Georg Fischer Harvel LLC

Engineering & Installation Guide

THE QUALITY LINE

Harvel.com

GEORG FISCHER
PIPING SYSTEMS

HPB-112/401
7-22-15

Engineering & Installation Guide

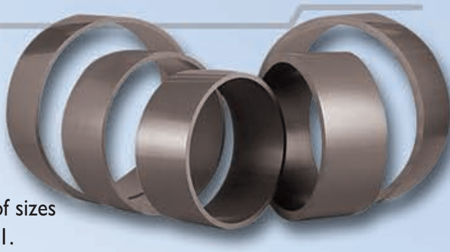
PVC and CPVC extruded pipe, duct, and machining stock.

THE QUALITY LINE

Quick Reference Guide

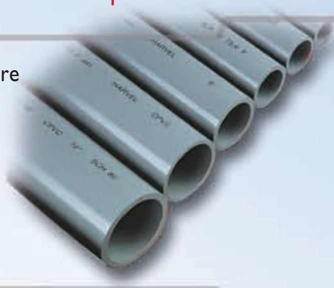
PVC Corrosion Resistant Pressure Pipe — 04 - 61

GF Harvel has expanded its original "quality line" of PVC pipe to include sizes 1/8" through 24" in Schedules 40, 80 and 120 as well as a broad range of sizes in SDR 13.5, 21, 26 and 41.



CPVC Corrosion Resistant Pressure Pipe — 04 - 61

Featuring superior high-temperature strength and chemical resistance, GF Harvel CPVC is used in a wide variety of piping system applications.

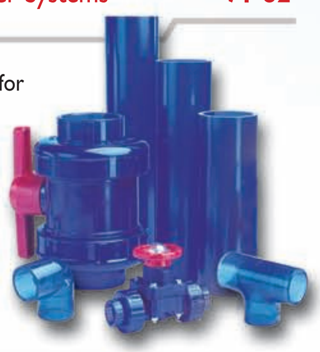


GF Harvel Clear™ PVC Piping Systems — 62-68

GF Harvel Clear™ Rigid PVC piping provides a versatile, cost-effective choice for semiconductor, sight-glass and dual-containment applications, where visual monitoring of the process is critical.

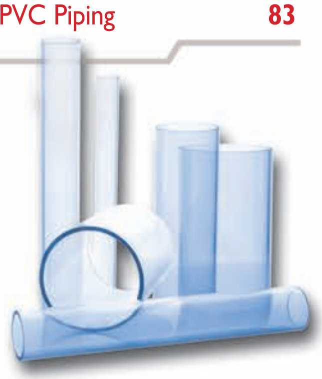
GF Harvel LXT® Ultra-pure Water Systems — 71-82

GF Harvel LXT® low-extractable piping for ultra-pure water systems offers fast, low-cost and reliable installations in semi-conductor, electronics, biotechnology and other industries.



GF Harvel EnviroKing®UV Clear PVC Piping — 83

GF Harvel EnviroKing®UV Clear PVC piping is a cost-effective solution for photobioreactors and other green energy applications.



84 — GF Harvel CPVC Fire Sprinkler

Since the inception of BlazeMaster® CPVC into the fire sprinkler industry more than twenty years ago, GF Harvel has been a select producer and an integral part of the product's outstanding success.

85-88 — GF Harvel HydroKing® CTS CPVC Plumbing Pipe / GF Harvel FlowGuard Gold® CTS CPVC Plumbing Pipe

GF Harvel HydroKing® and GF Harvel FlowGuard Gold® CTS CPVC plumbing pipe features outstanding corrosion resistance for hot and cold water plumbing applications.

89-94 — PVC Corrosion Resistant Duct

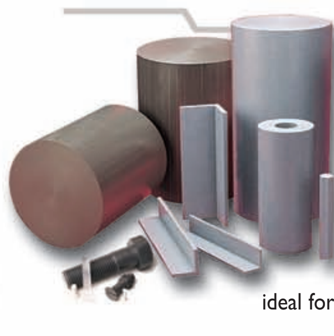
GF Harvel PVC duct provides long-lasting, cost-effective solutions for industrial and institutional corrosive fume exhaust and drain applications.

89-94 — CPVC Corrosion Resistant Duct

Superior flammability characteristics, as well as resistance to corrosion and chemical attack make GF Harvel seamless extruded CPVC duct ideally suited for large-diameter hot fume handling and drain applications.

95-99 — Machining Stock & Fabrication Products

GF Harvel extrudes PVC, CPVC and clear PVC in a wide range of sizes and shapes including hollow round bar and solid round, hex, rectangular and square bar, as well as angle and welding rod. Outstanding clarity and superior machining characteristics make GF Harvel machining stock and fabrication products ideal for numerous fabrication and decorative uses.



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⚠WARNING
❗NOTE

See Safety Alert Messages on p.160

Advantages of GF Harvel PVC and CPVC Products

Consistency/Quality – developed, processed, and designed to consistently meet and/or exceed industry standards for strength and durability

Chemically Resistant over a broad range of chemicals, concentrations and reagent mixtures

Strength – high tensile strength and well balanced physical properties provides long-term pressure bearing capability for aggressive fluid handling applications

Corrosion Resistant – Immune to electrolytic, galvanic and vapor phase corrosion

Clean, non-contaminating materials for use in potable water and other applications where contamination of fluids conveyed is critical

Lightweight – minimizes labor, handling and jobsite mechanical equipment; greatly reducing installation related costs

Simple Joining Methods – leak-free dependable joints via solvent cement joining minimizes equipment requirements and reduces installation costs

Rigid – requires fewer hangers and supports compared to other plastic pipe materials

Smooth Surfaces – reduce friction loss and provide good abrasion resistance

Low Thermal Conductivity – provides good insulation qualities with low heat transfer; less energy use overtime

Good electrical insulation values

Ease of Fabrication – can be easily machined, heat formed, welded, and subjected to a variety of other joining and fabrication techniques

Safety – industry regulated for toxological compliance (NSF Std 61); exhibit good fire performance characteristics (will not independently support combustion)

Typical Applications of GF Harvel Piping Products

GF Harvel PVC and CPVC piping products can be found in applications in the following industries where water, chemical and corrosive fluid production, transfer and mixing are utilized:

Chemical Process Industries: Chemical processing - Industrial waste - Laboratory Semiconductor - Pulp & Paper - Electroplating - Electronics Metal Treating - Chlor-Alkali - Fertilizer - Color industries - Textile - Mining - Air Pollution Control - Photo Finishing - Printing

Industrial Processing: Plant Water Distribution - Cooling Water - Waste-Water - Process Water - Reclaim - Waste Treatment - HVAC Pollution Control - Brine Production & Disposal

Power Generation: Boiler Feed Water - Atomic Energy - Fly Ash Slurries - Coal Mining - Gas Industry - Oil Refining Cooling Water - Water and Waste Water Treatment

Food and Beverage: Potable Water - Bottled Water - Ultra Pure Water - Food Processing - Meat Packing - Poultry Farming & Processing Distilled Water - Ice Production & Equipment

High Purity Applications: Semiconductor - Pharmaceutical Biotechnology - Chemical Manufacturing - Health Care - Universities - Clean Room Applications - Wet Bench Construction - Ultrapure Water

Water and Waste Water: Water Treatment - Waste Water Treatment - Reclaim Aeration - Desalination - Detention & Collection - Water Resource Conservation - Ground Remediation - Well Casing & Well Monitoring

Aquaculture: Life Support Systems - Public Aquariums - Fish Hatcheries - Lobster Ponds - Fish Ladders - Fish Farming etc.

Recreational: Water Parks - Theme Parks - Fountains - Water Features - Swimming Pools

Agricultural/Irrigation: Commercial Irrigation - Golf Courses - Farming - Genetic Engineering - Greenhouses

General Services: Hot and Cold Water Plumbing - Municipal Water - Process Water - Commercial Roof Drain - Bridge Drain - Industrial Parks - Shopping Centers - Surface Drainage - Landfill Marine Applications - Drain Waste & Vent

Fire Protection: NFPA 13 Light Hazard, 13R & 13D - Fire Sprinkler Systems found in Highrise Office Buildings - Hotels Motels - Dormitories - Apartments - Nursing Homes - Hospitals - Single Family Residences

Specialty Applications: Visual Leak Detection - Dual Containment - Decorative Applications - Civil Defense - Naval Military Applications - Fire Resistive Construction

GF Harvel
PVC and CPVC Materials

PVC

Polyvinyl Chloride (PVC) is an amorphous thermoplastic material that can be formulated or “compounded” to target a specific application. Minor ingredients must be blended with PVC resin to create a PVC compound that is processable into a finished product. The physical properties of PVC can be altered considerably to provide desirable properties by compounding techniques. Additives such as impact modifiers, stabilizers, lubricants, processing aids, pigments and other ingredients can be modified to obtain desirable properties. As such, PVC is available in a wide range of products from flexible tubing, film packaging materials, and vinyl siding, through various blends that can be used to produce rigid PVC pressure piping.

Georg Fischer Harvel LLC blends its own PVC compounds that are optimized specifically for GF Harvel’s quality line of rigid PVC piping products. GF Harvel utilizes several different PVC compounds formulated specifically for the production of different PVC product lines. This ensures tight control over consistency and quality in the end product, which has been optimized for chemical resistance and pressure bearing capability. GF Harvel PVC materials are listed by NSF International to NSF STD 61, toxicology, as being safe for use in potable water applications. ASTM Standard D1784, Standard Specification for rigid polyvinyl Chloride) (PVC) compounds and chlorinated (polyvinyl Chloride) (CPVC) compounds calls out minimum physical property requirements of compounds that are used in the production of PVC pipe and fittings. This standard classifies the physical properties through a “Cell Classification” system that calls out base resin, minimum impact strength, tensile strength, modulus of elasticity, heat deflection temperature under load, and flammability when tested per applicable ASTM standards. Unplasticized or rigid PVC compound used for the manufacture of pipe and fittings, has a Cell Classification of 12454 per ASTM D1784, and is also known as Type I Grade I PVC or PVC 1120. Refer to Physical Properties section, Chemical Resistance Data, and Industry Standards & Test Methods section for additional information.

PVC Cell Classification 12454 = PVC Type I, Grade I = Rigid (unplasticized) PVC = PVC 1120 = H707 PVC (GF Harvel tradename)

GF Harvel PVC Product Line

Schedule 40, Schedule 80 & Schedule 120 PVC Pressure Pipe
SDR Series Pressure Pipe (SDR 13.5, SDR 21, SDR 26 & SDR41)
GF Harvel Clear™ PVC Schedule 40 & Schedule 80 Pipe
PVC Duct
PVC Machining Shapes (solid bar, hollow bar, angle and other machine stock)
GF Harvel LXT® Ultra-Pure Water Piping
EnviroKing™UV Clear Piping
Custom Dimensions and Colors

CPVC

Chlorinated polyvinyl chloride (CPVC) is created by subjecting PVC resin to a post chlorination reaction that results in additional chlorine atoms on the base molecule. This results in an amorphous thermoplastic material similar to PVC with added advantages: a higher heat distortion temperature and improved fire performance properties at relatively low cost compared to alternate materials. As with PVC, the physical properties of CPVC can be altered considerably to provide desirable properties by compounding techniques. Due to its higher heat distortion temperature, GF Harvel CPVC can be used in piping applications at temperatures up to 60°F higher than PVC piping, having a maximum service temperature for pressure applications of 200°F. GF Harvel CPVC provides an economic solution for piping utilized in process piping, hot water and similar service applications where operating conditions exceed the recommended temperature limits of PVC. This greatly expands the application range for thermoplastic pipe, providing an economical solution for piping used in elevated temperature service.

GF Harvel utilizes several different CPVC compounds formulated specifically for the production of different CPVC end products. Refer to Physical Properties section, Chemical Resistance Data, and Industry Standards & Test Methods section for additional information. GF Harvel utilizes CPVC materials listed by NSF International to NSF STD 61, toxicology, as being safe for use in potable water applications. The Cell Classification call out for most CPVC piping materials per ASTM D1784 is as follows:

CPVC Cell Classification 23447 = CPVC Type IV, Grade I = Rigid (unplasticized) CPVC = CPVC

GF Harvel CPVC Product Line

Schedule 40 & Schedule 80 CPVC Pressure Pipe
CPVC Duct
CPVC Machining Shapes (solid bar, hollow bar, angle and other machine stock)
GF Harvel HydroKing® and GF Harvel FlowGuard Gold® CTS CPVC Hot and Cold Water Plumbing Pipe
GF Harvel CPVC Fire Sprinkler Pipe
GF Harvel FlameTech™

! NOTE Although PVC and CPVC are similar in nature they are not the same. Care should be used when investigating chemical resistance, joining/fabrication techniques, and service applications. GF Harvel utilizes several different PVC and CPVC compounds for the production of different product lines. Different compounds may exhibit slight variations in actual physical properties and resultant cell classifications as compared to those stated. Contact GF Harvel Tech Services for additional information if necessary.

