



## SECTION 02344

### GENERAL TUNNELING REQUIREMENTS

#### PART 1 GENERAL

##### 1.1 SECTION INCLUDES

- A. General requirements for tunneling operations.
- B. Placement of carrier pipe inside tunnel.
- C. End seal placement and backfill grouting between tunnel and carrier pipe.

##### 1.2 RELATED SECTIONS

- A. General Conditions, Supplementary Conditions, and Division 1 sections apply to the work of this section.
- B. Section 01010 SUMMARY OF WORK.
- C. Section 01300 SUBMITTALS.
- D. Section 01563 DEWATERING, EROSION AND SEDIMENTATION CONTROL.
- E. Section 01600 MATERIAL AND EQUIPMENT.
- F. Section 02015 BASELINE SUBSURFACE CONDITIONS SUMMARY.
- G. Section 02100 SITE PREPARATION.
- H. Section 02315 EXCAVATION.
- I. Section 02342 TUNNELING PITS.
- J. Section 02345 TUNNELING BY PIPE JACKING
- K. Section 02700 GRAVITY SANITARY SEWERS
- L. Section 02964 TUNNEL GROUTING.
- M. Section 02965 INSTRUMENTATION, MONITORING AND SETTLEMENT CONTROL.

##### 1.3 REFERENCES

- A. American Society for Testing and Materials (ASTM):
  - 1. C31 Standard Practice for Making and Curing Concrete Test Specimens in the Field.



2. C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
3. C143 Standard Test Method for Slump of Hydraulic Cement Concrete.
4. C150: Standard Specification for Portland Cement.
5. C157 Standard Test Method for Length Change of Hardened Hydraulic-Cement, Mortar, and Concrete.
6. C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

#### 1.4 DEFINITIONS

- A. Pipe Jacking: A method of tunnel construction where hydraulic jacks in the jacking pit are used to push carrier pipe or casing through the ground behind a tunnel boring machine or shield.

#### 1.5 SUBMITTALS

- A. Submit the following consistent with Section 01300 SUBMITTALS and the Drawings.
- B. Tunnel Contractor qualifications as outlined in Article 1.6.
- C. Operation Plan and Temporary Ground Control Plan as required in this Section.
- D. For the items listed below, submit design drawings and related supplemental information:
  1. Manufacturer's literature on tunneling equipment, jacking equipment, remote control system, steering and guidance system.
  2. Procedures and sequence for installing tunneled casing pipe.
  3. Face control methods, including shutdown procedures.
  4. Details of pipe lubrication system.
  5. Method and system to be used for removal and disposal of earth and rock material.
  6. Water control and disposal.
  7. Lighting and ventilation methods.
  8. Equipment and methods for monitoring air quality in the tunnel.
  9. Procedures and sequence for installing carrier pipe.
  10. Carriers, skids, and pipe blocking.
  11. Backfill grout mix design.
  12. Bulkhead with the capacity to resist grouting pressures.
  13. Description of two projects (with details of diameter and distance) on which the tunneling system has been successfully used.
- E. Submit for record, shift reports showing at least the following information:
  1. Tunnel advance with beginning and ending stations.
  2. Departure from specified line and grade.
  3. Soil types encountered by station and face position.
  4. Stations and quantities of boulders, cobbles, construction debris, water, and bedrock.
  5. Casing pipe lubrication quantities.
  6. Description of unusual conditions or incidents.



7. Soil removal volume for every casing pipe segment.
  8. Copies of jacking force logs (minimum of 1 reading per 8 foot of casing).
  9. Description of poor air quality and explosive gases detected.
- F. At the completion of each tunnel section, but before the tunneling or liner placement equipment is removed, submit a survey certifying that the tunnel meets the Contract requirements for line and grade.
- G. Submit surveys of in place carrier pipe before backfill grouting.
- H. Should the owner of a right-of-way over the work require approval of tunneling or mud jacking designs and shop drawings, furnish submittals to that owner and obtain the necessary approvals prior to furnishing the submittals specified above.
- I. CONTRACTOR'S professional engineers insurance certificate, per Article 1.12.

