



Plastic Pipe Handbook



ENGINEERING GUIDE



IP-4-0112

Providing customers with the best of what they need, when they need it has always been central to the SPEARS® philosophy. Backed by over 40 years of both product and process development experience, SPEARS® has become one of the leading manufacturers of thermoplastic valves, fittings, and piping system components including a full assortment of solvent cements and accessories. Innovative product designs and improvements, new technologies, and a fully integrated manufacturing system are all a part of SPEARS® ongoing commitment to Quality, Satisfaction, and Service.



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Purpose of this Manual

This manual is intended as resource for use by specification engineers, installers, and users in the selection, design and installation of PVC and CPVC systems installed using Spears® or other pipe products. All information contained within this manual is considered vital to obtain proper system performance and must be read and fully understood before attempting to install these products. If you have any questions about the safe and proper installation of these products, contact Spears® Manufacturing Company, 15853 Olden Street, Sylmar CA 91342 USA, Telephone (818) 364-1611.

Spears® PVC and CPVC Materials

PVC

Polyvinyl Chlorides (PVC) is one of the most widely used plastic piping materials. PVC is environmentally sound, provides long service life, is light weight and easy to install, has superior corrosion resistance, is cost effective, and widely accepted by codes. PVC pipe is manufactured by extrusion and PVC fittings are manufactured by injection molding or fabrication. PVC is an amorphous thermoplastic material with physical properties that make it suitable for a wide variety of pressure and non-pressure applications and can be compounded for optimum performance. PVC pipe and fittings are used for drain-waste-vent (DWV), sewers, water mains, water service lines, irrigation, conduit, and various industrial installations.

Spears® high quality PVC compounds give optimum chemical and corrosion resistance with a full range of pressure handling capabilities. Spears® PVC materials are certified by NSF International to applicable standards, including NSF Standard 61 for use in potable water service and to ASTM STD D1784, Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds that specifies Cell Classification for minimum physical property requirements. These include resin type, impact strength, tensile strength, modulus of elasticity in tension, heat deflection temperature and flammability. Spears® minimum PVC Cell Classification is 12454 for rigid (unplasticized) PVC.

The ASTM Type and Grade is PVC Type I, Grade I and the typical long and short term strength designation of material for pressure piping is PVC 1120.

See Industry Standards and Test Methods, Physical Properties and Chemical Resistance sections for additional information.

Spears® PVC Pipe & Systems Product Lines

EverTUFF® Industrial Schedule 80 Pressure Pipe & Fittings
Spears® Clear PVC Schedule 40 & Schedule 80 Pipe & Fittings
Spears® Low Extractable Ultra Pure Water Piping & Fittings
Spears® PVC Duct & Fittings
Spears® PVC Double Containment Pipe & Fittings
Spears® Supplemental PVC Fittings, Valves & Accessories

CPVC

Chlorinated polyvinyl chloride (CPVC) is created by post chlorination of the PVC polymer. This produces up to a 60°F higher heat handling capability than PVC and greater fire resistance, plus a broad range of chemical resistance. CPVC is excellent for use in process piping, hot and cold water service, corrosive waste drainage and other elevated temperature applications. CPVC provides relatively low cost compared to alternative materials for similar use. CPVC pipe is manufactured by extrusion and CPVC fittings are manufactured by injection molding or fabrication. Spears® produces a variety of CPVC pipe, fittings, valves, system accessories and specialty systems.

Spears® high quality CPVC compounds give optimum chemical and corrosion resistance with a full range of pressure handling capabilities. Spears® CPVC materials are certified by NSF International to applicable standards, including NSF Standard 61 for use in potable water service and to ASTM STD D1784, Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds that specifies Cell Classification for minimum physical property requirements. These include resin type, impact strength, tensile strength, modulus of elasticity in tension, heat deflection temperature and flammability. Spears® minimum CPVC Cell Classification is 23447 for rigid (unplasticized) CPVC.

The ASTM Type and Grade is CPVC Type IV Grade I and the typical long and short term strength designation of material for pressure piping is CPVC 4120.

See Industry Standards and Test Methods, Physical Properties and Chemical Resistance sections for additional information.

Spears® CPVC Pipe & Systems Product Lines

EverTUFF® Industrial Schedule 40 & Schedule 80 CPVC Pressure Pipe & Fittings
EverTUFF® CTS CPVC Hot and Cold Water Plumbing Distribution Pipe & Fittings
LabWaste™ CPVC Corrosive Waste Drainage System Pipe & Fittings
FlameGuard® CPVC Fire Sprinkler Products Pipe & Fittings
Spears® CPVC Duct & Fittings
Spears® CPVC Double Containment Pipe & Fittings
Spears® Supplemental CPVC Fittings, Valves & Accessories



Physical Properties of PVC & CPVC Pipe

GENERAL	PVC Value	CPVC Value	Test Method
Cell Classification	12454	23447	ASTM D 1784
Maximum Service Temp.	140°F	200°F	
Color	White, Dark Gray	Medium Gray	
Specific Gravity, (g/cu.cm @ 73°F)	1.41	1.51	ASTM D 792
Water Absorption % increase 24 hrs @ 25°C	0.05	0.03	ASTM D 570
Hardness, Rockwell	110 - 120	117 - 119	ASTM D 785
Poisson's Ratio @ 73°F	0.410	0.370	
MECHANICAL			
Tensile Strength, psi @ 73°F	7,450	7,900	ASTM D 638
Tensile Modulus of Elasticity, psi @ 73°F	420,000	426,000	ASTM D 638
Flexural Strength, psi @ 73°F	14,450	15,000	ASTM D 790
Flexural Modulus, psi @ 73°F	360,000	360,000	ASTM D 790
Compressive Strength, psi @ 73°F	9,600	10,000	ASTM D 695
Izod Impact, notched, ft-lb/in @ 73°F	0.75	2.9	ASTM D 256
THERMAL			
Coefficient of Linear Expansion (in/in/°F)	2.9×10^{-5}	3.2×10^{-5}	ASTM D 696
Coefficient of Thermal Conductivity			ASTM C 177
Calories • cm/second • cm ² • °C	3.5×10^{-4}	3.27×10^{-4}	
BTU • inches/hour • Ft.2 • °F	1.02	0.95	
Watt/m/K	0.147	0.137	
Heat Deflection Temperature			
Under Load (264 psi, annealed)	170	235	ASTM D 648
ELECTRICAL			
Dielectric Strength, volts/mil	1,413	1,250	ASTM D 149
Dielectric Constant, 60Hz, 30°F	3.70	3.70	ASTM D 150
Volume Resistivity, ohm/cm @ 95°C	1.2×10^{12}	3.4×10^{12}	ASTM D 257
Spears® PVC & CPVC Pipe is non-electrolytic			
FIRE PERFORMANCE			
Flammability Rating	V-0	V-0, 5VB, 5VA	UL-94
Flame Spread Index	<10	<10	
Flame Spread	0-25	<25	ULC
Smoke Generation	80-225	<50	ULC
Flash Ignition Temp.	730°F	900°F	
Average Time of Burning (sec.)	<5	<5	ASTM D 635
Average Extent of Burning (mm)	<10	<10	
Burning Rate (in/min)	Self Extinguishing	Self Extinguishing	
Softening Starts (approx.)	250°F	295°F	
Material Becomes Viscous	350°F	395°F	
Material Carbonizes	425°F	450°F	
Limiting Oxygen Index (LOI)	43	60	ASTM D 2863

NOTE: The physical properties shown above are considered general for PVC and CPVC. Contact Spears® Technical Services for additional information if necessary.

Dimensions & Pressure Ratings



PVC & CPVC pipe is produced in several different outside diameters, sizes and dimensions for different applications. Different classifications based on outside diameter are not interchangeable, but can often be connected with specialty adapter fittings.

Basic Pipe Sizing Classifications Based on Outside Diameter

- Iron Pipe Size (IPS) - PVC & CPVC Pressure Pipe and Drainage Waste & Vent DWV pipe, forms one of the most widely used sizing classifications including Schedule 40, 80 & 120 pipe and Class pipe in various Standard Dimension Ratios (SDR); plus several specialty piping products such as Spears® FlameGuard® CPVC Fire Sprinkler Systems, LabWaste™ CPVC Corrosive Waste Drainage Systems, and Low Extractable PVC Systems for Ultra Pure Water.
- Plastic Irrigation Pipe (PIP) – PVC for agricultural irrigation
- Copper Tube Size (CTS) – CPVC for Hot & Cold Waste Distribution
- Plastic Sewer Main (Type PSM) – PVC for gravity sewer mains
- AWWA C900/905 – PVC with Cast Iron O.D. for municipal water systems

The following Pipe Dimension Reference chart is for quick reference to some of the commonly used sizing classifications and nominal sizes. The following pages give additional detail for widely used PVC & CPVC pipe in IPS and CTS sizes.

Pipe Dimension Reference Chart

Pipe Type O.D. Size SDR	LH PIP 91	80 PIP 51	100 PIP 41	125 PIP 32.5	CL 63 IPS 64	CL 100 IPS 41	SEWER PSM 35	CL 125 IPS 32.5	CL 160 IPS 26	CL 200 IPS 21	40 DWV IPS —	80 DWV IPS —	SCH 40 IPS —	SCH 80 IPS —	C-900 CI DR 18
4"	O.D. 4.130 I.D. 4.000 Wall .065 PSI 43	4.130 3.968 .081 80	4.130 3.928 .101 100	4.130 3.876 .127 125	4.500 4.360 .070 63	4.500 4.280 .110 100	4.215 3.89 0.125 117.5	4.500 4.224 .138 125	4.500 4.154 .173 160	4.500 4.072 .214 200	4.500 3.998 .237 100	4.500 3.786 .337 100	4.500 3.998 .237 220	4.500 3.786 .337 320	4.800 4.22 .267 150
6"	O.D. 6.140 I.D. 6.000 Wall .070 PSI 43	6.140 5.898 .121 80	6.140 5.840 .150 100	6.140 5.762 .189 125	6.625 6.417 .104 63	6.625 6.301 .162 100	6.275 5.742 0.18 117.5	6.625 6.217 .204 125	6.625 6.115 .255 160	6.625 5.993 .316 200	6.625 6.031 .280 100	6.625 5.709 .432 100	6.625 6.031 .280 180	6.625 5.709 .432 280	6.900 6.08 .383 150
8"	O.D. 8.160 I.D. 7.984 Wall .088 PSI 43	8.160 7.840 .160 80	8.160 7.762 .199 100	8.160 7.658 .251 125	8.625 8.355 .135 63	8.625 8.205 .210 100	8.4 7.665 .024 117.5	8.625 8.095 .265 125	8.625 7.961 .332 160	8.625 7.805 .410 200	8.625 7.943 .322 100	8.625 7.565 .500 100	8.625 7.943 .322 160	8.625 7.565 .500 250	9.050 7.97 .503 150
10"	O.D. 10.200 I.D. 9.980 Wall .110 PSI 43	10.200 9.800 .200 80	10.200 9.702 .249 100	10.200 9.572 .314 125	10.750 10.414 .168 63	10.750 10.226 .262 100	10.5 9.563 0.3 117.5	10.750 10.088 .331 125	10.750 9.924 .413 160	10.750 9.748 .511 200	10.750 9.976 .365 100	10.750 9.492 .593 100	10.750 9.976 .365 140	10.750 9.492 .593 230	11.100 9.78 .617 150
12"	O.D. 12.240 I.D. 11.975 Wall .132 PSI 43	12.240 11.760 .240 80	12.240 11.642 .299 100	12.240 11.486 .377 125	12.750 12.352 .199 63	12.750 12.128 .311 100	12.5 11.361 0.36 117.5	12.750 11.966 .392 125	12.750 11.770 .490 160	12.750 11.538 .606 200	12.750 11.890 .406 100	12.750 11.294 .687 100	12.750 11.890 .406 130	12.750 11.294 .687 230	13.200 11.63 .733 150
14"	O.D. 14.280 I.D. 14.000 Wall .140 PSI 43	14.280 13.720 .280 80	14.280 13.584 .348 100	14.280 13.402 .439 125	*	*	*	*	14 12.86 0.538 160	*	14.000 13.072 .438 100	14.000 12.410 .750 100	14.000 13.072 .438 130	14.000 12.410 .750 220	15.3 13.48 0.85 235
15"	O.D. 15.300 I.D. 14.970 Wall .165 PSI 43	15.300 14.700 .300 80	15.300 14.550 .375 100	15.300 14.358 .471 125	*	*	15.3 13.898 0.44 117.5	*	*	*	*	*	*	*	*
16"	O.D. 16.000 I.D. 15.615 Wall .160 PSI 43	*	*	*	*	*	*	*	16 14.696 0.615 160	*	16.000 14.940 .500 100	16.000 14.214 .843 100	16.000 14.940 .500 130	16.000 14.214 .843 220	17.4 15.33 0.967 235
18"	O.D. 18.360 I.D. 17.964 Wall .198 PSI 43	18.701 17.967 .367 80	18.701 17.789 .456 100	18.701 17.551 .575 125	*	18.000 17.122 .439 100	18.701 17.629 0.536 117.5	*	18.000 16.616 .692 160	*	18 16.808 0.562 100	18.000 16.014 .937 100	18 16.808 0.582 120	18.000 16.014 .937 220	19.5 17.83 1.083 235
20"	O.D. 20.400 I.D. 19.962 Wall .219 PSI 43	*	*	*	*	20.000 19.026 .487 100	*	*	20.000 18.462 .769 160	*	20 18.863 0.533 100	20 17.814 1.031 100	20 18.863 0.533 120	20 17.614 1.031 220	21.6 19.03 1.2 235
21"	O.D. 21.000 I.D. 20.691 Wall .204 PSI 43	*	22.047 21.183 .432 80	22.047 20.971 .538 100	22.047 20.691 .678 125	*	22.047 20.783 0.632 117.5	*	*	*	*	*	*	*	*
24"	O.D. 24.000 I.D. 23.831 Wall .486 PSI 80	*	24.803 23.593 .605 100	24.803 23.277 .763 125	*	24.000 22.748 .585 100	24.8 23.381 0.711 117.5	*	24 22.043 0.923 160	*	24 22.54 0.687 100	24 21.418 1.218 100	24 22.54 0.687 120	24 21.418 1.218 210	25.800 23.73 1.200 235

* Information Not Available



Dimensions & Pressure Ratings

PVC PIPE

Schedule 40

Nom. Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./Ft.	Maximum W.P. PSI*
1/8	0.405	0.249	0.068	0.051	810
1/4	0.540	0.344	0.088	0.086	780
3/8	0.675	0.473	0.091	0.115	620
1/2	0.840	0.602	0.109	0.170	600
3/4	1.050	0.804	0.113	0.226	480
1	1.315	1.029	0.133	0.333	450
1-1/4	1.660	1.360	0.140	0.450	370
1-1/2	1.900	1.590	0.145	0.537	330
2	2.375	2.047	0.154	0.720	280
2-1/2	2.875	2.445	0.203	1.136	300
3	3.500	3.042	0.216	1.488	260
3-1/2	4.000	3.521	0.226	1.789	240
4	4.500	3.998	0.237	2.118	220
5	5.563	5.016	0.258	2.874	190
6	6.625	6.031	0.280	3.733	180
8	8.625	7.942	0.322	5.619	160
10	10.750	9.976	0.365	7.966	140
12	12.750	11.889	0.406	10.534	130
14	14.000	13.073	0.437	12.462	130
16	16.000	14.940	0.500	16.286	130
18	18.000	16.809	0.562	20.587	130
20	20.000	18.743	0.593	24.183	120
24	24.000	22.544	0.687	33.652	120

Schedule 80

Nom. Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./Ft.	Maximum W.P. PSI*
1/4	.540	.282	0.119	0.117	1130
3/8	.675	.403	0.126	0.162	920
1/2	.840	.526	0.147	0.231	850
3/4	1.050	.722	0.154	0.314	690
1	1.315	.936	0.179	0.462	630
1-1/4	1.660	1.255	0.191	0.654	520
1-1/2	1.900	1.476	0.200	0.793	470
2	2.375	1.913	0.218	1.097	400
2-1/2	2.875	2.290	0.276	1.674	420
3	3.500	2.864	0.300	2.242	370
3-1/2	4.000	3.326	0.318	2.735	350
4	4.500	3.786	0.337	3.277	320
5	5.563	4.768	0.375	4.078	290
6	6.625	5.709	0.432	6.258	280
8	8.625	7.565	0.500	9.506	250
10	10.750	9.493	0.593	14.095	230
12	12.750	11.294	0.687	19.392	230
14	14.000	12.410	0.750	23.261	220
16	16.000	14.213	0.843	29.891	220
18	18.000	16.014	0.937	35.419	220
20	20.000	17.814	1.031	45.879	220
24	24.000	21.418	1.218	64.959	210

SDR 13.5 - Class 315 Maximum W.P. 315 PSI* (all sizes)

Nominal Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./ft.
1/2	0.840	0.716	.062	0.096
3/4	1.050	0.874	.078	0.168
1	1.315	1.101	.097	0.257
1-1/4	1.660	1.394	.123	0.403
1-1/2	1.900	1.598	.141	0.525
2	2.375	2.003	.176	0.809
2-1/2	2.875	2.423	.213	1.189
3	3.500	2.950	.259	1.762
4	4.500	3.794	.333	2.908
6	6.625	5.584	.491	6.313

SDR 21 - Class 200 Maximum W.P. 200 PSI* (all sizes)

Nominal Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./Ft.
3/4	1.050	0.910	0.060	0.136
1	1.315	1.169	0.063	0.180
1-1/4	1.660	1.482	0.079	0.278
1-1/2	1.900	1.700	0.090	0.358
2	2.375	2.129	0.113	0.550
2-1/2	2.875	2.581	0.137	0.797
3	3.500	3.146	0.167	1.169
4	4.500	4.046	0.214	1.927
6	6.625	5.955	0.316	4.186
8	8.625	7.756	0.410	7.070
10	10.750	9.667	0.511	10.983
12	12.750	11.465	0.606	15.455
14	14.000	12.588	0.666	18.647
16	16.000	14.385	0.762	24.373
18	18.000	16.183	0.857	30.849
20	20.000	17.982	0.952	38.070
24	24.000	21.577	1.143	54.850

SDR 26 - Class 160 Maximum W.P. 160 PSI* (all sizes)

Nominal Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./Ft.
1	1.315	1.175	0.060	0.173
1-1/4	1.660	1.512	0.064	0.233
1-1/2	1.900	1.734	0.073	0.300
2	2.375	2.173	0.091	0.456
2-1/2	2.875	2.635	0.110	0.657
3	3.500	3.210	0.135	0.967
4	4.500	4.134	0.173	1.570
6	6.625	6.084	0.255	3.415
8	8.625	7.921	0.332	5.786
10	10.750	9.874	0.413	8.973
12	12.750	11.711	0.490	12.623
14	14.000	12.860	0.538	15.209
16	16.000	14.696	0.615	19.881
18	18.000	16.533	0.692	25.162
20	20.000	18.370	0.769	31.064
24	24.000	22.043	0.923	44.754

SDR 41 - Class 100 Maximum W.P. 100 PSI* (all sizes)

Nominal Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./Ft.
2-1/2	2.875	2.715	0.070	0.444
3	3.500	3.310	0.085	0.643
4	4.500	4.260	0.110	1.044
6	6.625	6.281	0.162	2.205
8	8.625	8.180	0.210	3.714
10	10.750	10.195	0.262	5.774
12	12.750	12.421	0.311	8.113
14	14.000	13.270	0.341	9.888
16	16.000	15.165	0.390	12.925
18	18.000	17.061	0.439	16.352
20	20.000	18.956	0.488	20.200
24	24.000	22.748	0.585	29.070

Dimensions & Pressure Ratings



SDR 32.5 - Class 125

Maximum W.P. 125 PSI* (all sizes)

Nom. Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./Ft.
1/2	.840	.750	.045	.071
3/4	1.050	0.950	0.050	0.099
1	1.315	1.215	0.051	0.126
1-1/4	1.660	1.520	0.060	0.221
1-1/2	1.900	1.760	0.060	0.255
2	2.375	2.209	0.073	0.378
2-1/2	2.875	2.679	0.088	0.541
3	3.500	3.264	0.108	0.793
4	4.500	4.204	0.138	1.280

SDR 32.5 - Class 125

Maximum W.P. 125 PSI* (all sizes)

Nom. Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./Ft.
6	6.625	6.196	0.204	2.732
8	8.625	8.063	0.265	4.658
10	10.750	10.048	0.331	7.252
12	12.750	11.919	0.392	10.182
14	14.000	13.088	0.430	12.270
16	16.000	14.957	0.492	16.037
18	18.000	16.826	0.554	20.307
20	20.000	18.696	0.615	25.063
24	24.000	22.436	0.738	36.072

Schedule 120

Nom. Pipe Size (in)	O.D.	Average I.D.	Minimum Wall	Nominal Wt./Ft.	Maximum W.P. PSI*
1/2	.840	.480	0.170	0.236	1010
3/4	1.050	.690	0.170	0.311	770
1	1.315	.891	0.200	0.464	720
1-1/4	1.660	1.204	0.215	0.649	600
1-1/2	1.900	1.423	0.225	0.787	540
2	2.375	1.845	0.250	1.111	470

Schedule 120

Nom. Pipe Size (in)	O.D.	Average I.D.	Minimum Wall	Nominal Wt./Ft.	Maximum W.P. PSI*
2-1/2"	2.875	2.239	0.300	1.615	470
3"	3.500	2.758	0.350	2.306	440
4"	4.500	3.574	0.437	3.713	430
6"	6.625	5.434	0.562	7.132	370
8"	8.625	7.189	0.718	11.277	380

Schedule 40

CPVC INDUSTRIAL PIPE

Schedule 80

Nominal Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./ft.	Maximum W.P. PSI*
1/8	0.405	0.249	0.095	0.055	910
1/4	0.540	0.344	0.119	0.093	780
3/8	0.675	0.473	0.126	0.125	620
1/2	0.840	0.602	0.147	0.184	600
3/4	1.050	0.804	0.154	0.245	480
1	1.315	1.029	0.179	0.360	450
1-1/4	1.660	1.360	0.191	0.487	370
1-1/2	1.900	1.590	0.200	0.581	330
2	2.375	2.047	0.218	0.779	280
2-1/2	2.875	2.445	0.276	1.229	300
3	3.500	3.042	0.300	1.610	260
4	4.500	3.998	0.337	2.292	220
6	6.625	6.031	0.432	4.039	180
8	8.625	7.942	0.500	6.079	160
10	10.750	9.976	0.593	8.618	140
12	12.750	11.889	0.687	11.397	130
14	14.000	13.073	0.750	13.482	130
16	16.000	14.940	0.843	17.619	130
18	18.000	16.809	0.937	22.271	130
20	20.000	18.743	1.031	26.162	120
24	24.000	22.544	1.218	36.406	120

Nominal Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./ft.	Maximum W.P. PSI*
1/8	0.405	0.195	0.095	0.068	1230
1/4	0.540	0.282	0.119	0.115	1130
3/8	0.675	0.403	0.126	0.158	920
1/2	0.840	0.526	0.147	0.232	850
3/4	1.050	0.722	0.154	0.314	690
1	1.315	0.936	0.179	0.461	630
1-1/4	1.660	1.255	0.191	0.638	520
1-1/2	1.900	1.476	0.200	0.773	470
2	2.375	1.913	0.218	1.070	400
2-1/2	2.875	2.29	0.276	1.632	420
3	3.500	2.864	0.300	2.186	370
4	4.500	3.786	0.337	3.196	320
6	6.625	5.709	0.432	6.102	280
8	8.625	7.565	0.500	9.269	250
10	10.750	9.493	0.593	13.744	230
12	12.750	11.294	0.687	18.909	230
14	14.000	12.41	0.750	22.681	220
16	16.000	14.213	0.843	29.162	220
18	18.000	16.014	0.937	36.487	220
20	20.000	17.814	1.031	44.648	220
24	24.000	21.418	1.218	63.341	210

SDR 11 - Copper Tube Size (CTS)

Maximum W.P. 400 PSI* (all sizes)

Nominal Pipe Size	Average O.D.	Average I.D.	Min. Wall	Wall TOL	Pressure Rating @ 73°F
1/2	0.625	0.469	0.057	±0.020	400
3/4	0.87	0.695	0.080	±0.020	400
1	1.125	0.901	0.102	±0.020	400
1 1/4	1.375	1.105	0.125	±0.020	400
1 1/2	1.625	1.309	0.148	±0.020	400
2	2.125	1.716	0.193	±0.023	400

SDR13.5 - Class 315

Maximum Working Pressure 315 psi (all sizes)

Nominal Pipe Size (in)	O.D.	Average I.D.	Min. Wall	Nominal Wt./ft.
3/4	1.050	0.874	0.078	0.182
1	1.315	1.101	0.097	0.278
1-1/4	1.660	1.394	0.123	0.436
1-1/2	1.900	1.598	0.141	0.568
2	2.375	2.003	0.176	0.875
2-1/2	2.875	2.423	0.213	1.286
3	3.500	2.950	0.259	1.906
4	4.500	3.794	.333	3.146
6	6.625	5.584	.491	6.828

Note: *Pressure ratings are for water, non-shock, @73°F. Threaded pipe requires a 50% reduction in the pressure ratings stated for plain-end pipe @ 73°F. Threading recommended for Schedule 80 or heavier walls only. Maximum service temperature for PVC is 140°F. Maximum service temperature for CPVC is 200°F. The pressure rating of the pipe must be de-rated when working at elevated temperatures.

Chemical resistance data should be referenced for proper material selection and possible de-rating when working with fluids other than water.



Dimensions & Pressure Ratings

Temperature De-rating

The pressure ratings given are for water, non-shock, @ 73°F. The specified derating factors for PVC or for CPVC are suitable for pipe conveying water at elevated temperatures. To determine elevated temperature rating, multiply 73°F [23°C] pressure rating by appropriate factor shown in the tables.

When working near maximum specified temperature, solvent cement joints are recommended in place of threaded connections. Where disassembly is required at elevated temperatures use Spears® Special reinforced (SR) adapters, flanges, unions or grooved coupling connections.

Only Schedule 80 or heavier wall thickness pipe (PVC or CPVC) should be threaded. Do NOT thread Schedule 40 pipe or other thinner-walled pipe such as SDR 13.5, SDR 21, SDR 26, etc. Threading requires a 50% reduction in the pipe's specified pressure rating @ 73°F.

See Chemical Resistance Data for Pressure Piping information for both chemical compatibility and potential temperature limitations when using certain chemicals.

PVC Pipe

Operating Temp (°F)	De-Rating Factor
73	1.00
80	0.88
90	0.75
100	0.62
110	0.51
120	0.40
130	0.31
140	0.22

EX: 2" PVC SCHEDULE 80 @ 120°F = 400 psi x 0.40 = 160 psi max. @ 120°F.

CPVC Pipe

Operating Temp (°F)	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

EX: 2" CPVC SCHEDULE 80 @ 120°F = 400 psi x 0.65 = 260 psi max. @ 120°F.

FLOW VELOCITY & FRICTION LOSS

Friction Loss Through Pipe

The Hazen-Williams equation below is widely used to calculate friction loss for water through PVC and CPVC pipe

$$f = .2083 \times \frac{(100)^{1.852}}{C} \times \frac{G^{1.852}}{di^{4.8655}}$$

Where: f = friction head of feet of water per 100' for the specific pipe size and I.D.

C = a constant for internal pipe roughness. 150 is the commonly accepted value for PVC and CPVC pipe.

G = flow rate of gallons per minute (U.S. gallons).

di = inside diameter of pipe in inches.

Friction Loss Through Fittings

Friction loss through fittings is expressed in equivalent feet of the same pipe size and schedule for the system flow rate. Schedule 40 head loss per 100' values are usually used for other wall thicknesses and standard iron pipe size O.D.'s.

Average Friction Loss for PVC and CPVC Fittings in Equivalent Feet of Straight Run Pipe

Item	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	6	8	10	12	14	16	18	20	24
Tee Run	1.0	1.4	1.7	2.3	2.7	4.0	4.9	6.1	7.9	12.3	14.0	17.5	20.0	25.0	27.0	32.0	35.0	42.0
Tee Branch	3.8	4.9	6.0	7.3	8.4	12.0	14.7	16.4	22.0	32.7	49.0	57.0	67.0	78.0	88.0	107.0	118.0	137.0
90° Ell	1.5	2.0	2.5	3.8	4.0	5.7	6.9	7.9	11.4	16.7	21.0	26.0	32.0	37.0	43.0	53.0	58.0	67.0
45° Ell	.8	1.1	1.4	1.8	2.1	2.6	3.1	4.0	5.1	8.0	10.6	13.5	15.5	18.0	20.0	23.0	25.0	30.0

Note: Values 10"-24": Approximate values from Nomograph.

Pressure Drop In Valves & Strainers

Pressure drop calculations can be made for valves and strainers for different fluids, flow rates, and sizes using the CV values and the following equation:

Where:

$$P = \frac{(G)^2 (S_g)}{(C_v)^2}$$

$$P = \text{Pressure drop in PSI; feet of water} = \frac{\text{PSI}}{.4332}$$

G = Gallons per minute

C_v = Gallons per minute water per 1 PSI pressure drop

S_g = Specific gravity of liquid (water = 1)

C_v Valves for Select Spears® Valves and Strainers

Nominal Size →	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	6	8	10	12
True Union 2000 Ball Valve ¹	29	63	120	243	357	599	856	1416	2865	1952	--	--	--
Single Entry Ball Valve ¹	38	76	146	292	412	720	--	1660	3104	--	--	--	--
True Union 2000 Ball Check Valve	6.3	17	25	65	86	130	200	275	500	800	--	--	--
Butterfly Valve (90° - Full Open)	--	--	--	--	81	109	192	345	411	1125	2249	4440	6309
Y-Check Valve	6.7	12.6	22.9	33.8	50.7	79.2	--	235	387	--	--	--	--
Y-Strainer (12 Mesh-Clean)	5.4	7.8	13.9	32.9	41.6	50.0	--	74.6	169.0	--	--	--	--
Basket Strainer (Clean)	4.5	10	15	30	46	72	110	172	270	630	750	893	1063

¹- Full Port Ball Valve Cv based on equivalent length of Schedule 80 pipe

Water Velocities

Velocities for water in feet per second at different GPM's and pipe inside diameters can be calculated as follows:

$$V = .3208 \frac{G}{A}$$

Where:

V = velocity in feet per second

G = gallons per minute

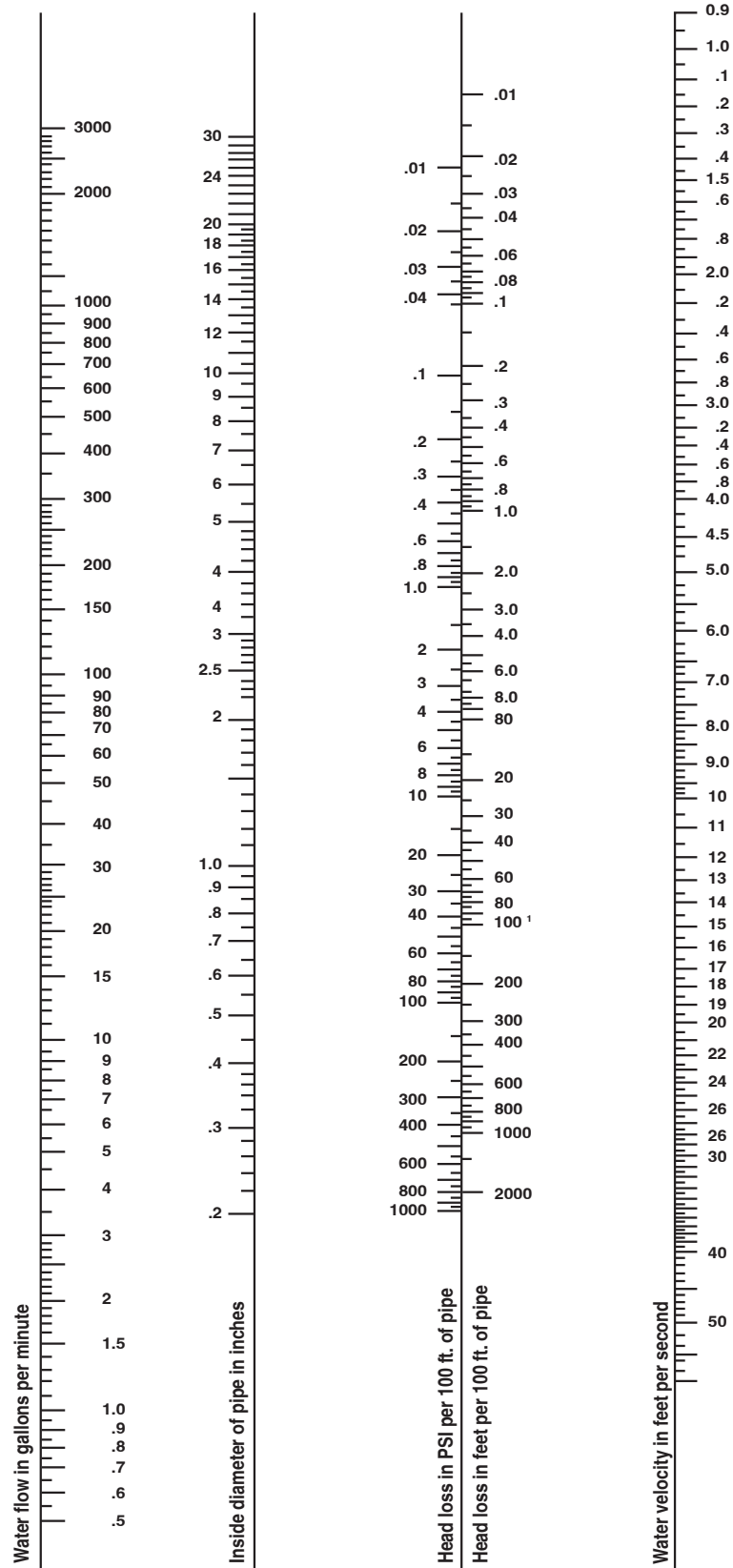
A = inside cross sectional area in square inches

CAUTION: Flow velocities in excess of 5.0 feet per second are not recommended for closed-end systems. Contact Spears® Technical Services for additional information.



Head Loss Characteristics of Water Flow Through Rigid Plastic Pipe – Nomograph

The nomograph provides approximate values for water flow, head loss and water velocity for a wide range of plastic pipe sizes. Two known variables must be used to obtain the other variables by lining up the values on the scales using a ruler or straight edge. Flow velocities in excess of 5.0 feet per second are not recommended.





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 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	1/8"			1/4"			3/8"			1/2"			3/4"			1"			1-1/4"			GPM
0.25	1.64	6.54	2.83	0.86	1.36	0.59	0.46	0.29	0.12													0.25
0.50	3.27	23.60	10.23	1.72	4.90	2.12	0.91	1.04	0.45													0.50
0.75	4.91	50.00	21.68	2.59	10.38	4.50	1.37	2.20	0.96													0.75
1	6.55	85.18	36.93	3.45	17.68	7.66	1.82	3.75	1.63	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	13.09	307.52	133.31	6.90	63.82	27.67	3.65	13.55	5.88	2.25	4.19	1.82	1.26	1.03	0.44	0.77	0.31	0.13	0.44	0.08	0.03	2
5				17.25	348.29	150.98	9.11	73.96	32.06	5.63	22.88	9.92	3.16	5.60	2.43	1.93	1.69	0.73	1.10	0.43	0.19	5
7							12.76	137.93	59.79	7.88	42.66	18.49	4.42	10.44	4.53	2.70	3.14	1.36	1.55	0.81	0.35	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	10
15													9.47	42.82	18.56	5.78	12.89	5.59	3.31	3.32	1.44	15
20													12.63	72.95	31.63	7.71	21.96	9.52	4.42	5.65	2.45	20
25																9.64	33.20	14.39	5.52	8.55	3.71	25
30																11.57	46.54	20.17	6.62	11.98	5.19	30
35																			7.73	15.94	6.91	35
40																			8.83	20.41	8.85	40
45																			9.94	25.39	11.00	45
50																			11.04	30.86	13.38	50

GPM	1-1/2"			2"			2-1/2"			3"			4"			5"			6"			GPM
2	0.32	0.04	0.02																			2
5	0.81	0.20	0.09	0.49	0.06	0.03																5
7	1.13	0.38	0.16	0.68	0.11	0.05	0.48	0.05	0.02													7
10	1.62	0.73	0.32	0.97	0.21	0.09	0.68	0.09	0.04	0.44	0.03	0.01										10
15	2.42	1.55	0.67	1.46	0.45	0.20	1.02	0.19	0.08	0.66	0.07	0.03										15
20	3.23	2.64	1.15	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	4.04	4.00	1.73	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	4.85	5.60	2.43	2.92	1.64	0.71	2.05	0.69	0.30	1.32	0.24	0.10	0.77	0.06	0.03	0.49	0.02	0.01				30
35	5.65	7.45	3.23	3.41	2.18	0.94	2.39	0.92	0.40	1.54	0.32	0.14	0.89	0.08	0.04	0.57	0.03	0.01				35
40	6.46	9.54	4.14	3.90	2.79	1.21	2.73	1.18	0.51	1.76	0.41	0.18	1.02	0.11	0.05	0.65	0.04	0.02				40
45	7.27	11.87	5.15	4.39	3.47	1.51	3.07	1.46	0.63	1.99	0.51	0.22	1.15	0.13	0.06	0.73	0.04	0.02				45
50	8.08	14.43	6.25	4.87	4.22	1.83	3.41	1.78	0.77	2.21	0.61	0.27	1.28	0.16	0.07	0.81	0.05	0.02	0.56	0.02	0.01	50
60	9.69	20.22	8.77	5.85	5.92	2.56	4.10	2.49	1.08	2.65	0.86	0.37	1.53	0.23	0.10	0.97	0.08	0.03	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	1.14	0.10	0.04	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	1.22	0.11	0.05	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	1.30	0.13	0.06	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	1.46	0.16	0.07	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	1.62	0.19	0.08	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	2.03	0.29	0.13	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	2.43	0.41	0.18	1.68	0.17	0.07	150
175										7.72	6.25	2.71	4.47	1.65	0.72	2.84	0.55	0.24	1.96	0.22	0.10	175
200										8.82	8.00	3.47	5.11	2.12	0.92	3.25	0.70	0.30	2.25	0.29	0.12	200
250										11.03	12.10	5.24	6.39	3.20	1.39	4.06	1.06	0.46	2.81	0.43	0.19	250
300													7.66	4.49	1.95	4.87	1.49	0.65	3.37	0.61	0.26	300
350													8.94	5.97	2.59	5.68	1.98	0.86	3.93	0.81	0.35	350
400													10.22	7.64	3.31	6.49	2.54	1.10	4.49	1.03	0.45	400
450																7.30	3.15	1.37	5.05	1.29	0.56	450
500																8.11	3.83	1.66	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.



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 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"			14"			16"			18"			20"			24"			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	0.96	0.02	0.01	0.73	0.01	0.01										400
450	2.91	0.34	0.15	1.85	0.11	0.05	1.30	0.05	0.02	1.08	0.03	0.01	0.82	0.02	0.01										450
500	3.24	0.41	0.18	2.05	0.14	0.06	1.44	0.06	0.02	1.19	0.04	0.02	0.91	0.02	0.01										500
750	4.85	0.87	0.38	3.08	0.29	0.12	2.17	0.12	0.05	1.79	0.08	0.03	1.37	0.04	0.02	1.08	0.02	0.01							750
1000	6.47	1.48	0.64	4.10	0.49	0.21	2.89	0.21	0.09	2.39	0.13	0.06	1.83	0.07	0.03	1.45	0.04	0.02	1.16	0.02	0.01				1000
1250				5.13	0.74	0.32	3.61	0.31	0.14	2.99	0.20	0.09	2.29	0.10	0.04	1.81	0.06	0.03	1.45	0.03	0.01				1250
1500				6.15	1.03	0.45	4.33	0.44	0.19	3.58	0.28	0.12	2.74	0.14	0.06	2.17	0.08	0.04	1.74	0.05	0.02	1.21	0.02	0.01	1500
2000							5.78	0.75	0.33	4.78	0.47	0.20	3.66	0.25	0.11	2.89	0.14	0.06	2.32	0.08	0.04	1.61	0.03	0.01	2000
2500							7.22	1.13	0.49	5.97	0.71	0.31	4.57	0.37	0.16	3.61	0.21	0.09	2.91	0.12	0.05	2.01	0.05	0.02	2500
3000										7.17	1.00	0.43	5.49	0.52	0.23	4.34	0.29	0.13	3.49	0.17	0.08	2.41	0.07	0.03	3000
3500													6.40	0.70	0.30	5.06	0.39	0.17	4.07	0.23	0.10	2.81	0.09	0.04	3500
4000																5.78	0.50	0.22	4.65	0.30	0.13	3.21	0.12	0.05	4000
4500																6.50	0.62	0.27	5.23	0.37	0.16	3.62	0.15	0.06	4500
5000																			5.81	0.45	0.19	4.02	0.18	0.08	5000
5500																			6.39	0.53	0.23	4.42	0.22	0.09	5500
6000																			6.97	0.63	0.27	4.82	0.25	0.11	6000
7000																						5.62	0.34	0.15	7000
7500																						6.03	0.39	0.17	7500
8000																						6.43	0.43	0.19	8000
8500																						6.83	0.49	0.21	8500

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 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	1/8"			1/4"			3/8"			1/2"			3/4"			1"			1-1/4"			GPM
0.25	2.67	21.47	9.31	1.29	3.57	1.55	0.63	0.63	0.27													0.25
0.50	5.35	77.52	33.60	2.59	12.88	5.58	1.25	2.27	0.98													0.50
0.75	8.02	164.25	71.20	3.88	27.29	11.83	1.88	4.80	2.08													0.75
1	10.69	279.84	121.31	5.17	46.49	20.15	2.51	8.18	3.55	1.48	2.24	0.97	0.78	0.48	0.21	0.47	0.14	0.06	0.26	0.03	0.01	1
2	21.39	1010.21	437.93	10.35	167.84	72.76	5.01	29.54	12.81	2.96	8.08	3.50	1.56	1.73	0.75	0.93	0.49	0.21	0.52	0.12	0.05	2
5				25.87	915.95	397.07	12.53	161.23	69.89	7.39	44.12	19.12	3.91	9.45	4.10	2.33	2.67	1.16	1.30	0.64	0.28	5
7							17.54	300.66	130.34	10.35	82.27	35.66	5.48	17.62	7.64	3.26	4.98	2.16	1.81	1.20	0.52	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	10
15													11.74	72.27	31.33	6.99	20.44	8.86	3.89	4.91	2.13	15
20													15.65	123.13	53.38	9.33	34.82	15.09	5.18	8.36	3.62	20
25																11.66	52.64	22.82	6.48	12.64	5.48	25
30																13.99	73.78	31.98	7.77	17.71	7.68	30
35																16.32	98.16	42.55	9.07	23.56	10.21	35
40																18.65	125.70	54.49	10.37	30.17	13.08	40
45																			11.66	37.53	16.27	45
50																			12.96	45.62	19.77	50
60																			15.55	63.94	27.72	60
70																			18.14	85.06	36.87	70
75																			19.43	96.66	41.90	75
80																			20.73	108.93	47.22	80
GPM	1-1/2"			2"			2-1/2"			3"			4"			5"			6"			GPM
1	0.19	0.01	0.01	0.11	0.00	0.00	0.08	0.00	0.00	0.05	0.00	0.00										1
2	0.38	0.05	0.02	0.22	0.02	0.01	0.16	0.01	0.00	0.10	0.00	0.00										2
5	0.96	0.29	0.13	0.56	0.08	0.04	0.39	0.03	0.01	0.25	0.01	0.01										5
7	1.34	0.54	0.24	0.78	0.15	0.07	0.55	0.06	0.03	0.35	0.02	0.01										7
10	1.92	1.05	0.46	1.12	0.30	0.13	0.78	0.12	0.05	0.50	0.04	0.02										10
15	2.87	2.23	0.97	1.67	0.63	0.27	1.17	0.26	0.11	0.75	0.09	0.04										15
20	3.83	3.80	1.65	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	4.79	5.74	2.49	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	5.75	8.04	3.49	3.35	2.28	0.99	2.34	0.95	0.41	1.49	0.32	0.14	0.85	0.08	0.04	0.54	0.03	0.01				30
35	6.71	10.70	4.64	3.91	3.03	1.31	2.73	1.26	0.55	1.74	0.43	0.18	1.00	0.11	0.05	0.63	0.04	0.02				35
40	7.66	13.71	5.94	4.46	3.88	1.68	3.11	1.62	0.70	1.99	0.54	0.24	1.14	0.14	0.06	0.72	0.05	0.02				40
45	8.62	17.05	7.39	5.02	4.83	2.09	3.50	2.01	0.87	2.24	0.68	0.29	1.28	0.17	0.08	0.81	0.06	0.02				45
50	9.58	20.72	8.98	5.58	5.87	2.54	3.89	2.45	1.06	2.49	0.82	0.36	1.42	0.21	0.09	0.90	0.07	0.03	0.63	0.03	0.01	50
60	11.50	29.04	12.59	6.69	8.22	3.56	4.67	3.43	1.49	2.99	1.15	0.50	1.71	0.30	0.13	1.08	0.10	0.04	0.75	0.04	0.02	60
70	13.41	38.64	16.75	7.81	10.94	4.74	5.45	4.56	1.98	3.48	1.54	0.67	1.99	0.39	0.17	1.26	0.13	0.06	0.88	0.05	0.02	70
75	14.37	43.90	19.03	8.37	12.43	5.39	5.84	5.18	2.25	3.73	1.74	0.76	2.14	0.45	0.19	1.35	0.15	0.06	0.94	0.06	0.03	75
80	15.33	49.48	21.45	8.93	14.01	6.07	6.23	5.84	2.53	3.98	1.97	0.85	2.28	0.51	0.22	1.44	0.16	0.07	1.00	0.07	0.03	80
90	17.24	61.54	26.68	10.04	17.42	7.55	7.01	7.26	3.15	4.48	2.45	1.06	2.56	0.63	0.27	1.62	0.20	0.09	1.13	0.09	0.04	90
100	19.16	74.80	32.42	11.16	21.18	9.18	7.79	8.83	3.83	4.98	2.97	1.29	2.85	0.76	0.33	1.80	0.25	0.11	1.25	0.10	0.04	100
125	23.95	113.07	49.02	13.95	32.02	13.88	9.73	13.34	5.78	6.22	4.49	1.95	3.56	1.16	0.50	2.24	0.38	0.16	1.57	0.16	0.07	125
150	28.74	158.49	68.71	16.74	44.88	19.45	11.68	18.70	8.11	7.47	6.30	2.73	4.27	1.62	0.70	2.69	0.53	0.23	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	3.14	0.70	0.30	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	3.59	0.90	0.39	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	4.49	1.36	0.59	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	5.39	1.90	0.83	3.76	0.79	0.34	300
350													9.97	7.78	3.37	6.29	2.53	1.10	4.38	1.05	0.46	350
400													11.39	9.96	4.32	7.18	3.24	1.41	5.01	1.35	0.59	400
450													12.82	12.39	5.37	8.08	4.04	1.75	5.64	1.68	0.73	450
500																8.98	4.90	2.13	6.26	2.04	0.89	500

