1.27 MANUFACTURER'S INSURANCE

A. ALL EQUIPMENT MANUFACTURERS, either direct or subcontractors to the general or mechanical contractors, SHALL HAVE in effect at TIME OF BID, CONTRACT AWARD, CONTRACT PERFORMANCE, and WARRANTY TERM, PRODUCT AND COMPREHENSIVE LIABILITY INSURANCE, INCLUDING SUDDEN AND ACCIDENTAL POLLUTION COVERAGE in the amount of FIVE MILLION DOLLARS, $5,000,000, through an insurance company with a minimum rating of A+ (SUPERIOR) XV according to the BEST'S INSURANCE REPORTS. All policies must be written on an OCCURRENCE BASIS. Policies written on a CLAIMS MADE BASIS are not acceptable. A typical CERTIFICATE OF INSURANCE attesting to the specified coverage issued by the responsible carrier naming the ENGINEER OF RECORD and the OWNER as ADDITIONAL INSURED must be presented to the named additional insured prior to contract award. A FAILURE TO COMPLY with this requirement BY THE BIDDER will require DISQUALIFICATION of the BID and CONTRACT AWARD.

1.28 MANUFACTURED EQUIPMENT

A. The specifications and drawings detail Smith & Loveless equipment and represent the minimum standard of quality for both equipment and materials of construction. The contractor shall prepare his bid on the basis of this equipment for the purpose of determining the low bid without consideration of a possible substitute. Substitution of other makes may be considered if the equipment proposed for substitution is superior or equal in quality and efficiency to the standards of quality named in the specifications and this is demonstrated to the satisfaction of the engineer. After award of the contract, a contractor wishing to offer a deduct for substitute equipment shall submit the following information with their proposal to the Engineer for review.

1.29 BID SUBMITTAL

A. This submittal shall include all necessary information for the proper determination of the acceptability of the proposed substitution and shall not necessarily be limited to the following.
   1. Complete description of the equipment, system, process, or function, including a list of system components and features, drawings, catalog information and cuts, manufacturer's specifications, including materials description.
   2. Performance data and curves, and horsepower requirements.
   3. Outside utility requirements, such as water power, air, etc.
   4. Functional description of any internal instrumentation and control supplied including list of parameters monitored, controlled, or alarmed.
   5. Addresses and phone numbers of nearest service centers and a listing of the manufacturer's or manufacturer's representatives' services available at these locations, including addresses and phone numbers of the nearest parts warehouses capable of providing full parts replacement and/or repair services.
   6. A list of five installations in the states where similar equipment by the manufacturer is currently in similar service; include contact name, telephone number, mailing address of the municipality or installation, engineer, owner, and installation contractor; if five installations do not exist, the list shall include all that do exist, if any.
   7. Detailed information on site, architectural, structural, mechanical, plumbing, electrical, and control, and all other changes or modifications to the design and construction work necessary to adapt the equipment or systems to the arrangement shown and/or functions described on the drawings and in the technical specifications. This shall include plan view and section sketches illustrating any additional space requirements necessary to provide the minimum adequate clear space within and around the equipment for operation and maintenance, as shown on the drawings and specified.
   8. All differences between the specifications and the proposed substitute equipment shall be clearly stated in writing under a heading of "differences".
   9. Other specified submittal requirements listed in the detailed equipment and material specifications.
   10. A completed and signed copy of the “Pump Station Certification Affidavit” which follows.

1.30 EVALUATION

A. Approval of the substitution to bid as an alternate shall in no way relieve the contractor from submitting the specified shop drawings for approval or complying fully with all provisions of the specifications and drawings.

B. If substituted equipment is accepted, the contractor shall, at his own expense, make any changes in the structures, piping, electrical, etc. necessary to accommodate the equipment. If engineering is required due to substitution of alternate equipment, the contractor shall pay for all engineering charges.

C. To receive final consideration, copies of the manufacturers' quotations for the equipment may be required to document the savings to the satisfaction of the engineer. It is the

intent that the owner shall receive the full benefit of the savings in cost of equipment and the contractor's bid price shall be reduced by an amount equal to the savings. In all technical and other evaluations, the decision of the engineer is final.

1.31 PACKAGE FEATURES

A. STATION MONITORING PACKAGE
   1. Pump overload trip alarm from starter overload trip
   2. Time delay to prevent simultaneous pump starts
   3. Phase failure/reversal monitor with pump motor shutdown on fault
   4. Control power failure alarm

1.32 ACCESSORIES

A. SECTION 1 - ALARM SENSORS
   1. LOW WET WELL LEVEL ALARM
      a. An adjustable displacement switch shall be provided to sense a low water level condition. The switch shall hang into the wet well and shall activate a contact to indicate the low water condition.

B. SECTION 2 - ALARM INDICATORS
   1. 120V ALARM LIGHT WITH FLASHER
      a. A vapor-proof light fixture with 50-watt flashing lamp for outdoor pole mounting shall be provided. The light shall flash during alarm conditions. The fixture shall be complete with a red globe and guard.
   2. PANEL MOUNTED MANUAL RESET ALARM SILENCE SWITCH
      a. A manual alarm silencing switch mounted on the control panel shall be provided. The switch shall be manually reset when the alarm condition is removed.
   3. REMOTE ALARM CONTACTS
      a. In addition to the common, powered local alarm connection, individual unpowered contacts shall be provided and wired to a terminal strip for field connection to a remote alarm monitoring system (not included).
   4. TEST UNIT WITH BATTERY FOR MULTI-SENSOR CHECK VALVE SWITCH [FOR USE WITH RELAY LOGIC CONTROLS.]
      a. To test or set the multi-sensor check valve switches using the built-in LED light with Relay Logic control systems, a separate hand held battery pack with connecting cord and plug shall be provided. This is to enable the operator to accurately set the trip point of the switch manually, by means of the built-in test light on the multi-sensor.

C. SECTION 3 - WET WELL ACCESSORIES
   1. WET WELL FALL PROTECTION BARRIER
      a. A fall protection safety barrier to prevent personnel, tools or equipment from falling through the manway opening and into the wet well when the manway cover is in the raised position, shall be provided by the station manufacturer for field installation in the wet well by the installing contractor. The fall protection barrier shall be constructed of aluminum bar grating and shall cover the area

beneath the manway cover. Stainless steel hinges and a lifting handle shall be provided for convenience. When fully open, the fall protection safety barrier can be latched open for safe entering and exiting of the wet well. All components shall be constructed of stainless steel except for the aluminum grating. The barrier shall be capable of holding a 400-pound concentrated load, when in the Closed position.

b. The wet well fall protection barrier kit shall include the aluminum grating barrier, 304 SST hinges, 304 SST mounting brackets, 304 SST hardware, the required number of 1/2" diameter 304 SST wedge anchors for the specific wet well kit size and a complete set of instructions for installation of the fall protection barrier in a foot diameter wet well.

D. SECTION 4 - MECHANICAL

1. ADDITIONAL SPARE MECHANICAL SEALS

a. In addition to the one standard spare mechanical seal, 2 additional spare mechanical seal(s) shall be provided per lift station. The spare seal(s) shall be packed in a suitable container and shall include complete installation instructions.

E. SECTION 5 - CONTROL PANEL

1. MAIN CIRCUIT BREAKER

a. A main circuit breaker shall be installed in the control panel to provide over-current protection for the station, and shall be capable of being used to disconnect the three-phase power to the pump station.

b. The breaker shall be operable without opening the panel, and shall be interlocked with the panel door. It shall be capable of being padlocked in the "Off" position.

2. MAIN DISCONNECT SWITCH

a. A main disconnect switch shall be provided to disconnect the three-phase power to the pump station. The switch shall be operable without opening the panel, and shall be interlocked with the panel door. It shall be capable of being padlocked in the "Off" position.

3. TIME DELAY

a. The control system shall provide for a time delay to prevent simultaneously starting the pump motors after power failure.

4. INTRINSICALLY SAFE CONTROL

a. Intrinsically safe relays to provide low current isolated switching for the float switches shall be provided.

5. NON-MERCURY FLOAT SWITCHES

a. The level control float switches shall be of the mercury free design, operated by a rolling steel ball traveling back and forth within a switch tube, to actuate a snap action switch, all mounted in a sealed plastic float housing, supported by a watertight cord. An integral weight shall cause inversion on submergence.

6. NEMA STARTERS

a. NEMA rated magnetic across-the-line starters with overload protection for each phase shall be provided for each pump motor to give positive protection against phase unbalance, thermal overload, phase loss and ground fault.

7. PUMP RUNNING LIGHTS
    a. A green panel light to indicate “Pump On” shall be provided for each main pump.
8. BASE1-BASE2-AUTO ALTERNATE SELECTOR SWITCH
    a. A 3-position selector switch shall be mounted on the face of the control panel to allow selection of either pump as the lead pump, or to allow for automatic alternation.
9. SURGE PROTECTIVE DEVICE
    a. A surge protective device for lightning and surge protection with an internal automatic discharge circuit and rated for three-phase service shall be provided.
10. TIME DELAY
    a. The pump control system shall provide for a time delay to prevent simultaneously starting the pump motors after power failure.
11. SEQUENTIAL ALTERNATION
    a. In lieu of the timed alternation system, provisions shall be made to alternate the pumps at the completion of each pumping cycle.
12. EXTRA 20 AMPERE CIRCUIT BREAKER(S)
    a. The main control panel shall contain __ spare 20 amp, single pole 120v circuit breaker(s) to power external equipment supplied by others.
13. ADD-A-PHASE INTERFACE
    a. Terminals shall be provided in the lift station control panel to facilitate connection to an external Add-A-Phase phase converter unit.

F. SECTION 6 - ENVIRONMENTAL
1. AUXILIARY STATION HEATER
    a. A 1300/1500 watt, dual range, electric heater with automatic circulating fan, thermostat control and an On/Off switch is to be provided. The heater is to be operated by connection to the station convenience receptacle.

G. SECTION 7 – MISCELLANEOUS (NOT USED)

PART 2 MEASUREMENT AND PAYMENT

2.01 LIFT STATION PACKAGE

A. The lift station package will be measured as a lump sum item.

2.02 PAYMENT

A. The lift station package will be paid at the appropriate contract lump sum price. This item includes all materials and labor necessary to supply and install the pumps, piping, fittings, valves, instruments, controls, and appurtenances per the plans and specifications.

B. Payment will be made under:

Item No.	Pay Item	Pay Unit
11310-2.02.A	LIFT STATION PACKAGE	LUMP SUM

END OF SECTION

APPENDIX A: PUMPING STATION OPERATING CONDITIONS

Pumping Station	Flow Rate (GPM)	Total Dynamic Head (ft)	Min Pump Efficiency (%)	Max Speed (RPM)	Min Motor Horsepower (hp)	Voltage /Phase	Static Suction Lift (ft)	Elevation above MSL (ft)	Min Head (ft)	Max Head (ft)
Grove	127	66	50	1750	7.5	230/3	19.5	354.9	44.5	66
Hillbrook	180	30	50	1200	5	208/3	16	287.85	14	30
Pleasant View	200	37	50	1200	5	200/3	16.7	247.9	19.4	37
Winplace	300	29	50	1200	5	230/3	26	286.06	10	28.5

Notes:

1. See Sections *Operating Conditions* and *Motors* for pertinent information located in the table.
2. Information presented in table is based on existing conditions and operations. Equipment shall match what is presented in the table.

SECTION 11347

SUBMERSIBLE WASTEWATER PUMPS – CONSTANT SPEED

PART 1 GENERAL

A. Scope:

1. This section specifies pumps and associated accessories for raw municipal wastewater pumping applications. Pumps will be installed in a dry-pit configuration. Equipment furnished to conform to the requirements of this Section. Pump units shall be complete with motor, combination mounting base and inlet reducing elbow with handhole, and other accessories as specified.
2. Manufacturers proposing to furnish equipment specified under this section shall hold current certification under ISO 9001-2001. Application for certification under ISO 9001 shall not be deemed as an acceptable substitute for current certification. Documentation attesting to current certification shall be signed by an officer of the manufacturer's corporation and shall be notarized.

