Rinker MATERIALS

PIPE STIFFNESS

Flexible pipe is designed as a soil-pipe interaction system and, as such, the loads resulting from the soils, construction, live loads, and impact must be evaluated for this type of design system to perform properly.

Other design considerations must be given proper attention as well, such as: handling and shipping; pipe weight; insitu soil conditions; temperature changes; differential movements; vibration; and future construction in the area of the existing flexible pipe line. These are just a few of the considerations that must be addressed by the Design Engineer and the Owner.

The ability to resist deformation under load has been historically defined within the flexible pipe industry as a minimum pipe stiffness of 46 psi. Until recently, this has been the benchmark for the thermoplastic industry. However; there exists several alternate terms being used as a mark for lesser stiffness pipe as compared with the stiffer pipe materials already accepted within the pipe market.

Terms such as:

Pipe Stiffness – psi	PS	$= EI/.149r^3$
Stiffness Factor - psi	SF	$= EI/r^3$
Flexibility Factor - in/lb	FF	$= D^2/EI$ or $\frac{26.85}{PSr}$
Ring Stiffness Constant - lbs/ft	RSC	$= 6.44\ EI/D^2$
Ring Stiffness – psi	RS	$= EI/r^3$
Ring Flexural Stiffness - lbs/ft	RFS	$= EI/D^2$
Pipe Class		= Varies

Simply stated:

Pipe stiffness for flexible pipe is the inherent strength measured in accordance with ASTM D 2412 Standard Test Method for "Determination of External Loading Characteristics of Plastic Pipe by Parallel - Plate Loading" measured at an industry standard of 5%.

$$\text{Pipe Stiffness (PS)} = \frac{F}{\Delta Y} \geq \frac{EI}{0.149r^3}$$

Where: PS = Pipe Stiffness, psi

F = Force, lbs/Lin

ΔY = Vertical Deflection, in

E = Modulus of Elasticity, psi

I = Moment of Inertia of Wall Cross Section per Unit Length of Pipe, in^4/Lin

r = Mean Radius of Pipe, in.

D = Mean Diameter of Pipe, in.

The Design Engineer should be cognizant of the fact that the rate of loading, duration of loading, and the amount of deflection used in determining stiffness all have an important impact on measured stiffness. The Engineer should also recognize and understand the significance of the difference in stiffness terminology currently being stated.

FACTORS AFFECTING STIFFNESS

Temperature:
Samples of plastics for testing are conditioned at a temperature of 73.4 deg. ± 3.6 deg.F. As the temperature increases, pipe stiffness decreases, i.e., pipe strung alongside a ditch exposed to elevated temperatures. As temperature decreases, pipe stiffness increases as does brittleness. Low stiffness pipe is difficult to install and maintain roundness at the higher temperatures. "Easy to handle, hard to install."

Time:

An important factor in the calculation of pipe deflection is pipe stiffness. Pipe stiffness decreases with time under constant load. Depending on the type of plastic pipe and cell classifications, the mechanical design properties for initial and 50 year tensile strengths varies from 30% to 52.9%, and the modulus of elasticity varies from 20% to 36% for their short term properties.

When designing for deflection, an initial deflection of 3.33% is recommended with an expected 50 year deflection of 5% using a design lag factor of 1.5. The Design Engineer must make up his mind to what the maximum acceptable deflection can be at the end of a 50 year service life.

PROFILE/THICKNESS

From a quality control and design consideration, the manufactured product must maintain a constant smooth wall thickness or profile. Any variance from the theoretical thickness or variances in profile alters the pipe stiffness values.

WHAT HAPPENS WITH REDUCED PIPE STIFFNESS?

1. Increased deflection.
2. Increased reliance on soil to carry the load and minimize deflection.
3. Decreased buckling resistance.
4. Increased distortion in pipe shape.
5. Increased strain in pipe wall.
6. Joint leaks.
7. Reduced hydraulic capacity.
8. Ground surface settlement.
9. Stress corrosion.

WHAT FACTORS AFFECT STIFFNESS PROPERTIES?

1. Strain
2. Temperature
3. Stress history
4. Creep characteristics
5. Manufacturing flaws and tolerances
6. Use of fillers
7. Type of resins

SPECIFICATION SUGGESTIONS

1. Specify a minimum pipe stiffness of 46 psi in accordance with ASTM 2412 at a 5% deflection.
2. Specify maximum allowable deflection of 3% at least 30 days after completed, and also prior to project acceptance by owner. Maximum long-term deflection shall not exceed 5%.
3. Physical testing of actual produced pipe for mechanical and chemical characteristics.
4. Require design calculations from the pipe suppliers.