Dimensions & Pressure Ratings

PVC Pipe

Schedule 40 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. 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 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI*
1/8	0.405	0.195	0.095	0.063	1,230
1/4	0.540	0.282	0.119	0.105	1,130
3/8	0.675	0.403	0.126	0.146	920
1/2	0.840	0.526	0.147	0.213	850
3/4	1.050	0.722	0.154	0.289	690
1	1.315	0.936	0.179	0.424	630
1-1/4	1.660	1.255	0.191	0.586	520
1-1/2	1.900	1.476	0.200	0.711	470
2	2.375	1.913	0.218	0.984	400
2-1/2	2.875	2.290	0.276	1.500	420
3	3.500	2.864	0.300	2.010	370
3-1/2	4.000	3.326	0.318	2.452	350
4	4.500	3.786	0.337	2.938	320
5	5.563	4.768	0.375	4.078	290
6	6.625	5.709	0.432	5.610	280
8	8.625	7.565	0.500	8.522	250
10	10.750	9.493	0.593	12.635	230
12	12.750	11.294	0.687	17.384	230
14	14.000	12.410	0.750	20.852	220
16	16.000	14.213	0.843	26.810	220
18	18.000	16.014	0.937	33.544	220
20	20.000	17.814	1.031	41.047	220
24	24.000	21.418	1.218	58.233	210

Schedule 120 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI*
1/2	0.840	0.480	0.170	0.236	1010
3/4	1.050	0.690	0.170	0.311	770
1	1.315	0.891	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
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

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

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.
1/2	0.840	0.696	0.062	0.110

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

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. 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	1.168
3-1/2	4.000	3.597	0.190	1.520
4	4.500	4.046	0.214	1.927
5	5.563	5.001	0.265	2.948
6	6.625	5.955	0.316	4.185
8	8.625	7.756	0.410	7.069

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

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. 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	0.966
3-1/2	4.000	3.672	0.154	1.250
4	4.500	4.134	0.173	1.569
5	5.563	5.108	0.214	2.411
6	6.625	6.084	0.255	3.414
8	8.625	7.921	0.332	5.784
10	10.750	9.874	0.413	8.971
12	12.750	11.711	0.490	12.620
14	14.000	12.860	0.538	15.205
16	16.000	14.696	0.615	19.877
18	18.000	16.533	0.692	25.156
20	20.000	18.370	0.769	31.057
24	24.000	22.043	0.923	44.744

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

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.
18	18.000	17.061	0.439	16.348
20	20.000	18.956	0.488	20.196
24	24.000	22.748	0.585	29.064

CPVC Pipe

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	0.096	780
3/8	0.675	0.473	0.091	0.128	620
1/2	0.840	0.602	0.109	0.190	600
3/4	1.050	0.804	0.113	0.253	480
1	1.315	1.029	0.133	0.371	450
1-1/4	1.660	1.360	0.140	0.502	370
1-1/2	1.900	1.590	0.145	0.599	330
2	2.375	2.047	0.154	0.803	280
2-1/2	2.875	2.445	0.203	1.267	300
3	3.500	3.042	0.216	1.660	260
3-1/2	4.000	3.521	0.226	1.996	240
4	4.500	3.998	0.237	2.363	220
5	5.563	5.016	0.258	2.874	190
6	6.625	6.031	0.280	4.164	180
8	8.625	7.942	0.322	6.268	160
10	10.750	9.976	0.365	8.886	140
12	12.750	11.889	0.406	11.751	130
14	14.000	13.073	0.437	13.916	130
16	16.000	14.940	0.500	18.167	130
18	18.000	16.809	0.562	22.965	130
20	20.000	18.743	0.593	29.976	120
24	24.00	22.544	0.687	37.539	120

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 derated 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.

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	0.117	1,130
3/8	0.675	0.403	0.126	0.162	920
1/2	0.840	0.526	0.147	0.238	850
3/4	1.050	0.722	0.154	0.322	690
1	1.315	0.936	0.179	0.473	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	37.419	220
20	20.000	17.814	1.031	45.879	220
24	24.000	21.418	1.218	64.959	210

Refer to chemical resistance and installation data. All PVC piping is produced from NSF approved compounds conforming to ASTM D1784 and is NSF listed for potable water use.

ASTM Standard D1784 Material equivalents:
Cell classification 12454 = PVC Type 1 Grade 1 = PVC1120
Cell classification 23447 = CPVC Type IV Grade 1 = CPVC4120

Schedule 40, 80 & 120 PVC pipe is manufactured in strict compliance with ASTM D1785. Schedule 40 & 80 CPVC pipe is manufactured in strict compliance with ASTM F441.

Temperature De-rating

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 (W.P.) 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.

Solvent-cemented joints should be utilized when working at or near maximum temperatures of the material selected. GF Harvel Plastics does not recommend the use of standard threaded connections at temperatures above 110°F for PVC or at temperatures above 150°F for CPVC; use specialty reinforced adapters, flanged joints, unions or roll grooved couplings where disassembly is necessary at elevated temperatures.

Threading of Schedule 40 pipe (PVC or CPVC) is not a recommended practice due to insufficient wall thickness. Thread only Schedule 80 or heavier walls. Threading requires a 50% reduction in pressure rating stated for plain end pipe @73°F.

Chemical resistance data should be referenced for proper material selection and possible pressure de-rating when working with fluids other than water. Refer to GF Harvel's chemical resistance guide for additional information.

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: 10" PVC SCHEDULE 80 @ 120°F = ?
230 psi x 0.40 = 92 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: 10" CPVC SCHEDULE 80 @ 120°F = ?
230 psi x 0.65 = 149.5 psi max. @ 120°F

Tolerances and Skid Quantites

Outside Diameters and Tolerances

Nom. Pipe Size (in.)	Outside Diam.	Tolerances For Max. and Min. Diameter O of R: Average.	Sch. 40	Sch. 80	Sch. 120	SDRs 21, 26 & 41	SDR 13.5
1/8	0.405	±0.004	±0.008	±0.008			
1/4	0.540	±0.004	±0.008	±0.008			
3/8	0.675	±0.004	±0.008	±0.008			
1/2	0.840	±0.004	±0.008	±0.008	±0.008	±0.015	±0.008
3/4	1.050	±0.004	±0.010	±0.010	±0.010	±0.015	±0.010
1	1.315	±0.005	±0.010	±0.010	±0.010	±0.015	±0.010
1-1/4	1.660	±0.005	±0.012	±0.012	±0.012	±0.015	±0.012
1-1/2	1.900	±0.006	±0.012	±0.012	±0.012	±0.030	±0.012
2	2.375	±0.006	±0.012	±0.012	±0.012	±0.030	±0.012
2-1/2	2.875	±0.007	±0.015	±0.015	±0.015	±0.030	±0.015
3	3.500	±0.008	±0.015	±0.015	±0.015	±0.030	±0.015
3-1/2	4.000	±0.008	±0.050	±0.015	±0.015	±0.050	
4	4.500	±0.009	±0.050	±0.015	±0.015	±0.050	
5	5.563	±0.010	±0.050	±0.030	±0.030	±0.050	
6	6.625	±0.011	±0.050	±0.035	±0.035	±0.050	
8	8.625	±0.015	±0.075	±0.075	±0.045	±0.075	
10	10.750	±0.015	±0.075	±0.075	±0.050	±0.075	
12	12.750	±0.015	±0.075	±0.075	±0.060	±0.075	
14	14.000	±0.015	±0.100	±0.100		±0.100	
16	16.000	±0.019	±0.160	±0.160		±0.160	
18	18.000	±0.019	±0.180	±0.180		±0.180	
20	20.000	±0.023	±0.200	±0.200		±0.200	
24	24.000	±0.031	±0.240	±0.240		±0.240	

Specifications applicable to Schedule 40, 80 and 120 piping are described in ASTM D1785
Specifications applicable to SDR 41, 26, 21 and 13.5 piping are described in ASTM D2241
O of R = Out of Roundness

Pallet & Truck Load Quantities

Size (in.)	Pcs./ Skid	Ft./ Skid	Skid Dim.	Schd. 40 & SDR's: Plain End Skids/ Truck	Schd. 40 & SDR's: Belled End Skids/ Truck	Schd. 80: Plain End Skids/ Truck	Schd. 80: Belled End Skids/ Truck
1/2	285	5700	44 x 08	32	N/A	32	N/A
3/4	263	5260	43 x 10	28	N/A	24	N/A
1	214	4280	44 x 12	24	N/A	20	N/A
1-1/4	118	2360	43 x 11	28	28	28	28
1-1/2	103	2060	43 x 12	28	28	28	28
2	83	1660	44 x 14	28	28	24	24
2-1/2	54	1080	44 x 14	28	28	24	24
3	42	840	42 x 16	24	24	24	24
4	26	520	44 x 16	24	24	24	24
5	20	400	42 x 19	20	20	20	20
6	17	340	43 x 21	16	16	16	16
8	11	220	36 x 27	12	12	12	12
10	7	140	43 x 23	12	12	12	12
12	5	100	36 x 27	12	12	12	12
14	5	100	42 x 31	12	12	12	12
16	3	60	48 x 19	10	10	10	10
*18	3	60	54 x 21	8	8	8	8
*18	2	40	36 x 21	8	8	8	8
20	2	40	40 x 23	16	16	16	16
24	2	40	48 x 28	12	12	12	12

***NOTE**: Skid quantities for 18" pipe vary; i.e. One row on truck = One skid of 3 pcs and one skid of 2 pcs= 8 skids of 3pcs and 8 skids of 2pcs per truck

Wall Thickness and Tolerances

Nominal Pipe Size (in.)	Schedule 40 Minimum	Schedule 40 Tolerance	Schedule 80 Minimum	Schedule 80 Tolerance	Schedule 120 Minimum	Schedule 120 Tolerance	SDR 41 Minimum	SDR 41 Tolerance	SDR 26 Minimum	SDR 26 Tolerance	SDR 21 Minimum	SDR 21 Tolerance	SDR 13.5 Minimum	SDR 13.5 Tolerance
1/8	0.068	+0.020	0.095	+0.020										
1/4	0.088	+0.020	0.119	+0.020										
3/8	0.091	+0.020	0.126	+0.020										
1/2	0.109	+0.020	0.147	+0.020	0.170	+0.020							0.062	+0.020
3/4	0.113	+0.020	0.154	+0.020	0.170	+0.020					0.060	+0.020		
1	0.133	+0.020	0.179	+0.021	0.200	+0.024			0.060	+0.020	0.063	+0.020		
1-1/4	0.140	+0.020	0.191	+0.023	0.215	+0.026			0.064	+0.020	0.079	+0.020		
1-1/2	0.145	+0.020	0.200	+0.024	0.225	+0.027			0.073	+0.020	0.090	+0.020		
2	0.154	+0.020	0.218	+0.026	0.250	+0.030			0.091	+0.020	0.113	+0.020		
2-1/2	0.203	+0.024	0.276	+0.033	0.300	+0.036			0.110	+0.020	0.137	+0.020		
3	0.216	+0.026	0.300	+0.036	0.350	+0.042			0.135	+0.020	0.167	+0.020		
3-1/2	0.226	+0.027	0.318	+0.038	0.350	+0.042			0.154	+0.020	0.190	+0.023		
4	0.237	+0.028	0.337	+0.040	0.437	+0.052			0.173	+0.020	0.214	+0.026		
5	0.258	+0.031	0.375	+0.045	0.500	+0.060			0.214	+0.027	0.265	+0.032		
6	0.280	+0.034	0.432	+0.052	0.562	+0.067			0.255	+0.031	0.316	+0.038		
8	0.322	+0.039	0.500	+0.060	0.718	+0.086			0.332	+0.040	0.410	+0.049		
10	0.365	+0.044	0.593	+0.071	0.843	+0.101			0.413	+0.050				
12	0.406	+0.049	0.687	+0.082	1.000	+0.120			0.490	+0.059				
14	0.437	+0.053	0.750	+0.090					0.538	+0.064				
16	0.500	+0.060	0.843	+0.101					0.615	+0.074				
18	0.562	+0.067	0.937	+0.112			0.439	+0.061	0.692	+0.083				
20	0.593	+0.071	1.031	+0.124			0.488	+0.068	0.769	+0.092				
24	0.687	+0.082	1.218	+0.146			0.585	+0.082	0.923	+0.111				

Physical Properties of PVC & CPVC Pipe

GENERAL	PVC Value	CPVC Value	Test Method
Cell Classification	12454	23447	ASTM D1784
Maximum Service Temp.	140°F	200°F	
Color	White, Dark Gray	Medium Gray	
Specific Gravity, (g/cu.cm @ 73°F)	1.40 +/-.02	1.52 +/-.02	ASTM D792
Water Absorption % increase 24 hrs @ 25°C	0.05	0.03	ASTM D570
Hardness, Rockwell	110 - 120	117	ASTM D785
Poisson's Ratio @ 73°F	0.410	0.386	
Hazen-Williams Factor	C =150	C = 150	
MECHANICAL			
Tensile Strength, psi @ 73°F	7,450	7,750	ASTM D638
Tensile Modulus of Elasticity, psi @ 73°F	420,000	360,000	ASTM D638
Flexural Strength, psi @ 73°F	14,450	13,000	ASTM D790
Flexural Modulus, psi @ 73°F	360,000	360,000	ASTM D790
Compressive Strength, psi @ 73°F	9,600	10,000	ASTM D695
Izod Impact, notched, ft-lb/in @ 73°F	0.75	2.0	ASTM D256
THERMAL			
Coefficient of Linear Expansion (in/in/°F)	2.9×10^{-5}	3.7×10^{-5}	ASTM D696
Coefficient of Thermal Conductivity			ASTM C177
(Cal.)(cm)/(cm^2)(Sec.)(°C)	3.5×10^{-4}	3.27×10^{-4}	
BTU/in/hr/ft^2/°F	1.02	0.95	
Watt/m/°K	0.147	0.137	
Heat Deflection Temperature Under Load (264 psi, annealed)	170°F	226°F	ASTM D648
Specific Heat, Cal./°C/gm	0.25		ASTM D2766
ELECTRICAL			
Dielectric Strength, volts/mil	1,413	1,250	ASTM D149
Dielectric Constant, 60Hz, 30°F	3.70	3.70	ASTM D150
Volume Resistivity, ohm/cm @ 95°C	1.2×10^{12}	3.4×10^{15}	ASTM D257
Power Factor, 1000Hz		0.007%	ASTM D150
GF Harvel PVC & CPVC Pipe is non-electrolytic			
FIRE PERFORMANCE			
Flammability Rating	V-0	V-0, 5VB, 5VA	UL-94
Flame Spread Index	<10	<10	ASTM E162
Flame Spread	0-25	<25	ASTM E-84/UL 723
		<25	ULC
Smoke Generation	80-225	≤50	ASTM E-84/UL 723
		<50	ULC
Flash Ignition Temp.	730°F	900°F	
Average Time of Burning (sec.)	<5	<5	ASTM D635
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 D2863
Clean Room Materials Flammability Test	N/A	FPI= 1.20 SDI = 0.09	FM 4910

NOTE The physical properties shown above pertain to GF Harvel PVC (SDR Series, Schedule 40, 80 & 120) and GF Harvel CPVC (Schedule 40 and 80) industrial pipe. The physical properties shown for CPVC pipe are considered general CPVC physical properties. GF Harvel utilizes several CPVC compounds for the production of different CPVC product lines. Different CPVC compounds may exhibit slight variations in actual physical properties as compared to those stated. Physical properties shown pertain to product lines stated. Refer to appropriate Specialty Piping Systems section for physical properties of specialty pipe (i.e. GF Harvel Clear,™ GF Harvel LXT,® GF Harvel EnviroKing,™ UV Clear, GF Harvel HydroKing® CTS CPVC, GF Harvel Fire Sprinkler Pipe, GF Harvel FlameTech™, etc.) Contact GF Harvel tech services for additional information if necessary.

