Chapter 8
Pipe Jacking

8-1. General

Pipe jacking is a method of installing a pipe under roadways, railways, runways or highways without using an open cut trench. The pipe jacking procedure uses a casing pipe of steel or reinforced concrete that is jacked through the soil. Sizes range from 460 to 2,740 mm (18 to 108 in.). Maximum jacking loads are controlled by pumping bentonite or suitable lubricants around the outside of the pipe during the jacking operation. Typically, jacks are oversized so they can be operated at a lower pressure and maintain a reserve jacking capacity. It is common to use a 24-hour operation when pushing pipe, reducing the possibility that the pipe will freeze or "set" in the ground. Another common practice is to place 38-mm- (1.5-in.-) diameter grout plugs in each section of pipe up to 1,220-mm (48-in.) diameter and three plugs in each section of pipe over 1,370 mm (54 in.) in diameter. These plugs are used to pump lubricants around the outside of the pipe during the jacking operation and to pump grout around the outside of the pipe after the push is completed. Refer to Figure 8-1 for casing pipe details. In accordance with the intent of EM 1110-2-1913 and para 1-6.e., a drainage detail shall be provided that is adequate to prevent formation of excess seepage gradients and piping in the region of the landside toe of levees underlain by pipes installed by jacking or other "trenchless" methods. The detail may consist of buried drainage features with suitable filter, drainage collection and discharge elements, an inverted filter and weight berm above the toe of the levee and the pipe installation pit, or a combination of these.

8-2. Materials

a. Steel pipe. New and unused sections of steel pipe are used for the casing pipe. Steel casing pipe sections are then joined with full circumferential welds and pushed through the soil. Typical nominal wall thicknesses for steel casing pipe indicated in Table 8-1 should be coordinated with the appropriate highway or railroad authorities as necessary.

b. Concrete pipe. The minimum recommended compressive strength for jacked concrete pipe is 35 MPa (5,000 psi). Typical axial jacking loads for concrete pipe are shown in Table 8-2. Concrete pipe should have full circumferential reinforcement and supplemental joint reinforcement when ASTM C 76M pipe is used. Provisions for intermediate jacking rings should be incorporated in the design when pushes are longer than 105 m (350 ft), and joints should be cushioned with plywood, manila rope, jute, or oakum. Pipe alignment for jacked pipe should be straight. Bell and spigots should be concentric with the pipe wall, and the outside wall should be straight walled with no bells.

8-3. Installation

a. Excavation. Pipe jacking operations require the excavation of a suitable jacking pit. Pits need to be shored because the side walls are normally cut vertical to conserve space. Pits should be large enough to accommodate the backstop, jacking equipment, spacer, muck removal equipment, and lubricant pump and lines. They should also have minimal walking room on each side of the jacking equipment. All equipment is normally centered along the center line of the casing pipe.

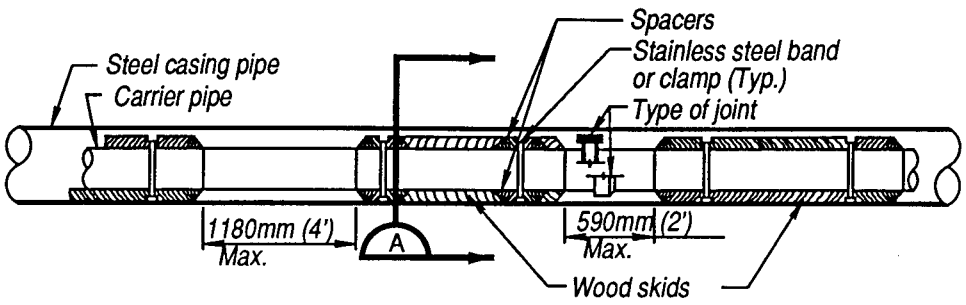
b. Backstop. The backstop is a rigid plate placed between the jack and the back wall of the pit that is used to distribute the jacking load into the ground. The load required to push the pipe through the ground depends on the method and lubricants used and equipment capacity. Small-diameter pipe can be jacked using a shoe on the front of the pipe. Large-diameter pipe can use an auger on the front of the pipe to cut the face material away and then push the muck through the pipe for removal. On pipe in nonrunning soils and that is large enough for workers to enter, hand excavation at the face of the pipe is possible.

c. Set. The casing pipe can "set" or freeze in the ground either when inadequate jacking force is available or when operation is stopped for a period of time. To prevent this set condition from occurring, the operation can use lubricants, oversized jacks, and a continuous operation.

