

STANDARD SPECIFICATIONS
SECTION 02420
TUNNELING

PART 1 GENERAL

1.1 DESCRIPTION

- A. Section includes requirements for constructing tunnels 48-inch and larger diameter.

1.2 DEFINITIONS

- A. Carrier Pipe: Sewer or water pipe.
- B. Tunnel Liner: Liner through which carrier pipe will be placed.

1.3 SUBMITTALS

- A. Submit following Section 01330.
1. Shop drawings for tunnel linings showing sizes, shapes, methods of attachment, and connection details including location and details of grout holes.
 2. Shop drawings of hold-down assemblies for carrier pipe.
 3. Shop drawings of bulkheads when indicated on Drawings.
 4. Shop drawings of access manholes indicated on Drawings.
 5. Design mixes for concrete, grout, and flowable fill.
 6. Tunnel Method of Construction: Tunnel Boring Machine (TBM) or hand excavation.
 7. Working Drawings and written procedure describing in detail proposed tunnel method and entire operation for information only, to include:
 - a. Tunnel shafts and support.
 - b. Dewatering.
 - c. Ground stabilization if proposed.
 - d. Excavation procedures.
 - e. Support of excavated tunnel and tunnel face.
 - f. Grouting procedures.
 - g. Detection of surface movement.
 - h. Procedure for installing pipe.
 - i. Supports and anchors.
 - j. Placement of material between pipe and tunnel liner when required.
 - k. Temporary bulkhead details used during construction.
 - l. Procedures for maintaining line and grade.
 8. If modifications to methods are required during construction, submit working drawings delineating modifications, including reasons for them.
- B. Submit following Section 01450 before delivery of materials.
1. Certified Test Reports:

- a. Tunnel liner plate segments for tunnel lining.
- b. Tunnel liner plate connectors.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Unload and handle materials with equipment of adequate capacity, equipped with slings to protect materials from damage.
 - 1. Store materials on site in reasonably level, well-drained area free from brush.
 - 2. Store individual pieces and bundles with safe walking space between to allow full view for inspection purposes.

1.5 PROJECT CONDITIONS

- A. Construct tunnel so as not to interfere with, interrupt, or endanger surface and activity thereon.
 - 1. Minimize subsidence of surface, structures, and utilities above and in vicinity of tunnel.
 - 2. Support ground continuously to prevent loss of ground and keep perimeters and face of tunnel, passages, and shafts stable.
 - 3. Be responsible for settlement resulting from tunnel operations.
 - 4. Repair and restore damaged property to its original condition before being disturbed at no cost to the Commission.
- B. Follow applicable ordinances, codes, statutes, rules, and regulations of State of Maryland, MSHA, applicable County building codes, affected Railroad Company, and applicable regulations of Federal Government, OSHA 29CFR 1926, and applicable criteria of ANSI A10.16-1995 (R2001), "Safety Requirements for Tunnels, Shafts, and Caissons."

1.6 ADDITIONAL CRITERIA FOR WORK UNDER RAILROADS

- A. Do not schedule tunnel construction within and adjacent to Railroad property until Engineer and Railroad approve submittals, including proper Railroad insurance.
 - 1. Approval does not relieve Contractor of responsibility for adequacy and safety of procedure.
- B. Give Railroad advance written notice as described in permit and copied to Engineer before entering and working on Railroad property.
- C. Place in effect, before work proceeds, safety, precautionary, and protective devices and services required by Railroad.
- D. Follow AREMA or other applicable railroad specification and permit requirements.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Liner Plates.
 - 1. Tolerances:
 - a. Variation in thickness of liner plates: Maximum, plus or minus 0.01 inch.
 - b. Fabricate similar segments to be interchangeable in individual rings in similar segments of other rings.
 - c. Space holes accurately so 2 rings may be bolted in any relative position with same size bolts in every bolt hole.
 - d. Tolerance of diameter to bolt holes: Plus or minus 0.02 inch from specified diameter.
 - e. Replace segments not complying with tolerances indicated.
 - 2. Steel Liner Skin: ASTM A569.
 - a. Use liner plate steel with minimum mechanical properties of flat plate before cold forming:
 - 1) Tensile strength: 42,000 psi.
 - 2) Yield strength: 28,000 psi.
 - 3) Elongation, 2 inches: 30 percent.
 - 4) Minimum liner plate thickness shown on Drawings.
 - b. If tunnel method of construction includes procedure to use installed liner plate for jacking purposes, increase liner plate thickness to withstand jacking pressure to be imposed.
 - c. Use liner plates of 2 or 4 flange type.
 - 1) Do not use 2 flange liner plates for tunnels under AMTRAK rights of way.
 - d. Approved manufacturers:
 - 1) American Commercial, Inc.
 - 2) Contech Construction Products, Inc.
 - 3. Coatings.
 - a. Liner plate coatings are not required on tunnels where annular space between liner plates and carrier pipe is filled with grout, concrete, or flowable fill. When annular space is not filled, coat liner plate:
 - 1) Liner Plate: Hot dipped galvanized following ASTM A123.
 - 2) Bolts and Nuts: Galvanized following ASTM A153.
 - 3) Liner plate shop-applied bituminous coat: AASHTO M190, Type A, fully bituminous coated; and use prime coat to assure compatibility with galvanized surface.
 - b. Protect coatings from damage during storage and transportation to Contract site.
 - 4. Bolts and Nuts: ASTM A307, Grade A, with rolled threads on bolts.
 - 5. Grout Holes for Each Ring of Liner Plate: Unless otherwise indicated on Drawings, use 2 minimum.
- B. Other Type Tunnel Liner Materials.
 - 1. Steel Pipe: Smooth walled steel pipe with minimum yield strength of 35,000 psi.
 - a. Minimum wall thickness: 3/8 inch or as indicated on Drawings.
 - b. Joints: Fully welded around circumference of pipe.