B. Type:

1. Pumps shall be vertical, submersible, centrifugal, non-clog type pumps suitable for pumping fluids containing unscreened wastewater solids at constant speed. The pumps shall be designed for continuous or cyclic operation under submerged, partially submerged or totally dry condition without damage to the pump and motor. Special attention shall be devoted to the shaft design to limit deflection under all operating conditions, as specified in this section.

C. Equipment List:

Item	Equipment Number
Submersible Wastewater Pump 1	N/A
Submersible Wastewater Pump 2	N/A

1.02 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

1. Section 01610 Basic Product Requirements

1.03 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Reference Table:

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
AISC	American Institute of Steel Construction—Manual of Practice
ANSI/API 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries (also referenced as ISO 13709-2009)
ANSI/ASME B46.1	Surface Texture, Surface Roughness, Waviness and Lay
ANSI/HI 9.1–9.5	Pumps – General Guidelines for Types, Applications, Definitions, Sound Measurements and Documentation
ANSI/HI 9.6.1	Rotodynamic Pumps—Guideline for NPSH Margin
ANSI/HI 9.6.2	Centrifugal and Vertical Pumps for Allowable Nozzle Loads
ANSI/HI 9.6.4	Rotodynamic Pumps—Vibration Measurements and Allowable Values
ANSI/HI 9.6.8	Rotodynamic Pumps—Guideline for Dynamics of Pumping Machinery
ANSI/HI 11.6	Submersible Pump Tests
ANSI/HI 14.1-14.2	Rotodynamic Pumps for Nomenclature and Definitions
ANSI/HI 14.3	Rotodynamic Pumps for Design and Application
ANSI/HI 14.4	Rotodynamic Pumps for Installation, Operation, and Maintenance
ANSI/HI 14.6	Rotodynamic Pumps for Hydraulic Performance Acceptance Tests
ASTM A27	Steel Castings, Carbon, for General Application
ASTM A36	Carbon Structural Steel
ASTM A148	Steel Castings, High Strength, for Structural Purposes
ASTM A322	Steel Bars, Alloy, Standard Grades
ASTM A564	Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
ASTM A571	Austenitic Ductile Iron Castings for Pressure-Containing Parts Suitable for Low-Temperature Service
ASTM A995	Standard Specification for Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts, Grades 2A, 3A, or 6A
ASTM B148	Aluminum-Bronze Sand Castings
AWWA C550	Protective Epoxy Coatings for Valves and Hydrants
ISO 1940-1:2003	Mechanical Vibration—Balance quality requirements for rotors in a constant (rigid) state—Part 1: Specification and verification of balance tolerances
ISO 9001	Quality Management Systems—Requirements, 3rd Edition (2000)

1.04 DEFINITIONS

A. Terminology used in this section conforms to the following definitions:
   1. Equipment Pad: concrete foundation (block or slab) supporting and elevating equipment mounts above the supporting structural floor slab or local grade.
   2. Mounting Pads: thickened or raised areas of baseplates and soleplates where the feet or mounting surfaces of mounted equipment and drivers rest on the baseplate or soleplate.
   3. Combination Base and Inlet Elbow: heavy-duty integrally cast one-piece base and reducing flanged elbow.
   4. Handhole: cleanout or inspection port integrally cast into the inlet reducing elbow.

5. Efficiency: For the purposes of this section and sections referencing this section, efficiency, as related to pumps, is the ratio of the pump output power (water horsepower [hp]) divided by the pump input power (brake horsepower) required to deliver the total head, with meanings as defined in ANSI/HI 14.2.6.6. For column-type pumps, efficiency is computed inclusive of inlet, bowl, column, and discharge head losses.
6. Net positive suction head, 3 percent reduction (NPSH3): For the purposes of this section and sections referencing this section, NPSH3 means the value of net positive suction head (NPSH) resulting in a reduction of 3 percent in the developed pump discharge head when the pump is tested in accordance with procedures established by ANSI/HI. NPSH3 is the successor designation to net positive suction head required (NPSHR). Where NPSHR is used in the contract documents it means NPSH3.
7. NPSH margin: For the purposes of this section and sections referencing this section, "NPSH margin," wherever used, means net positive suction head available (NPSHA) divided by the candidate pump's NPSH3 for the specific operating condition in question.
8. POR: preferred operating region as defined in ANSI/HI 9.6.3.
9. AOR: allowable operating region as defined in ANSI/HI 9.6.3.

1.05 ADMINISTRATIVE REQUIREMENTS

A. Unit Responsibility:
   1. Assign unit responsibility to the manufacturer of the vertical, nonclog submersible pumps provided for all equipment and accessories under this section. Have all mechanical equipment components, at least, of this entire equipment assembly furnished by the pump's manufacturer. Provide a completed, signed, and notarized Certificate of Unit Responsibility (Form attached at the end of this Section).

1.06 SUBMITTALS

A. Action Submittals:
   1. A copy of this Section, addendum updates included, along with the sections listed below shall be submitted with each paragraph check-marked to indicate compliance or marked to indicate requested deviations.
   2. The specification copies shall be complete with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Subcontractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Subcontractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
   3. Unit Responsibility Certification form attesting that unit responsibility has been assigned in accordance with the requirements of this Section. No other submittal

material will be reviewed until the certificate has been found in conformance with this requirement.

4. Predicted pump performance curves for each condition point specified showing head, power, efficiency, and NPSH3 on the ordinate plotted against capacity on the abscissa. All curves shall clearly display the specified operating conditions, POR and the manufacturer's limits for the AOR.
5. Drawings showing general dimensions and confirming the size of pumps, motors, drives and specified appurtenances; piping connections; construction details of equipment (including bearings and bearing isolators); wiring diagrams; and weight of equipment.
6. Manufacturer's data including materials of construction and equipment weight.
7. Motor Data.
8. Panel product literature and associated components.
9. List of miscellaneous items, cables, spare and replenishment parts.
10. Panel elementary/schematic wiring diagrams:
    a. Internal wiring connection diagrams.
    b. External wiring interconnection diagrams including interlocks.
    c. Power and control single line diagrams to comply with NEC Article 409.
11. Heat load calculations for each cabinet based on the highest ambient temperature for the area in which the subject panel will be located.
12. Panel dimensioned drawings including weights.
13. Panel assembly drawings including sections showing clearances between face and rear mounted equipment.
14. Proof of service of previously installed units of similar size and configuration in dry pits of the type specified in this Section.
15. Written factory tests report, as specified in paragraph 2.08.
16. Shaft deflection calculations.
17. Anchorage calculations and required documentation.
18. Cooling system calculations.
19. Manufacturer's operation and maintenance information.
20. 5-Year warrantee in accordance with paragraph 1.09.
21. Testing Forms.
22. Field vibration test protocol as specified in ANSI/HI 11.6.

B. Informational Submittals:
    1. Operating and maintenance submittals
    2. Vibration testing results and reports
    3. Machine alignment records
    4. Bearing calculations
    5. Equipment installation certification forms
    6. Training certification forms
    7. Field testing plan

1.07 QUALITY ASSURANCE

A. Qualifications:
   1. Independent testing agent hired by the Subcontractor for field vibration testing.

B. Critical Speeds: Critical Speeds shall be in accordance with this Section.

C. Vibration Limits: Vibration limits for submersible pumps shall be in accordance with ANSI/HI 11.6. Field testing shall be in accordance with paragraph 3.04 of this section.

D. Factory Testing:
   1. Factory testing shall be performed by the manufacturer prior to delivery in order to verify the accuracy and performance of the systems as specified. Factory Testing need not be witnessed by the Engineer, unless a special Witness Testing paragraph is included in this Section. However, the manufacturer shall certify and provide copies of the tests and guarantee the equipment's performance as specified in this Section. All certifications of Factory Testing shall be submitted and approved by the Engineer, prior to shipping equipment.
   2. Factory testing shall include at the minimum all standard tests recommended by the manufacturer.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Block shaft and prevent damage to bearings during shipment.

B. Damage.
   1. Equipment, products, and materials shall be shipped, handled, stored, and installed in ways which will prevent damage to the items. Damaged items will not be permitted as part of the work except in cases of minor damage that have been satisfactorily repaired and are acceptable to the Owner.

C. Equipment.
   1. Package and Marking:
      a. All equipment shall be protected against damage from moisture, dust, handling, or other cause during transport from manufacturer's premises to site. Each item or package shall be marked with the number unique to the specification reference covering the item.
      b. Stiffeners shall be used where necessary to maintain shapes and to give rigidity. Parts of equipment shall be delivered in assembled or sub assembled units where possible.
   2. Shipping:
      a. Bearing housings, vents and other types of openings shall be wrapped or otherwise sealed to prevent contamination by grit and dirt.
      b. Damage shall be corrected to conform to the requirements of the contract before the assembly is incorporated into the work. The Subcontractor shall bear the costs arising out of dismantling, inspection, repair and reassembly.

D. Factory Applied Coatings:

1. Unless otherwise specified, each item of equipment shall be shipped to the site of the work with the manufacturer's shop applied epoxy prime coating as specified. The prime coating shall be applied over clean dry surfaces in accordance with the coating manufacturer's recommendations. The prime coating will serve as a base for field-applied finish coats.

E. Storage:
   1. During the interval between the delivery of equipment to the site and installation, all equipment, unless otherwise specified, shall be stored in an enclosed space affording protection from weather, dust and mechanical damage and providing favorable temperature, humidity, and ventilation conditions to ensure against equipment deterioration. Manufacturer's recommendations shall be adhered to in addition to these requirements.
   2. Equipment and materials to be located outdoors may be stored outdoors if protected against moisture condensation. Equipment shall be stored at least 6 inches above ground. Temporary power shall be provided to energize space heaters or other heat sources for control of moisture condensation. Space heaters or other heat sources shall be energized without disturbing the sealed enclosure.

F. Protection of Equipment after Installation:
   1. After installation, all equipment shall be protected from damage from, including but not limited to, dust, abrasive particles, debris, and dirt generated by the placement, chipping, sandblasting, cutting, finishing and grinding of new or existing concrete, terrazzo and metal; and from the fumes, particulate matter, and splatter from welding, brazing and painting of new or existing piping and equipment. As a minimum, vacuum cleaning, blowers with filters, protective shieldings, and other dust suppression methods will be required at all times to adequately protect all equipment. During concreting, including finishing, all equipment that may be affected by cement dust must be completely covered. During painting operations, all grease fittings and similar openings shall be covered to prevent the entry of paint. Electrical switchgear, unit substation, and motor load centers shall not be installed until after all concrete work and sandblasting in those areas have been completed and accepted and the ventilation systems installed.

1.09 WARRANTY

A. Provide a Special 5-Year Warranty. The manufacturer shall warrantee the pumps provided under this section against defects in materials and workmanship for 5 years.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer’s products, nor shall it be construed that named manufacturer’s standard equipment or products will comply with the requirements of this Section. The manufacturer’s standard product may require modification to conform to specified requirements:
   1. Xylem - Flygt

2. Fairbanks Nijhuis
3. Approved Equal

2.02 PERFORMANCE/DESIGN CRITERIA

A. General:
   1. Pumps furnished under this section and any referencing section shall operate without loss of head due to cavitation or vibration over the entire specified range of flow and head conditions and are specifically selected for NPSH margin requirements detailed in paragraph 2.12. Pump selections that do not provide the specified margin will be rejected.
   2. Select pumps furnished under sections referencing this section that are designed in accordance with applicable portions of ANSI/HI 9.6.2, 9.6.3, 9.6.4, 9.6.6, 9.6.8 and 14.1-14.3 and the requirements of this section. Select pumps that are specifically designed to pump the fluid described in the detailed specification and to operate without clogging or fouling caused by material in the pumped fluid at any operating condition within the range of service specified. Clogging or fouling conditions may be of any cause, demonstrated by a 5 percent or greater capacity drift within 2 hours of sustained operation.

