DRISCOPIPE

TECHNICAL NOTE #21

PD TN-21
May 1996

HDPE PIPE BENDING, COILING, AND KINK RESISTANCE

INTRODUCTION Driscopipe® HDPE may be cold-bent as it is installed, thus eliminating the need for elbows in slight bends. The minimum bend radius that can be applied to the pipe without kinking varies with the diameter and wall thickness of the pipe. If adequate space is not available for the required radius, a fitting of the desired angle may be fused into the piping system to obtain the necessary change in angle.

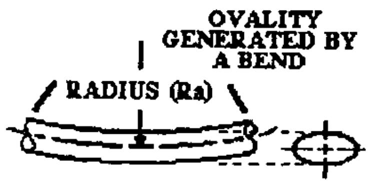
This Technical Note will briefly explain the principles of bending, coiling, and kink avoidance. The recommendations for the proper selection in radius of curvature for bending Driscopipe® are derived.

PRINCIPLES Kinking of a pipe is a site-specific localized structural instability which begins when excessive bending is introduced to the pipe without allowing a bend radius of curvature to reduce external stresses acting on the pipe. When this external stress exceeds the pipe ring stiffness, which is related to pipe Dimension Ratio (DR), failure due to kinking will occur.

As the pipe is bent to a radius of curvature several times the pipe outside diameter, there is a measurable flattening of the pipe cross-section and a slight wall thinning. This results in an elliptical cross sectional shape with a reduced moment of inertia. This in not as rigid as its circular cross-section in opposing bend moment stresses induced by the in-plane beam bending of the pipe.

The recommended ratio is determined by designing for king, longitudinal strain and axial strain.

DESIGN KINKING The limiting deflection to avoid kinking is estimated to be 20% ovality (ie: $\Delta Y / D < 0.20$). This limiting value assumes a perfectly round pipe at a uniform ambient temperature. To mathematically develop results, the following calculations are performed. The Reissner equation for deflection of pipe cross-section by longitudinal bending is:



$$\Delta Y / D = 2/3 * Z + (71/135) * Z^2 \quad \text{(Eq. 1)}$$

FIG. 1

SUMMARY GUIDELINES Based on the above equations, calculated data was generated to understand the effects of DR and bend radius on overall pipe deformation. Table 1 summarizes Phillips Driscopipe recommendations for pipe operating at 73.4° F:

Table 1

SDR	Minimum Allowable Bend Radius Ratio 73.4° F
32.5	>40 times outside diameter
26.0	>35 times outside diameter
21.0	>28 times outside diameter
19.0	>27 times outside diameter
17.0	>27 times outside diameter
15.5	>27 times outside diameter
13.5	>25 times outside diameter
11.0	>25 times outside diameter
9.0	>20 times outside diameter

Table 1 includes a safety factor of 2:1. The bend radius is calculated as follows. For example, if a 24" diameter SDR 21 pipe was to be bent, the minimum bend radius is:

$$R_a / D_o > 28$$
$$R_a = R_a / D_o * D_o$$
$$R_a = 28 * 24''$$
$$R_a = 672'' \text{ minimum Radius of Curvature}$$

Fittings If Tees, Ells, Flanges, or socket fusions are located in the bend zone, the minimum bend radius of curvature should be increased to forty (40) times the outside diameter of the pipe.

Temperature Affect While temperature does not significantly affect thick wall, low DR pipes, thin-wall higher DR pipes can be affected by the sun heating the crown of the pipe while the invert of the pipe is cooler. Consideration should be given to slightly increasing the R_a / D_o ratio on SDR 32.5 and SDR 26 during warm sunny days.

Note Kinking of a pipe is a site-specific localized structural instability of freestanding, externally unsupported pipe induced by in-plane bending stresses insufficiently opposed by pipe ring stiffness related to pipe Dimension Ratio (DR), which is related to moment of inertia.

REFERENCES

1. Timoshenko, S.P. and Gere, J.M., "Theory of Elastic Stability", 2nd Ed., McGraw Hill Book Co., Inc., 1961, pp 500-509.

2. Roark, J.R., "Formulas for Stress and Strain", 4th Ed., McGraw Hill Book Co., Inc., 1965, pp 161-166.

3. von K'arman, Th: "Uber die Formanderung dunnwandiger Rohre, insbesondere federnder Ausgleichrohre, "Zeirs. Vereines Deutscher Ing, vol. 55 pp 1889-1911.

where $z = 3 / 2 * (1 - v^2) * (D_o - t)^4 / ((16 * t^2) * R_a^2)$
and v = Poisson's ratio of pipe material (0.45)
R_a = Radius of curvature of bend in pipe (along axis), in inches
t = Wall thickness, in inches
D_o = Outside diameter of pipe, in inches
$SDR = D_o / t$

Longitudinal Strain The standard criteria for the coiling of HDPE pipe is to limit longitudinal strain to less than 5%, providing a calculated radius of curvature at 10 times the nominal pipe outside diameter, The equation for longitudinal strain is:

$$\varepsilon_l = D_o / 2 * R_a \quad \textbf{(Eq. 2)}$$

where ε_l = Longitudinal strain
D_o = Outside diameter of pipe
$R_a = D_o / 2 * \varepsilon_l$
$R_a = D_o / (2 * 0.05)$
$R_a = 10 * D_o$

Tangential Strain The equation for tangential strain is as follows.

$$\varepsilon_t = 4 * (t / Do) * (\Delta Y / D) \quad \textbf{(Eq. 3)}$$

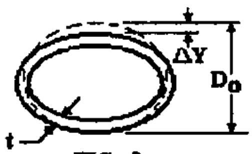


FIG. 2

where ε_t = tangential strain
D_o = Outside diameter of pipe
ΔY = Difference between the original outside diameter and deflected outside diameter of pipe

Based on standard DR's and an allowable tangential strain of 1.0%, the allowable deflections ΔY / D have been calculated.

SDR	Allowable Ring Deflection @ 73.4° F
32.5	8.1%
26.0	6.5%
21.0	5.2%
19.0	4.7%
17.0	4.2%
15.5	3.9%
13.5	3.5%
11.0	2.7%
9.0	2.2%