Engineering & Design Data

Hydraulic Shock

Hydraulic shock is the term used to describe the momentary pressure rise in a piping system which results when the liquid is started or stopped quickly. This pressure rise is caused by the momentum of the fluid; therefore, the pressure rise increases with the velocity of the liquid, the length of the system from the fluid source, or with an increase in the speed with which it is started or stopped. Examples of situations where hydraulic shock can occur are valves, which are opened or closed quickly, or pumps, which start with an empty discharge line. Hydraulic shock can even occur if a high speed wall of liquid (as from a starting pump) hits a sudden change of direction in the piping, such as an elbow. The pressure rise created by the hydraulic shock effect is added to whatever fluid pressure exists in the piping system and, although only momentary, this shock load can be enough to burst pipe and break fittings or valves.

A formula, which closely predicts hydraulic shock effects is:

$$p = v\left(\frac{SG-1}{2}C + C\right)$$

Where:

p = maximum surge pressure, psi

v = fluid velocity in feet per second

C = surge wave constant for water at 73°F

*SG = specific gravity of liquid (If SG is 1, then p = VC)

Example: A 2" PVC schedule 80 pipe carries a fluid with a specific gravity of 1.2 at a rate of 30 gpm and at a line pressure of 160 psi. What would the surge pressure be if a valve were suddenly closed?

From table 1: C = 23.9

$$p = (3.35)\left(\frac{(1.2-1)}{2}23.9 + 23.9\right)$$

p = (3.35) (26.3) = 88 psi

Total line pressure = 88 + 160 = 248 psi

Schedule 80 2" PVC has a pressure rating of 400 psi at room temperature.

Therefore, 2" schedule 80 PVC pipe is acceptable for this application.

NOTE The total pressure at any time in a pressure-type system (operating plus surge or water hammer) should not exceed 150 percent of the pressure rating of the system.

Table 1 - C-Surge Wave Constant

Pipe Size (in.)	PVC Sch. 40	PVC Sch. 80	CPVC Sch. 40	CPVC Sch. 80
1/8	34.7	41.3	32.9	39.4
1/4	33.6	39.3	31.8	37.5
3/8	30.2	35.6	28.4	33.8
1/2	29.3	34.2	27.6	32.3
3/4	26.4	30.9	24.8	29.1
1	25.4	29.6	23.8	27.8
1-1/4	23.0	27.0	21.5	25.3
1-1/2	21.8	25.7	20.4	24.1
2	20.0	23.9	18.6	22.4
2-1/2	20.8	24.5	19.4	22.9
3	19.4	23.1	18.1	21.6
3-1/2	18.6	22.2	17.3	20.7
4	17.9	21.5	16.7	20.1
5	16.8	20.3	15.6	19.0
6	16.0	20.0	14.9	18.6
8	15.0	18.8	13.9	17.5
10	14.3	18.3	13.3	17.1
12	13.8	18.1	12.8	16.9
14	13.7	18.1	12.7	16.8
16	13.7	17.9	12.7	16.7
18	13.7	17.8	12.7	16.6
20	13.3	17.7	12.4	16.5
24	13.1	17.6	12.2	16.3

Proper design when laying out a piping system will eliminate the possibility of hydraulic shock damage.

The following suggestions will help in avoiding problems:

1. In a plastic piping system, a fluid velocity not exceeding 5 ft./sec. will minimize hydraulic shock effects, even with quickly closing valves, such as solenoid valves.
2. Using actuated valves which have a specific closing time will eliminate the possibility of someone inadvertently slamming a valve open or closed too quickly. With pneumatic and air-spring actuators, it may be necessary to place a valve in the air line to slow down the valve operation cycle.
3. If possible, when starting a pump, partially close the valve in the discharge line to minimize the volume of liquid, which is rapidly accelerating through the system. Once the pump is up to speed and the line completely full, the valve may be opened.
4. A check valve installed near a pump in the discharge line will keep the line full and help prevent excessive hydraulic shock during pump start-up.

Head Loss Characteristics

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

The nomograph on the following page provides approximate values for a wide range of plastic pipe sizes. More precise values should be calculated from the Williams & Hazen formula. Experimental test value of C (a constant for inside pipe roughness) ranges from 155 to 165 for various types of plastic pipe. Use of a value of 150 will ensure conservative friction loss values. Since directional changes and restrictions contribute the most head loss, use of head loss data for comparable metal valves and fittings will provide conservative values when actual values for PVC and CPVC fittings and valves are not available.

Williams & Hazen formula.

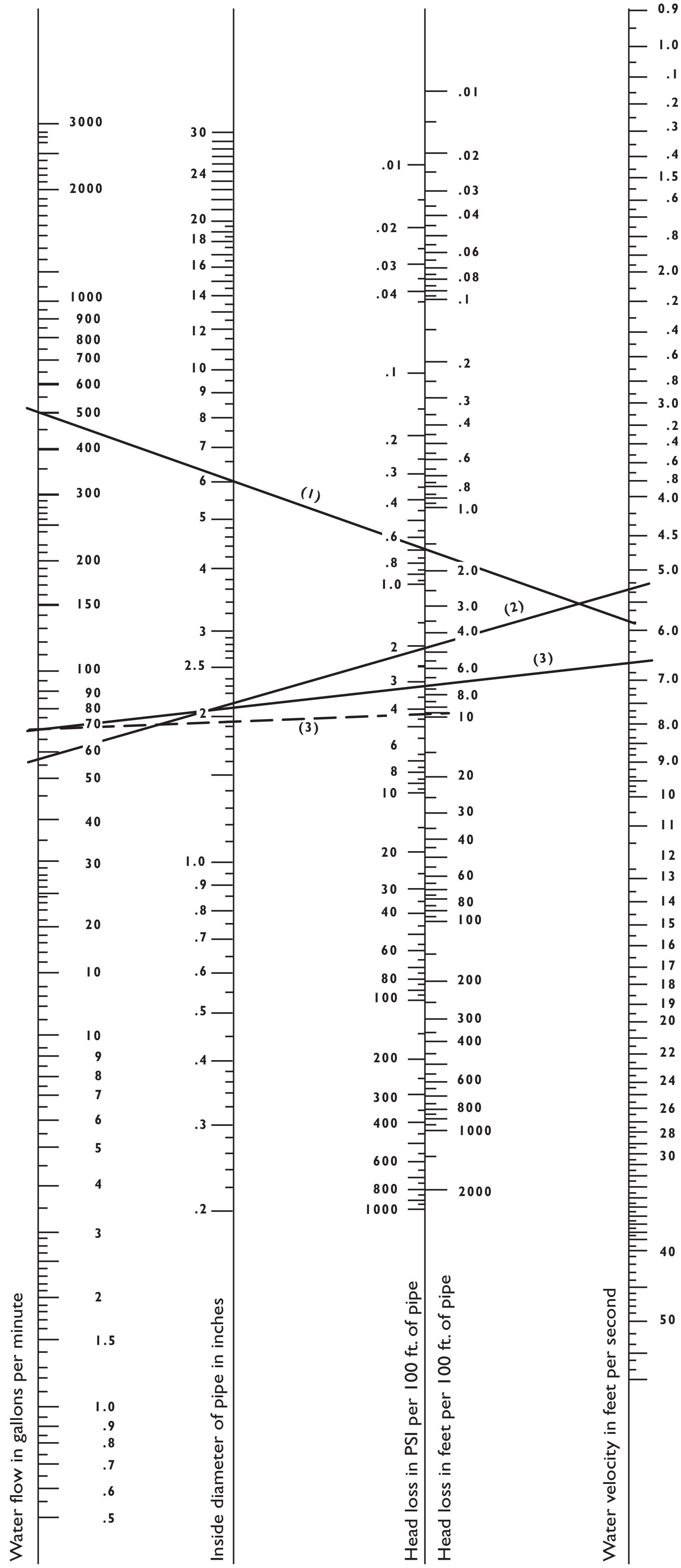
$$f = .2083 \times \left(\frac{100}{C}\right)^{1.852} \times \frac{G^{1.852}}{di^{4.8655}}$$

Where:

f = Friction head in feet of water per 100 feet
d = Inside diameter of pipe in inches
g = Flowing gallons per minute
C = Constant for inside roughness of the pipe
(C = 150 for thermoplastic pipe)

The nomograph is used by lining up values on the scales by means of a ruler or straight edge. Two independent variables must be set to obtain the other values. For example line (1) indicates that 500 gallons per minute may be obtained with a 6-inch inside diameter pipe at a head loss of about 0.65 pounds per square inch at a velocity of 6.0 feet per second. Line (2) indicates that a pipe with a 2.1 inch inside diameter will give a flow of about 60 gallons per minute at a loss in head of 2 pounds per square inch per 100 feet of pipe. Line (3) and dotted line (3) show that in going from a pipe 2.1-inch inside diameter to one of 2 inches inside diameter the head loss goes from 3 to 4 pounds per square inch in obtaining a flow of 70 gallons per minute. Flow velocities in excess of 5.0 feet per second are not recommended.

Nomograph courtesy of Plastics Pipe Institute, a division of The Society of The Plastics Industry.



Flow Velocity & Friction Loss

Friction Loss

Friction loss through PVC and CPVC pipe is most commonly obtained by the use of the Hazen-Williams equations as expressed below for water:

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

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.

Compared to other materials on construction for pipe, thermoplastic pipe smoothness remains relatively constant throughout its service life.

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 GF Harvel does not recommend flow velocities in excess of five feet per second for closed-end systems, particularly in pipe sizes 6" and larger. Contact GF Harvel tech services for additional information.

Thrust Blocking

In addition to limiting velocities to 5'/sec., especially with larger diameters (6" and above), consideration should be given to stresses induced with intermittent pump operation, quick opening valves and back flow in elevated discharge lines. Use of bypass piping with electrically actuated time cycle valves or variable speed pumps and check valves on the discharge side are suggested with the higher GPM rates. Thrust blocking should be considered for directional changes and pump operations in buried lines 10" and above, particularly where fabricated fittings are utilized. Above grade installations 10" and above should have equivalent bracing to simulate thrust blocking at directional changes and for intermittent pump operations. Thrust blocking of directional changes and time cycle valves are also recommended for large diameter drain lines in installations such as large swimming pools and tanks. Use of appropriate pump vibration dampers are also recommended.

THRUST IN POUNDS FROM STATIC INTERNAL PRESSURE

Pipe Size (in.)	Socket Depth (in.)	For Plug, 60° Ell, Cap Tee	For 22.5° Ell	For 45° Ell	For 90° Ell	Joint Resist. To Thrust	90° Ell Safety Factor
6	6	7,170	2,800	5,480	10,140	37,464	3.7
8	6	11,240	4,380	8,590	15,890	48,774	3.1
10	8	16,280	6,350	12,440	23,020	81,054	3.5
12	8	23,040	8,990	17,600	32,580	102,141	3.1
14	9	26,610	10,380	20,330	37,630	115,752	3.1
16	10	34,910	13,620	26,670	49,360	150,798	3.1
18	12	44,290	17,270	33,840	62,630	203,577	3.3
20	12	43,410	16,540	32,400	59,970	226,194	3.8
24	14	61,040	23,810	46,640	86,310	316,500	3.7

Socket depths are from ASTM D 2672 for belled-end PVC pipe. Working pressures utilized for the tabulation above are for Schedule 80 2"- 18" sizes and SDR 160 psi for 20" and 24" sizes.

The calculation for thrusts due to static internal pressure is:

$$\text{Thrust} = \frac{((\text{Avg I.D.})^2\,\pi)}{4} \bullet (\text{working pressure}) \bullet (x)$$

x = 1.0 for tees, 60° ells, plugs and caps, .390 for 22-1/2° bends, .764 for 45° ells, 1.414 for 90° ells

Joint Resistance to Thrust = (O.D.) (π) (socket depth) (300 psi)
300 psi = Minimum cement shear strength with good field cementing technique.