## 1.6 QUALITY ASSURANCE

- A. Perform all work in conformance with the Operation Plan, Temporary Ground Control Plan, and authorities having jurisdiction.
- B. Tunnel construction shall be conducted by a Contractor with the following qualifications:
1. Two projects demonstrating successful tunneling of 48-inch minimum diameter casing, with a minimum length of 200 feet through soils containing cobbles and boulders.

## 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Consistent with Section 01600 MATERIAL AND EQUIPMENT.
- B. Take care in loading, transporting and unloading to prevent damage to the support materials, pipe, or coatings. Do not drop pipe. Repair any damaged pipe or coatings in accordance with the manufacturer's requirements.
- C. Carefully inspect all pipes prior to installation. If any pipe fails to meet the specifications, remove and replace it with satisfactory pipe.

## 1.8 SITE CONDITIONS

- A. Inspect the locations where tunneling operations will be conducted and the pipe is to be installed, verify the conditions under which the work will be performed, and provide all necessary details, whether shown or not, for the orderly prosecution of the work.
- B. Request and obtain written authorization in accordance with the Document 00700 GENERAL CONDITIONS prior to working overtime, nights, or weekends.
- C. In conformance with General Conditions and Division 1, furnish special insurance, traffic control, flaggers and any other requirements imposed by the owner of the right(s)-of-way in which the work occurs.



- D. Subsurface exploration performed prior to construction indicates that the soils to be excavated may include cobbles and boulders of varying size. An allowance has been provided on the Bid Form for handling boulder and nested cobbles quantities that exceed those described in Section 02015 BASELINE SUBSURFACE CONDITIONS SUMMARY.

## 1.9 SEQUENCING AND SCHEDULING

- A. In conformance with the requirements of Section 01300 SUBMITTALS and Section 01010 SUMMARY OF WORK:
  - 1. Coordinate sequence and schedule with owners of roadway, walkway, or easement, or other public access and overlying right-of-way or real estate.
  - 2. Coordinate any required closings with owners of overlying roadway, walkway, easement or other public or private access.
  - 3. Construct the tunnel at Highway 13 before installing the open cut pipe segments to the tunnel pits.

## 1.10 OPERATION PLAN

- A. Prepare and follow an operation plan for protection of the public, structures, utilities, facilities, personnel and the work. The CONTRACTOR shall be responsible for providing a safe work place and to avoid hazard to life and property.
- B. Operation plan shall comply with all applicable sections of OSHA 1926.800 Subpart S – Underground Construction and include a plan for providing the CAR and other personnel requested by the CAR access to all areas of the project for observation of the Work. Access shall be provided at all times during work hours.
- C. CONTRACTOR shall perform the duties of an entry supervisor and attendant. CONTRACTOR shall provide the CAR and other personnel requested by the CAR all equipment required by the CONTRACTOR'S Operation Plan such as air monitor, self-contained rescue pack, lights, lifting harness, vests, ear plugs, and dust masks. CAR and other personnel requested by CAR will provide their own boots and hard hat.
- D. The Operation Plan shall include provisions to secure all excavations and secure all tunneling pits to prevent public access.

## 1.11 TEMPORARY GROUND CONTROL PLAN

- A. The CONTRACTOR shall be responsible for temporary control of the ground and for maintaining the stability of the ground during construction. CONTRACTOR'S Professional Engineer licensed in the State of Minnesota and experienced in underground work shall prepare and certify a temporary ground control plan that provides the access necessary to allow excavation and support installation. The CONTRACTOR shall follow the temporary ground control plan. The plan shall consist of evaluation, personnel access control and temporary support until the final structure is complete. Safety of the excavation and ground mass



stabilization activities during construction shall be the responsibility of the CONTRACTOR and no direction by the CAR shall remove or limit this responsibility.

## 1.12 PROFESSIONAL ENGINEER

- A. The professional engineer certifying the designs of this Section shall secure and maintain Engineer's Professional Liability Insurance with minimum limits of \$1 million per claim and \$1 million annual aggregate.

## PART 2 PRODUCTS

### 2.1 EQUIPMENT

- A. Tunneling equipment: Certified by manufacturer for intended purpose, diameter of pipe and expected loading.
- B. Closely review Section 02015 BASELINE SUBSURFACE CONDITIONS SUMMARY and boring information and carefully investigate soil conditions at the work site prior to submitting the bid. Select equipment to cope with the baseline conditions.