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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 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"			14"			16"			18"			20"			24"			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	1.06	0.03	0.01	0.81	0.02	0.01											400		
450	3.21	0.43	0.19	2.04	0.14	0.06	1.44	0.06	0.03	1.19	0.04	0.02	0.91	0.02	0.01											450		
500	3.57	0.52	0.23	2.27	0.17	0.07	1.60	0.07	0.03	1.33	0.05	0.02	1.01	0.02	0.01											500		
750	5.35	1.10	0.48	3.40	0.36	0.16	2.40	0.16	0.07	1.99	0.10	0.04	1.52	0.05	0.02	1.19	0.03	0.01								750		
1000	7.13	1.87	0.81	4.53	0.62	0.27	3.20	0.27	0.12	2.65	0.17	0.07	2.02	0.09	0.04	1.59	0.05	0.02	1.29	0.03	0.01					1000		
1250				5.66	0.94	0.41	4.00	0.40	0.17	3.31	0.25	0.11	2.53	0.13	0.06	1.99	0.07	0.03	1.61	0.04	0.02					1250		
1500				6.80	1.32	0.57	4.80	0.57	0.24	3.98	0.36	0.15	3.03	0.18	0.08	2.39	0.10	0.04	1.93	0.06	0.03	1.34	0.03	0.01	1500			
2000							6.40	0.96	0.42	5.30	0.61	0.26	4.04	0.31	0.14	3.18	0.18	0.08	2.57	0.10	0.05	1.78	0.04	0.02	2000			
2500										6.63	0.92	0.40	5.05	0.48	0.21	3.98	0.27	0.12	3.22	0.16	0.07	2.23	0.06	0.03	2500			
3000											7.95	1.29	0.56	6.06	0.67	0.29	4.78	0.37	0.16	3.86	0.22	0.10	2.67	0.09	0.04	3000		
3500													7.07	0.89	0.38	5.57	0.50	0.22	4.50	0.30	0.13	3.12	0.12	0.05	3500			
4000															6.37	0.64	0.28	5.15	0.38	0.16	3.56	0.15	0.07	4000				
4500																	7.16	0.79	0.34	5.79	0.47	0.20	4.01	0.19	0.08	4500		
5000																			6.43	0.57	0.25	4.45	0.23	0.10	5000			
5500																				7.08	0.68	0.30	4.90	0.28	0.12	5500		
6000																					7.72	0.80	0.35	5.34	0.33	0.14	6000	
7000																						6.23	0.44	0.19	7000			
7500																							6.68	0.49	0.21	7500		
8000																								7.12	0.56	0.24	8000	
8500																									7.57	0.62	0.27	8500

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FLOW VELOCITY & FRICTION LOSS

SCHEDULE 120																										
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 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"			2"			2-1/2"			3"				GPM
1	1.77	3.50	1.52	0.86	0.60	0.26	0.51	0.17	0.07	0.28	0.04	0.02	0.20	0.02	0.01	0.12	0.00	0.00	0.08	0.00	0.00	0.05	0.00	0.00	1	
2	3.54	12.62	5.47	1.72	2.16	0.94	1.03	0.62	0.27	0.56	0.14	0.06	0.40	0.06	0.03	0.24	0.02	0.01	0.16	0.01	0.00	0.11	0.00	0.00	2	
5	8.86	68.86	29.85	4.29	11.78	5.11	2.57	3.40	1.47	1.41	0.78	0.34	1.01	0.35	0.15	0.60	0.10	0.04	0.41	0.04	0.02	0.27	0.01	0.01	5	
7	12.41	128.41	55.67	6.00	21.97	9.52	3.60	6.33	2.75	1.97	1.46	0.63	1.41	0.65	0.28	0.84	0.18	0.08	0.57	0.07	0.03	0.38	0.03	0.01	7	
10	17.72	248.59	107.76	8.58	42.53	18.43	5.15	12.26	5.31	2.82	2.83	1.23	2.02	1.26	0.54	1.20	0.36	0.15	0.82	0.14	0.06	0.54	0.05	0.02	10	
15	4"			12.87	90.11	39.06	7.72	25.98	11.26	4.23	6.00	2.60	3.03	2.66	1.15	1.80	0.75	0.33	1.22	0.29	0.13	0.81	0.11	0.05	15	
20	0.64	0.05	0.02	17.16	153.52	66.55	10.30	44.25	19.18	5.64	10.23	4.43	4.04	4.54	1.97	2.40	1.28	0.56	1.63	0.50	0.22	1.07	0.18	0.08	20	
25	0.80	0.08	0.03				12.87	66.90	29.00	7.05	15.46	6.70	5.04	6.86	2.97	3.00	1.94	0.84	2.04	0.76	0.33	1.34	0.27	0.12	25	
30	0.96	0.11	0.05				15.45	93.77	40.65	8.46	21.67	9.39	6.05	9.61	4.17	3.60	2.72	1.18	2.45	1.06	0.46	1.61	0.38	0.17	30	
35	1.12	0.14	0.06				18.02	124.75	54.08	9.87	28.83	12.50	7.06	12.79	5.54	4.20	3.61	1.57	2.85	1.41	0.61	1.88	0.51	0.22	35	
40	1.28	0.19	0.08				20.60	159.75	69.25	11.28	36.92	16.01	8.07	16.37	7.10	4.80	4.63	2.01	3.26	1.80	0.78	2.15	0.65	0.28	40	
45	1.44	0.23	0.10	5"						12.69	45.92	19.91	9.08	20.37	8.83	5.40	5.76	2.50	3.67	2.24	0.97	2.42	0.81	0.35	45	
50	1.60	0.28	0.12	0.69	0.04	0.02				14.09	55.82	24.20	10.09	24.75	10.73	6.00	7.00	3.03	4.08	2.73	1.18	2.69	0.99	0.43	50	
60	1.92	0.39	0.17	0.83	0.05	0.02				16.91	78.24	33.92	12.11	34.70	15.04	7.20	9.81	4.25	4.89	3.82	1.66	3.22	1.39	0.60	60	
70	2.24	0.52	0.23	0.97	0.07	0.03				19.73	104.09	45.12	14.12	46.16	20.01	8.40	13.05	5.66	5.71	5.09	2.21	3.76	1.84	0.80	70	
75	2.40	0.59	0.26	1.04	0.08	0.03				21.14	118.27	51.27	15.13	52.45	22.74	9.00	14.82	6.43	6.11	5.78	2.51	4.03	2.10	0.91	75	
80	2.56	0.67	0.29	1.11	0.09	0.04				22.55	133.29	57.78	16.14	59.11	25.62	9.60	16.71	7.24	6.52	6.51	2.82	4.30	2.36	1.02	80	
90	2.88	0.83	0.36	1.25	0.11	0.05				25.37	165.78	71.87	18.16	73.52	31.87	10.81	20.78	9.01	7.34	8.10	3.51	4.84	2.94	1.27	90	
100	3.20	1.01	0.44	1.38	0.13	0.06	6"						20.18	89.36	38.74	12.01	25.26	10.95	8.15	9.85	4.27	5.37	3.57	1.55	100	
125	4.00	1.53	0.66	1.73	0.20	0.09	0.99	0.05	0.02				25.22	135.09	58.56	15.01	38.18	16.55	10.19	14.89	6.45	6.72	5.40	2.34	125	
150	4.80	2.14	0.93	2.08	0.28	0.12	1.19	0.07	0.03				30.26	189.35	82.08	18.01	53.52	23.20	12.23	20.87	9.05	8.06	7.57	3.28	150	
175	5.60	2.85	1.24	2.42	0.37	0.16	1.38	0.10	0.04							21.01	71.20	30.86	14.27	27.76	12.04	9.40	10.07	4.36	175	
200	6.40	3.65	1.58	2.77	0.48	0.21	1.58	0.12	0.05							24.01	91.17	39.52	16.30	35.55	15.41	10.75	12.89	5.59	200	
250	8.00	5.52	2.39	3.46	0.72	0.31	1.98	0.18	0.08							30.01	137.83	59.75	20.38	53.75	23.30	13.43	19.49	8.45	250	
300	9.60	7.74	3.36	4.15	1.01	0.44	2.37	0.26	0.11																300	
350	11.20	10.30	4.46	4.84	1.34	0.58	2.77	0.34	0.15																350	
400	12.80	13.19	5.72	5.54	1.72	0.74	3.16	0.44	0.19																400	
450	14.40	16.40	7.11	6.23	2.14	0.93	3.56	0.55	0.24																450	
500				6.92	2.60	1.13	3.95	0.67	0.29																500	
750				10.38	5.50	2.38	5.93	1.14	0.61																750	
1,000				13.84	9.37	4.06	7.91	2.40	1.04																1,000	
1,250							9.88	3.63	1.57																1,250	
1,500							11.86	5.09	2.21																1,500	
2,000							15.81	8.67	3.76																2,000	

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

SDR 11																			
Flow Rate (Gallons/ Minute)	Velocity Feet Per Second	Head Loss Feet of Water Per 100 Ft.	Pressure Loss PSI Per 100 Ft.	Velocity Feet Per Second	Head Loss Feet of Water Per 100 Ft.	Pressure Loss PSI Per 100 Ft.	Velocity Feet Per Second	Head Loss Feet of Water Per 100 Ft.	Pressure Loss PSI Per 100 Ft.	Velocity Feet Per Second	Head Loss Feet of Water Per 100 Ft.	Pressure Loss PSI Per 100 Ft.	Velocity Feet Per Second	Head Loss Feet of Water Per 100 Ft.	Pressure Loss PSI Per 100 Ft.	Velocity Feet Per Second	Head Loss Feet of Water Per 100 Ft.	Pressure Loss PSI Per 100 Ft.	Flow Rate (Gallons/ Minute)
GPM	1/2"			3/4"			1"			1-1/4"			1-1/2"			2"			GPM
1	1.71	3.19	1.38	0.80	0.50	0.22	0.48	0.15	0.06										1
2	3.42	11.53	5.00	1.60	1.82	0.79	0.96	0.53	0.23										2
3	5.13	24.43	10.59	2.40	3.85	1.67	1.44	1.12	0.49										3
4	6.83	41.62	18.04	3.20	6.55	2.84	1.93	1.91	0.83										4
5	8.54	62.91	27.27	4.00	9.91	4.29	2.41	2.89	1.25										5
6	10.25	88.18	38.23	4.79	13.89	6.02	2.89	4.05	1.76										6
7	11.96	117.32	50.86	5.59	18.47	8.01	3.37	5.39	2.34										7
8	13.67	150.23	65.13	6.39	23.66	10.26	3.85	6.90	2.99										8
9	15.38	186.85	81.00	7.19	29.42	12.76	4.33	8.58	3.72										9
10	17.08	227.11	98.45	7.99	35.76	15.50	4.82	10.43	4.52	3.23	3.94	1.71	2.31	1.75	0.76	1.35	0.49	0.21	10
15				11.99	75.78	32.85	7.22	22.11	9.58	4.84	8.35	3.62	3.47	3.71	1.61	2.03	1.03	0.45	15
20				15.98	129.11	55.97	9.63	37.67	16.33	6.46	14.23	6.17	4.63	6.33	2.74	2.70	1.76	0.76	20
25							12.04	56.94	24.69	8.07	21.51	9.33	5.78	9.56	4.15	3.38	2.66	1.15	25
30							14.45	79.82	34.60	9.68	30.15	13.07	6.94	13.40	5.81	4.05	3.73	1.62	30
35							16.86	106.19	46.03	11.30	40.11	17.39	8.09	17.83	7.73	4.73	4.96	2.15	35
40										12.91	51.37	22.27	9.25	22.83	9.90	5.40	6.35	2.75	40
45										14.52	63.89	27.70	10.41	28.40	12.31	6.08	7.89	3.42	45
50										16.14	77.66	33.66	11.56	34.52	14.96	6.75	9.60	4.16	50
55										17.75	92.65	40.16	12.72	41.18	17.85	7.43	11.45	4.96	55
60													13.88	48.38	20.97	8.10	13.45	5.83	60
70													16.19	64.37	27.90	9.46	17.89	7.76	70
80																10.61	22.91	9.93	80
90																12.16	28.50	12.35	90
100																13.51	34.64	15.02	100
125																16.89	52.37	22.70	125

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

SDR 13.5

Flow Rate (Gallons/ Minute)	cubic ft/sec	Velocity (ft/s)	Friction Head Loss (ft water/ 100ft)	Friction Pressure (psi/ 100ft)	Velocity (ft/s)	Friction Head Loss (ft water/ 100ft)	Friction Pressure (psi/ 100ft)	Velocity (ft/s)	Friction Head Loss (ft water/ 100ft)	Friction Pressure (psi/ 100ft)	Velocity (ft/s)	Friction Head Loss (ft water/ 100ft)	Friction Pressure (psi/ 100ft)	Velocity (ft/s)	Friction Head Loss (ft water/ 100ft)	Friction Pressure (psi/ 100ft)	Velocity (ft/s)	Friction Head Loss (ft water/ 100ft)	Friction Pressure (psi/ 100ft)	Velocity (ft/s)	Friction Head Loss (ft water/ 100ft)	Friction Pressure (psi/ 100ft)	Velocity (ft/s)	Friction Head Loss (ft water/ 100ft)	Friction Pressure (psi/ 100ft)	Flow Rate (Gallons/ Minute)					
GPM		1/2"			3/4"			1"			1-1/4"			1-1/2"			2"			2-1/2"			3"			GPM					
1	0.002	0.85	1.03	0.45	0.54	0.34	0.15																		1						
2	0.004	1.69	2.05	0.89	1.07	0.68	0.29	0.68	0.40	0.17	0.42	0.13	0.06	0.32	0.065	0.028	0.20	0.03	0.013						2						
5	0.011	4.22	11.58	5.01	2.68	3.82	1.65	1.69	1.24	0.54	1.05	0.39	0.17	0.80	0.20	0.088	0.51	0.075	0.033	0.35	0.038	0.016	0.24	0.02	0.009	5					
7	0.016	5.91	21.24	9.20	3.75	7.01	3.03	2.36	2.28	0.99	1.47	0.72	0.31	1.12	0.37	0.16	0.72	0.125	0.054	0.49	0.53	0.023	0.33	0.03	0.012	7					
10	0.022	8.44	40.46	17.52	5.35	13.34	5.78	3.37	4.33	1.87	2.10	1.37	0.59	1.60	0.71	0.31	1.02	0.24	0.10	0.70	0.09	0.039	0.47	0.04	0.017	10					
15	0.033	4"			8.03	28.27	12.24	5.06	9.18	3.97	3.15	2.91	1.26	2.40	1.50	0.65	1.53	0.50	0.22	1.04	0.20	0.087	0.70	0.08	0.035	15					
20	0.045	0.57	0.04	0.017	10.70	48.17	20.86	6.74	15.64	6.77	4.21	4.96	2.91	3.20	2.55	1.10	2.04	0.85	0.37	1.39	0.34	0.15	0.94	0.13	0.056	20					
25	0.056	0.71	0.06	0.026	5"			8.43	23.65	10.24	5.26	7.49	3.24	4.00	3.85	1.67	2.55	1.29	0.56	1.74	0.51	0.22	1.17	0.19	0.082	25					
30	0.067	0.85	0.08	0.035	0.56	0.03	0.013	10.11	33.15	14.35	6.31	10.50	4.55	4.80	5.40	2.34	3.05	1.80	0.78	2.09	0.71	0.31	1.41	0.27	0.12	30					
35	0.078	0.99	0.11	0.048	0.65	0.04	0.017					7.36	13.97	6.05	5.60	7.19	3.11	3.57	2.40	1.04	2.44	0.95	0.41	1.64	0.36	0.16	35				
40	0.089	1.14	0.14	0.060	0.74	0.05	0.022					8.41	17.90	7.75	6.40	9.20	3.98	4.08	3.07	1.33	2.78	1.21	0.52	1.88	0.46	0.20	40				
45	0.100	1.28	0.17	0.074	0.84	0.06	0.026	6"			9.46	22.26	9.64	7.20	11.44	4.95	4.59	3.82	1.65	3.13	1.51	0.65	2.11	0.58	0.25	45					
50	0.111	1.42	0.21	0.091	0.93	0.07	0.030	0.66	0.03	0.013	10.52	27.05	11.71	8.00	13.91	6.02	5.10	4.64	2.01	3.48	1.83	0.79	2.35	0.70	0.30	50					
60	0.134	1.70	0.29	0.13	1.12	0.10	0.043	0.79	0.04	0.017					9.60	19.50	8.44	6.12	6.50	2.81	4.18	2.57	1.11	2.82	0.98	0.42	60				
70	0.156	1.99	0.38	0.16	1.30	0.14	0.061	0.92	0.06	0.026							7.14	8.65	3.75	4.87	3.42	1.48	3.29	1.31	0.57	70					
75	0.167	2.13	0.44	0.19	1.40	0.16	0.069	0.98	0.07	0.030							7.65	9.83	4.26	5.22	3.88	1.68	3.52	1.49	0.65	75					
80	0.178	2.27	0.49	0.21	1.49	0.18	0.078	1.05	0.08	0.035							8.16	11.08	4.80	5.57	4.37	1.89	3.76	1.68	0.73	80					
90	0.201	2.56	0.61	0.26	1.67	0.22	0.095	1.18	0.09	0.039							9.18	13.78	5.97	6.27	5.44	2.36	4.23	2.09	0.90	90					
100	0.223	2.84	0.74	0.32	1.86	0.27	0.12	1.31	0.11	0.048							10.20	16.75	7.25	6.96	6.61	2.86	4.70	2.54	1.10	100					
125	0.279	3.55	1.13	0.49	2.33	0.40	0.18	1.64	0.17	0.074													8.70	10.01	4.33	5.88	3.84	1.66	125		
150	0.334	4.26	1.58	0.68	2.79	0.56	0.24	1.97	0.24	0.10													10.44	14.01	6.07	7.04	5.37	2.33	150		
175	0.390	4.97	2.10	0.91	3.26	0.75	0.33	2.30	0.32	0.14																8.22	7.15	3.10	175		
200	0.446	5.68	2.69	1.16	3.72	0.96	0.42	2.62	0.41	0.18																9.39	9.15	3.96	200		
250	0.557	7.10	4.07	1.76	4.66	1.46	0.63	3.28	0.62	0.27																11.74	13.86	6.00	250		
300	0.668	8.52	5.69	2.46	5.58	2.03	0.88	3.93	0.87	0.38																					300
350	0.780	9.94	7.58	3.29	6.52	2.70	1.17	4.59	1.16	0.50																					350
400	0.891	11.36	9.70	4.20	7.44	3.46	1.50	5.24	1.48	0.64																					400
450	1.003				8.37	4.31	1.87	5.90	1.84	0.80																					450
500	1.114				9.30	5.24	2.27	6.56	2.23	0.97																					500
750								9.83	4.73	2.05																					750
1000	2.228							13.11	8.06	3.49																					1000

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

SDR 21																									
Flow Rate (Gallons per 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 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 per Minute)
GPM	1/2"		3/4"			1"			1-1/4"			1-1/2"			2"			2-1/2"			3"			GPM	
1				0.49	0.16	0.07	0.30	0.05	0.02	0.19	0.01	0.01	0.14	0.01	0.00	0.09	0.00	0.00	0.06	0.00	0.00	0.04	0.00	0.00	1
2				0.99	0.56	0.24	0.60	0.17	0.07	0.37	0.05	0.02	0.28	0.03	0.01	0.18	0.01	0.00	0.12	0.00	0.00	0.08	0.00	0.00	2
5				2.46	3.06	1.33	1.49	0.91	0.39	0.93	0.29	0.12	0.71	0.15	0.06	0.45	0.05	0.02	0.31	0.02	0.01	0.21	0.01	0.00	5
7				3.45	5.71	2.48	2.09	1.69	0.73	1.30	0.53	0.23	0.99	0.27	0.12	0.63	0.09	0.04	0.43	0.04	0.02	0.29	0.01	0.01	7
10				4.93	11.06	4.80	2.99	3.27	1.42	1.86	1.03	0.45	1.41	0.53	0.23	0.90	0.18	0.08	0.61	0.07	0.03	0.41	0.03	0.01	10
15	4"			7.39	23.44	10.16	4.48	6.93	3.00	2.79	2.18	0.95	2.12	1.12	0.49	1.35	0.37	0.16	0.92	0.15	0.06	0.62	0.06	0.02	15
20	0.50	0.03	0.01	9.86	39.94	17.31	5.97	11.81	5.12	3.72	3.72	1.61	2.83	1.91	0.83	1.80	0.64	0.28	1.23	0.25	0.11	0.83	0.10	0.04	20
25	0.62	0.04	0.02	5"			7.47	17.85	7.74	4.65	5.63	2.44	3.53	2.89	1.25	2.25	0.97	0.42	1.53	0.38	0.16	1.03	0.14	0.06	25
30	0.75	0.06	0.03	0.49	0.02	0.01	8.96	25.02	10.85	5.58	7.89	3.42	4.24	4.05	1.75	2.70	1.35	0.59	1.84	0.53	0.23	1.24	0.20	0.09	30
35	0.87	0.08	0.03	0.57	0.03	0.01	10.45	33.28	14.43	6.51	10.49	4.55	4.94	5.38	2.33	3.15	1.80	0.78	2.15	0.71	0.31	1.44	0.27	0.12	35
40	1.00	0.10	0.04	0.65	0.04	0.02				7.43	13.44	5.83	5.65	6.89	2.99	3.60	2.31	1.00	2.45	0.90	0.39	1.65	0.34	0.15	40
45	1.12	0.13	0.05	0.73	0.04	0.02	6"			8.36	16.71	7.25	6.36	8.57	3.72	4.05	2.87	1.24	2.76	1.12	0.49	1.86	0.43	0.19	45
50	1.25	0.15	0.07	0.82	0.05	0.02	0.58	0.02	0.01	9.29	20.31	8.81	7.06	10.42	4.52	4.50	3.49	1.51	3.06	1.37	0.59	2.06	0.52	0.23	50
60	1.50	0.21	0.09	0.98	0.08	0.03	0.69	0.03	0.01				8.48	14.60	6.33	5.41	4.89	2.12	3.68	1.91	0.83	2.48	0.73	0.32	60
70	1.75	0.29	0.12	1.14	0.10	0.04	0.81	0.04	0.02				9.89	19.43	8.42	6.31	6.50	2.82	4.29	2.55	1.10	2.89	0.97	0.42	70
75	1.87	0.32	0.14	1.22	0.12	0.05	0.86	0.05	0.02				10.59	22.08	9.57	6.76	7.39	3.20	4.60	2.89	1.25	3.09	1.10	0.48	75
80	2.00	0.37	0.16	1.31	0.13	0.06	0.92	0.06	0.02							7.21	8.32	3.61	4.90	3.26	1.41	3.30	1.25	0.54	80
90	2.24	0.46	0.20	1.47	0.16	0.07	1.04	0.07	0.03	8"						8.11	10.35	4.49	5.52	4.06	1.76	3.71	1.55	0.67	90
100	2.49	0.55	0.24	1.63	0.20	0.09	1.15	0.08	0.04	0.68	0.02	0.01				9.01	12.58	5.46	6.13	4.93	2.14	4.13	1.88	0.82	100
125	3.12	0.84	0.36	2.04	0.30	0.13	1.44	0.13	0.06	0.85	0.04	0.02							7.66	7.46	3.23	5.16	2.85	1.23	125
150	3.74	1.17	0.51	2.45	0.42	0.18	1.73	0.18	0.08	1.02	0.05	0.02							9.19	10.45	4.53	6.19	3.99	1.73	150
175	4.36	1.56	0.68	2.86	0.56	0.24	2.01	0.24	0.10	1.19	0.07	0.03							10.73	13.90	6.03	7.22	5.31	2.30	175
200	4.99	2.00	0.87	3.26	0.71	0.31	2.30	0.30	0.13	1.36	0.08	0.04										8.25	6.80	2.95	200
250	6.24	3.02	1.31	4.08	1.08	0.47	2.88	0.46	0.20	1.70	0.13	0.06										10.31	10.27	4.45	250
300	7.48	4.23	1.84	4.90	1.51	0.65	3.45	0.65	0.28	2.04	0.18	0.08													300
350	8.73	5.63	2.44	5.71	2.01	0.87	4.03	0.86	0.37	2.38	0.24	0.10													350
400	9.98	7.21	3.13	6.53	2.57	1.12	4.61	1.10	0.48	2.71	0.30	0.13													400
450	11.22	8.97	3.89	7.35	3.20	1.39	5.18	1.37	0.59	3.05	0.38	0.16													450
500				8.16	3.89	1.69	5.76	1.66	0.72	3.39	0.46	0.20													500
750							8.64	3.52	1.53	5.09	0.97	0.42													750
1000										6.79	1.66	0.72													1000
1250										8.48	2.51	1.09													1250

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FLOW VELOCITY & FRICTION LOSS

SDR 26																															
Flow Rate (Gallons per 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 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 per Minute)
GPM	1"			1-1/4"			1-1/2"			2"			2-1/2"			3"			4"			5"			6"			GPM			
1	0.30	0.04	0.02	0.18	0.01	0.01	0.14	0.01	0.00	0.09	0.00	0.00	0.06	0.00	0.00	0.04	0.00	0.00										1			
2	0.59	0.16	0.07	0.36	0.05	0.02	0.27	0.02	0.01	0.17	0.01	0.00	0.12	0.00	0.00	0.08	0.00	0.00										2			
5	1.48	0.88	0.38	0.89	0.26	0.11	0.68	0.13	0.06	0.43	0.04	0.02	0.29	0.02	0.01	0.20	0.01	0.00										5			
7	2.07	1.65	0.71	1.25	0.48	0.21	0.95	0.25	0.11	0.61	0.08	0.04	0.41	0.03	0.01	0.28	0.01	0.01										7			
10	2.96	3.19	1.38	1.79	0.94	0.41	1.36	0.48	0.21	0.86	0.16	0.07	0.59	0.06	0.03	0.40	0.02	0.01										10			
15	4.44	6.76	2.93	2.68	1.98	0.86	2.04	1.02	0.44	1.30	0.34	0.15	0.88	0.13	0.06	0.59	0.05	0.02										15			
20	5.91	11.52	4.99	3.57	3.38	1.46	2.72	1.73	0.75	1.73	0.58	0.25	1.18	0.23	0.10	0.79	0.09	0.04	0.48	0.03	0.01							20			
25	7.39	17.41	7.55	4.47	5.10	2.21	3.40	2.62	1.14	2.16	0.87	0.38	1.47	0.34	0.15	0.99	0.13	0.06	0.60	0.04	0.02							25			
30	8.87	24.40	10.58	5.36	7.15	3.10	4.07	3.67	1.59	2.59	1.23	0.53	1.76	0.48	0.21	1.19	0.18	0.08	0.72	0.05	0.02	0.47	0.02	0.01				30			
35	10.35	32.46	14.07	6.25	9.52	4.13	4.75	4.89	2.12	3.03	1.63	0.71	2.06	0.64	0.28	1.39	0.24	0.11	0.84	0.07	0.03	0.55	0.03	0.01				35			
40	11.83	41.57	18.02	7.14	12.19	5.28	5.43	6.26	2.71	3.46	2.09	0.90	2.35	0.82	0.35	1.58	0.31	0.14	0.96	0.09	0.04	0.63	0.03	0.01				40			
45				8.04	15.16	6.57	6.11	7.78	3.37	3.89	2.60	1.13	2.65	1.02	0.44	1.78	0.39	0.17	1.08	0.11	0.05	0.70	0.04	0.02				45			
50				8.93	18.43	7.99	6.79	9.46	4.10	4.32	3.16	1.37	2.94	1.24	0.54	1.98	0.47	0.20	1.19	0.14	0.06	0.78	0.05	0.02	0.55	0.02	0.01	50			
60				10.72	25.83	11.20	8.15	13.26	5.75	5.19	4.42	1.92	3.53	1.73	0.75	2.38	0.66	0.29	1.43	0.19	0.08	0.94	0.07	0.03	0.66	0.03	0.01	60			
70							9.51	17.64	7.65	6.05	5.88	2.55	4.12	2.30	1.00	2.77	0.88	0.38	1.67	0.26	0.11	1.10	0.09	0.04	0.77	0.04	0.02	70			
75							10.19	20.05	8.69	6.49	6.69	2.90	4.41	2.62	1.13	2.97	1.00	0.43	1.79	0.29	0.13	1.17	0.10	0.05	0.83	0.04	0.02	75			
80							10.87	22.59	9.79	6.92	7.54	3.27	4.70	2.95	1.28	3.17	1.13	0.49	1.91	0.33	0.14	1.25	0.12	0.05	0.88	0.05	0.02	80			
90	8"						12.22	28.10	12.18	7.78	9.37	4.06	5.29	3.67	1.59	3.57	1.40	0.61	2.15	0.41	0.18	1.41	0.15	0.06	0.99	0.06	0.03	90			
100	0.65	0.02	0.01				13.58	34.16	14.81	8.65	11.39	4.94	5.88	4.46	1.93	3.96	1.71	0.74	2.39	0.50	0.22	1.56	0.18	0.08	1.10	0.08	0.03	100			
125	0.81	0.03	0.01							10.81	17.22	7.47	7.35	6.74	2.92	4.95	2.58	1.12	2.99	0.75	0.33	1.96	0.27	0.12	1.38	0.11	0.05	125			
150	0.98	0.04	0.02										8.82	9.45	4.10	5.94	3.62	1.57	3.58	1.06	0.46	2.35	0.38	0.16	1.65	0.16	0.07	150			
175	1.14	0.06	0.03	10"									10.29	12.57	5.45	6.93	4.81	2.09	4.18	1.41	0.61	2.74	0.50	0.22	1.93	0.21	0.09	175			
200	1.30	0.08	0.03	0.84	0.03	0.01										7.92	6.16	2.67	4.78	1.80	0.78	3.13	0.64	0.28	2.21	0.27	0.12	200			
250	1.63	0.11	0.05	1.05	0.04	0.02										9.91	9.31	4.04	5.97	2.72	1.18	3.91	0.97	0.42	2.76	0.42	0.18	250			
300	1.95	0.16	0.07	1.26	0.06	0.02	12"									11.89	13.06	5.66	7.17	3.81	1.65	4.69	1.36	0.59	3.31	0.58	0.25	300			
350	2.28	0.21	0.09	1.47	0.07	0.03	1.04	0.03	0.01	14"			16"						8.36	5.07	2.20	5.48	1.81	0.79	3.86	0.77	0.34	350			
400	2.60	0.27	0.12	1.68	0.09	0.04	1.19	0.04	0.02	0.99	0.03	0.01	0.76	0.01	0.01				9.56	6.50	2.82	6.26	2.32	1.01	4.41	0.99	0.43	400			
450	2.93	0.34	0.15	1.88	0.12	0.05	1.34	0.05	0.02	1.11	0.03	0.01	0.85	0.02	0.01				10.75	8.08	3.50	7.04	2.89	1.25	4.96	1.23	0.53	450			
500	3.25	0.41	0.18	2.09	0.14	0.06	1.49	0.06	0.03	1.23	0.04	0.02	0.95	0.02	0.01	18"						7.82	3.51	1.52	5.52	1.50	0.65	500			
750	4.88	0.88	0.38	3.14	0.30	0.13	2.23	0.13	0.06	1.85	0.08	0.04	1.42	0.04	0.02	1.12	0.02	0.01	20"						8.27	3.17	1.38	750			
1000	6.51	1.50	0.65	4.19	0.51	0.22	2.98	0.22	0.10	2.47	0.14	0.06	1.89	0.07	0.03	1.49	0.04	0.02	1.21	0.03	0.01				11.03	5.41	2.34	1000			
1250	8.13	2.26	0.98	5.23	0.78	0.34	3.72	0.34	0.15	3.09	0.21	0.09	2.36	0.11	0.05	1.87	0.06	0.03	1.51	0.04	0.02	24"						1250			
1500	9.76	3.17	1.38	6.28	1.09	0.47	4.47	0.47	0.21	3.70	0.30	0.13	2.84	0.16	0.07	2.24	0.09	0.04	1.81	0.05	0.02	1.26	0.02	0.01				1500			
2000				8.38	1.85	0.80	5.95	0.81	0.35	4.94	0.51	0.22	3.78	0.27	0.12	2.99	0.15	0.07	2.42	0.09	0.04	1.68	0.04	0.02				2000			
2500							7.44	1.22	0.53	6.17	0.77	0.34	4.73	0.40	0.18	3.73	0.23	0.10	3.02	0.14	0.06	2.10	0.06	0.02				2500			
3000										7.41	1.08	0.47	5.67	0.57	0.25	4.48	0.32	0.14	3.63	0.19	0.08	2.52	0.08	0.03				3000			
3500													6.62	0.75	0.33	5.23	0.42	0.18	4.23	0.25	0.11	2.94	0.10	0.05				3500			
4000																5.97	0.54	0.24	4.84	0.33	0.14	3.36	0.13	0.06				4000			
4500																6.72	0.68	0.29	5.44	0.41	0.18	3.78	0.17	0.07				4500			
5000																			6.05	0.49	0.21	4.20	0.20	0.09				5000			
5500																			6.65	0.59	0.25	4.62	0.24	0.10				5500			
6000																			7.26	0.69	0.30	5.04	0.28	0.12				6000			
7000																						5.88	0.38	0.16				7000			
7500																						6.30	0.43	0.19				7500			
8000																						6.72	0.48	0.21				8000			
8500																						7.14	0.54	0.24				8500			



FLOW VELOCITY & FRICTION LOSS

SDR 32.5

Flow Rate (Gallons per 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 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 per Minute)
GPM	6"			8"			10"			12"			14"			16"			18"			GPM
20	0.21	0.00	0.00	0.13	0.00	0.00	0.08	0.00	0.00	0.06	0.00	0.00	0.05	0.00	0.00	0.04	0.00	0.00	0.03	0.00	0.00	20
40	0.43	0.02	0.01	0.25	0.00	0.00	0.16	0.00	0.00	0.11	0.00	0.00	0.10	0.00	0.00	0.07	0.00	0.00	0.06	0.00	0.00	40
60	0.64	0.02	0.01	0.38	0.00	0.00	0.24	0.00	0.00	0.17	0.00	0.00	0.14	0.00	0.00	0.11	0.00	0.00	0.09	0.00	0.00	60
80	0.85	0.05	0.02	0.50	0.02	0.01	0.32	0.00	0.00	0.23	0.00	0.00	0.19	0.00	0.00	0.15	0.00	0.00	0.12	0.00	0.00	80
100	1.06	0.07	0.03	0.63	0.02	0.01	0.40	0.00	0.00	0.29	0.00	0.00	0.24	0.00	0.00	0.18	0.00	0.00	0.14	0.00	0.00	100
150	1.60	0.14	0.06	0.94	0.05	0.02	0.61	0.02	0.01	0.43	0.00	0.00	0.36	0.00	0.00	0.27	0.00	0.00	0.22	0.00	0.00	150
200	2.13	0.25	0.11	1.26	0.07	0.03	0.81	0.02	0.01	0.57	0.00	0.00	0.48	0.00	0.00	0.36	0.00	0.00	0.29	0.00	0.00	200
250	2.66	0.37	0.16	1.57	0.12	0.05	1.01	0.05	0.02	0.72	0.02	0.01	0.60	0.00	0.00	0.46	0.00	0.00	0.36	0.00	0.00	250
300	3.19	0.53	0.23	1.88	0.14	0.06	1.21	0.05	0.02	0.86	0.02	0.01	0.71	0.02	0.01	0.55	0.00	0.00	0.43	0.00	0.00	300
350	3.72	0.72	0.31	2.20	0.21	0.09	1.41	0.07	0.03	1.01	0.02	0.01	0.83	0.02	0.01	0.64	0.00	0.00	0.50	0.00	0.00	350
400	4.26	0.90	0.39	2.51	0.25	0.11	1.62	0.09	0.04	1.15	0.05	0.02	0.95	0.02	0.01	0.73	0.02	0.01	0.58	0.00	0.00	400
450	4.79	1.13	0.49	2.82	0.32	0.14	1.82	0.12	0.05	1.29	0.05	0.02	1.07	0.02	0.01	0.82	0.02	0.01	0.65	0.00	0.00	450
500	5.32	1.36	0.59	3.14	0.37	0.16	2.02	0.14	0.06	1.44	0.05	0.02	1.19	0.05	0.02	0.91	0.02	0.01	0.72	0.00	0.00	500
550	5.85	1.64	0.71	3.45	0.46	0.20	2.22	0.16	0.07	1.58	0.07	0.03	1.31	0.05	0.02	1.00	0.02	0.01	0.79	0.02	0.01	550
600	6.38	1.91	0.83	3.77	0.53	0.23	2.42	0.18	0.08	1.72	0.07	0.03	1.43	0.05	0.02	1.09	0.02	0.01	0.86	0.02	0.01	600
650	6.91	2.24	0.97	4.08	0.62	0.27	2.63	0.21	0.09	1.87	0.09	0.04	1.55	0.07	0.03	1.19	0.02	0.01	0.94	0.02	0.01	650
700	7.45	2.56	1.11	4.39	0.72	0.31	2.83	0.25	0.11	2.01	0.12	0.05	1.67	0.07	0.03	1.28	0.05	0.02	1.01	0.02	0.01	700
750	7.98	2.91	1.26	4.71	0.81	0.35	3.03	0.28	0.12	2.15	0.12	0.05	1.79	0.07	0.03	1.37	0.05	0.02	1.08	0.02	0.01	750
800	8.51	3.28	1.42	5.02	0.90	0.39	3.23	0.30	0.13	2.30	0.14	0.06	1.91	0.09	0.04	1.46	0.05	0.02	1.15	0.02	0.01	800
850	9.04	3.67	1.59	5.33	1.01	0.44	3.43	0.35	0.15	2.44	0.16	0.07	2.02	0.09	0.04	1.55	0.05	0.02	1.22	0.02	0.01	850
900				5.65	1.13	0.49	3.64	0.39	0.17	2.59	0.16	0.07	2.14	0.12	0.05	1.64	0.05	0.02	1.30	0.02	0.01	900
950				5.96	1.25	0.54	3.84	0.44	0.19	2.73	0.18	0.08	2.26	0.12	0.05	1.73	0.07	0.03	1.37	0.05	0.02	950
1000				6.28	1.36	0.59	4.04	0.46	0.20	2.87	0.21	0.09	2.38	0.14	0.06	1.82	0.07	0.03	1.44	0.05	0.02	1000
1050				6.59	1.50	0.65	4.24	0.51	0.22	3.02	0.23	0.10	2.50	0.14	0.06	1.92	0.07	0.03	1.51	0.05	0.02	1050
1100				6.90	1.64	0.71	4.45	0.55	0.24	3.16	0.25	0.11	2.62	0.16	0.07	2.01	0.09	0.04	1.59	0.05	0.02	1100
1150							4.65	0.60	0.26	3.30	0.25	0.11	2.74	0.16	0.07	2.10	0.09	0.04	1.66	0.05	0.02	1150
1200							4.85	0.67	0.29	3.45	0.28	0.12	2.86	0.18	0.08	2.19	0.09	0.04	1.73	0.05	0.02	1200
1250							5.05	0.72	0.31	3.59	0.30	0.13	2.98	0.21	0.09	2.28	0.09	0.04	1.80	0.07	0.03	1250
1300							5.25	0.76	0.33	3.73	0.32	0.14	3.10	0.21	0.09	2.37	0.12	0.05	1.87	0.07	0.03	1300
1350							5.46	0.83	0.36	3.88	0.35	0.15	3.22	0.23	0.10	2.46	0.12	0.05	1.95	0.07	0.03	1350
1400							5.66	0.88	0.38	4.02	0.39	0.17	3.33	0.23	0.10	2.55	0.12	0.05	2.02	0.07	0.03	1400
1450							5.86	0.95	0.41	4.17	0.42	0.18	3.45	0.25	0.11	2.64	0.14	0.06	2.09	0.07	0.03	1450
1500							6.06	0.99	0.43	4.31	0.44	0.19	3.57	0.28	0.12	2.74	0.14	0.06	2.16	0.09	0.04	1500
1600							6.47	1.13	0.49	4.60	0.48	0.21	3.81	0.30	0.13	2.92	0.16	0.07	2.31	0.09	0.04	1600
1700							6.87	1.25	0.54	4.88	0.55	0.24	4.05	0.35	0.15	3.10	0.18	0.08	2.45	0.09	0.04	1700
1800										5.17	0.60	0.26	4.29	0.39	0.17	3.28	0.21	0.09	2.59	0.12	0.05	1800
1900										5.46	0.67	0.29	4.53	0.42	0.18	3.47	0.23	0.10	2.74	0.12	0.05	1900
2000										5.74	0.74	0.32	4.76	0.46	0.20	3.65	0.25	0.11	2.88	0.14	0.06	2000
2100										6.03	0.81	0.35	5.00	0.51	0.22	3.83	0.28	0.12	3.03	0.16	0.07	2100
2200										6.32	0.88	0.38	5.24	0.55	0.24	4.01	0.30	0.13	3.17	0.16	0.07	2200
2300										6.61	0.97	0.42	5.48	0.60	0.26	4.20	0.32	0.14	3.31	0.18	0.08	2300
2400										6.89	1.04	0.45	5.72	0.65	0.28	4.38	0.35	0.15	3.46	0.18	0.08	2400
2500										7.18	1.11	0.48	5.95	0.72	0.31	4.56	0.37	0.16	3.60	0.21	0.09	2500
2600										7.47	1.20	0.52	6.19	0.76	0.33	4.74	0.39	0.17	3.75	0.23	0.10	2600
2700										7.76	1.29	0.56	6.43	0.81	0.35	4.92	0.44	0.19	3.89	0.23	0.10	2700
2800										8.04	1.38	0.60	6.67	0.88	0.38	5.11	0.46	0.20	4.04	0.25	0.11	2800
2900										8.33	1.48	0.64	6.91	0.92	0.40	5.29	0.48	0.21	4.18	0.28	0.12	2900
3000										8.62	1.57	0.68	7.15	0.99	0.43	5.47	0.51	0.22	4.32	0.30	0.13	3000
3100										8.90	1.66	0.72	7.38	1.06	0.46	5.65	0.55	0.24	4.47	0.30	0.13	3100
3200										9.19	1.78	0.77	7.62	1.13	0.49	5.84	0.58	0.25	4.61	0.32	0.14	3200
3300													7.86	1.18	0.51	6.02	0.62	0.27	4.76	0.35	0.15	3300
3400													8.10	1.25	0.54	6.20	0.65	0.28	4.90	0.37	0.16	3400
3500													8.34	1.31	0.57	6.38	0.69	0.30	5.04	0.39	0.17	3500
3600													8.57	1.38	0.60	6.57	0.74	0.32	5.19	0.42	0.18	3600
3700													8.81	1.45	0.63	6.75	0.76	0.33	5.33	0.44	0.19	3700
3800																6.93	0.81	0.35	5.48	0.46	0.20	3800
3900																7.11	0.85	0.37	5.62	0.48	0.21	3900
4000																7.30	0.88	0.38	5.76	0.51	0.22	4000
4100																7.48	0.92	0.40	5.91	0.53	0.23	4100
4200																7.66	0.97	0.42	6.05	0.55	0.24	4200
4300																			6.20	0.58	0.25	4300
4400																			6.34	0.60	0.26	4400
4500																			6.49	0.62	0.27	4500
4600																			6.63	0.65	0.28	4600
4700																			6.77	0.67	0.29	4700



FLOW VELOCITY & FRICTION LOSS

SDR 41										
Flow Rate (Gallons per 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 per Minute)
GPM	18"									GPM
750	1.05	0.02	0.01							750
1000	1.40	0.04	0.02	20"						1000
1250	1.75	0.05	0.02	1.42	0.03	0.01	24"			1250
1500	2.10	0.08	0.03	1.70	0.05	0.02	1.18	0.02	0.01	1500
2000	2.81	0.13	0.06	2.27	0.08	0.03	1.58	0.03	0.01	2000
2500	3.51	0.20	0.08	2.84	0.12	0.05	1.97	0.05	0.02	2500
3000	4.21	0.27	0.12	3.41	0.16	0.07	2.37	0.07	0.03	3000
3500	4.91	0.36	0.16	3.98	0.22	0.09	2.76	0.09	0.04	3500
4000	5.61	0.47	0.20	4.55	0.28	0.12	3.16	0.12	0.05	4000
4500	6.31	0.58	0.25	5.11	0.35	0.15	3.55	0.14	0.06	4500
5000				5.68	0.42	0.18	3.95	0.17	0.08	5000
5500				6.25	0.50	0.22	4.34	0.21	0.09	5500
6000				6.82	0.59	0.26	4.73	0.24	0.11	6000
7000							5.52	0.32	0.14	7000
7500							5.92	0.37	0.16	7500
8000							6.31	0.42	0.18	8000
8500							6.71	0.47	0.20	8500

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

SDR Pipe Pressure Surge (psi) at Different Velocities

SDR ➞	13.5	14	17	18	21	25	26	32.5	41
1 ft/sec	20.2	19.8	17.9	17.4	16.0	14.7	14.4	12.8	11.4
5 ft/Sec	101.0	99.1	89.5	86.9	80.2	---	71.9	64.1	57.0
10 ft/sec	201.9	198.1	179.0	173.8	160.4	146.7	143.7	128.2	113.9

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. Be careful in selecting check valves. Check valves operate on flow reversal and can be rapid closing. Spring or lever assisted swing check valves can reduce hydraulic shock by avoiding “slamming” the valve closed.