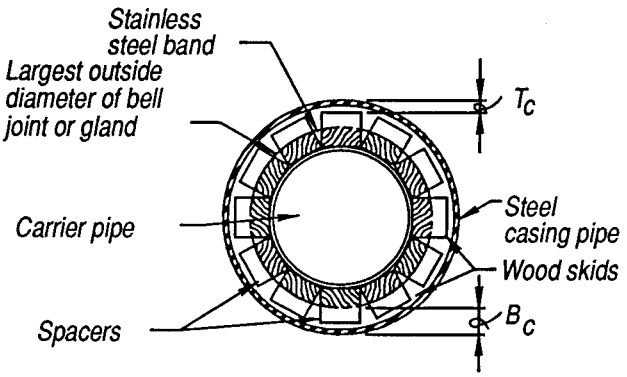
8-4. Loadings on Installed Pipe

a. Prism weight. The earth load on a jacked pipe is normally the prism weight of soil above the crown of the pipe. However, the full prism load does not occur unless the soil is saturated.

b. Cohesion of soil overburden. Cohesion of the overburden soil is used to reduce the earth load on the installed casing pipe as indicated by Equation 8-1. Typical values of cohesion are shown in Table 8-3.

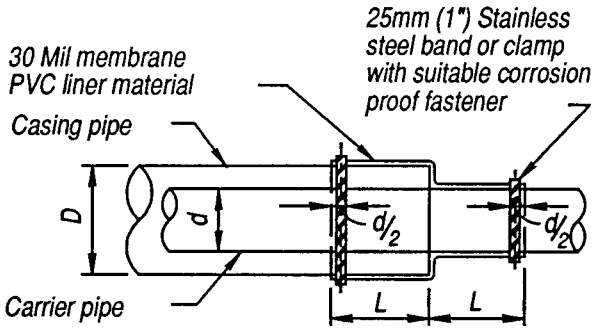


SKID DETAILS
NO SCALE



SECTION A
NO SCALE

CLEARANCE DISTANCE		
Carrier pipe size	B_C	T_C
150mm (6") Or less	13mm (")	18-25mm ("-1")
200mm (8")	18mm (")	25-37mm (1"-1 ")
250mm (10")	18mm (")	25-37mm (1"-1 ")
300mm (12")	18mm (")	25-37mm (1"-1 ")
345mm (14")	25mm (1")	25-37mm (1"-1 ")
400mm (16")	25mm (1")	50-75mm (2"-3")