B. Service Conditions:

Description	Value
Equipment	Two (2) Dry-Pit Vertical Submersible Pumps
Fluid type	Unscreened wastewater consisting of organic and inorganic materials, rocks, grit, petroleum products, and grease The pumped material will have a tendency to form long fibrous strings due to the rotation of water through the piping passageways.
Fluid temperature	40 to 115 degrees F
Hazardous Area Classification	Class I, Division II

C. Operating Conditions:
   1. The performance requirements presented in tabular form below are intended to describe the results of hydraulic calculations developed using a mathematical modeling program specifically developed for the purpose. The model was intentionally used to develop the limits of expected extremes in variation of static head, coefficients for pipeline resistance and turbulence losses through fittings and valves.
   2. Equipment furnished under this section shall be fully suitable for continuous operation at any specified condition or any condition lying between the extremes of the operating conditions specified in the following table. The total head in the information below is the total system head at the operating capacity, essentially a summation of the head of the two pumps at that capacity. The notes presented at the end of the table are intended to be complimentary to the information presented in the table.
   3. Pumps specified to operate at constant-speed shall function without loss of head or capacity due to cavitation or excessive vibration over the entire specified range of

flow and head conditions defined by the region bounded by Condition Points A, B, and C and any other continuous-duty operating condition specified in the detailed specification referencing this section. In addition, constant-speed pumps shall be selected to place Condition Point C in the detailed specification within the POR, or a modified POR if stipulated in the detailed pump specification.

4. POR:
   a. Unless otherwise specified, the POR for a given pump is as defined in ANSI/HI 9.6.3.
   b. The detailed specifications may stipulate a narrower POR than indicated in ANSI/HI 9.6.3.
   c. The suction-specific speed (S) shall not exceed 8,500, unless otherwise indicated in the detailed specifications.
   d. For high- S pumps (greater than 8,500) and other conditions as determined by the engineer, a narrower stable operating region may be defined in the detailed specifications and then identified in ANSI/HI 9.6.3 for the POR. The detailed specifications take precedence over this section.
   e. The detailed specification sections identify the duty points that must be within a pump's POR and those that may be within the AOR and take precedence over this section.

D. Table of Operating Conditions:

Operating Condition	Value
Equipment	Two (2) Dry-Pit Vertical Submersible Pumps
Rated Condition	
Capacity, gpm	100
Total Head, feet	89
Operating Head Range, feet	65 to 89

E. Design Requirements:

Item	Value
Equipment	Two (2) Dry-Pit Vertical Submersible Pumps
Pump	
Rigid sphere, inches diameter (min.), capable of passing through the pump from inlet to discharge (Impeller Alternate 1/Alternate 2)	4/3
Minimum efficiency at best efficiency point (BEP) at maximum speed, percent [1]	70
Piping connection size, inches, minimum	
Pump inlet	4
Pump discharge	4
Operating speed	Constant
Motor	
Horsepower	5
Type	Submersible, Vertical, Dry-Pit
Inverter duty	No
Space heater	No

Item	Value
Equipment	Two (2) Dry-Pit Vertical Submersible Pumps
Over temperature protection	Yes
Moisture sensors	Yes
Operating speed, rpm, maximum	1745
Voltage/Phase	208 VAC, 3 Phase

Notes:

1. *The minimum acceptable efficiency at best efficiency point (BEP) at the speed required to achieve the performance specified under Condition Points A and B. The minimum acceptable efficiency is not necessarily required to be associated with any operating condition specified in paragraph 2.03 Operating Conditions.*

F. With the exception of submersible pumps and the inlet connection for pumps designed to operate in open forebays or wetwells, pump connection nozzles shall be designed for the loads and moments stipulated in ANSI/HI 9.6.2. Where ANSI/HI 9.6.2 does not cover a specific pump type or category, or where that document is silent on allowable nozzle loads or a particular type of nozzle load (e.g., thermal pipe strain), the Subcontractor shall furnish documentation from the manufacturer attesting to the limitations on loads and moment forces that can be tolerated on each connection and recommended connection details to be used.

2.03 SYSTEM OPERATION

A. The pumps will be installed in a dry-pit configuration, existing reinforced concrete structure as shown on the Drawings.

B. The pumps will be operated by a control system that will start and stop the pumps at constant speed in accordance with the operating levels indicated on the Drawings. System design shall provide that pumps (No. 1 and 2) shall alternate as Lead/Lag. Periodically, the control system will be overridden permitting the wet well level to be drawn down until the pumps break suction.

C. Refer to paragraph 2.08 for control descriptions.

2.04 MATERIALS

A. Materials specified are considered the minimum acceptable for the purposes of durability, strength, and resistance to erosion and corrosion. The Subcontractor may propose alternative materials for the purpose of providing greater strength or to meet required stress limitations. However, alternative materials must provide at least the same qualities as those specified for the purpose.

B. Provide materials of construction in accordance with the following table:

Component	Material
Pump and motor casing	Cast iron, ASTM A48, Class 30 or 35
Impeller	Cast duplex stainless steel, ASTM A744 or European standard 1.4474, or Cast duplex stainless steel, ASTM A890 Grade 1B, or Hard Chrome Iron ASTM A532-IIIA
Motor and pump shaft	Stainless steel, ASTM A276 Type 329, 403, 416, 420 or ASTM A479 Type 403, 431
Pump base/stand	

Component	Material
Wearing rings	Stainless steel, ASTM A276 Series 440B or Cast duplex stainless steel, ASTM A890 Grade 1B or 5A
External bolts and nuts	Stainless steel, ASTM A276 Type 316
Anchor bolts	Stainless steel, ASTM A276 Type 316

2.05 COMPONENTS

A. General:

1. The motor and rotating parts shall be removable from the motor end of the pump. All motor mating surfaces where watertight sealing is required shall be machined and fitted with nitrile O-rings. The pump shall be fitted with a dynamically balanced non-clog impeller designed to pass coarse solids and stringy materials. The pump shall be listed by Factory Mutual or Underwriters Laboratory as conforming in all respects to the requirements in UL 1207.

B. Casing:

1. The volute casing shall be a one-piece casting with a tangential or center discharge nozzle. The volute shall be designed for efficient conversion of kinetic to potential energy and shall have clear passageways designed to pass the solid sphere specified in this Section. The solids passing capability of the furnished equipment will be subjected to a field test in accordance with paragraph 3.03.
2. The solids passing capability of the furnished equipment will be subjected to a field test in accordance with this Section.
3. The cutwater shall be specifically designed for use in fluids with stringy solids and rags. The volute casting shall be specifically designed to bear the loads associated with removal and placement of the pump when submerged or exposed and to withstand the loads imposed by the operations specified in this Section. The discharge nozzle shall be not less than the diameter specified in this Section and shall be reinforced for the loads imposed by the specified conditions of service. The volute casing shall be drilled and tapped or otherwise fitted with an inlet nozzle conforming to the requirements specified in this Section.

C. Shaft:

1. The pump shaft shall be turned, ground and polished, of proportions suitable for use in the specified application. The shaft shall be of sufficient section to limit deflection at the shaft seal to not more than 4.0 mils when the pump is operating at any continuous-duty point defined by the envelope of conditions specified in this Section. Additionally, under no circumstances shall the distance from the lower bearing and the hub of the impeller exceed two times the diameter of the shaft.
2. Select pump shafts installed on volute-type pumps to provide sufficient stiffness to operate without distortion or damaging vibration throughout the range of service specified. Limit shaft deflection at the face (impeller side) of the shaft seal to no more than 2 mils at any operating condition within the zone described by the specified continuous-duty operating conditions. Calculate deflection at the shaft seal as required by provisions set forth in ANSI/HI 14.3.

D. Wearing Rings:

1. Pumps shall be fitted with both stationary and rotating wearing rings. Except for the difference in hardness between stationary and rotating rings, wearing rings shall be of stainless steel and shall conform to the requirements of ANSI/API 610, paragraph 6.7 and material class S-8 (Table H.1, Annex H). Maximum wearing ring clearances shall not exceed 150 percent of the values stated in Table 6, ANSI/API 610. Minimum wearing ring hardness on the rotating ring shall be 350 Brinnel Hardness Number (BHN), with the stationary ring not less than 100 hardness points greater.
2. L-form wearing rings are not acceptable for wastewater or sewage pumping service.

E. Bearings:
1. Bearings shall be heavy-duty, oil lubricated or permanently greased lubricated anti-friction type double shielded and factory sealed. Bearings shall be designed for an L-10 rating life of at least 50,000 hours at any operating condition specified in this Section. Loads for radial bearing calculations shall be calculated in accordance with this Section.
2. Select bearings for other elements in the rotating system such as motors, intermediate shaft bearings, and flywheel bearings using the same criteria as specified for the pump. Base bearing selection upon the worst combination of continuous-duty operating conditions specified and include both steady-state and transient loads. Provide calculations supporting the selection of bearing sizes as and informational submittal.

F. Impeller:
1. Alternate 1: The impeller shall be dynamically balanced with a non-clogging design capable of passing solids, fibrous materials, heavy sludge, and other matter found in normal sewage applications through to the discharge nozzle. Impellers for pumps with discharge nozzles 4 inches in diameter and greater shall be not less than two-vane design. Fit between the impeller and the shaft shall be a sliding fit with a taper-lock bushing pressed by a screw that is threaded into the end of the shaft, or a slip fit onto the shaft and drive key and fastened to the shaft by an impeller nut having cover for protection from pumped fluid. A wearing ring system designed for abrasion resistance shall provide efficient sealing between the volute and impeller.
2. Alternate 2: The impeller shall be statically balanced, semi-open, multi- vane, back-swept, non-clog design. The impeller vane leading edges shall be mechanically self-cleaned upon each rotation as they pass across a spiral groove located on the volute suction which shall keep them clear of debris, maintaining an unobstructed leading edge. The impeller(s) vanes shall have screw-shaped leading edges capable of handling solids, fibrous materials, heavy sludge and other matter found in waste water. The screw shape of the impeller inlet shall provide an inducing effect for the handling of sludge and rag-laden wastewater. Impellers shall be locked to the shaft and shall be coated with alkyd resin primer.

G. Mechanical Seals:
1. The pump shall be provided with a tandem mechanical seal running in an oil reservoir, composed of two separate lapped face seals. The lower seal unit, between the pump and oil chamber, shall consist of one stationary and one positively driven, rotating tungsten-carbide or silicon-carbide ring, with each pair of rings held in contact by a separate spring. The upper seal unit, between the oil sump and the motor housing, shall consist of one stationary tungsten-carbide or silicon-carbide ring

and one positively driven tungsten carbide, or silicon-carbide ring. Ceramic seals will not be acceptable. The seals shall require neither maintenance nor adjustment and shall be easily replaceable. Conventional double mechanical seals with a single or a double spring between the rotating faces, or that require constant differential pressure to effect sealing and are subject to opening and penetration by pumping forces, will not be acceptable. The pump shall be capable of continuous submergence without loss of watertight integrity to a depth of 65 feet. The mechanical seal shall accommodate the manufacturer's shaft deflection at the seal face and shaft angularity with a safety factor of 3.

2. Each pump shall be provided with a seal lubricant chamber for the shaft sealing system. The seal lubricant chamber shall be designed to assure that an air pocket is provided in the seal lubricant chamber, to absorb the expansion of the seal lubricant due to temperature variations. The drain and inspection plug with positive anti-leak seal shall be easily accessible from the outside.

H. Motor:

1. Pumps shall be electric-motor driven unless otherwise specified. Select all motors to be non-overloading at any operating point along the pump's full-speed operating curve, including points located beyond specified operating conditions. Motors shall be capable of carrying the axial/radial load applied to the motor shaft with motor bearing life equivalent to the pump bearing life.
2. The pump motor shall be a squirrel-cage induction, shell type design, housed in an air-filled or an oil-filled, watertight chamber, NEMA B type with a service factor of 1.15 based upon nameplate rating. The manufacturer shall furnish an unqualified warranty guaranteeing (full replacement at no cost to the Owner) the performance of the motors furnished under this project for a period of five years when operating under the specified conditions.
3. The stator winding and stator leads shall be insulated with moisture resistant Class H insulation, which shall be rated at a temperature of 180 degrees C. Motor shall be provided with thermal sensors to protect the motor from excessive heating. Thermal sensors shall be as specified in this Section. The temperature rise of the motor shall not be in excess of that specified in NEMA MG-1 for class B insulating materials when operating continuously under load.
4. Motors shall be Factory Mutual or UL listed in accordance with UL 674 and 1207 for Class I, Group C and D hazardous atmospheres.
5. The motor shall be designed for continuous duty in air and in 95 degree Fahrenheit water, capable of sustaining a minimum of 10 starts per hour when operated with.
6. The junction chamber, containing the terminal board, shall be hermetically sealed from the motor. Connection between the cable conductors and stator leads shall be made with threaded compressed type binding post permanently affixed to a terminal board.
7. All vertical motors shall be solid-shaft construction. Hollow-shaft motors will not be accepted.