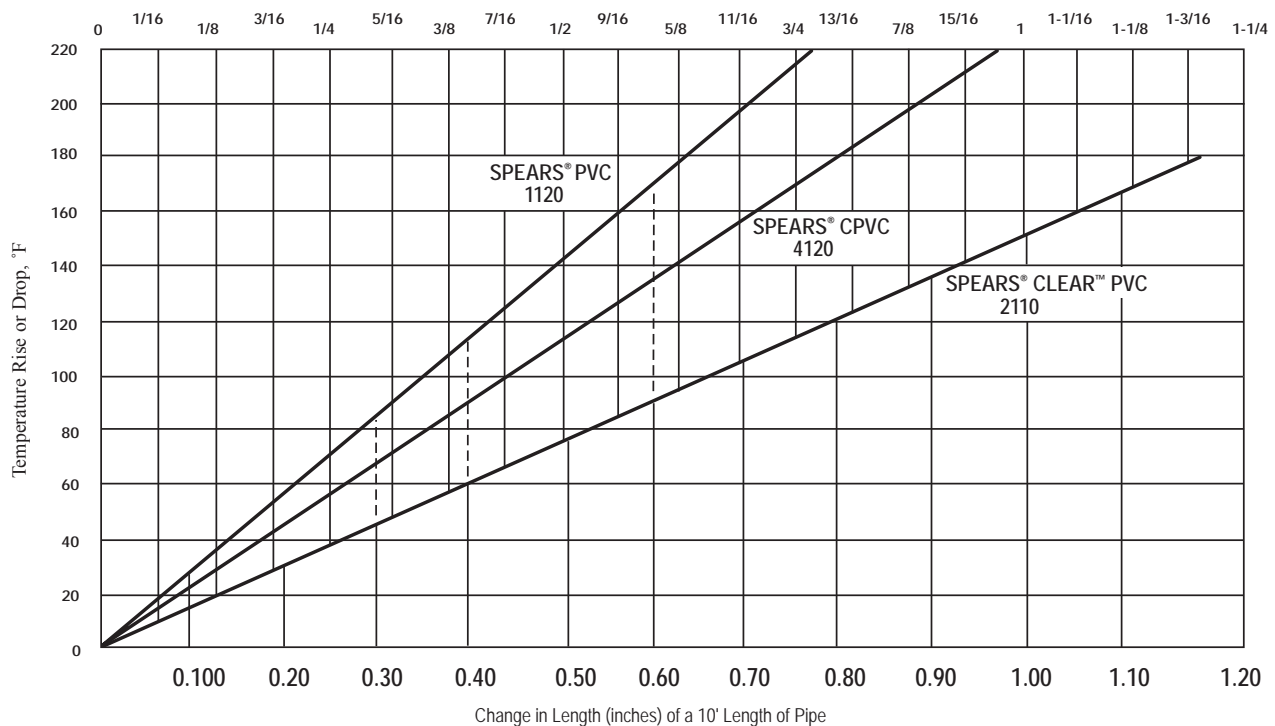
Thermal Expansion & Contraction

Piping systems expand and contract with changes in temperature. Thermoplastic piping expands and contracts more than metallic piping when subjected to temperature changes – as much as ten times that of steel. The effects of thermal expansion and contraction must be considered during the design phase, particularly for systems involving long runs, hot water lines, hot drain lines, and piping systems exposed to environmental temperature extremes. Installation versus working temperature or summer to winter extremes must be considered and addressed with appropriate system design to prevent damage to the piping system.

The degree of movement (change in length) generated as the result of temperature changes, must be calculated based on the type of piping material and the anticipated temperature changes of the system. The rate of expansion does not vary with pipe size. This movement must then be compensated for by the construction of appropriate sized expansion loops, offsets, bends or the installation of expansion joints. This absorbs the stresses generated, minimizing damage to the piping.

The following chart depicts the amount of linear movement (change in length, inches) experienced in a 10 ft length of pipe when exposed to various temperature changes.

Highly important is the change in length of plastic pipe with temperature variation. This fact should always be considered when installing pipe lines and allowances made accordingly.



The data furnished herein is based on information furnished by manufacturers of the raw material. This information may be considered as a basis for recommendation, but not as a guarantee. Materials should be tested under actual service to determine suitability for a particular purpose.

Calculating Linear Movement Caused by Thermal Expansion

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

$$\Delta L = 12 y l (\Delta T)$$

Where:

ΔL = expansion or contraction in inches

y = Coefficient of linear expansion of piping material selected

l = length of piping run in feet

ΔT = ($T_1 - T_2$) temperature change °F

Where:

T_1 = maximum system temperature of system and

T_2 = system temperature

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

Pipe Material	y
PVC Pressure Pipe (all schedules & SDR's) and PVC Duct	2.9×10^{-5}
CPVC Schedule 40 & Schedule 80 Pressure Pipe	3.2×10^{-5}
CPVC Duct	3.2×10^{-5}
CTS CPVC Plumbing Pipe	3.2×10^{-5}
Clear PVC Schedule 40 & Schedule 80 Pipe	4.1×10^{-5}
Spears® Low Extractable UPW Pipe	3.9×10^{-5}

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

$$\Delta L = 12 y l (\Delta T)$$

Where:

ΔL = linear expansion or contraction in inches $y = 2.9 \times 10^{-5}$ in/in/°F

$l = 100$ ft

$\Delta T = 41^\circ\text{F}$ ($73^\circ\text{F} - 32^\circ\text{F}$)

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

$\Delta L = 12 \text{ in/ft} \times 0.000029 \text{ in/in/ft} \times 100 \text{ ft} \times 41^\circ\text{F}$

$\Delta L = 1.43"$

In this example the piping would expand approximately 1-1/2" in length over a 100 ft 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

$$\Delta L = 12 y l (\Delta T)$$

Where:

ΔL = linear expansion or contraction in inches

$y = 3.2 \times 10^{-5}$ in/in/°F

$l = 100$ ft

$\Delta T = 100^\circ\text{F}$ ($180^\circ\text{F} - 80^\circ\text{F}$)

$\Delta L = 12 \text{ in/ft} \times 0.000032 \text{ in/in/ft} \times 100 \text{ ft} \times 100^\circ\text{F}$

$\Delta L = 3.84"$

In this example the piping would expand approximately 4" in length over a 100 ft 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 an 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:

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

Where:

l = Length of expansion loop in inches

E = Modulus of elasticity

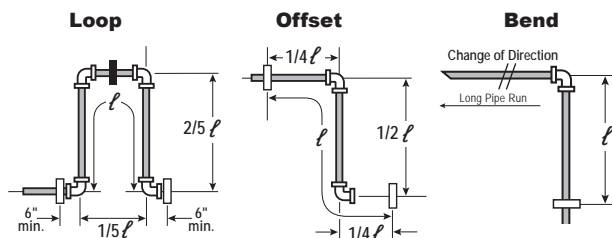
D = Average outside diameter of pipe

ΔL = Change in length of pipe due to temperature change

S = Working stress at max. temperature

$\Delta L = 12 \text{ in/ft} \times 0.000029 \text{ in/in/ft} \times 100 \text{ ft} \times 41^\circ\text{F}$

$\Delta L = 1.43"$



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 $\Delta L = 4.08"$

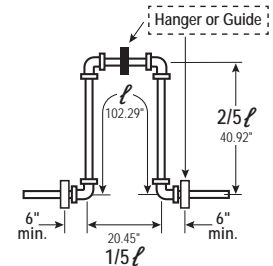
$$\ell = \frac{\sqrt{3ED(\Delta L)}}{2S}$$

$$\ell = \frac{\sqrt{3 \times 360,000 \times 2.375 \times 4.08}}{2 \times 500}$$

$$\ell = 102.29"$$

$$2/5 \ell = 40.92"$$

$$1/5 \ell = 20.46"$$



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:

$$S = E y \Delta T$$

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

$\Delta L = 12 \text{ y} l (\Delta T)$ Where:

ΔL = linear expansion or contraction in inches

$y = 3.2 \times 10^{-5} \text{ in./in./}^\circ\text{F}$

$l = 100 \text{ ft}$

$\Delta T = 100^\circ\text{F} (180^\circ\text{F} - 80^\circ\text{F})$

$\Delta L = 12 \text{ in./ft} \times 0.000032 \text{ in./in./ft} \times 100 \text{ ft} \times 100^\circ\text{F}$

$\Delta L = 3.84"$

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

The equation for determining induced stress can then be used:

$$S = E y \Delta T$$

Where:

S = stress induced in the pipe

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

y = Coefficient of thermal expansion = $3.2 \times 10^{-5} \text{ in./in./}^\circ\text{F}$

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

$S = 214,000 \times 0.000032 \times 100$

$S = 685 \text{ psi}$

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
PVC	73	2,000	400,000
	80	1,760	396,000
	90	1,500	375,000
	100	1,240	354,000
	110	1,020	333,000
	120	800	312,000
	130	620	291,000
	140	440	270,000
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

Thrust Blocking

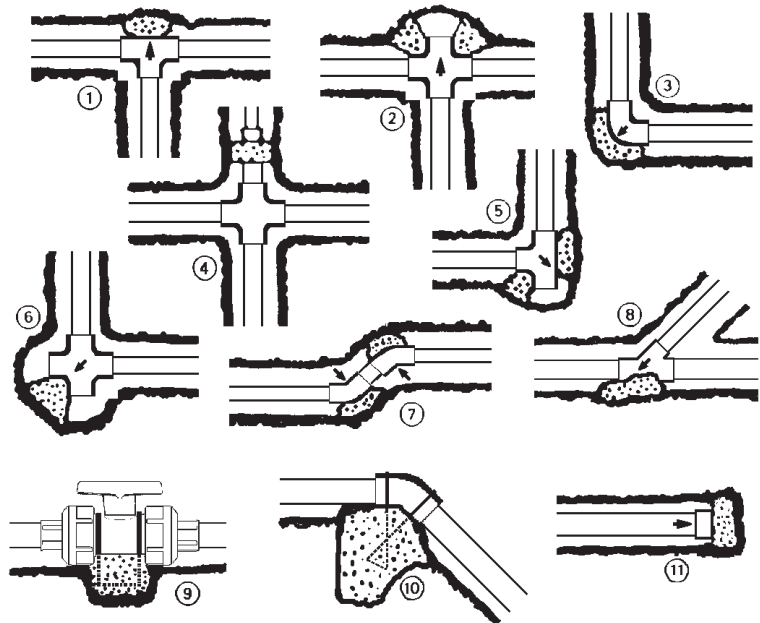
Thrust blocking prevents pipe movement when a pressure system is activated and pressurized. Thrust blocking is required at all points of change of direction in the pipe line. Most blocking is done where a fitting, valve, or hydrant is installed. There may be times when side blocking is necessary because of curvature occurring without the use of fittings. Usually good compacted backfill will provide the necessary anchor for side thrust. Concrete blocking is the most commonly recommended method of blocking. Concrete is placed directly on the fitting against the line of thrust. The concrete must also pour against undisturbed earth. The size of the blocking will vary with the size of pipe, working pressure exerted, type of fitting, degree of flow direction change, and the soil conditions. PVC and CPVC pipe are flexible and may pulsate under pressure variations. This does not harm the pipe or that part which is enclosed in concrete. It may cause wear at the interface of the concrete block and the backfill. For this reason, pipe and fittings should be wrapped with a one mill or heavier plastic sheeting prior to being embedded in concrete to prevent any possible damage.

THRUST BLOCKING – Water under pressure exerts thrust forces in piping systems. Thrust blocking should be provided, as necessary, to prevent movement of pipe or appurtenances in response to thrust.

Types Of Thrust Blocking:

If thrusts due to high pressure are expected, anchor valves as below. At vertical bends anchor to resist outward thrusts.

1. Thru line connection, tee
2. Thru line connection, cross used as tee
3. Direction change, elbow
4. Change line size, reducer
5. Direction change, tee used as elbow
6. Direction change, cross used as elbow
7. Direction change
8. Thru line connection, wye
9. Valve anchor
10. Direction change vertical, bend anchor
11. End Caps (above or below ground)



Thrust Blocking Is Required Wherever The Pipeline:

- * Changes direction (e.g., tees, bends, elbows and crosses)
- * Changes size at its reducers
- * Stops, as at dead ends
- * Valves and hydrants, at which thrust develops when closed.

Size And Type Of Thrust Blocking Depends On:

- * Maximum system pressure
- * Pipe size
- * Type and size of fittings or appurtenance
- * Line profile (horizontal or vertical bends)
- * Soil type

[See additional information under Installation Gasketed Pipe](#)

Critical Collapse Pressures

The **Critical Collapse Pressure** is directly related to the pipe wall thickness and represents the maximum allowable external load. External loads can result from conditions such as buried pipe soil loads; underwater applications; vacuum service; and pipe installed on pump suction lines. The actual external load being applied to the pipe is the difference between the external pressure and the internal pressure. As a result, a pressurized pipe can withstand a greater external load than an empty pipe.

Critical Collapse Pressure Rating of Various PVC and CPVC Pipe & Duct @ 73°F with No Safety Factor in PSI (Inches of Water)

Size(in.)	Duct	SDR 41	SDR 26	SDR 21	SCH 40	SCH 80	SCH 120
2	N/A	17* (470)	74* (2,048)	126* (3,487)	316 (8,746)	939 (25,989)	1309 (36,230)
2-1/2	N/A	17* (470)	74* (2,048)	126* (3,487)	451 (12,483)	975 (26,986)	1309 (36,230)
3	N/A	17* (470)	74* (2,048)	126* (3,487)	307 (8,497)	722 (19,983)	1128 (31,221)
3-1/2	N/A	17* (470)	74* (2,048)	126* (3,487)	217 (6,006)	578 (15,998)	N/A
4	N/A	17* (470)	74* (2,048)	126* (3,487)	190 (5,259)	451 (12,482)	1128 (31,221)
5	N/A	17* (470)	74* (2,048)	126* (3,487)	117 (3,238)	361 (10,000)	N/A
6	N/A (470)	17* (2,048)	74* (3,487)	126* (2,491)	90 (9,493)	343 (19,983)	722
6 x 1/8	5.2 (144)	N/A	N/A	N/A	N/A	N/A	N/A
6 x 3/16	0.7 (426)	N/A	N/A	N/A	N/A	N/A	N/A
8	10.0 (193)	17* (470)	74* (2,048)	126* (3,487)	58 (1,605)	235 (6,504)	N/A
10	5.4 (100)	17* (470)	74* (2,048)	126* (3,487)	49 (1,605)	217 (6,504)	N/A
12	3.0 (60)	17* (470)	74* (2,048)	126* (3,487)	42 (1,162)	199 (5,508)	N/A
14	2.5 (45)	17* (470)	74* (2,048)	126* (3,487)	40 (1,107)	194 (5,369)	N/A
16	1.6 (30)	17* (470)	74* (2,048)	126* (3,487)	40 (1,107)	181 (5,010)	N/A
18	1.0 (26)	17* (470)	74* (2,048)	126* (3,487)	33 (913)	162 (4,484)	N/A
20	1.3 (28)	17* (470)	74* (2,048)	126* (3,487)	28 (775)	157 (4,346)	N/A
24	1.0 (20)	17* (470)	74* (2,048)	126* (3,487)	25 (692)	150 (4,152)	N/A

1 psi = 2.036 inches of mercury

* SDR Pipe carries the same collapse ratings for all sizes due to the wall thickness/O.D. ratio

Standard temperature de-rating factors must be applied for use at elevated temperatures (see following Temperature Limitations section). Multiply the collapse pressure rating @ 73°F from the chart by the appropriate material de-rating factor.

Solvent-cemented connections are preferred over threaded or flanged joining in vacuum applications to reduce potential for leaks.

Temperature Limitations

PVC & CPVC

The maximum operating temperature for PVC pipe is 140°F and the maximum operating pressure for CPVC 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 PVC and 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:

De-Rating Factors

PVC Pipe		CPVC Pipe	
Temp (°F)	Working De-Rating Factor	Temp (°F)	Working De-Rating Factor
73	1.00	73-80	1.00
80	0.88	90	0.91
90	0.75	100	0.82
100	0.62	110	0.72
110	0.51	120	0.65
120	0.40	130	0.57
130	0.31	140	0.50
140	0.22	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 standard rigid PVC or CPVC 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 PVC and 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 PVC/CPVC products. Check with paint manufacture for compatibility. Oil-based paints should NOT be used.

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



Plastic piping systems must be engineered, installed, operated and maintained in accordance with accepted standards and procedures. It is absolutely necessary that all design, installation, operation and maintenance personnel be trained in proper handling, installation requirements and precautions for installation and use of plastic piping systems before starting.

Handling & Storage

Spears® products are packaged and shipped with care to avoid damage. Pipe and fittings should be stored and protected from direct exposure to sunlight. All pipe and accessories should be stored above ground and fully supported so as not to bend or excessively deflect under its own weight. Proper stacking techniques are necessary. Improper stacking can result in instability that may result in pipe damage or personnel injury.

Use care when transporting and storing the product to prevent damage. Piping products should not be dropped or have objects dropped on them. Do not drag pipe over articles or across the ground and do not subject pipe to external loads or over stacking. If extended storage in direct sunlight is expected, pipe should be covered with an opaque material while permitting adequate air circulation above and around the pipe as required to prevent excessive heat accumulation.

Spears® products should not be stored or installed close to heat-producing sources. PVC storage should not exceed 150°F and CPVC storage should not exceed 210°F. Handling techniques for PVC and CPVC pipe considered acceptable at warm temperatures may be unacceptable at very cold temperatures. When handling pipe in cold weather, consideration must be given to its lower impact strength. In subfreezing temperatures, extra caution in handling must be taken to prevent impact damage.

All pipe should be inspected for any scratches, splits or gouges before use. Damaged sections must be cut out and discarded.

Plastic Piping Tools

Basic tools used with Plastic Piping

Use tools that have been specifically designed for use with thermoplastic pipe and fittings when installing. A variety of tools that are designed for cutting, beveling, and assembling plastic pipe and fittings, are readily available through local wholesale supply houses dealing in plastic pipe and fittings.

▲ Warning Tools normally used with metal piping systems, such as hacksaws, water pump pliers, pipe wrenches, etc., can cause damage to plastic pipe and fittings. Visible and hidden fractures, scoring or gouging of material, and over tightening of plastic threaded connections are some of the common problems resulting from the use of incorrect tools and procedures.

Pipe Cutters

Pipe must be square-cut to allow for the proper joining of pipe end and the fitting socket bottom. Wheel type pipe cutters designed for plastic pipe provides easy and clean cuts on smaller pipe sizes. Care should be used with similar ratchet-type cutters to avoid damage to pipe. A slightly raised edge left on the outside of the pipe end after cutting with either device must be removed.

Pipe Cutters for Large Diameter Pipe

Blade cutters made for use with large diameter plastic pipe are easy to adjust and operate for square, burr-less cuts. Blades with carbide edges will provide longer life. With one style blade cutter, pipe ends may also be beveled for solvent joints while being cut by using an optional bevel tool in place of one cutter blade.

Hand Saws

A miter box or similar guide can be used with a fine-toothed saw blades (16 to 18 teeth per inch) having little or no set (maximum 0.025 inch).

Power Saws

Power saws are quite useful in operations where a large quantity of pipe is being cut. Blades designed for plastic pipe **MUST** be used. A cutting speed of 6,000 RPM, using ordinary hand pressure is recommended.

Pipe Beveling Tools

Power beveling tools, as well as hand beveling tools designed for use with plastic pipe are available. Pipe ends must be beveled (chamfered) to allow easy insertion of the pipe into the fitting and to help spread solvent cement and to prevent scraping cement from the inside of the fitting socket. A recommended bevel of 1/16" to 3/32" at a 10° to 15° angle can be achieved using a plastic pipe beveling tool, but can also be accomplished using a file designed for use on plastic.

Deburring Tools

Special plastic pipe deburring tools remove burrs from pipe ends quickly and efficiently. All burrs must be removed from the inside, as well as the outside, of the pipe ends to properly spread solvent cement when joining pipe and fitting.

Strap Wrenches

Strap wrenches with nylon straps treated for slip resistance and designed for use with plastic pipe provide gripping power for turning without scratching or deforming the pipe.

Chain Vises

Chain vises can be used to hold pipe. Vises made with jaws engineered for use with plastic pipe provide holding power without damage to the pipe.

Pullers & Joining Devices

Pipe and fitting pullers are available for joining large diameter plastic pipe and fittings. These tools are designed to allow the pipe to be inserted to the proper insertion depth, maintain proper alignment during assembly, and hold freshly solvent-cemented connections to prevent the fitting from backing-off until the initial set time is achieved.

Joining Methods –Solvent Cement Welding

Solvent cement welding is the most widely used joining method for PVC and CPVC pipe and fittings. Other methods such as threads, flanges and groove adapters can also be used. These are specifically useful where it is anticipated that the joint will have to be disassembled in the future.

Solvent Cement Safety Precautions

Solvent cement products are flammable and contain chemical solvents. Appropriate safety precautions must be taken BEFORE APPLYING PRIMER AND CEMENT. Read the cement can label!

▲ CAUTION

Virtually all solvent cements and primers for plastic pipe are flammable and should not be used or stored near heat, spark or open flames. Do not smoke during use. Eliminate all ignition sources. Primer and PVC cement should be stored in closed containers in the shade at temperatures between 40°F and 110°F; CPVC cement at temperatures between 40°F and 90°F. Use of a can with applicator attached to its lid is recommended. Verify expiration dates stamped on cements and primers prior to use.

Avoid breathing vapors. They should be used only with adequate ventilation. Explosion-proof general mechanical ventilation is recommended. In confined or partially enclosed areas, a ventilating device should be used. Containers should be kept tightly closed when not in use, and covered as much as possible when in use.

Avoid contact with skin and eyes. May be absorbed through the skin; wearing PVA coated protective gloves and an impervious apron are recommended. May cause eye injury. Use Eye protection and avoid eye contact. In case of contact flush with plenty of water for 15 minutes. If irritation persists, get medical attention. If swallowed, call a physician immediately and follow precautionary statement given on side panel of cement container. Keep out of reach of children.

Refer to Solvent Cement Material Safety Data Sheet (MSDS)

Use Caution with Welding Torches or other equipment where sparks might be involved at construction sites where plastic pipe has recently been solvent welded. Flammable vapors from cemented joints can stay within a piping system for some time. In all cases, lines should be flushed and purged to remove solvent vapors before welding.

Use Caution with Calcium Hypochlorite. Do not use a dry granular calcium hypochlorite as a disinfecting material for water purification in potable water piping systems. Granules or pellets of calcium hypochlorite (including their vapors) may react violently with solvent cements and primers if a water solution is not used. Chlorinated water solutions are nonvolatile and may be pumped into the piping system. Dry granular calcium hypochlorite should not be stored or used near solvent cements or primers.

Actually, solvent cementing is no more dangerous than putting gasoline in your automobile.

Solvent Cement and Primer Spills

Protect work areas prior to starting by using drop cloths in the event of a spill. Accidental spills should be wiped up immediately before the cement sets. Cement and/or primer spills can cause irreparable damage depending on the type of surface affected. Consult the manufacturer of the affected surface for possible suggestions.

Basic Solvent Cement Joints

The following is a general description of basic techniques used to make solvent cement joints. Adjustments will need to be made to method and tools used according to size of piping, but the same principles apply. Additional guidance can be found in ASTM D 2855, Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings. **Important:** Installers should verify that they can make satisfactory joints under varying conditions and should receive training in installation and safety procedures.

To consistently make good joints in PVC and CPVC piping products, the following should be carefully understood:

1. The joining surfaces of pipe and fitting must be softened and made semi-fluid.
2. Sufficient cement must be applied to fill the gap between pipe and fitting.
3. Assembly of pipe and fittings must be made while the surfaces are still wet and fluid.
4. Joint strength develops as the cement dries (cures). In the tight part of the joint (interference area) the surfaces will fuse together, in the loose part the cement will bond to both surfaces.

Cutting the Pipe

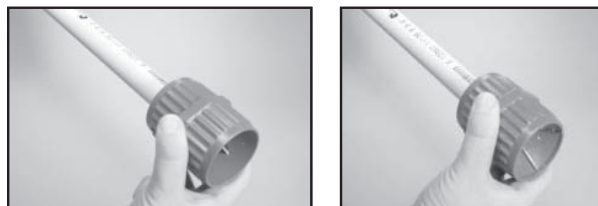
PVC or CPVC pipe can be cut easily with a ratchet cutter, wheel-type plastic pipe cutter (**NOTE:** be sure to remove any raised ridge produced by wheel cutters), a power saw, or any other fine-tooth saw. It is important that the cutting tools being used are designed for plastic pipe. To ensure that the pipe is cut square, use a miter box when cutting with a saw. Cutting pipe as square as possible provides the maximum bonding surface area.



Be careful not to split the tube if using a ratchet-type cutter, especially in temperatures below 50°F. If any damage or cracking is evident, cut off at least 2" of the pipe beyond any visible crack.

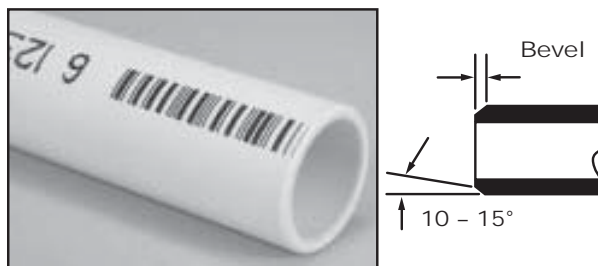
Deburring & Beveling

Burrs and filings can prevent contact between the tube and the fitting during assembly and must be removed from the outside and the inside of the pipe. A deburring/chamfering tool (or file) is suitable for this purpose:



Burrs Being Removed from Outside & Inside

A slight bevel (chamfer) must be placed at the outside end of the pipe to ease the entry of the tube into the socket and minimize the chance of cement being wiped off the fitting:



Bevel Outside End

Fitting & Joining Preparation

1. Using a clean, dry rag, wipe any loose dirt and moisture from the fitting's socket and pipe end. Moisture can slow the cure time, and at this stage of assembly, excessive moisture can reduce joint strength.
2. Check the dry fit of the pipe and fitting. The pipe should enter the fitting's socket easily 1/4 - 3/4 of the way (interference fit), or at least have interference between pipe and fitting bottom (net fit). **DO NOT** use any components that appear irregular or do not fit properly. Contact Spears® regarding any questions about usability.
3. Measure socket depth and mark on pipe for reference during cement application.
4. It is advisable to additionally mark pipe and fitting for alignment orientation position, especially with larger fittings.



Solvent Cementing Assembly

Verify the expiration date located on the solvent cement can. The cement can be used for a period of 2 years from the date stamped on the can. When cementing pipe and fittings in extremely cold temperatures, make sure the cement has not "JELLED." Jelled or expired cement must be discarded in an environmentally friendly fashion, in accordance with local regulations. To prolong the life of solvent cement, keep the containers tightly closed when not in use, and cover the container as much as possible during use. If an unopened solvent cement container is subjected to freezing temperatures, the cement may become extremely thick. Place the closed container in a room temperature area where, after a short time period, the cement will return to a usable condition. **DO NOT** attempt to heat solvent cement. The cement must be applied when the pipe and fittings are clean and free from any moisture and debris.

Primer Use - Softening of pipe and fitting joining surfaces can be achieved by the cement itself or by using a suitable primer. A primer will usually penetrate and soften the surfaces more quickly than the cement alone. However, special "one-step" cements formulated for use without primers are available. Check local codes (where required) for acceptable applications.

Apply Primer - USING AN APPLICATOR THAT IS AT LEAST 1/2 THE SIZE OF THE PIPE DIAMETER, vigorously scrub joining surface of fitting, of pipe and then again of fitting. Work quickly to apply 2-3 coats in this manner. SOLVENT CEMENT SHOULD THEN BE APPLIED WHILE PRIMER IS STILL WET.

Apply Solvent Cement - USING AN APPLICATOR THAT IS AT LEAST 1/2 THE SIZE OF THE PIPE DIAMETER, WORK THE CEMENT INTO THE JOINING SURFACES USING A CONTINUOUS, CIRCULAR MOTION.

Use sufficient cement, but avoid puddling the cement on or within the fitting and pipe. Puddled cement causes excess softening and damage to the PVC or CPVC material. If interference fit was at the bottom of the socket, use extra cement and make a 2nd application to pipe. WORK QUICKLY SO THAT PIPE AND FITTING CAN BE JOINED WHILE CEMENT IS STILL WET.

Apply the cement in the sequence pictured below:



1. Apply a coat to the pipe to depth of fitting socket

Work the cement into the joining surfaces using a continuous, circular motion.



2. Apply a medium coat to the fitting socket

Avoid puddling the cement in the sockets and avoid getting cement in other sockets or threaded connections.

3. Apply a second coat to the pipe end for sizes 1-1/4 inch and larger joints, or if interference fit was at socket bottom during dry-fit.

Assemble Joint

Immediately insert pipe into the fitting socket while rotating the pipe 1/4 turn. Align the fitting in the proper orientation at this time. Make sure the pipe bottoms out at the fitting's stop. Hold the assembly for at least 30 seconds to ensure initial bonding. Tapered pipe sockets can result in pipe backing out of the joint if not held under constant pressure. A bead of cement must be present around the pipe and fitting juncture. If this bead is not continuous around the socket's shoulder, insufficient cement was applied and the joint must be disassembled or cut out and replaced.



Any cement, in excess of the bead, can be wiped off with a dry, clean rag.

Set and Cure Times

SET TIME: The initial set time is the recommended waiting period before handling newly assembled joints. After initial set, the joints will withstand the stresses of normal installation. However, a badly misaligned installation will cause excessive stresses in the joint, pipe and fittings.

CURE TIME: The cure time is the recommended waiting period before pressurizing newly assembled joints.

The following basic guidelines should be used:

- The set and cure times for solvent cement depend on pipe size, temperature, relative humidity, and tightness of fit. Drying time is faster for drier environments, smaller pipe sizes, high temperatures, and tighter fits.
- Special care must be taken when assembling products in low temperatures (below 40°F) or high temperatures (above 80°F).
- Extra set and handling times must be allowed in colder temperatures. When cementing pipe and fittings in cold temperatures, make sure the cement has not "JELLED." Jelled cement must be discarded.
- In higher temperatures, make sure both surfaces to be joined are still wet with cement during assembly.
- The assembly must be allowed an initial set, without any stress on the joint
- Following the initial set period, the assembly can be handled carefully by avoiding stress on the joint.

Average Set Times

Temp. Range	Pipe Sizes 1/2" - 1-1/4"	Pipe Sizes 1-1/2" - 2"	Pipe Sizes 2-1/2" - 8"	Pipe Sizes 10" - 15"	Pipe Sizes 16" - 24"
60° - 100°F	2 Min.	5 Min.	30 Min.	2 Hrs.	4 Hrs.
40° - 60°F	5 Min.	10 Min.	2 Hrs.	8 Hrs.	16 Hrs.
0° - 40°F	10 Min.	15 Min.	12 Hrs.	24 Hrs.	48 Hrs.

Average Cure Times

Relative Humidity 60% or Less*	Pipe Sizes 1/2" – 1-1/4"		Pipe Sizes 1-1/2" – 2"		Pipe Sizes 2-1/2" – 8"		Pipe Sizes 10" – 15"	Pipe Sizes 16" – 24"
Temperature Range During Assembly and Cure Periods	Up to 160 psi	Above 160 to 370 psi	Up to 160 psi	Above 160 to 315 psi	Up to 160 psi	Above 160 to 315 psi	Up to 100 psi	Up to 100 psi
60° - 100°F	15 Min.	6 Hrs.	30 Min.	12 Hrs.	1-1/2 Hrs.	24 Hrs.	48 Hrs.	72 Hrs
40° - 60°F	20 Min.	12 Hrs.	45 Min.	24 Hrs.	4 Hrs.	48 Hrs.	96 Hrs.	6 Days
0° - 40°F	30 Min.	48 Hrs.	1 Hr.	96 Hrs.	72 Hrs.	8 Days	8 days	14 Days

NOTE In damp or humid weather allow 50%, more cure time. The cure schedules shown are suggested as guides only. They are based on laboratory test data, and should not be taken to be the recommendations of all cement manufacturers. Individual solvent cement manufacturer's recommendations for the particular cement being used should be followed.

Special Considerations for Working with Solvent Cement Welding

Handling of Cement

Keep cement containers covered while not in use. Cement with the lid left off can become thick and viscous, or gel like. This condition is typically a result of tetrahydrofuran (THF) solvent evaporation and the cement is useless. Do not try to restore the cement by stirring in a thinner. Smaller containers of cement are recommended to be used, especially in warm or hot weather. Prior to opening cans of cement, shake vigorously to properly mix resin and solvents. Solvents contained in PVC and CPVC cements are highly flammable and should not be used near an open flame. The area in which the cement is being used should be well ventilated, and prolonged breathing of the fumes should be avoided, as well as contact with the skin or eyes. Verify the expiration dates stamped on the cements and primers prior to use.

CEMENT AND PRIMER SHELF LIFE

Spears® Products	Shelf Life	Spears® Products	Shelf Life
Primers / Cleaners	3 years	CPVC Solvent Cement	2 years
PVC Solvent Cement	3 years	ABS Solvent Cement	3 years

Hot Weather Use

Problems can be avoided when solvent cementing in 95°F or higher temperatures by taking a few special precautions. Solvent cements evaporate faster at elevated temperatures and can dry out prematurely. This is especially true when there is a hot wind blowing. Dry cement on pipe or fitting socket prior to assembly will not bond. If the pipe has been in direct sunlight for any length of time, surface temperatures may be 20°F to 30°F above air temperature. Solvents attack these hot surfaces faster, deeper and dry out quicker. As a result, it is very important to avoid puddling inside sockets, assemble immediately while wet and to wipe off excess cement at the joint exterior.

Tips for Solvent Cementing in High Temperatures:

1. Store solvent cements in a cool or shaded area prior to use.
2. If possible, store the fittings and pipe, or at least the ends to be solvent welded, in a shady area before cementing.
3. Cool surfaces to be joined by wiping with a damp rag. HOWEVER, be sure that surfaces are dry prior to applying solvent cement.
4. Try to do the solvent cementing in cooler morning hours.
5. Make sure that both surfaces to be joined are still wet with cement when putting them together.

Cold Weather Use

Solvent Cements and primers have excellent cold weather stability and are formulated to have well balanced drying characteristics even in subfreezing temperatures. Good solvent cemented joints can be made in very cold conditions provided proper care and a little common sense are used. In cold weather, solvents penetrate and soften surfaces more slowly than in warm weather. The plastic is also more resistant to solvent penetration, therefore, it becomes more important to pre-soften surfaces. A longer cure time is necessary due to slower evaporation.

Tips for Solvent Cementing in Cold Temperatures:

1. Prefabricate as much of the system as possible in a heated work area.
2. Store cements in a warmer area when not in use and make sure they remain fluid.
3. Take special care to remove moisture, including ice and snow.
4. Use special care to ensure joining surfaces are adequately softened; more than one application may be necessary.
5. Allow a longer cure period before the system is used.

Effects of Tolerances and Fits

PVC pipe and fittings are manufactured to applicable ASTM Standards to produce an interference fit when assembled. However, minimum and maximum allowable tolerances permitted for pipe and fittings can result in variations. For example, fitting with the maximum diameter and the pipe with the minimum diameter, may result in a loose fit. Applying two coats of solvent cement will help assure a good joint. Conversely, if the pipe diameter is on the maximum side and the fitting on the minimum side, the interference may be too great and sanding of the pipe O.D. may be necessary to permit entrance.

Always check dry fits prior to making a joint. If fit is loose, multiple coats and use of an extra heavy bodied cement may be required. Mating components should be checked to assure that tolerances and engagements are compatible (see preceding Basic Solvent Cement Joints instructions). Inspect all pipe and fittings for damage or irregularities. Do not use any components that appear irregular or do not fit properly. Contact the appropriate manufacturer of the product in question to determine usability.



Large Diameter Pipe

Basic Solvent Cement Joint instructions apply to all sizes of pipe, but when making joints larger than 4", the use of two persons is recommended to properly apply cement and immediately assemble the joint while the cemented surfaces are still wet. Alignment of large diameter pipe and fittings during joining is critical since there is a greater potential for movement in the upper portion of a tapered socket that can result in misalignment. Special tools are commercially available for joining large diameter pipe.

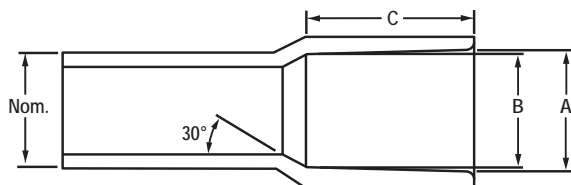
Be sure to use an appropriate size roller applicator with large diameter pipe, along with a heavy or extra heavy bodied cement that is medium to slow setting. These have increased gap filling capability and allow somewhat longer assembly time. However, applications of heavy coats of solvent cement and speed in making the joint is important. Under a damp or wet condition, solvent cement may absorb some moisture. Excessive moisture can slow down the cure and reduce joint strength. Spears® CPVC-24 heavy body or PVC-19 extra-heavy body solvent cements are excellent for joining large diameter pipe (see Solvent Cement Selection Guide in following sections).

Belled End Pipe

Commercially available belled end pipe can be used to eliminate the need for couplings. Where belled end pipe is used, it is suggested that the interior surface of the bell be penetrated exceptionally well with the primer.

NOTE, some manufacturers use a silicone release agent on the bellings plug, and a residue of this agent can remain inside the bell. Silicone will contaminate the joint and not allow proper solvent cement welding. All silicone residue must be removed in the cleaning process prior to solvent cementing.

Belled-End Pipe Dimensions



Nominal Size (in.)	Min.	A Max.	Min.	B Max.	C Min.
1-1/4	1.675	1.680	1.648	1.658	1.870
1-1/2	1.905	1.914	1.880	1.888	2.000
2	2.381	2.393	2.363	2.375	2.250
2-1/2	2.882	2.896	2.861	2.875	2.500
3	3.508	3.524	3.484	3.500	3.250
4	4.509	4.527	4.482	4.500	4.000
5	5.573	5.593	5.543	5.563	4.000
6	6.636	6.658	6.603	6.625	6.000
8	8.640	8.670	8.595	8.625	6.000
10	10.761	10.791	10.722	10.752	8.000
12	12.763	12.793	12.721	12.751	8.500
14	14.030	14.045	13.985	14.000	9.000
16	16.037	16.052	15.985	16.000	10.000
18	18.041	18.056	17.985	18.000	12.000
20	20.045	20.060	19.985	20.000	12.000
24	24.060	24.075	24.000	24.015	14.000

Estimated Quantities of Solvent Cement

A variety of conditions can affect the amount of solvent cement required for making reliable joints. These include pipe size, tolerances, socket depths as well as installation conditions and type of cement used. Fitting sockets are tapered for proper assembly, which produces a slight gap at the socket entrance when installed with pipe. As pipe sizes increase, heavier bodied cements should be used for increase gap filling capabilities. It is best to use liberal amounts of solvent cement since insufficient cement use is one of the most common reasons for joint failure. The following information on cement usage is a recommendation only and other factors or unanticipated conditions may be encountered. Quantities are based on use with average socket lengths of Spears® molded and fabricated fittings.

Standard Pipe Joints

Fitting Size (in.)	Joints per Pint	Joints per Quart	Joints per Gallon
1/2	150	300	1200
3/4	100	200	800
1	63	125	500
1-1/4	70	140	560
1-1/2	45	90	360
2	30	60	240
2-1/2	25	50	200
3	20	40	160
4	15	30	120
6	5	10	40
8	3	5	20
10	---	2-3	4-6
12	---	1-2	2-4

Large Diameter Pipe Joints

Fitting Size (in.)	Quarts per Joint	Joints per Gallon
14	0.75	5.33
16	1.25	3.20
18	1.50	2.67
20	2.00	2.00
24	2.75	1.45

Supplemental Information on Solvent Cementing

Applicators

A wide variety of daubers, brushes, and rollers are available. For proper solvent cement welding of pipe and fittings, the cement applicator must be no less than half the size of the pipe. Sufficient cement cannot be applied using daubers attached to the cement can lid on large diameter products (> 3"dia.) The following chart shows a variety of Spears® applicator sizes for use on different pipe diameters

SPEARS® APPLICATOR SELECTION GUIDE

For proper solvent cement welding of pipe and fittings, the cement applicator must be no less than half the size of the pipe

DAUBERS	Pipe Diameters						
	1/4"	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"
3/8" Dauber	•	•	•				
1/2" Dauber			•	•			
3/4" Dauber					•	•	
1-1/4" Dauber							•
ROLLERS & SWABS		SIZE		FOR PIPE DIAMETERS			
3020		3" Roller		3" - 6"			
6020		4" Roller		3" - 8"			
7020		7" Roller		6" +			
5520		4" Roller		6" +			
6520		6" Roller		6" +			
4020		4" Swab		6" +			
5020		4" Swab		3" - 8"			
4520		4" Swab		6" +			

Cleaners

Cleaners can be used to remove dirt, oil and grease from the bonding surfaces of PVC, CPVC, ABS and Styrene pipe and fittings. Use of a cleaner is recommended before priming of pipe and fittings.

Primers

The use of Primer is necessary to penetrate and dissolve the surface of the pipe and fitting prior to the application of cement. Special "one-step" cements formulated for use without primers are available. Check cement instructions and local codes (where required) for acceptable applications. Primer must be applied to both the pipe and fittings. Apply multiple coats of primer to the fitting socket and to the outside of the pipe ensuring that the entire surface is wet. Solvent cement must be applied immediately after primer while the surfaces are still tacky.

Solvent Cements

Solvent cements are produced for joining a variety of commercially available pipe and fitting materials, including PVC, CPVC and ABS plastics. Solvent cements are typically formulated using tetra hydro furan (THF). When properly applied, this solvent dissolves the mating surfaces of the pipe and fittings. Cyclohexanone is a typical retardant used to slow the rate of solvent evaporation. Immediate joining of the wet mating surfaces in one minute or less is essential to eliminate dry spots that will not bond. The bond interface is strongest at the area of interference fit where the softened semi-fluid surfaces of the pipe and fitting chemically fuse. Plastic resin fillers (dissolved PVC or CPVC) in the cement fill the gaps

between pipe and fitting. Cements are available in clear, white, gray and other colors to match the pipe or for specific application. **Inert pigments are used for coloration.** For example, white cements are made from titanium dioxide while gray cements are made from titanium dioxide and carbon black. As the solvent evaporates, pipe and fitting joint "cures", except for some residual solvent that dissipates over time. The resulting fused area is why this method is called "solvent cement welding" although no heat is applied to melt and fuse the bonded areas as in metal welding.

Solvent cements are formulated in regular bodied, medium bodied, heavy bodied, extra heavy bodied and specialty cements. Different types of cements have different set and cure times. Low VOC products - with lesser VOC emissions - will contribute to cleaner air and better workplace conditions. All Spears® solvent cement and primer products are certified as Low VOC.

1. Regular Bodied – Cements for smaller diameters (i.e. <4") and thin-wall classes and Schedule 40 piping with interference fits. Generally referred to as "regular body" such as Spears® PVC-00 and PVC-02 cements, these cements are fast setting.

2. Medium Bodied – Cements for smaller diameters (i.e. <4") for all classes, Schedule 40 and Schedule 80 pipe with interference fits such as Spears® PVC-05 and PVC-21 cements. These cements have better gap filling capability than regular bodied cement and are also considered fast setting

3. Heavy Bodied & Extra Heavy Bodied – Cements for both small and large diameters of heavier-wall Schedule 80 and Schedule 120 products. Heavy-body such as Spears® PVC-11 and CPVC-24 cements are classified as medium setting and extra heavy-body such as Spears® PVC-19 cement is classified as slow setting. These cements are formulated to fill larger gaps, dry slower and typically take longer to dry in order to provide more time to assemble joints.

4. Specialty Cements – Specialty cements formulated for use with specific products and applications, but can also be used with other applications of similar products. Examples include special cements such as Spears® PVC-25 Wet-N-Dry; transition cements such as Spears® MULTIPURPOSE-90 and Spears® ABS TO PVC-94; product specific cements such as Spears® ABS-71 and ABS-73; and one-step specialty cements. One-step cements do not require the use of primer prior to the application of the cement. Examples include Spears® FS-5 one-step cement for use with FlameGuard® CPVC Fire Sprinkler Products, Spears® LW-4 one-step cement for use with LabWaste™ CPVC Chemical Drainage Systems; Spears® EverTUFF® CTS-5 for use with CPVC hot and cold water plumbing systems, and Spears® LX-5 Low Extractable PVC cement for use in high purity applications (i.e. Spears® LOW EXTRACTABLE PVC products). In addition, special application cements such as Spears® CPVC-24 is formulated for improved chemical resistance to caustics and chemical applications with both PVC and CPVC products. In fact, CPVC-24 is one of the most versatile solvent cements on the market today!

Selecting the appropriate solvent cement and primer for the type of products being joined is important. The following selection guide can be used in selecting the right Spears® solvent cement and primer for your application.



Installation

Spears® Solvent Cement & Primer Selection Guide

Type	Body	Product	Color	Relative Set	Capacity	Features
PVC	Regular	PVC-00	Clear	Fast	Schedule 40 - 4"	
		PVC-02	Clear	Fast	Schedule 40 - 4"	Dries Clearest, slightly thicker than PVC-00
	Medium	PVC-05	Clear	Fast	All Classes & Schedules - 6" Schedule 80 - 4"	Industrial Duty Primerless Capability ¹
		PVC-21	Blue	Fast	Schedule 40 - 6" Schedule 80 - 4"	Primerless Capability ¹
	Heavy	PVC-11	Gray	Medium	All Classes & Schedules - 12"	Industrial Duty
		PVC-17	Clear/ Gray	Medium	All Classes & Schedules - 12" Non-pressure - 18"	Industrial Duty
	Heavy Extra	PVC19	White/ Gray	Slow	All Classes & Schedules Requiring High Gap Filling - 30"	Industrial Duty
	Specialty Cements	PVC-25	Aqua Blue	Very Fast	All Classes & Schedules - 6" Schedule 80 - 4"	Wet-N-Dry Formulation Primerless Capability ¹
		PVC-27	Clear	Very Fast	All Classes & Schedules - 6" Schedule 80 - 4"	Cold-N-Hot Formulation -15°F to 110°F Primerless Capability ¹
		PVC-50	Blue	Very Fast	Schedule 40 - 6" Schedule 80 - 4"	HOT PVC Formulation Primerless Capability ¹
		PVC-95	Clear/ Blue	Fast	All Classes & Schedules - 6" Schedule 80 - 3"	Flexible PVC for Flex-Flex, Flex-Rigid Joints
		LX-5	Clear	Fast	Low Extractable PVC Systems - 6"	One Step ² Low Extractable, High Purity Cement
CPVC	Heavy	CPVC-24	Gray/ Orange	Medium	All Classes & Schedules PVC or CPVC - All Sizes	Most Versatile, Chemically Resistant Cement for both CPVC & PVC Systems - including Duct - Industrial Duty
	Specialty Cements	LW-5	Mustard	Medium	LabWaste™ CPVC Drainage Systems - 24"	One Step ² Cement -Only LabWaste™ System Chemically Approved Cement
		FS-5	Red	Fast	CPVC Fire Sprinkler Systems - 3"	One-Step ² Cement for all CPVC Fire Sprinkler Systems - FlameGuard® & BlazeMaster®
		CTS-5	Yellow	Fast	CTS CPVC Systems - 2"	One-Step ² Cement for all CTS CPVC Systems - EverTUFF® & FlowGuard Gold®
ABS	Medium	ABS-71	Yellow/ Milky	Fast	All ABS Classes & Schedules - 8"	
		ABS-73	Black	Fast	All ABS Classes & Schedules - 8"	
Transition & Multipurpose	Medium	ABS TO PVC-94	Green	Fast	All Classes & Schedules - 6" (Except Schedule 80)	For ABS-to-PVC Transition Joints
		MULTIPUPOSE-90	Clear	Fast	All Classes & Schedules - 6" Schedule 80 - 4"	For PVC and CPVC pressure ABS and Styrene low-pressure systems
Primers & Cleaners		Primer-70	Purple/ Clear		All Classes & Schedules PVC & CPVC - 30"	Industrial Duty
		Primer-68	Purple/ Clear		All Classes & Schedules PVC & CPVC - 30"	
		Cleaner-65	Clear		All Classes & Schedules -All Sizes	For PVC, CPVC, ABS or Styrene

Notes

1= Primerless Capability indicates a cement can be used without primer in certain applications if local code permits. See specific cement information for further restrictions.