- 1) Weld of sufficient strength to withstand forces at pipe joints without distortion of pipes.
 - 2) Minimum welds: Follow WSSC Standard Detail.
 - 3) Coating: None.
2. Reinforced Concrete Pipe (RCP): ASTM C76, minimum Class IV, with concrete joint and smooth exterior without joint bulge.
 - a. Use resilient material for placement in joint to prevent concrete damage when jacking forces are applied.
- C. Grout.
1. Cement: ASTM C150, Type I or Type II.
 2. Water: See Section 03300.
 3. Sand: ASTM C404, Size No. 1.
 4. Voids Between Tunnel Liner and Existing Ground: Minimum compressive strength of 100 psi, attained within 24 hours, and sufficiently fluid to inject through lining and fill voids, with prompt setting to control grout flow.
 5. For Carrier Pipe Bedding and Filling Annular Space Between Tunnel Liner and Carrier Pipe: 3 parts ASTM C144 sand, to 1 part ASTM C150 cement.
- D. Concrete: For Cradle and Filling Void Between Tunnel Liner and Carrier Pipe: See Section 03300.
- E. Flowable Fill: For Filling Void Between Tunnel Liner and Carrier Pipe: See Section 03300.
- F. Subsurface Settlement Indicator: See Standard Detail M/7.0.
- G. Dielectric Material.
1. Thermoplastic: Minimum strength of 400 volts for each mil, and water absorption less than 0.02 percent (24-hour period).
- H. Surface Settlement Markers:
1. Within Bituminous Concrete Paved Areas: "p.k." nails.
 2. Within Nonpaved Areas: Wooden hubs.
 3. On Concrete Surfaces: Paint.
- I. Access Manhole: When required on Drawings and following Standard Details.
- J. Bulkhead: Follow Drawings or Standard Details.

PART 3 EXECUTION

3.1 GENERAL

- A. Review and interpret available geotechnical reports and investigate work site soil conditions before bidding.
 1. Encountering rock or water will not entitle Contractor to additional compensation.

- B. Dewatering: When water is encountered, develop and maintain dewatering system of sufficient capacity to remove water continuously, keeping excavations free of water until backfill operation is in progress.
 - 1. Keep removal of soils particles to minimum.
 - 2. Dewater into sediment trap following Section 01570.
 - 3. Observe settlement or displacement of surface facilities due to dewatering.
 - 4. Should settlement or displacement be detected, notify Engineer immediately and act to maintain safe conditions and prevent damage.

3.2 PREPARATION

- A. Excavate shafts following Working Drawings and Section 02315.
- B. Perform preliminary work, including constructing backstop (when used), placing guide timbers, and placing tunnel equipment.

3.3 SHAFT CONSTRUCTION

- A. Design, construct, maintain, and remove shaft, including damage attributed to shaft construction. Meet requirements of MOSH for tunnel shafts and ingress and egress to tunnel.
- B. Construct shafts following working drawings.
- C. Excavate, backfill, and grade following Section 02315 and to requirements specified herein.

3.4 TUNNEL EQUIPMENT

- A. Operate power machinery and tools within tunnel by electricity, compressed air, diesel with approved scrubber, or other approved power.
- B. Ground electrical tools and equipment following latest requirements of NEC.
- C. Use temporary electric lights to properly and safely illuminate tunnel construction area, including special illumination at working face.
 - 1. Thoroughly insulate and separate lighting circuits from power circuits, and enclose lights in wire cages.
 - 2. Secure electrical permits required for successful completion of this work.

3.5 VENTILATION AND AIR QUALITY

- A. For duration of tunnel project, operate and maintain installed ventilation system to meet safety and MOSH requirements.

3.6 TUNNEL OPERATIONS

- A. Control tunnel face using spaced support procedures such as breast plates, poling plates, face jacks, sliding tables, either singly or in combination.
- B. When using liner plates, advance excavation in increments sufficient for placement of 1 ring of liners and install liner plates immediately after each increment of excavation.
 - 1. Excavate so voids behind liner plates are minimized.
 - 2. Completely fill voids with grout followed immediately by grout placed under pressure specified below under GROUTING.
- C. Whenever tunnel operation is suspended, support tunnel face by positive means and keep dewatering system operating.
 - 1. Monitor conditions daily that might threaten tunnel stability by qualified personnel.