END SEAL DETAIL FOR CASING PIPE
NO SCALE

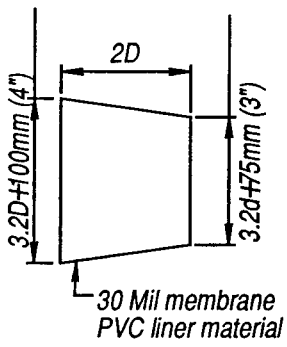


Figure 8-1. Casing pipe details

Table 8-1
Recommended Steel Pipe Nominal Wall Thicknesses

Pipe OD		Railroad		Highway	
Nominal mm (in.)	Actual mm (in.)	Bare mm (in.)	Coated mm (in.)	Bare mm (in.)	Coated mm (in.)
200 (8)	220 (8.625)	6 (0.250)	4.5 (0.188)	6 (0.250)	4.5 (0.188)
250 (10)	270 (10.75)	6 (0.250)	4.5 (0.188)	6 (0.250)	4.5 (0.188)
300 (12)	320 (12.75)	6 (0.250)	4.5 (0.188)	6 (0.250)	4.5 (0.188)
350 (14)	350 (14)	7 (0.281)	5 (0.219)	6 (0.250)	5 (0.219)
400 (16)	400 (16)	7 (0.281)	5 (0.219)	6 (0.250)	5 (0.219)
460 (18)	460 (18)	8 (0.312)	6 (0.250)	6 (0.250)	6 (0.250)
510 (20)	510 (20)	9 (0.344)	7 (0.281)	8 (0.312)	6 (0.250)
610 (24)	610 (24)	10 (0.406)	9 (0.344)	8 (0.312)	6 (0.250)
760 (30)	760 (30)	12 (0.469)	10 (0.406)	9 (0.375)	9 (0.375)
910 (36)	910 (36)	13 (0.532)	12 (0.469)	13 (0.500)	11 (0.438)
1070 (42)	1070 (42)	14 (0.563)	13 (0.500)	13 (0.500)	13 (0.500)
1220 (48)	1220 (48)	16 (0.625)	14 (0.563)	16 (0.625)	14 (0.563)
1370 (54)	1370 (54)	17 (0.688)	16 (0.625)	16 (0.625)	16 (0.625)
1520 (60)	1520 (60)	19 (0.750)	17 (0.688)	16 (0.625)	16 (0.625)
1680 (66)	1680 (66)	20 (0.813)	19 (0.750)	16 (0.625)	16 (0.625)
1830 (72)	1830 (72)	22 (0.875)	20 (0.813)	19 (0.750)	19 (0.750)

Note: Recommended minimum thicknesses are for a 1.4-m (4.5-ft) ground cover.

Table 8-2
Typical Pushing Requirements for Concrete Pipe

Pipe OD mm (in.)	Sandy Soil No Excavation at Face kN (tons)	Hard Soil Excavation at Face kN (tons)
50 (18)	8.90 (1.0)	3.56 (0.40)
610 (24)	12.45 (1.4)	4.63 (0.52)
760 (30)	17.79 (2.0)	6.76 (0.76)
910 (36)	17.79 (2.0)	6.76 (0.76)
1070 (42)	20.46 (2.3)	7.83 (0.88)
1220 (48)	24.02 (2.7)	8.90 (1.0)
1370 (54)	26.69 (3.0)	9.79 (1.1)
1520 (60)	29.36 (3.3)	10.68 (1.2)
1680 (66)	32.03 (3.6)	12.45 (1.4)
1830 (72)	34.69 (3.9)	13.34 (1.5)
1980 (78)	38.25 (4.3)	14.23 (1.6)
2130 (84)	40.92 (4.6)	15.12 (1.7)
2290 (90)	43.59 (4.9)	16.01 (1.8)
2440 (96)	46.26 (5.2)	16.90 (1.9)
2740 (108)	55.16 (6.2)	20.46 (2.3)

From: Horizontal Earth Boring and Pipe Jacking Manual No. 2, National Utility Contractors Association, Arlington, VA.

Table 8-3
Cohesion of Various Soils

Material		Cohesion, N/m^2 (psf)
Clay		
	Soft	1,915 (40)
	Medium	11,970 (250)
	Hard	47,880 (1,000)
Sand		
	Loose Dry	0 (0)
	Silty	4,788 (100)
	Dense	14,364 (300)
Topsoil		
	Saturated	4,788 (100)

$$W_t = C_t\, w\, B_t^2 - 2\, c\, C_t\, B_t \tag{8-1}$$

c. Earth load. Equation 8-2 is used to calculate the load the casing pipe needs to support. It includes the effects of cohesion in the overburden soil.

$$C_t = 1 - \frac{\left[e^{-2\,K\mu'\left(\frac{H}{B_t}\right)}\right]}{2\,K\mu'} \qquad (8\text{-}2)$$

where

W_t = earth load under tunneled or jacked conditions, N/m (lbf/ft)

C_t = load coefficient for tunneled or jacked pipe

w = unit weight of soil, N/m^3 (pcf)

B_t = maximum width of bore excavation, m (ft)

c = cohesion of soil above the excavation, N/m^2 (psf) (Table 8-3)

$K\mu'$ = 0.165 (sand/gravel), 0.150 (saturated top soil), 0.130 (clay), and 0.110 (saturated clay)

H = height of fill, m (ft)