2 = One Step designates a cement specifically designed for use without primer. CTS One Step acceptability depends on local code requirements.

CTS = Copper Tube Size, ASTM D2846 Hot and Cold Water Distribution Systems.

Joining Method - Threaded Connections

Threaded connections require the application of a thread sealant that is compatible with PVC and CPVC material. Spears® recommends the use of Spears® Blue 75 Thread Sealant.

CAUTION - Use only thread sealants recommended for PVC or CPVC plastic. Other joint compounds or pastes may contain substances that could cause stress cracks in PVC or CPVC materials.

Apply sealant to the male threads only. Make sure all threads are covered. **DO NOT** clog the waterway with excess sealant. If PTFE tape must be used, Spears® recommends a thickness of at least .0025" that meets or exceeds military specification, MIL-T-27730A. **DO NOT** use a combination of tape and thread sealant on the same joint. Apply PTFE tape in the direction of the threads by starting with the first full thread and continuing over the entire thread length. Make sure all threads are covered. Generally, 2 – 3 wraps are sufficient to produce a watertight connection.

DO NOT over-torque any threaded connections. Generally, one to two turns beyond finger-tight are required for a threaded connection. Use a smooth-jawed wrench or strap wrench when installing threaded connections.

Threading Pipe

PVC and CPVC pipe can be threaded using either standard hand pipe stocks or power-operated equipment. Since rigid PVC plastic pipe has the same outside diameter as standard steel pipe in comparable sizes, standard steel pipe taps and dies can be used. A cut thread or deep scratch results in a stress concentration point. As a result, only Schedule 80 and Schedule 120 pipe should be threaded. A 50% pressure de-rating is applied to threaded pipe to compensate for this. **DO NOT** thread Schedule 40 pipe. For optimum results in threading, use new taps and dies; but in any case, they should be cleaned and sharpened and in good condition. Power threading machines should be fitted with dies having a 5° negative front rake and ground especially for this type of pipe; tapered guide sleeves are not required. For hand stocks the dies should have a negative front rake of 5° to 10°. Dies which have been designed for use on brass or copper pipes may be used successfully. Carboloy dies give longer service. (Taps should be ground with a 0° to 10° negative rake, depending upon the size and pitch of the thread. Die chasers should have a 33° chamfer on the lead; a 10° front or negative

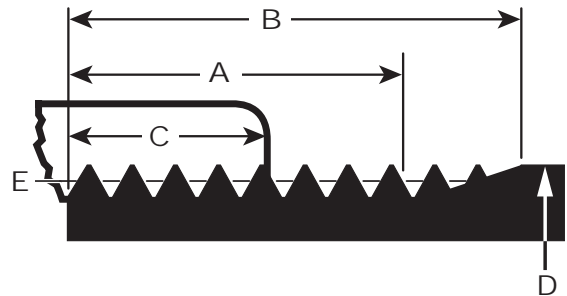
rake; and a 5° rake on the back or relief edge.). Self-opening die heads and collapsible taps, power threading machines and a slight chamfer to lead the tap or dies will speed production; however, taps and dies should not be driven at high speeds or with heavy pressure.

A tapered plug should be inserted into the pipe when threading, to hold the pipe round and to prevent the die from distorting and digging into the pipe wall. This insures uniform thread depth all the way around. Pipe for threading should be held in a suitable pipe vise, but saw-tooth jaws should not be used. Flanges and close nipples should be threaded in jigs or tapping fixtures. To prevent crushing or scoring the pipe, some type of protective wrap, such as canvas, emery paper, or a light metal sleeve should be used; rounding of chuck jaws will also be helpful. Rigid PVC or CPVC plastic pipe should be threaded without use of lubricants. Standard cutting oils can cause stress cracking in plastics and should not be used. Water-soluble oil or plain water is recommended. Degreasing with any solvents is not recommended, nor should solvents be used in any cleanup. Always clear cuttings from the die.

DO NOT OVER THREAD - To obtain a tight, leak proof joint, the thread dimensions shown in the table should be used. If pipe is over threaded, fittings cannot be run on far enough to make a tight seal.

American National Standards Institute Code B1.20.1 covers dimensions and tolerances for tapered pipe threads. **Only Schedule 80 or heavier wall pipe should be threaded.**

Angle between sides of thread is 60 degrees. Taper of thread, on diameter, is 3/4 inch per foot. The basic thread depth is 0.8 x pitch of thread and the crest and root are truncated an amount equal to 0.033 x pitch, excepting 8 threads per inch which have a basic depth of 0.788 x pitch and are truncated 0.045 x pitch at the crest and 0.033 x pitch at the root.



PIPE THREADS

Nominal Size (in.) (Max.) (in.)	Outside Diameter (in.) D	Number of Threads Per Inch	Normal Engagement By Hand (in.) C	Length of Effective Thread (in.) A	Total Length: End of pipe to vanishing point (in.) B	Pitch Diameter at end of Internal Thread (in.) E	Depth of Thread (Max.) (in.)
1/8	0.405	27	0.180	0.2639	0.3924	0.37476	0.02963
1/4	0.540	18	0.228	0.4018	0.5946	0.49163	0.04444
3/8	0.675	18	0.240	0.4078	0.6006	0.62701	0.04444
1/2	0.840	14	0.320	0.5337	0.7815	0.77843	0.05714
3/4	1.050	14	0.339	0.5457	0.7935	0.98887	0.05714
1	1.315	11-1/2	0.400	0.6828	0.9845	1.23863	0.06957
1-1/4	1.660	11-1/2	0.420	0.7068	1.0085	1.58338	0.06957
1-1/2	1.900	11-1/2	0.420	0.7235	1.0252	1.82234	0.06957
2	2.375	11-1/2	0.436	0.7565	1.0582	2.29627	0.06957
2-1/2	2.875	8	0.682	1.1375	1.5712	2.76216	0.10000
3	3.500	8	0.766	1.2000	1.6337	3.38850	0.10000
4	4.500	8	0.844	1.3000	1.7337	4.38713	0.10000
5	5.563	8	0.937	1.4063	1.8400	5.44929	0.10000
6	6.625	8	0.958	1.5125	1.9462	6.50597	0.10000



Joining Method - Flanged Connections

PVC and CPVC flanges are available in several designs, including solid one-piece flanges, two piece Van Stone style flanges featuring a moveable ring for bolt alignment, and blind flanges for capping off a piping run. Flanges are available in socket, spigot and threaded configurations and are coupling devices designed for joining IPS (Iron Pipe Size) plastic piping systems where frequent disassembly may be required, can be used as a transitional fitting for joining plastic to metal piping systems, and for connection to other flanged type valves and equipment. A gasket is used between flanges to form a water-tight seal. Proper gasket material should be selected for fluids compatibility. Most plastic flanges carry a maximum working pressure rating of 150 psi non-shock for water at 73°F. Pressure ratings may vary according to size and construction of the flange. Consult flange manufacturer.

Gaskets

Select appropriate size and bolt pattern gasket. Full faced, 1/8" thick elastomer gaskets with a Shore "A" Durometer of approximately 70 are recommended. Verify that the gasket material is suitable for use with the application fluids.

Bolt Patterns & Selection

Most PVC and CPVC flanges are produced with ANSI B16.5 Bolt Patterns for Class 125/150 flanges. Optional Class 300 bolt patterns (NOT a 300 psi rating), certain ANSI/Metric dual pattern flanges, and metric bolt patterns can be produced. Proper bolt size, number and length should be selected for the specific flanges and equipment being assembled. Bolt length requirements will vary according to the flange or equipment manufacturer. Always use 2-wide flat washers for each bolt, one under the bolt head and one under the nut (do not use thin "fender" washers).

Bolt Torque

Threads should be cleaned and well lubricated (**WARNING:** Use only bolt lubricants compatible with PVC or CPVC material). Actual field conditions may require variations in these recommendations. **UNNECESSARY OVER TORQUING WILL DAMAGE THE FLANGE.** Torque should always be applied in approximately 5 ft-lb. increments using a 180° opposing sequence.

Flange Make-up

Follow proper solvent cementing and/or threaded component procedures as applicable to join the flange to the pipe. Once a flange is joined to pipe, the method for joining two flanges is as follows:

1. Piping runs joined to the flanges must be installed in a straight line position to the flange to avoid stress at the flange due to misalignment. Piping must also be secured and supported to prevent lateral movement which can create stress and damage the flange.
2. With gasket in place, align the bolt holes of the mating flanges by rotating the ring into position.
3. Insert all bolts, washers (two standard flat washers per bolt), and nuts.
4. Make sure the faces of the mating surfaces are flush against gasket prior to bolting down the flanges.
5. Tighten the nuts by hand until they are snug. Establish uniform pressure over the flange face by tightening the bolts in 5 ft.-lb. increments according to the sequence shown in the following table using a 180° opposing sequence.

6. Care must be taken to avoid "bending" the flange when joining a Spears® flange to a "raised face" flange, or a wafer-style valve. Do not use bolts to bring together improperly mated flanges.

Recommended Flange Bolt Torque for Plastic Flanges

Flange Size (in.)	No. of Bolt Holes	Bolt Dia. (in.)	Min. Bolt Length (in.)	Torque ft.-lb.
1/2	4	1/2	2	12
3/4	4	1/2	2	12
1	4	1/2	2-1/4	12
1-1/4	4	1/2	2-1/4	12
1-1/2	4	1/2	2-1/2	25
2	4	5/8	3	25
2-1/2	4	5/8	3-1/4	25
3	4	5/8	3-1/4	25
4	8	5/8	3-1/2	25
6	8	3/4	4	40
8	8	3/4	4-1/2	40
10	12	7/8	5	64
12	12	7/8	5	95
14	12	1	5-1/2	110
16	16	1	6-1/2	110
18	16	1-1/8	4-1/8	110
20	20	1-1/8	5-1/2	110
24	20	1-1/4	5-1/2	110

Note: Minimum bolt length is based on connecting two (2) Spears® flanges, two flat washers, gasket and nut. Adjustments will need to be made to accommodate valves and other equipment.

Joining Method – Mechanical Grooved Couplings

In many installations where transition to metal pipe, or where disassembly is a prime factor, metallic grooved style couplings with gasket seal can be used to join PVC and CPVC pipe to alternate IPS size piping materials. In addition to the ease of disassembly, this type of connection also allows for a certain degree of angular adjustment and expansion/contraction. Special rolled-groove pipe can be joined, but easy to use molded Grooved Coupling Adapters then can be solvent cemented to plain end pipe are available for use with metallic grooved couplings.

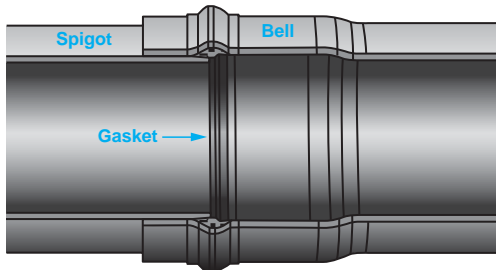
Only flexible style metallic grooved couplings are recommended for use with plastic pipe. Rigid style couplings should not be used as these can provide a compressive/shear load to plastic pipe resulting in failure. Always check the compatibility of the grooved coupling gasket material with the intended application fluids.

INOTE A gasket/joint lubricant is recommended to prevent pinching the gasket and to assist the seating and alignment processes during assembly of grooved couplings. Certain lubricants may contain a petroleum base or other chemicals, which will cause damage to the plastic pipe, gasket and adapter. Always verify the suitability for use of the selected lubricant with the lubricant manufacturer.

Joining Method - Gasketed Pipe

Standards and Specifications

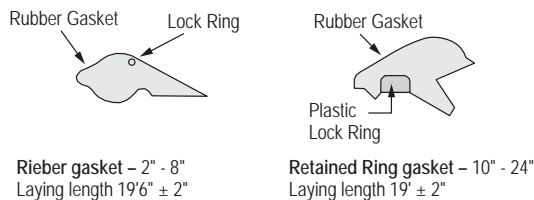
Since integral gasket bells are commercially available on a variety of pipe dimensions, applicable standards are dependent on the pipe dimension chosen. PVC pipe is manufactured from a Type I, Grade I PVC material per ASTM D 1784. Gasket pipe utilizes flexible elastomeric seals for pressure pipe. When properly assembled these joints meet the requirements of push-on joints per ASTM D 3139. The gaskets used should be manufactured in strict compliance with ASTM F477 requirements. SDR Series gasketed pipe is manufactured to ASTM D 2241. PVC Schedule 40, 80 and 120 gasketed pipe is manufactured to ASTM D 1785.



Typical Gasket Joint

Gasket Design

Gasketed pipe utilizes either gaskets that are locked in place at the factory as part of the manufacturing process, or insertable elastomer gaskets. Two styles of factory-installed gaskets are typically used. The Rieber style gasket with internally molded-in metal ring, and the Retained Ring style gasket. This technique also prevents fish mouthing or dislocation of the seal during assembly. The standard gasket material typically used for both factory-installed gasket systems is Styrene Butadiene Rubber (SBR) which offers excellent physical properties and good chemical resistance. Other gasket materials are commercially available to meet demanding chemical resistance requirements.



Gasketed pipe offers low assembly force; flexibility to allow for variations in line pressure and changing working conditions; compensation for movement due to thermal expansion and contraction; a certain amount of allowable joint deflection; and positive, leak-free seals for both high- and low-pressure applications as well as vacuum service.

Field Assembly of Gasketed Joint

PVC pipes are assembled in the field by following a few simple steps, as outlined below:

Step 1: Pipe end should have 15° bevel. Field cut pipe must be cut square and a 15° bevel applied to the cut spigot end. Factory pipe ends may have an insertion depth guide mark. If not, or if field cut, measure bell depth and mark on spigot end for insertion reference.

Step 2: Check that gasket is properly positioned in the bell groove. Clean the beveled end of the spigot and the gasket in the bell groove to be sure they are free of any particles or debris

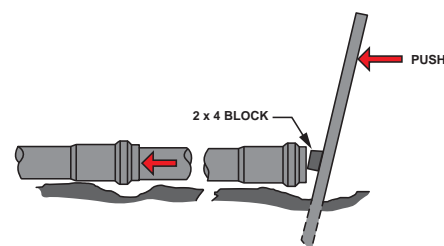


Step 3: Apply a lubricant recommended for PVC to the spigot end. Avoid applying lubricant directly on the gasket in the bell instead of the spigot.

WARNING: Some lubricants, oils or greases may not be compatible with PVC and can cause stress cracking. Verify PVC compatibility with the lubricant manufacturer.



Step 4: Insert and push lubricated spigot past the gasket into the bell until the guide mark on the spigot is meets the end of the bell. It is usually possible to manually insert the spigot into the bell on pipe sizes 3" and smaller. Mechanical assistance may be needed for insertion on larger sizes. The "bar and block method" can be used, which allows the installer to feel the amount of force being used and whether the joint goes together smoothly.



"Bar and Block" Method for Mechanical Insertion of Spigot Into Bell



Deflection

Gasketed joints permit an angular deflection of 2° at the joint. Adequate deflection can usually be achieved for gentle curves by using the inherent flexibility of the pipe itself, without using joint deflection.

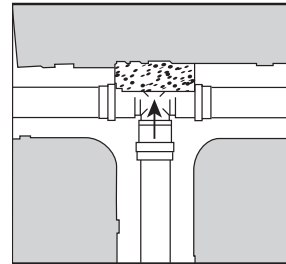
Thrust Blocking Gasket Joints

All gasket-joint piping requires adequate thrust restraints to prevent movement from forces generated by changes in direction, valve operation, dead ends, reduction in pipe size, and other areas where thrusts can be developed. The size and type of thrust restraint depends on the pipe size, type of fitting, soil properties, and water-hammer possibilities. Keeping flow velocities at or below 5 ft/sec will help minimize surge pressures. Fittings and valves used to make vertical changes in direction should be anchored to the thrust restraint to prevent outward and upward thrusts at the fitting junctures. In pressure lines, valves 3" in diameter and larger should be anchored to the thrust restraint to prevent movement when operated. Consideration should also be given for the proper support, anchoring, and thrust restraint for lines installed on slopes.

The size of thrust block required (in square feet) can be determined by dividing the total thrust developed (in psi) by the capacity of the soil (in pounds/square foot).

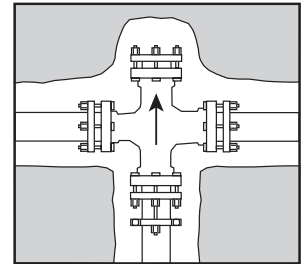
The most common method of thrust blocking involves the pouring of concrete (to the size of block required) between the pipe fitting and the bearing wall of the trench. Mechanical thrust restraint with PVC pipe.

Thrust Blocks

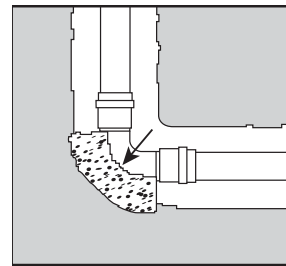


Thru Line connection, tee

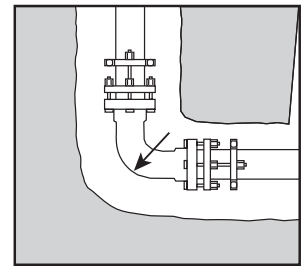
Thrust Retainers



Thru Line connection, cross used as tee



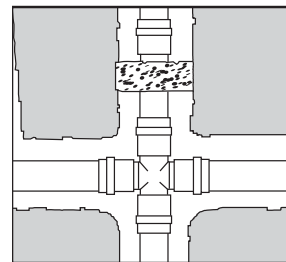
Direction change, elbow



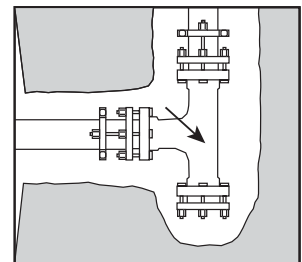
Direction change, elbow

Thrust in lb. @ 100 psi Operating Pressure

Pipe Size (in.)	90° Bend	45° Bend	22.5° Bend	Tee, Cap Plug, 60° Bend
2	645	350	180	455
2-1/2	935	510	260	660
3	1,395	755	385	985
4	2,295	1,245	635	1,620
6	4,950	2,680	1,370	3,500
8	8,375	4,540	2,320	5,930
10	13,040	7,060	3,600	9,230
12	18,340	10,000	5,240	13,000
14	21,780	11,770	6,010	15,400
16	28,440	15,370	7,850	20,110
18	35,990	19,450	9,930	25,450
20	44,430	24,010	12,260	31,420
24	63,970	34,570	17,650	45,240



Change line size, reducer



Direction change, tee used as elbow

Safe Bearing Capacity

Soil	Capacity (lb./sq. ft.)
Muck, peat, etc.	0
Soft clay	1,000
Sand	2,000
Sand and gravel	3,000
Sand and gravel cemented with clay	4,000
Hard shale	10,000

Assembly Instructions

Step One: Make certain pipe ends and gasket areas are free of dirt and debris. Support spigot end of pipe above ground to prevent dirt contamination when lubricant is applied.

Step Two: Apply a light coating of recommended lubricant to spigot end and sealing section of gasket.

WARNING – Use only lubricants specifically designated for use with PVC pipe. Certain greases, oils and vegetable oils will cause stress cracking in PVC materials.

Step Three: Align pipe ends. Push spigot end into gasket bell so that the reference mark is even with the entrance of the gasket bell.

Pounds of Force Required to Assemble Gasket Pipe

Rieber		Retaining Ring	
Pipe Size (in.)	ft.-lb.	Pipe Size (in.)	ft.-lb.
2	113	10	250
2-1/2	124	12	300
3	137	14	385
4	157	16	360
6	284	18	450
8	352	20	520
		24	600

Estimated Gasket Pipe Lubricant Use

Nominal Pipe Size (in.)	Avg. Number of Joints Per Pint (1 lb.) Container of lubricant
2	70
2-1/2	60
3	50
4	35
6	20
8	14
10	10
12	7
14	5
16	3
18	2
20	1.5
24	1

Trenching: Initial Backfill

Trench depth is determined by the intended service and local conditions. Gasket pipe should be buried a minimum of 12" below frost line in areas subject to freezing, or a minimum depth of 18" - 24" where there is no frost. Permanent lines subjected to heavy traffic should have a minimum cover of 24". In areas not subject to freezing, a minimum cover of 12" to 18" is usually sufficient for small-diameter piping subjected to light traffic. Bearing stresses must be calculated to determine the amount of cover required. Reference to applicable local, state, or national codes is also recommended.

The trench bottom should be continuous, relatively smooth, and free of rocks and debris. Adequate backfill should be in place immediately after installation, prior to filling or testing the line, to help distribute the effects of expansion/contraction evenly over each pipe length. The initial backfill material should consist of particles of 1/2" in size or less, and properly tamped. Generally a minimum of 6" - 12" of backfill is desirable for the initial phase.

Where hardpan, ledge rock, or large boulders are encountered, the trench bottom should be padded with sand or compacted fine-grain soils to provide adequate protection. Joints should be left exposed for visual inspection during testing. Testing should be done before final backfill.

Testing

If separate tests are to be conducted for pressure and leakage, pressure testing should be conducted first.

WARNING: Air must be completely vented from the line prior to pressure testing; entrapped air can generate excessive surge pressures that are potentially damaging and can cause bodily injury or death. Air relief valves should be provided.

Section of pipe should be tested as it is installed to verify proper installation and joint assembly. Make certain the section of piping to be tested is backfilled sufficiently to prevent movement under test pressure. If concrete thrust blocks are utilized, allow sufficient time for concrete to set up prior to testing. Test ends must be capped and braced properly to withstand thrusts developed during testing. The following table provides the water volume requirements of various sizes of schedule and SDR series pipe.

Water Volume Gallons / 100'

Pipe Size (in.)	Sch. 40	Sch. 80	Sch. 120	SDR. 21	SDR. 26	SDR. 41
2	17	15	14	19	20	–
3	38	34	32	41	43	–
4	66	60	54	68	70	–
6	150	135	123	146	152	–
8	260	237	–	248	258	–
10	409	373	–	–	401	–
12	582	528	–	–	565	–
14	703	637	–	–	681	–
16	917	836	–	–	889	–
18	–	1060	–	–	1125	1195
20	–	–	–	–	1390	1475
24	–	–	–	–	2000	2125

Final Backfill

Backfilling should be conducted in layers; each layer must be compacted sufficiently so that lateral soil forces are developed uniformly. Under certain conditions it may be desirable to pressurize line during the backfill operation. Vibratory methods are recommended when compacting sand or gravel. Sand and gravel containing a significant proportion of fine-grained materials (silt, clay, etc.) should be compacted by mechanical tampers. When water flooding is used, sufficient cover must be provided by the initial backfill to ensure complete coverage of the pipe; precautions must be taken to prevent "floating" the pipe in the trench. Additional layers of backfill should not be applied until the water flooded backfill is firm enough to walk on. In all cases, the backfill should be placed and spread in uniform layers to eliminate voids. Large rocks, frozen dirt clods, and other debris larger than 3" should be removed to prevent damage to the pipe. Rolling equipment or heavy tampers should only be used to consolidate the final backfill. Additional information pertaining to underground installation is contained in ASTM D 2774 (Underground Installation of Thermoplastic Pressure Pipe), and ASTM D 2321 (Underground Installation of Flexible Thermoplastic Sewer Pipe).



Transition Joints & Specialty Fittings

PVC and CPVC pipe can be connected to steel, copper, brass, other metals and other plastic materials using a variety of transition fittings including unions, compression fittings, special reinforced adapters, flanged joints and grooved mechanical coupling joints.

Do not use regular PVC or CPVC female threaded fittings for connection to metal male threads. Spears® Special Reinforced (SR) female plastic threaded fittings are excellent for plastic to metal transitions. Unlike conventional plastic female adapters, these fittings incorporate the use of a stainless steel restraining collar located on the exterior of the FIPT threads of the adapter. This design allows direct connection to male metal threads without the need for pressure de-rating normally associated with conventional FIPT adapters, as the radial stress generated by thread engagement is contained. Other PVC/CPVC adapter fittings with brass or steel threads can also be used for transition to metal male threads.

If regular non-reinforced plastic threads must be transitioned to metal threads, the recommended joint is to use male plastic threads into female metal threads.

Underground Installation

Underground piping must be installed in accordance with any applicable codes. Attention should be given to local pipe laying techniques applicable to area subsoil. This may provide insights to particular pipe bedding issues. The following information is applicable to solvent cement joining of PVC and CPVC piping as a general guide. Refer to Gasketed Pipe section for additional information on installation of gasketed pipe.

Inspection: Before installation, PVC and CPVC piping products should be inspected for cuts, scratches, gouges or split ends. Damaged sections found must be cut-out and discarded.

Trenching: The trench should be as narrow as possible while providing adequate width to allow convenient installation. Minimum trench widths may be utilized by joining pipe outside of the trench and lowering it into the trench after adequate joint strength has been achieved. Refer to solvent cement instructions for recommended joint set and cure time.

Trench widths will have to be wider where pipe is joined in the trench or where thermal expansion and contraction is a factor.

Thermoplastic pipe should ALWAYS be installed below the frost level according to local conditions. Pipe for conveying liquids susceptible to freezing should be buried no less than 12" below the maximum frost level. Permanent lines subjected to heavy traffic should have a minimum cover of 24". For light traffic 12" to 18" is normally sufficient for small diameter pipe (typically < 3" diameter). With larger sizes, bearing stresses should be calculated to determine cover required.

When it is installed beneath surfaces that are subject to heavy weight or constant traffic such as roadways and railroad tracks, thermoplastic piping should be run within a metal or concrete casing. Refer to Critical Collapse Pressure Ratings for additional information.

The trench bottom should be continuous, relatively smooth and free of rocks. Where ledge rock, hardpan or boulders are encountered, it is necessary to pad the trench bottom using a minimum of four (4) inches of tamped earth or sand beneath the pipe as a cushion and for protection of the pipe from damage.

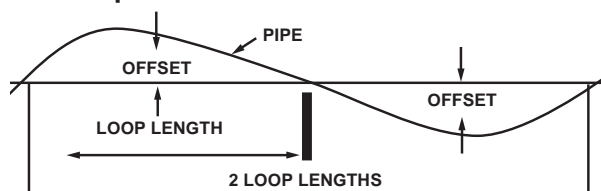
Sufficient cover must be maintained to keep external stress levels below acceptable design stress. Reliability and safety of service is of major importance in determining minimum cover. Local, state and national codes may also govern.

Snaking of Pipe may be used for small diameter piping systems (typically < 3"), but may also apply to larger diameter piping under specific applications and site conditions. Snaking of pipe is used to compensate for thermal expansion and contraction due to temperature changes. Snaking is particularly necessary on piping solvent welded during the late afternoon or a hot summer's day where drying time will extend through the cool of the night where thermal contraction could result in joint pull out. This snaking is also especially necessary with pipe that is laid in its and is backfilled with cool earth before the joints are thoroughly dry.

After the pipe has been solvent welded and allowed to set properly, snake the pipe beside the trench during its required cure time. **BE ESPECIALLY CAREFUL NOT TO APPLY ANY STRESS THAT WILL DISTURB THE UNCURED JOINT.**

For Pipe Diameters < 3" diameter

Loop Offset in Inches for Contraction:



Maximum Temperature Variation, °F, Between Time of Solvent Welding and Final Use

Loop Length	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
LOOP OFFSET										
20	3"	4"	5"	5"	6"	6"	7"	7"	8"	8"
50	7"	9"	11"	13"	14"	16"	17"	18"	19"	20"
100	13"	18"	22"	26"	29"	32"	35"	37"	40"	42"

Expansion and contraction can be excessive in systems operating at near or at the maximum allowable temperature ranges with intermittent flow and buried lines. In these cases the lines should not be snaked. The use of properly installed expansion joints within a suitable concrete enclosure can be used. A section of larger diameter PVC pipe or other suitable sleeve should be used over the carrier pipe to pass through the wall of the concrete to minimize the potential for damage (scratching & scarring) as the result of movement caused by thermal expansion/contraction. Expansion joints should be suitably anchored independently of the carrier line. Axial guides should be used to direct movement into the expansion joint.

Backfilling: Underground pipe should be inspected and tested for leaks prior to backfilling. In hot weather, it is best to backfill early in the morning when the line is fully contracted and there is reduced chance of insufficiently dried joints being subject to contraction stresses.

The pipe should be uniformly and continuously supported over its entire length on firm, stable material. Blocking should not be used to change pipe grade or to intermittently support pipe across excavated sections.

Pipe is installed in a wide range of subsoils that must be stable and applied so as to physically shield the pipe from damage. Follow local pipe laying experience that may indicate particular pipe bedding problems.

Surround the pipe with 6" or 8" of backfill materials free of rocks and having a particle size of 1/2" or less. It should be placed in layers. Each soil layer should be sufficiently compacted to uniformly develop lateral passive soil forces during the backfill operation. It may be advisable to pressurize the pipe to 15 - 25 psi during the backfilling.

Vibratory methods are preferred when compacting sand or gravels. Best results are obtained when the soils are in a nearly saturated condition. Where water flooding is used, the initial backfill should be sufficient to insure complete coverage of the pipe. Additional material should not be added until the water flooded backfill is firm enough to walk on. Care should be taken to avoid floating the pipe.

Sand and gravel containing a significant proportion of fine-grained material, such as silt and clay, should be compacted by hand or, preferably by mechanical tamper.

The remainder of the backfill should be placed and spread in uniform layers to fill the trench completely so that there will be no unfilled spaces under or around rocks or lumps of earth in the backfill. Remove large or sharp rocks, frozen clods and other debris greater than 3" in diameter. Rolling equipment or heavy tampers should only be used to consolidate the final backfill.

Avoid threaded connections in underground applications. Where transition to alternate materials is required the use of a flange component with suitable gasket is recommended. At vertical transitions from below ground systems to connections above ground, follow above ground installation procedures with regard to compensating for thermal expansion/contraction, weatherability, and proper support recommendations. Valves and other concentrated weight loads should be independently supported. Avoid excessive bending of pipe; excessive deflection of pipe and joints can reduce pressure bearing capability and cause failure.

Additional information on underground installations is contained in ASTM D 2774 "Underground Installation of Thermoplastic Pressure Piping", ASTM F 645, Standard Guide For "Selection Design and Installation of Thermoplastic Water Pressure Piping Systems", and ASTM D 2321 "Underground Installation of Flexible Thermoplastic Sewer Pipe."

Above Ground Installation

Thermal Expansion & Contraction

Attention must be given to above ground 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 building 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.

Outdoor Applications & Protection

PVC and CPVC piping system must be protected from freezing. Many standard cold weather piping design and installation practices can be used to protect the system from freezing such as use of pipe insulation, anti-freeze solutions, and heat trace tapes. The suitability and compatibility of these products for use with PVC and CPVC should be verified with product manufacturers prior to use.

Caution should be exercised in installing PVC and CPVC piping products in metal boxes or enclosures exposed to direct sunlight. Such enclosures can act as "ovens" that significantly increase the environmental temperature over ambient air conditions, resulting in product damage and failure.

PVC and CPVC piping exposed to the direct sunlight (UV radiation) should be painted with a reflective, light colored acrylic or latex paint. Avoid dark colors, especially black. Heat absorption can exceed the heat handling capacity of the pipe and fitting material. Compatibility information regarding use with PVC/CPVC products should be confirmed with the paint manufacturer. Oil-based paints should not be used.

Hangers and Supports

Hanger Support Spacing

Support location and spacing depends on the pipe diameter, system operating temperature, and the location of any concentrated stress loads (i.e., valves, flanges, test equipment and any other heavy system components). Hangers must have an adequate load-bearing surface free of any rough or sharp edges that could damage the pipe during use. Hangers also must not restrict linear movement of the system in order to allow thermal expansion and contraction from temperature changes.

Proper support spacing can be calculated similarly to that of metal systems by using simple and continuous beam calculations. This can be achieved using the maximum fiber stress of the material, or deflection based on the long term modulus of the material at the temperature selected as the limiting factors.



Anchor Selection

Hangers designed for metallic pipe can be used if they provide an adequate load-bearing surface, which is smooth and free of rough or sharp edges that could damage the pipe. Improper supports can generate excessive sag resulting in failure. Movement caused by thermal expansion/contraction and pressure fluctuations must be considered. Hangers and supports used must permit axial movement of the system, but not compress the pipe. Supplemental guides may be required in addition to hangers in order to maintain alignment and direct movement into in-line Expansion Joints.

Placement

Hangers should be installed within two feet of each side of a pipe joint; while changes in direction should be supported as close as possible to the fitting to reduce stress. Heavy system components such as valves, flanged assemblies, tees and other concentrated stress loads must be independently supported. Valves should additionally be adequately braced to prevent movement/stress loads from operational torque. Support of potential solids accumulation loads within the line should also be considered.

Precautions

Protective sleeves or pads used between the pipe and the hanger will distribute stress loads over a greater surface area, especially when using U-bolt or roller type hangers. Protective sleeves or pads should also be used when horizontal pipe is resting on concrete or other abrasive support structures. Do not allow piping to contact abrasive surfaces that could cause damage during axial movement. Avoid contact with heat producing sources. Do not install plastic piping in close proximity to steam lines or other high temperature equipment without providing appropriate protection to prevent damage from distortion or expansion/contraction.

Care should be taken to avoid over tightening of anchors, clamps or other support devices. This can distort or even fracture the piping.

Vertical lines must be supported properly at intervals that will prevent excessive loading on the fitting at the lower end. Hangers and clamps suitable for this purpose include riser clamps or double bolt type clamps installed in such a manner that will allow for movement of the pipe due to thermal expansion and contraction. Clamps and hangers used must not compress, distort, cut or abrade the piping. Common practice is to install clamps just below a coupling so that the shoulder of the coupling rests on the clamp. Fittings can be modified in the field to achieve this by cutting a coupling in two, just above the stop at the socket bottom, and then cutting this piece in half lengthwise to provide two halves which do not contain the stop. The two halves are then solvent cemented to the pipe at the proper location so that the shoulder of the modified coupling rests on the clamp. Riser clamps that utilize compression to support the pipe weight should not be used.

Anchor Guides

Anchors direct movement of the piping by providing restraint at key points such as long straight runs, at changes in direction of the system, and where expansion joints and other methods of thermal compensation are utilized. They may be used to control forces caused by expansion and contraction, generated by pressure surges, vibration, and other transient conditions. Guides are necessary to help direct this movement between anchors by allowing longitudinal movement while restricting lateral movement. Depending on the application and type, guides may or may not act as supports. Support guides should have the same load bearing surface and other requirements of hangers designed for the system. Guides must be rigidly attached to the structure to prevent lateral movement, but should not restrict longitudinal movement of the pipe through the guide. Anchors and guides must be engineered and installed without point loading the system.

Recommended Pipe Support Spacing

The following hanger support spacing recommendations are according to size, schedule, and operating temperatures. Do not clamp supports tightly – this restricts axial movement of the pipe. If short spacing is necessary, continuous supports may be more economical. These are considered conservative in nature and are based on straight runs of un-insulated lines with fluids with a specific gravity of 1.00 or less. These values do not consider concentrated weight loads or aggressive reagents.

PVC PIPE SUPPORT SPACING (ft.)

PIPE SIZE (in.)	SCHEDULE 40					SCHEDULE 80					SCHEDULE 120				
	60°F	80°F	100°F	120°F	140°F	60°F	80°F	100°F	120°F	140°F	60°F	80°F	100°F	120°F	140°F
1/4	4	3-1/2	3-1/2	2	2	4	4	3-1/2	2-1/2	2	---	---	---	---	---
3/8	4	4	3-1/2	2-1/2	2	4-1/2	4-1/2	4	2-1/2	2-1/2	---	---	---	---	---
1/2	4-1/2	4-1/2	4	2-1/2	2-1/2	5	4-1/2	4-1/2	3	2-1/2	5	5	4-1/2	3	2-1/2
3/4	5	1/2	4	2-1/2	2-1/2	5-1/2	5	4-1/2	3	2-1/2	5-1/2	5	4-1/2	3	3
1	5-1/2	5	4-1/2	3	2-1/2	6	5-1/2	5	3-1/2	3	6	5-1/2	5	3-1/2	3
1-1/4	5-1/2	5-1/2	5	3	3	6	6	5-1/2	3-1/2	3	6-1/2	6	5-1/2	3-1/2	3-1/2
1-1/2	6	5-1/2	5	3-1/2	3	6-1/2	6	5-1/2	3-1/2	3-1/2	6-1/2	6-1/2	6	4	3-1/2
2	6	5-1/2	5	3-1/2	3	7	6-1/2	6	4	3-1/2	7-1/2	7	6-1/2	4	3-1/2
2-1/2	7	6-1/2	6	4	3-1/2	7-1/2	7-1/2	6-1/2	4-1/2	4	8	7-1/2	7	7-1/2	4
3	7	7	6	4	3-1/2	8	7-1/2	7	4-1/2	4	8-1/2	8	7-1/2	5	4-1/2
3-1/2	7-1/2	7	6-1/2	4	4	8-1/2	8	7-1/2	5	4-1/2	9	8-1/2	7-1/2	5	4-1/2
4	7-1/2	7	6-1/2	4-1/2	4	9	8-1/2	7-1/2	5	4-1/2	9-1/2	9	8-1/2	5-1/2	5
5	8	7-1/2	7	4-1/2	4	9-1/2	9	8	5-1/2	5	10-1/2	10	9	6	5-1/2
6	8-1/2	8	7-1/2	5	4-1/2	10	9-1/2	9	6	5	11-1/2	10-1/2	9-1/2	6-1/2	6
8	9	8-1/2	8	5	4-1/2	11	10-1/2	9-1/2	6-1/2	5-1/2	---	---	---	---	---
10	10	9	8-1/2	5-1/2	5	12	11	10	7	6	---	---	---	---	---
12	11-1/2	10-1/2	9-1/2	6-1/2	5-1/2	13	12	10-1/2	7-1/2	6-1/2	---	---	---	---	---
14	12	11	10	7	6	13-1/2	13	11	8	7	---	---	---	---	---
16	12-1/2	11-1/2	10-1/2	7-1/2	6-1/2	14	13-1/2	11-1/2	8-1/2	7-1/2	---	---	---	---	---
18	13	12	11	8	7	14-1/2	14	12	11	9	---	---	---	---	---
20	14	12-1/2	11-1/2	10	8-1/2	15-1/2	14-1/2	12-1/2	9-1/2	---	---	---	---	---	---
24	15	13	12-1/2	11	9-1/2	17	15	14	12-1/2	10-1/2	---	---	---	---	---
SDR 41					SDR 26										
18	13	12	11	8	7	14-1/2	14	12	9	8	---	---	---	---	---
20	13-1/2	12-1/2	11-1/2	8-1/2	7-1/2	15	14-1/2	12-1/2	9-1/2	8-1/2	---	---	---	---	---
24	14	13	12	9	8	15-1/2	15	13	10	9	---	---	---	---	---

■ **NOTE** Although support spacing is shown at 140°F for PVC, consideration should be given to the use of CPVC or continuous support above 120°F. The possibility of temperature overrides beyond regular working temperatures and cost may make either of the alternatives more desirable. This chart based on continuous spans and for un-insulated line carrying fluids of specific gravity up to 1.00.



Installation

CPVC PIPE SUPPORT SPACING (ft.)

PIPE SIZE (in.)	SCHEDULE 40						SCHEDULE 80					
	73°F	100°F	120°F	140°F	160°F	180°F	73°F	100°F	120°F	140°F	160°F	180°F
1/2	5	4-1/2	4-1/2	4	2-1/2	2-1/2	5-1/2	5	4-1/2	4-1/2	3	2-1/2
3/4	5	5	4-1/2	4	2-1/2	2-1/2	5-1/2	5-1/2	5	4-1/2	3	2-1/2
1	5-1/2	5-1/2	5	4-1/2	3	2-1/2	6	6	5-1/2	5	3 1/2	3
1-1/4	5-1/2	5-1/2	5-1/2	5	3	3	6-1/2	6	6	5-1/2	3 1/2	3
1-1/2	6	6	5-1/2	5	3-1/2	3	7	6-1/2	6	5-1/2	3 1/2	3-1/2
2	6	6	5-1/2	5	3-1/2	3	7	7	6-1/2	6	4	3-1/2
2-1/2	7	7	6-1/2	6	4	3-1/2	8	7-1/2	7-1/2	6-1/2	4 1/2	4
3	7	7	7	6	4	3-1/2	8	8	7-1/2	7	4 1/2	4
3-1/2	7-1/2	7-1/2	7	6-1/2	4	4	8-1/2	8-1/2	8	7-1/2	5	4-1/2
4	7-1/2	7-1/2	7	6-1/2	4-1/2	4	8-1/2	9	8-1/2	7-1/2	5	4-1/2
6	8-1/2	8	7-1/2	7	5	4-1/2	10	9-1/2	9	8	5 1/2	5
8	9-1/2	9	8-1/2	7-1/2	5-1/2	5	11	10-1/2	10	9	6	5-1/2
10	10-1/2	10	9-1/2	8	6	5-1/2	11-1/2	11	10-1/2	9-1/2	6 1/2	6
12	11-1/2	10-1/2	10	8-1/2	6-1/2	6	12-1/2	12	11-1/2	10-1/2	7 1/2	6-1/2
14	12	11	10	9	8	6	15	13-1/2	12-1/2	11	9 1/2	8
16	13	12	11	9-1/2	8-1/2	7	16	15	13-1/2	12	10	8-1/2

■ **NOTE** This chart based on continuous spans and for un-insulated line carrying fluids of specific gravity up to 1.00.

