Expansion and Contraction of PVC Schedule 40, PVC Schedule 80, PVC PR 200 and PVC PR 160

ABS, PVC and CPVC pipe, like other piping materials, undergo length changes as a result of temperature variations above and below the installation temperature. They expand and contract 4.5 to 5 times more than steel or iron pipe. The extent of the expansion or contraction is dependent upon the piping material's coefficient of linear expansion, the length of pipe between directional changes, and the temperature differential.

The coefficients of linear expansion (Y) for ABS, PVC, and CPVC (expressed in inches of expansion per 10°F temperature change per 100 feet of pipe) are as follows:

Material	Y (in./10°F/100 ft)
ABS	0.66
ABS Plus	0.500
PVC	0.36
CPVC	0.408

The amount of expansion or contraction can be calculated using the following formula:

$$e = \frac{Y\ (T1\text{-}T2)}{10} \times \frac{Lp}{100}$$

e = Dimensional change due to thermal expansion or contraction (in.)

Y = Expansion coefficient (See table above.) (in./10°F/100 ft)

(T1-T2) = Temperature differential between the installation temperature and the maximum or minimum system temperature, whichever provides the greatest differential (°F).

Lp = Length of pipe run between changes in direction (ft)

Example: How much expansion (e) can be expected in a 60 foot straight run of 2" diameter PVC pipe installed at 70°F and operating at 120°F?

Solution:

$$e = .360\ \frac{(120 - 70)}{10} \times \frac{60}{100} = .360 \times 5 \times .6 = 1.08 \text{ inches}$$

There are several ways to compensate for expansion and contraction. The most common methods are:

1. Expansion Loops (Fig. 1)
2. Offsets (Fig. 2)
3. Change in direction (Fig. 3)

Expansion Joints

A wide variety of products are available to compensate for thermal expansion in piping systems including:

- Piston type expansion joints
- Bellows type expansion joints
- Flexible bends

The manufacturers of these devices should be contacted to determine the suitability of their products for the specific application. In many cases these manufacturers provide excellent technical information on compensation for thermal expansion. Information on these manufacturers and industry standard may be obtained through the Expansion Joint Manufacturers Association WWW.EJMA.ORG.

When installing an expansion loop, no rigid or restraining supports should be placed within the leg lengths of the loop. The loop should be installed as closely as possible to the mid-point between anchors. Piping support guides should restrict lateral movement and direct axial movement into the loop. Lastly, the pipe and fittings should be solvent cemented together, rather than using threaded connections.

Modulus of Elasticity & Working Stress
Table 1

	ABS		PVC		CPVC	
	Modulus of Elasticity (psi)	Working Stress (psi)	Modulus of Elasticity (psi)	Working Stress (psi)	Modulus of Elasticity (psi)	Working Stress (psi)
73° F	250,000	N/A	420,000	2,000	370,000	2,000
90° F	240,000	N/A	380,000	1,500	360,000	1,820
100° F	230,000	N/A	350,000	1,240	350,000	1,640
120° F	215,000	N/A	300,000	800	340,000	1,300
140° F	195,000	N/A	200,000	400	325,000	1,000
160° F	180,000	N/A	N/A	N/A	310,000	800
180° F	N/A	N/A	N/A	N/A	290,000	500

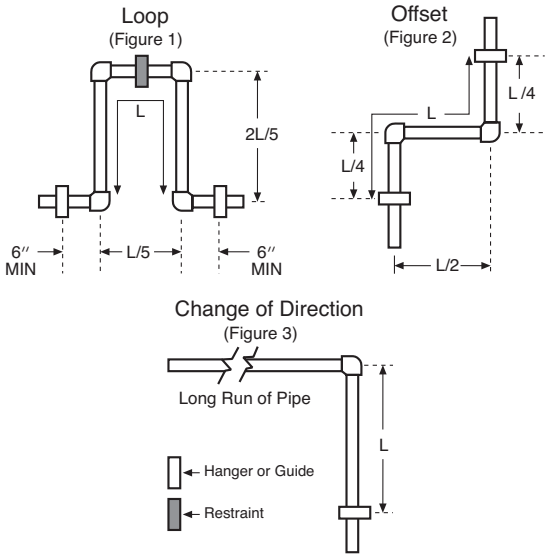
Modulus Data is Modulus of Elasticity in Tension per ASTM D 638

Expansion Loop Formula

$$L = \sqrt{\frac{3\ ED\ (\Delta L)}{2S}}$$

Where:

L = Loop length (in.)
E = Modulus of elasticity at maximum temerature (psi) (Table 1)
S = Working Stress at maximum temperature (psi) (Table 1)
D = Outside diameter of pipe (in.) (pages 22-34)
ΔL = Change in length due to change in temperature (in.)



