PPFA UserBulletin

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User Bulletin #17: Provisions for Expansion and Contraction in Plastic DWV and Roof Drain Systems

Provisions for Expansion and Contraction in Plastic DWV and Roof Drain Systems

Introduction

ABS and PVC plastic piping systems expand and contract with temperature changes more than metallic piping systems. Plastic systems are, however, less rigid than metal systems and can in most cases absorb repeated flexing. In fact, ABS and PVC pipe will develop less force than metal pipe when exposed to a temperature change.

Thermal expansion is generally not an issue in single family or low rise residential construction. However, in some cases involving extreme temperature ranges, high rise applications, long, straight pipe runs, or in installations where pipe is restrained special provisions may be required.

Important issues to consider include; making the calculations for thermal expansion where you have long piping runs, layouts to compensate for expansion and contraction are considered; and users should also consider referencing the ASPE Plumbing Components and Equipment Volume 4, Chapter 11, Thermal Expansion.

Temperature Ranges

Plumbing systems can be exposed to temperatures of zero or below to over 100° F during installation or if a building is left unheated for extended periods. Some installations, such as drains in unheated parking garages, may be subjected to the whole range of temperatures continually. Some installations in attics can also be exposed to higher temperatures.

Sanitary waste water temperatures of 60° F to 140º F should be considered for DWV piping systems. However, in laboratory tests, plastic pipe flowing full of 140° F water reached an outside surface temperature of only 110° F. In addition, only the smallest pipe sizes are likely to see the full water temperature extreme since the temperature moderates as it flows into the larger pipes. Neither roof drains nor DWV systems are expected to run full, especially with water at the extreme temperatures.

***NOTE**: This PPFA User Bulletin is designed to provide guidance in achieving the efficient, effective and proper use of plastic piping systems. The suggestions and advice contained in the Bulletin are offered merely to provide plastic pipe users with a general frame of reference. Because specific situations may and often do require special treatment, the suggestions and advice are obviously not universally applicable. Therefore, the user should carefully assess the requirements of his specific situation before making practical application of anything contained in this publication.*

Construction Codes

Installation shall be done in accordance with all applicable construction codes and the manufacturer's instructions.

The International Plumbing Code (IPC) requires that piping be installed so as to prevent stresses and strains that exceed the structural strength of the pipe or fittings. Provisions must be made to protect piping from damage resulting from expansion, contraction and structural settlement.

Expansion Coefficients

The coefficients of expansion for ABS and PVC materials have been established and published for years. Table 1 lists the "free body" coefficients that are determined under laboratory conditions in which unrestrained specimens are brought to complete temperature equilibrium at each extreme.

Expansion/Contraction of Piping

For any selected temperature range the theoretical expansion/contraction can be readily calculated using the formula given under Table 1 using the ABS or the PVC coefficient of expansion. The values calculated for a range of temperature changes and pipe run lengths are shown in Table 2 for PVC and Table 4 for ABS.

However, installed piping hardly ever attains the "free body" condition because all surface contact would have to be free of friction and there could be no end or branch connections. In addition, while installed DWV piping can be expected to reach temperature equilibrium, this takes time and is most likely to occur in the middle of the temperature range rather than at the extremes produced in the flow of hot and cold waste. Therefore the selection of a "temperature range" and the recognition of the normal amount of restraint that results as part of every installation is the challenge in this process.

Providing for Expansion/Contraction

Compensation for thermal expansion in a piping system must be addressed by the engineer of record or qualified installing contractor. Compensation for thermal expansion may be accomplished by the installation of offsets, changes in direction, expansion joints or in some circumstances by restraining the system. Of primary concern is the connection between the long straight branch line and a stack fitting, because the stack is comparatively rigid and is held in place by the floor penetrations. Care should be taken to ensure that fittings, especially branch fittings such as wye's and tee's, are not exposed to stress due to alignment during installation or thermal expansion and contraction. Provisions for the branch line expansion must be made so that excessive force is not exerted on the stack wye or tee branch which can be accomplished by allowing the branch expansion to be absorbed at the outer end or by restraints. Proper hanger and restraint usage is needed at all changes in direction.

Expansion joints must be installed in accordance with manufacturer's written instructions.

Several manufactures produce ABS and PVC expansion joints for DWV piping systems in sizes 1 1/2 -inch through 4- inch. The Expansion Joint Manufacturers Association (www.ejma.org) publishes a comprehensive selection and application guide for expansion joints in multiple configurations and manufacturers. Properly designed and anchored, thermal expansion in DWV systems can be compensated for by restraining movement in the system.