PVC PIPE SUPPORT SPACING (FT) AT °F (°C)

NOMINAL PIPE SIZE (in.)	SCHEDULE 40					
	20°F (-7°C)	60°F (16°C)	80°F (27°C)	100°F (38°C)	120°F (49°C)	140°F (60°C)
1/4	4.5	4.0	3.5	3.5	2.0	2.0
3/8	4.5	4.0	4.0	3.5	2.5	2.0
1/2	5.0	4.5	4.5	4.0	2.5	2.5
3/4	5.5	5.0	4.5	4.0	2.5	2.5
1	6.0	5.5	5.0	4.5	3.0	2.5
1 1/4	6.0	5.5	5.5	5.0	3.0	3.0
1 1/2	6.5	6.0	5.5	5.0	3.5	3.0
2	6.5	6.0	5.5	5.0	3.5	3.0
2 1/2	7.5	7.0	6.5	6.0	4.0	3.5
3	8.0	7.0	7.0	6.0	4.0	3.5
4	8.5	7.5	7.0	6.5	4.5	4.0
6	9.5	8.5	8.0	7.5	5.0	4.5
8	10.0	9.0	8.5	8.0	5.0	4.5
10	11.0	10.0	9.0	8.5	5.5	5.0
12	12.0	11.5	10.5	9.5	6.5	5.5
14	13.0	12.0	11.0	10.0	7.0	5.0
16	14.0	13.0	12.0	11.0	8.0	6.0

PVC PIPE SUPPORT SPACING (FT) AT °F (°C)

NOMINAL PIPE SIZE (in.)	SCHEDULE 80					
	20°F (-7°C)	60°F (16°C)	80°F (27°C)	100°F (38°C)	120°F (49°C)	140°F (60°C)
1/4	4.5	4.0	4.0	3.5	2.5	2.0
3/8	5.0	4.5	4.0	4.0	2.5	2.5
1/2	5.5	5.0	4.5	4.5	3.0	2.5
3/4	6.0	5.5	5.0	4.5	3.0	2.5
1	6.5	6.0	5.5	5.0	3.5	3.0
1 1/4	7.0	6.0	6.0	5.5	3.5	3.0
1 1/2	7.0	6.5	6.0	5.5	3.5	3.5
2	7.5	7.0	6.5	6.0	4.0	3.5
2 1/2	8.5	7.5	7.5	6.5	4.5	4.0
3	9.0	8.0	7.5	7.0	4.5	4.0
4	10.0	9.0	8.5	7.5	5.0	4.5
6	11.0	10.0	9.5	9.0	6.0	5.0
8	12.5	11.0	10.5	9.5	6.5	5.5
10	13.5	12.0	11.5	10.0	7.0	6.0
12	14.5	13.0	12.0	10.5	7.5	6.5

PVC PIPE SUPPORT SPACING (FT) AT °F (°C)

NOMINAL PIPE SIZE (in.)	SDR 13.5					
	20°F (-7°C)	60°F (16°C)	80°F (27°C)	100°F (38°C)	120°F (49°C)	140°F (60°C)
1/4	4.5	4.0	4.0	3.5	C	C
3/4	5.0	4.5	4.0	3.5	C	C
1	5.5	5.0	4.5	4.0	2.5	C
1 1/4	5.5	5.0	5.0	4.5	2.5	2.5
1 1/2	6.5	6.0	5.5	5.0	3.5	3.0
2	7.0	6.5	6.0	5.5	3.5	3.0
2 1/2	8.0	7.0	7.0	6.0	4.0	3.5
3	8.5	7.5	7.0	6.5	4.0	3.5
4	9.5	8.5	8.0	7.0	5.0	4.5

PVC PIPE SUPPORT SPACING (FT) AT °F (°C)

PIPE SIZE (in.)	SDR-26					
	20°F (-7°C)	60°F (16°C)	80°F (27°C)	100°F (38°C)	120°F (49°C)	140°F (60°C)
1	3.0	2.5	2.5	2.5	C	C
1 1/4	3.0	2.5	2.5	2.5	C	C
1 1/2	3.0	3.0	2.5	2.5	C	C
2	3.0	3.0	2.5	2.5	C	C
2 1/2	3.5	3.5	3.0	2.5	2.0	C
3	5.0	4.0	4.0	3.5	2.5	2.0
4	6.0	5.5	4.5	4.0	3.0	2.0
5	6.0	5.5	5.0	4.5	3.0	2.5
6	6.5	6.0	5.5	5.0	3.5	3.0
8	7.0	6.0	6.0	5.5	3.5	3.0
10	7.5	7.0	6.0	6.0	4.0	3.5
12	8.5	8.0	7.5	6.5	4.5	4.0
14	9.0	8.5	7.5	7.0	5.0	2.5
16	10.0	9.0	8.5	7.5	5.5	4.0
18	11.0	9.5	9.0	8.0	6.0	4.5
20	12.0	10.0	9.5	8.5	6.5	5.0
24	13.0	11.0	10.0	9.0	7.0	5.5

PVC PIPE SUPPORT SPACING (FT) AT °F (°C)

NOMINAL PIPE SIZE (in.)	SDR-21					
	20°F (-7°C)	60°F (16°C)	80°F (27°C)	100°F (38°C)	120°F (49°C)	140°F (60°C)
1/4	2.5	2.0	2.0	C	C	C
1	3.0	2.5	2.5	2.0	C	C
1 1/4	3.5	3.0	3.0	2.5	C	C
1 1/2	4.0	3.5	3.0	2.5	2.0	C
2	4.0	3.5	3.0	3.0	2.0	2.0
2 1/2	4.5	4.0	4.0	3.5	2.0	2.0
3	5.0	4.0	3.5	3.5	2.5	2.0
4	8.0	7.0	6.5	6.0	4.0	3.5
5	7.0	6.5	4.0	4.0	2.0	1.5
6	6.0	5.5	5.0	5.0	3.0	2.5
8	6.5	6.0	5.5	5.0	3.5	3.0
10	7.0	6.5	6.0	5.5	3.5	3.0
12	7.5	7.0	6.5	5.5	4.0	3.5

PVC PIPE SUPPORT SPACING (FT) AT °F (°C)

NOMINAL PIPE SIZE (in.)	SDR-41					
	20°F (-7°C)	60°F (16°C)	80°F (27°C)	100°F (38°C)	120°F (49°C)	140°F (60°C)
4	3.5	3.0	2.5	2.5	C	C
6	4.0	3.5	3.0	3.0	2.0	C
8	4.0	3.5	3.5	3.0	2.0	C
10	4.5	4.0	3.5	3.5	2.5	2.0
12	5.0	5.0	4.5	4.0	2.5	2.5
14	5.5	5.0	4.5	4.0	3.0	2.0
16	6.0	5.0	5.0	4.5	3.0	2.5
18	6.5	6.0	5.5	5.0	3.5	2.5
20	7.5	6.0	6.0	5.0	4.0	3.0
24	8.0	6.5	6.5	5.5	4.0	3.0



Installation

CPVC PIPE SUPPORT SPACING (FT) AT °F (°C)

NOMINAL PIPE SIZE (in.)	SCHEDULE 40						
	60°F (16°C)	100°F (38°C)	120°F (49°C)	140°F (60°C)	160°F (71°C)	180°F (82°C)	200°F (93°C)
1/4	4.5	4.0	3.5	3.5	2.0	2.0	C
3/8	4.5	4.0	4.0	3.5	2.5	2.0	C
1/2	5.0	4.5	4.5	4.0	2.5	2.5	C
3/4	5.5	5.0	4.5	4.0	2.5	2.5	C
1	6.0	5.5	5.0	4.5	3.0	2.5	C
1 1/4	6.0	5.5	5.5	5.0	3.0	3.0	1.5
1 1/2	6.5	6.0	5.5	5.0	3.5	3.0	1.5
2	6.5	6.0	5.5	5.0	3.5	3.0	1.5
2 1/2	7.5	7.0	6.5	6.0	4.0	3.5	1.5
3	8.0	7.0	7.0	6.0	4.0	3.5	2.0
4	8.5	7.5	7.0	6.5	4.5	4.0	2.0
5	9.5	8.5	8.0	7.5	5.0	4.5	2.0
6	9.5	8.5	8.0	7.5	5.0	4.5	2.0
8	10.0	9.0	8.5	8.0	5.0	4.5	2.0
10	10.5	9.5	9.0	8.5	5.5	5.0	2.0
12	11.0	10.0	9.5	9.0	6.0	5.5	2.5

CPVC PIPE SUPPORT SPACING (FT) AT °F (°C)

NOMINAL PIPE SIZE (in.)	SCHEDULE 80						
	60°F (16°C)	100°F (38°C)	120°F (49°C)	140°F (60°C)	160°F (71°C)	180°F (82°C)	200°F (93°C)
1/4	4.5	4.0	4.0	3.5	2.5	2.0	C
3/8	5.0	4.5	4.5	4.0	2.5	2.5	C
1/2	5.5	5.0	4.5	4.5	3.0	2.5	C
3/4	5.5	5.5	5.0	4.5	3.0	2.5	C
1	6.0	6.0	5.5	5.0	3.5	3.0	1.5
1 1/4	6.5	6.0	6.0	5.5	3.5	3.0	1.5
1 1/2	7.0	6.5	6.0	5.5	3.5	3.5	2.0
2	7.0	7.0	6.5	6.0	4.0	3.5	2.0
2 1/2	8.0	7.5	7.5	6.5	4.5	4.0	2.5
3	8.0	8.0	7.5	7.0	4.5	4.0	2.5
4	8.5	9.0	8.5	7.5	5.0	4.5	2.5
5	10.0	9.5	9.0	8.0	5.5	5.0	3.0
6	10.0	9.5	9.0	8.0	5.5	5.0	3.0
8	11.0	10.5	10.0	9.0	6.0	5.5	3.5
10	11.5	11.0	10.5	9.5	6.5	6.0	4.0
12	12.5	12.0	11.5	10.5	7.5	6.5	4.5



Spears® PVC clear Schedule 40 or Schedule 80 piping provides optimum clarity for critical visual monitoring of processes fluids. Joined using standard solvent cement welding with clear cement, clear systems provide the many benefits of regular PVC, such as excellent corrosion resistance, smooth interior walls, non-contaminating, non-conductive, light weight, good pressure handling capacity, superior impact strength and does not support bacterial growth.

A supplemental line of 1/4" through 12" Spears® PVC clear fittings are available. Socket-style fittings are manufactured in strict dimensional compliance with ASTM D 2466 to Schedule 40 requirements. Spears® Special Reinforced Plastic Thread (SR) female threaded transition fittings, incorporating a stainless steel retaining ring, reduce problems associated with over tightening and provide a strong, leak-tight seal for plastic-to-metal transitions. Specialty transition fittings are manufactured to Schedule 80 dimensions per the applicable requirements of ASTM D 2467. See Spears® Schedule 40 or Schedule 80 fitting weight and dimension publications for available sizes and configurations. Spears® PVC clear can be easily installed with systems of regular PVC pipe, fittings and valves. In addition, an endless selection of fully compatible PVC components and accessories are readily available.

Material

Spears® PVC clear piping is produced from a rigid, lead-free virgin Polyvinyl Chloride (PVC) compound with superior impact resistance and a maximum service temperature of 140°F when appropriate temperature/pressure de-rating factors are applied. Spears® PVC clear materials are certified by the NSF International for use with potable water under ANSI/NSF Standard 61 and acceptable for food contact under the provisions of Title 21 of the United States FDA Code of Federal Regulations. Spears® PVC clear piping also exhibits excellent flammability characteristics and will not sustain combustion when flame source is removed.

Spears® PVC clear provides the excellent chemical resistance properties of PVC piping. It is resistant to most acids, bases, salts and oxidants. PVC chemical resistance data should be referenced for proper application. Although this material maintains its physical properties when exposed to many substances, exposure to certain chemicals can affect the clarity of the product over time. Certain nitrogen containing organics, bleaches, oxidative agents and acids may result in discoloration. Testing under actual use conditions is recommended. Exposure to sunlight (Ultra Violet Radiation) will also affect clarity. Clear products do not contain UV stabilizers and are not recommended for outdoor use unless adequate protection is applied.

Clear PVC Pipe Physical Properties

GENERAL	Value	Test Method
Cell Classification	12454	ASTM D 1784
Maximum Service Temp.	140°F	
Color	Transparent	
Specific Gravity, (g/cu.cm @ 73°F)	1.33	ASTM D 792
Hardness, Shore D	84	ASTM D 2240
Hazen-Williams Factor	C = 150	
MECHANICAL		
Tensile Strength, psi @ 73°F	7,260	ASTM D 638
Tensile Modulus of Elasticity, psi @ 73°F	392,000	ASTM D 638
Flexural Strength, psi @ 75°F	12,000	ASTM D 790
Flexural Modulus, psi @ 75°F	389,000	ASTM D 790
Compressive Strength, psi @ 75°F	8,300	ASTM D 695
Compressive Modulus, psi @ 75°F	307,000	ASTM D 695
Notched Izod Impact - .125" Injection Molded	23 ft.-lbs./in.	ASTM D 256
Notched Izod Impact - .125" With Flow-Comp. Molded	8.0 ft.-lbs./in.	ASTM D 256
Notched Izod Impact - .125" Cross Flow-Comp. Molded	2.0 ft.-lbs./in	ASTM D 256
THERMAL		
Coefficient of Linear Expansion (in/in/°F)	4.1 x 10 ⁻⁵	ASTM D 696
Heat Distortion Temp., 264 psi, .125 in. Bars	154°F	ASTM D 648
Glass Transition Temp.	176°F	
FIRE PERFORMANCE		
Flammability Rating	V-0	UL-94



Special Pipe – Spears® PVC Clear

Schedule 40 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI
1/4	0.540	0.344	0.088	0.086	390
3/8	0.675	0.473	0.091	0.115	310
1/2	0.840	0.602	0.109	0.170	300
3/4	1.050	0.804	0.113	0.226	240
1	1.315	1.029	0.133	0.333	220
1-1/4	1.660	1.360	0.140	0.450	180
1-1/2	1.900	1.590	0.145	0.537	170
2	2.375	2.047	0.154	0.720	140
2-1/2	2.875	2.445	0.203	1.136	150
3	3.500	3.042	0.216	1.488	130
3-1/2	4.000	3.521	0.226	1.789	120
4	4.500	3.998	0.237	2.118	110
6	6.625	6.031	0.280	3.73	90
6-1/2	6.625	6.335	0.110	1.64	45
8	8.625	7.942	0.322	5.619	80
10	10.750	9.976	0.365	7.532	70

Schedule 80 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI
1/4	0.540	0.282	0.119	0.105	570
3/8	0.675	0.403	0.126	0.146	460
1/2	0.840	0.526	0.147	0.213	420
3/4	1.050	0.722	0.154	0.289	340
1	1.315	0.936	0.179	0.424	320
1-1/4	1.660	1.255	0.191	0.586	260
1-1/2	1.900	1.476	0.200	0.711	240
2	2.375	1.913	0.218	0.984	200
3	3.500	2.864	0.300	2.010	190
4	4.500	3.786	0.337	2.938	160
6	6.625	5.709	0.432	5.610	140

De-Rating Factor

Operating Temp (°F)	De-Rating Factor
73	1.00
80	0.88
90	0.75
100	0.62
110	0.51
120	0.40
130	0.31
140	0.22

EX: 4" PVC SCHEDULE 40
CLEAR @ 120°F = ?
110 psi x 0.40 = 44 psi max.
@ 120°F

Critical Collapse Pressure PSI @ 73°F

Pipe Size (in.)	SCH 40	SCH 80
1/4	7,504	22,172
3/8	3,714	11,869
1/2	3,255	9,370
3/4	1,722	4,985
1	1,399	3,841
1-1/4	767	2,158
1-1/2	554	1,599
2	327	1,014
2-1/2	431	1,176
3	279	809
3-1/2	211	632
4	169	521
6	84	333
8	57	-
10	43	-

THE MAXIMUM SERVICE TEMPERATURE FOR PVC CLEAR IS 140°F.

Threading of Schedule 40 PVC Clear pipe is not a recommended practice due to insufficient wall thickness.

Joining Methods

Spears® PVC Clear pipe is easily joined by standard solvent cementing process, threaded connections and flanges. To maintain system clarity, Spears® recommends the use of a clear, medium-bodied, fast-setting cement in conjunction with a clear primer for optimum joint integrity. See Installation section for industrial pressure pipe for guidelines.

Thermal Expansion and Contraction

Standard calculations for thermal expansion and contraction may be applied to Spears® PVC clear. The coefficient of linear expansion for Spears® Clear pipe is 4.1×10^{-5} in./in./°F. The rate of expansion or contraction can be calculated as follows:

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

Where:

ΔL = expansion or contraction in inches

$y = 4.1 \times 10^{-5}$ (coefficient of linear expansion)

L = length of piping run in feet

T = temperature change °F ($T_{\text{max.}} - T_{\text{@ installation}}$)

Hangers and Supports

Spears® PVC clear piping should be mounted and supported in the same manner as PVC industrial piping. Support location and spacing are based on the pipe diameter, operating temperature of the system, and the location of any concentrated stress loads (i.e., valves, flanges, and any other heavy system components). As with regular PVC piping, hangers used must have an adequate load-bearing surface free of any rough or sharp edges that could damage the piping during use. They must also not restrict linear movement of the system due to the effects of expansion and contraction; over tightening must be avoided. See Hangers and Supports section for industrial pressure pipe for additional information.



Developed for Ultra-pure Water

Spears® Low Extractable piping is produced from a non-contaminating PVC material specially developed for ultra-pure water (UPW) systems in semiconductor, electronics, university research laboratories, hospital dialysis, industrial laboratories, Federal and state police forensic laboratories and biotechnology applications. Spears® Low Extractable PVC material has been subjected to independent laboratory leach studies during both static and dynamic exposure to 18.2 meg-ohm deionized water. Tests have shown relatively low TOC, Anion/Cation and trace metal contamination levels in comparison to conventional high purity piping system materials including PVDF and Natural Polypropylenes

Spears® Low Extractable Piping Systems offer unique advantages for many ultra-pure water applications:

- Complete line of pipe, fittings and valves IPS Sizes 1/2" – 6" diameters
- Strong Schedule 80 dimensions for pressure service
- Advanced Spears® Low Extractable material significantly reduces leachable contamination compared to conventional PVC and other piping materials.
- Exceptionally smooth interior walls minimize particle generation and reduce potential for bacterial growth.
- Fast, reliable installation with simple, inexpensive joining methods
- Proprietary one-step fast-setting joining method reduces TOC contamination and rinses up quickly
- Unique blue translucency enables visual inspection of joint integrity
- Good chemical/corrosion resistance, high-impact strength, low thermal conductivity
- Bagged, sealed and boxed on-line for use in high-purity environments
- High Quality
- Low Maintenance
- Cost Effective

Material

Spears® Low Extractable piping is produced from an innovative PVC compound that has been specifically formulated to reduce leachable contamination when exposed to ultra-pure water environments. Minor ingredients necessary for processing have been scrupulously selected to address their potential for contamination, and are then carefully blended in precise ratios. This results in a much cleaner material than conventional PVC compounds, and compares favorably to alternate materials typically used for UPW piping applications. This has been validated with extensive static and dynamic leach studies during exposure to 18.2 megohm ultra-pure water conducted by a reputable third party.

Spears® Low Extractable material meets the toxicological requirements of NSF International Standard 61 as being safe for use in potable water applications, and also complies with the provisions of Title 21 of the United States FDA Code of Federal Regulations as being safe for use in food contact applications.

Physical Properties

Although the extractable contaminants of Spears® Low Extractable are much lower than common PVC piping, Spears® Low Extractable has physical properties very similar to those of conventional PVC piping. As a result, Spears® Low Extractable products exhibit the well-known physical characteristics and other benefits of conventional PVC piping, such as good chemical and corrosion resistance, low thermal conductivity, high strength-to-weight ratio, good impact resistance, and ease of installation.

Physical Properties	Value	Test Method
Cell Classification	12343	ASTM D 1784
Specific Gravity	1.327	ASTM D 792
	(g/cu.Cm @ 73°F)	
Tensile Strength, @ yield	6720 psi	ASTM D 638
Tensile Modulus of Elasticity	384,200 psi	ASTM D 638
Flexural Strength, @ yield	11,440 psi	ASTM D 790
Flexural Modulus of Elasticity	378,000 psi	ASTM D 790
Izod Impact (avg 2 complete breaks) (avg 3 partial & 2 complete breaks)	1.3 ft-lbs /inch 10.9 ft-lbs /inch	ASTM D 256
Coefficient of Linear Expansion	3.89×10^{-5} in/in°F	ASTM D 696
Compressive Strength	8732 psi	ASTM D 695
Heat Distortion Temperature	152°F	ASTM D 648
Hardness, Shore D	82.2 ± 3	ASTM D 2240
Maximum Temperature Use	140°F	



Special Pipe – Spears® Low Extractable PVC

Design and Dimensions

Spears® Low Extractable piping is produced to Schedule 80 dimensions in strict accordance with ASTM D 1785, and exhibits a Type II pressure rating. Spears® Low Extractable fittings are produced to Schedule 80 dimensions per ASTM D 2467. Joining of product produced to the dimensional requirements of these standards ensures that strong connections with good pressure-bearing capability can be made up quickly and consistently using common, inexpensive tools. See Spears® Low Extractable fitting weight & dimension and price list publication for fitting information and selection.

SCHEDULE 80

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P.
1/2	0.840	0.526	0.147	0.213	420
3/4	1.050	0.722	0.154	0.289	340
1	1.315	0.936	0.179	0.424	320
1-1/4	1.660	1.255	0.191	0.586	260
1-1/2	1.900	1.476	0.200	0.711	240
2	2.375	1.913	0.218	0.984	200
3	3.500	2.864	0.300	2.010	190
4	4.500	3.786	0.337	2.938	160
6	6.625	5.709	0.432	5.610	140

The pressure ratings given are for water, non-shock, @ 73°F. The following temperature de-rating factors are to be applied to the working pressure ratings (WP) listed when operating at elevated temperatures.

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

De-Rating Factors

Operating Temp (°F)	De-Rating Factor
73	1.00
80	0.88
90	0.75
100	0.62
110	0.51
120	0.40
130	0.31
140	0.22

Processing & Packaging

Correct processing techniques ensure proper dispersion and fusion of the compound, resulting in uniform properties of this special materials. Optimizing processing conditions and providing smooth internal surfaces greatly reduce the potential for extractable and particle contaminants.

Spears® Low Extractable pipe and fittings are specially handled to minimize contamination, sealed in anti-static polybags and boxed on-line at time of manufacture.

Solvent Cement Joining

The Spears® Low Extractable system is primarily joined with standard solvent cementing using a special one-step solvent-cement specifically formulated for use with this product in UPW application. When properly used, this system results in very short cure times prior to pressure testing, and produces a solvent-cemented assembly with an exceptionally low percentage of chemical additives, reducing the potential for system contamination. The use of solvent cements and/or primers other than Low Extractable One-Step is not acceptable. Installers must become familiar with solvent cementing procedures prior to assembly. See Installation section for basic guidelines to solvent cement welding. All solvent cemented connections must be allowed to set and cure properly prior to pressure testing or rinsing.

Low Extractable UPW Solvent Cement Set and Cure Times

Set and cure times are a function of pipe size, temperature, pressure, humidity and tightness of fit. The initial set time is the recommended waiting period prior to handling a newly assembled joint. After the initial set time, the joints will withstand the stresses of normal installation. The cure time is the recommended waiting period prior to pressurizing newly assembled joints. Minimum cure time prior to pressure testing is dependent on pipe size, temperature, humidity, tightness of fit and test pressure required. Longer cure times must be allowed when working at higher humidity and colder temperatures. Refer to the following tables for minimum set and cure times.

Initial Set Time

Temp	Pipe Size 1/2" – 1-1/4"	Pipe Size 1-1/2" – 2"	Pipe Size 3" – 6"
60° - 100°F	2 min	3 min	30 min
40° - 60°F	5 min	8 min	2 hrs
0° - 40°F	10 min	15 min	12 hrs

Joint Cure Schedule

Relative Humidity 60% or less*	Pipe Size 1/2" – 1-1/4"		Pipe Size 1-1/2" – 2"		Pipe Size 3" – 6"
Temp Range during assembly and cure periods	up to 160 psi	160 to 370 psi	up to 160 psi	160 to 315 psi	up to 160 psi
60° - 100°F	15 min	6 hrs	25 min	12 hrs	1-1/2 hrs
40° - 60°F	20 min	12 hrs	30 min	24 hrs	4 hrs
0° - 40°F	30 min	48 hrs	45 min	96 hrs	72 hrs

If damp or humid weather allow 50 percent longer cure times.

Additional Joining Methods

Additional joining devices include flanges, unions, and threaded adapters produced from this special material. See Installation section for basic guidelines to flange and threaded joint make up. UPW applications typically require use of PTFE envelope gaskets for flanges and TFE tap sealant on threaded joints.



Hangers and Supports

As with standard PVC piping, support location and spacing is dependent on the pipe diameter, operating temperature of the system, and the location of any concentrated stress loads (i.e., valves, flanges, test equipment and any other heavy system components). Hangers used must have an adequate load-bearing surface free of any rough or sharp edges that could damage the pipe during use, must not restrict linear movement due to thermal expansion and contraction. See Installation section specified spacing and guideline applicable to Schedule 80 PVC pipe.

Thermal Expansion and Contraction

As with all thermoplastic piping materials, consideration must be given during the design of the system to the effects of thermal expansion and contraction. The coefficient of linear expansion for Spears® Low Extractable pipe is 3.89×10^{-5} in./in./°F. The rate of expansion or contraction can be calculated as follows:

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

Where:

ΔL = amount of expansion or contraction in inches $y = 3.89 \times 10^{-5}$

L = length of piping run in feet

ΔT = temperature change °F

($T_{max} - T$ @ time of installation or lowest system temperature or maximum system temperature, whichever is greater.)

Additional Considerations

Proper system engineering, design, construction practices and operation are the responsibility of the design authority. Consideration must be given to ensure the Spears® Low Extractable system is not exposed to any conditions that will exceed the product limitations regarding temperature, pressure, chemical compatibility, and mechanical strength.

Spears® does not recommend the use of this product for the distribution of compressed air or gases.

Excessive surge pressure must be avoided. The system must be designed to ensure that surge potentials generated by pump operation, entrapped air, flow velocity, and valve closure are kept to a minimum. Spears® does not recommend flow velocities in excess of five feet per second.

Spears® Low Extractable piping systems are not formulated for outdoor use. Prolonged exposure to ultraviolet radiation (UVR) will affect physical properties.

Spears® recommends that newly installed systems be allowed to cure for a minimum period of 24 hours prior to rinsing procedures to reduce the potential for TOC contamination. Rinsing procedures, chemical rinse and other cleanup/disinfection procedures to be used are at the discretion of the system design authority.

Spears® Low Extractable piping is compatible with hydrogen peroxide at concentrations up to 30% at 73°F. Contact Spears® for additional chemical compatibility information concerning the use of Spears® Low Extractable products.

Application Qualification Testing

Static Leach Analysis

Detailed extractable analysis is conducted on piping samples after seven-day static leach utilizing 18.2 megohm ultra-pure water at ambient temperature. Static leach of large pipe samples (120-square-inch wet surface area) is representative of a piping system “off-line” for an extended period of time. Under these conditions the effects of UPW can be extremely aggressive, severely affecting the amount of leachable contaminants present within the piping material.

Pipe Material

Element	DL (Detection Limit) ppb	Spears® Low Extractable	High Purity PVDF	High Purity PP	Brand X Clean PVC	Conv. PVC	CPVC
TO C	5	59	90	94	1176	*	50
Fluoride	2	*	77	*	*	*	*
Chloride	0.25	2.33	1.0	0.66	2.45	0.84	49.54
Aluminum	0.05	0.30	2.3	0.68	0.54	3.10	1.16
Barium	0.01	0.04	0.24	0.09	0.01	0.22	0.05
Calcium	3	7	*	12	206	2787	15
Magnesium	0.02	0.81	0.66	1.0	2.15	11.15	2.17
Sodium	0.06	0.83	0.51	0.18	0.49	1.23	23.22
Tin	0.02	0.93	*	*	0.15	0.51	1.19
Zinc	0.06	0.49	0.47	0.96	*	0.51	1.19

* = Below Detection Limit

- All samples pre-rinsed identically with UPW prior to test.
- Independent Laboratory Extractable Analysis (Balazs Analytical Laboratory)
- Seven-Day Static Leach @ ambient temperature
- 450mL 18.2 megohm ultra-pure water
- 120-square-inch wet surface contact area
- Based on 1" diameter pipe without solvent-cemented joint
- Concentration units expressed as ug/L of Leachate (ppb)



Special Pipe – Spears® Low Extractable PVC

Dynamic Leach Analysis

Spears® Low Extractable piping has been subjected to on-line dynamic flow analysis with 18.2 megohm UPW to evaluate particles, TOC, resistivity, anions, cations, and trace metals. This testing utilized solvent-cemented flange assemblies (spool piece) to see the effect that the cement had on TOC, resistivity and particle generation in a freshly assembled pipe section. Grab samples were also pulled periodically (at start-up, five minutes, 50 minutes and five hours) to analyze anions, cations and trace metals under flowing conditions. Spears® Low Extractable Flanges were assembled utilizing Low Extractable One-Step Cement and allowed to cure 24 hours prior to testing. Dynamic testing revealed that Spears® Low Extractable piping assemblies did not contribute significantly to particle generation or leachable contamination under flowing conditions throughout the test duration. Additional detailed information is available from Spears®.

Dynamic Test Description

Ambient temperature dynamic leach utilizing 18.2 megohm UPW flowing at 9.35 GPM (turbulent flow). 1" diameter pipe 30" long, solvent-cemented flanges each end (approximately 82-square-inch wet surface contact area). Approximately 1-1/2 grams of Low Extractable solvent cement used in assembly of components. Solvent-cemented assembly was allowed to cure 24 hours prior to start-up. Dynamic test was conducted for a period of five hours.

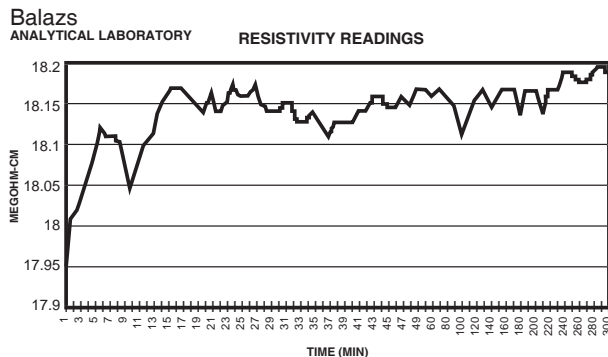
Leachable Contamination

Anions/Cations – IC grab sample analysis revealed low levels of sulfate (0.15 ppb) five minutes into the test, and low levels of ammonium at 50 minutes (0.05 ppb) and five hours (0.07 ppb) into the test. All other IC contaminants were below the limit of detection.

Trace Metals – Of the 68 trace metal contaminants evaluated, all were below the limit of detection with the exception of aluminum, detected at 0.012 ppb at the five-minute interval. This element remained below the limit of detection throughout the remainder of the leach.

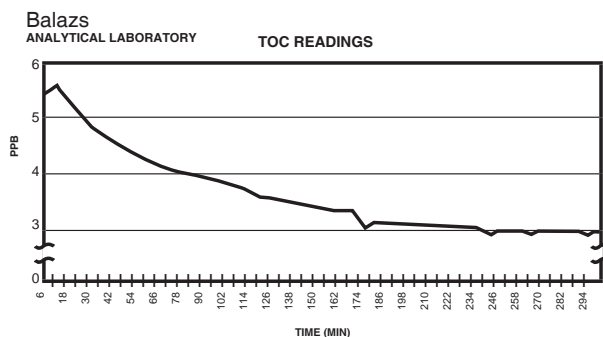
Resistivity

Resistivity measured 17.95 megohms at the start of the leach and rose quickly to 18.12 megohms during the first 6 minutes. Resistivity readings continued to rise until reaching the background level of 18.2 megohms after five hours of leaching.



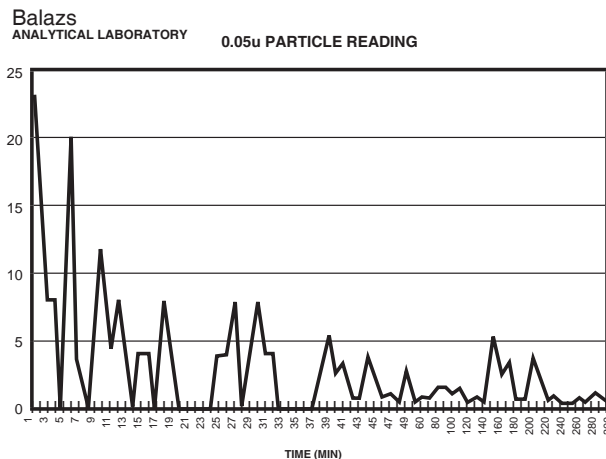
Total Oxidizable Carbon (TOC)

Dynamic testing revealed that after four hours of leaching, TOC readings reached and maintained the background levels throughout the test duration. This data confirmed the fast cure time of Low Extractable One-Step Cement. Conventional solvent cements and primers used for joining typically effect TOC contamination as a result of the leach.



Particles

Dynamic testing revealed that average particle counts decreased rapidly during the first six minutes of the leach. After 12 minutes of leaching the average smallest particles measured (0.05 micron size range) were representative of the background levels.



Surface Analysis

Spears® Low Extractable piping has a non-porous, exceptionally smooth interior surface that greatly reduces the potential for extractable and particle contamination while impeding bacterial growth. Spears® Low Extractable components (pipe and fittings) exhibit an average Roughness Analysis value of: $\leq .25 \mu\text{m}$ ($\leq 10 \mu\text{inch}$) and has been evaluated side-by-side with other common piping materials at various magnifications for surface roughness comparison.



Patented

Spears® LabWaste™ CPVC Drainage System is a Complete system of pipe, fittings & solvent cement featuring excellent chemical resistance, fire performance properties, light weight and ease of installation. Designed and specifically tested for use in commercial, industrial, and institutional drainage system applications involving corrosive /acid wastes, this unique product developed by Spears® has been awarded a U.S. Patent, No. 7,178,557. Available in nominal 1-1/2" through 24" Iron Pipe Size (IPS) diameters..

IMPORTANT – The information in this section is introductory only. Please refer to Spears® publication, **LabWaste™ CPVC Technical Information & Installation Guide**, for additional details and technical information.

Laboratory Applications

Its broad range of resistance to chemical and corrosive wastes make Spears® **LabWaste™** CPVC systems very well suited for commercial, institutional and academic laboratory drainage installations. These applications are best characterized as the routine disposal of a wide variety of hot and cold chemicals in relatively small quantities accompanied by water for the purpose of dilution and flushing. Due to the interactions potentially encountered in multi-chemical laboratory drainage disposal, Spears® recommends routine flushing of the system with water during disposal as a part of prudent laboratory practices. A properly designed and installed **LabWaste™** CPVC system provides total dilution and disposal need for years of dependable service.

Industrial & Commercial Special Waste Applications

Spears® **LabWaste™** CPVC products can be used in a very broad variety of dedicated waste applications with proper evaluation of waste medium and service conditions. For non-laboratory applications, refer to CPVC pressure system resistance data in this manual for appropriate chemical resistance guidelines. DO NOT follow **LabWaste™** Chemical Resistance Table recommendations for laboratory use in Spears® technical information guide. Please contact Spears® Technical Services for additional information.

Listings & Approvals

Spears® **LabWaste™** CPVC Drainage System is manufactured in strict compliance to ASTM F 2618, is listed by IC-ES-PMG for conformance to both the Uniform Plumbing Code and the International Plumbing for chemical waste systems under PMG-1018, and is certified by NSF International both to IAPMO IGC 210 and for use in corrosive waste systems (NSF®-cw).

Fire Resistance

Material used in Spears® **LabWaste™** CPVC systems has a UL 94 flammability rating of V-0, 5VB. Pipe and fittings have been Listed and rated based on *finished product* tests, as opposed to a material test only, for surface burning characteristics of flame spread and smoke density developed by Underwriters Laboratories of Canada under standard test method CAN/ULC S102.2-M88. Additional test of **LabWaste™** pipe with dry fit caps was conducted by Southwest Research Institute (SwRI) Department of Fire Technology under UL 723/ASTM E 84 (modified to test finished product). Pipe and fitting components ratings are below the 25 maximum flame spread and 50 maximum smoke density developed typically required for exposed air plenum installation. Check local codes for acceptability. Use of approved plenum wrap or transition connectors to other material may be used if required.

Pipe Dimensions

Spears® **LabWaste™** CPVC Drainage System products produced to ASTM F 2618 have the same dimensional specifications for pipe as for Schedule 40 CPVC through 24" nominal IPS diameters. See corresponding pipe dimensions section in this manual.

Fittings Configurations

Spears® a wide variety of LabWaste™ CPVC drainage pattern fittings produced to ASTM F 2618. See Spears® publication, **LabWaste™ CPVC Technical Information & Installation Guide** for fitting details.

Joining Methods

Solvent Cement Welding

Spears® **LabWaste™** CPVC Drainage System piping is joined using a special one-step solvent cement specifically listed and approved for use in CPVC corrosive waste applications. Follow basic solvent cementing guideline under the Installation section using only LabWaste™ CPVC one-step solvent cement.

Transitions & Other Connections

Standard threaded and flanged connections can be made using **LabWaste™** system components. A variety of special connectors are produced for transition to polypropylene, Duriron and glass systems waste piping systems.

Please refer to Spears® publication, **LabWaste™ CPVC Technical Information & Installation Guide**, for Physical Properties, Engineering Data, and **LabWaste™** Chemical Resistance Guide for laboratory applications. DO NOT use Chemical Resistance Guide for Pressure Piping contained in this manual.



Special Pipe – Spears® FlameGuard® CPVC Fire Sprinkler Piping Systems

Spears® FlameGuard® CPVC Fire Sprinkler Products are manufactured from high quality, Post-Chlorinated Poly Vinyl Chloride (CPVC), a specialty thermoplastic material tested and approved by certifying agencies for use in CPVC fire sprinkler systems. Spears® FlameGuard® CPVC Fire Sprinkler Products provide unique advantages over traditional metal fire sprinkler systems through superior hydraulics, ease of installation and handling.

IMPORTANT – The information in this section is introductory only. **Spears® publication FG-3, FlameGuard® CPVC Fire Sprinkler Products, must be used and followed.** National Fire Protection Association (NFPA) Standards 13, 13R, and 13D must be referenced for design and installation requirements in conjunction with the FG-3 manual and all local codes. Details of product listings, requirements and limitations are beyond the scope of this publication.

Listings & Approvals

Spears® FlameGuard® CPVC Fire Sprinkler Products are fully tested and approved for use in wet pipe fire sprinkler systems by Underwriters Laboratories Inc., FM Global, and the Loss Prevention Certification Board. Spears® FlameGuard® CPVC Fire Sprinkler Products are approved for use in low pressure dry pipe or pre-action systems by Underwriters Laboratories Inc. and for use in Light Hazard Occupancies (NFPA 13), and Residential Occupancies (NFPA 13R & 13D). The Listing also includes use in Return Air Plenums (NFPA 90A), use in Underground Service Mains (NFPA 24), and use in exposed systems with certain restrictions when installed in accordance with Spears® FG-3 installation instructions. Spears® FlameGuard® CPVC Fire Sprinkler Products are listed by NSF International for use in potable water systems.

Product Ratings

Spears® FlameGuard® CPVC fire sprinkler pipe is produced to SDR 13.5 dimensions in strict accordance with ASTM F 442 and Listed for a rated working pressure of 175 psi @150°

Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.
3/4	1.050	0.874	0.078	0.168
1	1.315	1.101	0.097	0.262
1-1/4	1.660	1.394	0.123	0.418
1-1/2	1.900	1.598	0.141	0.548
2	2.375	2.003	0.176	0.859
2-1/2	2.875	2.423	0.213	1.257
3	3.500	2.950	0.259	1.867

Joining Method

Spears® FlameGuard® CPVC piping is joined using a special one-step solvent cement specifically listed and approved for use in CPVC fire sprinkler systems. See Spears® FG-3 installation instructions for use, applicable set and cure times and additional information.



Hot & Cold Water Distribution Systems

Spears® EverTUFF® Copper Tube Size (CTS) CPVC is a complete hot and cold water plumbing system consisting of pipe, fittings and solvent cement for plumbing applications. Spears® EverTUFF® CTS CPVC pipe is easily joined using solvent cement welding, is light weight, thermally efficient and code approved to provide cost-effective long-term system service.

Product Standards

Spears® EverTUFF® CTS pipe and fittings are manufactured in strict compliance to ASTM D 2846, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot and Cold-Water Distribution Systems. This standard defines requirements for materials, workmanship, dimensions, tolerances, pressure-bearing capability, and thermocycling resistance. Spears® EverTUFF® CTS SDR 11 plumbing pipe and fittings are manufactured to specifications in accordance with this standard. SDR series pipe is based on an outside-diameter-to-wall- thickness ratio. This is a constant regardless of pipe diameter, therefore all sizes of pipe carry the same pressure rating of 100 psi @ 180°F and is suitable for use with commercial hot water.

Performance Testing

Spears® EverTUFF® CTS CPVC pipe is tested and independently certified by NSF International to the requirements of ASTM D 2846 under NSF Standard 14 and for use in potable (drinking) water service under NSF Standard 61.

Code Approvals

Major building codes have approved the use of CPVC piping as an acceptable material for plumbing systems, provided that the piping conforms to applicable industry standards and has been listed by a third party for conformance to NSF Standard 14 and/or NSF Standard 61 requirements. Code bodies that accept the use of CPVC include BOCA National Plumbing Code, National Standard Plumbing Code, SBCCI Standard Plumbing Code, International Plumbing Code, and the Uniform Plumbing Code to name a few. The user should determine approval and installation requirements according to local code having jurisdiction prior to use.

Dimensions

CPVC CTS Series pipe shall be manufactured in strict accordance to the requirements of ASTM D 2846 to SDR 11 dimensions and tolerances. Each production run of pipe manufactured in compliance to this standard, shall also meet or exceed the test requirements for materials, workmanship, burst pressure, flattening resistance, and extrusion quality and dimensions as defined in ASTM D 2846. This pipe shall be produced in CTS diameters (1/2" through 2" sizes) to SDR 11 specifications.

Nominal Pipe Size (in.)	Average O.D.	O.D. TOL	Average I.D.	Min. Wall	Rating @ Wt./ft.	PSI Pressure Rating @	
						73°F	180°F
1/2	0.625	±.003	0.469	0.068	0.090	400	100
3/4	0.875	±.003	0.695	0.080	0.149	400	100
1	1.125	±.003	0.901	0.102	0.240	400	100
1-1/4	1.375	±.003	1.105	0.125	0.353	400	100
1-1/2	1.625	±.004	1.309	0.148	0.489	400	100
2	2.125	±.004	1.716	0.193	0.829	400	100

PIPE SIZES SHOWN ARE MANUFACTURED IN STRICT COMPLIANCE WITH
ASTM D 2846 ASTM STANDARD D 1784 MATERIAL EQUIVALENTS:
Cell Classification 23447 = PVC Type IV Grade I CPVC = CPVC 4120

Pressure Ratings

The Spears® CPVC system, including the joint, has a continuous rated working pressure of 100 psi at 180°F or 400 psi at 73°F. CPVC systems have the capability to withstand short term temperature/pressure increases above 100 psi at 180°F, as evidenced by their ability to consistently surpass the 48-hour, 150-psi Uniform Building Code test at 210°F. CPVC pipe should not be used where temperatures will consistently exceed 180°F.

Pressure-Temperature De-Rating Factors For CTS CPVC 4120 SDR 11 Piping Systems

°F	Factor	Rating, PSI
73	1.00	400
80	1.00	400
90	0.91	360
100	0.82	325
120	0.65	260
140	0.50	200
160	0.40	160
180	0.25	100

The pressure de-rating factor is the same for all pipe sizes. Example: Determine the maximum allowable operating pressure for a CTS CPVC piping system with an operating temperature of 140°F. Using de-rating factor of 0.50 for 140° from the above chart, the maximum allowable operating pressure = 400 x 0.50 = 200 psi.



Installation

Installation shall be in accordance with the requirements of the local code having jurisdiction, the solvent cement manufacturer recommendations, and Spears® publication CTS-3, CPVC CTS Products Design and Installation Manual.

Joining Methods

Spears® EverTUFF® CTS CPVC pipe is easily joined by standard solvent cementing process, threaded connections and flanges Solvent Cement Welding.

Solvent Cement Welding

This is the most common joining method used with CTS CPVC See Installation section for industrial pressure pipe for basic solvent cementing guidelines.

CTS Solvent Cement Selection

Codes require use of solvent cement conforming ASTM F 493 and designated specifically for use with CTS CPVC products in accordance with ASTM D 2846. Spears® EverTUFF® CTS-5 CTS CPVC “One-step” (primerless) cements may be used without primer if codes permit, or may be used with a primer where required by code - always CHECK LOCAL CODES.

Set and Cure Times

Pipe and fitting joint assembly must be allowed to set without any stress on the joint for one to five minutes depending on the pipe size and temperature. Following the initial set period, the assembly can be handled carefully.

FOLLOW THE CEMENT MANUFACTURER’S RECOMMENDED CURE TIMES PRIOR TO PRESSURE TESTING – FAILURE TO DO SO WILL RESULT IN JOINT FAILURE.

Minimum Cure Time Prior to Testing at 150 psi with Cold Water (based on use of one-step CPVC cement or two-step cement systems)

Pipe Size (in.)	Ambient Temperature During Cure Tim		
	>60°F	40°F - 60°F	<40°F
3/8	1 hr	2 hrs	4 hrs
1/2	1 hr	2 hrs	4 hrs
3/4	1 hr	2 hrs	4 hrs
1	1 hr	2 hrs	4 hrs
1-1/4	2 hrs	4 hrs	8 hrs
1-1/2	2 hrs	4 hrs	8 hrs
2	2 hrs	4 hrs	8 hrs

NOTE Wait 24 hours prior to putting system into hot water service when installed at cure temperatures above 60°F; wait 48 hours prior to putting system into hot water service when installed at cure temperatures below 40°F Solvent Cement Joining

Wall Penetration

Building codes require that a fire-rated wall or floor must be sealed back to its original integrity when penetrated. Several sealants and materials are suitable for use with Spears® EverTUFF® CTS CPVC pipe to construct an appropriate UL Classified fire-rated penetration system. (When installed properly, these systems will provide a two-hour fire rating. Consult local building code requirements.

NOTE Caution: Certain fire-stopping sealants and components contain stress cracking agents and other chemicals which may cause damage to CPVC piping; contact the appropriate manufacturer for compatibility with CPVC prior to use.

NOTE When installing CPVC in areas where the system must be drained to protect it from freezing, the lines must be sloped to drain.

Underslab Installations

Spears® EverTUFF® CTS CPVC products are approved for underslab installations (with joints) in all model-plumbing codes. When performing underslab installations, it is important to support the tube evenly on a smooth surface. The bedding and backfill should be sand or clean soil that is free from sharp rocks and other debris that could damage the pipe.

Underslab installations that contain joints must be pressure tested before pouring the slab. **NOTE:** IAPMO IS 2098, “Installation Standard for CPVC Solvent Cemented Hot and Cold Water Distribution Systems,” requires a test at 150 psi for 2 hours. The pipe should be sleeved where it penetrates the slab, along with construction joints within the slab. Spears® EverTUFF® CTS pipe is also manufactured in coils for underslab installations to eliminate joints. When turning coiled pipe up through a slab, into walls, etc., make sure the pipe does not kink. Sections of pipe that contain kinks must be cut out and replaced.

Freeze Protection/Sunlight Exposure

CPVC piping must be protected from freezing in all installation locations. Attention shall be paid to local insulating techniques and codes that require a particular method. Use only methods and materials suitable for use with CPVC piping. Where freezing is not an issue, CPVC shall not be installed so as to be subject to direct sunlight after installation and not installed on the surface of a building, unless protected by a covering or a chemically compatible paint, such as water based Latex.

Hose Bibb Installation

Hose bibbs are to be connected only to metal system components which are adequately anchored to the building structure. CPVC plastic systems must terminate in the wall.



Water Heater Connections

Before attempting to use Spears® EverTUFF® CTS CPVC in water heater connections, determine if local plumbing codes contain detailed requirements for connections to gas or electric storage-type heaters.

DO NOT use Spears® EverTUFF® CTS CPVC products with commercial-type, non-storage water heaters.

For areas where local plumbing codes do not have requirements, the following information can be used as a guide for water heater connections:

- On electric water heaters, CPVC can be joined directly to the heater, using metal-to-CPVC transition fittings.
- On high-efficiency gas water heaters that use plastic vent piping, CPVC can be joined directly to the heater in the same way as an electric water-heater connection.
- On all other gas water heaters, there should be at least 6" of clearance between the exhaust flue and any CPVC tubing. A minimum of 6" metallic pipe should connect directly to the heater so that the CPVC tubing cannot be damaged by the buildup of excessive, radiant heat from the flue.
- A temperature/pressure relief valve should be installed so that the sensing element contacts the water at the top of the heater.
- Spears® EverTUFF® CTS CPVC products are approved by all model codes for use as relief-valve drain lines. A metal-to-CPVC transition fitting should be used to connect the tubing to the relief valve, with the tubing continued to the outlet. Both horizontal and vertical pressure relief drain should be supported every 3 feet. For horizontal runs, slope the tubing toward the outlet. Pipe must discharge to the atmosphere at an approved location.
- Instantaneous water heaters (i.e., under sink units) require at least 6" of metallic pipe connected to heater inlet and no CPVC installed down stream.

TRANSITION JOINTS AND FITTINGS

Spears® EverTUFF® CTS CPVC pipe can be connected to copper, brass, valves, and other materials using a variety of transition fittings including unions, compression fittings, specially reinforced male and female adapters, flanged joints, grooved joints and other readily available transition fittings.

Do not thread CPVC pipe and do not use regular CPVC female threaded fittings. Regular CPVC male threaded fittings shall only be used on cold water applications. Special reinforced male adapters, female adapters and other fittings with brass threads are recommended for hot water applications and threaded transitions to metal pipe. All approved threaded CPVC joints must be accessible. (See also Water Heater Connections section for additional installation details).

