North American Pipe Corporation®

TECHNICAL BULLETIN

Changing Direction of PVC Pipelines

There are three methods to change the direction PVC pipelines: fittings, angular joint deflection, or longitudinal bending.

Fittings

Fittings that change the direction of pipelines include elbows, tees, and wyes. They can be used at any point in a line; however, the change in direction at the fitting causes a reactionary thrust force. This thrust force attempts to push the pipe joints apart and must be counteracted by using thrust blocks, external pipe restraints, solvent welded joints, or self-restrained pipe such as our Certa-Lok® family of products.

Angular Joint Deflection

The designs of some pipe joint styles permit one pipe segment to be deflected after assembly. North American Pipe Corporation produces PVC pipe products in four different joint styles: Gasketed Integral Bell (IB), Certa-Lok® Restrained Joint (RJ), Certa-Lok Restrained Joint Integral Bell (RJIB), and Solvent Welded (SW). The maximum angular deflection permitted varies for each joint type.

A simple formula may be used to calculate the horizontal or vertical offset at the end of the deflected pipe:

$$A = 12\ L \sin\beta$$

Where L = laying length of pipe, feet
β = maximum joint deflection angle, degrees
A = offset at the end of the deflected pipe, inches

Angular Joint Deflection

Joint Type	Maximum Angular Joint Deflection
IB	1°
Certa-Lok RJ	0.5° per Side of Coupling 1° Total per Joint
Certa-Lok RJIB	0.5°
SW	None

Angular Joint Deflection

Pipe Lay Length (ft)	Maximum Offset of Deflected Pipe (in)			
	IB	RJ	RJIB	SW
10	2.09	2.09	1.05	Not Permitted
14	2.93	2.93	1.47	Not Permitted
20	4.19	4.19	2.09	Not Permitted
22	4.61	4.61	2.30	Not Permitted
40	8.38	8.38	4.19	Not Permitted
42	8.80	8.80	4.40	Not Permitted

Longitudinal Bending

Due to the flexible nature of PVC, longitudinal bending of PVC pipe is possible as long as the flexural stress limits of the pipe are not exceeded. The following formulae can be used to calculate the minimum bend radius, angle of lateral deflection, and the distance offset at the end of a flexed, solid wall pipe. The values for modulus of elasticity and allowable flexural stress are temperature dependent.

$$R_b = \frac{ED_O}{24S_b}$$

$$\alpha = \frac{57.3\ L}{2R_b}$$

$$A = 24R_b \sin^2\alpha$$

Where
R_b = pipe bending radius, feet
E = PVC modulus of elasticity, psi
D_O = pipe outside diameter, inches
S_b = allowable flexural stress, psi
α = angle of lateral deflection, degrees
L = lay length of pipe, feet
A = offset of the end of the bended pipe, inches

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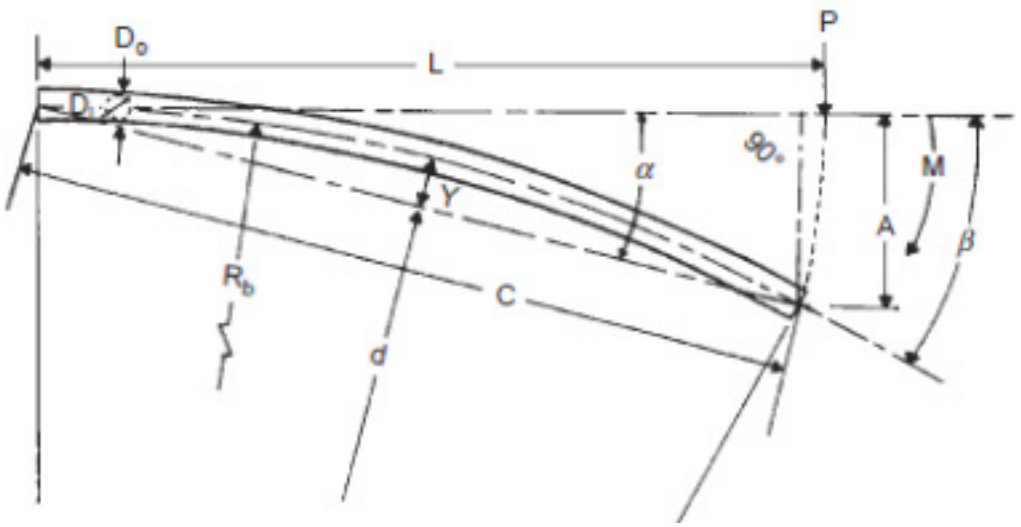

Figure 1: Longitudinal Bending Diagram
(From PVC Pipe Association Handbook of PVC Pipe Design and Construction)

The following tables summarize these calculations for our common product families and lay lengths for pipe at 73.4°F.