Thermal Expansion & Expansion Loop Lengths

Figure 1 shows how supports and guides at offsets and changes in direction accommodate pipe expansion and con- traction. Table 2 provides amount of expansion (in) for PVC pipe based on run length (ft) and temperature change (° F). Table 3 provides Expansion Loop Lengths (in) for PVC based on pipe size and amount of expansion (in). Tables 4 & 5 provide similar information for ABS pipe.

Formula for PVC Table 3:

$L_o = [1.5\ ^{E}/s]^{½}\ [D\Delta\ L]^{½}$

L_o = Loop Length (in)
E = Modulus of elasticity (psi)
S = Stress (psi)
D = Pipe OD (in)
Δ L = Pipe Expansion (in)

Formula for ABS Table 5:

$L_o = [1.5\ ^{1}/\in]^{½}\ [D\Delta\ L]^{½}$

L_o = Loop Length (in)
$\in$ = Strain (in/in)
D = Pipe OD (in)
Δ L = Pipe Expansion (in)

Note: The PVC Loop Length Table is based on Limiting Stress (R & G Sloane - 1978). The ABS Loop Length Table is based on Limiting Strain. For a detailed discussion of these formulas and their derivation see PPI TR-21 Thermal Expansion and Contraction in Plastic Piping Systems. Modulus of Elasticity (E), Stress (S) and Strain ($\in$) are related by the formula $E = S/\in$.

Conclusions

Based on all available information, PPFA recommends that the above provisions be considered in addition to all specific requirements of the local plumbing code and manufacturer's installation instructions. All these methods have been found to be effective when properly utilized based on the job site conditions encountered.

Table 1: Coefficients of Expansion

	in/in/° F
ABS Cell class 42222	5.5×10^{-5}
PVC Cell class 12454	3.0×10^{-5}

Thermal Expansion Formula: $\Delta L = 12eL\ (\Delta T)$

ΔL = Pipe expansion (in)
e = Coefficient of Thermal Expansion (in/in/°F)
L = Length of run (ft)
ΔT = Temperature Change (° F)

Thermal Expansion Compensation

The change in length of pipe with temperature variation should always be considered when installing pipe lines and provisions made to compensate for this change in length. Tables 2 & 4 have been prepared to assist you in determining this expansion. The pipe Thermal Expansion tables represent the calculated values of pipe length changes (ΔL) in inches based on pipe run lengths of 10 to 100 feet and temperature changes of 30° F to 100° F.

Table 2: PVC Pipe Thermal Expansion (in)

Temp. change	Length of run (ft)									
DT (°F)	10	20	30	40	50	60	70	80	90	100
30	0.11	0.22	0.32	0.43	0.54	0.65	0.76	0.86	0.97	1.08
40	0.14	0.29	0.43	0.58	0.72	0.86	1.01	1.15	1.30	1.44
50	0.18	0.36	0.54	0.72	0.90	1.08	1.26	1.40	1.62	1.80
60	0.22	0.43	0.65	0.85	1.08	1.30	1.51	1.73	1.94	2.16
70	0.25	0.50	0.76	1.01	1.26	1.51	1.76	2.02	2.27	2.52
80	0.29	0.58	0.86	1.15	1.44	1.73	2.02	2.30	2.59	3.24
90	0.32	0.65	0.97	1.30	1.62	1.94	2.27	2.59	2.92	3.24
100	0.36	0.72	1.03	1.44	1.80	2.16	2.52	2.88	3.24	3.60

Example: highest temperature expected:	120° F
Lowest temperature expected:	50° F
Total change (ΔT):	70° F
Length of run:	40 ft

From 70° F (ΔT) row, read 1.01 inches length change

Table 3: PVC Pipe Expansion Loop Lengths (in)

Nom. pipe size	Avg. O.D.	Length of run (ft)									
		10	20	30	40	50	60	70	80	90	100
		Length of loop (in)									
1-1/2	1.900	16	23	28	33	36	40	43	46	49	51
2	2.375	18	26	32	36	41	45	48	52	55	58
3	3.500	22	31	38	44	49	54	58	63	66	70
4	4.500	25	35	43	50	56	61	66	71	75	79
6	6.625	30	43	53	61	68	74	80	86	91	96
8	8.625	35	49	60	69	78	86	92	98	104	110
10	10.750	39	55	67	77	87	95	102	110	116	122
12	12.750	42	60	73	84	94	103	112	119	126	133

Note: Table based on stress and modulus of elasticity at 130° F. Per R. & G Sloane, 1978.
ΔT = 50° F
S = 600 psi
E = 3.1 x 10^{-5} psi

Table 4: ABS Pipe Thermal Expansion (in)

