SECTION 02400
TUNNELING

1.0 GENERAL

A. Description

Tunneling shall include, but not necessarily be limited to, furnishing and installing tunnel liners beneath railways, roadways, or other locations indicated on the Plans and in accordance with the Contract Documents.

B. Related Work Include Elsewhere

1. Removal or Abandonment of Existing Utilities: Section 02050
2. Aggregate Backfill: Section 02240
3. Trench Excavation, Backfill, and Compaction: Section 02250
4. Water Main Installation and Chlorination: Section 02551
5. Gravity Sanitary Sewer and House Connections: Section 02561
6. Sanitary Sewer Force Mains: Section 02563
7. Cast-in-Place Concrete: Section 03300
8. Flowable Fly Ash: Section 03500
9. Mortar: Section 04100

C. Quality Assurance

The Commission will inspect all materials before, during, and after installation to ensure compliance with the Contract Documents.

2.0 MATERIALS

A. Materials Furnished by the Commission

The Commission will not furnish any materials for tunneling.

B. Contractor's Options

None.

C. Detailed Material Requirements

1. Portland Cement Concrete

   Portland cement concrete for invert cradles shall be Mix No. 1 as specified in Section 03300.

2. Mortar for Grout

For filling voids outside the liner plate, the grout shall conform to the requirements of Section 04100 and the following. The mortar shall be composed on one (1) part Portland Cement (Type 1) and three (3) parts sand with only enough water to permit the material to flow properly. The grout shall remain fluid long enough to be injected through the lining and to fill the voids and shall set promptly enough to avoid grout flowing into the new annular space after the next advance.

3. Flowable Fly Ash

Flowable fly ash fill shall be as specified in Section 03500, and used as fill inside of the tunnel to the levels shown on the Contract Drawings.

4. Liner Plate

a. Steel liner plate shall conform to requirements of ASTM A 569. Liner plate steel shall have the minimum mechanical properties of flat plate before cold forming as follows:

Tensile strength	=	42,000 psi
Yield strength	=	28,000 psi
Elongation, 2 inches	=	30%

At least 10% of the number of liner plates shall be drilled, tapped, and fitted with a cast iron grout plug. The actual location and spacing of the plugs shall be determined by the Contractor and approved by the Commission.

b. Bolts and nuts shall conform to requirements of ASTM A 307. The bolts shall have rolled threads.

c. Coatings

1. Liner plate shall be hot dipped galvanized to meet requirements of AREA Chapter 1, Part 4, Section 4.13 Specification for Corrugated Structure Steel Plate Pipe, Pipe Arches and Arches. Bolts and nuts shall be galvanized to meet requirements of ASTM A 153.

2. Liner plate shall be bituminous coated to meet requirements of AREA Chapter 1, Part 4, Section 4.6.1. Specification for Bituminous Coated Galvanized Steel Pipe and Pipe Arches. Provide prime coat as required to assure compatibility with galvanized surface.

5. Carrier Pipe

Carrier pipe shall be as specified in the Contract Documents and meet the requirements specified in Sections 02551, 02561, or 02563 as appropriate.

6. Surface Settlement Markers

a. Surface settlement markers within pavement areas shall be P.K. nails.

b. Surface settlement markers within non-paved areas shall be wooden hubs.

7. Skids/Blocking

Skids and/or blocking for securing carrier pipes shall be constructed of pressure treated lumber suitable for exterior use or of a Commission approved molded plastic construction (insulators).

3.0 EXECUTION

A. Construction Criteria

1. Tunnels for installing pipelines or other utilities shall be of sufficient size to allow, at all points, the proper joining of pipes and the proper refill around them. Tunnels shall be timbered or lined where and to such extent as may be necessary to support the tunnel in accordance with accepted methods. All methods of tunneling used shall be subject to the approval of the Commission, however, the safety of the tunnel construction and the protection, repair, or replacement of the tunneled obstruction shall be the sole responsibility of the Contractor.

2. Tunnel construction shall be performed in a manner that will minimize movement of the ground in front of and surrounding the tunnel, and prevent subsidence of the surface above and in the vicinity of the tunnel. During all stages of tunnel construction, the ground shall be continuously supported and controlled in a manner that will prevent loss of ground and keep the perimeters and face of the tunnel stable. The Contractor shall be responsible for all settlement resulting from tunnel operations and shall repair and restore damaged property to its original condition at no cost to the Commission.

3. The Contractor shall comply with applicable ordinances, codes, statutes, rules, and regulations of the State of Maryland, SHA, applicable Commission building codes, and/or affected Railroad Company and applicable regulations of the Federal Government.

B. Job Conditions

1. Maintain an adequate supply of straight and tapered liner segments at the site at all times.

2. Prevent damage to protective coatings during storage and delivery. Keep wire ropes, chains, or hooks from direct contact with the coated surfaces.

3. Dewatering, if required, shall be performed in accordance with Section 02512.

C. Equipment

1. Tunneling equipment shall be of U.S. Bureau of Mines approved types.

2. Tunnel shields shall have uniform exterior surface from leading edge of head or poling plates to the rear edge of the tail. A horse-shoe-shape shield may have a closed or open bottom; a circular shield shall have a closed bottom.

3. A substantially proportioned hood shall be provided which projects not less than 2 feet beyond the shield bottom with sufficient rear overhang or tail to provide at least 12 inches of overlap beyond the last element erected when the shield has been shoved forward to the fullest extent possible. The annular space between the tail and the lining shall be as small as current practice indicates, but in no case shall it be greater than 1 ½ inches.

4. Provide each shield with suitably designed breast-jacks or breast-tables or both, and such other bracing as is necessary to support the face of the tunnel excavation without loss of ground.

