

## Appendix G

### Design examples for thrust restraint

Pipe inside diameter, D, in	= 72
Laying length, L <sub>p</sub> , ft	= 24
Operating pressure, P <sub>w</sub> , psi	= 150
Field test pressure, psi	= 180
Height of earth cover, H, ft	= 5
Unit weight of fill material, w, lb/ft <sup>3</sup>	= 120
Coefficient of friction between pipe and backfill, μ	= 0.30

Check thrust restraint requirement for the following two conditions:

Case I: Horizontal long-radius curve achieved by the use of standard pipe with 5° beveled spigots.

Case II: 75° horizontal elbow having a tangent length of 5 feet x 5 feet restrained with welded joints.

<b>Reference</b>	Case I
	<b>Horizontal thrust</b>
Eq. 9.2-1	$T = 2PA \sin \frac{\Delta}{2}$
Figure 2.1-3	D <sub>j</sub> = 76.5 in For 5° bevel at field test pressure, $T = 2(180) \frac{\pi(76.5)^2}{4} \sin\left(\frac{5}{2}\right) = 72,200 \text{ lb}$
	<b>Frictional restraint</b>
Eq. 9.4-2	W = w B <sub>c</sub> H
Figure 2.1-3	B <sub>c</sub> = 84.5 in = 7.04 ft For H = 5 ft, W = 120(7.04)(5) = 4220 lb/LF
Appendix B	W <sub>p</sub> = 1,650 lb/LF W <sub>w</sub> = 1,760 lb/LF
	Movement of the joint will not occur when
Eq. 9.4-1	$T \leq \mu L_p (W_p + W_w + 2W)$ $\leq 0.3(24)[1,650 + 1,760 + 2(4,220)] = 85,300 \text{ lb}$ Since T = 72,200 lb, no additional restraint is required

## Reference

Case II

### Horizontal thrust

For 75° elbow at  $P_w = 150$  psi,

$$\begin{aligned} \text{Eq. 9.2-1} \quad T &= 2(150) \frac{\pi(76.5)^2}{4} \sin\left(\frac{75}{2}\right) \\ &= 839,000 \text{ lb} \end{aligned}$$

At field test pressure of 180 psi,

$$\begin{aligned} \text{Eq. 9.2-1} \quad T &= 2(180) \frac{\pi(76.5)^2}{4} \sin\left(\frac{75}{2}\right) \\ &= 1,007,000 \text{ lb} \end{aligned}$$

### Required welded length on each leg of the elbow

$$\text{Eq. 9.5-2} \quad L = \frac{T}{2\mu (W_p + W_w + 2W)}$$

At test pressure,

$$\begin{aligned} L &= \frac{1,007,000}{2(0.3)[1,650 + 1,760 + 2(4,220)]} \\ &= 142 \text{ ft} \end{aligned}$$

### Cylinder thicknesses

$$\text{Eq. 9.5-8} \quad t_{y(\text{elbow})} = \frac{T}{2\pi D_y f_s}$$

Figure 2.1-3

$$D_y = 75.9 \text{ in}$$

At  $P_w$ , use  $f_s = 13,500$  psi

$$t_{y(\text{elbow})} = \frac{839,000}{2\pi(75.9)13,500} = 0.130 \text{ in}$$

At field test pressure, use  $f_s = 16,500$  psi

$$\text{Eq. 9.5-8} \quad t_{y(\text{elbow})} = \frac{1,007,000}{2\pi(75.9)16,500} = 0.128 \text{ in}$$

Operating pressure controls

$$t_{y(\text{elbow})} = 0.130 \text{ in}$$

For welded pipe sections, cylinder thickness

$$\text{Eq. 9.5-9} \quad t_y = \frac{(L - l)}{L} t_{y(\text{elbow})}$$

Weld 6 joints on both sides of the elbow

Cylinder thicknesses are as shown