I. Cooling System:

1. The cooling system shall be compatible with the installation configuration shown on the Drawings (dry-pit mounting) as well as the contemplated control schedule, which may require that the motor case to be exposed continuously or intermittently.
2. Cooling system shall be closed-loop, completely self-contained and not require an external source of cooling liquid.
3. The cooling jacket shall encircle the stator housing to provide cooling for the motor under all conditions (i.e., submerged or non- submerged).
4. The cooling system shall not employ the pumped fluid to directly cool the motor through wastewater passageways incorporated into the motor shell.
5. The system shall be designed to prevent clogging by virtue of dimensions and configuration and shall be specifically configured to maintain motor temperatures within conservative limits.

J. Temperature Sensors:
1. The stator shall be equipped with three thermal sensors, embedded in the end coils of the stator winding (one sensor in each stator phase). These shall be wired to the specified motor protection relay for motor protection.

K. Moisture Detection:
1. Provide motors with a moisture detection system.
   a. A primary moisture detector shall be provided in the stator housing leakage chamber.
   b. A second moisture detector shall be located in the motor junction box or inspection chamber.
2. All moisture detectors shall be wired to the motor junction box for connection to the specified motor protection relay.
3. Moisture detectors shall be either mechanical float switch or capacitance probe type as recommended by the manufacturer.

L. Motor Protection Relay:
1. Provide motor protection relay to protect motor from high temperature and moisture.
2. During normal pump operation, the temperature switch shall be closed and the leakage switch shall be normally open. Sensor circuit shall operate on 12 or 24 VDC feed from the main relay body. The relay shall be provided with LEDs to indicate status of relay on face for leakage, temperature, and supply voltage.
3. Latch detection of open temperature switch. An external reset shall be required to clear alarm. Retain relay state during power failures for temperature.
4. Moisture detection shall auto reset.
5. Power supply shall be 120 VAC.
6. Provide one SPDT contact for remote over-temperature alarming. Provide one SPDT contact for remote moisture detection alarming.
7. Relay shall be UL or UR approved, suited for panel installation.
8. Relay shall be mounted inside the associated pump's motor controller panel. Mounting shall be DIN rail mount or back panel mount. Coordinate to provide relay for installation at the shop where the associated motor controller is being

fabricated. Coordinate size, wiring, and mounting of the relay into the motor controller.

9. Relay manufacturer shall be Xylem-Flygt, ATC Diversified Electronics, Dwyer, or approved substitute.

M. Cables:

1. The pump shall have two cables. One cable shall be for power, and one cable shall be for control (the motor thermal sensors and moisture detector). For Smaller units it will be acceptable to have shielded sensor wires within the body of the power cable, precluding the need for a second pilot cable.
2. The cable design shall be suitable for installation in a sanitary sewer dry-pit pumping station.
3. The cable length shall not exceed the product manufacturer's recommended length, unless otherwise specified.
4. The Subcontractor shall be responsible for determining the length of cable required to wire the motors and sensors from the dry-pit to the terminal boxes or cabinets as shown on the Drawings.
5. The Subcontractor shall provide additional cable length for slack to allow the pumps to be removed from the dry-pit. The length of cable for slack shall be based on the pump manufacturer's recommendation.
6. Cable Entry Seal:
   a. The cable entry water seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall be comprised of individual cylindrical elastomer clamps having a close tolerance fit against the cable conductor insulation and the entry inside diameter and compressed by the entry body containing a strain relief function, separate from the function of sealing the cable.
   b. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland, potting chamber or terminal board, which shall isolate the motor interior from foreign material gaining access through the pump top. If a potting chamber is used, the potting procedure shall employ an epoxy-potting compound combined with a procedure that insures penetration of the compound into the individual cable conductor strands to prevent development of wicking pathways for entrance of water into the motor.
7. Cable Disconnection:
   a. The pump shall be designed such that power/ control cable can be removed from the pump motor without breaking the cable seal. The power/ control cable shall be sealed to a removable motor chamber cap that shall be universally mateable to the same manufacturer's pump series. The pump shall be able to be removed from the wet well and disconnected from the cable by removing the motor chamber cap. A spare removable chamber cap with 15 feet of cable shall be provided.

N. Terminal boxes: A terminal box shall be provided for each submersible pump. Cords from the pumps shall be connected to the terminal boxes with plugs. The contractor shall terminate submersible cables into plugs to mate up with receptacles located in the terminal boxes per this section.

1. Boxes, Plugs, and Receptacles:

a. Class I, Division II, Group D.
b. Water tight.
c. The receptacle/plug shells shall be machined from Stainless Steel type 316.
d. See the drawings for information about boxes, conduits, and cords.

2. Pump terminal box:
   a. Contain a ground stud bonded to the enclosure and support four #8 AWG crimped one hole standard barrel terminal lugs.
   b. Box shall have two receptacles/plugs on the bottom. One receptacle/plug for motor power and one receptacle/plug for motor sensors.
3. Acceptable plug/receptacle manufacturers:
   a. Vantage Technologies
   b. Or approved substitute

O. Pump Anchorage:
1. The Subcontractor shall hold the pump manufacturer responsible for the design of the anchor-bolting system and equipment supports for each separately mounted component furnished under this section.
2. Select anchor bolts and connecting bolts for pumps and assemblies supported by other assemblies furnished under this section, or sections referencing this section. All operation and maintenance (O&M) manuals for pumps and assemblies shall contain criteria for anchor and base bolt torque values.
3. When equipment is fabricated or cast with feet or mounting surfaces that are not fastened to a common baseplate or soleplate, as in dry-pit bottom suction pumps, the equipment may be supported on individual concrete piers or equipment pads in lieu of a common baseplate or soleplate and equipment pad. In such instances, the equipment shall be supported at the feet or mounting surfaces on individual mounting blocks, which shall be leveled and grouted into place on individual piers or equipment pads. All mounting blocks shall be furnished with jackscrew threads (three locations, minimum) tapped in the mounting block for the purpose of leveling mounting blocks with jackscrews.
4. Cementitious Non-shrink Grout may be used for setting bearing surfaces of baseplates, soleplates, or mounting blocks on equipment pads where equipment drivers are 20 horsepower and smaller and the combined weight of equipment and driver is less than 1000 pounds.

P. Base and Suction Elbow:
1. Heavy-duty fabricated steel base with openings large enough to permit access to the suction elbow and cleanout, bolted directly to the volute. The base shall be designed to support the assembled weight of the pump and motor.
2. A flanged suction elbow, matching piping materials specified in the Contract Documents, to provide a smooth transition of flow from the connected suction piping to impeller eye. Suction elbow shall be of the reducing type, as applicable, sized to connect directly to the suction pipe diameter as shown on the Drawings.
3. Provide an inspection port (handhole cleanout), not less than 4-inches in diameter, for access to pump impeller and wearing rings via suction elbow or pump casing. Inspection port to be drilled and tapped, fitted with a valved 2-inch diameter drain. Bolted-in-place design in accordance with ANSI B16.1, Class 125.

Q. Accessories:

1. Pumps shall be provided with discharge elbow connections, metric to english pipe increaser, cable holder assemblies, safety chain hook assemblies, anchor bolts, and all other accessories necessary to complete the installation as specified. All connecting hardware and miscellaneous attachments shall be constructed out of ASTM A276, Type 316 stainless steel. Dielectric isolation shall be provided for dissimilar metals.

R. Level Instruments:

1. Provide level instruments to meet the pump control operation requirements defined in this section. Provide cable of sufficient length to reach the control panel from the wet well.
2. Manufacturer to provide sensor, transmitter, cable length and meter.
3. Application/Calibration: Switch set point and reset point to be field adjusted.
4. Install as shown on the Drawings and in accordance with manufacturer's instructions.
    a. Float Switch:
        1) Switch shall be free-floating type, suspended from an oil-resistant waterproof cable. The cable shall be designed to support the weight of the float without additional strain relief and permanently sealed where it enters the float body.
        2) The conductors shall be a minimum size of 18 AWG. The switch shall be a single pole double throw dry contact type and not rated at less than 10 amperes at 120 Vac. Mercury switches are not acceptable. The float shall have a PVC or ABS corrosion and impact resistant shell.
        3) Candidate manufacturers include:
            a) Magnetrol Model T10
            b) Warrick Series M
            c) Or Approved Equal
    b. Hydrostatic Transducer/Transmitter:
        1) Sensor/Transmitter: Shall be of the diaphragm type constructed of 316 stainless steel. FM approved for Class 1, Division 1.
            a) Housing: Type 316 stainless steel
            b) Wetted Seals: Viton or equal
            c) Cable Jacket: Polyethylene, FEP, Polyurethane, Tefzel, or equal
            d) Output: One 4-20 mA, 2-wire
            e) HART standard communication protocol
            f) Accuracy: 0.25% full scale
            g) Operating Temperature: -25 to 180 degrees Fahrenheit
            h) Accessories: Cable suspension hardware
            i) Candidate Manufacturers:
                (1) GE Druck Well Level Monitor RTX Series
                (2) Ametek Model 575P
                (3) Dwyer/Mercoid Series PBLT
                (4) Or Approved Equal

2) Meter:
   a) Enclosure: NEMA 4X
   b) Mounting: Instrument stand
   c) Power Supply: 120Vac, 5W maximum
   d) Analog Input: 4-20 mA DC (from transmitter)
   e) Analog Output: One 4-20 mA DC isolated into a minimum of 500 ohms.
   f) Display: Graphic LCD with digital scalable process level and level display graph
   g) Accessories: Mounting hardware
   h) Candidate Manufacturers:
      (1) Ametek Model DMC
      (2) Dwyer/Mercoid A-900 Series
      (3) Or Approved Equal

2.06 BALANCE

A. The balancing for pumps and associated components shall conform to the requirements set forth in ANSI/API 610, paragraph 6.9.4.1 (equivalent to ISO 1940 or ANSI 2.19 Grade 2.5), unless other portions of this project manual impose more restrictive requirements. It is the intent that the components be balanced as an assembly ("rotor") in accordance with ANSI/API 610 definitions. For extended-shaft pumps, balance impeller(s) and shaft up to the first coupling with the line-shaft.

B. For separately balanced components, perform a residual unbalance inspection after rotor assembly per ANSI/API 610 requirements, as described in Annex J of that document. Provide copies of worksheets and demonstrate that tolerances are in compliance (i.e., rotor has passed) in addition to other reporting requirements of this paragraph.

C. Furnish all balance logs, certified correct and signed by the chief engineer or individual in responsible charge of the manufacturing facility.

2.07 MACHINING

A. Unless otherwise specified, provide machined surfaces with a 125 Ra (micro-inch) finish without any grooves, surface imperfections, or machining marks. Mating surfaces shall be coplanar within a maximum of 0.002 inch. Bearing housings and seals shall have collinear centerlines within less than 0.001-inch total difference. Provide shafts with a 63 Ra (1.6-micron) finish at fit areas (coupling, sleeves, impeller) and 125 Ra (3.2-micron) finish at the clear spans.

2.08 CONTROL DESCRIPTIONS

A. The control system for the pumping system will reside outdoors as shown on the Drawings and include the following features:
   1. Each pump shall be equipped with a HAND/OFF/AUTO hand switch. HOA to be located at the control panel.

