Table I

Modulus of Elasticity & Stress vs. Temperature				
Temperature °F	**73°**	**80°**	**90°**	**100°**
Modulus of Elasticity "E" x 10^5 psi	4.23	4.14	3.99	3.85
Working Stress "S" psi	2,000	1,875	1,715	1,560
Temperature °F	**110°**	**120°**	**140°**	**150°**
Modulus of Elasticity "E" x 10^5 psi	3.70	3.55	3.23	3.08
Working Stress "S" psi	1,415	1,275	1,000	875

Table II

Physical & Thermal Properties			
Property		**CPVC**	**ASTM**
Specific Gravity	"Sp. Gr."	1.55	D 792
IZOD Impact Strength (ft. lbs./inch of notch)		3.0	D 256A
Modulus of Elasticity, psi	"E"	4.23×10^5	D 638
Ultimate Tensile Strength, psi		8,400	D 638
Compressive Strength, psi	"s"	9,600	D 695
Poisson's Ratio	"n"	.35 - .38	–
Working Stress @ 73°F, psi	"S"	2,000	D 1598
Hazen-Williams "C"Factor	"C"	150	–
Coefficient of Linear Expansion in./(in. °F)	"e"	3.4×10^{-5}	D 696
Thermal Conductivity BTU in/hr/ft^2/°F	"k"	0.95	C 177
Upper Temperature Limit	"°F"	210	–
Flammability		Flame Retardant	
Electrical Conductivity		Non Conductor	

Thermal Expansion

GF Harvel CPVC Fire Sprinkler Products, like all piping materials, will expand and contract with changes in temperature. The coefficient of linear expansion is 0.000034 inch/inch/°F. A 25°F change in temperature will cause an expansion of 1/2 inch for a 50 foot straight length. For most operating and installation conditions, the effects of thermal expansion and contraction are usually absorbed by the system at changes in direction of the piping. However, long straight runs of piping are more susceptible to experiencing measurable movement with changes in temperature (i.e. pipe installed in un-heated building during winter, then brought under heat as construction progresses). The installation of expansion loops, offsets, or bends is required on long straight runs to compensate for this movement. This will allow the piping system to absorb forces generated by expansion/contraction without damage.

The change in length caused by thermal expansion or contraction can be calculated as follows:

ΔL = 12 eL (ΔT)

e = 3.4×10^{-5} in./in. °F (Coefficient of Linear Expansion – Table II.)

L = Length of Run in Feet

ΔT = Temperature Change in °F (difference between lowest system temperature and maximum system temperature – whichever is greatest)

Example: How much will a 40 ft. run of 2" GF Harvel CPVC Fire Sprinkler pipe expand if the expected ambient temperature will range from 45° to 85°F?

ΔL = 12 eL (ΔT)

ΔL = 12 (.000034) x 40 x 40

ΔL = .65"

The change in length (ΔL) in inches based on temperature change and length of run is shown in Table III.

Table III

Temp. Change ΔT °F	Length of Run in Feet 5	10	15	20	25	30	35
	Thermal Expansion ΔL (In.)						
20	.04	.08	.12	.16	.20	.24	.29
30	.06	.12	.24	.24	.31	.37	.43
40	.08	.16	.33	.41	.41	.49	.57
50	.10	.20	.41	.51	.51	.61	.72
60	.12	.24	.49	.61	.61	.73	.86
70	.19	.29	.57	.71	.71	.88	1.00
80	.16	.33	.65	.82	.82	.98	1.14
90	.18	.37	.73	.92	.92	1.10	1.29
100	.20	.41	.82	1.02	1.02	1.22	1.43

Thermal Expansion in Inches

Temp. Change ΔT °F	Length of Run in Feet (cont.) 40	45	50	70	90	120	160
	Thermal Expansion ΔL (In.)						
20	.33	.37	.41	.57	.73	.98	1.31
30	.49	.55	.61	.86	1.10	1.47	1.96
40	.65	.74	.82	1.14	1.47	1.96	2.61
50	.82	.92	1.02	1.43	1.84	2.45	3.26
60	.98	1.10	1.22	1.71	2.20	2.94	3.92
70	1.14	1.29	1.43	2.00	2.57	3.43	4.57
80	1.31	1.47	1.63	2.28	2.94	3.92	5.22
90	1.47	1.66	1.84	2.57	3.30	4.41	5.88
100	1.63	1.84	2.04	2.86	3.67	4.90	6.53

Once the change in length (ΔL) has been determined, the length of an offset, expansion loop, or bend required to compensate for this change can be calculated as follows:

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

ℓ = Length of Expansion Loop in inches

E = Modulus of Elasticity at 100°F (Table I)

D = Average O.D. of Pipe

ΔL = Change in Length of Pipe Due to Change in Temperature (Table III)

S = Working Stress at 100°F (Table I)

The length of an offset, expansion loop, or bend required to compensate for this movement (ℓ) based on pipe size and length of run is shown in Table IV. These values are based on a temperature change (ΔT) of 70°F which covers most installation temperature ranges.