3.7 INSTALLATION OF TUNNEL LINER PLATES

- A. Install liner plates to avoid damage to liner plates or coating.
 - 1. Replace damaged liner plates and repair damaged coating to Engineer's acceptance.
- B. Clean foreign matter from surfaces of flanges, which will be in contact with each other, avoiding damage to coating in cleaning process.
 - 1. Keep surfaces free from material that could interfere with proper bearing and water tightness.
- C. Bolt liner plates following liner plate manufacturer's recommendations.

3.8 GROUTING

- A. Fill voids between earth and tunnel liner with grout.
- B. Grout with pump and injection system that will deliver grout in smooth even flow without surge.
 - 1. Develop uniform pressure at grout hole connection sufficient to fill voids without disturbing liner plates, adjacent utilities, structures, or roadways.
 - 2. Use hoses having minimum inside diameter of 1-1/2-inches and minimum capacity of 1/2 cubic yards.
 - 3. Grouting Procedure.
 - a. Grout between liner plates and excavation as soon as practicable, but at no time leave more than 2 liner plate rings ungrouted.
 - b. Leave no rings ungrouted when work is interrupted or at end of work shift.
 - c. Grout each adjacent set of holes progressively.
 - d. Install bulkheads or similar devices in order to grout rings complete.
 - e. Proceed from lowest grout hole of each ring, grouting progressively upward.
 - f. When going from lower to higher grout holes, do not make connection to higher holes until grout has completely filled space below.

- g. Continue grouting until grout appears in next set of grout holes, which shall be kept open during grouting to permit escape of air and water.

3.9 DETECTION OF MOVEMENT

A. Surface Settlement Markers.

1. Unless otherwise specified, shown on Drawings or directed by Engineer, locate surface settlement markers according to a grid, spaced 10 feet by 10 feet and extending as shown on Drawings, but not less than 20 feet either side of the tunnel centerline.
2. Establish elevation of settlement markers to bench marks unaffected by tunnel operations.
3. Take readings and permanently record:
 - a. Before start of dewatering operations and/or shaft excavation.
 - b. After steel casing has been advanced beyond pavement limits of each roadway.
4. Take elevation measurements to nearest 0.01 foot, and furnish reports to Engineer.
5. In event of settlement or heave on any marker:
 - a. Immediately cease work and take immediate action to prevent further settlement or heave and concurrently report settlement or movement to Engineer
 - b. Restore surface elevations to that existing before start of tunnel operations at no cost to the Commission.

B. Subsurface Indicators.

1. When shown on Drawings, install subsurface settlement indicators following Standard Details before start of dewatering or tunneling.
2. Monitor movements of indicators to accuracy of 0.01 foot following approved schedule.
3. Whenever tunneling occurs within 50 feet of indicator, monitor movements of indicator before and after each advance of tunnel face within 50 feet of indicator.

- C. Report settlement or movement immediately to Engineer and take immediate remedial action, at no cost to the Commission, except when from dewatering operations.

3.10 FIELD QUALITY CONTROL

A. Tunnel Liner Plates.

1. Inside dimensions of ring measured along diameter at any location.
 - a. Do not vary more than 3 percent of liner plate diameter.

- B. Construct tunnel to line and grade following Drawings to allow minimum concrete cradle thickness of 4 inches measured from face of flange to outside of carrier pipe.

3.11 INSTALLATION OF CARRIER PIPE: Follow Sections 02315, 02510, and 02530, Standard Details, and Drawings.

- A. Use thermoplastic or other dielectric material (except wood) between carrier pipe and tunnel liner plate or steel sleeve to prevent metal-to-metal contact and damage to pipe and coating during placement.
- B. Hold Down Method in Tunnel.
 - 1. Water mains, force mains, and pressure sewer mains: Concrete invert and hold down assembly following Standard Details and Drawings.
 - 2. Gravity sewer: Fill annular space between pipe and tunnel lining with concrete, grout, or flowable fill following Standard Details and Drawings.
- C. Bulkhead: Follow Drawings.

3.12 ACCESS MANHOLES: Install at each end of tunnel liner when required on Drawings and following Standard Details.

PART 4 MEASUREMENT AND PAYMENT

4.1 TUNNEL LINERS

- A. Measurement: By linear foot following Drawings.
- B. Payment: At unit price for each linear foot listed in Bid Schedule.
 - 1. Payment includes excavation, backfill, access shafts, disposal of excess excavated material, providing tunnel liner, grout, concrete invert with anchors, subsurface settlement indicators, settlement markers, bulkheads, and filling annular space where indicated.
 - 2. Carrier pipe installed inside tunnel liner is measured and paid for as described elsewhere in Specifications.

4.2 ACCESS MANHOLE

- A. Measurement: By vertical foot measured from top of base slab to bottom of frame of various types and sizes installed complete, in place, including installation of Commission furnished frame and cover.
- B. Payment: At unit price for each vertical foot as listed in Bid Schedule.
 - 1. Payment includes excavation, bedding and backfill, and provision of manhole complete.

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