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

	Size (in.)																	
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	0.8	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

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

Pressure Drop in Valves and 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:

$$P = \frac{(G)^2 \text{ (specific gravity liquid)}}{(\text{CV Factor})^2}$$

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

G = Gallons per minute

CV = Gallons per minute per 1 PSI pressure drop

CV Factors GPM

	Size (in.)										
Item	**1/4**	**3/8**	**1/2**	**3/4**	**1**	**1-1/4**	**1-1/2**	**2**	**2-1/2**	**3**	**4**
True Union Ball Valve	1.0	8.0	8.0	15.0	29.0	75.0	90.0	140.0	330.0	480.0	600.0
Single Entry Ball Valve	1.0	8.0	8.0	16.0	29.0	75.0	90.0	140.0	330.0	480.0	600.0
QIC Ball Valve	-	-	8.0	15.0	29.0	75.0	90.0	140.0	-	-	-
True Check Ball Valve	1.0	3.0	4.6	10.0	28.0	45.0	55.0	90.0	225.0	324.0	345.0
Y-Check Valve	-	-	5.0	6.0	12.5	40.0	40.0	65.0	130.0	160.0	250.0
3-Way Flanged Ball Valve	-	-	5.0	10.0	16.0	-	45.0	55.0	-	200.0	350.0
Needle Valve Full Open	5.0	7.5	8.0	-	-	-	-	-	-	-	-
Angle Valve	1.0	-	5.0	10.0	16.0	-	45.0	70.0	-	-	-
Y-Strainer (clean screen)	-	-	3.8	6.6	8.4	20.0	25.0	35.0	60.0	60.0	95.0
Simplex Basket Strainer (clean screen)	-	-	6.0	9.5	29.0	-	40.0	55.0	-	125.0	155.0
Duplex Basket Strainer (clean screen)	-	-	5.0	6.0	7.0	-	28.0	35.0	-	80.0	100.0

Schedule 40

Flow Rate (GPM)	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.)
	1/8"			1/4"			3/8"		
0.25	1.64	6.54	2.83	0.86	1.36	0.59	0.46	0.29	0.12
0.50	3.27	23.60	10.23	1.72	4.90	2.12	0.91	1.04	0.45
0.75	4.91	50.00	21.68	2.59	10.38	4.50	1.37	2.20	0.96
1	6.55	85.18	36.93	3.45	17.68	7.66	1.82	3.75	1.63
2	13.09	307.52	133.31	6.90	63.82	27.67	3.65	13.55	5.88
5				17.25	348.29	150.98	9.11	73.96	32.06
7							12.76	137.93	59.79
10									

Flow Rate (GPM)	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.)
	1/2"			3/4"			1"			1-1/4"		
1	1.13	1.16	0.50	0.63	0.28	0.12	0.39	0.09	0.04	0.22	0.02	0.01
2	2.25	4.19	1.82	1.26	1.03	0.44	0.77	0.31	0.13	0.44	0.08	0.03
5	5.63	22.88	9.92	3.16	5.60	2.43	1.93	1.69	0.73	1.10	0.43	0.19
7	7.88	42.66	18.49	4.42	10.44	4.53	2.70	3.14	1.36	1.55	0.81	0.35
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
15		4"		9.47	42.82	18.56	5.78	12.89	5.59	3.31	3.32	1.44
20	0.51	0.03	0.01	12.63	72.95	31.63	7.71	21.96	9.52	4.42	5.65	2.45
25	0.64	0.05	0.02		5"		9.64	33.20	14.39	5.52	8.55	3.71
30	0.77	0.06	0.03	0.49	0.02	0.01	11.57	46.54	20.17	6.62	11.98	5.19
35	0.89	0.08	0.04	0.57	0.03	0.01				7.73	15.94	6.91
40	1.02	0.11	0.05	0.65	0.04	0.02				8.83	20.41	8.85
45	1.15	0.13	0.06	0.73	0.04	0.02		6"		9.94	25.39	11.00
50	1.28	0.16	0.07	0.81	0.05	0.02	0.56	0.02	0.01	11.04	30.86	13.38
60	1.53	0.23	0.10	0.97	0.08	0.03	0.67	0.03	0.01			
70	1.79	0.30	0.13	1.14	0.10	0.04	0.79	0.04	0.02			
75	1.92	0.34	0.15	1.22	0.11	0.05	0.84	0.05	0.02			
80	2.04	0.39	0.17	1.30	0.13	0.06	0.90	0.05	0.02			

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 (GPM)
1-1/2"			2"			2-1/2"			3"			
0.16	0.01	0.00	0.10	0.00	0.00	0.07	0.00	0.00	0.04	0.00	0.00	1
0.32	0.04	0.02	0.19	0.01	0.00	0.14	0.00	0.00	0.09	0.00	0.00	2
0.81	0.20	0.09	0.49	0.06	0.03	0.34	0.02	0.01	0.22	0.01	0.00	5
1.13	0.38	0.16	0.68	0.11	0.05	0.48	0.05	0.02	0.31	0.02	0.01	7
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
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
3.23	2.64	1.15	1.95	0.77	0.34	1.37	0.33	0.14	0.88	0.11	0.05	20
4.04	4.00	1.73	2.44	1.17	0.51	1.71	0.49	0.21	1.10	0.17	0.07	25
4.85	5.60	2.43	2.92	1.64	0.71	2.05	0.69	0.30	1.32	0.24	0.10	30
5.65	7.45	3.23	3.41	2.18	0.94	2.39	0.92	0.40	1.54	0.32	0.14	35
6.46	9.54	4.14	3.90	2.79	1.21	2.73	1.18	0.51	1.76	0.41	0.18	40
7.27	11.87	5.15	4.39	3.47	1.51	3.07	1.46	0.63	1.99	0.51	0.22	45
8.08	14.43	6.25	4.87	4.22	1.83	3.41	1.78	0.77	2.21	0.61	0.27	50
9.69	20.22	8.77	5.85	5.92	2.56	4.10	2.49	1.08	2.65	0.86	0.37	60
			6.82	7.87	3.41	4.78	3.32	1.44	3.09	1.15	0.50	70
			7.31	8.94	3.88	5.12	3.77	1.63	3.31	1.30	0.56	75
			7.80	10.08	4.37	5.46	4.25	1.84	3.53	1.47	0.64	80

NOTE GF Harvel 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 GF Harvel 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.

Schedule 40

Flow Rate (GPM)	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 (GPM)
		4"			5"			6"									2"			2-1/2"			3"		
90	2.30	0.48	0.21	1.46	0.16	0.07	1.01	0.07	0.03		8"					8.77	12.53	5.43	6.15	5.28	2.29	3.97	1.82	0.79	90
100	2.55	0.59	0.25	1.62	0.19	0.08	1.12	0.08	0.03	0.65	0.02	0.01				9.74	15.23	6.60	6.83	6.42	2.78	4.41	2.22	0.96	100
125	3.19	0.89	0.38	2.03	0.29	0.13	1.40	0.12	0.05	0.81	0.03	0.01				12.18	23.03	9.98	8.54	9.70	4.21	5.52	3.35	1.45	125
150	3.83	1.24	0.54	2.43	0.41	0.18	1.68	0.17	0.07	0.97	0.04	0.02							10.24	13.60	5.90	6.62	4.70	2.04	150
175	4.47	1.65	0.72	2.84	0.55	0.24	1.96	0.22	0.10	1.13	0.06	0.03		10"								7.72	6.25	2.71	175
200	5.11	2.12	0.92	3.25	0.70	0.30	2.25	0.29	0.12	1.29	0.08	0.03	0.82	0.02	0.01							8.82	8.00	3.47	200
250	6.39	3.20	1.39	4.06	1.06	0.46	2.81	0.43	0.19	1.62	0.11	0.05	1.03	0.04	0.02							11.03	12.10	5.24	250
300	7.66	4.49	1.95	4.87	1.49	0.65	3.37	0.61	0.26	1.94	0.16	0.07	1.23	0.05	0.02		12"								300
350	8.94	5.97	2.59	5.68	1.98	0.86	3.93	0.81	0.35	2.27	0.21	0.09	1.44	0.07	0.03	1.01	0.03	0.01		14"			16"		350
400	10.22	7.64	3.31	6.49	2.54	1.10	4.49	1.03	0.45	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				7.30	3.15	1.37	5.05	1.29	0.56	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		18"		8.11	3.83	1.66	5.61	1.56	0.68	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	1.08	0.02	0.01		20"					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	750
1,000	1.45	0.04	0.02	1.16	0.02	0.01				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	1,000
1,250	1.81	0.06	0.03	1.45	0.03	0.01		24"					5.13	0.74	0.32	3.61	0.31	0.14	2.99	0.20	0.09	2.29	0.10	0.04	1,250
1,500	2.17	0.08	0.04	1.74	0.05	0.02	1.21	0.02	0.01				6.15	1.03	0.45	4.33	0.44	0.19	3.58	0.28	0.12	2.74	0.14	0.06	1,500
2,000	2.89	0.14	0.06	2.32	0.08	0.04	1.61	0.03	0.01							5.78	0.75	0.33	4.78	0.47	0.20	3.66	0.25	0.11	2,000
2,500	3.61	0.21	0.09	2.91	0.12	0.05	2.01	0.05	0.02							7.22	1.13	0.49	5.97	0.71	0.31	4.57	0.37	0.16	2,500
3,000	4.34	0.29	0.13	3.49	0.17	0.08	2.41	0.07	0.03										7.17	1.00	0.43	5.49	0.52	0.23	3,000
3,500	5.06	0.39	0.17	4.07	0.23	0.10	2.81	0.09	0.04													6.40	0.70	0.30	3,500
4,000	5.78	0.50	0.22	4.65	0.30	0.13	3.21	0.12	0.05																4,000
4,500	6.50	0.62	0.27	5.23	0.37	0.16	3.62	0.15	0.06																4,500
5,000				5.81	0.45	0.19	4.02	0.18	0.08																5,000
5,500				6.39	0.53	0.23	4.42	0.22	0.09																5,500
6,000				6.97	0.63	0.27	4.82	0.25	0.11																6,000
7,000							5.62	0.34	0.15																7,000
7,500							6.03	0.39	0.17																7,500
8,000							6.43	0.43	0.19																8,000
8,500							6.83	0.49	0.21																8,500

NOTE GF Harvel 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 GF Harvel 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.

Schedule 80

Flow Rate (GPM)	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.)
	1/8"			1/4"			3/8"		
0.25	2.67	21.47	9.31	1.29	3.57	1.55	0.63	0.63	0.27
0.50	5.35	77.52	33.60	2.59	12.88	5.58	1.25	2.27	0.98
0.75	8.02	164.25	71.20	3.88	27.29	11.83	1.88	4.80	2.08
1	10.69	279.84	121.31	5.17	46.49	20.15	2.51	8.18	3.55
2	21.39	1010.21	437.93	10.35	167.84	72.76	5.01	29.54	12.81
5				25.87	915.95	397.07	12.53	161.23	69.89
7							17.54	300.66	130.34
10									

Flow Rate (GPM)	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 (GPM)
	1/2"			3/4"			1"			1-1/4"			1-1/2"			2"			2-1/2"			3"			
1	1.48	2.24	0.97	0.78	0.48	0.21	0.47	0.14	0.06	0.26	0.03	0.01	0.19	0.01	0.01	0.11	0.00	0.00	0.08	0.00	0.00	0.05	0.00	0.00	1
2	2.96	8.08	3.50	1.56	1.73	0.75	0.93	0.49	0.21	0.52	0.12	0.05	0.38	0.05	0.02	0.22	0.02	0.01	0.16	0.01	0.00	0.10	0.00	0.00	2
5	7.39	44.12	19.12	3.91	9.45	4.10	2.33	2.67	1.16	1.30	0.64	0.28	0.96	0.29	0.13	0.56	0.08	0.04	0.39	0.03	0.01	0.25	0.01	0.01	5
7	10.35	82.27	35.66	5.48	17.62	7.64	3.26	4.98	2.16	1.81	1.20	0.52	1.34	0.54	0.24	0.78	0.15	0.07	0.55	0.06	0.03	0.35	0.02	0.01	7
10	14.78	159.26	69.04	7.82	34.11	14.79	4.66	9.65	4.18	2.59	2.32	1.00	1.92	1.05	0.46	1.12	0.30	0.13	0.78	0.12	0.05	0.50	0.04	0.02	10
15	4"			11.74	72.27	31.33	6.99	20.44	8.86	3.89	4.91	2.13	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	0.57	0.04	0.02	15.65	123.13	53.38	9.33	34.82	15.09	5.18	8.36	3.62	3.83	3.80	1.65	2.23	1.07	0.47	1.56	0.45	0.19	1.00	0.15	0.07	20
25	0.71	0.06	0.03	5"			11.66	52.64	22.82	6.48	12.64	5.48	4.79	5.74	2.49	2.79	1.63	0.70	1.95	0.68	0.29	1.24	0.23	0.10	25
30	0.85	0.08	0.04	0.54	0.03	0.01	13.99	73.78	31.98	7.77	17.71	7.68	5.75	8.04	3.49	3.35	2.28	0.99	2.34	0.95	0.41	1.49	0.32	0.14	30
35	1.00	0.11	0.05	0.63	0.04	0.02	16.32	98.16	42.55	9.07	23.56	10.21	6.71	10.70	4.64	3.91	3.03	1.31	2.73	1.26	0.55	1.74	0.43	0.18	35
40	1.14	0.14	0.06	0.72	0.05	0.02	18.65	125.70	54.49	10.37	30.17	13.08	7.66	13.71	5.94	4.46	3.88	1.68	3.11	1.62	0.70	1.99	0.54	0.24	40
45	1.28	0.17	0.08	0.81	0.06	0.02	6"			11.66	37.53	16.27	8.62	17.05	7.39	5.02	4.83	2.09	3.50	2.01	0.87	2.24	0.68	0.29	45
50	1.42	0.21	0.09	0.90	0.07	0.03	0.63	0.03	0.01	12.96	45.62	19.77	9.58	20.72	8.98	5.58	5.87	2.54	3.89	2.45	1.06	2.49	0.82	0.36	50
60	1.71	0.30	0.13	1.08	0.10	0.04	0.75	0.04	0.02	15.55	63.94	27.72	11.50	29.04	12.59	6.69	8.22	3.56	4.67	3.43	1.49	2.99	1.15	0.50	60
70	1.99	0.39	0.17	1.26	0.13	0.06	0.88	0.05	0.02	18.14	85.06	36.87	13.41	38.64	16.75	7.81	10.94	4.74	5.45	4.56	1.98	3.48	1.54	0.67	70
75	2.14	0.45	0.19	1.35	0.15	0.06	0.94	0.06	0.03	19.43	96.66	41.90	14.37	43.90	19.03	8.37	12.43	5.39	5.84	5.18	2.25	3.73	1.74	0.76	75
80	2.28	0.51	0.22	1.44	0.16	0.07	1.00	0.07	0.03	20.73	108.93	47.22	15.33	49.48	21.45	8.93	14.01	6.07	6.23	5.84	2.53	3.98	1.97	0.85	80