TEMP. CHANGE DT (° F)	LENGTH OF RUN (FT)									
	10	20	30	40	50	60	70	80	90	100
30	0.20	0.40	0.59	0.79	0.99	1.19	1.39	1.58	1.78	1.98
40	0.26	0.53	0.79	1.06	1.32	1.58	1.85	2.11	2.38	2.64
50	0.33	0.66	0.99	1.32	1.65	1.98	2.31	2.64	2.97	3.30
60	0.40	0.79	1.19	1.58	1.98	2.38	2.77	3.17	3.56	3.98
70	0.46	0.92	1.39	1.85	2.31	2.77	3.23	3.70	4.16	4.62
80	0.53	1.08	1.58	2.11	2.64	3.17	3.70	4.22	4.75	5.28
90	0.59	1.19	1.78	2.38	2.97	3.56	4.16	4.75	5.35	5.94
100	0.66	1.32	1.98	2.64	3.30	3.96	4.62	5.28	5.94	6.60

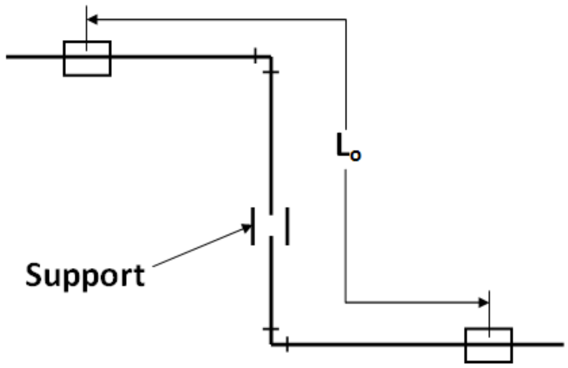
Example:
Highest heat expected: 120° F
Lowest temperature expected: 50° F.
Total temperature change: 70° F
Length of run: 40 ft
Length change: Read the change in length in inches by going to 70° F, go to 40 feet of run column, row, read 1.85 inches length change.

Table 5: ABS Pipe Expansion Loop Length (in)

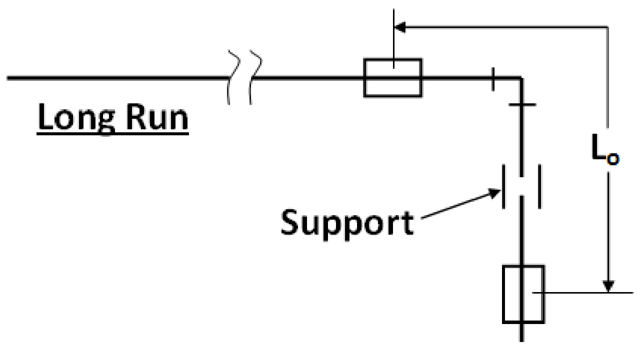
NOM. PIPE SIZE	AVG. O.D.	LENGTH OF RUN (FT)									
		10	20	30	40	50	60	70	80	90	100
1-1/2	1.900	16	23	28	32	36	39	43	45	48	51
2	2.375	18	25	31	36	40	44	48	51	54	57
3	3.500	22	31	38	44	49	53	58	62	65	69
4	4.500	25	35	43	48	55	61	65	70	74	78
6	6.625	30	42	52	60	67	74	79	86	90	95
8	8.825	34	48	59	68	77	84	91	97	103	108
10	10.750	38	54	68	76	85	94	101	108	115	121
12	12.750	42	59	72	83	93	102	110	118	126	132

Based on 50° F temperature change and Limiting Strain of 0.0035 in/in. PPI TR 21.

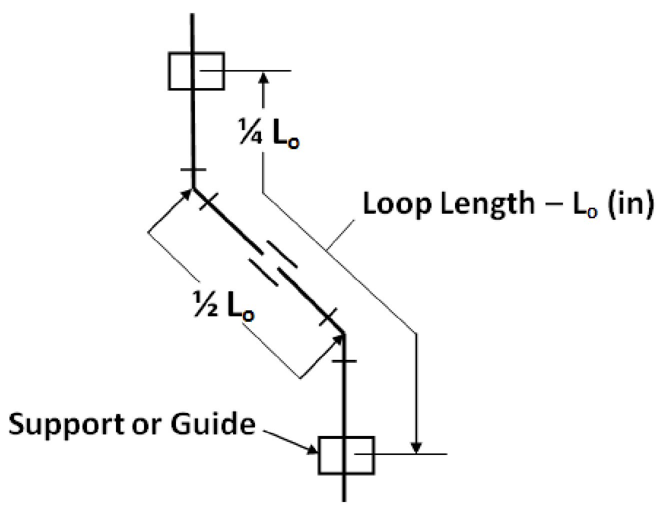
Figure 1: Offset & Change of Direction Configurations



Horizontal offset.



Change of direction.



Vertical or horizontal offset.