2. Pumps shall operate in both manual and automatic modes. Manual operation shall be available both locally and via SCADA. Automatic operation will be controlled via the control panel with remote monitoring and control available via SCADA.
3. Pumps shall operate based on level in the wet well based on level setpoints to drawn down the liquid level.
4. The level in the wet well will be continuously monitored via a 4-20 mA submersible hydrostatic level transducer and transmitter as the primary device. The starting and stopping of the pumps will be controlled based on operator adjustable level setpoints.
5. Individual pump operation shall follow a typical constant speed pump control strategy. When a pump is called to start, it shall start at full speed to draw down the level set point as required.
6. Each pump shall have the capability for automatic alternation via software alternation switch. The Lead pump shall be operator selectable using the panel mounted selector switch on the control panel door. When the switch is activated, the operating pump(s) shall be rotated automatically after each stop cycle.
7. The Lead pump shall be operator selectable using the panel mounted selector switch on the control panel door. Should the Lead pump fail and a pump fault is indicated, that pump shall automatically become the last pump in the alternating sequence and the standby pump shall be called to operate. Normal alternation sequencing may resume once the failure condition is corrected and the failed pump has been reset.
8. When the Lead pump is in AUTO mode, the pump shall be called to run when the wet well level reaches the PUMP ON set point (operator adjustable) for 10 seconds. The pump shall be called to shut off when the wet well level reaches the PUMP OFF set point (operator adjustable) for 10 seconds.
9. If any pump is called to run and a running status is not received within 10 seconds (operator adjustable, 0-20 seconds) or the running status is lost, the pump shall be considered out of service and a fault is generated. The pump run command for the out of service pump shall be removed and the next pump in the alternation sequence shall be called to run.
10. If any time during the AUTO mode pump operation the hydrostatic transmitter signal fails (i.e., goes outside the 4-20 mA range), the speed of all running pumps shall be fixed at their current speed and an alarm shall be generated.

B. Pump Protection Controls:
1. Moisture sensor shall be wired to activate an indicator in the control panel and to send an alarm to SCADA. Upon detection of moisture the alarm shall be activated, but the pump shall be allowed to run.
2. Temperature switch shall be wire to disable the pump if excessive heat is detected and send an alarm to SCADA. The thermostats shall reset automatically after the motor windings have cooled down. Provide provision for manual reset of the motor.

2.09 CONTROL PANEL

A. Panels shall be provided with instruments used for control, monitoring, and alarming. The control panel for the pumps shall be designed in accordance with this section and the Contract Drawings, and to support the specified operation.

B. The control panel shall be NEMA 4X with 3 point latching handle, 316-stainless steel, with sun shield, painted white (front, sides, back, and top) and shall be constructed by a UL-508A approved panel supplier and shall bear a UL 508A label. Where intrinsic safety barriers are used within a control panel, provide UL 698A factory applied label as required by UL. Desired dimensions to be per shown on the Drawings.

C. The control panel shall be accept a single 230 VAC, 60 Hz, 3-phase power supply circuit as shown on the Drawings. The control panel shall develop all other required control voltages internally; no other power source will be provided to the control panel.

D. Control panels shall be constructed in accordance with requirements specified in UL 508A and in NEC article 409. The control panel shall contain operator control devices, control relays, indicating lights and other panel devices, as required, for system operation and as shown on the Drawings and specified herein.

E. The control system shall be configured that, upon loss of power and return of power, the system shall reset and return to the ready state. Provide a main circuit breaker disconnecting means, with externally operable handle with the control panel door closed, flange type, 230 Vac, three phase, 60 Hz.

F. Furnish all necessary overcurrent protective devices, terminal blocks and overload relays for complete motor protection. All other control devices located within the panel shall be suitable for operation from voltage sources derived from, and located within, the control panel. 230 Vac power equipment shall be separated from the 120 VAC equipment. Mounting hardware shall be 316 stainless steel. If a programmable logic controller is furnished to perform control logic functions internal to the panel, it shall be a product of the Rockwell Automation (Allen-Bradley) Micro Logix or approved equal. The controls shall be wired and arranged such that the pumps may be started and speed controlled manually in the event of a PLC failure.

G. Panel containing 120-volt powered equipment shall use the din-rail power distribution method with fuses and blown fuse indication. Power is restricted to 120 Vac and 24 Vdc.

H. Panels containing voltages greater than 480 Vac shall be separated from the control section by physical barrier.

I. Panel containing direct current powered instruments or serving as the termination point for transmission loop powered field instruments shall contain direct current power supply system.

J. Prior to shipment, the panel manufacturer shall test the functional operation of the control panel as described in the control descriptions herein.

K. External door-mounted components and the panel description shall be identified with plastic nameplates. Machine embossed metallic adhesive labels shall identify tag number of instruments inside panels. Nameplates shall be attached to panel surfaces, not to instruments. Instrument tag numbers shall be identified on the panel rear. Provide RTV sealant for nameplates for NEMA-4X stainless steel panels. Submit nameplate legend with panel submittal.

L. Instruments shall be mounted for access to components and ease of removal. Cutouts for future equipment shall be blanked off with suitable covers.

M. Panels to be installed with specified mounting requirements as indicated on the Drawings.

N. Panels shall be provided with grounding as indicated on the Drawings.

O. Subcontractor shall furnish an Arc Flash Hazard Analysis Study based upon IEEE 1584 guide to performing Arc Flash Hazard calculations and meeting the requirements of NFPA 70E – Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D. Arc Flash Labels shall be provided on all new panels installed in this project. Affix arc flash label on electrical equipment before startup during construction. Arc flash labels shall be constructed of UV resistance, wet rated and suitable for the environment in which the label will reside in.

P. Panel Layout:
   1. Provide spare contiguous sub-panel area for future expansion.
   2. Provide minimum of 20 percent spare terminal blocks, with a minimum of 10 analog, discrete, power.
   3. Provide a minimum of 12 inches clear space from the bottom of the panel to the bottom of the subpanel.
   4. Separation between the power components (over 120 Vac) and the control/instrument components (120 Vac and less) by locating the power components and the control/instrument components in separate sections of the cabinet enclosure.
   5. Power cabinet section and the control/instrument cabinet section with separate door handles.
   6. Separation between the power components and the control/instrument components using barriers.
   7. External lockable circuit breaker handle for the main panel disconnect.
   8. Individual power and control components with internal circuit breakers, as required.
   9. Motor controllers, as required by the specifications herein.
   10. Displays with door-in-door construction accessible by opening the cabinet outer door.
   11. Face mounted equipment flush or semi-flush with flat-back escutcheons.
   12. Panel inner door contains a copy of the record elementary and wiring diagrams, or reference as allowed per NEC Article 409.
   13. Panel inner door contains a drawing holder.
   14. Panel drawings enclosed in a transparent, protective jacket.
   15. Panel functions as specified.
   16. Panels with floor stands, to raise the top of the panel to 60 inches above the floor or work platform.

Q. Pushbuttons:
   1. Pushbuttons shall be flush head, heavy-duty, with NEMA rating to match enclosure type. Momentary contact type, UL listed.

R. Indicating Lights:
   1. Indicating lights shall be heavy-duty full voltage 120 Vac or 24 Vdc push-to-test LED type with NEMA rating to match enclosure type for installation in a 30.5mm hole. Furnish with a 28 chip high visibility LED. Control panel indicating lights and lens color shall match existing.

S. Enclosures:
   1. Panel enclosures shall comply with the requirements of NEC Article 409 and NEMA 250.
   2. Candidate Manufacturers:
      a. Hoffmann Enclosures, Inc.
      b. Gulf States Engineering
      c. Or Approved Equal

T. Panel Wiring:
   1. All factory wiring required for equipment specified under this Section shall be included and shall have been tested for installation integrity as part of factory testing specified in this Section.

U. Surge Protection:
   1. Surge protection shall be provided to protect the electronic instrumentation systems from surges propagating along the signal and power supply lines. The protection level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, be maintenance free, and self-restoring.

V. Lightning Protection:
   1. Provide lightning protection as required. Lightning protection devices provide full protection from line to line and from line to ground.

W. Features:
   1. Control shall include HAND/OFF/AUTO mode selection, pump Lead/Lag, motor protection, and reset button to clear motor protection alarms.
   2. Panels shall contain distribution components, power supplies, and transformers, as required, to derive power for all instruments and equipment provided as part of the pump package.
   3. Separate pump and control circuit breaker with intrinsically safe module for floats.
   4. Dry contact and indicating lights located on the front of the panel for pump running, pump fail, moisture sensor, motor over temperature, and high level alarm.
   5. Suitable for service from a single 230 Vac, three-phase service.
   6. Provide intrinsically safe relays for use with the level switches to meet hazardous ratings.
   7. Pump protection relay for each pump for connecting the motor leak and temperature detectors.
   8. Internal enclosure heater.
   9. Terminal strip for connection of external devices.
   10. Motor starter.

11. External Signal Interface: Provide dry contact closures for connection to SCADA rated 0.5 amps at 12 or 24 Vdc for the following conditions:
    a. Each pump running status.
    b. High level alarm.
    c. Each pump ready status. Ready status is panel has power and pumps set to AUTO mode with no active alarms present.

X. Each panel is to include the following pushbuttons, selector switches, and indicating lights:
    1. HOA Switch
    2. Pump Sequence Switch
    3. Manual Speed Control
    4. Run Light
    5. Off Light
    6. Pump Fault Light
    7. Motor Over-Temperature Light
    8. Reset Button

Y. Spare Parts:
    1. The following spare parts shall be provided:
        a. Five each of each type of light bulb used in the panels.
        b. Five each of each type and rating of fuse used in the panels.
        c. Five each of each type primary protector surge suppressor used in the panels.
        d. Two each of each type of surge protective device used in panels.

2.10 FINISHES

A. All colors for coatings shall be as selected or approved by the Owner.

B. Existing coatings damaged by work in this Contract shall be repaired. Repair coating system shall be existing material, finish, and color. Repair coatings in accordance with the coating manufacturer's recommendations. Submit proposed colors to the Owner.

C. All pump parts and associated components which will be in contact with the pumped liquid or submerged after installation shall be prepared in accordance with SSPC SP-5 (White Metal Blast Cleaning) to achieve a uniform surface profile of 2.0 to 2.5 mils.

D. Damage shop coating shall be cleaned in accordance with SSPC SP-5 (White Metal Blast Cleaning) and vacuum cleaning and spot primed with the primer specified. Shop epoxy primed surfaces shall require light abrasive blasting or abrading prior to receiving finish coats if the maximum recoat time for the primer has been exceeded. This cleaning must produce a uniform 1.0 to 1.5 mils profile in the intact shop primer.

E. Prime coat may be thinned and applied as recommended by the CSM, provided the coating as applied complies with prevailing air pollution control regulations.

F. System thickness shall be 16 dry film.

G. Prime Coat: Shop applied, ne coat at CSM's recommended dry film thickness. Prime coat shall be an epoxy compatible with the specified finish coat.

H. Finish Coat: Field applied, two or more coats at CSM's recommended dry film thickness per coat to the specified system thickness. Finish coat shall be an epoxy per the candidate CSMs:
   1. Sherwin Williams (First Coat: Seaguard 6000 Epoxy N11-400; Finish Coat: Seaguard 6000 Epoxy N11-400)
   2. Tnemec (First Coat: Series V69; Finish Coat: Series V69)

2.11 SPARE PARTS

A. Provide the following spare parts for each model and size of pump furnished for this Section:
   1. One complete set of all gaskets and seals
   2. One complete sets of all bearings
   3. One complete sets of mechanical seals
   4. One complete sets of discharge connection sealing devices
   5. One removable cable seal chamber cap with cable length as required in this Section.
   6. If oil-filled motor is furnished, provide spare oil in sufficient quantity to allow for one-time flushing and replacement of coolant for all installed pumps.