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Schedule 80

Flow Rate (GPM)	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 (GPM)
		4"			**5"**			**6"**						**1-1/2"**			**2"**			**2-1/2"**			**3"**		
90	2.56	0.63	0.27	1.62	0.20	0.09	1.13	0.09	0.04				17.24	61.54	26.68	10.04	17.42	7.55	7.01	7.26	3.15	4.48	2.45	1.06	90
100	2.85	0.76	0.33	1.80	0.25	0.11	1.25	0.10	0.04		**8"**		19.16	74.80	32.42	11.16	21.18	9.18	7.79	8.83	3.83	4.98	2.97	1.29	100
125	3.56	1.16	0.50	2.24	0.38	0.16	1.57	0.16	0.07	0.89	0.04	0.02	23.95	113.07	49.02	13.95	32.02	13.88	9.73	13.34	5.78	6.22	4.49	1.95	125
150	4.27	1.62	0.70	2.69	0.53	0.23	1.88	0.22	0.10	1.07	0.06	0.02	28.74	158.49	68.71	16.74	44.88	19.45	11.68	18.70	8.11	7.47	6.30	2.73	150
175	4.98	2.16	0.93	3.14	0.70	0.30	2.19	0.29	0.13	1.25	0.07	0.03		**10"**		19.53	59.70	25.88	13.63	24.88	10.79	8.71	8.38	3.63	175
200	5.70	2.76	1.20	3.59	0.90	0.39	2.51	0.37	0.16	1.43	0.10	0.04	0.91	0.03	0.01	22.32	76.45	33.14	15.57	31.86	13.81	9.96	10.73	4.65	200
250	7.12	4.17	1.81	4.49	1.36	0.59	3.13	0.57	0.25	1.78	0.14	0.06	1.13	0.05	0.02	27.90	115.58	50.10	19.47	48.17	20.88	12.44	16.22	7.03	250
300	8.55	5.85	2.54	5.39	1.90	0.83	3.76	0.79	0.34	2.14	0.20	0.09	1.36	0.07	0.03		**12"**		23.36	67.52	29.27	14.93	22.74	9.86	300
350	9.97	7.78	3.37	6.29	2.53	1.10	4.38	1.05	0.46	2.50	0.27	0.12	1.59	0.09	0.04	1.12	0.04	0.02		**14"**			**16"**		350
400	11.39	9.96	4.32	7.18	3.24	1.41	5.01	1.35	0.59	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	12.82	12.39	5.37	8.08	4.04	1.75	5.64	1.68	0.73	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		**18"**		8.98	4.90	2.13	6.26	2.04	0.89	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	1.19	0.03	0.01		**20"**					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	750
1,000	1.59	0.05	0.02	1.29	0.03	0.01				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	1,000
1,250	1.99	0.07	0.03	1.61	0.04	0.02		**24"**					5.66	0.94	0.41	4.00	0.40	0.17	3.31	0.25	0.11	2.53	0.13	0.06	1,250
1,500	2.39	0.10	0.04	1.93	0.06	0.03	1.34	0.03	0.01				6.80	1.32	0.57	4.80	0.57	0.24	3.98	0.36	0.15	3.03	0.18	0.08	1,500
2,000	3.18	0.18	0.08	2.57	0.10	0.05	1.78	0.04	0.02							6.40	0.96	0.42	5.30	0.61	0.26	4.04	0.31	0.14	2,000
2,500	3.98	0.27	0.12	3.22	0.16	0.07	2.23	0.06	0.03										6.63	0.92	0.40	5.05	0.48	0.21	2,500
3,000	4.78	0.37	0.16	3.86	0.22	0.10	2.67	0.09	0.04										7.95	1.29	0.56	6.06	0.67	0.29	3,000
3,500	5.57	0.50	0.22	4.50	0.30	0.13	3.12	0.12	0.05													7.07	0.89	0.38	3,500
4,000	6.37	0.64	0.28	5.15	0.38	0.16	3.56	0.15	0.07																4,000
4,500	7.16	0.79	0.34	5.79	0.47	0.20	4.01	0.19	0.08																4,500
5,000				6.43	0.57	0.25	4.45	0.23	0.10																5,000
5,500				7.08	0.68	0.30	4.90	0.28	0.12																5,500
6,000				7.72	0.80	0.35	5.34	0.33	0.14																6,000
7,000							6.23	0.44	0.19																7,000
7,500							6.68	0.49	0.21																7,500
8,000							7.12	0.56	0.24																8,000
8,500							7.57	0.62	0.27																8,500

NOTE GF Harvel 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 GF Harvel 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.

Schedule 120

Flow Rate (GPM)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Flow Rate (GPM)
	1/2"			3/4"			1"			1-1/4"			1-1/2"			2"			2-1/2"			3"			
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	6"						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	8"						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										24.46	75.34	32.66	16.12	27.32	11.84	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

NOTE GF Harvel 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 GF Harvel 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.

Schedule 120

Flow Rate (GPM)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Flow Rate (GPM)
		4"			6"			8"																	
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
2,500																									2,500
3,000																									3,000
3,500																									3,500
4,000																									4,000
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8,500																									8,500

NOTE GF Harvel 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 GF Harvel 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.

SDR 21

Flow Rate (GPM)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Flow Rate (GPM)
		1/2"			3/4"			1"			1-1/4"			1-1/2"			2"			2-1/2"			3"		
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

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SDR 21

Flow Rate (GPM)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Flow Rate (GPM)
		4"			5"			6"			8"														
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
1,000										6.79	1.66	0.72													1,000
1,250										8.48	2.51	1.09													1,250
1,500																									1,500
2,000																									2,000
2,500																									2,500
3,000																									3,000
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NOTE GF Harvel 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 GF Harvel 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.

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SDR 26

Flow Rate (GPM)	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.)
		1/2"			3/4"			1"			1-1/4"	
1							0.30	0.04	0.02	0.18	0.01	0.01
2							0.59	0.16	0.07	0.36	0.05	0.02
5							1.48	0.88	0.38	0.89	0.26	0.11
7							2.07	1.65	0.71	1.25	0.48	0.21
10							2.96	3.19	1.38	1.79	0.94	0.41
15		4"					4.44	6.76	2.93	2.68	1.98	0.86
20	0.48	0.03	0.01				5.91	11.52	4.99	3.57	3.38	1.46
25	0.60	0.04	0.02		5"		7.39	17.41	7.55	4.47	5.10	2.21
30	0.72	0.05	0.02	0.47	0.02	0.01	8.87	24.40	10.58	5.36	7.15	3.10
35	0.84	0.07	0.03	0.55	0.03	0.01	10.35	32.46	14.07	6.25	9.52	4.13
40	0.96	0.09	0.04	0.63	0.03	0.01	11.83	41.57	18.02	7.14	12.19	5.28
45	1.08	0.11	0.05	0.70	0.04	0.02		6"		8.04	15.16	6.57
50	1.19	0.14	0.06	0.78	0.05	0.02	0.55	0.02	0.01	8.93	18.43	7.99
60	1.43	0.19	0.08	0.94	0.07	0.03	0.66	0.03	0.01	10.72	25.83	11.20
70	1.67	0.26	0.11	1.10	0.09	0.04	0.77	0.04	0.02			
75	1.79	0.29	0.13	1.17	0.10	0.05	0.83	0.04	0.02			
80	1.91	0.33	0.14	1.25	0.12	0.05	0.88	0.05	0.02			
90	2.15	0.41	0.18	1.41	0.15	0.06	0.99	0.06	0.03		8"	
100	2.39	0.50	0.22	1.56	0.18	0.08	1.10	0.08	0.03	0.65	0.02	0.01
125	2.99	0.75	0.33	1.96	0.27	0.12	1.38	0.11	0.05	0.81	0.03	0.01
150	3.58	1.06	0.46	2.35	0.38	0.16	1.65	0.16	0.07	0.98	0.04	0.02
175	4.18	1.41	0.61	2.74	0.50	0.22	1.93	0.21	0.09	1.14	0.06	0.03
200	4.78	1.80	0.78	3.13	0.64	0.28	2.21	0.27	0.12	1.30	0.08	0.03
250	5.97	2.72	1.18	3.91	0.97	0.42	2.76	0.42	0.18	1.63	0.11	0.05

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 (GPM)
	1-1/2"			2"			2-1/2"			3"		
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
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
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
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
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
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
2.72	1.73	0.75	1.73	0.58	0.25	1.18	0.23	0.10	0.79	0.09	0.04	20
3.40	2.62	1.14	2.16	0.87	0.38	1.47	0.34	0.15	0.99	0.13	0.06	25
4.07	3.67	1.59	2.59	1.23	0.53	1.76	0.48	0.21	1.19	0.18	0.08	30
4.75	4.89	2.12	3.03	1.63	0.71	2.06	0.64	0.28	1.39	0.24	0.11	35
5.43	6.26	2.71	3.46	2.09	0.90	2.35	0.82	0.35	1.58	0.31	0.14	40
6.11	7.78	3.37	3.89	2.60	1.13	2.65	1.02	0.44	1.78	0.39	0.17	45
6.79	9.46	4.10	4.32	3.16	1.37	2.94	1.24	0.54	1.98	0.47	0.20	50
8.15	13.26	5.75	5.19	4.42	1.92	3.53	1.73	0.75	2.38	0.66	0.29	60
9.51	17.64	7.65	6.05	5.88	2.55	4.12	2.30	1.00	2.77	0.88	0.38	70
10.19	20.05	8.69	6.49	6.69	2.90	4.41	2.62	1.13	2.97	1.00	0.43	75
10.87	22.59	9.79	6.92	7.54	3.27	4.70	2.95	1.28	3.17	1.13	0.49	80
12.22	28.10	12.18	7.78	9.37	4.06	5.29	3.67	1.59	3.57	1.40	0.61	90
13.58	34.16	14.81	8.65	11.39	4.94	5.88	4.46	1.93	3.96	1.71	0.74	100
			10.81	17.22	7.47	7.35	6.74	2.92	4.95	2.58	1.12	125
						8.82	9.45	4.10	5.94	3.62	1.57	150
	10"					10.29	12.57	5.45	6.93	4.81	2.09	175
0.84	0.03	0.01							7.92	6.16	2.67	200
1.05	0.04	0.02							9.91	9.31	4.04	250

NOTE GF Harvel 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 GF Harvel 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.

SDR 26

Flow Rate (GPM)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Friction Flow Velocity (ft/sec.)	Friction Loss (Ft.Water 100ft.)	Loss (psi/ 100ft.)	Flow Rate (GPM)
		4"			5"			6"			8"			10"									3"		
300	7.17	3.81	1.65	4.69	1.36	0.59	3.31	0.58	0.25	1.95	0.16	0.07	1.26	0.06	0.02		12"					11.89	13.06	5.66	300
350	8.36	5.07	2.20	5.48	1.81	0.79	3.86	0.77	0.34	2.28	0.21	0.09	1.47	0.07	0.03	1.04	0.03	0.01		14"			16"		350
400	9.56	6.50	2.82	6.26	2.32	1.01	4.41	0.99	0.43	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	400
450	10.75	8.08	3.50	7.04	2.89	1.25	4.96	1.23	0.53	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	450
500		18"		7.82	3.51	1.52	5.52	1.50	0.65	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	500
750	1.12	0.02	0.01		20"		8.27	3.17	1.38	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	750
1,000	1.49	0.04	0.02	1.21	0.03	0.01	11.03	5.41	2.34	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	1,000
1,250	1.87	0.06	0.03	1.51	0.04	0.02		24"		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	1,250
1,500	2.24	0.09	0.04	1.81	0.05	0.02	1.26	0.02	0.01	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	1,500
2,000	2.99	0.15	0.07	2.42	0.09	0.04	1.68	0.04	0.02				8.38	1.85	0.80	5.95	0.81	0.35	4.94	0.51	0.22	3.78	0.27	0.12	2,000
2,500	3.73	0.23	0.10	3.02	0.14	0.06	2.10	0.06	0.02							7.44	1.22	0.53	6.17	0.77	0.34	4.73	0.40	0.18	2,500
3,000	4.48	0.32	0.14	3.63	0.19	0.08	2.52	0.08	0.03										7.41	1.08	0.47	5.67	0.57	0.25	3,000
3,500	5.23	0.42	0.18	4.23	0.25	0.11	2.94	0.10	0.05													6.62	0.75	0.33	3,500
4,000	5.97	0.54	0.24	4.84	0.33	0.14	3.36	0.13	0.06																4,000
4,500	6.72	0.68	0.29	5.44	0.41	0.18	3.78	0.17	0.07																4,500
5,000				6.05	0.49	0.21	4.20	0.20	0.09																5,000
5,500				6.65	0.59	0.25	4.62	0.24	0.10																5,500
6,000				7.26	0.69	0.30	5.04	0.28	0.12																6,000
7,000							5.88	0.38	0.16																7,000
7,500							6.30	0.43	0.19																7,500
8,000							6.72	0.48	0.21																8,000
8,500							7.14	0.54	0.24																8,500

NOTE GF Harvel 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 GF Harvel 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.

SDR 41

Flow Rate (GPM)	Flow Velocity (ft./sec.)	Friction Loss (Ft.Water/ 100ft.)	Friction Loss (psi/ 100 ft.)	Flow Velocity (ft./sec.)	Friction Loss (Ft.Water 100ft.)	Friction Loss (psi/ 100 ft.)	Flow Velocity (ft./sec.)	Friction Loss (Ft.Water 100ft.)	Friction Loss (psi/ 100 ft.)	Flow Rate (GPM)
	18"			20"			24"			
750	1.05	0.02	0.01							750
1,000	1.40	0.04	0.02							1,000
1,250	1.75	0.05	0.02	1.42	0.03	0.01				1,250
1,500	2.10	0.08	0.03	1.70	0.05	0.02	1.18	0.02	0.01	1,500
2,000	2.81	0.13	0.06	2.27	0.08	0.03	1.58	0.03	0.01	2,000
2,500	3.51	0.20	0.08	2.84	0.12	0.05	1.97	0.05	0.02	2,500
3,000	4.21	0.27	0.12	3.41	0.16	0.07	2.37	0.07	0.03	3,000
3,500	4.91	0.36	0.16	3.98	0.22	0.09	2.76	0.09	0.04	3,500
4,000	5.61	0.47	0.20	4.55	0.28	0.12	3.16	0.12	0.05	4,000
4,500	6.31	0.58	0.25	5.11	0.35	0.15	3.55	0.14	0.06	4,500
5,000				5.68	0.42	0.18	3.95	0.17	0.08	5,000
5,500				6.25	0.50	0.22	4.34	0.21	0.09	5,500
6,000				6.82	0.59	0.26	4.73	0.24	0.11	6,000
7,000							5.52	0.32	0.14	7,000
7,500							5.92	0.37	0.16	7,500
8,000							6.31	0.42	0.18	8,000
8,500							6.71	0.47	0.20	8,500

NOTE GF Harvel 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 GF Harvel 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.