Thermal Expansion in DWV and Storm Drainage Stacks

Plastic piping expands and contracts at a much greater rate than comparable metallic systems. Engineers, designers and installers should use resources such as the American Society of Plumbing Engineers Plumbing Engineering Design Handbook Volume 4, Chapter 11 (www.aspe.org) and the applicable local plumbing code to install stacks with adequate compensation for expansion and contraction. For vertical stacks in multi-story applications, compensation for expansion, contraction or building settling is often accommodated by the use of offsets or expansion joints. Secure above-ground vertical DWV or storm-drainage piping at sufficiently close intervals to maintain proper alignment and to support the weight of the piping and its contents. Support stack at base, and if over two stories in height, support stack at base and at each floor with approved riser clamps. Stacks should be anchored so that movement is directed to the offsets or expansion joints. If using expansion joints always follow the installation instructions and recommendations of the joint manufacturer. Compensation for thermal movement is usually not required for a vent system.

NOTICE

Failure to compensate for expansion and contraction caused by temperature change may result in system failure and property damage.

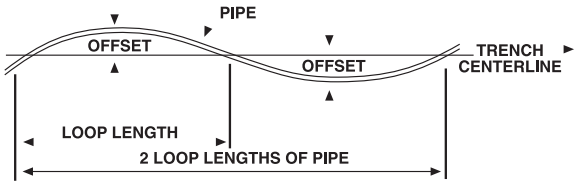
- Do not restrict expansion or contraction. Restraining movement in piping systems is not recommended and may result in joint or fitting failure.
- Use straps or clamps that allow for piping system movement.
- Align all piping system components properly without strain. Do not bend or pull pipe into position after being solvent welded.
- Do not terminate a pipe run against a stationary object (example: wall or floor joist).
- Do not install fittings under stress.

Thermal Expansion in Underground Systems

Compensation for expansion and contraction in underground applications is normally achieved by snaking the pipe in the trench. Solvent cemented joints must be used.

The following table shows recommended offsets and loop lengths for piping up to 3″ nominal size.

Loop Length In Feet	Max. Temp. Variation °F, Between Installation and Final Operation									
	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
	Loop Offset In Inches									
20	3.0	3.5	4.5	5.0	6.0	6.5	7.0	7.0	8.0	8.0
50	7.0	9.0	11.0	13.0	14.0	15.5	17.0	18.0	19.0	20.0
100	13.0	18.0	22.0	26.0	29.0	31.5	35.0	37.0	40.0	42.0



Note: This manual is not a complete engineering reference addressing all aspects of design and installation of thermal expansion in piping systems. Many excellent references are available on this topic. The American Society of Plumbing Engineers (www.ASPE.org) Data Book, Volume 4, 2008, Chapter 11 is an excellent resource for engineers on designing for thermal expansion.

Expansion and Contraction of CTS CPVC

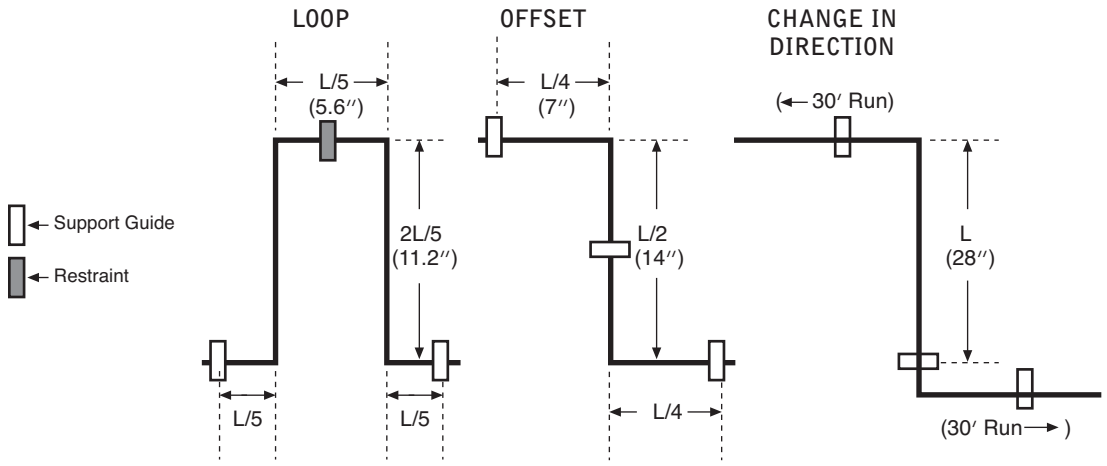
Basic expansion loop requirements for FlowGuard Gold® and ReUze® CTS CPVC are described below. One or more expansion loops, properly sized, may be required in a single straight run. The following charts can be used to determine expansion loop and offset lengths.

Expansion Loop Length (L), inches
for
100°F Temperature Change

Length of Run in Feet

Nominal Dia., In.	20′	40′	60′	80′	100′
½	16	23	28	32	36
¾	19	29	33	38	43
1	22	31	38	44	49
1¼	24	34	42	48	54
1½	26	37	45	52	59
2	30	42	52	60	67

Example: Tubing Size = 1/2″ Length of run = 60′ L = 28″ (from table)



NOTICE

Failure to compensate for expansion and contraction caused by temperature change may result in system failure and property damage.

- Do not restrict expansion or contraction. Restraining movement in piping systems is not recommended and may result in joint or fitting failure.
- Use straps or clamps that allow for piping system movement.
- Align all piping system components properly without strain. Do not bend or pull pipe into position after being solvent welded.
- Do not terminate a pipe run against a stationary object (example: wall or floor joist).
- Do not install fittings under stress.