### 2.2 MATERIALS

- A. Carrier Pipe (within jacked pipe casing):
  - 1. Pipe meeting the requirements of Section 02700 GRAVITY SANITARY SEWERS and as shown on the Drawings.
- B. Carrier Pipe Support and Spacers: Use manufactured spacers to position and support the carrier pipe within the casing as shown on the Drawings or recommended by the pipe manufacturer.
  - 1. Material shall be sound and compatible to prevent galvanic corrosion. Wood skids are not allowed.
  - 2. Spacing: as shown on the Drawings or recommended by the pipe manufacturer, whichever is less
  - 3. Acceptable manufacturers:
    - a. Raci North America
    - b. Pipeline Seal and Insulator, Inc
    - c. Cascade Waterworks Mfg. Co
    - d. CCI Pipeline Systems, LLC
    - e. Approved equal
- C. Flexible Foam Expansion Joint Filler: Synthetic foam of isomeric polymers in a very small, closed-cell structure. Joint filler shall be non-absorbent and have a resiliency of 99%.
  - 1. Acceptable Products:
    - a. CERAMAR, 1" thick, by W.R. Meadows
    - b. Approved equal.

- D. Bentonite: API Specification 13A, high swelling montmorillonite, capable of mixing with water to form a stable homogeneous suspension.
- E. Portland Cement: ASTM C 150, Type I/II.
- F. Flyash: ASTM C618.
- G. Water: Potable and complying with ASTM C 94.

## 2.3 MIXES

- A. Backfill grout for annular space between tunnel casing and carrier pipe.
  - 1. Cellular (foam) Concrete Grout
    - a. For use in any length of tunnel.
    - b. Design and mix proportions by the CONTRACTOR's Professional Engineer.
    - c. Low density, non-bleeding cellular concrete.
    - d. Portland cement, flyash and water slurry blended with a high stability pre-generated foaming agent.
    - e. Fluid (10-inch slump), pumpable.
    - f. Wet Density: greater than 30 pounds per cubic foot.
    - g. 28-day Compressive Strength: 100 psi minimum.
    - h. Adjust proportions to meet project requirements.
  - 2. If water is entering the tunnel, the backfill grout shall have a minimum density of 70 pcf so that the water will be displaced by the grout.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. Examine soil profiles during construction of tunneling pits prior to starting tunneling operations or undertake an independent sampling and testing program. Cost for the independent sampling and testing program shall be the CONTRACTOR's expense.
- B. Identify deviations in soil materials from those described in Section 02015 BASELINE SUBSURFACE CONDITIONS SUMMARY and shown on the Project soil boring logs. Immediately report deviations to CAR.

### 3.2 TUNNELING METHOD

- A. The tunnel shall be constructed by first installing a casing pipe in accordance with the following methods:
  - 1. Section 02345 TUNNELING BY PIPE JACKING and the Drawings.

### 3.3 GENERAL



- A. Site Preparation: Conform to the requirements of Section 02100 SITE PREPARATION. Confine work to area within rights-of-way and permanent easements.
- B. Tunneling Pits: Launch and receiving pits shall conform to the requirements of Section 02342 TUNNELING PITS. Provide sufficient room for the proper installation of both the casing and carrier pipes
- C. Miscellaneous trenching shall conform to the requirements of Section 02315 EXCAVATION. Provide excavation support as required.
- D. Notify the CAR, roadway, and utility owners at least seven days in advance of the planned start of work within the roadway, utility, or surface right-of-way, or as required by the applicable permit, whichever is more stringent.
- E. Control dust, fumes, vapors and gases and provide ventilation according to the requirements of the authorities having jurisdiction.
- F. Conduct all operations such that trucks and other vehicles do not interfere with traffic or create a mud, dust, or noise nuisance on roadways and to adjacent properties. Promptly clean up, remove, and dispose of mud and spoils.
- G. Whenever there is a condition that is likely to endanger the stability of the excavation, roads, railroad tracks, or adjacent structures, the CONTRACTOR shall operate with a full crew 24 hours a day, including weekends and holidays, without interruption, until those conditions no longer jeopardize stability.
- H. Place Bedding and Backfill Material for the carrier pipe beyond the end of the casing pipe in tunneling pits installed by open-cut trenching in conformance with Section 02315 EXCAVATION and the Drawings.