Standard compression fittings with brass ferrules can be used; however, TFE tape must be applied over the brass ferrule to compensate for the dissimilar thermal expansion rates

between the brass and CPVC. Caution must be exercised to prevent over tightening of compression fittings. Use extreme care when soldering any metal system to prevent flame contact with or heat distortion in CPVC pipe and fittings .

Assembling Threaded Connections

Threaded connections require the application of a thread sealant that is compatible with CPVC material. Spears® recommends the use of Spears® Blue 75 Thread Sealant. Apply sealant to the male threads only. Make sure all threads are covered. DO NOT clog the waterway with excess sealant. If TFE tape is used, Spears® recommends a thickness of at least .0025" that meets or exceeds military specification, MIL-T-27730A. DO NOT use a combination of tape and thread sealant on the same joint. Apply TFE tape in the direction of the threads by starting with the first full thread and continuing over the entire thread length. Make sure all threads are covered. Generally, 2 - 3 wraps are sufficient to produce a watertight connection.

DO NOT over-torque any threaded connections. Generally, one to two turns beyond finger-tight are required for a threaded connection. Factory testing has indicated that 10 - 25 ft-lbs of torque is adequate to obtain a leak-free seal. Spears® recommends the use of a strap wrench when installing threaded connections.

Hanger/Support Spacing

Spears® EverTUFF® CTS CPVC pipe is rigid, it requires fewer supports than flexible, plastic systems.

Vertical runs should be supported at each level so that the weight of the run is not placed on a fitting or a joint. Horizontal runs require support every 3 feet for 1/2" - 1" diameter pipe and every 4 feet for 1-1/4" and larger diameters. Support spacing should be in accordance with applicable local codes. Horizontal runs must be braced so that the stress loads (caused by bending or snaking) will not be placed on a fitting or a joint. Hanger support spacing information is shown in Table A.

Spears® recommends that hangers, designed for supporting CPVC, be used to support CPVC piping. However, some hangers, designed for steel pipe, may be used if their suitability is clearly established. These hangers must be selected to accommodate the specific pipe size. In addition, they cannot contain rough or sharp edges that contact the pipe, and they must not bind the pipe from axial movement that is caused by expansion and contraction.

Pipe Size (in.)	Maximum Hanger Support Spacing
3/8	3 ft
1/2	3 ft
3/4	3 ft
1	3 ft
1-1/4	4 ft
1-1/2	4 ft
2	4 ft



Thermal Expansion

All piping systems expand and contract with changes in temperature. This issue must be addressed with appropriate system design to prevent damage to the system. Spears® EverTUFF® CTS CPVC pipe will expand or contract approximately 3.8 inches per 100 feet of pipe with every 100°F of temperature rise or fall. The effects of expansion/contraction are usually absorbed by the system at changes of direction in the piping. In other words, long, straight runs of piping are more susceptible to experiencing measurable movement with changes in temperature. As with other piping materials, the installation of an expansion loop or offset is required on long, straight runs which will allow the piping system to absorb the forces generated by expansion/contraction without damage. The rate of expansion does not vary with pipe size. The effects of expansion/contraction are more pronounced on hot water lines. See Thermal Expansion & Contraction section under Engineering and Design Data for Industrial Piping in this manual for information on calculating movement and expansion loops.

System Testing

Once the system has been installed and allowed to cure properly the system shall be tested in accordance with applicable code requirements. When testing with water (hydrostatic testing), the system must be slowly filled with water and the air bled from the highest and furthest points in the system before test pressure is applied. Air must be removed from piping systems to prevent it from being locked in the system when pressure is applied. Failure to do so could be harmful to job site personnel should a failure occur. If a leak is found, the affected product must be cut out and discarded. A new section can be installed using couplings or other approved means.

PVC & CPVC Corrosion Resistant Duct

PVC & CPVC DUCT

Spears® PVC and CPVC seamless round extruded duct is available in 6" through 24" diameters with cold-rolled fabricated duct available in 26" through 48". Excellent for industrial and institutional corrosive fume exhaust and drain applications.

Physical Properties

Spears® PVC and CPVC Duct Systems exhibit high tensile strength, various temperature ranges, low thermal conductivity, good electrical properties and excellent chemical/corrosion resistance to a variety of aggressive substances. Its physical properties allow it to perform great in aggressive environments that are not suitable for other types of materials, plus its lightweight provides construction advantages, ease of fabrication and at a lower cost.

PVC & CPVC Duct Physical Properties

GENERAL	VALUE		TEST METHOD
	PVC Duct	CPVC Duct	
Cell Classification	12454	23437	ASTM D 1784
Maximum Service Temp.	140°F	200°F	---
Color	Dark Gray	Medium Gray	---
Specific Gravity (g/cu.cm @ 73°F)	1.40 +/-0.02	1.52 +/-0.02	ASTM D 792
Water Absorption % increase 24 hrs @ 25°C	0.05	0.03	ASTM D 570
Hardness: Rockwell	110 - 120	118	ASTM D 785
Poisson's Ratio @ 73°F	0.410	0.430	---
Hazen-Williams Factor	C = 150	C = 150	---
MECHANICAL			
Tensile Strength, psi @ 73°F	7,450	7,960	ASTM D 638
Tensile Modulus of Elasticity, psi @ 73°F	420,000	373,000	ASTM D 638
Flexural Strength, psi @ 73°F	14,450	13,300	ASTM D 790
Flexural Modulus, psi @ 73°F	360,000	348,000	ASTM D 790
Compressive Strength, psi @ 73°F	9,600	6,000	ASTM D 695
Compressive Modulus, psi @ 73°F	---	12000	ASTM D 695
Izod Impact, notched ft-lb/in @ 73°F	0.75	2.0	ASTM D 256
THERMAL			
Coefficient of Linear Expansion (in/in/°F)	2.9×10^{-5}	3.9×10^{-5}	ASTM D 696
Coefficient of Thermal Conductivity	3.5×10^{-4}	3.27×10^{-4}	ASTM C 177
BTU • inches/hour • Ft. ²	1.02	0.95	---
Watt/m/K	0.147	0.137	---
Heat Deflection Temperature Under Load (264psi - annealed)	170	225	ASTM D 648
ELECTRICAL			
Dielectric Strength, volts/mil	1,413	1,250	ASTM D 149
Dielectric Constant, 60Hz @ 30°F	3.70	2.90	ASTM D 150
Volume Resistivity, ohm/cm @ 95°C	1.2×10^{12}	3.4×10^{12}	ASTM D 257
Power Factor	---	0.012	ASTM D 150
PVC & CPVC Pipe is non-electrolytic			
FIRE PERFORMANCE			
Flammability Rating	V-0	V-0, 5VB, 5VA	UL-94
Flame Spread Index	<10	<10	ASTM E 162
Flame Spread	0-25	5	ULC
Smoke Generation	80-225	<25	ULC
Flash Ignition Temp.	730°F	900°F	---
Average Time of Burning (sec.)	<5	<5	ASTM D 635
Average Extent of Burning (mm)	<10	<10	ASTM D 635
Burning Rate (in/min)	Self Extinguishing	Self Extinguishing	---
Softening Starts (approx.)	250°F	295°F	---
Material Becomes Viscous	350°F	395°F	---
Material Carbonizes	425°F	450°F	---
Limiting Oxygen Index (LOI)	---	55	ASTM D 2863
Clean Room Materials	---	FPI= 1.90	---
Flammability Test	N/A	SDI= 0.03	FM 4910



PVC & CPVC Corrosion Resistant Duct

Materials

PVC

Spears® PVC duct is extruded seamless round or cold-rolled fabricated from dark-gray-colored Type I, Grade I PVC material having a Cell Classification of 12454 per ASTM D 1784 (PVC 1120), and has a maximum service temperature of 140°F. Spears® PVC duct is chemically resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Unlike metallic materials, vapor phase or liquid-vapor phase corrosion is generally less aggressive with thermoplastics than the liquid phase corrosion. When in question, testing must be conducted under actual use conditions to verify compatibility. Detailed chemical resistance data should be referenced for proper material selection.

CPVC

Spears® CPVC Duct is extruded seamless round or cold-rolled fabricated from a light-gray-colored CPVC material with a Cell Classification of 23437 per ASTM D 1784 and has a maximum service temperature of 200°F for hot fumes. In addition, CPVC duct also has excellent fire performance properties. It has been subjected to large-scale testing having a flame spread rating of <25, and a smoke development rating of <50 making it ideal for use in critical areas (such as air plenums) where fire performance issues are of a concern. Spears® CPVC Duct is chemically resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Although the chemical resistance of PVC and CPVC are similar they are not the same. Detailed chemical resistance data should be referenced for proper material selection.

Flammability

Spears® duct has excellent flammability properties and will not independently support combustion - it will not burn unless a flame is constantly applied and will stop burning once the flame is removed. Spears® CPVC duct has improved fire performance properties over PVC with low flame-spread and smoke-generation properties. Refer to the Fire Performance section of the PVC & CPVC Duct Physical Properties table.

Dimensions

Spears® seamless round duct is extruded in Iron Pipe Size (IPS) dimensions with large internal flow areas that can easily be adapted to other common IPS fittings, reducing fabrication and installation time.

PVC Extruded Round Duct Dimensions

Size (in.)	AVG. O.D.	AVG. O.D.TOL.	O of R TOL.	MIN. Wall	AVG. Wall	MAX. Wall	WT.(lbs.) Per Ft.
6 x 1/8	6.625	+/- .020	+/- .050	0.105	0.122	0.140	1.530
6	6.625	+/- .020	+/- .050	0.172	0.187	0.202	2.275
7	7.375	+/- .020	+/- .050	0.172	0.187	0.202	2.534
8	8.625	+/- .020	+/- .075	0.172	0.187	0.202	2.982
9	9.375	+/- .025	+/- .075	0.172	0.187	0.202	3.239
10	10.750	+/- .025	+/- .075	0.172	0.187	0.202	3.733
11	11.375	+/- .025	+/- .075	0.172	0.187	0.202	3.944
12	12.750	+/- .025	+/- .075	0.172	0.187	0.202	4.440
14	14.000	+/- .030	+/- .075	0.172	0.187	0.202	4.884
16	16.000	+/- .030	+/- .075	0.172	0.187	0.202	5.586
18	18.000	+/- .040	+/- .080	0.172	0.187	0.202	6.750
20	20.000	+/- .070	+/- .140	0.199	0.219	0.239	8.144
24	24.000	+/- .090	+/- .180	0.230	0.250	0.270	11.163

O of R = Out of Roundness Factor at time of extrusion *I.D. Sizes

CPVC Extruded Round Duct Dimensions

Size (in.)	AVG. O.D.	AVG. O.D.TOL.	O of R TOL.	MIN. Wall	AVG. Wall	MAX. Wall	WT.(lbs.) Per Ft.
6	6.625	+/- .020	+/- .050	0.172	0.187	0.202	2.555
8	8.625	+/- .020	+/- .075	0.172	0.187	0.202	3.349
10	10.750	+/- .025	+/- .075	0.172	0.187	0.202	4.192
12	12.750	+/- .025	+/- .075	0.172	0.187	0.202	4.986
14	14.000	+/- .030	+/- .075	0.172	0.187	0.202	5.485
16	16.000	+/- .030	+/- .075	0.172	0.187	0.202	6.273
18	18.000	+/- .040	+/- .080	0.172	0.187	0.202	7.580
20	20.000	+/- .070	+/- .140	0.199	0.219	0.239	9.146
24	24.000	+/- .090	+/- .180	0.230	0.250	0.270	12.536

O of R = Out of Roundness Factor at time of extrusion

Large Diameter Duct

Spears® fabricated round duct (26" & larger diameter) is cold rolled from extruded PVC or CPVC sheet material. The seam is thermal fused utilizing computerized welding. The sheet edges are heated and pressed together pneumatically achieving 100% weld strength using no filler rod. Wall thickness is 3/16" for sizes up to 32" diameter. Above 32" diameter, 1/4" material will be used, unless otherwise specified. Cold rolled duct is produced in 4' lengths. Large duct fittings can be fabricated to order. Contact Spears® with requirements for additional information.

System Components

Fittings fabricated from Spears® duct are available in most configurations. All duct fittings, fume hoods, fume scrubbers, fans, blast gates and other system components should be fabricated from PVC/CPVC sheet or duct of the same wall thickness and from materials that conform to ASTM D 1784.

Storage and Handling

Although Spears® duct is tough and corrosion resistant, it should not be dropped nor have objects dropped on it. Reasonable care and common sense should be used, including during transport and storage to prevent distortion. Duct should not be stored close to heat-producing sources, subjected to external loads (i.e., heavy objects, over strapping, etc.) or over stacked when stored. When stored outdoors, Spears® duct must be covered with an opaque material to reduce the risk of heat absorption and discoloration. Prior to use, inspect duct for scratches, splits or gouges. If found, these sections must be cut out and discarded.



Product Ratings and Capability

Spears® PVC and CPVC duct is excellent for harsh environments and has been used at various negative and positive pressure conditions in diverse laboratory and industrial applications. Product ratings will vary according to size and temperature. The ratings in the following tables are based on a 1.5:1 safety factor.

Positive Pressure

PVC and CPVC duct can endure greater levels of positive internal pressure than negative internal pressure. The following tables show the maximum recommended internal positive pressure rating in PSI for PVC and CPVC duct at various temperatures.

Negative Pressure Ratings

PVC MAX. Internal Negative Pressure Rating Inches of Water @ Various Temperatures °F

Size (in.)	TEMPERATURE °F							
	73	80	90	100	110	120	130	140
6 x 1/8	115	101	86	71	59	46	36	25
6	415	365	311	257	212	166	129	91
7	301	265	226	187	153	120	93	66
8	188	166	141	117	96	75	58	41
9	146	129	110	91	75	59	45	32
10	97	85	73	6	50	39	30	21
11	82	72	61	51	42	33	25	18
12	58	51	44	36	30	23	18	13
14	44	39	33	27	22	18	14	10
16	29	26	22	18	15	12	9	6
18	21	18	16	13	11	8	6	4
20	24	21	18	15	12	10	7	5
24	21	18	16	13	11	8	6	4

PSI = Inches of Water x .0361; Inches of Mercury = Inches of Water x .07355 MAX.
Internal Positive Pressure Rating

Positive Pressure Ratings

PVC MAX. Internal Positive Pressure Rating PSI @ Various Temperatures °F

Size (in.)	TEMPERATURE °F							
	73	80	90	100	110	120	130	140
6 x 1/8	42	37	31	26	21	17	13	9
6	70	62	52	43	35	28	22	15
7	64	56	48	40	32	25	20	14
8	53	47	40	33	27	21	16	12
9	74	65	55	46	38	29	23	16
10	43	39	32	27	22	17	13	9
11	61	53	46	38	31	24	19	13
12	36	32	27	22	18	14	11	8
14	33	29	25	20	17	13	10	7
16	28	25	21	17	14	11	9	6
18	25	22	19	15	13	10	8	5
20	26	23	20	16	13	10	8	6
24	25	22	19	15	13	10	8	5

CPVC MAX. Internal Negative Pressure Rating Inches of Water @ Various Temperatures °F

Size (in.)	TEMPERATURE °F						
	73	100	120	140	160	180	200
6	426	371	316	263	208	153	98
8	193	168	143	118	93	70	45
10	100	86	73	60	48	35	23
12	60	51	43	36	28	20	13
14	45	38	33	26	21	15	10
16	30	26	21	18	13	10	6
18	26	23	20	16	13	10	6
20	28	25	21	16	13	10	6
24	20	18	15	13	10	6	3

PSI = Inches of Water x .0361; Inches of Mercury = Inches of Water x .07355

CPVC MAX. Internal Positive Pressure Rating PSI @ Various Temperatures °F

Size (in.)	TEMPERATURE °F						
	73	100	120	140	160	180	200
6	70	56	45	35	26	16	13
8	53	43	33	26	20	13	10
10	43	35	28	21	16	10	8
12	36	30	23	18	15	8	6
14	33	26	21	16	13	8	6
16	28	23	18	13	11	6	5
18	25	20	15	11	10	5	5
20	26	21	16	13	10	6	5
24	25	20	15	11	10	5	5

NOTE: Maximum values stated are for extruded duct pipe only, and incorporate a 1.5:1 safety factor. Consideration should be given to system design, method of fabrication, and joining which may require additional system de-rating. Spears® PVC/CPVC Duct piping are not designed for distribution of compressed air or gases.



Duct System Installation

Joining Techniques

Spears® duct can be easily assembled in the field using standard thermoplastic pipe-joining techniques. The most common methods are solvent-cementing or thermal hot air welding, fusion welding and butt-welding can also be used. Retaining duct and fittings with suitable drilled holes and sheet metal screws may also be used, depending on application requirements.

Solvent Cementing

Typical duct fittings are fabricated from duct and with belled-end sockets that can be joined using solvent-cementing. This is the same basic process used for over 50 years in pressure pipe installation using the application of a primer and solvent cement to join system components. Properly made solvent cement joints are chemically fused together providing a leak-tight seal when cured. A minimum socket depth of 3" (all sizes) is necessary to provide sufficient surface-to-surface contact of the parts being joined. The use of extra-heavy-bodied solvent is recommended to handle the gap-filling required due to larger dimensional tolerances in duct piping. Use extra care when solvent cementing duct diameters 18" and larger to ensure tight fit of mating components. Do not use solvent cement for any type of end-to-end joining. See Installation section for industrial pressure pipe for guidelines on solvent cement welding.

Thermal Welding

Thermal welding requires the use of a hot-air welder and PVC or CPVC welding rod. Clean hot air from the welder preheats the duct material and welding rod while pressure is applied to the weld area as the rod is guided. This results in the surfaces of the parts being thermally fused together at the weld seam. Only welding rod produced from the same material being joined (same Cell Classification) should be used. Due to the significantly different thermal properties of the plastics, hot-air welding of CPVC is generally more difficult than PVC. Only personnel specifically trained in hot-air welding of PVC or CPVC should conduct all welding.

Hangers and Supports

As with all piping systems, proper support spacing is critical to minimize deflection and sagging. Additional support consideration must be given to concentrated loads, additional weight of accumulated solids, and independent support at fans, flexible connections, hoods, scrubbers, tanks, and other system components for potential stresses on the system.

Drains must be installed where accumulation of moisture is expected and at low points in the system (these locations should be specified on system specification drawings). Proper system inspection, cleaning and maintenance should be enforced to prevent the formation of additional weight loads. Refer to the following tables for maximum support spacing of horizontal air-filled duct with an allowable 1/8" deflection at various temperatures.

Hangers and supports shall be securely fastened to the building structure to avoid vibration, and should be installed in such a manner as to prevent conditions of stress on the system (properly aligned). Seismic design and construction practices for hangers and supports shall be followed where applicable.

Hangers selected must have an adequate load-bearing surface free of rough or sharp edges to prevent damage to the duct during use. Use corrosive-resistant material for hangers and hanger hardware that is suitable for the system environment. Hangers must not restrict linear movement due to expansion and contraction. Avoid over tightening to prevent duct deformation and restriction of movement. Refer to the following illustration for examples of typical hangers.

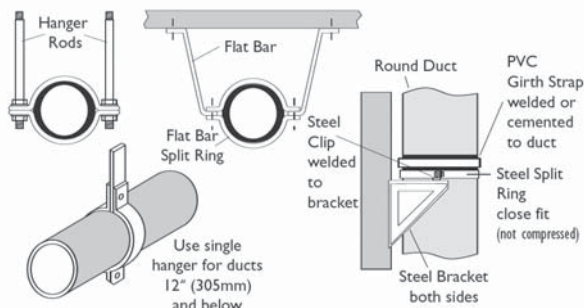
Hanger Support Spacing

PVC Duct Maximum Hanger Support Spacing In Feet

Size (in.)	TEMPERATURE °F							
	73	80	90	100	110	120	130	140
6 x 1/8	9.5	9	9	8.5	8	7.5	7	6.5
6	10	10	9.5	9	8.5	8	7.5	6.5
7	10	10	9.5	9	8.5	8	7.5	7
8	10	10	10	10	9	9	8	7.5
9	10	10	10	10	10	9	8.5	8
10	10	10	10	10	10	10	9	8.5
11	10	10	10	10	10	10	9.5	9
12	12	12	12	12	10	10	10	9.5
14	12	12	12	12	11.5	11.5	11	10
16	12	12	12	12	12	12	11	10
18	12	12	12	12	12	12	11.5	11
20	12	12	12	12	12	12	12	11.5
24	12	12	12	12	12	12	12	12

CPVC Duct Maximum Hanger Support Spacing In Feet

Size (in.)	TEMPERATURE °F						
	73	100	120	140	160	180	200
6	10	10	10	10	10	8	8
8	10	10	10	10	10	8	8
10	10	10	10	10	10	10	10
12	10	10	10	10	10	10	10
14	12	12	12	12	10	10	10
16	12	12	12	12	12	10	10
18	12	12	12	12	12	12	12
20	12	12	12	12	12	12	12
24	12	12	12	12	12	12	12



Thermal Expansion and Contraction

The coefficient of linear expansion (γ) for Spears® duct can be found in the physical properties table (PVC = 2.9×10^{-5} in/in/°F; CPVC = 3.9×10^{-5} in/in/°F). As with all piping products, thermal expansion and contraction of the system must be considered and properly addressed during the design and installation of the system. The expansion or contraction rate of Spears® duct can be calculated as follows:

Thermal Expansion and Contraction for PVC Duct

$$\Delta L = \gamma L (\Delta T)$$

Where:

ΔL = expansion or contraction of duct in inches

$\gamma = 2.9 \times 10^{-5}$ in/in/°F (PVC duct material Coefficient of thermal expansion)

L = Length of duct run in feet

ΔT = Temperature change °F ($T_{\text{max.}} - T_{\text{in.}}$)

$T_{\text{max.}}$ = Maximum change in operating temperature (F)

$T_{\text{in.}}$ = temperature at time of installation (F)

Thermal Expansion and Contraction for CPVC Duct

$$\Delta L = \gamma L (\Delta T)$$

Where:

ΔL = expansion or contraction of duct in inches

$\gamma = 3.9 \times 10^{-5}$ in/in/°F (CPVC duct material Coefficient of thermal expansion)

L = Length of duct run in feet

ΔT = Temperature change °F ($T_{\text{max.}} - T_{\text{in.}}$)

$T_{\text{max.}}$ = Maximum change in operating temperature (F)

$T_{\text{in.}}$ = temperature at time of installation (F)

In-line expansion joints, either flexible sleeve type or O-ring piston type are the most common means of accommodating thermal expansion and contraction in duct systems. Using expansion loops and offsets where required can also be used, but require significantly more space.



Other Design Considerations

The duct system must not be exposed to conditions that will exceed product limitations regarding temperature, pressure, chemical compatibility and mechanical strength. Care must be taken to ensure that fume hood design, capture velocities, flow velocities, and flow volumes are adequate to properly convey the corrosive fumes being extracted while maintaining safety to personnel and protection of other equipment from corrosive attack. An optimum velocity for most systems is 1,500 feet per minute (FPM), which allows for future expansion of the system by increasing the fan size. With the exception of some heavy metals extraction, velocities exceeding 3,000 FPM are generally not recommended. This is especially true in systems carrying solid particles where excessive static electricity can be generated. Minimum exhaust volume requirements in cubic feet per minute (CFM), must be calculated according to type and concentration of fumes being transported. Sufficient access for inspection and equipment maintenance must be provided. Size transition sections in mains and sub mains should be appropriately tapered for optimum flow conditions. A minimum taper of 5" in length for each 1" change in duct diameter is recommended. Branches should enter the main at the large end at angles no greater than 45° and not directly opposite each other. The designing engineer is responsible for ensuring that the system is in compliance with any applicable pollution control and building codes.



Chemical Resistance

This section is to provide information on the transport of various chemicals using PVC and CPVC thermoplastic piping materials. This information is compiled from commercially available industry sources. These recommendations are guidelines for use and the final decision regarding material suitability must rest with the end-user.

Please note that Spears® CPVC piping products can be classified into two basic applications, pressure systems and corrosive waste drainage systems. For this reason, you will find two distinct chemical resistance tables in this section. **IMPORTANT:** Corrosive waste drainage system data should not be used for pressure system or dedicated service applications.

PVC and CPVC thermoplastic piping products are resistant to corrosion typically encountered with metal systems and the effects of galvanic and electrochemical corrosion are non-existent since both of these materials are non-conductors.

Types of Chemical Attack on Plastics

In general, chemicals that affect plastics do so in one of two ways. One effect is chemical solvation or permeation; the other is direct chemical attack. In the case of solvation or permeation, physical properties may be affected, but the polymer molecule structure itself is not chemically changed, degraded or destroyed. In solvation or permeation, gas, vapor or liquid molecules pass through the polymer, typically without damaging the plastic material itself. If the chemical can be removed completely, the plastic is generally restored to its original condition. Direct chemical attack occurs when exposure to a chemical causes a chemical alteration of the polymer molecules. Direct chemical attack may cause profound, irreversible changes that cannot be restored by removal of the chemical.

Other Consideration

While the effect of each individual chemical is specific, some chemicals can be grouped into general categories based on similarities in chemical characteristics. PVC and CPVC are inert to most mineral acids, bases, salts and paraffinic hydrocarbons, and compares favorably to other non-metals in these chemical environments.

Generally, the resistance of a particular plastic to a specific chemical decreases with an increase in concentration. Also, the resistance of a particular plastic to a specific chemical generally decreases as temperature increases, generally decreases with increasing applied stress, and generally decreases where temperature or applied stress are varied or cycled. These effects can be greater overall in combination.

In some cases, combinations of chemicals may have a synergistic effect on a thermoplastic material where the individual chemicals do not. It cannot be assumed that an individual chemical's lack of effect would apply for combinations that include several chemicals. When the possible combined effect of several chemicals is unknown, the material should be tested in the complete chemical mixture(s) in question.

Caution Areas

- Chlorinated and aromatic hydrocarbons, esters, or ketones are not recommended for use with PVC or CPVC thermoplastic piping materials. Although the chemical resistance of PVC and CPVC compounds is similar, they are not always the same.
- Chemical compatibility of a piping system must also take into consideration the compatibility of all system components. This includes elastomers (gaskets, O-rings, etc), valves and valve components, as well as thread pastes, lubricants, cleaning and wetting agents (surfactants).
- Applications involving certain oils, surfactants, and greases may result in environmental stress cracking. Environmental stress cracking occurs when system components are subjected to an incompatible chemical in the presence of stress.
- Certain substances called out on the following pages reference chemicals in a gaseous state. These substances are not recommended for pressure service. They are shown to provide the chemical resistance of PVC and CPVC when coming into contact with these substances. (i.e. exposure to or immersion in these substances).
- PVC Clear piping has the same basic chemical resistance as regular PVC. However certain nitrogen-containing organics, bleaches, oxidizing agents and acids will result in discoloration. Testing under actual use conditions is recommended.
- The following chemical resistance data is based primarily on plastic material test specimens that have been immersed in the chemical, and to a lesser degree, on field-experience. In most cases, detailed information on the test conditions (such as exposure time), and on test results (such as change in weight, change in volume, and change in strength) is not available.

While some chemicals may be acceptable with certain temperature limitations, the use of PVC and CPVC piping with liquid hydrocarbons such as gasoline and jet fuels should be limited to short-term exposure such as secondary containment systems. This piping is not recommended for long-term exposure to liquid hydrocarbons.

PVC and CPVC have also been used successfully in contaminated water recovery systems where very low levels (PPM/PPB range) of certain incompatible substances are present. However, since most remediation projects involve low pressure/vacuum type applications for a limited period of time, the use of PVC and CPVC can be used in these types of applications.

DISCLAIMER OF LIABILITY

There are many variables beyond our control in the application of thermoplastic piping in chemical service. All statements made herein are offered in good faith and believed to be accurate at the time of its preparation, but are offered without any warranty, expressed or implied, by information sources or Spears® Manufacturing Company. Compliance with all applicable federal, state and local laws and regulations remains the responsibility of the user.



CHEMICAL RESISTANCE DATA FOR PRESSURE PIPING

R = Recommended NR = Not Recommended

C = Caution, actual testing suggested; suspect @ certain stress levels ? = Incomplete Data; actual testing required

CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV, Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Acetaldehyde	NR	NR	NR	NR	NR	NR	NR
Acetamide	NR	NR	NR	NR	NR	NR	NR
Acetic Acid, 10%	R	R	R	R	R	R	R
Acetic Acid, 20%	R	R	R	NR	NR	NR	NR
Acetic Acid, Glacial	R	NR	NR	NR	NR	NR	NR
Acetic Acid, pure	NR	NR	NR	NR	NR	NR	NR
Acetic Anhydride	NR	NR	NR	NR	NR	NR	NR
Acetone, < 5%	?	?	NR	NR	R	R	R
Acetone, > 5%	NR	NR	NR	NR	NR	NR	NR
Acetyl Nitrile	NR	NR	NR	NR	NR	NR	NR
Acetylene	R	R	R	R	C	C	C
Acrylic Acid	NR	NR	NR	NR	NR	NR	NR
Adipic Acid: sat. in water	R	R	R	R	R	R	R
Allyl Alcohol, 96%	R	NR	NR	NR	C	C	C
Allyl Chloride	NR	NR	NR	NR	NR	NR	NR
Alum, all varieties	R	R	R	R	R	R	R
Aluminum Acetate	R	R	R	R	R	R	R
Aluminum Alum	R	R	R	R	R	R	R
Aluminum Chloride	R	R	R	R	R	R	R
Aluminum Fluoride	R	R	R	R	R	R	R
Aluminum HydroxideR		R	R	R	R	R	R
Aluminum Nitrate	R	R	R	R	R	R	R
Aluminum Oxylchloride	R	R	R	R	?	?	?
Aluminum Sulfate	R	R	R	R	R	R	R
Amines	NR	NR	NR	NR	NR	NR	NR
Ammonia (gas:dry)	R	R	R	R	NR	NR	NR
Ammonia (liquid)	NR	NR	NR	NR	NR	NR	NR
Ammonium Acetate	R	R	R	R	R	R	R
Ammonium Alum	R	R	R	R	R	R	R
Ammonium Bisulfate	R	R	?	?	R	R	R
Ammonium Carbonate	R	R	R	R	R	R	R
Ammonium Chloride	R	R	R	R	R	R	R
Ammonium Dichromate	R	?	?	?	R	R	R
Ammonium Fluoride, < 25%	R	NR	NR	NR	R	R	R
Ammonium Fluoride, > 25%	?	NR	NR	NR	R	R	R
Ammonium Hydroxide	R	R	R	R	NR	NR	NR
Ammonium Metaphosphate	R	R	R	R	R	R	R
Ammonium Nitrate	R	R	R	R	R	R	R
Ammonium Persulfate	R	R	R	R	R	?	?
Ammonium Phosphate	R	R	R	R	R	R	C
Ammonium Sulfate	R	R	R	R	R	R	R
Ammonium Sulfide	R	R	R	R	R	R	R
Ammonium Tartrate	R	R	R	R	R	R	R
Ammonium Thiocyanate	R	R	R	R	R	R	R
Amyl Acetate	NR	NR	NR	NR	NR	NR	NR
Amyl Alcohol	R	NR	NR	NR	C	C	NR
Amyl Chloride	NR	NR	NR	NR	NR	NR	NR
Aniline	NR	NR	NR	NR	NR	NR	NR

CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV, Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Aniline Chlorohydrate	NR	NR	NR	NR	NR	NR	NR
Aniline Hydrochloride	NR	NR	NR	NR	NR	NR	NR
Anthraquinone	?	?	?	?	?	?	?
Anthraquinone Sulfonic Acid	R	R	R	R	?	?	?
Antimony Trichloride	R	R	R	R	R	R	R
Aqua Regia	NR	NR	NR	NR	R	NR	NR
Aromatic Hydrocarbons	NR	NR	NR	NR	NR	NR	NR
Arsenic Acid 80%	R	R	R	R	R	R	R
Arsenic Trioxide (powder)	R	?	?	?	R	NR	NR
Arylsulfonic Acid	R	R	R	NR	?	?	?
Barium Carbonate	R	R	R	R	R	R	R
Barium Chloride	R	R	R	R	R	R	R
Barium Hydroxide 10%	R	R	R	R	R	R	R
Barium Nitrate	R	?	?	?	R	R	R
Barium Sulfate	R	R	R	R	R	R	R
Barium Sulfide	R	R	R	R	R	R	R
Beer	R	R	R	R	R	R	R
Beet Sugar Liquors	R	R	R	R	R	R	R
Benzaldehyde: 10%	R	NR	NR	NR	NR	NR	NR
Benzaldehyde: > 10%	NR	NR	NR	NR	NR	NR	NR
Benzalkonium Chloride	R	?	?	?	NR	NR	NR
Benzene	NR	NR	NR	NR	NR	NR	NR
Benzoic Acid	R	R	R	R	R	C	NR
Benzyl Alcohol	NR	NR	NR	NR	NR	NR	NR
Benzyl Chloride	NR	NR	NR	NR	NR	NR	NR
Bismuth Carbonate	R	R	R	R	R	R	R
Black Liquor	R	R	R	R	R	R	R
Bleach (15% CL)	R	R	R	R	R	R	R
Borax	R	R	R	R	R	R	R
Boric Acid	R	R	R	R	R	R	R
Brine (acid)	R	?	?	?	R	R	R
Bromic Acid	R	R	R	R	R	R	R
Bromine Liquid	NR	NR	NR	NR	NR	NR	NR
Bromine Vapor 25%	R	R	R	R	NR	NR	NR
Bromine Water	R	R	NR	NR	?	?	?
Bromobenzene	NR	NR	NR	NR	NR	NR	NR
Bromotoluene	NR	NR	NR	NR	NR	NR	NR
Butadiene	R	R	NR	NR	C	C	C
Butane	R	R	NR	NR	C	C	C
Butanol: primary	R	R	NR	NR	C	C	C
Butanol: secondary	R	NR	NR	NR	C	C	C
Butyl Acetate	R	NR	NR	NR	NR	NR	NR
Butyl Carbitol	?	?	?	?	NR	NR	NR
Butyl Mercaptan	NR	NR	NR	NR	NR	NR	NR
Butyl Phenol	R	NR	R	NR	NR	NR	NR
Butyl Stearate	R	?	?	?	NR	NR	NR
ButylCellosolve	R	?	?	?	NR	NR	NR
Butyne Diol	R	?	?	?	?	?	?

CHEMICAL RESISTANCE DATA FOR PRESSURE PIPING



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CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV, Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Butyric Acid < 1%	R	NR	NR	NR	R	R	R
Butyric Acid > 1%	R	NR	NR	NR	NR	NR	NR
Cadmium Acetate	R	R	?	?	R	R	R
Cadmium Chloride	R	R	?	?	R	R	R
Cadmium Cyanide	R	R	R	R	R	R	R
Cadmium Sulfate	?	?	?	?	R	R	R
Caffeine Citrate	R	?	?	?	R	R	R
Calcium Acetate	R	R	R	R	R	R	R
Calcium Bisulfide	R	R	R	R	R	R	R
Calcium Bisulfite	R	R	R	R	R	R	R
Calcium Bisulfite Bleach Liquor	R	?	?	?	R	R	R
Calcium Carbonate	R	R	R	R	R	R	R
Calcium Chlorate	R	R	?	?	R	R	R
Calcium Chloride	R	R	R	R	R	R	R
Calcium Hydroxide	R	R	R	R	R	R	R
Calcium Hypochlorite	R	R	R	R	R	R	R
Calcium Nitrate	R	R	R	R	R	R	R
Calcium Oxide	R	R	?	?	R	R	R
Calcium Sulfate	R	R	R	R	R	R	R
Camphor (crystals)	R	?	?	?	NR	NR	NR
Cane Sugar Liquors	R	R	R	R	R	R	R
Caprolactam	?	?	?	?	NR	NR	NR
Caprolactone	?	?	?	?	NR	NR	NR
Carbitol	R	?	?	?	NR	NR	NR
Carbon Dioxide	R	R	R	R	R	R	R
Carbon Dioxide (aqueous solution)	R	R	?	?	R	R	R
Carbon Disulfide	NR	NR	NR	NR	NR	NR	NR
Carbon Monoxide	R	R	R	R	R	R	R
Carbon Tetrachloride	R	NR	NR	NR	NR	NR	NR
Carbonic Acid	R	R	R	R	R	R	R
Carene 500	R	?	NR	NR	?	?	?
Castor oil	R	R	R	R	C	C	C
Caustic Potash	R	R	R	R	R	R	R
Caustic Soda	R	R	R	R	R	R	R
Cellosolve	R	NR	R	NR	NR	NR	NR
Cellosolve Acetate	R	?	R	?	NR	NR	NR
Chloral Hydrate	R	R	R	R	NR	NR	NR
Chloramine	R	?	?	?	R	R	R
Chloric Acid up to 20%	R	R	R	R	R	R	R
Chloride Water	R	R	R	R	R	R	R
Chlorinated Solvents	NR	NR	NR	NR	NR	NR	NR
Chlorinated Water (Hypochlorite)	R	R	R	R	R	R	R
Chlorine (dry liquid)	NR	NR	NR	NR	NR	NR	NR
Chlorine (liquid under pressure)	NR	NR	NR	NR	NR	NR	NR
Chlorine Dioxide aqueous (sat'd 0.1%)	?	?	?	?	R	?	?

CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV, Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Chlorine Gas (dry)	NR	NR	NR	NR	NR	NR	NR
Chlorine Gas (wet)	NR	NR	NR	NR	NR	NR	NR
Chlorine Water (sat'd 0.3%)	R	R	R	R	R	R	R
Chlorine (trace in air)	R	?	R	?	R	R	R
Chloroacetic Acid	R	R	R	NR	NR	NR	NR
Chloroacetyl Chloride	R	?	R	?	NR	NR	NR
Chlorobenzene	NR	NR	NR	NR	NR	NR	NR
Chloroform	NR	NR	NR	NR	NR	NR	NR
Chloropicrin	NR	NR	NR	NR	NR	NR	NR
Chlorosulfonic Acid	R	NR	R	NR	NR	NR	NR
Chlorox Bleach Solution	R	?	?	?	C	C	C
Chrome Alum	R	R	R	R	R	R	R
Chromic Acid 10%	R	R	R	R	R	R	R
Chromic Acid 40%	?	?	?	?	R	R	R
Chromic Acid 50%	NR	NR	NR	NR	?	?	?
Chromic Acid/Sulfuric Acid/ water-50%/15%/35%	R	NR	?	?	?	?	?
Chromic/Nitric Acid (15%/35%)	R	R	?	?	R	C	NR
Chromium Nitrate	R	?	?	?	R	R	R
Citric Acid	R	R	R	R	R	R	R
Citrus Oils	?	?	?	?	NR	NR	NR
Coconut Oil	R	R	?	?	NR	NR	NR
Copper Acetate	R	R	R	R	R	R	R
Copper Carbonate	R	R	R	R	R	R	R
Copper Chloride	R	R	R	R	R	R	R
Copper Cyanide	R	R	R	R	R	R	R
Copper Fluoride	R	R	R	R	R	R	R
Copper Nitrate	R	R	R	R	R	R	R
Copper Sulfate	R	R	R	R	R	R	R
Corn Oil	R	?	R	?	NR	NR	NR
Corn Syrup	R	R	R	R	R	R	R
Cottonseed Oil	R	R	R	R	NR	NR	NR
Creosote	NR	NR	NR	NR	NR	NR	NR
Cresylic Acid 50%	R	R	R	NR	NR	NR	NR
Crotonaldehyde	NR	NR	NR	NR	NR	NR	NR
Crude Oil	R	R	R	NR	NR	NR	NR
Cumene	?	?	?	?	NR	NR	NR
Cupric Fluoride	R	R	R	R	R	R	R
Cupric Sulfate	R	R	R	R	R	R	R
Cuprous Chloride	R	R	R	R	R	R	R
Cyclanones	R	R	?	?	?	?	?
Cyclohexane	NR	NR	NR	NR	NR	NR	NR
Cyclohexanol	NR	NR	NR	NR	NR	NR	NR
Cyclohexanone	NR	NR	NR	NR	NR	NR	NR
D.D.T. (Xylene Base)	NR	NR	NR	NR	NR	NR	NR
Desocyphephrine Hydrochloride	R	?	R	?	?	?	?
Detergents	R	R	R	R	C	C	C
Dextrin	R	R	R	R	R	R	R



CHEMICAL RESISTANCE DATA FOR PRESSURE PIPING

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CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV - Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Dextrose	R	R	R	R	R	R	R
Diacetone Alcohol	R	?	?	?	C	?	?
Diazo Salts	R	R	R	R	?	?	?
Dibutoxy Ethyl Phthalate	NR	NR	NR	NR	NR	NR	NR
Dibutyl Phthalate	NR	NR	NR	NR	NR	NR	NR
Dibutyl Sebacate	R	NR	?	?	NR	NR	NR
Dichlorobenzene	NR	NR	NR	NR	NR	NR	NR
Dichloroethylene	NR	NR	NR	NR	NR	NR	NR
Diesel Fuels	R	R	R	R	NR	NR	NR
Diethyl Ether	R	?	R	?	NR	NR	NR
Diethylamine	NR	NR	NR	NR	NR	NR	NR
Diglycolic Acid	R	R	R	R	NR	NR	NR
Dill Oil	?	?	?	?	NR	NR	NR
Dimethyl Hydrazine	NR	NR	NR	NR	NR	NR	NR
Dimethylamine	R	R	NR	NR	NR	NR	NR
Dimethylformamide	NR	NR	NR	NR	NR	NR	NR
Dioctylphthalate	NR	NR	NR	NR	NR	NR	NR
Dioxane (1, 4)	NR	NR	NR	NR	NR	NR	NR
Disodium Phosphate	R	R	R	R	R	R	R
Distilled Water	R	R	R	R	R	R	R
EDTA Tetrasodium	?	?	?	?	R	R	R
Ethyl Ester (ethyl acrylate)	NR	NR	NR	NR	NR	NR	NR
Epsom Salt	R	?	R	?	R	R	R
Esters	NR	NR	NR	NR	NR	NR	NR
Ethanol > 5%	R	R	R	NR	C	C	C
Ethanol up to 5%	R	R	R	NR	R	R	R
Ethers	NR	NR	NR	NR	NR	NR	NR
Ethyl Acetate	NR	NR	NR	NR	NR	NR	NR
Ethyl Acrylate	NR	NR	NR	NR	NR	NR	NR
Ethyl Alcohol	R	R	R	NR	C	C	C
Ethyl Chloride	NR	NR	NR	NR	NR	NR	NR
Ethyl Chloroacetate	NR	NR	NR	NR	NR	NR	NR
Ethyl Ether	NR	NR	NR	NR	NR	NR	NR
Ethylene Bromide	NR	NR	NR	NR	NR	NR	NR
Ethylene Chlorohydrin	NR	NR	NR	NR	NR	NR	NR
Ethylene Diamine	NR	NR	NR	NR	NR	NR	NR
Ethylene Dichloride	NR	NR	NR	NR	NR	NR	NR
Ethylene Glycol	R	R	R	R	C	C	C
Ethylene Oxide	NR	NR	NR	NR	NR	NR	NR
Fatty Acids	R	R	R	R	C	C	C
Ferric Acetate	R	NR	?	?	R	R	R
Ferric Chloride	R	R	R	R	R	R	R
Ferric Hydroxide	R	R	R	R	R	R	R
Ferric Nitrate	R	R	R	R	R	R	R
Ferric Sulfate	R	R	R	R	R	R	R
Ferrous Chloride	R	R	R	R	R	R	R
Ferrous Hydroxide	R	?	R	?	R	R	R
Ferrous Nitrate	R	?	R	?	R	R	R

CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Ferrous Sulfate	R	R	R	R	R	R	R
Fish Solubles	R	R	R	R	?	?	?
Fluorine Gas	R	NR	NR	NR	NR	NR	NR
Fluorine Gas (wet)	R	NR	R	NR	NR	NR	NR
Fluoroboric Acid	R	R	R	R	?	?	?
Fluorosilicic Acid 25%	R	R	R	R	R	C	C
Formaldehyde	R	R	NR	NR	NR	NR	NR
Formic Acid < 25%	R	NR	R	NR	R	R	R
Formic Acid > 25%	?	?	?	?	C	?	NR
Freon 11	R	R	NR	NR	NR	NR	NR
Freon 113	R	?	R	?	NR	NR	NR
Freon 114	R	?	R	?	NR	NR	NR
Freon 12	R	R	R	R	NR	NR	NR
Freon 21	NR	NR	NR	NR	NR	NR	NR
Freon 22	NR	NR	NR	NR	NR	NR	NR
Fructose	R	R	R	R	R	R	R
Fruit juices & pulp	R	R	R	R	R	R	R
Furfural	NR	NR	NR	NR	NR	NR	NR
Gallic Acid	R	R	R	R	?	?	?
Gas (Coke Oven)	NR	NR	NR	NR	?	?	?
Gasoline	NR	NR	NR	NR	NR	NR	NR
Gasoline, HighOctane	NR	NR	NR	NR	NR	NR	NR
Gasoline Jet Fuel	NR	NR	NR	NR	NR	NR	NR
Glucose	R	R	R	R	R	R	R
Glycerine	R	R	R	R	R	R	R
Glycol	R	R	R	R	C	C	C
Glycol Ethers	?	?	?	?	NR	NR	NR
Glycolic Acid	R	R	R	R	?	?	?
Grape Sugar	R	R	R	R	R	R	R
Green Liquor	R	R	?	?	R	R	R
Halocarbon Oils	?	?	?	?	NR	NR	NR
Heptane	R	R	R	NR	C	?	?
Hercolyn	R	?	?	?	?	?	?
Hexane	R	NR	NR	NR	C	C	C
Hexanol, Tertiary	R	R	R	NR	C	C	C
Hydrazine	NR	NR	NR	NR	NR	NR	NR
Hydrobromic Acid 20%	R	R	R	R	?	?	?
Hydrochloric Acid 10%	R	R	R	R	R	R	R
Hydrochloric Acid 30%	R	R	R	R	R	R	R
Hydrochloric Acid 36%	R	R	R	R	R	R	C
Hydrochloric Acid Concentrated	R	R	R	NR	?	?	?
Hydrochloric Acid pickling	R	R	R	R	R	R	R
Hydrocyanic Acid	R	R	R	R	?	?	?
Hydrofluoric Acid 3%	R	R	R	R	R	?	?
Hydrofluoric Acid 48%	R	NR	R	NR	NR	NR	NR
Hydrofluoric Acid 50%	R	NR	NR	NR	NR	NR	NR
Hydrofluoric Acid 70%	NR	NR	NR	NR	NR	NR	NR
Hydrofluorsilicic Acid 30%	R	R	R	R	R	?	C

