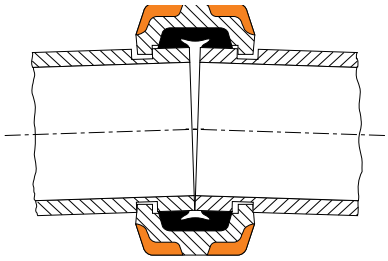
THE VICTAULIC PIPING METHOD FOR ACCOMMODATING PIPE OFFSETS

1. Pipe Offsets

Victaulic flexible couplings offer the designer a method to accommodate offsets of pipe runs due to misalignment or building settlement. The offset transition can be achieved only with flexible couplings as they allow for angular deflection at each joint.



Offsets are determined by the amount of lateral misalignment on the particular pipe run and the length along the pipe run that is required for the parallel shift of the run. On Figure 1, these two parameters are shown as the Y-Displacement (lateral misalignment) and the X-Displacement (offset length), respectively. Also, shown on Figure 1, is how flexible couplings deflect from the straight line to allow for the misalignment/settlement.

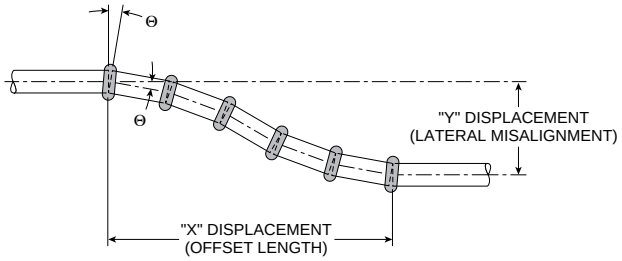


Figure 1

The pipe spools are first deflected in the direction of the misalignment until the mid-point of a particular pipe spool is more than half of the required Y-Displacement. This spool then becomes a transition spool as an equal number of couplings and pipe spools are required on either side of the transition spool to deflect the pipeline back to its original direction.

A major objective in designing for a misalignment is to achieve the required Y-Displacement using the minimum number of couplings. To this end, because of symmetry around a transition point, as explained earlier, the point of inflection is a pipe spool and not a coupling. Therefore, for all calculations and results published in this section, an even number of couplings and an odd number of pipe spools have been used. Also, to maximize the deflection at each joint, cut groove pipe should be considered. Should roll grooved joints be used, then the deflection available will be one-half that of a cut grooved joint.

The number of couplings and the length of the pipe spools are the two variables that can be altered to obtain the desired misalignment. Other factors, such as the maximum angle of deflection at each coupling and the maximum pipe end separation are a function of the size and style coupling being used (refer to coupling Performance Data).

The following is a technical explanation of the formulas derived to calculate the number of couplings, spool length, "X" and "Y" Displacements. For convenience, examples are shown in this report and the use of the Tables at the end of this section provide an easy selection.

The geometric derivation to accommodate offsets starts with the deflection on one pipe spool from the pipe run at the angle Θ (see Figure 2).

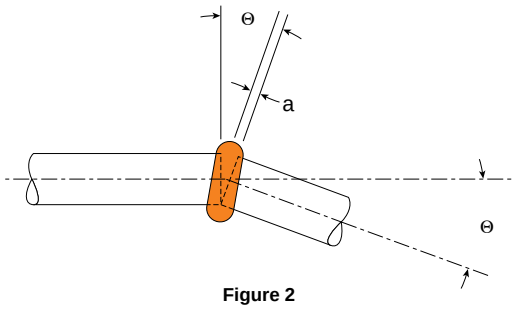


Figure 2

The Y-Displacement from the pipe run centerline after the first deflected spool is shown as $\Delta Y_1 = (L+a)\ SIN\ \Theta$, where "L" is the length of the pipe spool and "a" is one-half the maximum pipe end separation for the particular coupling to be used. As the second spool is connected and deflected, also at the angle Θ, the total angle of deflection from the pipe run is Θ + Θ, or 2Θ (see Figure 3).

