FLOW VELOCITY & FRICTION LOSS

SCHEDULE 40

Flow Rate (Gallons/ Minute)	Flow Velocity (ft/sec.)	Friction Loss (Ft.Water/ 100ft)	Friction Loss (psi/ 100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft.Water/ 100ft)	Friction Loss (psi/ 100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft.Water/ 100ft)	Friction Loss (psi/ 100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft.Water/ 100ft)	Friction Loss (psi/ 100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft.Water/ 100ft)	Friction Loss (psi/ 100ft)	Flow Rate (Gallons/ Minute)
GPM	1/2"			3/4"			1"			1-1/4"			1-1/2"			**GPM**
1	1.13	1.16	0.50	0.63	0.28	0.12	0.39	0.09	0.04	0.22	0.02	0.01				1
2	2.25	4.19	1.82	1.26	1.03	0.44	0.77	0.31	0.13	0.44	0.08	0.03	0.32	0.04	0.02	2
5	5.63	22.88	9.92	3.16	5.60	2.43	1.93	1.69	0.73	1.10	0.43	0.19	0.81	0.20	0.09	5
7	7.88	42.66	18.49	4.42	10.44	4.53	2.70	3.14	1.36	1.55	0.81	0.35	1.13	0.38	0.16	7
10	11.26	82.59	35.80	6.31	20.21	8.76	3.86	6.08	2.64	2.21	1.57	0.68	1.62	0.73	0.32	10
15				9.47	42.82	18.56	5.78	12.89	5.59	3.31	3.32	1.44	2.42	1.55	0.67	15
20				12.63	72.95	31.63	7.71	21.96	9.52	4.42	5.65	2.45	3.23	2.64	1.15	20
25							9.64	33.20	14.39	5.52	8.55	3.71	4.04	4.00	1.73	25
30							11.57	46.54	20.17	6.62	11.98	5.19	4.85	5.60	2.43	30
35										7.73	15.94	6.91	5.65	7.45	3.23	35
40										8.83	20.41	8.85	6.46	9.54	4.14	40
45										9.94	25.39	11.00	7.27	11.87	5.15	45
50										11.04	30.86	13.38	8.08	14.43	6.25	50
60													9.69	20.22	8.87	60

GPM	2"			2-1/2"			3"			4"			6"			GPM
5	0.49	0.06	0.03													**5**
7	0.68	0.11	0.05	0.48	0.05	0.02										**7**
10	0.97	0.21	0.09	0.68	0.09	0.04	0.44	0.03	0.01							**10**
15	1.46	0.45	0.20	1.02	0.19	0.08	0.66	0.07	0.03							**15**
20	1.95	0.77	0.34	1.37	0.33	0.14	0.88	0.11	0.05	0.51	0.03	0.01				**20**
25	2.44	1.17	0.51	1.71	0.49	0.21	1.10	0.17	0.07	0.64	0.05	0.02				**25**
30	2.92	1.64	0.71	2.05	0.69	0.30	1.32	0.24	0.10	0.77	0.06	0.03				**30**
35	3.41	2.18	0.94	2.39	0.92	0.40	1.54	0.32	0.14	0.89	0.08	0.04				**35**
40	3.90	2.79	1.21	2.73	1.18	0.51	1.76	0.41	0.18	1.02	0.11	0.05				**40**
45	4.39	3.47	1.51	3.07	1.46	0.63	1.99	0.51	0.22	1.15	0.13	0.06				**45**
50	4.87	4.22	1.83	3.41	1.78	0.77	2.21	0.61	0.27	1.28	0.16	0.07	0.56	0.02	0.01	**50**
60	5.85	5.92	2.56	4.10	2.49	1.08	2.65	0.86	0.37	1.53	0.23	0.10	0.67	0.03	0.01	**60**
70	6.82	7.87	3.41	4.78	3.32	1.44	3.09	1.15	0.50	1.79	0.30	0.13	0.79	0.04	0.02	**70**
75	7.31	8.94	3.88	5.12	3.77	1.63	3.31	1.30	0.56	1.92	0.34	0.15	0.84	0.05	0.02	**75**
80	7.80	10.08	4.37	5.46	4.25	1.84	3.53	1.47	0.64	2.04	0.39	0.17	0.90	0.05	0.02	**80**
90	8.77	12.53	5.43	6.15	5.28	2.29	3.97	1.82	0.79	2.30	0.48	0.21	1.01	0.07	0.03	**90**
100	9.74	15.23	6.60	6.83	6.42	2.78	4.41	2.22	0.96	2.55	0.59	0.25	1.12	0.08	0.03	**100**
125	12.18	23.03	9.98	8.54	9.70	4.21	5.52	3.35	1.45	3.19	0.89	0.38	1.40	0.12	0.05	**125**
150				10.24	13.60	5.90	6.62	4.70	2.04	3.83	1.24	0.54	1.68	0.17	0.07	**150**
175							7.72	6.25	2.71	4.47	1.65	0.72	1.96	0.22	0.10	**175**
200							8.82	8.00	3.47	5.11	2.12	0.92	2.25	0.29	0.12	**200**
250							11.03	12.10	5.24	6.39	3.20	1.39	2.81	0.43	0.19	**250**
300										7.66	4.49	1.95	3.37	0.61	0.26	**300**
350										8.94	5.97	2.59	3.93	0.81	0.35	**350**
400										10.22	7.64	3.31	4.49	1.03	0.45	**400**
450													5.05	1.29	0.56	**450**
500													5.61	1.56	0.68	**500**