AWWA C900 & C900 Certa-Lok® Pipe
S_b = 800 psi, E = 400,000 psi

Nom. Size	D_o (in)	R_b (ft)	L = 20'		L = 40'	
			α (deg)	A (in)	α (deg)	A (in)
4"	4.800	100	5.7	23.92		
6"	6.900	144	4.0	16.67		
8"	9.050	189	3.0	12.72		
10"	11.100	231	2.5	10.37		
12"	13.200	275	2.1	8.72		
14"	15.300	319	1.8	7.53	3.6	30.08
16"	17.400	363	1.6	6.62	3.2	26.46
18"	19.500	406	1.4	5.91	2.8	23.62
20"	21.600	450	1.3	5.33	2.5	21.32
24"	25.800	538	1.1	4.47	2.1	17.85

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ASTM D2241, D2241 Certa-Lok® & Certa-Flo™
S_b = 800 psi, E = 400,000 psi

Nom. Size	D_o (in)	R_b (ft)	L = 10'		L = 20'		L = 40'		L = 42'	
			α (deg)	A (in)	α (deg)	A (in)	α (deg)	A (in)	α (deg)	A (in)
1½"	1.900	31.7	9.0	18.79	18.1	73.31				
2"	2.375	39.6	7.2	15.08	14.5	59.36	29.0	222.61	30.4	243.25
2½"	2.875	47.9	6.0	12.48	12.0	49.37	23.9	189.01	25.1	207.13
3"	3.500	58.3	4.9	10.26	9.8	40.75	19.6	158.25	20.6	173.76
4"	4.500	75.0	3.8	7.99	7.6	31.82	15.3	125.01	16.0	137.49
6"	6.625	110	2.6	5.43	5.2	21.68	10.4	86.01	10.9	94.72
8"	8.625	144	2.0	4.17	4.0	16.67				
10"	10.750	179	1.6	3.35	3.2	13.38				
12"	12.750	213	1.3	2.82	2.7	11.29				
14"	14.000	233			2.5	10.28				
16"	16.000	267			2.1	9.00				

Plastic Irrigation Pipe
S_b = 1,000 psi, E = 400,000 psi

Nom. Size	D_o (in)	R_b (ft)	L = 20'		L = 22'		L = 40'	
			α (deg)	A (in)	α (deg)	A (in)	α (deg)	A (in)
6"	6.140	102	5.6	23.38	11.2	92.64	11.8	102.00
8"	8.160	136	4.2	17.62	8.4	70.09	8.8	77.22
10"	10.200	170	3.4	14.10	6.7	56.22		
12"	12.240	204	2.8	11.76	5.6	46.92		

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ASTM D3034 Pipe S_b = 2,000 psi, E = 400,000 psi						
Nom. Size	D_o (in)	R_b (ft)	L = 14'		L = 20'	
			α (deg)	A (in)	α (deg)	A (in)
4"	4.215	35.1	11.4	33.04	16.3	66.51
6"	6.275	52.3	7.7	22.36	11.0	45.35
8"	8.400	70.0	5.7	16.75	8.2	34.06
10"	10.500	87.5	4.6	13.41	6.5	27.31
12"	12.500	104	3.9	11.27	5.5	22.97
15"	15.300	128	3.1	9.22	4.5	18.79

Open-Cut (Trench) and Exposed Installations
The maximum offsets of angular joint deflection and longitudinal bending cannot be combined. For design planning purposes, only the offset from angular joint deflection or longitudinal bending can be used. If greater offsets are required, utilize shorter pipe segments or place a fitting in the line.

When bending PVC pipe longitudinally, the two pipe segments of the assembled joint must remain in straight alignment through bracing or backfill. A fulcrum should be created at the inside of the curve of the pipe's midpoint using compacted backfill.

We recommend that only manual force be used to bend PVC pipe in open-cut and exposed installations. Using mechanical equipment could easily surpass the allowable flexural stress limits of the pipe. For this reason, longitudinal bending of pipe sized larger than 12" is not recommended in open-cut installations due to the large forces required.

Horizontal Directional Drilling and Pipe Bursting Installations
As a pipeline is flexed underground through a drilled bore path, longitudinal bending becomes the dominating effect to control. Proper installation planning must include a check that the bore path's radius of curvature at all locations does not violate the bend radius of our PVC pipe products.

Additionally, maximum angular joint deflection and minimum bend radius requirements must be adhered to for the section of pipe assembled prior to entrance in to the underground bore path. The point at which a joint drops into the bore mud is especially critical to monitor.

If a pipe joint is over-deflected, the sealing integrity of the gasket can be compromised allowing bore mud to enter the joint surfaces.

Warnings
The assembly of all pipe joints should be performed with both segments in straight alignment and in accordance with all manufacturer and industry standard instructions. Spigot insertion depths must still be maintained on gasketed integral bell PVC pipe joints after angular joint deflection and longitudinal bending.

Exceeding the posted maximum angular joint deflection values can cause failure of the pipe through fracture or loss of gasket sealing integrity.

Violating the minimum bend radius of a pipe segment will subject the pipe wall to excessive stresses that can cause fracture.

References

- Uni-Bell PVC Pipe Association. *Handbook of PVC Pipe Design and Construction*. 5th Ed. Chapters 8, 10, & 13.