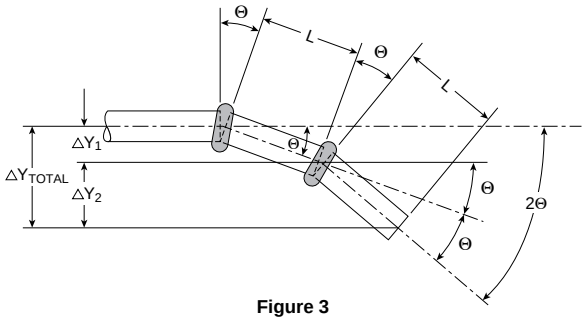


Figure 3

The Y-Displacement due to the second coupling and pipe spool is $\Delta Y_2 = (L+a)\ SIN\ 2\Theta$.

Since the length of each pipe spool is equal, then the total Y-Displacement to the end of the second pipe spool from the pipe run is the sum of each spool or:
$\Delta Y_{TOTAL} = \Delta Y_1 + \Delta Y_2 = (L+a)\ (SIN\ \Theta + SIN\ 2\Theta)$.

When the value of ΔY_{TOTAL} is at least half of the required Y-Displacement, then the last calculated pipe length up to that point becomes the point of transition. Geometrical symmetry about this point allows that the actual Y-Displacement of the completed misalignment will be equal to two times the ΔY_{TOTAL} up to the transition spool piece plus the Y-Displacement of the spool piece itself, or:

$$Y\text{ - Displacement} = (L + a)\ [2(SIN\ \Theta) + 2(SIN\ 2\Theta) + \ldots$$
$$2\ (SIN\ (l - 1)\ \Theta) + (L + a)\ [SIN\ l\Theta]$$

Where "l" is the number of spool pieces to achieve the transition and is equal to one-half of the number of couplings involved in the misalignment.

This expression is mathematically simplified to:

$$\text{Y-Displacement} = (L + a)\left[SIN\, l\theta + 2\sum_{n=1}^{l-1} SIN\ \ n\Theta\right]$$

Where n = the total number of couplings in the misalignment, and l = n/2.

By using the same geometric and trigonomic relations, the distance in the X direction required for the misalignment is as follows:

$$\text{Y-Displacement} = (L + a)\left[COS\, l\theta + 2\sum_{n=1}^{l-1} COS\ n\Theta\right]$$

For convenience, Tables 1 through 6 provide the number of Victaulic flexible couplings (i.e. S/75, 77, 791, 78) and cut grooved pipe spool lengths to obtain required offset lengths (X-Displacements) and misalignments (Y-Displacements) for nominal pipe sizes of 4 - 12" (100 - 300 mm). For other Victaulic couplings, pipe sizes or pipe preparation, use the previous formulas or contact Victaulic for details.

Example 1
A designer wants to connect a 6" (150 mm) feed main from an existing building to a new structure. There is 66" (1676 mm) of pipe run between the connection points, and it is expected that a settlement of 3" (76.2 mm) will occur. To utilize the maximum deflection available, cut grooved pipe nipples will be used.

Requirements
Y - Displacement = 3" (76.2 mm)
X - Displacement = less than 66" (1676 mm)

Using Styles 75, 77, 791 or 78 Victaulic Flexible Couplings:
Maximum Pipe End Separation = .25" (6.4 mm) (From performance data for coupling)
Design Pipe End Separation* = .188" (4.8 mm)
½ Pipe End Separation, a = 0.094" (2.4 mm)
Maximum Angle of Deflection = 2° 10´= 2.167°
Design Angle of Deflection*, Θ = 1° 38´= 1.625°

*Reduced by 25% for design and installation purposes. The published maximum pipe end separation and angular deflection figures should be reduced by 50% for ¾" - 3½" (20 - 90 mm) sizes, and 25% for 4" and larger sizes.

