PVC PIPE PERFORMANCE FACTORS

PVC pipe, like all flexible pipe products, is very dependent on the surrounding soil for its structural capacity, in addition, the pipe material must have sufficient inherent strength to utilize the beneficial soil forces.

Material characteristics should include known initial and long-term properties:

- Modulus of elasticity
- Tensile and compressive strength
- Strain limits
- Environmental stress crack resistance (ESCR)
- Slow crack growth resistance (SCR)
- UV resistance

While PVC pipe may have been used in some locations for many years, historical performance may not necessarily be indicative of the product produced today, being affected by material formulation currently being used. It has come to our attention that some PVC pipe manufacturers have increased the amount of filler material from the 5 to 10% maximum filler content used in the past. While such **fillers may increase the initial strength, they also may decrease the long-term strength as filler concentrations increase.** Specifications should limit total filler concentrations to 10% or less.

The pipe designation of SDR 35 represents a ratio which is simply the outside diameter of the pipe divided by the wall thickness for a solid wall cross-section. SDR 35, from a strength classification requirement for PVC pipe, requires a minimum pipe stiffness of 46 psi at 5% deflection, for SDR 26 - 115 psi, and for SDR 23.5 - 153 psi.

The key to requiring a particular SDR for plastic pipe is no different than for other pipe products such as (rigid) concrete pipe. The strength required depends on the installation. For granular soil and high compaction, a lesser strength can be used, whereas for an alternative installation using dumped material, a greater pipe strength would be required.

The recommended wall thickness for plastic pipe therefore is a function of the installation, the applied load and the material cell classification. As an illustration of these factors we have analyzed the four performance modes of flexible pipe, wall compression, deflection, buckling and strain for 12" through 36" diameter pipe.

According to our analysis, for 5% deflection, assuming a moderately compacted (85%) sand and gravel backfill or dumped crush rock, we determined the SDR, wall thickness and pipe stiffness as follows:

DIA. (INCHES)	FILL HT. (FEET)	SDR	WALL THICKNESS (INCHES)	PS (PSI)
12	2	35	0.364	46
	10	35	0.364	46
	15	26	0.500	115
	20	>23.5	>0.558	>153
15	2	35	0.454	46
	10	35	0.454	46
	15	26	0.625	115
	20	>23.5	>0.698	>153
18	2	35	0.545	46
	10	35	0.545	46
	15	26	0.750	115
	20	>23.5	>0.837	>153
21	2	35	0.636	46
	10	35	0.636	46
	15	26	0.875	115
	20	>23.5	>0.978	>153

DIA. (INCHES)	FILL HT. (FEET)	SDR	WALL THICKNESS (INCHES)	PS (PSI)
24	2	35	0.727	46
	10	35	0.727	46
	15	26	1.000	115
	20	>23.5	>1.116	>153
27	2	35	0.818	46
	10	35	0.818	46
	15	26	1.125	115
	20	>23.5	>1.256	>153
30	2	35	0.909	46
	10	35	0.909	46
	15	26	1.250	115
	20	>23.5	>1.340	>153
33	2	35	1.000	46
	10	35	1.000	46
	15	26	1.375	115
	20	>23.5	>1.535	>153
36	2	35	1.091	46
	10	35	091	46
	15	26	1.500	115
	20	>23.5	1.674	>153

While dumped angular shaped crush rock may develop an E' (soil modulus) value of approximately 750 psi, such **dumped material does not assure that haunch support, which is very important for flexible pipe, will be achieved. ASTM D2321 requires that all materials, including Class 1 (angular crush rock) be hand placed in the haunches. If dumped crushed rock is to be used, it should be recognized that the same angular shape that provides resistance to the horizontal deformation of the pipe also provides resistance to filling the space under the haunches of the pipe, and must be hand placed to be effective.**

It is also extremely important to understand there is a significant difference between dumped sand and gravel and dumped angular crushed rock in providing the soil portion of the soil structure interaction system.

In view of the hand placement requirements under the pipe haunches and the effect that an angular shape vs. a partially angular shape can have on performance of a dumped material, it is suggested a minimum compaction of 85% standard Proctor be the lower limit for all rock or gravel backfill.

The above tabular data has assumed the compacted backfill extends for a minimum distance of one pipe diameter each side of the pipe **and the adjacent soil has a minimum modulus of 1500 psi.**

The performance of flexible pipe is such that **if the adjacent material within two pipe diameter of the installed pipe is disturbed, it could affect the performance of that pipe-soil system.** This is because the soil typically provides 90 to 95% of the system's strength.

PVC pipe is known to be subject to UV degradation which may cause changes in the material properties. In the formulation of PVC compounds stabilizers are typically included to prevent such degradation. **Evidence of such degradation may be observed as a color change. It is suggested any pipe showing this change be rejected and that standards be established requiring the pipe be shielded from such UV exposure.**

Various chemicals, including oils, acids or solvents, can have a deleterious effect on plastics, particularly when such materials are subject to strain. Normally, storm drains are not subject to this exposure; however, spills and unauthorized dumping may take place. It is suggested that **samples cut from actual pipe produced be subjected to chemical resistance tests**, while under stress, to verify the finished product meets the chemical resistance requirements.

The performance of a product whose strength and serviceability are so installation dependent can only be evaluated by field inspection to assure the performance is as designed. **This necessitates that compaction of both the embedment material and the insitu soil be measured along the entire length of the line and that deflection of the entire line be checked using a mandrel or a deflectometer.** Such devices to measure compaction and deflection must be agency certified. While deflection of pipe is not the only indicator of performance, it

is the easiest performance mode to assess. Historically, inspections of flexible products have indicated pipe deflection is a good measure and tends to represent the quality of the soil-pipe system. **In view of the time dependent characteristics of plastic, deflection measurements in the first year should not exceed 3%**, in order to help assure the long-term performance of 5% will not be exceeded.

The importance of inspection of the backfill, in particular in the haunch area, and the installed soil-pipe system cannot be over emphasized. **There are documented cases where on-going inspections of such systems showed continuing deformation as a function of time**, even though the initial inspection indicated acceptable performance as specified.