Table IV

Expansion Loop Length in Inches

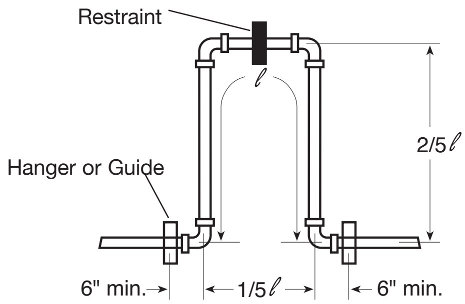
Nominal Pipe Size (in.)	Avg. O.D.	Length of Run in Feet 5	10	15	20	25	30	35
		Length of Loop (In.) Temperature = 30°F - 100°F ΔT = 70°F						
3/4	1.050	7	11	13	15	17	18	20
1	1.315	8	12	14	17	19	20	22
1-1/4	1.660	9	13	16	19	21	23	25
1-1/2	1.900	10	14	20	22	22	25	27
2	2.375	11	16	19	22	25	27	30
2-1/2	2.875	12	18	21	25	27	30	33
3	3.500	13	19	24	27	30	33	36

Nominal Pipe Size (in.)	Avg. O.D.	Length of Run in Feet (cont.) 40	45	50	70	90	120	160
		Length of Loop (In.) Temperature = 30°F - 100°F ΔT = 70°F						
3/4	1.050	21	22	24	28	32	37	42
1	1.315	24	25	26	31	35	41	47
1-1/4	1.660	26	28	30	35	40	46	53
1-1/2	1.900	28	30	32	38	43	49	57
2	2.375	32	34	35	42	48	55	63
2-1/2	2.875	35	37	39	46	52	60	70
3	3.500	38	41	43	51	58	67	77

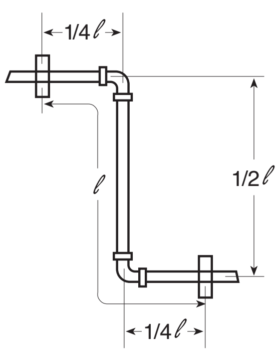
NOTE: Table IV is based on Stress & Modulus of Elasticity @ 100°F

Expansion Loop and Offset Configurations

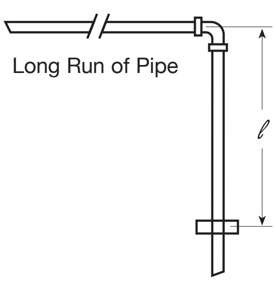
Loop



Offset



Change of Direction



Hangers or guides should only be placed in the loop, offset or change of direction as indicated above. Piping supports should restrict lateral movement and should direct axial movement into the expansion loop.

Thermal Expansion — Sample Calculation

Example: How much expansion can be expected in a 200 ft. run of 2" GF Harvel Fire Sprinkler CPVC pipe and how long should the expansion loop be to compensate for this expansion? (The expected temperature range will be from 40°F to 110°F.)

First Find: ΔT = (Change in Temperature)

ΔT = T2 - T1

ΔT = 10°F - 40°F

ΔT = 70°F

To Find: ΔL = (Amount of Expansion in in. from Table III.)

ΔL = DL of 160 ft. with a DT of 70°F + DL of 40 ft. with a DT of 70°F

ΔL = 4.57" + 1.14"

ΔL = 5.71"

— OR —

$\Delta L = 12eL(\Delta T)$

e = 3.4 x 10-5 (from Table II.)

L = Length of Run in Feet

ΔT = Change in Temperature in °F

ΔL = 12 x .000034 x 200 x 70

ΔL = 5.71"

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

ℓ = Length of Expansion Loop in inches

E = Modulus of Elasticity at 100°F (Table I)

D = Average O.D. of Pipe

ΔL = Change in Length of Pipe Due to Change in Temperature (Table III)

S = Working Stress at 100°F (Table I)

To find the length of the expansion loop or offset in inches

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

ℓ = Length of Expansion Loop in inches

E = Modulus of Elasticity at maximum temperature from Table I

D = Average Outside Diameter of the pipe from Table IV

S = Working Stress at maximum temperature from Table I

ΔL = Change in Length of Pipe Due to Change in Temperature from Table III

$$\ell = \sqrt{\frac{3 \times 370{,}000 \times 2.375 \times 5.71}{2 \times 1415}}$$

$$\ell = \sqrt{5319}$$

$$\ell = 72.93"$$