

SECTION 02330

TUNNEL GROUT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Mix design requirements, testing, furnishing and production of grout for:
 - 1. Pressure grouting of bolted liner plates for shafts.
 - 2. Pressure grouting of primary tunnel liner.
 - 3. Pressure grouting of jacked-pipe.
 - 4. Annular grouting of cased or uncased sewer pipe.
 - 5. Grouting of the annular space between the sanitary sewer pipe and the primary tunnel liner.
 - 6. Grouting voids in ground resulting from caving, loss of ground, or settlement.
 - 7. Grouting of manholes constructed in shafts.
- B. Compaction grouting is not part of this specification.

1.02 UNIT PRICE

- A. No separate payment will be made for work performed under this Section. Include the cost of such work in contract unit prices for work of which it is a component part.

1.03 DEFINITIONS

- A. Pressure Grouting. Filling a void behind a liner or pipe with grout under pressure sufficient to ensure void is properly filled but without overstressing temporary or permanent ground support, or causing ground heave to occur.
- B. Back Grouting. Secondary pressure grouting to ensure that voids have been filled between primary tunnel or shaft liners and the surrounding ground.
- C. Annular Grouting. Filling the annular space between the carrier pipe and the primary tunnel liner, casing, or ground, by pumping.

- D. Ground Stabilization Grouting. The filling of voids, fissures, or under-slab settlement due to caving or loss of ground by injecting grout under gravity or pressure to fill the void.

1.04 SUBMITTALS

- A. Make submittals in accordance with all provisions and sections of these specifications.
- B. Submit a description of materials, grout mix, equipment and operational procedures to accomplish each grouting operation. The description may include sketches as appropriate, indicating type and location of mixing equipment, pumps, injection points, venting method, flowlines, pressure measurement, volume measurement, grouting sequence, schedule, and stage volumes.
- C. Submit a grout mix design report, including:
 - 1. Grout type and designation.
 - 2. Grout mix constituents and proportions, including materials by weight and volume.
 - 3. Grout densities and viscosities, including wet density at point of placement.
 - 4. Initial set time of grout.
 - 5. Bleeding, shrinkage/expansion.
 - 6. Compressive strength.
- D. For cellular grout, also submit the following:
 - 1. Foam concentrate supplier's certification of the dilution ratio for the foam concentrate.
 - 2. A description of the proposed cellular grout production procedures.
- E. Maintain and submit logs of grouting operations indicating pressure, density, and volume for each grout placement.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Grouting materials: Conform to Section 03305 - Concrete for Utility Construction, except as modified in the following paragraphs.

B. Grout Type Applications.

1. Grout for pressure grouting and back grouting: Sand-cement mortar mix.
2. Grout for annular grouting: Low density (cellular) grout or sand-cement mortar mix.
3. Grout for filling space around manholes in shafts: Sand-cement mortar mix.
4. Ground stabilization: Sand cement mortar mix.
5. Do not include toxic or poisonous substances in the grout mix or otherwise inject such substances underground.

2.02 GROUT

A. Employ and pay for a commercial testing laboratory, acceptable to the Owner's Representative, to prepare and test the grout mix design. Develop one or more mixes based on the following criteria as applicable:

1. Size of the annular void between sewer pipe and liner, or size of the void between primary liner and the surrounding soil.
2. Absence or presence of groundwater.
3. Adequate retardation.
4. Non-shrink characteristics.
5. Pumping distances.

B. Prepare mixes that satisfy the required application. Materials used in grout mix shall meet the following standards:

1. Cement: ASTM C150.
2. Fly Ash: ASTM C618.
3. Water: Potable.
4. Foam: ASTM C869.
5. Slurry: ASTM C138.
6. Cellular Grout: ASTM C138.

7. Sand for sand-cement mortar mix: ASTM C144.
- C. Provide grout that meets the following minimum requirements:
 1. Minimum 28 day unconfined compressive strength: 1,000 psi for sand-cement mortar grout; 300 psi for cellular grout.
 2. Determine strength by ASTM C942.
 - D. Fluidifier. Use a fluidifier, meeting ASTM C937, which holds the solid constituents of the grout in colloidal suspension and is compatible with the cement and water used in the grouting operations.
 - E. Admixtures.
 1. Use admixtures meeting ASTM C494 and ASTM C1017 as required, to improve pumpability, to control time of set, to hold sand in suspension and to reduce segregation and bleeding.
 2. For cellular grout, do not use foam or admixtures that promote steel corrosion.
 3. Ensure that admixtures used in a mix are compatible. Provide written confirmation from the admixtures' manufacturers of their compatibility.

PART 3 EXECUTION

3.01 PREPARATION

- A. Notify the Owner's Representative at least 24 hours in advance of grouting operations.
- B. Select and operate grouting equipment to avoid damage to new or existing underground utilities and structures.
- C. In selection of grouting placement consider pipe flotation, length of pipe, length of tunnel, depth from surface, type of sewer pipe, type of pipe blocking and bulkheading, grout volume and length of pipe to be grouted between bulkheads.
- D. Operate any dewatering systems until the grouting operations are complete.

3.02 EQUIPMENT

- A. Batch and mix grout in equipment of sufficient size and capacity to provide the necessary quality and quantity of grout for each placement stage.