NOTE: Spears® recommends that Flow Velocities be maintained at or below 5 feet per second in large diameter piping systems (i.e. 6" diameter and larger) to minimize the potential for hydraulic shock. Refer to Spears® engineering section entitled "Hydraulic Shock" for additional information. Friction loss data based on utilizing mean wall dimensions to determine average ID; actual ID may vary.

Suitable for Oil-Free air handling to 25 psi, not for distribution of compressed air or gas
See Spears® Product Sourcebook for product offerings

FLOW VELOCITY & FRICTION LOSS

SCHEDULE 40										
Flow Rate (Gallons/ Minute)	Flow Velocity (ft/sec.)	Friction Loss (Ft. Water/100ft)	Friction Loss (psi/100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft. Water/100ft)	Friction Loss (psi/100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft. Water/100ft)	Friction Loss (psi/100ft)	Flow Rate (Gallons/ Minute)
GPM	**8"**			**10"**			**12"**			**GPM**
100	0.65	0.02	0.01							**100**
125	0.81	0.03	0.01							**125**
150	0.97	0.04	0.02							**150**
175	1.13	0.06	0.03							**175**
200	1.29	0.08	0.03	0.82	0.02	0.01				**200**
250	1.62	0.11	0.05	1.03	0.04	0.02				**250**
300	1.94	0.16	0.07	1.23	0.05	0.02				**300**
350	2.27	0.21	0.09	1.44	0.07	0.03	1.01	0.03	0.01	**350**
400	2.59	0.27	0.12	1.64	0.09	0.04	1.16	0.04	0.02	**400**
450	2.91	0.34	0.15	1.85	0.11	0.05	1.30	0.05	0.02	**450**
500	3.24	0.41	0.18	2.05	0.14	0.06	1.44	0.06	0.02	**500**
750	4.85	0.87	0.38	3.08	0.29	0.12	2.17	0.12	0.05	**750**
1000	6.47	1.48	0.64	4.10	0.49	0.21	2.89	0.21	0.09	**1000**
1250				5.13	0.74	0.32	3.61	0.31	0.14	**1250**
1500				6.15	1.03	0.45	4.33	0.44	0.19	**1500**
2000							5.78	0.75	0.33	**2000**
2500							7.22	1.13	0.49	**2500**

NOTE: Spears® recommends that Flow Velocities be maintained at or below 5 feet per second in large diameter piping systems (i.e. 6" diameter and larger) to minimize the potential for hydraulic shock. Refer to Spears® engineering section entitled "Hydraulic Shock" for additional information. Friction loss data based on utilizing mean wall dimensions to determine average ID; actual ID may vary.