Try: 4 Couplings (n = 4) l = n/2 = 2

Spool Lengths, L = 12"
a = .094"
Θ = 1.625°

$$\text{Y-Displacement} = (L + a)\left[SIN\, l\theta + 2\sum_{n=1}^{l-1} SIN\ n\Theta\ \right]$$

= (12 + .094) {SIN (2 ✕ 1.625) + 2
[SIN(1 ✕ 1.625]}

= 12.094 {.057 + 2 (.028)} = 1.37"

Not enough; Y-Displacement of 3" (76.2 mm) is required, so try six couplings:
n = 6
l = n/2 = 3
L = 12"
a = .094"
Θ = 1.625°

Y-Displacement = (12 + .094) {SIN (3✕1.625) + 2
[SIN (1✕1.625) + SIN (2✕1.625)]}

= 12.094 {.085 + 2 [.028 + .057]} = 3.08"

Y-Displacement is sufficient (exceeds 3" requirement).

Check: X-Displacement

$$\text{X-Displacement} = (L + a)\left[COS\, l\theta + 2\sum_{n=1}^{l-1} COS\ n\Theta\right]$$

n = 6
l = n/2 = 3
L = 12"
a = .094"
Θ = 1.625°
= 12.094 {COS (3 ✕ 1.625) + 2[COS (1 ✕ 1.625)
+ COS (2 ✕ 1.625)]}

X-Displacement=60.38" (1533.7 mm)
X-Displacement is sufficient (less than 66"/1676 mm requirement)

With six (6) 6" (150 mm) flexible couplings and five (5) 12" (300 mm) cut groove pipe spools, the misalignment can be accommodated, attaining the required Y-Displacement in the limited X-Displacement. This information can be found in the Tables for Offset Results for 6" (150 mm) (Nominal) Pipe. See Example 2 for a demonstration of how to use the Tables to solve offset problems.

Example 2
A designer wants to connect two 10" (250 mm) parallel pipelines whose centers are misaligned by 4" (101.6 mm). The pipe ends are separated by 120" (3048 mm).

Using the Table for 10" (250 mm) (Nominal) Pipe, search for a coupling quantity and spool length combination that allows for a maximum Y-displacement of 4" (101.6 mm) in a minimum X-Displacement of 120". From this Table, eight (8) 10" (250 mm) flexible couplings with 16" (406.4 mm) long cut grooved spool pieces will accommodate the Displacement = 4.493"/114.1 mm). The excess distance between the 120" (3048 mm) required and the 112.548" (2859 mm) shown in the Table can be attained either through adjustment of the pipe lengths along the entire pipe run, or the addition of one extra pipe spool approximately 7.5" (190.5 mm).

From the Table, it is evident that there are several other combinations to accommodate the offset, all perfectly acceptable. However, the best selection is one which minimizes the number of couplings, thereby reducing overall costs and improving efficiency.

Offset Results for 4" (100 mm) (Nominal) Pipe

26.03-1A

Number of Couplings	Dimensions Inches/millimeters		
	Spool Length	X-Displacement	Y-Displacement
4	6 152	18.250 464	1.015 26
4	9 229	27.234 692	1.515 38
4	12 305	36.218 920	2.015 51
4	15 381	45.203 1148	2.515 64
4	18 457	54.187 1376	3.015 77
4	21 533	63.171 1605	3.514 89
4	24 610	72.156 1833	4.014 102
6	6 152	30.368 771	2.283 58
6	9 229	45.319 1151	3.406 87
6	12 305	60.269 1531	4.530 115
6	15 381	75.220 1911	5.654 144
6	18 457	90.170 2290	6.778 172
6	21 533	105.121 2670	7.902 201
6	24 610	120.071 3050	9.025 229
8	6 152	42.424 1078	4.054 103
8	9 229	63.309 1608	6.050 154
8	12 305	84.195 2139	8.046 204
8	15 381	105.080 2669	10.041 255
10	6 152	54.395 1382	6.326 161
10	9 229	81.174 2062	9.441 240
12	6 152	66.261 1683	9.095 231