### 3.4 FACE CONTROL AND GROUND SUPPORT

- A. The tunneling method selected by CONTRACTOR shall provide full support and control of the ground during all phases of the work and shall allow access to and removal of obstructions, cobbles or boulders at the tunnel face.
  - 1. Where sands overlie clayey sand in the face, the tunneling equipment and methods shall prevent the sands from running or flowing and causing unacceptable settlements.
- B. Tunnel in a manner to prevent voids from developing outside the casing. Use and operate tunnel equipment features to minimize the amount of voids and ground loosening around the tunnel.
- C. Bury the tunnel head to prevent ground intrusion whenever the tunneling operation is idle.

### 3.5 TOLERANCES

- A. Maintain alignment and elevation of the casing pipe consistently throughout the tunneling operation within the following tolerance limits.



1. Construct to the dimensions, alignment and grade shown on the Drawings.
  2. Prevent abrupt deviations from planned horizontal and vertical alignment and in any case not more than 1/4 inch in 8 feet.
  3. Elevation: Plus or minus 1.5 inches from elevation shown on the Contract Drawings.
  4. Horizontal Alignment: A maximum deviation of 1.0 feet from plan location.
  5. Maintain the minimum clearance between the casing and carrier pipe as shown on the Drawings
  6. Allow the CAR access to verify alignment and grade.
- B. Install carrier pipe to tolerances as specified in Section 02700 GRAVITY SANITARY SEWERS without intermediate high or low points that may trap liquid or air in the pipe after installation.

### **3.6 CONSOLIDATION GROUTING**

- A. Where shown on the Drawings, specified in the Specifications, ordered by the CAR, or as necessary, design and place consolidation grouting as specified in Section 02964 TUNNEL GROUTING to prevent voids from occurring at the excavated face that may result in liner overloading or ground surface settlement.
- B. Use consolidation grout stabilization as specified and as necessary for groundwater control along and at the tunnel face if required.
- C. Consolidation grout ahead and around boulders if required for excavation ahead of the leading edge of the tunneling equipment.

### **3.7 WATER CONTROL**

- A. Manage and discharge water from dewatering operations into approved receiving basins in accordance with all applicable regulatory requirements as required by Section 01563 DEWATERING, EROSION AND SEDIMENTATION CONTROL.
- B. Keep tunnel and pit subgrades continuously free from standing water and surface runoff during tunnel operations. Do not dewater through the casing.
- C. Conduct dewatering as required prior to the start of tunneling to a minimum of 2-feet below tunnel invert or use a tunneling method that prevents groundwater flow into the tunnel.
- D. Design tunneling equipment together with the cuttings removal system to control groundwater from entering the tunnel.

### **3.8 SETTLEMENT AND DAMAGE CONTROL**

- A. Operate tunneling equipment to minimize lost ground and to comply with specified limits for preventing settlement, movement, cracking, or damage of roadways, roadbeds, tunnels, surface structures, utilities, or adjacent structures. If any movement or settlement occurs or which causes or might cause damage



over, along, or adjacent to the work, stop tunneling operations immediately except for those activities which will assist in making the work secure and prevent further movement, settlement, or damage.

- B. Conduct settlement monitoring program as specified in Section 02965 INSTRUMENTATION, MONITORING AND SETTLEMENT CONTROL.
- C. Keep settlements within limits specified in Section 02965 INSTRUMENTATION, MONITORING AND SETTLEMENT CONTROL. Conduct remedial activities, as ordered by the CAR, if settlements are greater than specified.
- D. Resume tunneling operations only after conditions specified in Section 02965 INSTRUMENTATION, MONITORING AND SETTLEMENT CONTROL are met.
- E. If roadways, roadbeds, tunnel, utilities, or structures are damaged by tunneling operations, immediately replace or repair to original or better condition and to the satisfaction of the CAR at no additional cost to the COUNCIL.
- F. Mud Jacking:
  - 1. Mud jacking to level the roadway surfaces is required to correct any settlement over allowable limits to the satisfaction of the Minnesota Department of Transportation (MnDOT) or other roadway owner.
  - 2. Use materials, methods, equipment that conforms to MnDOT standards for such work.
  - 3. Traffic control is the responsibility of the CONTRACTOR and must meet the requirements of the MnDOT and local roadway owner.
  - 4. Furnish submittals of all materials, methods, equipment and schedule for review by the CAR and the roadway owner.