FLOW VELOCITY & FRICTION LOSS

SCHEDULE 80

Flow Rate (Gallons/ Minute)	Flow Velocity (ft/sec.)	Friction Loss (Ft. Water/ 100ft)	Friction Loss (psi/ 100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft. Water/ 100ft)	Friction Loss (psi/ 100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft. Water/ 100ft)	Friction Loss (psi/ 100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft. Water/ 100ft)	Friction Loss (psi/ 100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft. Water/ 100ft)	Friction Loss (psi/ 100ft)	Flow Rate (Gallons/ Minute)
GPM	**1/2"**			**3/4"**			**1"**			**1-1/4"**			**1-1/2"**			**GPM**
1	1.48	2.24	0.97	0.78	0.48	0.21	0.47	0.14	0.06	0.26	0.03	0.01	0.19	0.01	0.01	**1**
2	2.96	8.08	3.50	1.56	1.73	0.75	0.93	0.49	0.21	0.52	0.12	0.05	0.38	0.05	0.02	**2**
5	7.39	44.12	19.12	3.91	9.45	4.10	2.33	2.67	1.16	1.30	0.64	0.28	0.96	0.29	0.13	**5**
7	10.35	82.27	35.66	5.48	17.62	7.64	3.26	4.98	2.16	1.81	1.20	0.52	1.34	0.54	0.24	**7**
10	14.78	159.26	69.04	7.82	34.11	14.79	4.66	9.65	4.18	2.59	2.32	1.00	1.92	1.05	0.46	**10**
15				11.74	72.27	31.33	6.99	20.44	8.86	3.89	4.91	2.13	2.87	2.23	0.97	**15**
20				15.65	123.13	53.38	9.33	34.82	15.09	5.18	8.36	3.62	3.83	3.80	1.65	**20**
25							11.66	52.64	22.82	6.48	12.64	5.48	4.79	5.74	2.49	**25**
30							13.99	73.78	31.98	7.77	17.71	7.68	5.75	8.04	3.49	**30**
35							16.32	98.16	42.55	9.07	23.56	10.21	6.71	10.70	4.64	**35**
40							18.65	125.70	54.49	10.37	30.17	13.08	7.66	13.71	5.94	**40**
45										11.66	37.53	16.27	8.62	17.05	7.39	**45**
50										12.96	45.62	19.77	9.58	20.72	8.98	**50**
60										15.55	63.94	27.72	11.50	29.04	12.59	**60**
70										18.14	85.06	36.87	13.41	38.64	16.75	**70**
75										19.43	96.66	41.90	14.37	43.90	19.03	**75**
80										20.73	108.93	47.22	15.33	49.48	21.45	**80**
90													17.24	61.54	26.68	**90**
100													19.16	74.80	32.42	**100**
125													23.95	113.07	49.02	**125**
150													28.74	158.49	68.71	**150**

GPM	2"			2-1/2"			3"			4"			6"			GPM
1	0.11	0.00	0.00	0.08	0.00	0.00	0.05	0.00	0.00							**1**
2	0.22	0.02	0.01	0.16	0.01	0.00	0.10	0.00	0.00							**2**
5	0.56	0.08	0.04	0.39	0.03	0.01	0.25	0.01	0.01							**5**
7	0.78	0.15	0.07	0.55	0.06	0.03	0.35	0.02	0.01							**7**
10	1.12	0.30	0.13	0.78	0.12	0.05	0.50	0.04	0.02							**10**
15	1.67	0.63	0.27	1.17	0.26	0.11	0.75	0.09	0.04							**15**
20	2.23	1.07	0.47	1.56	0.45	0.19	1.00	0.15	0.07	0.57	0.04	0.02				**20**
25	2.79	1.63	0.70	1.95	0.68	0.29	1.24	0.23	0.10	0.71	0.06	0.03				**25**
30	3.35	2.28	0.99	2.34	0.95	0.41	1.49	0.32	0.14	0.85	0.08	0.04				**30**
35	3.91	3.03	1.31	2.73	1.26	0.55	1.74	0.43	0.18	1.00	0.11	0.05				**35**
40	4.46	3.88	1.68	3.11	1.62	0.70	1.99	0.54	0.24	1.14	0.14	0.06				**40**
45	5.02	4.83	2.09	3.50	2.01	0.87	2.24	0.68	0.29	1.28	0.17	0.08				**45**
50	5.58	5.87	2.54	3.89	2.45	1.06	2.49	0.82	0.36	1.42	0.21	0.09	0.63	0.03	0.01	**50**
60	6.69	8.22	3.56	4.67	3.43	1.49	2.99	1.15	0.50	1.71	0.30	0.13	0.75	0.04	0.02	**60**
70	7.81	10.94	4.74	5.45	4.56	1.98	3.48	1.54	0.67	1.99	0.39	0.17	0.88	0.05	0.02	**70**
75	8.37	12.43	5.39	5.84	5.18	2.25	3.73	1.74	0.76	2.14	0.45	0.19	0.94	0.06	0.03	**75**
80	8.93	14.01	6.07	6.23	5.84	2.53	3.98	1.97	0.85	2.28	0.51	0.22	1.00	0.07	0.03	**80**
90	10.04	17.42	7.55	7.01	7.26	3.15	4.48	2.45	1.06	2.56	0.63	0.27	1.13	0.09	0.04	**90**
100	11.16	21.18	9.18	7.79	8.83	3.83	4.98	2.97	1.29	2.85	0.76	0.33	1.25	0.10	0.04	**100**
125	13.95	32.02	13.88	9.73	13.34	5.78	6.22	4.49	1.95	3.56	1.16	0.50	1.57	0.16	0.07	**125**
150	16.74	44.88	19.45	11.68	18.70	8.11	7.47	6.30	2.73	4.27	1.62	0.70	1.88	0.22	0.10	**150**
175	19.53	59.70	25.88	13.63	24.88	10.79	8.71	8.38	3.63	4.98	2.16	0.93	2.19	0.29	0.13	**175**
200	22.32	76.45	33.14	15.57	31.86	13.81	9.96	10.73	4.65	5.70	2.76	1.20	2.51	0.37	0.16	**200**
250	27.90	115.58	50.10	19.47	48.17	20.88	12.44	16.22	7.03	7.12	4.17	1.81	3.13	0.57	0.25	**250**
300				23.36	67.52	29.27	14.93	22.74	9.86	8.55	5.85	2.54	3.76	0.79	0.34	**300**
350										9.97	7.78	3.37	4.38	1.05	0.46	**350**
400										11.39	9.96	4.32	5.01	1.35	0.59	**400**
450										12.82	12.39	5.37	5.64	1.68	0.73	**450**
500													6.26	2.04	0.89	**500**