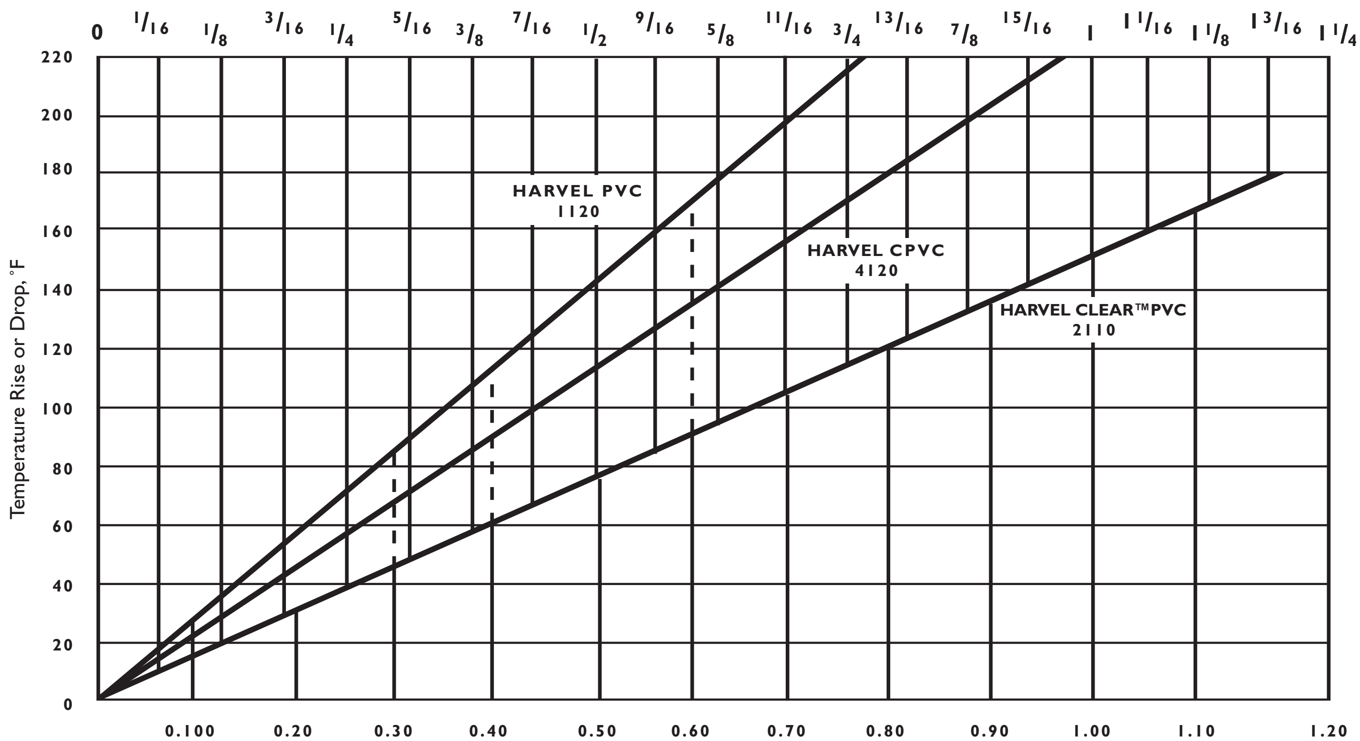
Thermal Expansion & Contraction

All piping systems expand and contract with changes in temperature. Thermoplastic piping expands and contracts more than metallic piping when subjected to temperature changes. This issue must be 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. In many cases this movement must then be compensated for by the construction of appropriate sized expansion loops, offsets, bends or the installation of expansion joints.

These configurations will absorb the stresses generated from the movement, thereby minimizing damage to the piping. 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 (i.e. summer to winter).

The following chart depicts the amount of linear movement (change in length, inches) experienced in a 10ft 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.



NOTE 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.

Engineering & Design Data

Calculating Linear Movement Caused by Thermal Expansion

The rate of movement (change in length) caused by thermal expansion or contraction can be calculated as follows:

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

Where:
ΔL = expansion or contraction in inches
y = Coefficient of linear expansion of piping material selected
l = length of piping run in feet
$\Delta T = (T_1 - T_2)$ temperature change °F

Where:
T_1 = maximum service temperature of system and
T_2 = temperature at time of installation (or difference between lowest system temperature and maximum system temperature – whichever is greatest)

Coefficient of Linear Expansion (y) of Various GF Harvel Piping Products (in/in/°F) per ASTM D696

Pipe Material	y
GF Harvel PVC Pressure Pipe (all schedules & SDR's) and PVC Duct	2.9×10^{-5}
GF Harvel CPVC Schedule 40 & Schedule 80 Pressure Pipe	3.7×10^{-5}
GF Harvel CPVC Duct	3.9×10^{-5}
GF Harvel CTS CPVC Plumbing Pipe	3.2×10^{-5}
GF Harvel Clear PVC Schedule 40 & Schedule 80 Pipe	4.1×10^{-5}
GF Harvel LXT UPW Pipe	3.9×10^{-5}

Note: Refer to appropriate physical Properties Tables for additional detailed information

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.

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

Where:
ΔL = linear expansion or contraction in inches
$y = 2.9 \times 10^{-5}$ in/in/°F
l = 100ft
ΔT = 41°F (73°F – 32°F)

ΔL = 12 in/ft x 0.000029 in/in/ft x 100ft x 41°F

ΔL = 1.43"

In this example the piping would expand approximately 1½" 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

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

Where:
ΔL = linear expansion or contraction in inches
$y = 3.7 \times 10^{-5}$ in/in/°F
l = 100ft
ΔT = 100°F (180°F-80°F)

ΔL = 12 in/ft x 0.000037 in/in/ft x 100ft x 100°F

ΔL = 4.44"

In this example the piping would expand approximately 4.5" in length over a 100 ft straight run once the operating temperature of 180°F was obtained.

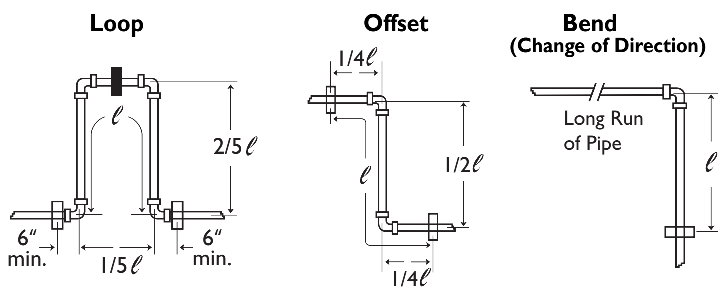
Compensating for Movement Caused by Thermal Expansion/Contraction

In most piping applications the effects of thermal expansion/contraction are usually absorbed by the system at changes of direction in the piping. However, 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 joints, expansion loops or offsets is required on long, straight runs. This will allow the piping system to absorb the forces generated by expansion/contraction without damage.

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

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

Where:
ℓ = Length of expansion loop in inches
E = Modulus of elasticity
D = Average outside diameter of pipe
ΔL = Change in length of pipe due to temperature change
S = Working stress at max. temperature



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

Example: 2" Schedule 80 CPVC pipe operating temperature 180°F; installed at 80°F where ΔL = 4.08"

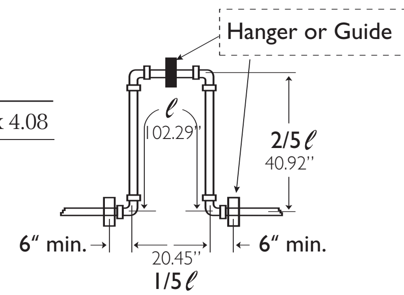
$$\ell = \sqrt{\frac{3ED(\Delta L)}{2S}}$$

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

ℓ = 102.29"

2/5 ℓ = 40.92"

1/5 ℓ = 20.46"



Engineering & Design Data

Thermal Stress

Compressive stress is generated in piping that is restrained from expanding in cases where the effects of thermal expansion are not addressed. This induced stress can damage the piping system leading to premature failure, and in some cases also cause damage to hangers and supports or other structural members. The amount of compressive stress generated is dependent on the pipe materials coefficient of thermal expansion and its tensile modulus and can be determined by the following equation:

$S = Ey\Delta T$

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

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

The stress induced into the pipe as a result of thermal influences must not exceed the maximum allowable working stress of the pipe material. The maximum allowable working stress (fiber stress) is dependent on the temperature the pipe is exposed to. Increases in temperature will reduce the allowable stress as shown the table below.

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

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

Where:
ΔL = linear expansion or contraction in inches
y = 3.7×10^{-5} in/in/˚F
l = 100ft
ΔT = 100˚F (180˚F – 80˚F)
ΔL = 12 in/ft x 0.000037 in/in/ft x 100ft x 100˚F
ΔL = 4.44"

In this example the piping would expand approximately 4.5" in length over a 100 ft straight run

Stress generated from this expansion if no allowances are made to compensate for it:

$S = Ey\Delta T$

Where:
S = stress induced in the pipe
E = Modulus of Elasticity at 180˚F = 214,000
y = Coefficient of thermal expansion = 3.7×10^{-5} in./in./˚F
ΔT = total temperature change of the system = 100˚F
S = 214,000 x 0.000037 x 100
S = 792 psi

From chart at left, maximum allowable stress for CPVC at 180˚F is 500 psi; in this example the stress generated from this expansion in a restrained piping system exceeds the maximum allowable stress and will result in failure of the piping.

Negative Pressure Applications

CRITICAL COLLAPSE PRESSURE is the maximum allowable pressure that can be applied externally to pipe, and is directly related to the wall thickness of the pipe selected. Examples of external pressure conditions can occur: when buried pipe is subjected to 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 which counteract each other. As a result, a pressurized pipe can withstand a greater external load than an empty pipe.

Critical Collapse Pressure Rating of GF Harvel PVC and CPVC Piping in PSI (and Inches of Water) – Based @ 73°F with No Safety Factor

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	17* (470)	74* (2,048)	126* (3,487)	90 (2,491)	343 (9,493)	722 (19,983)
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

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

Georg Fischer Harvel LLC recommends the use of solvent-cemented connections when using PVC/CPVC piping in vacuum service applications. Threaded connections are not recommended due to the greater potential for leakage when used in negative pressure applications.

1 psi = 2.036 inches of mercury

De-Rating Factors

PVC Pipe

Temp (°F)	Working 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

CPVC Pipe

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

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

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

Temperature Limitations

PVC

Georg Fischer Harvel LLC PVC piping products are manufactured from a Type I, Grade I PVC compound with a Cell Classification of 12454 per ASTM D1784. GF Harvel PVC Schedule 40 and Schedule 80 pipe is manufactured in strict compliance to ASTM D1785 using this material, and consistently meets or exceeds the requirements of this standard with regard to materials, workmanship, dimensions, sustained pressure, burst pressure, flattening resistance and extrusion quality.

The maximum operating temperature for PVC pipe produced to these standards is 140˚F. As with all thermoplastic materials, an increase in temperature results in an increase in impact strength and a decrease in tensile strength and pipe stiffness, which reduces the pressure rating. The mechanical properties of PVC pipe manufactured to the above referenced standards are routinely tested and recorded at 73˚F based on testing per applicable ASTM material test standards. Appropriate temperature de-rating factors must be applied when working at elevated temperatures to determine maximum allowable pressure. The following temperature de-rating factors are to be applied to the working pressure ratings stated for the products at 73˚F 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.

Temp (°F)	Working 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: 10" PVC SCHEDULE 80 @ 120°F = ?
230 psi x 0.40 = 92 psi max. @ 120°F

THE MAXIMUM SERVICE TEMPERATURE FOR PVC IS 140°F.

Solvent cemented joints should be utilized when working at or near maximum temperatures. GF Harvel Plastics does not recommend the use of PVC for threaded connections at temperatures above 110˚F; use flanged joints, unions, or roll grooved couplings where disassembly is necessary at elevated temperatures.

It is a documented fact that as temperatures fall below 73˚F, tensile strength and pipe stiffness values increase thereby increasing the pipes pressure bearing capability and resistance to bending deflection. However, as with most materials impact resistance and ductility decrease at colder temperatures. In addition, a drop in temperature will cause the piping to contract, which must be addressed with proper system design. Due to PVC's coefficient of thermal expansion, a 20-foot length of pipe will contract approximately 3/4" when cooled from 95˚F to -5˚F.

Since pressure bearing capacity is not reduced with a decrease in temperature, PVC pipe is suitable for use at colder temperatures provided the fluid medium is protected from freezing, consideration is given to the effects of expansion and contraction, and additional care and attention are given during handling, installation and operation of the system to prevent physical damage caused by impact or other mechanical forces.

It should be noted that Georg Fischer Harvel LLC routinely conducts drop impact testing on our PVC piping products at 73˚F as well as 32˚F. The impact resistance of PVC pipe at 32˚F vs. 73˚F is dependent on the pipe diameter as well as the wall thickness of the product. To our knowledge, definitive testing has not been conducted to establish an accurate ratio of the actual reduction in impact strength on the entire range of sizes/dimensions of PVC piping at lower temperatures.

CPVC

Georg Fischer Harvel LLC CPVC piping products are manufactured from a Type IV, Grade I CPVC compound with a Cell Classification of 23447 per ASTM D1784. GF Harvel CPVC Schedule 40 and Schedule 80 pipe is manufactured in strict compliance to ASTM F441 using this material, and consistently meets or exceeds the requirements of this standard with regard to materials, workmanship, dimensions, sustained pressure, burst pressure, flattening resistance and extrusion quality.

The maximum operating temperature for CPVC pipe produced to these standards is 200˚F. As with all thermoplastic materials, an increase in temperature results in an increase in impact strength and a decrease in tensile strength and pipe stiffness, which reduces the pressure rating. The mechanical properties of CPVC pipe manufactured to the above-referenced standards are routinely tested and recorded at 73˚F based on testing per applicable ASTM material test standards. Appropriate temperature de-rating factors must be applied when working at elevated temperatures to determine maximum allowable pressure. The following temperature de-rating factors are to be applied to the working pressure ratings stated for the products at 73˚F 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.

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

EX: 10" CPVC SCHEDULE 80 @ 120°F = 230 psi x 0.65 = 149.5 psi max. @ 120°F

THE MAXIMUM SERVICE TEMPERATURE FOR CPVC IS 200°F.

Solvent-cemented joints should be utilized when working at or near maximum temperatures. GF Harvel Plastics does not recommend the use of CPVC for threaded connections at temperatures above 150˚F; use flanged joints, unions, or roll grooved couplings where disassembly is necessary at elevated temperatures.