2.12 SOURCE QUALITY CONTROL

A. Non-Witnessed Testing:
   1. Provide non-witnessed factory testing at a location in the Continental United States. Unless specified otherwise, performance-test pumps in accordance with ANSI/HI 14.6, with the above restrictions on motor power overload. Include in the factory tests test data for each full-speed performance requirement and any other points stipulated for this test procedure in the detailed specification. Conduct these tests with the pump inlet throttled to provide the specified NPSHA. Include shaft vibration and case noise in the test data at the full-speed operating conditions.
   2. Duplicate the test setup in the manufacturer's test facility as closely as possible to the inlet conditions in the proposed installation, using temporary baffles and other means, within the limitations of the test facility. Where centrifugal pumps are furnished with inlet elbows, inlet adapters or inlet reducers as a part of the manufacturer's scope of supply, test the pumps with the elbow, adapter, or reducer fitted to the pump and apply specified performance criteria to the complete pump assembly, including losses through any elbow, adapter, or reducer. Where submersible pumps are to be furnished with inlet nozzles and/or discharge elbows or adapters, test the pumps with these components fitted to the pumps. Apply the specified performance requirements to the complete pumping assembly including any inlet nozzles, and discharge elbows or adapters. Include in the certified test data separate readings for inlet and discharge head for each data point.
   3. Take not less than eight test points, including not less than three within plus or minus 8 percent (in terms of rated flow) of the rated condition (Condition Point A) and not less than two test points within plus or minus 4 percent of the pump's BEP at the

test speed. In addition, one test point is sufficient to define head and power requirements at shutoff head.

4. Perform NPSH3 tests in accordance with ANSI/HI 14.6, paragraph 14.6.5.8.2.1, Type 1 Test except that not less than four tests should be performed at the test motor speed to completely cover the range of operating conditions specified in the detailed specification. One of the test points shall be at the BEP flow to confirm the test pump's S. The translation of test results to specified operating conditions shall be in accordance with ANSI/HI 14.6, paragraph 14.6.6.1.1 so long as the exponent used can be supported by certified test data performed on a pump of the same type, size, speed, and specific speed as that of the proposed pump. Include NPSH3 tests at both the proposed and test speeds in test data justifying the exponent, test points at BEP, and at least three other points on the test pump head/capacity curve at least 15 percentage points removed from the BEP. Use the results of the NPSH3 tests to confirm the NPSH margins for each specified operating condition as specified in paragraph 1.04 NPSH margin limitations. Perform NPSH3 tests for column type (axial, mixed-flow, and vertical-turbine) pumps using the open sump/water level or closed tank/tank pressure methods described in ANSI/HI 14.6, Table 14.6.5.8.2.1. Perform NPSH3 tests for submersible wastewater pumps using the method described in Figure 11.6.8 in ANSI/HI 11.6. Extend all NPSH3 tests from 50 percent to 140 percent of best efficiency flow at full speed, or to not less than 10 percent (in terms of flow) past the flow at Operating Condition B, whichever is greater. For a given pump, if the manufacturer can provide documentation that the upper flow limit of the AOR on the right side of the pump curve is less than 140 percent of best efficiency flow, the AOR may be used as the limit for the NPSH3 test. Cause for rejection is failure to achieve specified performance or performance proposed in accepted submittal documents (capacity and head, efficiency, or NPSH3), whichever is more restrictive.
5. All test procedures shall be in strict conformance with the referenced standards. However, prediction of performance of a trimmed impeller from test data of the larger impeller will not be permitted. If trimming is required, re-test the pump. Do not allow deviations from specified operating conditions, though allowed by the referenced standards, to result in overload of the driver furnished with the equipment, nor allow such deviations to result in power requirements greater than the driver's nameplate (1.0 service factor) rating.
6. The Subcontractor shall furnish the Purchaser with not less than 2 weeks' advance written notice of the date and place of the non-witnessed tests.
7. All test results, including test logs and generated curves, shall be certified correct by the chief engineer or individual in responsible charge of the manufacturer's test facility, and shall be submitted.

B. Factory Testing:
   1. Submit factory testing results report and certification of satisfactory testing of each unit as specified. Include in the certified material copies of test logs and resulting performance curves.

C. Hydrostatic tests:
   1. Subject all pressure-sustaining parts to factory hydrostatic tests. Unless otherwise specified, conform hydrostatic tests to the requirements of ANSI/HI 11.6 for submersible pumps and ANSI/HI 14.6 for dry pit pumps. Unless otherwise indicated

in the detailed specifications, hold castings at the test pressure for the duration indicated in ANSI/HI 11.6 and 14.6.

2. For process pumps designed in accordance with ANSI/API 610, hydrostatic testing must comply with the requirements of paragraph 8.3.2 of ANSI/ ANSI/API 610. Test results shall be certified correct by the chief engineer or individual in responsible charge of the manufacturing facility.

D. Motor tests:
   1. First check impeller, motor rating, and electrical connections for compliance with the specifications
   2. Subject all motor circuits to electrical resistance tests to confirm functionality

E. Performance Guarantee:
   1. Subject each pump to performance testing. Pump performance (flow and head, efficiency, and NPSH3) shall be guaranteed by the pump manufacturer to the criteria specified under this paragraph.
   2. Equipment performance documentation, including test data, where tests are specified, shall include sufficient test points (not less than eight) to document hydraulic performance along the complete head/capacity curve from shutoff to maximum capacity, and covers full-speed operating points specified in the detailed specification section referencing this section. Tests conducted at specified operating conditions shall be with the inlet throttled to produce the NPSHA indicated for that specific condition in the detailed specification. Perform NPSH3 tests for not less than four full-speed operating conditions, but not less than specified operating conditions and at the best efficiency point (BEPQ).
   3. Test procedures shall be as set forth in ANSI/HI 14.6, and as specifically detailed in these specifications. However, any increase in flow or head permitted under specified acceptance grade(s) cannot result in overload (nameplate basis, S. F. = 1.0) of the specified motor power rating at any location on the pump's head/capacity curve. Conduct performance tests at the specified maximum speed. Affinity relationship-predicted test results will not be accepted. For column-type pumps, include in the performance documentation curves showing both bowl efficiency and overall efficiency (including inlet, bowl, column, and discharge head losses) at maximum operating speed for the application.
   4. The acceptance criteria for head and capacity test results shall be based upon the rated condition specified in the detailed specification and as required in ANSI/HI 11.6 and 14.6 for acceptance Grade 1U, with the above-stated limitation with respect to motor power overload.
   5. Where there are none stipulated, the acceptance criteria for head and capacity test results for the other specified duty conditions in the detailed specification shall be as required in ANSI/HI 11.6 and 14.6 for acceptance grade 3B, with the above-stated limitation with respect to motor power overload.
   6. The acceptance criteria for NPSH3 at any specified operating condition shall be the values proposed by the Subcontractor in the curves submitted under this Section, and duly accepted by the Construction Manager, with a tolerance of plus 0, minus unlimited, with the exception that S, as calculated for the specific pump, does not exceed the limitation established in this Section. If the NPSH3 data result in an increase in S, the manufacturer shall confirm that the stable operating region for the pump corresponds to the POR as defined in ANSI/HI 9.6.3, and that the operating

conditions specified to be within the POR are within the stable operating region for the pump. In addition, the manufacturer shall identify the onset of suction recirculation and confirm that the onset of suction recirculation is outside of the specified operating range.

7. Include in the guarantee a statement to the effect that the pump will operate within the operating regions specified in the detailed specification. The guarantee shall be in writing and signed by the chief engineer or individual in responsible charge of the test facility. Under no circumstances should deviations from specified operating conditions result in overload of the driver furnished with the equipment, nor should such deviations result in power requirements greater than the driver's nameplate (1.0 service factor) rating.

F. NPSH margin limitations:

1. General:

a. Pumps furnished under this section and sections referencing this section shall be selected for NPSH margin limitations using the criteria set forth in this section. Base NPSH3 characteristics for the candidate pump upon documented test data not more than 5 years old. Perform testing on a pump not more than two nominal pump diameters larger or smaller than the proposed pump with an impeller of the same geometry as that proposed for the pump to be used for the subject application, and operating at either the same speed as the pump for the proposed application or a speed that provides plus or minus 10 percent of the impeller inlet velocity if reduced-speed testing is used. For very large pumps that cannot be accommodated in the manufacturer's test pit, the use of a model pump, sized in accordance with ANSI/HI 14.6, Appendix K, is acceptable. The contractor shall document the basis for pump selection based upon NPSH margin limitations as set forth in this paragraph.

b. The detailed specification sections provide NPSHA information for anticipated operating conditions for each application. This information is generally referenced to a specific elevation, stated in terms of project datum. The contractor is responsible for requiring the pump manufacturer to adjust the NPSHA information in the specification section to the elevation of the pump impeller eye for the specific pump model and size proposed for the application. NPSH3, as used in the following paragraphs, means the NPSH3 at the impeller eye, determined in accordance with ANSI/HI 11.6 or 14.6, as applicable for the proposed pump. The contractor shall require the pump manufacturer to document the method used to determine NPSH3 for the proposed pump and justifying compliance with the NPSH margin limitations established under this paragraph for each specified operating condition in material submitted under this Section. Include in the documentation justification of the NPSH3 tests used to develop NPSH3 characteristics, including the following:

1) Date, test procedure, and test logs of original NPSH3 information used to project requirements for the pump selected for the application

2) Test pump size, impeller diameter, impeller model, eye diameter, and speed

3) Calculations projecting NPSH3 test information to NPSH3 curve information for the pump proposed for the application

4) Calculations demonstrating compliance with the NPSH margin requirements established in this paragraph

c. The contractor shall submit the manufacturer's margin calculations justifying the proposed pump selection with the material required under this Section. The NPSH margin ratios specified in this paragraph are the minimum acceptable margin ratios. If the proposed pump requires greater margin ratios to operate within the specified operating conditions without loss of head due to cavitation, then it is the responsibility of the contractor to bear costs associated with achieving the required margin ratio by lowering the elevation of the pump setting, lowering the elevation of the structure, or through other means. Subject any such adjustments to review and acceptance by the Construction Manager if necessary.

d. Individual restrictions are applicable to NPSH margin depending upon the type of pumping equipment and the fluid to be pumped as set forth in ANSI/HI 9.6.1, Table 9.6.1.5.5. Under no circumstances may the absolute value of the NPSH3 margin be less than 3.5 feet.

PART 3 EXECUTION

3.01 EQUIPMENT MOUNTING

A. Mounting for pumps specified in this section shall be as follows:
   1. Position equipment pad/mounting blocks and equipment anchors for final placement of equipment
   2. Use a bolting template to position equipment anchors
   3. Level mounting plates/blocks
   4. Pour grout bed supporting each mounting plate/block
   5. Eliminate grout voids
   6. Tension equipment anchors

3.02 PANEL INSTALLATION

A. Control panels to be supported and mounted as shown on the Drawings.

B. Steel used for support of equipment shall be 316 stainless steel. Support systems including panels shall be designed to prevent deformation greater than 1/8-inch under the attached equipment load and external load of 200 pounds in any direction. Panels shall be mounted with stainless steel Unistrut, fittings, and fasteners.

C. Floor mounted cabinets shall be mounted on 3-1/2-inch minimum height concrete pads or grouted bases as specified.

D. Panels shall be shimmed to precise alignment so that doors operate without binding. Sealant shall be provided under panels not located in dry control or electrical equipment rooms.

E. Outdoor Panel Shade Covers:
   1. Fabricate the custom aluminum panel shade cover and mount the panels facing away from the prevailing sun or wind.
   2. Fabricate based upon known panel dimensions or accepted submittal drawing dimensions.

3.03 COATINGS

A. Finish Coating: see paragraph 2.10.

3.04 FIELD QUALITY CONTROL

A. Alignment:
   1. Alignment work shall be performed by journeyman millwrights skilled in this type of work under the supervision of a technician trained by the manufacturer.
   2. Machines supported on integral feet or support pads shall be leveled, grouted and aligned in the following order: driven machine, intermediate bearings or machines, and driver.
   3. Machines shall be rough aligned without any connections to piping, electrical, and instrumentation systems.
   4. Upon completion of all field connections, alignment shall be rechecked to demonstrate no change. If change has occurred, the Subcontractor shall eliminate any external forces affecting machine alignment.
   5. A factory authorized installation technician representing the equipment manufacturer shall witness final alignment work. After completion of alignment work, acceptance of the work shall be documented in writing by factory installation technician.
   6. Submit alignment records as both hard copy and electronically as informational submittal. Hard copy shall be signed and dated by the technician performing the alignment work.