NOTE: Spears® recommends that Flow Velocities be maintained at or below 5 feet per second in large diameter piping systems (i.e. 6" diameter and larger) to minimize the potential for hydraulic shock. Refer to Spears® engineering section entitled "Hydraulic Shock" for additional information. Friction loss data based on utilizing mean wall dimensions to determine average ID; actual ID may vary.

Suitable for Oil-Free air handling to 25 psi, not for distribution of compressed air or gas

See Spears® Product Sourcebook for product offerings

FLOW VELOCITY & FRICTION LOSS

SCHEDULE 80

Flow Rate (Gallons/Minute)	Flow Velocity (ft/sec.)	Friction Loss (Ft. Water/100ft)	Friction Loss (psi/100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft. Water/100ft)	Friction Loss (psi/100ft)	Flow Velocity (ft/sec.)	Friction Loss (Ft. Water/100ft)	Friction Loss (psi/100ft)	Flow Rate (Gallons/Minute)
GPM	8"			10"			12"			**GPM**
125	0.89	0.04	0.02							**125**
150	1.07	0.06	0.02							**150**
175	1.25	0.07	0.03							**175**
200	1.43	0.10	0.04	0.91	0.03	0.01				**200**
250	1.78	0.14	0.06	1.13	0.05	0.02				**250**
300	2.14	0.20	0.09	1.36	0.07	0.03				**300**
350	2.50	0.27	0.12	1.59	0.09	0.04	1.12	0.04	0.02	**350**
400	2.85	0.34	0.15	1.81	0.11	0.05	1.28	0.05	0.02	**400**
450	3.21	0.43	0.19	2.04	0.14	0.06	1.44	0.06	0.03	**450**
500	3.57	0.52	0.23	2.27	0.17	0.07	1.60	0.07	0.03	**500**
750	5.35	1.10	0.48	3.40	0.36	0.16	2.40	0.16	0.07	**750**
1000	7.13	1.87	0.81	4.53	0.62	0.27	3.20	0.27	0.12	**1000**
1250				5.66	0.94	0.41	4.00	0.40	0.17	**1250**
1500				6.80	1.32	0.57	4.80	0.57	0.24	**1500**
2000							6.40	0.96	0.42	**2000**

NOTE: Spears® recommends that Flow Velocities be maintained at or below 5 feet per second in large diameter piping systems (i.e. 6" diameter and larger) to minimize the potential for hydraulic shock. Refer to Spears® engineering section entitled "Hydraulic Shock" for additional information. Friction loss data based on utilizing mean wall dimensions to determine average ID; actual ID may vary.

