15. Deflection of Pipe Joints.

a. General.

1) Pipe joints may be deflected to obtain a horizontal curvature, vertical curvature or a combination.

b. Alignment Design.

1) Design maximum deflection angle (MD) of any pipe joint in a single plane, or a combination of both planes, cannot exceed the angles shown in the Deflection Tables under Part One, Section 12 (Allowable Joint Deflections). To determine the joint deflection in either the horizontal or vertical planes, use Formula "A" and Figure "A", under Part One, Section 12 (Allowable Joint Deflections).

2) When the alignment requires a combination of horizontal and vertical joint deflections, determine the design maximum deflection angle (MD) of the pipe joint using formulas "G", "H" and "I", as shown below. Determine the horizontal joint deflection (Θ_H) using Formula "G".

FORMULA "G" See Formula "A" under Part One, Section 13 (Allowable Joint Deflections).

$$\mathbf{H = \Theta_H = 2 \tan^{-1} (L \div 2R)}$$

After solving horizontal joint deflection (H), solve for the maximum vertical joint deflection (MV) using Formula “H”.

FORMULA "H"

$$\mathbf{MV = \Theta_V = \cos^{-1} \left(\cos (MD) \div \cos (H)\right)}$$

Where:

MD	=	design maximum deflection angle from Tables "3", "3.1", "4", "5.0", "5.1", "5.2", "5.3" and "5.4" (Part One, Section 13 (Allowable Joint Deflections).
MV	=	maximum vertical joint deflection angle
V	=	joint deflection angle in the vertical plane
H	=	joint deflection angle in the horizontal plane
R	=	radius of curve
Θ_H	=	horizontal deflection angle
Θ_V	=	vertical deflection angle
L	=	laying length (use twenty (20) feet)

After solving for the maximum vertical joint deflection angle (MV) distance, determine the vertical profile of the pipeline alignment by finding the vertical offset distance from Formula "I".

FORMULA "I"

$$\mathbf{VS = \sin \Theta \times L}$$

Where:

VS	=	vertical offset distance
Θ	=	vertical deflection
L	=	laying length (use 20 feet)

Example: <u>Determining the Vertical Deflections for a Horizontal Curve.</u>

A curved alignment on a 24-inch pipeline in the horizontal plane (plan view) R = 800 feet. Find the maximum vertical joint deflections (MV) (on profile), by computing the horizontal deflection (H) first and then solve for the vertical angle using Formula "G" and Formula "H".

Using Formula "G"

$$\begin{aligned} H = \Theta_H &= 2\tan^{-1}(L \div 2R) \\ &= 2\tan^{-1}(20 \div 2 \times 800) \\ &= 2\tan^{-1} 0.0125 \\ &= 2 \times 0.71616 \\ H = \Theta_H &= 1.4323199^\circ \text{ or } 01^\circ 25'56'' \end{aligned}$$

Then, using Formula "H", solve for the maximum vertical joint deflection (MV).

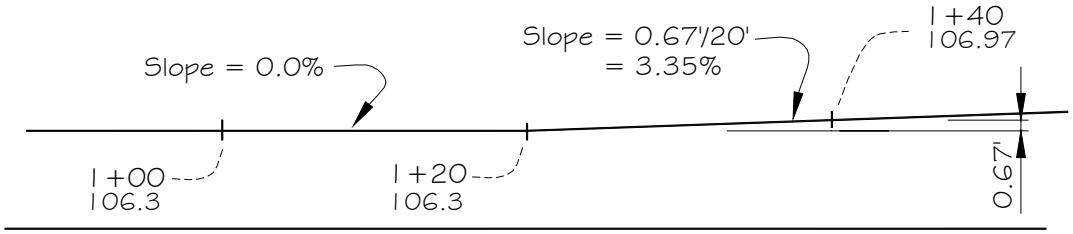
$$\begin{aligned} MV = \Theta_V &= \cos^{-1}\left(\cos(MD) \div \cos(H)\right) \\ &\quad \text{for 24" pipeline, push-on joints, from Table "3", } MD = 02^\circ 24' \\ &= \cos^{-1}(\cos 02^\circ 24' \div \cos 01^\circ 25'56'') \\ &= \cos^{-1}(\cos 02^\circ 24'00'' \div \cos 01^\circ 25'56'') \\ &= \cos^{-1}(0.9991228 \div 0.9996876) \\ &= \cos^{-1} 0.999435 \\ MV = \Theta_V &= 1.9260754^\circ \text{ or } 01^\circ 55'34'' \end{aligned}$$

On each twenty (20) foot length of pipe, the allowable vertical joint deflection is 01°55'34".

Find the offset distance, for each pipe length in the profile (vertical offset distance), use Formula "I":

$$\begin{aligned} VS &= \sin\Theta \times L \\ &= \sin 01^\circ 55'34'' \times 20 \\ &= 0.0336106 \times 20 \\ VS &= 0.67 \text{ feet} \end{aligned}$$

"VS" is the distance the pipe may be deflected from the previous pipe section, as shown in Sketch "F".



SKETCH "F"

PROFILE - Deflections at Pipe Joints