CHEMICAL RESISTANCE DATA FOR PRESSURE PIPING



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C = Caution, actual testing suggested; **suspect @** certain stress levels **? = Incomplete Data**; actual testing required

CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Hydrogen	R	R	R	R	C	C	C
Hydrogen Peroxide 30%	R	R	R	R	R	?	?
Hydrogen Peroxide 90%	R	R	R	R	?	?	?
Hydrogen Phosphide	R	R	NR	NR	?	?	?
Hydrogen Sulfide	R	R	R	R	R	R	R
Hydroquinone	R	R	R	R	R	R	R
Hydroxylamine Sulfate	R	R	R	R	?	?	?
Hypochlorite (Potassium & Sodium)	R	?	R	?	R	R	R
Hypochlorous Acid	R	R	R	R	R	R	R
Iodine	NR	NR	NR	NR	R	R	R
Iodine Solution 10%	NR	NR	NR	NR	?	?	?
Isopropanol	?	?	?	?	C	C	C
Kerosene	R	R	R	R	C	C	C
Ketones	NR	NR	NR	NR	NR	NR	NR
Kraft Liquors	R	R	R	R	R	R	R
Lactic Acid 25%	R	R	R	R	R	R	R
Lactic Acid 80%	R	?	?	?	R	C	C
Lard Oil	R	R	R	R	C	C	C
Lauric Acid	R	R	R	R	C	C	C
Lauryl Chloride	R	?	R	NR	NR	NR	NR
Lead Acetate	R	R	R	R	R	R	R
Lead Chloride	R	R	R	R	R	R	R
Lead Nitrate	R	R	R	R	R	R	R
Lead Sulfate	R	R	R	R	R	R	R
Lemon Oil	?	?	?	?	NR	NR	NR
Limonene	?	?	?	?	NR	NR	NR
Linoleic Acid	R	R	R	R	C	C	C
Linoleic Oil	R	R	R	NR	C	C	C
Linseed Oil	R	R	R	R	NR	NR	NR
Liquors	R	R	?	?	?	?	?
Lithium Bromide	R	R	R	R	R	R	R
Lithium Sulfate	R	R	R	R	R	R	R
Lubricating Oils, ASTM#1	R	R	R	R	?	?	?
Lubricating Oils, ASTM#2	R	R	R	R	?	?	?
Lubricating Oils, ASTM#3	R	R	R	NR	?	?	?
Lux Liquid	R	NR	R	NR	?	?	?
Machine Oil	R	R	R	R	C	C	C
Magnesium Carbonate	R	R	R	R	R	R	R
Magnesium Chloride	R	R	R	R	R	R	R
Magnesium Citrate	R	R	?	?	R	R	R
Magnesium Fluoride R	R	R	R	R	R	R	
Magnesium Hydroxide	R	R	R	R	R	R	R
Magnesium Nitrate	R	R	R	R	R	R	R
Magnesium Oxide	R	R	R	R	R	R	R
Magnesium Salts	R	R	R	R	R	R	R
Magnesium Sulfate	R	R	R	R	R	R	R
Maleic Acid 50%	R	R	R	R	R	R	R
Manganese Chloride	R	R	R	R	R	R	R

CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV, Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Manganese Sulfate	R	R	R	R	R	R	R
Mercurial Ointment Blue 5%	R	?	R	?	?	?	?
Mercuric Chloride	R	R	R	R	R	R	R
Mercuric Cyanide	R	R	R	R	R	R	R
Mercuric Sulfate	R	R	R	R	R	R	R
Mercurous Nitrate	R	R	R	R	R	R	R
Mercury	R	R	R	R	R	R	R
Mercury Ointment Ammoniated	R	?	R	?	?	?	?
Methanol <10%	R	R	R	R	R	R	R
Methanol >10%	R	R	R	R	NR	NR	NR
Methoxyethyl Oleate	R	?	R	?	NR	NR	NR
Methyl Cellosolve	NR	NR	NR	NR	NR	NR	NR
Methyl Chloride	NR	NR	NR	NR	NR	NR	NR
Methyl Ethyl Ketone	NR	NR	NR	NR	NR	NR	NR
Methyl Formate	?	?	?	?	NR	NR	NR
Methyl Iso-Butyl Ketone	NR	NR	NR	NR	NR	NR	NR
Methyl Methacrylate	R	?	R	?	NR	NR	NR
Methyl Salicylate	R	?	R	?	NR	NR	NR
Methyl Sulfate	R	NR	R	NR	?	?	?
Methyl Sulfuric Acid	R	R	R	R	?	?	?
Methylamine	NR	NR	NR	NR	NR	NR	NR
Methylene Bromide	NR	NR	NR	NR	NR	NR	NR
Petroleum Liquifier	R	R	R	R	?	?	?
Petroleum Oils (Sour)	R	NR	R	NR	C	C	C
Phenol	NR	NR	NR	NR	R	R	R
Phenyldiazine	NR	NR	NR	NR	NR	NR	NR
Phenyldiazine Hydrochloride	NR	NR	NR	NR	NR	NR	NR
Phosgene, Gas	R	?	R	?	NR	NR	NR
Phosgene, Liquid	NR	NR	NR	NR	NR	NR	NR
Phosphoric Acid, up to 85%	R	R	R	R	R	R	R
Phosphorous Pentoxide	R	NR	R	NR	R	R	R
Phosphorous Trichloride	NR	NR	NR	NR	NR	NR	NR
Phosphorous, (Yellow)	R	NR	R	NR	R	R	R
Photographic Solutions: Dektal Developer	R	R	R	R	?	?	?
Photographic Solutions: DK #3	R	R	R	R	?	?	?
Photographic Solutions: Kodak Fixer	R	R	R	R	?	?	?
Photographic Solutions: Kodak Short Stop	R	R	R	R	?	?	?
Picric Acid	NR	NR	NR	NR	NR	NR	NR
Plating Solutions: Brass	R	R	R	R	R	R	R
Plating Solutions: Cadmium	R	R	R	R	R	R	R
Plating Solutions: Copper	R	R	R	R	R	R	R
Plating Solutions: Gold	R	R	R	R	R	R	R
Plating Solutions: Indium	R	R	R	R	R	R	R
Plating Solutions: Lead	R	R	R	R	R	R	R
Plating Solutions: Nickel	R	R	R	R	R	R	R



CHEMICAL RESISTANCE DATA FOR PRESSURE PIPING

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CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Plating Solutions: Rhodium	R	R	R	R	R	R	R
Plating Solutions: Silver	R	R	R	R	R	R	R
Plating Solutions: Tin	R	R	R	R	R	R	R
Plating Solutions: Zinc	R	R	R	R	R	R	R
Polyethylene Glycol	?	?	?	?	NR	NR	NR
Potash (Sat. Aq.)	R	R	?	?	R	R	R
Potassium Acetate	R	R	R	R	R	R	R
Potassium Alum	R	R	R	R	R	R	R
Potassium Amyl Xanthate	R	NR	NR	NR	?	?	?
Potassium Bicarbonate	R	R	R	R	R	R	R
Potassium Bichromate	R	R	R	R	R	R	R
Potassium Bisulfate	R	R	R	R	R	R	R
Potassium Borate	R	R	R	R	R	R	R
Potassium Bromate	R	R	R	R	R	R	R
Potassium Bromide	R	R	R	R	R	R	R
Potassium Carbonate	R	R	R	R	R	R	R
Potassium Chlorate	R	R	R	R	R	R	R
Potassium Chloride	R	R	R	R	R	R	R
Potassium Chromate	R	R	R	R	R	R	R
Potassium Cyanate	R	R	R	R	R	R	R
Potassium Cyanide	R	R	R	R	R	R	R
Potassium Dichromate	R	R	R	R	R	R	R
Potassium Ethyl Xanthate	R	NR	NR	NR	?	?	?
Potassium Ferricyanide	R	R	R	R	R	R	R
Potassium Ferrocyanide	R	R	R	R	R	R	R
Potassium Fluoride	R	R	R	R	R	R	R
Potassium Hydroxide	R	R	R	R	R	R	R
Potassium Hypochlorite	R	R	R	R	R	R	R
Potassium Iodide	R	R	R	R	R	R	R
Potassium Nitrate	R	R	R	R	R	R	R
Potassium Perborate	R	R	R	R	R	R	R
Potassium Perchlorate	R	R	R	R	R	R	R
Potassium Permanganate 10%	R	R	R	R	R	R	R
Potassium Permanganate 25%	R	NR	R	NR	R	R	C
Potassium Persulfate	R	R	R	R	R	?	?
Potassium Phosphate	R	R	R	R	R	R	R
Potassium Sulfate	R	R	R	R	R	R	R
Potassium Sulfide	R	R	R	R	R	R	R
Potassium Sulfite	R	R	R	R	R	R	R
Potassium Triphosphosphate	R	R	R	R	R	R	R
Propane	R	R	R	R	C	C	C
Propane Gas	R	R	R	R	C	C	C
Propanol 0.5%	R	R	R	?	R	?	R
Propanol > 0.5%	R	R	R	NR	C	C	C
Propargyl Alcohol	R	R	R	NR	C	C	C
Propionic Acid 2%	?	?	?	?	R	R	R
Propionic Acid > 2%	?	?	?	?	NR	NR	NR
Propylene Dichloride	NR	NR	NR	NR	NR	NR	NR
Propylene Glycol 25%	?	?	?	?	C	C	C

CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Propylene Glycol > 25%	?	?	?	?	NR	NR	NR
Propylene Oxide	NR	NR	NR	NR	NR	NR	NR
Pyridine	NR	NR	NR	NR	NR	NR	NR
Pyrogalllic Acid	R	NR	R	NR	?	?	?
Rayon Coagulating Bath	R	R	R	R	?	?	?
Refinery Crudes	R	R	?	?	C	C	C
Rochelle Salts	R	R	?	?	R	R	R
Salicylic Acid	R	R	R	R	R	R	R
Santicizer	NR	NR	NR	NR	?	?	?
Sea Water	R	R	R	R	R	R	R
Selenic Acid	R	R	R	?	?	?	?
Sewage	R	R	R	R	R	R	R
Silicic Acid	R	R	R	R	R	?	?
Silicone Oil	?	?	?	?	R	?	?
Silver Chloride	R	R	R	R	R	R	R
Silver Cyanide	R	R	R	R	R	R	R
Silver Nitrate	R	R	R	R	R	R	R
Silver Sulfate	R	R	R	R	R	R	R
Soaps	R	R	R	R	R	R	R
Sodium Acetate	R	R	R	R	R	R	R
Sodium Alum	R	R	R	R	R	R	R
Sodium Arsenate	R	R	R	R	R	?	?
Sodium Benzoate	R	R	R	R	R	R	R
Sodium Bicarbonate	R	R	R	R	R	R	R
Sodium Bichromate	R	R	R	R	R	R	R
Sodium Bisulfate	R	R	R	R	R	R	R
Sodium Bisulfite	R	R	R	R	R	R	R
Sodium Borate	R	R	R	R	R	R	R
Sodium Bromide	R	R	R	R	R	R	R
Sodium Carbonate	R	R	R	R	R	R	R
Sodium Chlorate	R	NR	R	NR	R	R	R
Sodium Chloride	R	R	R	R	R	R	R
Sodium Chlorite	NR	NR	NR	NR	R	R	R
Sodium Chromate	R	R	R	R	R	R	R
Sodium Cyanide	R	R	R	R	R	R	R
Sodium Dichromate	R	R	R	R	R	R	R
Sodium Ferricyanide	R	R	R	R	R	R	R
Sodium Ferrocyanide	R	R	R	R	R	R	R
Sodium Fluoride	R	R	R	R	R	R	R
Sodium Formate	?	?	?	?	R	R	R
Sodium Hydroxide 50%	R	R	R	R	R	R	R
Sodium Hypobromite	R	R	R	R	R	R	R
Sodium Hypochlorite	R	R	R	R	R	R	R
Sodium Iodide	R	R	R	R	R	R	R
Sodium Metaphosphate	R	R	R	R	R	R	R
Sodium Nitrate	R	R	R	R	R	R	R
Sodium Nitrite	R	R	R	R	R	R	R
Sodium Perchlorate	R	R	R	R	R	R	R
Sodium Peroxide	R	R	R	R	R	R	R

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CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Sodium Silicate	R	NR	R	NR	R	R	R
Sodium Sulfate	R	R	R	R	R	R	R
Sodium Sulfide	R	R	R	R	R	R	R
Sodium Sulfite	R	R	R	R	R	R	R
Sodium Thiosulfate	R	R	R	R	R	R	R
Sodium Tripolyphosphate	?	?	?	?	R	R	R
Sour Crude Oil	R	R	R	R	C	C	C
Soybean Oil	R	R	R	R	NR	NR	NR
Stannic Chloride	R	R	R	R	R	R	R
Stannous Chloride	R	R	R	R	R	R	R
Stannous Sulfate	R	R	R	R	R	R	R
Starch	R	R	R	R	R	R	R
Stearic Acid	R	R	R	R	R	?	?
Stoddards Solvent	NR	NR	NR	NR	C	C	C
Styrene	NR	NR	NR	NR	NR	NR	NR
Succinic Acid	R	R	R	R	R	R	R
Sugar	R	R	R	R	R	R	R
Sulfamic Acid	NR	NR	NR	NR	R	R	R
Sulfite Liquor	R	R	R	R	?	?	?
Sulfur	R	R	R	R	R	?	?
Sulfur Dioxide dry	R	R	R	R	R	R	R
Sulfur Dioxide wet	R	NR	NR	NR	R	R	R
Sulfur Trioxide	R	R	R	R	R	R	R
Sulfuric Acid 70%	R	R	R	R	R	R	R
Sulfuric Acid 80%	R	R	NR	NR	R	R	R
Sulfuric Acid 85%	R	R	NR	NR	R	C	NR
Sulfuric Acid 90%	R	NR	NR	NR	R	C	NR
Sulfuric Acid 98%	?	NR	NR	NR	R	NR	NR
Sulfuric Acid Fuming	NR	NR	NR	NR	NR	NR	NR
Sulfuric Acid Pickling	R	R	?	?	R	R	R
Sulfurous Acid	R	R	R	R	?	?	?
Tall Oil	R	R	R	R	C	C	C
Tan Oil	R	R	R	R	?	?	?
Tannic Acid 30%	R	R	R	R	R	?	?
Tanning Liquors	R	R	R	R	?	?	?
Tartaric Acid	R	R	R	R	R	?	?
Terpenes	?	?	?	?	NR	NR	NR
Terpineol	R	?	R	?	NR	NR	NR
Tetraethyl Lead	R	?	R	NR	?	?	?
Texanol	?	?	?	?	NR	NR	NR
Thionyl Chloride	NR	NR	NR	NR	NR	NR	NR
Thread Cutting Oil	R	?	R	?	C	C	C
Titanium Tetrachloride	R	NR	R	NR	?	?	?
Toluol or Toluene	NR	NR	NR	NR	NR	NR	NR
Transformer Oil	R	R	R	R	C	C	C
Tributyl Citrate	R	?	R	?	NR	NR	NR
Tributyl Phosphate	NR	NR	NR	NR	NR	NR	NR
Trichloroacetic Acid	R	?	R	?	NR	NR	NR
Trichloroethylene	NR	NR	NR	NR	NR	NR	NR

CHEMICAL REAGENT	PVC Type 1 1120 (12454)		PVC Clear 2110 (12454)		CPVC Type IV Grade 1 4120 (23447)		
	73°F	140°F	73°F	140°F	73°F	140°F	180°F
Triethanolamine	R	NR	R	NR	NR	NR	NR
Trilonex	NR	NR	NR	NR	?	?	?
Trimethyl Propane	R	R	R	NR	?	?	?
Trimethylamine	R	NR	R	NR	?	?	?
Trisodium Phosphate	R	R	R	R	R	R	R
Turpentine	R	R	NR	NR	NR	NR	NR
Urea	R	R	R	R	R	R	R
Urine	R	R	R	R	R	R	R
Vaseline	NR	NR	NR	NR	?	?	?
Vegetable Oils	R	?	R	?	NR	NR	NR
Vinegar	R	R	R	R	R	R	R
Vinyl Acetate	NR	NR	NR	NR	NR	NR	NR
Water: Acid Mine	R	R	R	R	R	R	R
Water: Deionized	R	R	R	R	R	R	R
Water: Demineralized	R	R	R	R	R	R	R
Water: Distilled	R	R	R	R	R	R	R
Water: Fresh & Salt	R	R	R	R	R	R	R
Water: Swimming Pool	R	R	R	R	R	R	R
WD-40	?	?	?	?	C	C	C
Whiskey	R	R	R	R	R	R	R
White Liquor	R	R	R	R	R	R	R
Wines	R	R	R	R	R	R	R
Xylene or Xylol	NR	NR	NR	NR	NR	NR	NR
Zinc Acetate	R	R	R	R	R	R	R
Zinc Carbonate	R	R	R	R	R	R	R
Zinc Chloride	R	R	R	R	R	R	R
Zinc Nitrate	R	R	R	R	R	R	R
Zinc Sulfate	R	R	R	R	R	R	R



CHEMICAL RESISTANCE DATA FOR LabWaste™ CPVC DRAINAGE SYSTEM

Chemical Resistance Tables

The following Chemical Data for **LabWaste™** CPVC Drainage System table recommendations apply only to non-pressure, laboratory drainage applications, which are those characterized as the routine disposal of a wide variety of hot and cold chemicals in relatively small quantities accompanied by water for the purpose of dilution and flushing. This is an integral requirement of Prudent Laboratory Practices, regardless of piping material used. For use of **LabWaste™** CPVC products in continuous or dedicated chemical waste drainage systems, chemical resistance data for pressure applications must be followed (see preceding Chemical Resistance Data for Pressure Piping table).

Resistance Rating Codes

R = Recommended

C = Use with Caution.

N = Not Recommended.

--- = No data available

IMPORTANT NOTE: Chemical Resistance data is provide for material compatibility information purposes only and in no way addresses the legal discharge of chemicals into any waste system, some of which may be prohibited by law. Nor does the data address the compatibility of chemical mixtures, issues of hazardous decomposition, or other potentially dangerous circumstances that might be involved. Data is applicable to laboratory drainage systems only and may not be suitable for continuous service or pressure applications.

CHEMICAL	RATING	CHEMICAL	RATING	CHEMICAL	RATING
A		Ammonium Nitrate	R	Bromphenol Blue	R
Acacia, Gum Arabic	R	Ammonium Persulfate	R	Bromthymol Blue	R
Acetaldehyde	R	Ammonium Phosphate	R	Butadiene	R
Acetamide	R	Monobasic/Dibasic	R	Butane	R
Acetic Acid Vapor 25%	R	Ammonium Sulfate	R	Butyl Acetate	C
Acetic Acid 60%	R	Ammonium Sulfite	R	Butyl Alcohol	C
Acetic Acid 85%	R	Ammonium Sulfite	R	Butyl Cellosolve	R
Acetic Acid Glacial	R	Ammonium Thiocyanate	R	n-Butyl Chloride	---
Acetic Anhydride	R	Amyl Acetate	C	Butylene (C)	---
Acetone	R	Amyl Alcohol 1%	R	Butyl Phenol	C
Acetophenone	C	Amyl Alcohol >1%	C	Butyl Phthalate	---
Acetyl Chloride	R	n-Amyl Chloride	C	Butyl Stearate	---
Acetylene	N	Aniline	C	Butynediol	---
Acetylnitrile	R	Aniline Chlorohydrate	C	Butyric Acid	R
Acetylsalicylic acid, aspirin	R	Aniline Hydrochloride	C		
Acrylic Acid	R	Anthraquinone	R	C	
Acrylonitrile	R	Anthraquinone	R	Cadium Cyanide	R
Adenine, 6-aminopurine	R	Sulfonic Acid	R	Calcium Acetate	R
Adenosine Triphosphate	R	Antimony Trichloride	R	Calcium Bisulfide	R
Adipic Acid	R	Aqua Regia	R	Calcium Bisulfate	R
Agarose	R	Argon	---	Calcium Carbonate	R
Alizarin stain		Arsenic Acid	R	Calcium Chlorate	R
Mordant Red 11	R	Aryl Sulfonic Acid	R	Calcium Chloride	R
Alizarin Red S		Ascorbic Acid	R	Calcium Fluoride	R
Mordant Red 3	R	L-Asparagine	R	Calcium Hydroxide	R
Alizarin Yellow R		Asphalt	N	Calcium Hypochlorite	R
Mordant Orange 1	R			Calcium Nitrate	R
Allyl Alcohol	R	B		Calcium Oxide	R
Allyl Chloride	N	Barium Acetate	R	Calcium Sulfate	R
Aluminum Acetate	R	Barium Carbonate	R	Camphor	---
Aluminum Ammonium	R	Barium Chloride	R	Cane Sugar Liquors	R
Aluminum Chloride	R	Barium Hydroxide	R	Caprylic Acid	---
Aluminum Fluoride	R	Barium Nitrate	R	Carbitol	---
Aluminum Hydroxide	R	Barium Sulfate	R	Carbolic Acid	R
Aluminum Nitrate	R	Barium Sulfide	R	Carbon Dioxide Dry	R
Aluminum Oxychloride	R	Beer	R	Carbon Dioxide Wet	R
Aluminum Potassium	R	Beer Sugar Liquors	R	Carbon Disulfide	C
Aluminum Potassium Sulfate, Alum	R	Benzaldehyde	R	Carbon Monoxide	R
Aluminum Sulfate	R	Benzene	C	Carbon Tetrachloride	N
Ammonia Anhydrous	R	Benzene Sulfonic Acid	R	Carbonic Acid	R
Ammonia Gas	R	Benzoic Acid	R	Castor Oil	C
Ammonia Liquid	R	Benzyl Alcohol	R	Caustic Potash	R
Ammonia Acetate	R	Bismuth Carbonate	R	Caustic Soda	R
Ammonium Bicarbonate	R	Bluret	R	Cellosolve	C
Ammonium Bifluoride	R	Black Liquor	R	Cellosolve Acetate	R
Ammonium Bisulfide	R	Bleach 5%	R	Chloral Hydrate	R
Ammonium Bromide	R	Bleach 12%	R	Chloramine	R
Ammonium Carbonate	R	Blood	R	Chloric Acid	R
Ammonium Chloride	R	Borax	R	Chloric Acid 20%	R
Ammonium Citrate	R	Boric Acid	R	Chlorine, Aqueous	R
Ammonium Dichromate	R	Brake Fluid	---	Chlorinated Water 10 PPM	R
Ammonium Dihydrogen Phosphate	R	Brine	R	Chlorinated Water Sat'd	R
Ammonium Ferric Sulfate	R	Brilliant Blue G-250	R	Chloroacetic Acid	R
Ammonium Ferrous Sulfate	R	Brilliant Blue R-250	R	Chloroacetyl Chloride	---
Ammonium Fluoride 10%	R	Brilliant Cresyl Blue	R	Chlorobenzene	N
Ammonium Fluoride 25%	R	Brilliant Green	R	Chlorobenzyl Chloride	N
Ammonium Hydroxide		Bromocresal Green	R	Chloroform	N
10% - 28%	R	Bromocresal purple	R	Chlorophenol Red	R
Ammonium Hydroxide		Bromic Acid	R	Chloropicrin	---
100%	R	Bromine Liquid	R	Chlorosulfonic Acid	R
Ammonium Iodide	R	Bromine Vapor	R	Chromic Acid 10%	R
		Bromine Water	R	Chromic Acid 30%	R
		Bromotoluene	---	Chromic Acid 40%	R

CHEMICAL RESISTANCE DATA FOR LabWaste™ CPVC DRAINAGE SYSTEM



CHEMICAL	RATING
Chromic Acid 50%	C
Chromium	R
Chromium Tetroxide	R
Citric Acid	R
Clayton Yellow	R
Coconut Oil	C
Coffee	R
Congo Red solution	R
Copper Acetate	R
Copper Carbonate	R
Copper Chloride	R
Copper Cyanide	R
Copper Fluoride	R
Copper Nitrate	R
Copper Sulfate	R
Corn Oil	C
Corn Syrup	R
Cottonseed Oil	C
m-Cresal Purple	R
Cresal Red	R
Creosote	N
Cresol	N
Cresylic Acid	R
Croton Aldehyde	R
Crude Oil	R
Cumene	C
Cupric Chloride	R
Cupric Fluoride	R
Cupric Nitrate	R
Cupric Sulfate	R
Cuprous Chloride	R
Cyclohexane	R
Cyclohexanol	R
Cyclohexanone	R
D	
Decahydronaphthalene	R
Detergents	R
Dextrin	R
Dextrose	R
Diacetone Alcohol	R
Diastase of malt	R
Dibutoxyethyl Phthalate	N
Dibutyl Ether	R
Dibutyl Phthalate	N
Dibutyl Sebacate	N
Dichlorobenzene	R
Dichloroethylene	N
2,6 - Dichloroindophenal	R
Diesel Fuels	R
Diethylamine	R
Diethyl Cellosolve	R
Diethyl Ether	R
Diglycolic Acid	R
Dimethylamine	R
Dimethyl Formamide	R
Dimethylhydrazine	R
Dimethyl Phthalate	N
Dimethyl Sulfoxide	R
Diethyl Phthalate	N
Dodecyl Alcohol	R
Dodecyl Sulfate	R
Dioxane	R
Diphenyl Oxide	---
Disodium Phosphate	R
Drierite	R
E	
Eosin Y	R
Eriochrome Black T	R
Ether	R
Ethyl Acetate	R
Ethyl Acetoacetate	R
Ethyl Acrylate	R
Ethyl Alcohol	R
Ethyl Benzene	C
Ethyl Chloride	N
Ethyl Chloroacetate	N
Ethylene Bromide	N
Ethylene Chloride	N
Ethylene Chlorohydrin	N
Ethylenediamine	R
Ethylene Dichloride	N
Ethylene Glycol	C
Ethylene Oxide	R

CHEMICAL	RATING
Ethyl Ether	R
Ethyl Formate	R
Ethylene Glycol	R
2-Ethylhexanol	R
Ethyl Mercaptan	R
Ethyl Oxalate	R
F	
Fast Green FCF	R
Fatty Acids	R
Fehlings solution A	R
Fehlings solution B	R
Ferric Ammonium Sulfate	R
Ferric Chloride	R
Ferric Hydroxide	R
Ferric Nitrate	R
Ferric Sulfate	R
Ferrous Chloride	R
Ferrous Hydroxide	R
Ferrous Nitrate	R
Ferrous Sulfate	R
Fish Oil	R
Fluoboric Acid	R
Fluorine Gas (Dry)	R
Fluorine Gas (Wet)	R
Fluosilicic Acid 30%	R
Fluosilicic Acid 50%	R
Formaldehyde Dilute	R
Formaldehyde 35%	R
Formaldehyde 37%	R
Formaldehyde 50%	C
Formic Acid	R
Freon	R
Freon 12	R
Freon 21	---
Freon 22	R
Freon 113	C
Freon 114	---
Fructose	R
Furfural	R
G	
Gallic Acid	R
Gasoline	R
Gasohol	R
Gelatin	R
Glauber's Salt	---
Glucose	R
Glue, PVA	R
Glutathione	R
Glycerine	R
Glycine	R
Glycogen	R
Glycol	C
Glycol Amine	---
Glycolic Acid	R
Glyoxal	R
Grape Sugar	R
Grease	---
Green Liquor	R
H	
Heptane (Type 1)	R
n-Hexane	R
Hexamethylenediamine	R
Hexanol, Tertiary	R
Hydraulic Oil	---
Hydrazine	R
Hydrobromic Acid 20%	R
Hydrobromic Acid 50%	R
Hydrochloric Acid 10%	R
Hydrochloric Acid 30%	R
Hydrocyanic Acid	R
Hydrofluoric Acid Dilute	R
Hydrofluoric Acid 30%	R
Hydrofluoric Acid 50%	R
Hydrofluoric Acid 100%	R
Hydrofluosilicic Acid 50%	R
Hydrogen	R
Hydrogen Cyanide	R
Hydrogen Fluoride	C
Hydrogen Peroxide 50%	R
Hydrogen Peroxide 90%	R
Hydrogen Phosphide	R

CHEMICAL	RATING
Hydrogen Sulfide Dry	R
Hydrogen Sulfide Wet	R
Hydrogen Sulfide, aqueous	R
Hydroquinone, aqueous	R
Hydroxylamine Hydrochloride	R
Hydroxylamine Sulfate	R
Hypochlorous Acid	R
I	
Indigo Carmine	R
Inks	R
Iodine	R
Iodine solution, Lugol's	R
Iron Phosphate	---
Isobutane	C
Isobutyl Alcohol	R
Isocetane	R
Isopropyl Acetate	R
Isopropyl Alcohol	R
Isopropyl Chloride	N
Isopropyl Ether	R
Isophorone	R
J	
Janus Green	R
JP-3 Fuel	R
JP-4 Fuel	R
JP-5 Fuel	R
JP-6 Fuel	R
K	
Kerosene	R
Ketchup	R
Kraft Liquors	R
L	
Lactic Acid 25%	R
Lactic Acid 80%	R
Lactose	R
Lard Oil	C
Latex	---
Lauric Acid	R
Lauryl Chloride	R
Lead Acetate	R
Lead Chloride	R
Lead Nitrate	R
Lead Sulfate	R
Lemon Oil	R
Ligroin	R
Limonene	R
Lime Slurry	R
Lime Sulfur	R
Linoleic Acid	C
Linoleic Oil	---
Linseed Oil	C
Liqueurs	R
Lithium Bromide	R
Lithium Carbonate	R
Lithium Chloride	R
Lithium Hydroxide 50%	R
Lithium Nitrate	R
Lithium Sulfate	R
Lubricating Oil #1	R
Lubricating Oil #2	R
Lubricating Oil #3	R
Ludox	---
Luminol 3-amino	R
Phthalhydrazide	R
DL-lysine Hydrochloride	R
Lysozyme	R
M	
Magnesium Acetate	R
Magnesium Bromide	R
Magnesium Carbonate	R
Magnesium Chloride	R
Magnesium Citrate	R
Magnesium Fluoride	---
Magnesium Hydroxide	R
Magnesium Nitrate	R
Magnesium Oxide	---
Magnesium Sulfate	R
Malachite Green	R



CHEMICAL	RATING	CHEMICAL	RATING	CHEMICAL	RATING
Maleic Acid	R	Orange G - acid orange 10	R	Potassium Nitrate	R
Malic Acid	R	Orange IV - acid orange 5	R	Potassium Nitrite	R
Maltose	R	Orcinol	R	Potassium Perborate	R
Manganese Chloride	R	Osmium Tetroxide	R	Potassium Perchlorate	R
Manganese Nitrate	R	Oxalic Acid	R	Potassium Permanganate 10%	R
Manganese Sulfate	R	Oxygen Gas	R	Potassium Permanganate 25%	R
Menthol	R	Ozone	R	Potassium Persulfate	R
Mercuric Chloride	R	Ozonized Water	R	Potassium Phosphate	R
Mercuric Cyanide	R			Potassium Sodium Tartrate	R
Mercuric Sulfate	R			Potassium Sulfate	R
Mercurous Nitrate	R			Potassium Sulfide	R
Mercury	R			Potassium Sulfite	R
Methane	R			Potassium Thiocyanate	R
Methanol	R			Propane	R
DL-methionine	R			Propargyl Alcohol	R
Methoxyethyl Oleate	---			Propionic Acid	R
Methyl Acetate	R			Propyl Acetate	---
Methyl Acetone	R			Propyl Alcohol	R
Methyl Acrylate	---			N-Propyl Bromide	---
Methyl Amine	R			Propylene Dichloride	N
Methyl Bromide	N			Propylene Glycol	R
Methyl Cellulosolve	R			Propylene Oxide	R
Methyl cellulose	R			Pyridine	R
Methyl Chloride	N			Pyrogalllic Acid	R
Methyl Chloroform	N			Pyrrrole	R
Methyl Ethyl Ketone	R				
Methyl Formate	R				
Methyl Green	R				
Methyl Isobutyl Carbinol	R				
Methyl Isobutyl Ketone	R				
Methyl Isopropyl Ketone	R				
Methyl Methacrylate	R				
Methyl Red	R				
Methyl Sulfate	R				
Methyl Violet-2B	R				
Methyl Violet-6B	R				
Methylene Blue	R				
Methylene Bromide	N				
Methylene Chloride	N				
Methylene Chlorobromide	N				
Methylene Iodine	N				
Methylsulphuric Acid	R				
Milk	R				
Mineral Oil	R				
Molasses	R				
Monochloroacetic Acid	R				
Monochlorobenzene	N				
Monoethanolamine	R				
Monosodium Glutamate	R				
Motor Oil	R				
Morpholine	R				
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CHEMICAL RESISTANCE DATA FOR LabWaste™ CPVC DRAINAGE SYSTEM



CHEMICAL	RATING
Sodium Metaphosphate	R
Sodium Nitrate	R
Sodium Nitrite	R
Sodium Palmirate	R
Sodium Perborate	R
Sodium Perchlorate	R
Sodium Periodate	R
Sodium Peroxide	R
Sodium Phosphate Acid	R
Sodium Phosphate Alkaline	R
Sodium Phosphate Neutral	R
Sodium Propionate	R
Sodium Silicate	R
Sodium Sulfate	R
Sodium Sulfide	R
Sodium Sulfite	R
Sodium Thiosulphate	R
Sour Crude Oil	R
Soybean Oil	C
Stannic Chloride	R
Stannous Chloride	R
Stannous Sulfate	R
Starch	R
Stearic Acid	R
Streptomycin Sulfate	R
Strontium Bromide	R
Strontium Chloride	R
Styrene	N
Succinic Acid	R
Sugar	R
Sulfamic Acid	R
Sulfate Liquors	R
Sulfite Liquors	R
Sulfur	R
Sulfur Chloride	R
Sulfur Dioxide Gas Dry	R
Sulfur Dioxide Gas Wet	R
Sulfur Trioxide Gas Dry	---
Sulfur Trioxide Gas Wet	N
Sulfuric Acid Up to 30%	R
Sulfuric Acid 50%	R
Sulfuric Acid 60%	R
Sulfuric Acid 70%	R
Sulfuric Acid 80%	R
Sulfuric Acid 90%	R
Sulfuric Acid 93%	R
Sulfuric Acid 94%	R
Sulfuric Acid 95%	R
Sulfuric Acid 96%	R
Sulfuric Acid 98%	R
Sulfuric Acid 100%	R
Sulfurous Acid	R
T	
Tall Oil	R
Tannic Acid	R
Tanning Liquors	R
Tar	C
Tartaric Acid	R
Terpineol	---
Tetrachloroethane	N
Tetrachloroethylene	N
Tetracycline hydrochloride	R
Tetraethyl Lead	R
Tetrahydrofuran	R
Tetralin	N
Thiamine Hydrochloride	R
Thionin	R
Thionyl Chloride	R
Thymol	R
Titanium Dioxide	R
Titanium Tetrachloride	R
Toluene	C
Tomato Juice	R
Transformer Oil	R
Transformer Oil DTE/30	R
Tributyl Citrate	---
Tributyl Phosphate	R
Trichloroacetic Acid	R
Trichloroethylene	N
Triethanolamine	R
Triethylamine	R
Trimethylpropane	R

CHEMICAL	RATING
Trisodium Phosphate	R
Trypsin	R
Tung Oil	C
Turpentine	C
U	
Urea	R
Urease	R
Urine	R
V	
Varnish	---
Vaseline	C
Vegetable Oil	C
Vinegar	R
Vinyl Acetate	R
W	
Water, Acid Mine	R
Water, Deionized	R
Water, Distilled	R
Water, Potable	R
Water, Salt	R
Water, Sea	R
Water, Soft	R
Water, Waste	R
Whiskey	R
White Liquor	R
Wine	R
X	
Xylene	C
Z	
Zinc Acetate	R
Zinc Carbonate	R
Zinc Chloride	R
Zinc Nitrate	R
Zinc Stearate	R
Zinc Sulfate	R



INDUSTRY STANDARDS & TEST METHODS

Spears[®] products are manufactured in strict compliance with applicable industry standards and specifications to ensure strength, durability and safety. Although not inclusive, the following list of internationally recognized standards, specifications, test methods and practices relate to PVC and CPVC thermoplastic piping products and related components.

ASTM STANDARD SPECIFICATIONS

ASTM D 1784	Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D 1785	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe- Schedules 40- 80 and 120
ASTM D 6263	Standard Specification for Extruded Bars Made From Rigid Poly (Vinyl Chloride) (PVC) and Chlorinated Poly (Vinyl Chloride) (CPVC)
ASTM D 2464	Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings- Schedule 80
ASTM D 2467	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings- Schedule 80
ASTM D 2241	Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure Rated Pipe (SDR Series)
ASTM F 441	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe- Schedules 40 and 80
ASTM F 442	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)
ASTM D 2672	Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement
ASTM D 2846	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems
ASTM D 2466	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings- Schedule 40
ASTM D 3139	Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D 2665	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain-Waste- and Vent Pipe and Fittings
ASTM F 437	Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings- Schedule 80
ASTM F 438	Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings- Schedule 40
ASTM F 439	Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings- Schedule 80
ASTM F 477	Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F 480	Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR)- Schedule 40 and Schedule 80
ASTM F 493	Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
ASTM F 656	Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM F 913	Standard Specification for Thermoplastic Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM D 1866	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Schedule 40 Drainage and DWV Fabricated Fittings

ASTM STANDARD TEST METHODS

ASTM D 1598	Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
ASTM D 1599	Standard Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe & Fittings
ASTM D 2837	Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials
ASTM D 2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D 2444	Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
ASTM D 2564	Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D 2152	Standard Test Method for Adequacy of Fusion by Acetone Immersion
ASTM D 2122	Standard Test Method for Determining Dimensions of Thermoplastic Pipe & Fittings
ASTM F 610	Standard Test Method for Evaluating the Quality of Molded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings by the Heat Reversion Technique

ASTM STANDARD PRACTICES

ASTM D 2855	Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D 2774	Standard Practice for Underground Installation of Thermoplastic Pressure Piping
ASTM D 2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM F 402	Standard Practice for Safe Handling of Solvent Cements- Primers- and Cleaners Used for Joining Thermoplastics Pipe and Fittings
ASTM F 690	Standard Practice for Underground Installation of Thermoplastic Pressure Piping Irrigation System
ASTM F 1057	Standard Practice for Evaluating the Quality of Extruded Poly (Vinyl Chloride) (PVC) Pipe by the Heat Reversion Technique
ASTM F 645	Standard Guide for Selection- Design- and Installation of Thermoplastic Water Pressure Systems



CSA STANDARD

CSA B137.3-99	Rigid Polyvinyl Chloride (PVC) Pipe for Pressure Applications
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FIRE PERFORMANCE

ULC-S102.2-M88	Standard Method of Test for Surface Burning Characteristics of Flooring- Floor Covering- and Miscellaneous Materials and Assemblies
UL 723	Test for Surface Burning Characteristics of Building Materials
UL1821	Thermoplastic Sprinkler Pipe and Fittings for Fire Protection Service
UL 1887	Standard for Safety for Fire Test of Plastic Sprinkler Pipe for Flame and Smoke Characteristics
UL 94	Test for Flammability of Plastic Materials for Parts in Devices and Appliances
FM1635	Plastic Pipe & Fittings for Automatic Sprinkler Systems
FM4910	Clean Room Materials Flammability Test Protocol
ASTM E 84	Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM D 635	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Manufacturing in a Horizontal Position
ASTM E 162	Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source
ASTM D 2863	Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Manufacturing (Oxygen Index)

TOXICOLOGY

NSF Standard 61	Drinking Water System Components - Health Effects
NSF Standard 14	Manufacturing Piping System Components and Related Materials
United States FDA Code of Federal Regulations	Title 21



INDUSTRY PIPING FORMULAS

Pressure Rating

$$P = \frac{2St}{D-t} \quad S = \frac{P(D-t)}{2t}$$

P is the pressure rating in psi.

S is the Hydrostatic Design Basis (usually 4000 psi) divided by the safety factor (which is 2 for the three standards).

DR is the Dimension Ratio for D2241 and C905 but is OD/t for D1785

Where:

P = pressure, psi

S = circumferential stress, psi

D = outside diameter of pipe, inches

d = inside diameter of pipe, inches (average based on mean wall)

t = average wall thickness, inches

Volume capacity-gallons per ft. length = VG = V x 0.004329

Volume capacity-cubic inches per ft. length = V = 0.7854 x d² x 12

Outside pipe surface, sq. ft per ft. length = AO = $\frac{D^2 \pi}{12}$

Inside pipe surface, sq. ft. per ft. length = A_I = $\frac{d \pi}{12}$

Cross-sectional plastic area, sq. in. = A = $\frac{(D^2 - d^2) \pi}{4}$

Cross sectional flow area, sq. in. = A_F = $\frac{d^2 \pi}{4}$

Weight of PVC pipe, lb. per ft. length = W_{PVC} = .632 x A

Weight of CPVC pipe, lb. per ft. length = W_{CPVC} = .705 x A

Weight of water in pipe, lb. per ft. length = W_W = 0.433 A_F

Weight of water filled pipe, lb. per ft. length = W_{WFP} = W_{PVC} (or W_{CPVC}) + W_W

Radius of gyration, inches = r_g = $\sqrt{\frac{D^2 + d^2}{4}}$

Moment of inertia, inches fourth = I = A r_g² .0491 (D⁴ - d⁴)

Section modulus, inches cube = Z = $\frac{2I}{D}$ / = 0.0982 x $\frac{(D^4 - d^4)}{D}$

Thermal Expansion and Contraction

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

Where:

Δ L = expansion or contraction of pipe in inches

y = Coefficient of thermal expansion

(see PVC or CPVC material Thermal properties)

L = Length of pipe run in feet

Δ T = Temperature change °F (Maximum temperature – Temperature @ Installation or maximum system temperature – lowest system temperature, whichever is greater)



Friction Loss (Hazen-Williams equations)

$$f = .2083 \times (100/C)^{1.852} \times \frac{G^{1.852}}{d^{4.8655}}$$

Where:

f = friction head of feet of water per 100' for the specific pipe size and I.D.