Hydraulic Shock

Hydraulic shock is the rapid increase in pressure due to a shock wave produced by a sudden change in system fluid velocity. If uncontrolled or insufficient pressure rated piping is used, these pressure surges can easily burst pipe and break valves or fittings. The term "water hammer" commonly used is derived from the sounds produced, but it is the hydraulic shock vibrations that can be damaging to piping systems. This is typically the result of sudden starting or stopping of a flowing column of liquid, such as water. Energy from the momentum of water in motion is converted to pressure when the flow is abruptly halted. A shock wave is produced that travels through the piping until it is stopped and bounces back to the original obstruction. This instantaneous shock to the system can lead to excessively high pressures. Hydraulic shock is frequently produced by rapid valve opening and closing, pumps starting and stopping, or even from a high speed wall of water hitting a change of direction fitting, such as an elbow. The effect is greater as piping systems is longer, the velocity change is greater and closing time is shorter.

Evaluating Hydraulic Shock Pressure Surges

An indication of the maximum surge pressure relative to velocity changes is essential in estimating the pressure rating requirements in designing a piping system. The following chart gives the maximum surge pressure at velocities of 1, 5 and 10 feet per second for different sizes of pipe, based on instantaneous valve closure in a PVC system. While listed, 10 feet per second is not recommended and is shown for comparative purposes. Velocity is best held to a maximum of 5 feet per second in plastic systems.

Schedule 40 Pipe Pressure Surge (psi) at Different Velocities

Size ⇨	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	6	8	10	12
1 ft/sec	27.3	24.6	23.8	21.6	20.5	18.8	19.7	18.4	16.9	15.1	14.2	13.5	13.0
5 ft/Sec	136.3	123.2	119.1	108.1	102.6	94.2	98.5	91.8	84.5	75.4	70.8	67.4	65.2
10 ft/sec	272.7	246.3	238.2	216.3	205.1	188.3	196.9	183.5	169.0	150.9	141.6	134.8	130.5

Schedule 80 Pipe Pressure Surge (psi) at Different Velocities

Size ⇨	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	6	8	10	12
1 ft/sec	32.2	29.2	28.0	25.5	24.3	22.6	23.2	21.8	20.3	18.9	17.8	17.3	17.1
5 ft/Sec	161	145.8	139.9	127.7	121.7	113.1	115.8	109.1	101.6	94.4	88.8	86.6	85.5
10 ft/sec	322	291.7	279.9	255.4	243.4	226.2	231.7	218.1	203.1	188.9	177.6	173.1	171.0

Controlling Hydraulic Shock in System Design & Operation

Since hydraulic shock is a function of speed, mass and time, there are several ways to prevent, minimize or eliminate system damage by limiting or controlling the magnitude of pressure surges.

• **Limit Fluid Velocity -** One of the safest surge control techniques in plastic systems is to limit fluid velocities to a maximum of 5 ft./second. Attempt to balance system operation flow demands and the magnitude of velocity variations.

• **Control Valve Closing Time -** Avoid rapid opening and closing. Pneumatic or electric actuation may be considered for greater control. Use of multi-turn or gear operated valves may also be beneficial in slowing valve opening and closing. When all valves and controls are properly sized and adjusted, surges generated by changes in pump flows and demands can be reduced to non-harmful levels.

• **Control Pump Operation -** Operate the system to maintain uniform pump flow rates. Use slow starting pumps where long runs and larger diameters are downstream. Where possible, partially close discharge valves to minimize volume when starting pumps, until lines are completely filled. Air chambers or surge relief tanks in conjunction with pressure regulating and surge relief valves can be used at pumping stations.

• **Check Valves -** Installing a check valve in pump discharge lines will aid in keeping the line full. Check valves operate on flow reversal and can be rapid closing. Place check valve at least ten pipe diameters from a pump or change of direction.

Thermal Expansion & Contraction

Attention must be given to installations where ambient temperature swings can cause thermoplastic systems to expand and contract both indoors and out. For example, a system installed in an unheated vessel during the winter months will expand considerably when temperatures rise. Conversely, systems installed at higher ambient temperatures will contract as temperatures fall. Refer to Thermal Expansion & Contraction section for additional information.