It is a documented fact that as temperatures fall below 73˚F, tensile strength and pipe stiffness values increase thereby increasing the pipes pressure bearing capability and resistance to bending deflection. However, as with most materials impact resistance and ductility decrease at colder temperatures. In addition, a drop in temperature will cause the piping to contract, which must be addressed with proper system design. Due to CPVC's coefficient of thermal expansion, a 20-foot length of pipe will contract approximately 7/8" when cooled from 95˚F to -5˚F.

Since pressure bearing capacity is not reduced with a decrease in temperature, CPVC pipe is suitable for use at colder temperatures provided the fluid medium is protected from freezing, consideration is given to the effects of expansion and contraction, and additional care and attention are given during handling, installation and operation of the system to prevent physical damage caused by impact or other mechanical forces.

An accurate ratio of the actual reduction in impact strength on specific sizes/dimensions of CPVC piping at lower temperatures has not yet been determined with physical testing due to the numerous variables involved. However, preliminary drop impact testing that has been conducted on limited sizes reveals a reduction in drop impact strength of approximately 60% on pipe that was tested at 32˚F compared to the same size of pipe tested at 73˚F. The impact resistance of CPVC pipe at 32˚F vs. 73˚F is dependent on the pipe diameter as well as the wall thickness of the product.

Weatherability

Testing and past field experience studies have concluded that when conventional Type I, Grade I (Cell Classification 12454) rigid PVC pipe is exposed to UV radiation from sunlight the following conditions have been noted:

- The effects of exposure to UV radiation results in a color change to the product, slight increase in tensile strength, slight increase in modulus of tensile elasticity, and a slight decrease in impact strength.
- UV degradation occurs only in the plastic material directly exposed to UV radiation and to extremely shallow penetration depths (frequently less than 0.001 inch).
- UV degradation does not continue when exposure to UV is terminated.
- UV radiation will not penetrate even thin shields such as paint coatings, clothing or wrapping.

Based on these studies, Georg Fischer Harvel LLC recommends that PVC and CPVC piping products (i.e. pipe, duct and shapes) exposed to the direct effects of UV radiation be painted with a light colored acrylic or latex paint that is chemically compatible with the PVC/CPVC products. Compatibility information should be confirmed with the paint manufacturer. The use of oil-based paints is not recommended.

When painted the effects of exposure to sunlight are significantly reduced, however, consideration should be given to the effects of expansion/contraction of the system caused by heat absorption in outdoor applications. The use of a light colored, reflective paint coating will reduce this affect, however, the system must also be designed and installed in such a manner to reduce the effects of movement due to thermal expansion. Information concerning expansion and contraction, proper hanger support spacing and other design criteria can be found in this engineering and installation guide.

It should be noted that GF Harvel's standard formulation of PVC compound (H707) used in the manufacture of our rigid PVC pipe and duct contains ≳1-1/2% of Titanium Dioxide (TiO_2), a natural UV inhibitor. GF Harvel's CPVC compounds used in the manufacture of rigid CPVC pipe and duct contains at least 2% Titanium Dioxide (TiO_2). GF Harvel's conventional Clear PVC piping products do not contain UV inhibitors and should not be exposed to UV radiation.

Installation

The following information is considered general in nature and is provided as a reference to assist in ensuring the highest system integrity during installation. Plastic piping systems must be designed, engineered, installed, and operated in accordance with accepted industry standards and practices, as well as any applicable code requirements. Suitability for the intended service must be clearly established prior to use. Proper selection, application, and installation of plastic piping products are the responsibility of the end user.

Storage & Handling

GF Harvel piping products are inspected, handled and loaded with great care at the factory using methods that have been developed specifically for plastic pipe to ensure that damage is minimized and overall quality is maintained during shipping. It is the carrier's responsibility to deliver the shipment in good condition. It is the receiver's responsibility to ensure that there has been no loss or damage, and that the products are unloaded and stored properly after receipt. Reasonable care and common sense should be used when handling and storing GF Harvel thermoplastic piping products.

Thermoplastic pipe and fittings may be stored indoors or outside in yards. If stored outdoors, pipe and fittings should be protected from direct exposure to sunlight, and pipe should be properly supported in storage to prevent sagging or bending. Pipe should be stored at the job site on level ground in the unit packages (skids) provided by the factory. Caution must be exercised to avoid compression, damage or deformation. When unit packages are stacked, care must be used to ensure that the weight of the upper units does not cause deformation to pipe in the lower units (i.e. stack palletized pipe wood on wood). Package units should not be stacked more than 8 feet high. Care must be used to ensure that the height of the stack does not result in instability, which can cause collapse, pipe damage or personnel injury. Unit packages should be supported by wooden racks or other suitable means, and spaced properly to prevent damage.

Thermoplastic pipe must not be stored in tightly enclosed areas subject to elevated temperatures or close to heat producing sources such as heaters, boilers, steam lines, engine exhaust, etc. Exposure to excessive temperatures will result in distortion and deformation of the product. When stored outdoors GF Harvel thermoplastic pipe must be covered with a non-transparent material. This covering must provide adequate air circulation above and around the pipe as required to prevent excessive heat absorption that can result in discoloration and deformation of the product. PVC piping products in storage should not be exposed to temperatures above 150°F. CPVC piping products in storage should not be exposed to temperatures above 210°F.

Although GF Harvel products are tough and corrosion resistant, they should not be dropped, have objects dropped on them, nor subjected to external loads. Thermoplastics can be damaged by abrasion and gouging. Pipe must not be dragged across the ground or over obstacles. Impacts such as dropping and/or rough handling should be avoided, particularly in cold weather. The product shall be inspected for any scratches, splits or gouges that may have occurred from improper handling or storage. If found, damaged sections must be cut out and discarded.

Plastic Piping Tools

Tools used with Plastic Piping

The use of tools that have been specifically designed for use with thermoplastic pipe and fittings is strongly recommended to obtain optimum results when installing thermoplastic piping systems. 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 Improper use of tools normally used with metal piping systems, i.e., hacksaws, water pump pliers, pipe wrenches, etc., can cause damage to plastic pipe and fittings. Visible and non-visible fractures, scoring or gouging of material, and over tightening of plastic threaded connections are some of the major problems associated with the use of incorrect tools and/ or procedures.

Pipe Cutters

Plastic pipe must have square-cut ends to allow for the proper interfacing of the pipe end and the fitting socket bottom. A wheel type pipe cutter, with special blades for plastic pipe, provides easy and clean cutting action. The raised bead left on the outside of the pipe after cutting must then be removed. A miter box saw may also be used to produce square-cut ends.

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.

Power Saws

Power saws especially for use with plastic pipe are available. These are particularly useful in prefabrication operations where a large quantity of pipe is being cut. Blades designed for thermoplastic pipe **MUST** be used. Follow manufacturer's instructions regarding speed, set and proper use of tool.

Pipe Beveling Tools

Portable and mounted power beveling tools, as well as hand beveling tools specifically 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 prevent scraping the solvent 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 quickly achieved using a plastic pipe beveling tool.

Deburring Tools

A smooth, beveled pipe end helps spread the solvent easily as the pipe is joined to the fitting. All burrs must be removed from the inside, as well as the outside, of the pipe ends. Special plastic pipe deburring tools debur pipe ends quickly and efficiently.

Strap Wrenches

Strap wrenches with special woven nylon straps are extra strong and are treated for slip resistance. These strap wrenches, designed for use with plastic pipe, provide gripping power for turning, without scratching or deforming the pipe.

Chain Vises

Chain vises are made with jaws for holding plastic pipe. Jaws engineered for use with plastic pipe provide holding power, without damage to the pipe.

Joining Devices

Pipe and fitting pullers are available designed specifically 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. The use of these types of tools can also reduce assembly time.

Fabrication

Cutting

It is important that cutting tools used are designed for use on plastic pipe. GF Harvel rigid PVC and CPVC plastic pipe can be readily cut with an appropriate hand saw, power saw, or plastic tubing cutters. With a circular power saw, a cutting speed of 6,000 RPM, using ordinary hand pressure, is recommended. With band saws, a cutting speed of 3,600 feet per minute, using hand pressure, is recommended. Under some circumstances a lathe can be used. Best results are obtained with fine-toothed saw blades (16 to 18 teeth per inch) and little or no set (maximum 0.025 inch). Cuts must be square and smooth, particularly if the pipe is to be threaded. A miter box or similar guide should be used when cutting by hand. The cut ends can be beveled with a hand file, and the interior deburred with a regular tool or knife. Dust and chips should be removed to eliminate fluid stream contamination. The pipe should be well supported during cutting and protected from nicks and scratches by wrapping in canvas or similar material. Use of wheel type pipe cutters is not recommended, since they tend to generate heat and will produce a raised ridge, which increases the beveling effort required.

Threading

GF Harvel PVC and CPVC pipe can be threaded using either standard hand pipe stocks or power-operated equipment. Since GF Harvel 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 represents a stress concentration point and therefore only schedule 80 and schedule 120 pipe should be threaded.** The 50% pressure de-rating is provided to compensate for this. The thread grooves would be too deep for the relatively thin walls of schedule 40 pipe. For optimum results in threading, use new taps and dies; but in any case, they should be cleaned and sharpened 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.

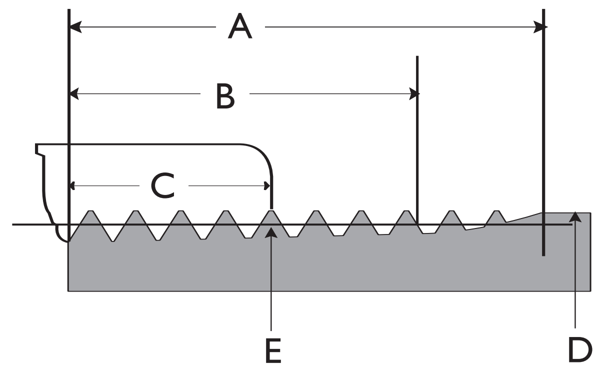
A tapered plug should be inserted into the pipe when threading, to hold the pipe round and to prevent the die from distorting and digging into the pipe wall. This insures uniform thread depth all the way around. Pipe for threading should be held in a suitable pipe vise, but saw-tooth jaws should not 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. GF Harvel rigid PVC or CPVC plastic pipe can be threaded without use of external lubricants; but cutting oils which require degreasing type solvents are not recommended, nor should such solvents be used in any cleanup operation. Water-soluble oil or plain water is recommended. Clearing of cuttings from the die is strongly recommended.

Installation

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 vanish 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

Hot Gas Welding

The most important and most versatile of welding methods is the hot gas or hot air welding method which in principle is similar to that of oxyacetylene welding of metals, but with a difference in technique involved. Commercially available hot gas welding equipment is employed, with a temperature at the tip of approximately 600˚F, and a welding temperature of approximately 500˚F. Welding rods employed are of PVC or CPVC and are available in different sizes to suit individual jobs. All types of welding may be performed with a joint efficiency of 60 to 90 percent for non-pressure rated systems. Although high weld strength is possible, welds should be positioned so they are in tension or compression. Bending stresses should be avoided and suitable gussets should be employed. Use of this technique as a substitute for tees on branches from main runs is not recommended for pressure systems. Only highly trained personnel should attempt this operation. Further details on this process, as well as names of welding equipment manufacturers and schools for plastics welding operators, will be supplied on request. New equipment for butt-welding the joints of fabricated fittings produce higher strength fittings at the weld areas. Nevertheless, polyester fiberglass overwrap may still be desirable for pressurized systems. Hot gas welding of CPVC is much more difficult and should be done only by experienced personnel.

Heat Bending

Bending of Clear PVC pipe may be desirable under certain conditions where long-radius bends and unusual configurations are required. Various sizes and wall thicknesses of rigid PVC pipe have been successfully heat-formed for many years into numerous angles, long-radius sweeps for conduit and flow conditions, U-bends for thermal compensation, and offsets in congested areas.

The following information is provided as a general guide for a better understanding of heat bending techniques commonly used in the field, and does not attempt to address specialized shop fabrication methods or procedures.

Successful bending requires that the appropriate amount of heat be applied uniformly to the required length of pipe to be bent. This presents the greatest challenge for field bending, as the heating method used must provide the necessary amount of heat over the required length of pipe in a reasonable amount of time. Several common pipe heating methods used in the field involve the use of hot air ovens, electric box heaters, electric pipe heating blankets, and flameless hot gas torches. Temperatures necessary to heat the pipe are dependent on pipe size and the severity of the desired bend radius. In general, PVC pipe should be heated from 225˚F to 275˚F for the minimum amount of time necessary to achieve uniform softening. Care should be taken to avoid exposing the pipe to bending temperatures for an excessive length of time, as irreparable distortion and deformation will occur. Localized overheating must be avoided. Successful minor bends (< 30°) can be achieved with minimum distortion in the lower temperature range (225°F) without internal support. Sharp bends (> 30°) require higher temperatures (250°-275°F) as well as internal support to prevent wall distortion/collapse.

Common methods used to provide internal support to the pipe during the bending process include using a filling medium such as sand or perlite (cat litter), inserting a coiled spring into the pipe, or in some cases providing internal pressure. Filling the pipe with fine grain sand or perlite prior to heating furnishes the internal support necessary to prevent collapse, while at the same time provides an excellent medium for uniform heat distribution during the heating process.

The filling medium used should be packed tightly into the pipe to achieve the desired bend radius with minimum distortion.

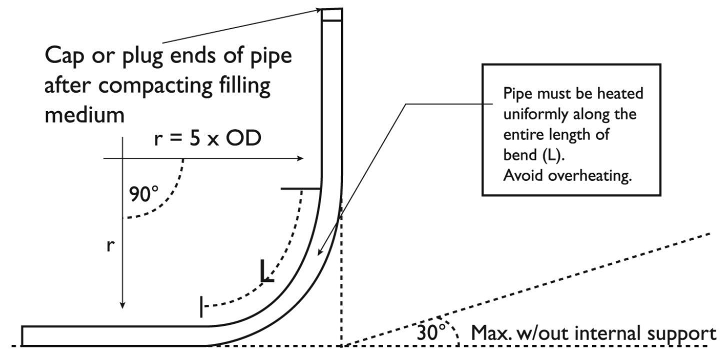
During this process, the pipe ends are capped or plugged and the filling medium is compacted as much as possible to remove any air pockets prior to heating. Once the bend is formed and cooled, the sand is emptied from the pipe and any remaining particles can be easily removed by rinsing with water.