C = a constant for internal pipe roughness (=150 for thermoplastic pipe)

G = flow rate of U.S. gallons per minute

d = inside diameter of pipe in inches

Water Velocities

$$V = .3208 \times \frac{G}{A}$$

Where:

V = velocity in feet per second

G = gallons per minute

A = inside cross sectional area in square inches

Gallons Per Minute Through Pipe

$$\text{GPM} = 0.0408 \times \text{Pipe Diameter Inches}^2 \times \text{Feet Per Minute Velocity}$$

Pressure Drop in Valves

$$P = \frac{G^2 \times S_g}{C_v^2}$$

Where:

P = Pressure drop in PSI; feet of water = PSI/.4332

G = Gallons per minute

S_g = Specific gravity of liquid

C_v = Gallons per minute per 1 PSI pressure drop (see Valve product C_v from manufacturer)

Water Conversions

1 foot of head = 0.434 PSI

1 gallon = 231 cubic inch = 8.333 pounds

1 pound water = 27.7 cubic inches

1 cubic foot water = 7.5 gallon = 62.5

pounds (salt water = 64.3 pounds)

1 miner's inch = 9 to 12 gallons per minute

$$\text{Horsepower to Raise Water} = \frac{\text{Gallons Per Minute} \times \text{Total Head in Feet}}{3960}$$



BASIC CONVERSIONS

VOLUME

<u>Convert From</u>	<u>Into</u>	<u>Multiply By</u>
Acre-feet	Cu feet	43560
	Cu meters	1233.482
	Cu yards	1613.33
Cu Centimeters	Gallons (US)	3.259×10^5
	Cu feet	3.5315×10^{-5}
	Cu inches	0.06102
	Cu meters	1×10^{-6}
	Cu yards	1.308×10^{-6}
	Gallons (US liq)	0.00026
	Liters	0.00099
	Ounces (US liq)	0.03381
Cu Feet	Pints (US liq)	0.00211
	Quarts (US liq)	0.00106
	Acre-feet	2.296×10^{-5}
	Cu centimeters	28316.8
	Cu inches	1728.0
	Cu meters	0.02832
	Cu yards	0.03704
	Gallons (US liq)	7.48052
	Liters	28.316
	Ounces (US liq)	957.506
Cu Inches	Pints (US liq)	59.8442
	Quarts (US liq)	29.922
	Acre-feet	1.329×10^{-8}
	Cu centimeters	16.3871
	Cu feet	0.000579
	Cu meters	1.639×10^{-5}
	Cu yards	2.143×10^{-5}
	Gallons (US liq)	0.00433
	Liters	0.01639
	Ounces (US liq)	0.55411
Cu Meters	Pints (US liq)	0.03463
	Quarts (US liq)	0.01732
	Acre-feet	0.00081
	Cu centimeters	1×106
	Cu feet	35.147
	Cu inches	61023.7
	Cu yards	1.30795
	Gallons (US liq)	264.172
	Liters	999.97
	Pints (US liq)	2113.38
Cu Yards	Quarts (US liq)	1056.69
	Acre-feet	6.198×10^{-4}
	Cu centimeters	764554.9
	Cu feet	27
	Cu inches	46656
	Cu meters	0.76455
	Gallons (US liq)	201.974
	Liters	764.553
	Quarts (US liq)	807.896

VOLUME - continued

<u>Convert From</u>	<u>Into</u>	<u>Multiply By</u>
Gallons (US liq)	Acre-feet	3.068×10^{-6}
	Cu centimeters	3785.41
	Cu feet	0.13368
	Cu inches	231
	Cu meters	0.00378
	Cu yards	0.00495
	Liters	3.7853
	Ounces (US liq)	128
	Pints (US liq)	8
	Quarts (US liq)	4
Liters	Acre-feet	8.106×10^{-7}
	Cu centimeters	1.000.03
	Cu feet	0.03532
	Cu inches	61.002
	Cu meters	0.00100003
	Cu yards	0.00131
	Gallons (US liq)	0.26148
	Ounces (US liq)	33.81497
	Pints (US liq)	2.1134
	Quarts (US liq)	1.0567
Ounces (US liq)	Cu Centimeters	29.5737
	Cu inches	1.80469
	Cu meters	2.957×10^{-5}
	Gallons (US liq)	0.00781
	Liters	0.02957
	Pints (US liq)	0.0625
	Quarts (US liq)	0.0312
	Cu Centimeters	473.176
	Cu feet	0.01671
	Cu inches	28.875
Pints (US liq)	Cu yards	0.000619
	Gallons (US liq)	0.125
	Liters	0.47316
	Quarts (US liq)	0.5

PRESSURE

<u>Convert From</u>	<u>Into</u>	<u>Multiply By</u>
Atmospheres	BAR	1.01325
	Ft H ₂ O @ 68°F	33.96
	Grams/sq cm	1033.23
	In Hg @ 32°F	29.9213
	In H ₂ O @ 68°F	407.5
	Kg/sq cm	1.03322
	Kg/sq meter	10332
	kilo Pascals	101.3
	mm Hg @ 32°F	760
	Pounds/sq ft	2116
	Pounds/sq in	14.6960

BASIC CONVERSIONS



PRESSURE - continued

Convert From	Into	Multiply By
BAR	Atmospheres	0.98692
	Ft H ₂ O @ 68°F	33.51
	Grams/sq cm	1019.72
	In Hg @ 32°F	29.530
	In H ₂ O @ 68°F	407.5
	Kg/sq cm	1.01972
	Kg/sq meter	10197
	kilo Pascals	100
	mm Hg @ 32°F	0.1333
	Pounds/sq ft	2089.0
	Pounds/sq in	14.5038
Ft H ₂ O @ 68°F	Atmospheres	0.98692
	BAR	2.984 X 10 ⁻²
	In Hg @ 32°F	0.8812
	In H ₂ O @ 68°F	12
	Kg/sq cm	3.043 X 10 ⁻²
	Kg/sq meter	304.3
	kilo Pascals	2.984
	mm Hg @ 32°F	22.38
	Pounds/sq ft	62.32
	Pounds/sq in	0.4328
Grams/sq cm	Atmospheres	0.00097
	BAR	0.00098
	In Hg @ 32°F	0.02896
	Kg/sq cm	1.01972
	Kg/sq meter	1000
	kilo Pascals	100
	mm Hg @ 32°F	0.73556
	Pounds/sq ft	2.0481
	Pounds/sq in	0.01422
In Hg @32°F	Atmospheres	0.03342
	BAR	0.03386
	Ft H ₂ O @ 68°F	1.135
	Grams/sq cm	34.532
	In H ₂ O @ 68°F	13.62
	Kg/sq cm	3.453 X 10 ⁻²
	Kg/sq meter	345.3
	kilo Pascals	3.386
	mm Hg @ 32°F	25.4
	Pounds/sq ft	70.73
	Pounds/sq in	0.4912
In H ₂ O @ 68°F	Atmospheres	2.454 X 10 ⁻³
	BAR	2.49 X 10 ⁻³
	Ft H ₂ O @ 68°F	8.333 X 10 ⁻²
	In Hg @ 32°F	7.343 X 10 ⁻²
	Kg/sq cm	2.53 X 10 ⁻³
	Kg/sq meter	25.38
	kilo Pascals	0.249
	mm Hg @ 32°F	1.865
	Pounds/sq ft	5.197
	Pounds/sq in	3.609 X 10 ⁻²

PRESSURE - continued

Convert From	Into	Multiply By
Kg/sq cm	Atmospheres	0.9678
	BAR	0.98066
	Ft H ₂ O@68°F	32.87
	In Hg @32°F	28.959
	In H ₂ O @ 68°F	394.4
	Kg/sq meter	1 X 10 ⁴
	kilo Pascals	98.07
	mm Hg @32°F	735.6
	Pounds/sq ft	2048
	Pounds/sq in	14.22
Kg/sq meter	Atmospheres	9.678 X 10 ⁻⁵
	BAR	9.807 X 10 ⁻⁵
	Ft H ₂ O@68°F	3.287 X 10 ⁻³
	Grams/sq cm	0.1
	In Hg @32°F	0.0029
	In H ₂ O @ 68°F	3.944 X 10 ⁻²
	Kg/sq cm	0.001
	kilo Pascals	9.807 X 10 ⁻³
	mm Hg @32°F	0.07356
	Pounds/sq ft	0.20482
	Pounds/sq in	1.422 X 10 ⁻³
kilo Pascals	Atmospheres	9.869 X 10 ⁻³
	BAR	0.01
	Ft H ₂ O@68°F	0.3351
	In Hg @32°F	0.2953
	In H ₂ O @ 68°F	4.022
	Kg/sq cm	1.02 X 10 ⁻²
	Kg/sq meter	102
	mm Hg @32°F	7.501
	Pounds/sq ft	20.89
	Pounds/sq in	0.145
mm Hg @32°F	Atmospheres	1.316 X 10 ⁻³
	BAR	1.333 X 10 ⁻³
	Ft H ₂ O@68°F	4.468 X 10 ⁻²
	Grams/sq cm	1.3595
	In Hg @32°F	3.937 X 10 ⁻²
	In H ₂ O @ 68°F	0.5362
	Kg/sq cm	1.36 X 10 ⁻³
	Kg/sq meter	13.595
	kilo Pascals	0.1333
	Pounds/sq ft	2.7845
	Pounds/sq in	0.0193
Pounds/sq ft	Atmospheres	4.73 X 10 ⁻⁴
	BAR	4.79 X 10 ⁻⁴
	Ft H ₂ O@68°F	1.605 X 10 ⁻²
	Grams/sq cm	0.48824
	In Hg @32°F	2.036
	In H ₂ O @ 68°F	0.1926
	Kg/sq cm	4.88 X 10 ⁻⁴
	Kg/sq meter	4.882
	kilo Pascals	4.79 X 10 ⁻²
	mm Hg @32°F	0.3591
	Pounds/sq in	6.945 X 10 ⁻³



BASIC CONVERSIONS

PRESSURE - continued

Convert From	Into	Multiply By
Pounds/sq in	Atmospheres	6.805×10^{-2}
	BAR	6.895×10^{-2}
	Ft H ₂ O @ 68°F	1.605×10^{-2}
	Grams/sq cm	70.307
	In Hg @ 32°F	2.036
	In H ₂ O @ 68°F	27.73
	Kg/sq cm	7.031×10^{-2}
	Kg/sq meter	703.1
	kilo Pascals	6.895
	mm Hg @ 32°F	51.72
	Pounds/sq ft	144

VELOCITY (Distance-time)

Convert From	Into	Multiply By
Feet/day	Feet/ second	1.157×10^{-5}
	Kilometers/hour	1.27×10^{-5}
	Meters/second	3.528×10^{-6}
	Miles/hour	7.891×10^{-6}
Feet/ second	Feet/ day	8.64×10^4
	Kilometers/hour	1.097
	Meters/second	0.3048
	Miles/hour	0.6818
Kilometers/hour	Feet/day	7.874×10^4
	Feet/ second	0.9113
	Meters/second	0.2778
	Miles/hour	0.6214
Meters/second	Feet/day	2.835×10^5
	Feet/ second	3.281
	Kilometers/hour	3.6
	Miles/hour	2.237
Miles/hour	Feet/day	1.267×10^5
	Feet/ second	1.467
	Kilometers/hour	1.609
	Meters/second	0.447

DISCHARGE RATES (Volume-time)

Convert From	Into	Multiply By
Acre-feet/day	Cu feet/second	0.5042
	Cu meters/day	1234
	Gallons/minute	226.3
	Liters/second	14.28
	Acre-feet/day	1.983
Cu feet/second	Cu meters/day	2447
	Gallons/minute	448.8
	Liters/second	28.32
	Acre-feet/day	6.051×10^6
Cu meters/day	Cu feet/second	3.051×10^6
	Gallons/minute	1.369×10^9
	Liters/second	8.64×10^7
	Acre-feet/day	4.419×10^{-3}
Gallons/minute	Cu feet/second	2.228×10^{-3}
	Cu meters/day	5.45
	Liters/second	6.309×10^{-2}
	Acre-feet/day	6.309×10^{-2}

DISCHARGE RATES - continued

Convert From	Into	Multiply By
Liters/second	Acre-feet/day	7.005×10^{-2}
	Cu feet/second	3.531×10^{-2}
	Cu meters/day	86.4
	Gallons/minute	15.85

TORQUE

Convert From	Into	Multiply By
Foot-pounds	Inch-pounds	12
	KF force-meters	1382.552×10^{-4}
Inch-pounds	Newton-meters	1.356
	Foot-pounds	0.8333
	KF force-meters	11547.344×10^{-6}
	Newton-meters	11559.357×10^{-5}
KF force-meters	Foot-pounds	7.233
	Inch-pounds	86.8
Newton-meters	Newton-meters	9.807
	Foot-pounds	7374.631×10^{-4}
	Inch-pounds	8.651
	KF force-meters	10196.798×10^{-5}

DENSITY

Convert From	Into	Multiply By
Pounds/Cu inch	Pounds/Cu feet	1728
	Pounds/gallon	231
	Grams/Cu cm	27.68
	Grams/liter	2.768×10^4
Pounds/Cu feet	Pounds/Cu inch	5.787×10^{-4}
	Pounds/gallon	0.1337
	Grams/Cu cm	1.6×10^{-2}
	Grams/liter	16.02
Pounds/gallon	Pounds/Cu inch	4.33×10^{-3}
	Pounds/Cu feet	7.481
	Grams/Cu cm	0.1198
	Grams/liter	119.8
Grams/Cu cm	Pounds/Cu inch	3.61×10^{-2}
	Pounds/Cu feet	62.43
	Pounds/gallon	8.345
	Grams/liter	1000
Grams/liter	Pounds/Cu inch	3.61×10^{-5}
	Pounds/Cu feet	6.24×10^{-2}
	Pounds/gallon	8.35×10^{-3}
	Grams/Cu cm	0.001

ENERGY

Convert From	Into	Multiply By
British Thermal Unit (BTU)	Foot-pound	777.9
	Horsepower-hr	3.929×10^{-4}
	Joules	1055
	Calorie	252
Kilowatt-hr	Kilowatt-hr	2.93×10^{-4}
	Foot-pound	777.9

BASIC CONVERSIONS



ENERGY - continued

<u>Convert From</u>	<u>Into</u>	<u>Multiply By</u>
Foot-pound	BTU	1.285×10^{-3}
	Horsepower-hr	5.051×10^{-7}
	Joules	1.356
	Calorie	0.3239
	Kilowatt-hr	3.766×10^{-7}
Horsepower-hr	BTU	2545
	Foot-pound	1.98×10^6
	Joules	2.685×10^6
	Calorie	6.414×10^5
	Kilowatt-hr	0.7457
Joules	BTU	9.481×10^{-4}
	Foot-pound	0.7376
	Horsepower-hr	3.725×10^{-7}
	Calorie	0.2389
	Kilowatt-hr	2.778×10^{-7}
Calorie	BTU	3.968×10^{-3}
	Foot-pound	3.087
	Horsepower-hr	1.559×10^{-6}
	Joules	4.186
	Kilowatt-hour	1.163×10^{-6}
Kilowatt-hr	BTU	3413
	Foot-pound	2.655×10^6
	Horsepower-hr	1.341
	Joules	3.6×10^6
	Calorie	8.601×10^5

MASS

<u>Convert From</u>	<u>Into</u>	<u>Multiply By</u>
Ounce	Pound	0.0625
	Kilogram	0.02834952
	Short ton	3.125×10^{-5}
	Long ton	2.79×10^{-5}
	Metric ton	2.835×10^{-5}
Pound	Ounce	16
	Kilogram	0.4536
	Short ton	0.0005
	Long ton	0.0004464
	Metric ton	0.0004536
Kilogram	Ounce	35.27396
	Pound	2.20462
	Short ton	0.001102
	Long ton	0.00098
	Metric ton	0.091
Short ton	Ounce	32000
	Pound	2000
	Kilogram	907.18
	Long ton	0.89266
	Metric ton	0.90718
Long ton	Ounce	35840
	Pound	2240
	Kilogram	1016.05
	Short ton	1.12
	Metric ton	1.10605



Words, Terms, & Phrases Used in the Plastic Industry

ABRASION RESISTANCE: Ability to withstand the effects of repeated wearing, rubbing, scraping, etc.

ACCEPTANCE TESTING: Testing performed on a product to determine whether or not an individual lot of the product conforms with specified requirements.

ACIDS: One of a class of substances compounded of hydrogen and one or more other elements, capable of uniting with a base to form a salt, and in aqueous solution, turning blue litmus paper red.

ACRYLATE RESINS: A class of thermoplastic resins produced by polymerization of acrylic acid derivatives.

ACRYLONITRILE-BUTADIENE-STYRENE (ABS) PIPE AND FITTING PLASTICS: Plastics containing polymers or blends of polymers containing butadiene, acrylonitrile, and styrene or substituted styrene plus lubricants, stabilizers, and colorants.

ADHESIVE: A substance capable of holding materials together by surface attachment.

AGING: The effect of time on plastics exposed indoors at ordinary conditions of temperature and relatively clean air.

ALKALIES: Compounds capable of neutralizing acids and usually characterized by an acrid taste. Can be mild like baking soda or highly caustic like lye.

ALIPHATIC: Derived from or related to fats and other derivatives of the paraffin hydrocarbons, including unsaturated compounds of the ethylene and acetylene series.

ALKYD RESINS: A class of resins produced by condensation of a polybasic acid or anhydride and a polyhydric alcohol.

ALLYL RESINS: A class of resins produced from an ester or other derivative of allyl alcohol by polymerization.

ANIONS: Atoms or group of atoms carrying a negative charge. The charge results because there are more electrons than protons in the anion. Anions can be a source of micro contamination in high purity water applications.

ANNEAL: To prevent the formation of or remove stresses in plastics parts by controlled cooling from a suitable temperature.

APPARENT DENSITY: The weight per unit volume of a material including voids inherent in the material as tested.

AROMATIC: A large class of cyclic organic compounds derived from, or characterized by the presence of the benzene ring and its homologs.

AUTHORITY HAVING JURISDICTION (AHJ): the individual official, board, department, or agency established and authorized by a state, county, city, or other political subdivision, created by law to administer and enforce specified requirements.

BACKFILL: All material used to fill the trench from bedding to finished surface.

BACKFILL, FINAL: Material used to fill the trench from initial backfill to finished surface.

BACKFILL, INITIAL: Material used to fill the trench from top of bedding to a designated height over the pipe.

BACKFILL, UNCONSOLIDATED: Non-compacted material in place in trench.

BEAM LOADING: The application of a load to a pipe between two points of support, usually expressed in newtons (or pounds force) and the distance between the centers of the supports.

BEDDING, n: Materials placed in the bottom of the trench on top of the foundation soil which provides stable bottom support for buried pipe including the trench bottom groove support angle or select material placed around the pipe, and envelope or filter materials where used during insulation.

BEDDING, v: Placement of support materials for buried pipe.

BELL END: The enlarged portion of a pipe that resembles the socket portion of a fitting and that is intended to be used to make a joint.

BEVELED PIPE: A pipe with an end chamfered to assist in assembly into a socket connection.

BLISTER: Undesirable rounded elevation of the surface of a plastic, whose boundaries may be either more or less sharply defined, somewhat resembling in shape a blister on the human skin. A blister may burst and become flattened.

BOND: To attach by means of an adhesive.

BRITTLE FAILURE: A pipe failure mode which exhibits no visible (to the naked eye) permanent material deformation (stretching, elongation, or necking down) in the area of the break.

BUILDING SANITARY SEWER: That part of the horizontal piping of a sanitary drainage system which extends from the building sanitary drain, receives the discharge of the building sanitary drain, and conveys it to a public sewer, private sewer, individual sewage disposal system, or other point of disposal.

BUILDING STORM SEWER: That part of the horizontal piping of a storm drainage system which extends from the building storm drain, receives the discharge of the building storm drain, and conveys it to a public storm sewer, private storm sewer, or other point of disposal.

BURNED: Showing evidence of thermal decomposition through some discoloration, distortion, or destruction of the surface of the plastic.

CALENDERING: A process by which a heated rubber plastic product is squeezed between heavy rollers into a thin sheet or film. The film may be frictioned into the interstices of cloth, or it may be coated onto cloth or paper.

CAST RESIN: A resinous product prepared by pouring liquid resins into a mold and heat treating the mass to harden it.

CATALYSIS: The acceleration (or retardation) of the speed of a chemical reaction by the presence of a comparatively small amount of a foreign substance called a catalyst.

CATIONS: Atoms or group of atoms carrying a positive charge. The charge results because there are more protons than electrons in the cation. Cations can be a source of micro contamination in high purity water applications.



CELLULOSE: Inert substance, chemically a carbohydrate, which is the chief component of the solid structure of plants, wood, cotton, linen, etc.

CELLULOSE ACETATE: A class of resins made from a cellulose base, either cotton linters or purified wood pulp, by the action of acetic anhydride and acetic acid.

CEMENT: A dispersion of "solution" of unvulcanized rubber or a plastic in a volatile solvent. This meaning is peculiar to the plastics and rubber industries and may or may not be an adhesive composition (See also Solvent Cement).

CHLORINATED POLY VINYL CHLORIDE PLASTICS (CPVC): Plastics based on chlorinated poly (vinyl chloride) in which the chlorinated poly (vinyl chloride) is in the greatest amount by weight.

COALESCENCE: The union or fusing together of fluid globules or particles to form larger drops or a continuous mass.

COEXTRUSION: A process whereby two or more heated or unheated plastic material streams forced through one or more shaping orifice(s) become one continuously formed piece.

COLD FLOW: Change in dimensions or shape of some materials when subjected to external weight or pressure at room temperature.

COMPACTION, SOIL: Act of packing soil with mechanical force to increase its density.

COMPOSITE PIPE: Pipe consisting of two or more different materials arranged with specific functional purpose to serve as pipe.

COMPOUND: A combination of ingredients before being processed or made into a finished product. Sometimes used as a synonym for material, formulation.

CONDENSATION: A chemical reaction in which two or more molecules combine, usually with the separation of water or some other simple substance.

CONDUCTIVITY: Inverse of resistivity, used to assess ionic concentration by measuring conductance of flow of electric current.

CONDUIT: A tubular raceway for carrying electric wires, cables, or other conductors.

COPOLYMER: The product of simultaneous polymerization of two or more polymerizable chemicals, commonly known as monomers.

CRAZING: Fine cracks at or under the surface of a plastic.

CREEP: The unit elongation of a particular dimension under load for a specific time following the initial elastic elongation caused by load application. It is expressed usually in inches per inch per unit of time.

CROSS LINKING: The formation of a three dimensional polymer by means of interchain reactions resulting in changes in physical properties.

CURE TIME (Solvent Cement): The necessary waiting period before pressurizing newly assembled joints in which the solvents in the cement must evaporate to produce joint strength.

DEGRADATION: A deleterious change in the chemical structure of a plastic.

DEIONIZED RESINS (DI RESINS): Electrically charged synthetic resin beads (typically produced from polystyrene resins) used to remove ionic contaminants as a means of purifying water through the ion exchange process.

DEIONIZED WATER (DI WATER): Water that has been purified by removing dissolved solids through an ion exchange process where ionic contaminants are removed.

DELAMINATION: The separation of the layers of material in a laminate.

DETECTION LIMIT (DL): With regard to micro contaminant analysis, it is the lowest measurable quantity of a particular element that is detectable by the analytical detection method used.

DETERIORATION: A permanent change in the physical properties of a plastic evidenced by impairment of these properties.

DIELECTRIC CONSTANT: Specific inductive capacity. The dielectric constant of a material is the ratio of the capacitance of a condenser having that material as dielectric to the capacity of the same condenser having a vacuum as dielectric.

DIELECTRIC STRENGTH: This is the force required to drive an electric current through a definite thickness of the material; the voltage required to break down a specified thickness of insulation.

DIFFUSION: The migration or wandering of the particles or molecules of a body of fluid matter away from the main body through a medium or into another medium.

DIMENSIONAL STABILITY: Ability of a plastic part to maintain its original proportions under conditions of use.

DIMENSION RATIO (DR): The average specified diameter of a pipe or tubing divided by the minimum specified wall thickness. The DR values shall be rounded to the nearest 0.5 unless otherwise specified (See also Standard Dimensional Ratio).

DUCTILE FAILURE: A pipe failure mode which exhibits material deformation (stretching, elongation, or necking down) in the area of the break.

DUROMETER: Trade name of the Shore Instrument Company for an instrument that measures hardness. The rubber or plastics durometer determines the "hardness" of rubber or plastics by measuring the depth of penetration (without puncturing) of blunt needle compressed on the surface for a short period of time.

DYNAMIC LEACH ANALYSIS: Relates to analytical testing of piping materials that are tested during exposure to UPW under flowing conditions. Under flowing conditions (dynamic), grab samples of high purity water are periodically pulled from the water flowing through the pipe and are subjected to leach analysis to quantify TOC, anions, cations & trace metals and other leachable contaminants that may be present under flowing conditions. Dynamic leach analysis also enables "on-line" testing of other potential contamination by continually monitoring resistivity, particles, and TOC overtime.



GLOSSARY OF TERMS

ELASTIC LIMIT: The load at which a material will no longer return to its original form when the load is released.

ELASTOMER: The name applied to substances having rubber like properties.

ELECTRICAL PROPERTIES: Primarily the resistance of a plastic to the passage of electricity, e.g. dielectric strength.

ELONGATION: The capacity to take deformation before failure in tension and is expressed as a percentage of the original length.

EMBEDMENT: The placement of materials completely around the pipe to provide support.

EMULSION: A dispersion of one liquid in another possible only when they are mutually insoluble.

ENVIRONMENTAL STRESS CRACKING (ESC): The development of cracks in a material that is subjected to stress or strain in the presence of specific chemicals.

ESTER: A compound formed by the elimination of water during the reaction between an alcohol and an acid; many esters are liquids. They are frequently used as plasticizers in rubber and plastic compounds.

ETHYL CELLULOSE: A thermoplastic material prepared by the ethylation of cellulose by diethyl sulfate or ethyl halides and alkali.

EXTRUSION: A process in which heated or unheated plastic is forced through a shaping orifice (a die) in one continuously formed shape as film, sheet, rod, or tubing.

EXTENDER: A material added to a plastic composition to reduce its cost.

FABRICATE: Method of forming a plastic into a finished article by machining, drawing, and similar operations.

FILLER: A material added to a plastic composition to impart certain qualities in the finished article.

FITTING: A piping component used to join or terminate sections of pipe or to provide changes of direction or branching in a pipe system.

FLEXURAL STRENGTH: The outer fiber stress, which must be attained in order to produce a given deformation under a beam load.

FORMULATION: A combination of ingredients before being processed or made into a finished product. Sometimes used as a synonym for material, compound.

FUSE: To join two plastic parts by softening the material by heat or solvents.

GATE: In an injection mold, a constriction in the flow channel between the runner and the mold cavity.

GENERIC: Common names for types of plastic materials. They may be either chemical terms or coined names. They contrast with trademarks, which are the property of one company.

GRAVITY FLOW: Liquefied medium conveyance that is induced by a positive elevation head such as a downward pipeline slope or a higher elevation reservoir.

GRAY WATER: The waste water of a system that may be a combination of the liquid and water-carried wastes except human wastes.

HARDNESS: A comparative gauge of resistance to indentation, not of surface hardness or abrasion resistance.

HEAT RESISTANCE: The ability to withstand the effects of exposure to high temperature. Care must be exercised in defining precisely what is meant when this term is used. Descriptions pertaining to heat resistance properties include: boilable, washable, cigarette proof, sterilizable, etc.

HIGH-DENSITY POLYETHYLENE PLASTICS (HDPE): *n*—those linear polyethylene plastics, g.v., having a standard density of 0.941 g/cm³ or greater.

HOOP STRESS: The circumferential stress imposed on a cylindrical wall by internal pressure loading.

IONIC CONTAMINATION: Electrically charged atoms or groups of atoms that can be a source of micro contamination in high purity water applications. Ionic contaminants are typically removed by the ion exchange (deionization) process (i.e. deionized water).

IMPACT STRENGTH: Resistance or mechanical energy absorbed by a plastic part to such shocks as dropping and hard blows.

IMPERMEABILITY: Permitting no passage into or through a material.

INJECTION MOLDING: Method of forming a plastic to the desired shape by forcing heat softened plastic into a relatively cool cavity where it rapidly solidifies.

KETONES: Compounds containing the carbonyl group (CO) to which is attached two alkyl groups. Ketones, such as methyl ethyl Ketone, are commonly used as solvents for resins and plastics.

LIGHT STABILITY: Ability of a plastic to retain its original color and physical properties upon exposure to sun or artificial light.

LIGHT TRANSMISSION: The amount of light that a plastic will pass.

LONGITUDINAL STRESS: The stress imposed on the long axis of any shape. It can be either a compressive or tensile stress.

LOW-DENSITY POLYETHYLENE PLASTICS (LDPE): *n*—those branched polyethylene plastics, q.v., having a standard density of 0.910 to 0.925 g/cm³.

LUBRICANT: A substance used to decrease the friction between solid faces, and sometimes used to improve processing characteristics of plastic compositions.

MODULUS: The load in pounds per square inch or kilos per square centimeter of initial cross sectional area necessary to produce a stated percentage elongation which is used in the physical testing of plastics.

MOISTURE RESISTANCE: Ability to resist absorption of water.



MONOMER: The simplest repeating structural unit of a polymer; for addition polymers this represents the original unpolymerized compound.

NON FLAMMABLE: Will not support combustion.

NON-PRESSURE RATED PIPE (NPR): Pipe designed for gravity-conveyed medium which must resist only intermittent static pressures and does not have a pressure rating.

NONRIGID PLASTIC: A plastic which has a stiffness or apparent modulus of elasticity of not over 10,000 psi at 23°C which is determined in accordance with the Standard Method of Test for Stiffness in Flexure of Plastics.

NON TOXIC: Non poisonous.

ORANGE PEEL: Uneven surface somewhat resembling an orange peel.

ORGANIC CHEMICAL: Originally applied to chemicals derived from living organisms, as distinguished from “inorganic” chemicals found in minerals and inanimate substances; modern chemists define organic chemicals more exactly as those, which contain the element carbon.

PHENOLIC RESINS: Resins made by reaction of a phenol compound or tar acid with an aldehyde; more commonly applied to thermosetting resins made from pure phenol.

PLASTIC: A material that contains as an essential ingredient an organic substance of large molecular weight, is solid in its finished state, and, at some stage in its manufacture or in its processing into finished articles, can be shaped by flow.

PLASTICITY: A property of plastics and resins which allows the material to be deformed continuously and permanently without rupture upon the application of a force that exceeds the yield value of the material.

PLASTICIZER: A liquid or solid incorporated in natural and synthetic resins and related substances to develop such properties as resiliency, elasticity, and flexibility.

POLYETHYLENES: A class of resins formed by polymerizing ethylene, a gas obtained from petroleum hydrocarbons.

POLYMER: A product resulting from a chemical change involving the successive addition of a large number of relatively small molecules (monomer) to form the polymer, and whose molecular weight is usually a multiple of that of the original substance.

POLYMERIZATION: Chemical change resulting in the formation of a new compound whose molecular weight is usually a multiple of that of the original substance.

POLYPROPYLENE (PP): *n*—a polymer prepared by the polymerization of propylene as the sole monomer.

POLYVINYL CHLORIDE (PVC): Polymerized vinyl chloride, a synthetic resin, which when plasticized or softened with other chemicals has some rubber like properties. It is derived from acetylene and anhydrous hydrochloric acid.

POROSITY: Presence of numerous visible voids.

POWER FACTOR: The ratio of the power in watts delivered in an alternating current circuit (real power) to the volt-ampere input (apparent power). The power factor of

insulation indicates the amount of the power input, which is consumed as a result of the impressed voltage forcing a small leakage current through the material.

PRESSURE RATING (PR): The estimated maximum water pressure the pipe is capable of withstanding continuously with a high degree of certainty that failure of the pipe will not occur.

PRIMER: An organic solvent or a blend of solvents, which enhances adhesion, applied to plastic pipe and fittings prior to application of a solvent cement.

QUICK BURST TEST: An internal pressure test designed to produce failure of a piping component over a relatively short period of time, usually measured in seconds. Quick Burst tests are typically specified as a 60 to 70 second test in applicable ASTM Standards for pipe and fittings.

RECYCLED PLASTIC: A thermoplastic material recovered from usually melt processed scrap of varying sources, sometimes completely different in form from their original state.

RESILIENCE: Usually regarded as another name for elasticity. While both terms are fundamentally related, there is a distinction in meaning. Elasticity is a general term used to describe the property of recovering original shape after a deformation. Resilience refers more to the energy of recovery; that is, a body may be elastic but not highly resilient.

RESIN: An organic substance, generally synthetic, which is used as a base material for the manufacture of some plastics.

RESISTIVITY: As related to high purity water systems, it is used to assess ionic contaminant concentrations by measuring opposition to the flow of electric current in the water, and is typically measured in meg-ohms (expressed as meg-ohm resistivity of the water) to quantify the water purity.

REWORK PLASTIC: A thermoplastic plastic from a manufacturer's own production that has been reground or pelletized for reuse by that same manufacturer.

RO WATER (REVERSE OSMOSIS): Water that has been stripped of contaminants (purified) through the reverse osmosis purification process. Reverse osmosis is a filtration process whereby pressurized feed water flows across a membrane. The filtered water is known as permeate because it has penetrated the membrane. The RO process removes most organic compounds, up to 99% of all ions, and is more efficient than many alternate water purification methods.

RIGID PLASTIC: A plastic which has a stiffness or apparent modulus of elasticity greater than 100,000 psi at 23°C when determined in accordance with the Standard Method of Test for Stiffness in Flexure of Plastics.

SIMULATED WEATHERING: The exposure of plastics to cyclic laboratory conditions of high and low temperatures, high and low relative humidities, and ultraviolet radiant energy in an attempt to produce changes in their properties similar to those observed on long time continuous exposure outdoors. The laboratory exposure conditions are usually intensified beyond those encountered in actual outdoor exposure in an attempt to achieve an accelerated effect.



GLOSSARY OF TERMS

SIMULATED AGING: The exposure of plastics to cyclic laboratory conditions of high and low temperatures, and high and low relative humidities in an attempt to produce changes in their properties similar to those observed on long time continuous exposure to conditions of temperature and relative humidity commonly encountered indoors or to obtain an acceleration of the effects of ordinary indoor exposure. The laboratory exposure conditions are usually intensified beyond those actually encountered in an attempt to achieve an accelerated effect.

SOLVENT: The medium within which a substance is dissolved; most commonly applied to liquids used to bring particular solids into solution, e.g., acetone is a solvent for PVC.

SOLVENT CEMENT: Dissolved plastic resin or compound in a suitable solvent or mixture of solvents. The solvent cement dissolves the surfaces of the pipe and fittings to form a bond (weld) between the mating surfaces provided the proper cement is used for the particular materials and proper techniques are followed.

SOLVENT CLEANER: An organic solvent used to remove foreign matter from the surface of plastic pipe and fittings.

SPECIFIC GRAVITY: Ratio of the mass of a body to the mass of an equal volume of water at 4°C, or some other specified temperature.

SPECIFIC HEAT: Ratio of the thermal capacity of a substance to that of water at 15°C.

STABILIZER: A chemical substance, which is frequently added to plastic compounds to inhibit undesirable changes in the material, such as discoloration due to heat or light.

STANDARD DIMENSION RATIOS (SDR): A specific ratio of the average specified outside diameter to the minimum specified wall thickness (D0/t) for outside diameter-controlled plastic pipe.

STATIC LEACH ANALYSIS: Relates to analytical testing of materials that are tested during exposure to UPW (or other test medium) under static or non-flowing conditions (soak). Test method is used to quantify the degree of micro contaminants that are extracted or “leached” from the material being immersed. Various test methods are utilized to quantify any leachates detected.

STRAIN: The change per unit of length in a linear dimension of a body, that accompanies a stress. Strain is a dimensionless quantity which may be measured conveniently in percent, in inches per inch, in millimeters per millimeter, etc.

STRENGTH: The mechanical properties of a plastic, such as a load or weight carrying ability, and ability to withstand sharp blows. Strength properties include tensile, flexural, and tear strength, toughness, flexibility, etc.

STRESS CRACK: External or internal cracks in a plastic caused by tensile stresses less than that of its short time mechanical strength.

STYRENE PLASTICS: Plastics based on polymers of styrene or copolymers of styrene with other monomers, the styrene being the greatest amount by mass.

SUSTAINED PRESSURE TEST: A constant internal pressure test for an extended period of time. One thousand hours is a commonly used period of time in pipe and fitting tests.

TEAR STRENGTH: Resistance of a material to tearing (strength).

TENSILE STRENGTH: The capacity of a material to resist a force tending to stretch it. Ordinarily the term is used to denote the force required to stretch a material to rupture, and is known variously as “breaking load”, “breaking stress”, “ultimate tensile strength”, and sometimes erroneously as “breaking strain”. In plastics testing, it is the load in pounds per square inch or kilos per square centimeter of original cross-sectional area, supported at the moment of rupture by a piece of test sample on being elongated.

THERMAL CONDUCTIVITY: Capacity of a plastic material to conduct heat.

THERMAL EXPANSION: The increase in length of a dimension under the influence of a change in temperature.

THERMOPLASTIC MATERIALS: Plastic materials that repeatedly can be softened by heating and hardened by cooling through a temperature range characteristic of the plastic, and that in the softened state can be shaped by flow into articles by molding or extrusion.

THERMOSET MATERIALS: Plastic materials, which undergo a chemical change and harden permanently when heated in processing. Further heating will not soften these materials.

TOTAL ORGANIC CARBON (TOC): A measurement of total organic carbon (synonymous with total oxidizable carbon and total organic chemicals) that is used to quantify organic contamination present in water. Organic matter plays a major role in water systems, as it affects biogeochemical processes, nutrient cycling, biological availability, chemical transport and interactions. It also has direct implications in the planning of water treatment and equipment. Organic matter content is typically measured as total organic carbon and dissolved organic carbon. Organic matter in water consists of thousands of components, including macroscopic particles, colloids, dissolved macromolecules, and specific compounds. As a result, the concentration of TOC's present within the water can be of a concern in high purity water as it is a form of micro contamination.

TRANSLUCENT: Permitting the passage of light, but diffusing it so that objects beyond cannot be clearly distinguished.

VINYL CHLORIDE PLASTICS: Plastics based on resins made by the polymerization of vinyl chloride or co polymerization of vinyl chloride with minor amounts (not over 50 per cent) of other unsaturated compounds.

ULTRAPURE WATER (UPW): Water that has been purified by various methods and/or combination of methods (i.e. Reverse Osmosis, deionization etc.). The produced water is extremely pure and contains no to very low concentration of salts, organic/pyrogene components, oxygen, suspended solids and bacteria. Water quality standards are used to define the purity requirements of the UPW based on the intended application. Ultrapure water is a very aggressive cleaning agent and is used in a variety of industries (semiconductor, pharmaceutical, health care, electronics etc.) where maintaining high purity is a requirement.

VINYL PLASTICS: Plastics based on resins made from vinyl monomers, except those specifically covered by other classifications, such as acrylic and styrene plastics. Typical vinyl plastics are polyvinyl chloride, polyvinyl acetate, polyvinyl alcohol, and polyvinyl butyral, and copolymers of vinyl monomers with unsaturated compounds.

VIRGIN PLASTIC: A plastic material in the form of pellets, granules, powder, or liquid that has not been subjected to use or processing other than that required for its initial manufacture.

VISCOSITY: The property of resistance to flow exhibited within the body of a material.

VOLATILE: Property of liquids to pass away by evaporation.

VOLUME RESISTIVITY: The electrical resistance of a 1 centimeter cube of the material expressed in ohm centimeters.

WATER ABSORPTION: The percentages by weight of water absorbed by a sample immersed in water. Dependent upon area exposed.

WATER VAPOR TRANSMISSION: The penetration of a plastic by moisture in the air.

WEATHER RESISTANCE: The ability of a plastic to retain its original physical properties and appearance under prolonged exposure to outdoor weather.

WELDING: The joining of two or more pieces of plastic by fusion of the material in the pieces at adjoining or nearby areas either with or without the addition of plastic from another source.

YIELD POINT: The point at which a material will continue to elongate at no substantial increase in load during a short test period.

YIELD STRESS: The force, which must be applied to a plastic to initiate flow.



SPEARS® PRODUCT LINE OVERVIEW



PLASTIC PIPE FITTINGS & VALVES

Ball Valves & 3-Way Ball Valves - PVC & CPVC

True Union 2000 - 1/2" - 8" • Compact 1/2" - 6" (PVC & CPVC) •
Single Entry 1/2" - 4" (PVC Gray & White) • Utility 1/2" - 6" (PVC Gray, White & CPVC)

Lab Valve Ball Valves - PVC & CPVC

With Tubing Adapter Kits 1/4" • General Purpose Valves 1/4" - 3/8"

PVC, CPVC & Polypropylene Industrial Swing Check Valves

Fully Serviceable • Quick Response • Flanged End Connection 3/4" - 8"

PVC Utility Swing Check & Spring Check Valves

White/Clear • Regular 1/2" - 8" • True Union Socket/Thread
& Compression End 1/2" - 4"

PVC In-line Adjustable Spring Check Valves

Male-Female • Female-Male • Female-Female Thread 1/2" - 1"

PVC & CPVC Diaphragm Check Valves

Self-Closing Design • Socket & Thread Style

PVC & CPVC Butterfly Check Valves

Wafer • Flanged • Thread • Spigot • Grooved Style 2" - 24"

PVC & CPVC Y-Pattern & Y-Check Valves

Socket • SR Thread • True Union Socket/Thread • Flanged 1/2" - 4"

Ball Check Valves - PVC & CPVC

True Union 1/2" - 8"

Diaphragm Valves - PVC, CPVC & Polypropylene

True Union Socket/Thread & SR Thread Style 1/2" - 2" •
Spigot Style 1/2" - 2" • Flanged Style 1/2" - 8"

PVC & CPVC Gate & Plug Gate Valves

Socket/Thread 1/2" - 4" • Flanged 1/2" - 6"

PVC & CPVC Globe Valves

Flanged 2-1/2" - 6"

Butterfly Valves - PVC, CPVC & Polypropylene

PVC & CPVC 1-1/2" - 14" • Polypropylene 1-1/2" - 60"

High Purity Butterfly Valves - PTFE Lined

Patented Non-Elastomer Contact Disc & Liner Seal •
Gear Operated 2" - 6"

Factory Actuated Valves

True Union Ball Valves 1/2" - 6" • Diaphragm Valves 1/2" - 8" •
Butterfly Valves 1-1/2" - 60" • Electric • Pneumatic •
Unitized Actuated Diaphragm Valves 1/2" - 2"





SPEARS® PRODUCT LINE OVERVIEW

PVC Schedule 40 Fittings

White • Clear • Black •
Injection Molded 1/4" - 12" •
Unions 1/4" - 6" •
Fabricated Fittings through 24"

PVC Schedule 80 Fittings

Injection Molded Fittings 1/4" - 12" •
Unions 1/4" - 6" • Molded Flanges 1/2" - 16" •
Fabricated Fittings & Flanges through 24"

Schedule 80 Polypropylene Fittings

Special Reinforced (SR)
Plastic Thread Design
Sizes 1/2" - 2"

CPVC Schedule 80 Fittings

Injection Molded Fittings 1/4" - 12" •
Unions 1/4" - 6" • Molded Flanges 1/2" - 12" •
Fabricated Fittings & Flanges through 16"

CPVC CTS (Copper Tube Size) Pipe, Fittings & Valves

Injection Molded Fittings 1/2" - 2" • Patented SR Female
Adapters 1/2" - 1" • Socket Style Valves 1/2" - 2" • CTS Pipe 1/2" - 2" •
1/4-Turn Angle Supply Stop 1/2" - 1/2"x3/8"

PVC & CPVC Special Reinforced (SR) Fittings & Adapters

Patented Reinforcement Design Eliminates Split Threads •
Schedule 40 • Schedule 80 • CTS • Fire Sprinkler Adapters •
Selected Fittings • Female Adapters • Unions 1/2" - 6"

PVC & CPVC Clamp-On Saddles

Injection Molded 2-piece Saddle With Bolt Hardware •
Piloted O-ring Seal • Patented SR Threads •
Single or Double Outlet Configurations •
For Pipe Sizes 2" - 12" • Socket/Thread Outlets 1/2" - 6"

PVC & CPVC Tank Adapters

Strong Buttress Thread Adapter Nut 1/2" - 8" •
Neoprene • EPDM • FKM Gasket

Insert Fittings

PVC Multi Configurations 1/2" - 8" •
PVC & PP No-Clamp 3/8" Spiral Barbed Insert •
Couplings • Tees • 90° Elbows

CPVC Fire Sprinkler Pipe & Fittings

Multiple Fitting Configurations & Pipe 3/4" - 3" •
UL, FM & LPC Approved • **TorqueSafe™**
Gasket Sealed Head Adapter • SR Head Adapters •
Grooved Couplings • Unions • Flanges



PVC Heavy Duty Swing Joints

Multiple Configurations • Multiple Outlets 1", 1-1/4", 1-1/2" •
Spigot • MIPT • FIPT • SR FIPT • Male Acme Thread •
Buttress Thread Internal Connections • 315 PSI Rating

PVC & CPVC Threaded Pipe Nipples

Schedule 80 • Lengths to 48" • Pipe Sizes 1/8" - 12"

PVC Irrigation Specialties

Irrigation Filters • Hose Filters • Hose Fittings •
Sprinkler Sleds • Dri-Splice Waterproof Connectors •
Manifold Fittings

PVC Schedule 40 Water Well Fittings

Caps • Couplings • Adapters 4-1/2" - 5"

PVC & CPVC Fabricated Duct Fittings

Vent Caps • Dampers • Fittings through 24"

PVC & CPVC Fabricated Fittings & Manifolds

Multiple Standard Configurations •
Specialty Fittings sizes 36" through 48" •
Low Head • PIP • Class • DWV •
Low Pressure Schedule 40 & 80 • Risers •
Flanges • Adapters • Gasketed Fittings

PVC White & Gray Compression Couplings

Buna-N, EPDM Gaskets • Sizes 1/2" - 6"

PVC & CPVC Repair Couplings

EPDM or FKM Seals • Sizes 1/2" - 6"

PVC Molded DWV Fittings

ASTM D 2665 • 1-1/2" - 12"

PVC Backwater Valves

With Optional Extensions • Socket 2" - 6"

PVC & CPVC Industrial Pipe & Duct

CPVC Schedule 40 & Schedule 80 Pipe •
PVC Schedule 80 Pipe •
PVC & CPVC Fume & Air Duct •
Sizes through 12"





SPEARS® PRODUCT LINE OVERVIEW



LabWaste™ CPVC Corrosive Waste Drainage System

Solvent Cement Welded System •
Pipe - Cement - Fittings •
Sizes 1-1/2" - 12"

Low Extractable High Purity PVC System Pipe, Valves & Fittings Specialty Line

Sizes 1/2" - 6" Solvent Cement Weld System

Complete Double Containment Systems in Virtually Any Size

Constructed with Spears® Quality Fittings

Expansion Joints Compensate For Thermal Expansion & Contraction

O-ring sealed, telescoping, design 1/2" - 14"

Hot-Tap Saddles For Branch Line Connections Under Pressure

2" - 6" Saddles with 3/4" - 1-1/2" Outlets

PVC & CPVC Y-Strainers

Gray or Clear • Multiple Screen Options •
Socket, SR Thread, Union •
Sizes 1/2" - 4"

PVC & CPVC Basket Strainers

Full Flow Design 2" - 12"
Single & Duplex

PVC & CPVC Tee-Style Filters

50 & 100 GPM • 2-1/2"/3" x 2-1/2"/3" Inlet/Outlet

Assorted Process Monitoring Fittings

Gauge Guards • Needle Valves • Gauge Saddles •
Gauge & Probe Tees Featuring Special
Reinforced (SR) Thread Connections

Low VOC Solvent Cements & Primer

PVC, CPVC, ABS, ABS-TO-PVC, Multipurpose,
Specialty Cements, Primers & Accessories • Sizes
1/4 Pt, 1/2 Pt, Pint, Quarts, Gallons, 5-Gallon





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American Society for
Testing and Materials



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International



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Approvals



Underwriters
Laboratories



Certificate No. 293
The Loss Prevention
Certification Board



MEMBER
04-05



Certifications and Approvals Applicable to Specific Products Only



PVC & CPVC SCHEDULE 80 SPECIAL REINFORCED FITTINGS

Avoid Split Threads!



Patented Advanced Design

Spears® Patented Schedule 80 Special Reinforced (SR) Fittings reduce problems associated with over tightening of female plastic pipe threads. Not just an added ring, this unique precompression design compensates for expansion forces generated from tapered pipe thread joint make-up. Radial-stress is reduced in normal installations and contained in severe over tightening situations.

Improved Sealing Capability

Since fitting expansion is contained, thread contact and corresponding seal is improved.

Excellent Plastic-to-Metal Transition Fitting — Without Pressure De-Rating

Spears® patented SR design and manufacturing process allows direct connection to threaded metal pipe through one simple adapter. Superior Strength of the SR Fitting eliminates the need for pressure de-ratings in system transitions normally associated with traditional non-reinforced plastic threaded fittings. Material thermal expansion/contraction differences are equalized by the restraining collar. You get low cost, worry-free plastic-to-metal transitions every time.

Full ASTM Schedule 80 Conformance

All SR Fittings conform to either ASTM D 2467 (PVC) or F 439 (CPVC) dimensional and hydrostatic pressure test requirements.

Chemical & Corrosion Resistant

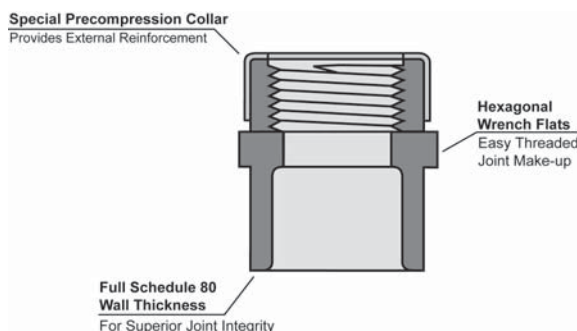
SR Fittings are produced in PVC White, PVC Gray and Industrial CPVC thermoplastic compounds for superior chemical and corrosion resistance to system fluids. External special reinforcing ring provides excellent resistance to corrosive environments.

Versatile 1/4" through 4" Size Availability

Spears® SR Fittings are available in slip socket, spigot and reducing configurations of female adapters, tees, 90° ells and unions.

Potable Water Approved

Certified by NSF International. Lead-free thermoplastic compounds are safe for use in drinking water systems.



Sample Engineering Specification

All threaded plastic connections and threaded plastic-to-metal transition connections shall be made with Spears® Special Reinforced (SR) Fittings. All fittings shall be Schedule 80, conforming to ASTM D 2467 (PVC) or F 439 (CPVC). All fittings shall be approved for potable water service.



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