Calculating Linear Movement Caused by Thermal Expansion

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

ΔL = 12 yl (ΔT)

Where

ΔL = Expansion or contraction in inches
y = Coefficient of linear expansion of piping material selected
l = Length of piping run in feet
ΔT = (T1 - T2) temperature change °F

Where:

T1 = Maximum system temperature and
T2 = System temperature at installation or minimum system temperature

Coefficient of Linear Expansion (y) of Spears® Marine Products (in/in/°F) per ASTM D 696

Pipe Material	y
CPVC Schedule 40 & Schedule 80 Pressure Pipe	3.2×10^{-5}

Example 1: Calculate the change in length for a 100 foot straight run of 2" Schedule 80 CPVC pipe operating at a temperature of 73°F; installed at 32°F.

ΔL = 12 yl (ΔT)

Where:

ΔL = linear expansion or contraction in inches y = 3.2×10^{-5} in/in/°F

l = 100ft

ΔT = 41°F (73°F - 32°F)

ΔL = 12 in/ft x 0.000032 in/in/°F x 100 ft x 41°F

ΔL = 1.57"

In this example the piping would expand approximately 1-1/2" in length over a 100 foot straight run once the operating temperature of 73°F was obtained.

Example 2: 100 foot straight run of 2" Schedule 80 CPVC pipe operating temperature 180°F; installed at 80°F

ΔL = 12 yl (ΔT)

Where:

ΔL = Linear expansion or contraction in inches

y = 3.2×10^{-5} in/in/°F

l = 100 ft

ΔT = 100°F (180°F - 80°F)

ΔL = 12 in/ft x 0.000032 in/in/°F x 100ft x 100°F

ΔL = 3.84"

In this example the piping would expand approximately 4" in length over a 100 foot straight run once the operating temperature of 180°F was obtained.

Compensating for Movement Caused by Thermal Expansion/Contraction

Thermal expansion/ contraction are usually absorbed by the system at changes of direction. Long, straight runs are more susceptible to measurable movement with changes in temperature and the installation of expansion joints, expansion loops or offsets is required. This will allow the system to absorb expansion/contraction forces without damage.

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

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

Where:

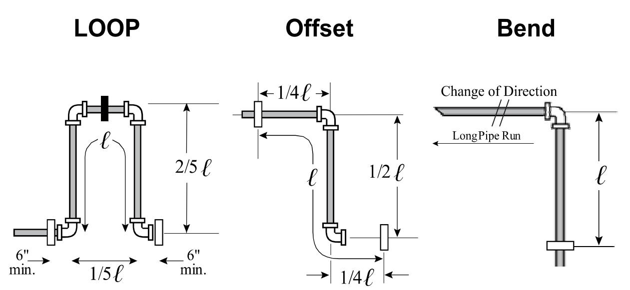
ℓ = Length of expansion loop in inches

E = Modulus of elasticity

D = Average outside diameter of pipe

ΔL = Change in length of pipe due to temperature change

S = Working stress at max. temperature



Hangers or guides should only be placed in the loop, offset, or change of direction as indicated above, and must not compress or restrict the pipe from axial movement. Piping supports should restrict lateral movement and should direct axial movement into the expansion loop configuration. Do not restrain "change in direction" configurations by butting up against joists, studs, walls or other structures. Use only solvent-cemented connections on straight pipe lengths in combination with 90° elbows to construct the expansion loop, offset or bend. The use of threaded components to construct the loop configuration is not recommended. Expansion loops, offsets, and bends should be installed as nearly as possible at the midpoint between anchors. Concentrated loads such as valves should not be installed in the developed length. Calculated support guide spacing distances for offsets and bends must not exceed recommended hanger support spacing for the maximum anticipated temperature. If that occurs, the distance between anchors will have to be reduced until the support guide spacing distance is equal to or less than the maximum recommended support spacing distance for the appropriate pipe size at the temperature used.

