900 SEWERAGE WORK

ITEM 909 - TUNNEL - JACKED LINER

909.01 Description. This work shall consist of furnishing and installing a tunnel liner of sufficient diameter to permit the installation of the sewer therein and encasing the sewer in the liner. This work shall include all excavation, shoring and bracing, jacking pit and appurtenances (unless separate bid item), backstops, jacks, jacking shields, hoods, breasting attachments, grout holes and plugs, grout and other incidentals as needed for the installation. The liner may be installed by jacking and hand mining, by spoil removal with a boring auger, *or by tunnel boring machine*.

909.02 Materials. Materials shall be as follows:

1. Tunnel liner 909.06
2. Cement for grout 701
3. Sand for grout 703.03
4. Concrete, Class A/Class C 499, 905
5. Pipe sewer 901.02

909.03 General. The requirements of Section 908.03 shall apply to work in jacked tunnels. Jacking will be permitted in one direction only.

1. **Boring.** This method consists of pushing (jacking) the pipe into the earth with a boring auger rotating within the pipe to remove the spoil. This method is generally limited to 48 inch (1.2 m) and smaller lines.

2. **Jacking.** This method consists of pushing sections (strings) of pipe into position with *a tunnel boring machine, or* with jacks placed against a backstop and excavation performed by hand within the jacking shield or

liner at the head of the pipe. This is generally used on tunnel liners greater than 30 inches (762 mm) in diameter.

909.04 Construction Layout and Alignment Holes. Shall conform to 908.04.

909.05 Jacking Shield.

1. **Jacking Shield for Reinforced Concrete Pipe.** A separate jacking shield, *a tunnel boring machine* or a shield fabricated as a special section of reinforced concrete pipe with steel cutting edge, hood, breasting attachments, and other necessary appurtenances cast into the pipe shall be provided when required by the Engineer. The wall thickness and reinforcing shall be designed for the jacking stresses. The fabricated shield will not remain as a part of the tunnel liner unless specifically designed to do so; and the design is approved by the Engineer.

2. **Jacking Shield for Smooth Steel Pipe Liner.** A separate shield, or the leading section of conduit can be equipped with a jacking head securely anchored thereto to prevent wobble and variation in alignment, shall be provided when required by the Engineer. A modified section of standard pipe may be utilized if approved by Engineer and incorporates the necessary breasting attachments and capability to completely bulkhead the face.

3. **Boring Head and Auger Assembly.** The Contractor shall submit details showing the equipment to be utilized and the methods of operation. The Engineer may require devices to prevent the cutting head from leading the pipe; the cutting head to be designed to obstruct the flow of soft or poor soil through the face; and the assembly of cutter head and augers to be designed to allow the entire removal of the boring equipment from inside the liner. The Contractor shall limit the over cut to the minimum amount required for the installation and shall conduct his operations to prevent unsupported excavation ahead of the liner pipe.

909.06 Tunnel Lining. The tunnel lining shall provide strength commensurate with the tunnel diameter, depth of cover, jacking thrust and shall have adequate buckling resistance, all in accordance with the design requirements of the authorizing entity. Design calculations *prepared and stamped by a Professional Engineer registered in the State of Ohio and* demonstrating the capability of the materials proposed shall be submitted to the Engineer.

1. **Reinforced Concrete Pipe Liner.** Shall have tongue and groove joints and shall conform to ASTM C-76, Class V Wall C for railroad installation. For other installations, the pipe design shall be approved by the Engineer.

2. **Smooth Steel Pipe.** Shall have a minimum yield strength of 35,000 psi. (241 MPa) Maximum diameter allowed will be 72 inches (1.8 m) (nominal). *Tunneling procedures described under Item 908 shall be used if larger than 72 inch (1.8 m) size is required*. The following are minimum wall thicknesses for the nominal size shown for railway installations with 5 foot 6 inches (1.7 m) of cover (minimum).

Nominal Diameter Inches (mm)	**Nominal Thickness Inches (mm)**
10 and under (254)	0.188 (4.8)
12 and 14 (305 and 355)	0.250 (6.3)
16 (406)	0.281 (7.1)
18 (457)	0.312 (7.9)
20 and 22 (508 and 558)	0.344 (8.7)
24 (609)	0.375 (9.6)
26 (660)	0.406 (10.3)
28 (711)	0.438 (11.1)
30 (762)	0.469 (11.9)
32 (812)	0.500 (12.7)
34 and 36 (863 and 914)	0.532 (13.5)
38 (927)	0.562 (14.3)
40 (1016)	0.594 (15.1)
42 (1067)	0.625 (15.9)
44 and 46 (1118 and 1168)	0.657 (16.7)
48 (1219)	0.688 (17.4)
50 (1270)	0.719 (18.2)
52 (1321	0.750 (19.0)
54 (1371)	0.781 (19.8)
56 and 58 (1422 and 1473)	0.812 (20.6)
60 (1524)	0.844 (21.4)
62 (1575)	0.875 (22.2)
64 (1625)	0.906 (23.0)
66 and 68 (1676 and 17257)	0.938 (23.8)
70 (1778)	0.969 (24.6)
72 (1829)	1.000 (25.4)

Wall thicknesses for other conditions of loading will be considered when justified by the submitted engineering calculations.

Joints between sections of steel pipe shall be fully welded around the circumference. The Contractor shall be responsible for providing any stress transfer across the joint necessary to ensure capability to resist the jacking forces involved.

909.07 Excavation. The Contractor shall excavate all material of whatever nature encountered, including rock, necessary for the construction of the work. All excavated material shall be considered unclassified material. Excavation shall not be advanced beyond the edge of the hood, shield or liner, except in rock.

909.08 Soil Stabilization. The requirements as stated in Section 908.08 apply.

909.09 Dewatering. The requirements as stated in Section 908.09 apply.

909.10 Grouting. Where conditions permit, grouting may be placed by grout pipes from the ground surface. On railroad and main highway installations the grouting shall be from within the jacked liner, or other approved method.

Grouting hole locations for smooth steel liners shall be in accordance with 908.10. For railroads the tapped grout holes *shall be* 1 1/2 inches (38 mm) minimum, for reinforced concrete pipe, *grout holes* shall be cast into the liner at manufacture. The holes shall be spaced 4 feet (1.2 m) longitudinally and approximately 3 feet (0.9 m) circumferentially. For other installations the grouting arrangement shall be approved by the Engineer.

The grout shall be 1:3 (cement:sand) cement grout. The grouting shall commence immediately upon completion of the jacking/boring operation. The grouting machine, gauge, pressures and cold weather instructions shall be in accordance with Section 908.10.

909.11 Fill Material. The requirements as stated in Section 908.11 apply.

909.12 Method of Measurement. The length of jacked liner and appurtenances to be paid for will be the actual number of linear feet (meters) accepted, as measured along the centerline of the sewer lines. When the tunnel shaft-jacking pit is included in the tunnel liner unit prices, measurement will be from the center of the jacking pit to the end of the tunnel liner.

909.13 Basis of Payment. The accepted number of linear feet (meters) of tunnel-jacked liner of the sizes required will be paid for at the contract unit prices per linear foot (meters) complete in place. Payment for the encased pipe will be made under Item 901.

Payment will be made under:

Item	Unit	Description
909	Linear Foot (Meter)	Tunnel - Jacked Liner for ____ Inch (mm) Diameter Pipe Including Jacking Pit
909	Linear Foot (Meter)	Tunnel - Jacked Liner for ____ Inch (mm) Diameter Pipe Excluding Jacking Pit