### 3.9 CARRIER PIPE INSTALLATION

- A. Inspect each joint prior to insertion into the tunnel. Support carrier pipe within the casing so that pipe bells do not rest directly on the casing. Distribute the load of the carrier pipe along the tunnel in accordance with carrier pipe or spacer manufacturer recommendations.
  - 1. Place carrier pipe spacer immediately adjacent to the assembly reference mark on the spigot end of the pipe to avoid over insertion during installation of the pipe in the casing.
  - 2. Provide minimum of 3 inches of clearance for backfill grout between largest radius of the carrier pipe, joint or coupling.

### 3.10 BACKFILL GROUTING

- A. Thoroughly clean and remove all dirt, debris, and water from the interior of the casing before placing backfill grout.
- B. If water enters the tunnel, stop it or divert it around the pipe so that it does not affect the integrity of the backfill grout. If water is present, backfill grout shall have a minimum density of 70 pcf so that the water will be displaced by the grout.



- C. Construct a solid concrete block and mortar bulkhead in the annular space between the carrier pipe and casing pipe after the carrier pipe has been installed. Wrap the portion of the carrier pipe passing through the block bulkhead with flexible foam expansion joint material, as shown on the Drawings. Secure expansion joint materials with three uniformly spaced stainless bands.
- D. After the carrier pipe has been inspected and tested, fill the annular space between casing and carrier pipe completely with backfill grout in two lifts in a manner to prevent the occurrence of any voids between the casing and the carrier pipe. Place grout from the downstream end and vent as necessary. Pump at a pressure below that which may endanger rupture of the casing or carrier pipe. After complete filling, maintain a pressure of at least 4 psi for 30 minutes to ensure annular space remains filled.

### 3.11 FIELD QUALITY CONTROL

- A. Survey the in-place casing pipe and furnish results of alignment and grade plots to CAR. Superimpose these plots on a copy of the design alignment for comparison to verify compliance with alignment tolerances.
- B. Replace rejected tunnels at the CONTRACTOR's expense. This will include any additional fittings, manholes, or appurtenances needed to replace the rejected work.
- C. The CAR may request up to 5 inspection holes at no extra cost to determine the completeness of backfill grouting. Drill holes through grout holes or pipe at locations selected by the CAR. The holes shall have a minimum diameter of 1.5 inches. Drill holes in pipe and patch as recommended by the pipe manufacturer.
  - 1. If a void is found, the inspection hole will be used as a grout hole. Place grout to fill the void.
  - 2. Holes that encounter voids will not be counted against the inspection hole allowance.
  - 3. Clean out and fill grout holes as recommended by the pipe manufacturer. Repair interior pipe lining or coating per the lining or coating manufacturer's recommendations.
- D. The CAR may sound the interior of the carrier pipe with a hammer to detect voids between carrier pipe and initial support. Completely fill voids detected.

### 3.12 SITE RESTORATION

- A. Conform to requirements of Section 01563 DEWATERING, EROSION AND SEDIMENTATION CONTROL, and perform final restoration in accordance with Drawings.
- B. Remove all equipment, supplies, excess excavation materials and miscellaneous items associated with the tunneling operation and leave the site in a clean and tidy condition.
- C. If required by the owner of the right-of-way, coordinate and schedule a final inspection of the work by the owner of the right-of-way.



### 3.13 TESTING AND INSPECTION

- A. Provide adequate facilities for safe storage and proper curing of grout test cylinders collected by the COUNCIL'S ITL onsite for first 24 hours, and for additional time as may be required before transporting to test lab.
- B. Provide grout for testing of slump, and for making cylinders. When grout is pumped, samples used shall be taken from discharge end of pump hose.
- C. Specimens will be made, cured, and tested by the COUNCIL'S ITL in accordance with ASTM C31 and ASTM C39.
- D. Frequency of testing may be changed at discretion of CAR. Cylinders will be taken once for each 50 yards, of grout placed.

**END OF SECTION**