Offset Results for 5" (125 mm) (Nominal) Pipe

26.03-2A

Number of Couplings	Dimensions Inches/millimeters		
	Spool Length	X-Displacement	Y-Displacement
4	6 152	18.260 464	0.824 21
4	9 229	27.250 692	1.230 31
4	12 305	36.240 920	1.636 42
4	15 381	45.229 1149	2.041 52
4	18 457	54.219 1377	2.447 62
4	21 533	63.209 1606	2.853 72
4	24 610	72.199 1834	3.258 83
6	6 152	30.403 772	1.853 47
6	9 229	45.370 1152	2.766 70
6	12 305	60.337 1533	3.678 93
6	15 381	75.305 1913	4.591 117
6	18 457	90.272 2293	5.503 140
6	21 533	105.240 2673	6.415 163
6	24 610	120.207 3053	7.328 186
8	6 152	42.503 1080	3.293 84
8	9 229	63.428 1611	4.914 125
8	12 305	84.352 2143	6.535 166
8	15 381	105.277 2674	8.156 207
8	18 457	126.201 3206	9.776 248
8	21 533	147.126 3737	11.397 289
10	6 152	54.548 1386	5.140 131
10	9 229	81.402 2068	7.671 195
10	12 305	108.257 2750	10.201 259
12	6 152	66.523 1690	7.394 188
12	9 229	99.273 2522	11.034 280
14	6 152	78.416 1992	10.052 255

Offset Results for 6" (150 mm) (Nominal) Pipe

26.03-3A

Number of Couplings	Dimensions Inches/millimeters		
	Spool Length	X-Displacement	Y-Displacement
4	6 152	18.267 464	0.691 18
4	9 229	27.259 692	1.032 26
4	12 305	36.252 921	1.372 35
4	15 381	45.245 1149	1.713 44
4	18 457	54.238 1378	2.053 52
4	21 533	63.230 1606	2.394 61
4	24 610	72.223 1834	2.734 70
6	6 152	30.422 773	1.555 39
6	9 229	45.399 1153	2.321 59
6	12 305	60.376 1534	3.087 78
6	15 381	75.353 1914	3.852 98
6	18 457	90.330 2294	4.618 117
6	21 533	105.307 2675	5.384 137
6	24 610	120.285 3055	6.149 156
8	6 152	42.548 1081	2.764 70
8	9 229	63.495 1613	4.124 105
8	12 305	84.442 2145	5.485 139
8	15 381	105.389 2677	6.845 174
8	18 457	126.336 3209	8.206 208
8	21 533	147.283 3741	9.566 243
8	24 610	168.230 4273	10.927 278
10	6 152	54.635 1388	4.316 110
10	9 229	81.533 2071	6.440 164
10	12 305	108.430 2754	8.565 218
10	15 381	135.328 3437	10.689 272
12	6 152	66.674 1694	6.210 158
12	9 229	99.497 2527	9.267 235
14	6 152	78.653 1998	8.445 215
16	6 152	90.564 2300	11.019 280