5. Provide on each shield a propulsion system capable of moving the shield in a forward direction while maintaining line, grade, and direction. The propulsion system shall be designed to prevent the shield from moving backward despite a failure of any element of the propulsion system and shall not over stress or distort the lining.

6. Prevent grout from leaking into the tunnel space between the shield and lining by incorporating a seal in the tail of each shield.

7. The shield shall be equipped with an erector arm or system capable of handling the largest sizes of lining and of erecting the sections of the lining to the required tolerances without damage to the lining.

D. Power Supply

1. All power machinery and tools within the tunnel shall be operated by electricity, compressed air, diesel with approved scrubber, or other approved power. All electrical tools and equipment shall be grounded in accordance with the latest requirements of the National Electrical Code.

2. Temporary electric lights shall be provided to properly and safely illuminate all parts of the tunnel construction area including special illumination at the working faces. Lighting circuits shall be thoroughly insulated and separated from power circuits; and all lights shall be enclosed in wire or plastic cages. The Contractor shall secure all electrical permits necessary for the installation and operation of this service.

E. Operations by Tunnel Shields and Machines

1. On initial set-up, the tunnel shields or tunneling machines shall be supported and properly set at lines and grades which will permit the correct installation of the tunnel lining. During forward movement of the shield provide sufficient support at the excavation face to prevent movement of any materials except such materials as are physically displaced by the elements of the shield itself.

2. The face shall be controlled using such support procedures as breasting, poling plates, face jacks, sliding tables, either singly or in combination, spaced as necessary.

3. Advance excavation for the tunnel liner in increments sufficient for the erection of one ring of liners and install liner plates immediately after each increment of excavation. Carry on excavation in such a manner that voids behind the liner plates are held to a minimum. Completely fill such voids with grout placed under pressure.

4. Whenever tunnel excavation is suspended or shut down, and there is danger of water infiltration from any source, maintain on duty qualified personnel to observe conditions that might threaten the stability of the heading. Contractor may substitute acceptable observation devices such as closed circuit TV that enables continuous monitoring of conditions at the face by qualified observers from outside the tunnel.

5. During shut down periods, support the face of the excavation by positive means; no support shall rely solely on hydraulic pressure.

F. Installation of Tunnel Linings

1. Install the tunnel lining in a manner that will not damage the lining or coating.

2. Ensure that the edges are clean and free from material that could interfere with proper bearing.

3. Install bolts for liner plates in accordance with liner plate manufacturer's recommendations and retention or replace any bolt which does not meet the requirements.

4. Assemble liners to the lines and grades shown on the Plans or as directed by the Commission.

G. Grouting

1. Fill annular voids between the tunnel excavation and the tunnel liner with grout mix.

2. Filling voids with grout shall generally proceed from the bottom grout hole of each ring to the top hole.

3. Vent air through one of the upper holes.

4. The grout pump and injection system shall be a type that will deliver the grout in a smooth even flow without surge. The grouting circuit shall contain a return line to allow return of the grout from the nozzle to the supply tanks. The grouting equipment shall be capable of developing a uniform pressure of 50 psi at the grout hole connection and equipped with hoses with a minimum inside diameter of 1 ½ inches. The grouting equipment shall have a minimum capacity of ½ cubic yards.

5. Grouting between the liner plates and excavation shall follow progressively with each adjacent set of holes provided in the liner plates.

6. In general, grouting shall proceed from the lowest grout hole of each ring and proceed progressively upward. When going from lower to higher grout holes, do not make connection to the higher holes until grout has completely filled the space below. Fill all voids completely at the close of each 8 hour work period.

7. Continue grouting until grout appears in the next set of grout pipes, which shall be kept open during grouting to permit escape of air and water.

H. Installation of Carrier Pipe

1. Carrier pipe shall be installed within the tunnel liner as shown in the Contract Documents and as specified in Sections 02551, 02561 and 02563.

2. Provide bedding and anchorage in accordance with the Plans and Contract Documents.

3. Provide wooden skids or other approved devices as required to eliminate damage to pipe.

4. After line is tested, fill annular space between pipe(s) and tunnel with sand or with flowable fly ash fill in SHA rights of way or if approved by the Commission. Positive means shall be provided to hold the pipe in place and to prevent flotation.

I. Closing

1. Each end of the tunnel shall be bulkheaded in accordance with Section 02050.

4.0 METHOD OF MEASUREMENT

A. Tunneling

Measurement for earth tunneling and liners will be made horizontally along the centerline of the tunnel satisfactorily installed between the ends of the tunnel.

B. Carrier Pipe

Carrier pipe will not be measured as it will be incidental to the tunnel liner installation.

5.0 BASIS OF PAYMENT

A. General

1. Payment will be made at the unit and/or lump sum price bid. The price bid shall include and cover furnishing all labor, tools, equipment, and materials necessary to complete the work as shown and specified in strict accordance with the Contract Documents.

2. Payment will be made for contingent items when approved by the Commission.

3. Should a contractor elect to install a tunnel in lieu of a bore and jack under roads trees, sidewalks, curbs, pipelines, or similar obstructions that are not specifically noted as a tunneling operation in the Contract Documents it shall be done at no additional cost to the Commission.

B. Liner Plate

Payment for liner plate will be made per linear foot for the various diameters of liner plate furnished and installed by the tunneling operations. The price(s) bid shall include the traffic control, excavation, support, grouting, backfill, compaction, and restoration; removal and disposal of excess excavated material; dewatering, settlement monitoring; furnishing and placing flowable fly ash fill within the tunnel liner plate; carrier pipe, fittings, jointing material, joint restraint, testing, disinfection (if applicable), and incidental items to complete the installation.

C. Carrier Pipe

Payment for carrier pipe will not be made as it will be incidental to the tunnel installation.

****END OF SECTION 02400****