B. Vibration Test:
   1. Vibration levels shall be determined by affixing suitable sensors to the top of the motor housing in both the x-x (parallel to the nozzle) and y-y (perpendicular to the nozzle) directions. The Subcontractor or his designated testing agent shall provide all sensors and monitoring equipment.
   2. As a condition precedent to final acceptance of the equipment, the pumps shall be individually operated at all specified operating conditions. The Subcontractor shall provide the means to recirculate pumped fluid or alternatively throttle the pumps to achieve the specified head at specified flow.
   3. Vibration levels shall not exceed that specified in ANSI/HI 11.6 when the pump is operating within the manufacturer's listed POR. When operating at conditions outside the POR, vibration levels shall be no more than 125 percent of that specified in ANSI/HI 11.6.
   4. Vibration measurements and limits to be in accordance with ISO 10816 for equipment specified in this Section. Ensure that the RMS vibration velocity does not exceed the limits established in ISO 10816.
   5. Provide vibration test results and reports as an informational submittal, and provide the signature of the responsible professional vibration analysis specialist. Ensure that the vibration spectra is of sufficient resolution for legibility of magnitude and frequency data to be properly reviewed by the Engineer.

C. Manufacturer Services:

1. On-Site Inspections and Training: Provide a factory-trained manufacturer's representative at the Site for the following activities. Specified durations do not include travel time to or from the Site.
    a. Installation Inspections: Assist, supervise, and inspect the Subcontractor's activities during installation. Provide 8 inspection hours..
    b. Component Test Phase Inspections: Assist, supervise, and inspect the Subcontractor's activities during the system test phase. Provide 8 inspection hours.
    c. System Test Phase Inspections: Assist, supervise, and inspect the Subcontractor's activities during the system test phase. Provide 8 inspection hours.
    d. Operational Test Phase Inspections: Assist, supervise, and inspect the Subcontractor's activities during the operational test phase. Provide 8 inspection hours.
    e. Training Sessions: Provide a minimum of 8 hours classroom training for each training session. Conduct two training sessions as necessary, one training session per week on two consecutive weeks to accommodate the shift schedules of operation and maintenance staff.
    f. Provide a completed Manufacturer's Installation Report. Prepare and submit report within 30 days after completion of field testing and operation instruction. The report shall include the following:
        1) Installation Certification Form including:
            a) Contract No.
            b) Specification Section
            c) Equipment Name
            d) Subcontractor
            e) Manufacturer of Equipment
            f) Comments related to equipment installation
            g) Signed and dated by Manufacturer and Subcontractor
        2) Field testing reports
        3) Description of installation deficiencies unresolved to the Owner's satisfaction
        4) Record copy of materials used for training sessions including an outline summary of the course
        5) Training Certification Form including:
            a) Names of Owner's personnel in attendance
            b) Operations (start-up procedures, shutdown procedures, normal operation procedures, and any others)
            c) Maintenance (any maintenance items required for the equipment)
            d) Signed and dated by Manufacturer and Subcontractor

3.05 SYSTEMS START UP

A. Subcontractor shall provide a Testing and Startup Manager who will be responsible for overseeing, organizing, administering, recording, and documenting all aspects of the testing and startup efforts, including development of Testing and Startup Plans.

B. Subcontractor is responsible for providing test gauges, meters, recorders and monitors, and associated assemblies, as required, to supplement or augment the Work specified in the Contract Documents to facilitate compliance with Testing and Startup requirements. Select devices designed to measure the performance of the specific equipment and systems incorporated into the Work.

C. The Subcontractor shall provide temporary systems, piping, valving, drains, etc. to facilitate any of the field tests.

D. Subcontractor shall perform component testing, functional testing, startup testing, and acceptance testing of all installed component and systems.

E. Operations Testing shall not commence until all tagging and labeling including but not limited to piping, conduit, wires, panels, and equipment, have been completed.

F. Acceptance Testing shall not commence until training has been completed.

G. At the satisfactory conclusion of each test phase, the Subcontractor shall dismantle and remove all temporary valving, hose, and other equipment used during the test.

H. All deficiencies found during any test phase and subsequent correction thereof, must be inspected and approved by the Owner prior to re-testing or continuation of testing. The Subcontractor shall correct all noted deficiencies.

I. If any portion of a test does not pass, the Subcontractor shall correct the problem in a timely manner and repeat the test until it passes to the satisfaction of the Owner.

J. If a failure of any component or system occurs during the Startup Testing, the entire test shall be re-started. The Subcontractor shall be responsible for any direct costs incurred by the Owner during associated idle time due to such failure. Such costs of idle time shall include equipment rental and any other direct incidental costs due to the delay.

K. Once testing has been completed, all equipment and components shall be rechecked for proper alignment and realigned, loose connections, unusual movement, or other indications of improper operating characteristics.

L. Field test reports shall be submitted.

PART 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Pumps and Controls

1. Pumps and controls will be measured as a lump sum item.

4.02 PAYMENT

A. Pumps and Controls

1. Pumps and controls will be paid at the appropriate contract lump sum price. This item includes all materials and labor necessary to supply and install the pumps, controls, instruments, and appurtenances per the plans and specifications.

4.03 PAYMENT WILL BE MADE UNDER:

Item No.	Pay Item	Pay Unit
11347-4.02.A	PUMPS AND CONTROLS	LUMP SUM

END OF SECTION

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SECTION 16485

VARIABLE FREQUENCY MOTOR CONTROLLERS

PART 1 GENERAL

1.01 SCOPE

A. This section specifies 208 Vac rated adjustable frequency drive motor controller systems using insulated gate bipolar transistors (IGBT) for pulse width modulation technology (PWM).

B. The AFDs specified in this section shall be the product of a single vendor and mounted in the specified cabinet enclosure.

C. The terms AFD (adjustable frequency drive), ASD (adjustable speed drive), VFD (variable frequency drive), and VSD (variable speed drive) are interchangeable for the purposes of this specification.

D. Refer to the drawings for control and monitoring requirements including special interlocking requirements.

E. System Requirements:

1. The AFD system shall convert 240 volt, single phase, 60-Hertz nominal input to a suitable 3Ø voltage and frequency to cause a premium efficient, inverter duty, squirrel-cage induction motor to run at a speed proportional to an external input analog 4 to 20 ma dc or digital input command as specified for the required AFD speed range.
2. The motor and wire for a single phase to three pahse conversion requires 75% more ampacity capacity as the original motor.
3. The AFD system shall include rectifier units, inverter units, control circuitry, protective equipment, input line reactors and output load reactors and other filters and accessories as necessary to provide the specified functions to meet voltage and current harmonics at the specified point of common connection and to mitigate the motor reflected voltage wave. Unless otherwise specified, the point of common connection for AFDs shall be the 480 distribution bus (motor control center, distribution panel, etc.) immediately upstream of the AFD.
4. The AFD system torque requirement shall match the pump torque requirement. Verify the pump type and select variable torque (VT) or constant torque (CT) as specified in the AFD Schedule. Select 6-Pulse units for small pump motors and 18-Pulse units for large pump motors.

F. AFD Schedule:

Equipment	Drive Number	Drive Horse Power	Drive Speed Range	AFD Type	AFD Enclosure & Mounting	Distance (ft) from AFD to Driven Equipment Motor
Pump 1	VFD-1	7.5/15	900-1800	[CT] [6P]	NEMA-3R Gasketed, Wall Mount	10
Pump 2	VFD-2	7.5/15	900-1800	[CT] [6P]	NEMA-3R Gasketed, Wall Mount	10

1.02 QUALITY ASSURANCE

A. References:

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEEE 519	IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power System
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 2	Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts
NEMA ICS 6	Industrial Control and Systems: Enclosures
NEMA ICS 7	Industrial Control and Systems: Adjustable-Speed Drives
NEMA ICS 7.1	Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems
NFPA 70	National Electrical Code (NEC)
UL Standard 508	Industrial Control Equipment

B. Industry Standards:

1. The AFD shall be UL 508 listed and shall conform to the requirements specified in NEMA ICS 2, 6, 7 and 7.1.

C. Unit Responsibility:
   1. The Subcontractor shall submit letters of certification with the shop drawings from the AFD manufacturer, the motor manufacturer, and the driven equipment manufacturer stating that they have reviewed each application and that the combination will satisfy the application duties required, for the actual motor sizes required, regardless of deviations from the scheduled "nominal horsepower."

1.03 PRODUCT HANDLING

A. AFD units shall be shipped in air-cushion vans to ensure against shipping damage and packed in suitable protective containers. The units shall be inspected upon receipt for damage.

1.04 SUBMITTALS

1. Certificate of Unit Responsibility attesting that the Subcontractor has assigned, and that the manufacturer accepts, unit responsibility. No other submittal material will be reviewed until the certificate has been received and found to be in conformance with these requirements.
2. Catalog and technical data including outline dimensions, shipping section dimensions, weight, and foundation requirements for all assemblies.
3. Schematic diagrams and wiring connection diagram showing functions and identification of terminals.
4. Voltage and current Total Harmonic Distortion (THD) calculations with line reactors or filter design to mitigate harmonics to meet IEEE-519, if applicable.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Owner and Engineer believe the following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. This statement, however, shall not be construed as an endorsement of a particular manufacturer's products, nor shall it be construed that named manufacturers' standard equipment or products will comply with the requirements of this Section. AFDs shall be installed in the custom enclosures as specified and Candidate manufacturers include:
   1. ABB ACQ-580
   2. Toshiba Series:
      a. W7 18-Pulse for centrifugal fan and pump motors
      b. G7 18-Pulse for slow speed and high-torque motors
   3. Cutler-Hammer SV9000
   4. General Electric AF-300
   5. Siemens Model 6SE32
   6. Square D Altivar Series
   7. Siemens-Robicon
   8. Allen Bradley
   9. Or equal

2.02 ENCLOSURES

A. Provide AFD in NEMA enclosures with fan cooling and conformal coating protection on circuit boards for corrosive atmosphere protection.
   1. General:
      a. Provide enclosures with AFDs and custom control as required for the project and as indicated on the drawings. Each drive shall be designed for stand-alone operation and multiple drives shall not utilize shared components. Review the project site location, elevation, temperature, humidity, plant atmosphere, and load current-torque requirements to size the AFD and its associated enclosure with requirements specified herein and the control and monitoring devices and interlocks as indicated.
      b. Enclosures shall be designed for indoor service. Each AFD system shall be mounted in a NEMA 250 internally force ventilated enclosure with UL approved Class 1 filters on ventilation openings. Enclosures shall be fabricated from 12-gage minimum thickness sheet steel with an interior frame or formed to provide a rigid structure.
      c. Provide enclosure size to allow entry of power source and motor load cables as indicated on the drawings. Submit drawing of the source and load power cable location within the enclosure and indicated barriers from control and instrument wiring.
      d. Door width shall not exceed 30 inches and shall be hung on removable-pin hinges, with three-point latch hardware, and handle latch for 3/8-inch-shackle padlock.
   2. Finish and Coatings:
      a. AFD systems enclosures shall be finished with corrosion protection coatings inside and outside for hydrogen sulfide atmospheres. The electrical and electronic assemblies shall have conformal coatings.

2.03 AFD ASSEMBLIES

A. General:
   1. AFDs shall include the following assemblies:
      a. Power disconnect using a thermal magnetic circuit breaker or fused disconnect sized for the specific application by the manufacturer.
      b. Control circuitry interface with Operator Interface Unit
      c. Output protection including phase overload

B. AFD Features:
   1. Provided with the following features:
      a. Fused control circuit transformer and microprocessor for system logic sequencing functions. Provide fuses with blown fuse indicator lamps.
      b. Accept 4 to 20 mAdc speed reference signal.
      c. A 4 to 20 mAdc output signal proportional to inverter output frequency for the speed range specified.
      d. Adjustable minimum/maximum frequency limits:
         1) Minimum frequency shall be adjustable from 6 to 40 Hertz.