Example: 2" Schedule 80 CPVC pipe operating temperature 180°F; installed at 80°F where ΔL = 3.84"

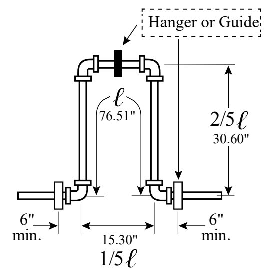
$$\ell = \sqrt{\frac{3ED\,(\Delta L)}{2S}}$$

$$\ell = \sqrt{\frac{3 \times 214{,}000 \times 2.375 \times 3.84}{2 \times 500}}$$

$$\ell = 76.51''$$

$$2/5\ \ell = 30.60''$$

$$1/5\ \ell = 15.30''$$



Thermal Stress

Compressive stress in piping restrained from expanding can damage the piping system and in some cases damage hangers and supports. The amount of stress generated is dependent on the pipe material's coefficient of thermal expansion and its tensile modulus using the following equation:

S = EyΔT

Where

S = Stress induced in the pipe

E = Modulus of Elasticity at maximum system temperature y = Coefficient of thermal expansion

ΔT = Total temperature change of the system

The stress induced must not exceed the pipe material maximum allowable working stress (fiber stress). Increases in temperature will reduce the allowable stress as shown the table.

Example: 100 ft straight run of 2“ Schedule 80 CPVC pipe operating temperature 180°F; installed at 80°F.

ΔL = 12 yl (ΔT) Where:

ΔL = Linear expansion or contraction in inches

y = 3.2 x 10^{-5} in/in/°F

l = 100ft

ΔT = 100°F (180°F - 80°F)

ΔL = 12 in/ft x 0.000032 in/in/°F x 100 foot x 100°F

ΔL = 3.84"

The piping would expand approximately 4" in length in a 100 ft straight run

The equation for determining induced stress can then be used:

S = EyΔT

Where:

S = Stress induced in the pipe

E = Modulus of Elasticity at 180°F = 214,000

y = Coefficient of thermal expansion = 3.2 x 10^{-5} in./in./°F

ΔT = Total temperature change of the system = 100°F

S = 214,000 x .000032 x 100

S = 685 psi

From chart, maximum allowable stress for CPVC at 180°F is 500 psi; Stress generated from this expansion in a restrained piping system exceeds the maximum allowable stress and will result in failure of the piping, unless compensation is made for thermal expansion.

Maximum Allowable Working (Fiber) Stress and Tensile Modulus at Various Temperatures

Temp (°F)		Maximum Allowable Working (Fiber) Stress, psi	Tensile Modulus of Elasticity, psi
CPVC	73	2,000	364,000
	90	1,820	349,000
	100	1,640	339,000
	110	1,500	328,000
	120	1,300	316,000
	140	1,000	290,000
	160	750	262,000
	180	500	214,000
	200	400	135,000

Temperature Limitations

CPVC

The maximum operating temperature for CPVC Schedule 40/80 marine pipe is 200°F. As temperatures increase, impact strength typically increases while tensile strength and pipe stiffness decrease resulting in reduced applicable pressure ratings. Physical properties of CPVC pipe are generally specified at 73°F per applicable ASTM material test standards. The maximum allowable pressure at elevated temperatures is determined by multiplying the 73°F pressure rating by the applicable material de-rating factor for the elevated use temperature shown in the following chart. See Marine Pipe General Information for pipe pressure ratings @ 73°F.

De-Rating Factors

CPVC Pipe	
Temp (°F)	Working De-Rating Factor
73-80	1.00
90	0.91
100	0.82
110	0.72
120	0.65
130	0.57
140	0.50
150	0.42
160	0.40
170	0.29
180	0.25
200	0.20

Appropriate temperature de-rating factors must be applied at temperatures other than 73°F based on the material selected.

Multiply the collapse pressure rating of the selected pipe at 73°F, by the appropriate de-rating factor to determine the collapse pressure rating of the pipe at the elevated temperature chosen.

Weatherability

When rigid CPVC marine pipe is exposed to UV radiation from sunlight, the following conditions have been noted:

- A color change, slight increase in tensile strength, slight increase in modulus of tensile elasticity, and a slight decrease in impact strength may occur.
- Material directly exposed to UV radiation results in extremely shallow penetration depths (frequently less than 0.001 inch).
- The effects of UV exposure do not continue when exposure to UV is terminated.
- The effects of UV exposure do not penetrate even thin shields such as paint coatings, or wrapping.

It is recommended that CPVC piping products exposed to the direct affects of sunlight be painted with a light colored acrylic or latex paint that is chemically compatible with the CPVC products. Check with paint manufacture for compatibility. Oil-based paints should **NOT** be used.

Additional consideration should be given to the effects of expansion/contraction caused by heat absorption from sunlight in outdoor applications.