- B. Use equipment for grouting of a type and size generally used for the work, capable of mixing grout to a homogeneous consistency, and providing means of accurately measuring grout component quantities and accurately measuring pumping pressures. Use pressure grout equipment which delivers grout to the injection point at a steady pressure.

3.03 PRESSURE GROUTING FOR PRIMARY TUNNEL AND SHAFT LINER

- A. Perform grouting operations to fill voids outside of the primary tunnel or shaft liner.
- B. For nonexpendable primary liners installed behind a shield or tunnel boring machine (TBM), fill voids with sand-cement grout promptly after each ring of the liner is out of the shield. Keep the grout pressure below a value that may cause damage or distortion to the installed liner plate rings. Provide seals on the tail of the shield or TBM which will prevent grout from spilling.
- C. For nonexpendable primary liners installed by hand mining or in shafts, grout once every 4 feet or more frequently if conditions dictate.
- D. Control grout pressures so that tunnel or shaft liner is not overstressed, and ground heave is avoided.
- E. For liner requiring grout, perform back grouting once each shift, or more often if required to ensure that all voids are filled.

3.04 ANNULAR GROUTING FOR SEWER LINE IN TUNNELS AND IN CASED OR UNCASED AUGERS

- A. Fill the annular space between the sewer pipe and the tunnel primary liner, casing or ground, with grout.
- B. Placement
 1. Placement Limits: The limits of each grout placement stage shall be predetermined by the size and capacity of the batching equipment and the initial set time of the proposed grout. Under no circumstances shall placement continue at a grout port longer than that period of time for the mix to take initial set. Grout hole spacing and locations shall be located according to the number of stages necessary to grout tunnel liners. A stage or lift cannot be installed on another lift until a proper set has been attained. Have placement procedures approved by the admixture or additive manufacturer.
 2. Limit pressure on the annular space to prevent damage or distortion to the pipe or liner. Define the limiting and estimated required pressure range.

Provide an open ended, high point tap or equivalent vent and monitor it at the bulkhead opposite to the point of grouting.

3. Pump grout until a material discharging is similar in consistency to that at point of injection.
 4. In a primary lined tunnel, limit length of pipe installed to 200 feet or less before grouting the same length of sewer line. Repeat this cycle until all pipe is installed and grouted.
- C. Remove temporary bulkheads installed for grouting.
 - D. Batch and mix cellular grout mechanically to ensure consistency of the mix. Wet solids thoroughly before introduction of the foaming agent. Operate the batching system to maintain slurry weight within 3 percent of design density. Introduce foam into slurry in accordance with the manufacturer's recommendations.

3.05 PRESSURE GROUTING FOR JACKED PIPE

- A. For jacked pipe 60 inches in diameter or greater, pressure grout the annulus after installation, displacing the bentonite lubrication. Jacked pipes less than 60-inch diameter may be left ungrouted unless the excavated diameter exceeds the external pipe diameter by more than one inch.
- B. Inject grout through grout holes in the sewer pipe. Drilling holes from the surface or through the carrier pipe walls is not allowed. Perform grouting by injecting it at the pipe invert with bentonite displacement occurring through a high point tap or vent.
- C. Control ground water as necessary to permit completion of grouting without separation of the grout materials.
- D. Limit pressures to prevent damage or distortion to the pipe or to keep flexible pipe within acceptable tolerances.
- E. Pump grout until material discharging is similar in consistency to that at point of injection.

3.06 GROUND STABILIZATION GROUTING

- A. Completely fill voids outside the limits of excavation caused by caving or collapse of ground. Fill with gravity or pressure injected sand-cement grout as necessary to fill the void.

- B. Take care in grouting operations to prevent damage to adjacent utilities or public or private property. Grout at a pressure that will not distort or damage any portion of the work or existing installations or structures.
- C. Verify that the void has been filled by volumetric comparisons and visual inspection. In the case of settlement under existing slabs, take cores as directed by the Owner's Representative, at no additional cost to the Owner, to demonstrate that the void has been filled.

3.07 QUALITY CONTROL

- A. Pressure Grouting for Primary Tunnel and Shaft Liners
 - 1. For each shaft, make one set of four compressive test specimens for each 30-foot depth and one set for any remaining portion less than a 30-foot increment.
 - 2. Make one set of four compressive test specimens for every 200 feet of primary lined, (non-expandable) tunnel requiring grout.
- B. Annular Grouting for Sewer Line in Tunnels and in Cased or Uncased Augers.
 - 1. Make one set of four compressive test specimens for every 200 feet of sewer pipe installed in primary lined tunnel.
 - 2. For cased or uncased augers, make one set of four compressive test specimens for each grouting operation, or for each 100 feet of pipe installed, whichever is more frequent.
 - 3. For cellular grout, check the slurry density both at point of batching and placement at least twice each hour in accordance with ASTM C138. Record density, time, and temperature. Density must be within 3 percent of design density at point of batching and 5 percent of design density at point of placement.
- C. Pressure Grouting for Jacked Pipe. Make one set of four compressive test specimens for every 400 feet of jacked pipe pressure grouting.
- D. Ground Stabilization Grouting.
 - 1. Make one set of four compressive test specimens for every location where ground stabilization grouting is performed.

END OF SECTION