2) Maximum frequency shall be adjustable from 48 to 90 Hertz.

e. Adjustable and independent timed linear acceleration and deceleration functions, adjustable from 6 to 20 seconds.

f. Current limiting.

g. Automatic restart.

h. Control Wiring:

1) 600 volt stranded copper

2) 90 degrees C color-coded insulation

3) No. 16 AWG

i. Wiring Identification and Termination:

1) Crimp type wire lugs with sleeve type markers at each termination point and numbered terminal blocks for external connections.

j. Conformal coated terminal blocks for control and signal wires entering and leaving the controller.

k. Control Power:

1) Provide a 120 Vac, triple fused, control power transformer for cooling fans and external control circuits when required. Control circuits shall be isolated from power circuits by distance and by insulated barriers.

l. Provide 120 Vac or 24 Vdc as required for Operator Interface Unit.

C. Functional Requirements:

1. Supply Power:

a. Operate continuously with supply power of 480 volts plus or minus 10 percent, 60 Hertz plus or minus 3 percent and remain on line and operate without damage to the AFD or connected load during a supply power under-voltage variation to the drive up to 85% of its nominal value for 30 milliseconds at full load.

2. Environmental Conditions:

a. Ambient temperature:

1) 0 to + 40 degrees C / 104 degrees F

b. Atmosphere:

1) Hydrogen Sulfide

3. Load:

a. Capable of driving the specified maximum motor load continuously and under the following conditions:

1) Deliver 110 percent of the specified load for up to 60 seconds in variable torque applications.

2) Deliver 150 percent of the specified load for up to 60 seconds in constant torque applications.

4. Efficiency:

a. Not less than 95 percent at 60 Hertz output driving the specified maximum load at rated torque and speed at 40 degrees C ambient based on measured input power versus output power with all specified components in the system.

5. Frequency and Voltage Regulation:

a. Output frequency regulated to within 0.6 Hertz of the signal/output frequency relationship. Output voltage regulated to within 1.0 percent to produce minimum motor heating at any operating frequency within the specified range.

6. Frequency Range:
   a. AFD shall be capable of continuous operation with the specified load at any frequency between 6 and 60 Hertz unless noted otherwise.
7. Space and AFD Access:
   a. Enclosure size shall not exceed the size allotments specified on the drawings nor shall any portion of the AFD system exceed a height of 90 inches.
   b. Front accessible only and shall not require rear access.
   c. Mount against the wall without any clearance for ventilation or other purposes.
   d. Submit AFD in the enclosure drawing with the detail of front door and the internal arrangement, including the feeder and motor cables, and the control cables, and the instrument cable location and terminations.
8. Ambient Noise:
   a. Free field noise generated shall not exceed 85 dBA at 3 feet out from any point on the AFD enclosure under any normal operating condition.
9. Motor Coordination:
   a. AFDs shall be configured as required to maintain output voltage peaks at the connected motor windings from reaching levels damaging to the motor insulation. Provide protection integral to the AFD or as protective hardware to be installed at the motors.
      1) Where motor terminator units are provided, they shall be rated for the environment in which they are located. Motor terminator units shall be:
         a) Allen Bradley 1204 Motor Terminator for AFD with the maximum carrier frequency of 6 kilohertz,
         b) Cutler Hammer Reflected Wave Trap (RWT) with the maximum carrier frequency of 12 kilohertz,
         c) Or Equal product

D. Protection and Annunciation:
   1. Overcurrent Protection:
      a. Electronic current limit at 150 percent of motor nameplate current and provide motor running overcurrent protection in compliance with NFPA 70.
   2. Short Circuit Protection:
      a. Protected against load faults: bolted faults, phase to phase or phase to ground shall not damage the unit. Fault protection based on a power source short circuit capacity of 42,000 amperes RMS symmetrical at the AFD power input terminals with impedance or current limiting device provided.
   3. Line Voltage:
      a. Protected against high and low line voltage on one or more phases.
   4. Internal Faults:
      a. Internal fault monitoring system to detect malfunctions to protect from transient and sustained faults and to limit damage that may be caused.
   5. Motor Over Temperature:

a. Interface to motor over temperature device 2-ampere output contact to shut down and alarm if the motor becomes overheated.

6. Fault Alarm:
   a. Indicates the cause of any shutdown visible on the AFD keypad/display without opening the AFD enclosure. As a minimum, the following faults shall be alarmed:
      1) Motor over-temperature
      2) Motor overcurrent
      3) Incoming power line over/under/unbalanced-voltage
      4) AFD over-temperature
      5) AFD over-voltage
      6) AFD control failure
7. Safety Features:
   a. The AFD shall include:
      1) Padlock main disconnect handle in the “Off” position.
      2) Mechanical interlock to prevent opening enclosure door with disconnect in the “On” position while the unit door is open.
      3) Auxiliary contact on main disconnect to isolate 120Vac control power when fed from external source.
      4) Barriers and warning signs on terminals that are energized with the power disconnect “OFF”.
      5) Separation and insulated barriers between the power and control and instrument products.
      6) External emergency stop input
8. Reverse Direction Protection:
   a. Provide protection from inadvertent operation in reverse where reverse rotation can damage the driven equipment.
9. Critical Speed Bypass:
   a. Provide capability to program speed bypass for minimum two critical speed points.
10. Transient Voltage Protection:
    a. Provide solid state transient voltage protection to meet or exceed ANSI C37.90.

2.04 CONTROL AND MONITORING DEVICES

A. Front door mounted on the AFD enclosure between 36 inches and 72 inches above the floor for each unit:
   1. Digital Operator keypad/display.
   2. Local-Off-Remote door mounted selector switch.
   3. Manual speed control: Potentiometer function
   4. Internal terminal strips for remote monitoring:
      a. Run status
      b. Trouble / Fail alarm
      c. Auto Mode status
      d. Additional devices as indicated on the drawings.

B. Operator Interface Unit:
   1. Digital keypad/display for monitoring and controlling the drive and to input drive parameter settings with a backlit LCD or equally visible display with a minimum of 16 characters per line.
   2. Digital keypad for numerical settings in English engineering units and a guide to parameter settings. Setup operations and adjustments stored in non-volatile EEPROM memory transferable to new and spare boards. Settings shall be protected from unauthorized tampering, revision, or adjustment by a personal lockout code.
   3. The digital keypad to provide programming of the drive and include:
      a. Up and Down Arrow Keys:
         1) Increase or decrease output frequency or data values.
      b. Monitor Key:
         1) Selection of control mode.
      c. Run and Stop Keys:
         1) Starting and stopping in the manual mode.
      d. Fault Clear / Enter Keys:
         1) Reset fault conditions and enter chang
      e. Program Key:
         1) Enter the program mode and adjust parameters.
      f. Remote / Local Location Keys:
         1) Operation location and local speed control.
      g. Auto / Manual Mode Keys:
         1) Program mode.
      h. Number Keys:
         1) 0 through 9 keys to access specific parameters.
      i. Keypad Digital Illustrations:
         1) English and display the last 5 faults.
      j. Frequency / Motor Speed Indication:
         1) Calibrated in Hertz and RPM.
      k. Run Status Indication.
      l. Ready Status Indication.
      m. Fault Alarm Indication.

C. Control and Monitoring Communication
      a. EtherNet Communication Card

2.05 KEYPAD FUNCTIONS AND OPERATION

A. Adjustment of the following parameters through the OIU digital keypad:
   1. Current limit and torque boost.
   2. Maximum voltage level.
   3. Minimum/Maximum speed, Volts/Hertz, Upper and Lower limit.
   4. Adjustable acceleration rate and deceleration rate.
   5. Electronic thermal overload setting.

6. Coast, controlled ramp or DC injection selectable modes of stopping.
7. PID setpoint and time-function selection.
8. Critical frequency avoidance:
    a. Three set points selectable from 0 to maximum frequency with set points adjustable from 0-30 Hertz.

2.06 ARC FLASH MITIGATION METHODS

A. The following arc flash and mitigation method requirements shall apply. Refer to specification section 26 05 74, NFPA-70 (NEC) for arc mitigation requirements, and NFPA-70E (Standard for Electrical Safety in the Workplace) for equipment labeling requirements.

B. Equipment Labels:
    1. Equipment labels shall be installed on the outside of the electrical equipment enclosure, cabinet, and panels to avoid opening the equipment to access the manufacture's data or the equipment ratings.

C. Insulated Power Bus and Insulated Cable Boots:
    1. Provide insulated power bus in power distribution equipment where accessible to installers or maintenance workers.
    2. Provide cable boots for power conductor connections to insulate the exposed power conductor connections.

D. [Power and Control Equipment Separation-for purpose of arc flash rating:
    1. Provide separation between power equipment and controls within an enclosure, cabinet, or panel by the uses of barriers, separate access doors, or by other means.
    2. Provide separation barriers between main breaker feeders coming into equipment and other termination points or bussing on the load side of the main breaker.]

2.07 NAMEPLATES

A. Nameplates shall be provided for all drive enclosures. Provide equipment tag numbers and descriptions as shown on the drawings.

2.08 SPARE PARTS

A. The following spare parts shall be supplied with each type or frame size AFD:
    1. Three sets of all replaceable fuses.

2.09 PRODUCT DATA

A. The following information shall be provided:
    1. Operation and maintenance information including:
        a. Final reviewed submittal.
        b. As-built drive configuration settings.
    2. Installation certification.
    3. Training certification.

PART 3 EXECUTION

3.01 FIELD INSTALLATION

A. Each adjustable speed controller shall be installed and tested by the Subcontractor with the assistance of factory-trained pump manufacturer engineer/technician and AFD engineer/technician in accordance with the manufacturer's specifications and witnessed by the Engineer.

B. Manufacturers' factory representatives shall provide field testing for devices including the setup of the Operator Interface Unit and the setup of the data communication devices, where used. Upon satisfactory completion of the testing, the Subcontractor shall submit two certified copies of the test report to the Engineer.

C. Component failure during testing will require repeating any test associated with the failure or modified components to demonstrate proper operation.

1. Adjust drive and perform "start-up" tests as recommended by manufacturer. Set parameters and carrier frequency for existing motors to avoid insulation damage.
2. Establish proper direction of rotation for the motor controlled by the drive. Verify that the AFD is precluded from operating in a direction that can damage the driven equipment. Change motor or AFD power lead connection and not the AFD direction, where rotation is incorrect.
3. Verify that the drive will operate properly both in the "manual speed control mode" and in the "remote or automatic mode" from a remote speed signal input.
4. Set the maximum "locked rotor" current drawn during start-up recommended by the manufacturer and approved by the Engineer.
5. Set the minimum and maximum speeds and the acceleration and deceleration "ramps" recommended by the Engineer.
6. Verify the motor high temperature switch contacts are wired into the AFD 120 Vac control circuit and will trip on high winding temperature. Test or simulated the alarm and trip feature at the motor for high temperature and for high vibration, where used.
7. Operate the drive at 100 percent speed for one hour and monitor output current. The output current shall remain below the full load current listed on the motor nameplate.
8. Check for excessive heating of the drive and motor. Report any discrepancies to the Engineer.

3.02 HARMONIC TESTING

A. A Testing Firm shall perform a harmonics acceptant test with all AFD motor controllers operating to verify compliance with IEEE-519 of less than 5 percent voltage THD and 12 percent current THD at the defined point of common connection when running from Power Utility power source with a BMI-Dranetz or equal harmonic test set that provides a hard-copy record of the test results.

B. The test shall also be run with power sourced from the standby generator where such a power source is being used at the project site. THD shall be limited to a maximum level of 8 percent voltage THD on standby generator operation.

C. Submit the test performance to the Engineer per latest version NETA ATS Acceptance Testing Specifications.

3.03 TRAINING

A. Two hours of onsite AFD operation and maintenance training shall be provided for the Owner's Operation and Maintenance Staff.

B. Manufacturers' factory representative shall conduct the training, upon acceptance of a resume submitted by the trainer.

C. Training shall be certified by manufacturer in written form.

END OF SECTION

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