Offset Results for 8" (200 mm) (Nominal) Pipe

26.03-4A

Number of Couplings	Dimensions Inches/millimeters		
	Spool Length	X-Displacement	Y-Displacement
4	6 152	18.273 464	0.532 14
4	9 229	27.268 693	0.794 20
4	12 305	36.264 921	1.056 27
4	15 381	45.260 1150	1.318 33
4	18 457	54.255 1378	1.580 40
4	21 533	63.251 1607	1.842 47
4	24 610	72.247 1835	2.103 53
6	6 152	30.441 773	1.197 30
6	9 229	45.428 1154	1.786 45
6	12 305	60.414 1535	2.375 60
6	15 381	75.400 1915	2.964 75
6	18 457	90.387 2296	3.553 90
6	21 533	105.373 2676	4.143 105
6	24 610	120.360 3057	4.732 120
8	6 152	42.592 1082	2.127 54
8	9 229	63.561 1614	3.174 81
8	12 305	84.530 2147	4.221 107
8	15 381	105.498 2680	5.268 134
8	18 457	126.467 3212	6.315 160
8	21 533	147.435 3745	7.363 187
8	24 610	168.404 4277	8.410 214
10	6 152	54.720 1390	3.322 84
10	9 229	81.660 2074	4.958 126
10	12 305	108.599 2758	6.593 167
10	15 381	135.538 3443	8.229 209
10	18 457	162.478 4127	9.864 251
10	21 533	189.417 4811	11.500 292
12	6 152	66.819 1697	4.782 121
12	9 229	99.715 2533	7.136 181
12	12 305	132.611 3368	9.490 241
12	15 381	165.507 4204	11.844 301
14	6 152	78.884 2004	6.505 165
14	9 229	117.719 2990	9.708 247
16	6 152	90.908 2309	8.492 216

Offset Results for 10" (250 mm) (Nominal) Pipe

26.03-5A

Number of Couplings	Dimensions Inches/millimeters		
	Spool Length	X-Displacement	Y-Displacement
4	8 203	24.274 617	0.565 14
4	12 305	36.270 921	0.844 21
4	16 406	48.267 1226	1.124 29
4	20 508	60.263 1530	1.403 36
4	24 610	72.259 1835	1.682 43
6	8 203	40.445 1027	1.271 32
6	12 305	60.434 1535	1.899 48
6	16 406	80.422 2043	2.528 64
6	20 508	100.411 2550	3.156 80
6	24 610	120.399 3058	3.784 96
8	8 203	56.602 1438	2.260 57
8	12 305	84.575 2148	3.376 86
8	16 406	112.548 2859	4.493 114
8	20 508	140.522 3569	5.610 142
8	24 610	168.495 4280	6.726 171
10	8 203	72.739 1848	3.530 90
10	12 305	108.687 2761	5.274 134
10	16 406	144.635 3674	7.019 180
10	20 508	180.584 4587	8.763 223
10	24 610	216.532 5500	10.508 267
12	8 203	88.851 2257	5.081 129
12	12 305	132.762 3372	7.593 193
12	16 406	176.673 4487	10.104 257
14	8 203	104.934 2665	6.914 176
14	12 305	156.793 3983	10.331 262
16	8 203	120.982 3073	9.027 229

Offset Results for 12" (300 mm) (Nominal) Pipe

26.03-6A

Number of Couplings	Dimensions Inches/millimeters		
	Spool Length	X-Displacement	Y-Displacement
4	8 203	24.276 617	0.474 12
4	12 305	36.273 921	0.708 18
4	16 406	48.271 1226	0.942 24
4	20 508	60.268 1531	1.176 30
4	24 610	72.266 1836	1.410 36
6	8 203	40.452 1027	1.065 27
6	12 305	60.444 1535	1.592 40
6	16 406	80.436 2043	2.118 54
6	20 508	100.428 2551	2.645 67
6	24 610	120.420 3059	3.171 81
8	8 203	56.618 1438	1.894 48
8	12 305	84.599 2148	2.830 72
8	16 406	112.581 2860	3.765 96
8	20 508	140.562 3570	4.701 119
8	24 610	168.543 4281	5.637 143
10	8 203	72.770 1848	2.958 75
10	12 305	108.734 2762	4.420 112
10	16 406	144.697 3675	5.883 149
10	20 508	180.661 4589	7.345 187
10	24 610	216.625 5502	8.807 224
12	8 203	88.905 2258	4.259 108
12	12 305	132.842 3374	6.364 162
12	16 406	176.780 4490	8.469 215
12	20 508	220.718 5606	10.574 269
14	8 203	105.019 2667	5.796 147
14	12 305	156.920 3986	8.660 220
14	16 406	208.821 5304	11.525 293
16	8 203	121.109 3076	7.568 192
16	12 305	180.962 4596	11.308 287