To provide fabrication consistency in the field, standard pipe bending forms which provide the required radius and are sized (grooved) for the proper diameter can be used to bend plastic pipe. Plywood jigs constructed on site have also been used successfully in many applications. The minimum radius at bend should not be less than five times the pipe outside diameter to prevent flattening. Due to the recovery characteristics of the material, the pipe should be bent slightly beyond the desired radius and allowed to spring back to the required angle once uniformly heated at the correct temperature. When the bend is obtained, the pipe should be held in place and cooled quickly using a wet sponge or other application of water.

It should be noted that most bending procedures will induce stress into the pipe wall which can be retained in the material after the bend radius is formed. The amount of stress induced is dependent on the severity of the bend, the diameter and wall thickness of the pipe bent, and the bending method used. This residual stress will be added to the normal stresses created by internal pressure, installation procedures, and the effects of temperature. Therefore, pipe bending should be limited to applications for use at ambient temperatures or lower where maximum operating pressures are not utilized. It should also be noted that during the bending process of clear PVC pipe, the material will become cloudy during the heating process but will regain clarity when cooled, provided excessive bending stresses are not retained. The use of a filling medium during the bending process can also cause slight pitting and other interior surface blemishes depending on the method used.

! NOTE Attempting to form bends in rigid thermoplastic piping at temperatures too low (below 200°F) can induce excessive stress into the pipe, thereby jeopardizing its physical performance.

HEAT BENDING OF RIGID PVC THERMOPLASTIC PIPING



$$L = \frac{r \times \alpha \times \pi}{180}$$

Where:
L = Length of bend arc
r = minimum bend radius (5 x Pipe O.D.)
α = Desired angle in degrees
π = 3.14

Example:

What is the length of the arc needed to bend 2" Sch 40 clear pipe into an 90° ell?

O.D. of 2" IPS pipe = 2.375"
r = 5 x 2.375" or 11.875"
α = 90°

$$L = \frac{11.857 \times 90 \times 3.14}{180}$$

L = 18.6"

1. Follow appropriate safety precautions prior to conducting any heat bending procedures.
2. Bending procedures must be conducted in a well ventilated area, using protective clothing (gloves, apron etc.) to prevent damage or injury.
3. Do not expose pipe to open flames or excessive temperatures.
4. Bends greater than 30° require internal pipe support to prevent distortion.
5. Compact filling medium prior to bending.
6. Minimum radius at bend should not be less than 5 times the pipe O.D. to prevent kinking.
7. Calculate required length of bend based on angle needed, and heat this entire area uniformly.
8. Avoid overheating.
9. Cool bend with water to "set-up" desired angle.

The data furnished herein is provided as a courtesy and is based on past experience, limited testing, and other information believed to be reliable. This information may be considered as a basis for recommendation only, and not as a guarantee for its accuracy, suitability for particular applications, or the results to be obtained there from. Materials should be tested under actual service to determine suitability for a particular purpose.

Joining Techniques

Solvent Cementing

The solvent-cemented connection in thermoplastic pipe and fittings is the last vital link in a plastic pipe installation. It can mean the success or failure of the system as a whole. Accordingly, it requires the same professional care and attention that are given to other components of the system. There are many solvent cementing techniques published covering step by step procedures on just how to make solvent cemented joints. However, we feel that if the basic principles involved are explained, known and understood, a better understanding would be gained as to what techniques are necessary to suit particular applications, temperature conditions, and variations in size and fits of pipe and fittings.

Safety Precautions

Solvent cement products are flammable and contain chemical solvents, therefore appropriate safety precautions should be taken. Read the cement can label!

Be aware at all times of good safety practices. Solvent cements for pipe and fittings are flammable, so there should be no smoking or other sources of heat or flame in working or storage areas. Be sure to work only in a well-ventilated space and avoid unnecessary skin contact with all solvents. More detailed safety information is available from the solvent cement manufacturer.

⚠CAUTION BEFORE APPLYING PRIMER AND CEMENT, appropriate safety precautions should be taken.

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 cement should be stored in closed containers in the shade at temperatures between 40˚F and 110˚F.

Avoid breathing vapors. *They should be used only with adequate ventilation. Explosion-proof general mechanical ventilation or local exhaust is recommended to maintain vapor concentrations below recommended exposure limits. In confined or partially enclosed areas, a ventilating device should be used to remove vapors and minimize their inhalation. A NIOSH-approved organic vapor cartridge respirator with full face-piece is recommended. Commercially available respirators especially designed to minimize the inhalation of organic vapors can also be used. Containers should be kept tightly closed when not in use, and covered as much as possible when in use.*

Avoid frequent 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. Avoid any contact with eyes; splash proof chemical goggles are recommended. 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.*

Containers should be kept tightly closed when not in use and covered as much as possible when in use. Use of an applicator can with applicator attached to a lid is especially recommended. ***Verify expiration dates stamped on cements and primers prior to use.***

REFER TO SOLVENT CEMENT MANUFACTURERS MATERIAL SAFETY DATA SHEETS (MSDS) PRIOR TO USE

⚠WARNING Use Caution with Welding Torches
At construction sites where plastic pipe is being installed or has recently been solvent welded, special caution should be taken when using welding torches or other equipment where sparks might be involved. Flammable vapors from cemented joints sometimes linger within or around a piping system for some time. Special care must be taken when using a welding torch in these applications:

- Well casing installations
- Elevator shafts or similar applications where fumes could accumulate
- Installing pumps
- Installation of plastic pipe systems in industrial plants

In all cases, lines should be purged to remove solvent vapors before welding.

⚠WARNING 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. The introduction of granules or pellets of calcium hypochlorite with solvent cements and primers (including their vapors) may result in violent chemical reactions if a water solution is not used. It is advisable to purify lines by pumping chlorinated water into the piping system—this solution will be nonvolatile.

Furthermore, 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
Work areas should be protected by using drop cloths in the event of an accidental spill. Cement and/or primer spills can cause irreparable damage depending on the type of surface affected. Accidental spills should be wiped up immediately before the cement sets. A mild soap and water mixture may aid in removal of a stain; however, the use of solvents or harsh cleansers may do more damage than good. In the event of a spill, consult the manufacturer of the affected surface for possible suggestions. Protecting the work area prior to starting is recommended.

People have learned they must be careful with gasoline. Although solvent cements are not as flammable as gasoline, users must also learn to be careful. Again, accidents and injuries have seldom occurred in the use of these products. Help maintain and improve this excellent record by following the above recommendations.

Basic Principles of Solvent Cementing

The solvent-cemented connection in thermoplastic pipe and fittings is the last vital link in a plastic pipe installation. It can mean the success or failure of the system as a whole. Accordingly, it requires the same professional care and attention that are given to other components of the system. There are many solvent cementing techniques published covering step-by-step procedures on just how to make solvent cemented joints. However, we feel that if the basic principles involved are explained, known and understood, a better understanding would be gained as to what techniques are necessary to suit particular applications, temperature conditions, and variations in size and fits of pipe and fittings.

Be aware at all times of good safety practices. Solvent cements for pipe and fittings are flammable, so there should be no smoking or other sources of heat or flame in working or storage areas. Be sure to work only in a well-ventilated space and avoid unnecessary skin contact with all solvents. Refer to Safety Precautions section for additional information.

To consistently make good joints, the following should be carefully understood:

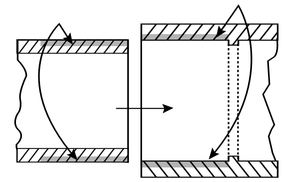
1. The joining surfaces must be softened and made semi-fluid.
2. Sufficient cement must be applied to fill the gap between pipe and fitting.
3. Assembly of pipe and fittings must be made while the surfaces are still wet and fluid.
4. Joint strength develops as the cement dries. In the tight part of the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

Important: Installers should verify for themselves that they can make satisfactory joints under varying conditions and should receive training in installation and safety procedures.

Softening and Penetration

These areas must be softened and penetrated. This can be achieved by the cement itself, by using a suitable primer, or by the use of both primer and cement. A suitable primer will usually penetrate and soften the surfaces more quickly than the cement alone.

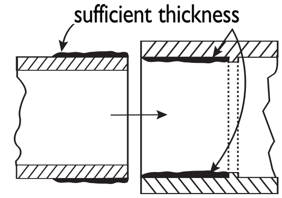
Marked areas must be softened and penetrated



Sufficient Application of Cement

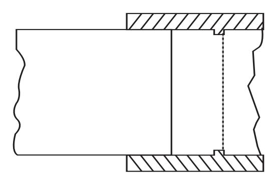
More than sufficient cement to fill the gap in the loose part of the joint must be applied. In addition to filling the gap, adequate cement layers will penetrate the joining surfaces and remain fluid until the joint is assembled.

Cement coatings of sufficient thickness



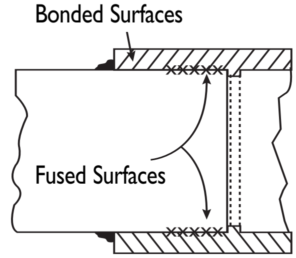
If the cement coatings on the pipe and fittings are wet and fluid when assembly takes place, they will tend to flow together and become one layer. Also, if the cement is wet, the surfaces beneath them will still be soft, and these softened surfaces in the tight part of the joint will tend to fuse together.

Surfaces must be assembled while they are wet and soft



As the solvent dissipates, the cement layer and the softened surfaces will harden with a corresponding increase in joint strength. A good joint will take the required working pressure long before the joint is fully dry and final strength is obtained. In the tight (fused) part of the joint, strength will develop more quickly than in the looser (bonded) part of the joint. Information about the development of bond strength of solvent cemented joints is available.

Bonded Surfaces



Installation

Hot Weather

There are many occasions when solvent cementing GF Harvel piping products in 95˚F temperatures and over cannot be avoided. If a few special precautions are taken, problems can be avoided. Solvent cements contain high-strength solvents which evaporate faster at elevated temperatures. This is especially true when there is a hot wind blowing. 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 and deeper, especially inside a joint. Thus, it is very important to avoid puddling inside sockets, and to wipe off excess cement outside.

Tips to Follow when 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. 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

Solvent Cement products 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 attack, therefore, it becomes more important to pre-soften surfaces. Because of slower evaporation, a longer cure time is necessary.

Tips to Follow when 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.

Follow appropriate set and cure times prior to pressure testing.

Getting Started

- Review Safety Precautions
- Review Cement Can Label
- Review Assembly Instructions
- Condition pipe and fittings being joined to the same temperature conditions prior to use

Inspection Before Use

Pipe and fittings should always be inspected for damage before actual installation. Pipe or pipe fittings with cuts, gouges, scratches, splits, or other signs of damage from improper handling or storage should not be used. Damaged sections on lengths of pipe can easily be cut out using proper techniques for cutting thermoplastic pipe.

Check Material

Make sure the fittings, valves, and pipe being joined are of the same type of plastic product (i.e. PVC or CPVC). It is unwise to use Type I and Type II PVC, for example, in the same installation. The expansion and contraction features, pressures, etc., are vastly different, and use of mixed materials could cause failure. It is also recommended that the fittings and pipe should be of the same schedule. It is not recommended that Schedule 40 fittings, for example, be used with Schedule 80 pipe, since the pressure rating, socket depth, and other features may not lend themselves to a Schedule 80 installation. Make sure that the proper primer and cement is being used with the proper pipe and fittings. Never use CPVC cement on Type I PVC pipe or, conversely, never use PVC cement on CPVC pipe and fittings. Verify the expiration dates stamped on the cements and primers prior to use (date codes can typically be found on the bottom of the container).

Handling of Cement

Keep cement containers covered while not in use. If the container of cement with the lid off is subjected to prolonged exposure to air, the cement in the can becomes thick and viscous, or gel like. Chances are that this condition has been brought about by the evaporation of the tetra hydro furan (THF) solvent. If this occurred, the cement is useless. Do not try to restore the cement by stirring in a thinner. For this reason, it is suggested that smaller containers of cement, rather than the large container, be used, especially in warm or hot weather. Prior to using an unopened can of cement, it is well to shake it vigorously to insure proper dispersion of the resin and solvents. Keep in mind that the solvents contained in PVC 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. All PVC cement should be handled in the same manner as a very fast-drying lacquer. Verify the expiration dates stamped on the cements and primers prior to use.

Estimated Quantities of Solvent Cement

Estimated quantities of GF Harvel PVC and CPVC cement can vary due to installation conditions, tolerance variations, and socket depths. Fabricated and belled fittings will usually require larger quantities. It is better practice to error on the liberal side than skimp if precautions as outlined in GF Harvel's instructions are recognized and followed. Field conditions or a combination of factors could occur during installation that has not yet been encountered. Consequently, the information contained herein may be considered as a basis for recommendation but not as a guarantee.

Fabricated fittings socket depths can vary with respect to manufacturer or if the fitting is pressure rated. The cement requirements shown for these sizes are based upon the socket depths shown. If the socket depth is shorter, a smaller quantity of cement can be utilized. For example, if the socket depth of a 12" fitting is only 5," you would take 5/8.5 of the cement quantity shown per joint. If the socket depth is 9" for a 12" fitting, you would take 9/8.5 of the cement quantity shown.

Quantities of P-70 Primer requirements average 1/3 of the cement requirements.

Estimated Number of Joints per Pint and Quart Sizes Based on Pipe Diameter

	PINT				QUART			
Size Fitting (in.)	No. of Joints	No. of Couplings or 90s	No. of Tees	No. of Belled Pipe Joints	No. of Joints	No. of Couplings or 90s	No. of Tees	No. of Belled Pipe Joints
1/2	190	95	64	N/A	380	190	127	N/A
3/4	120	60	40	N/A	240	120	80	N/A
1	100	50	33	N/A	200	100	66	N/A
1-1/4	70	35	24	N/A	140	70	48	N/A
1-1/2	50	25	17	N/A	100	50	33	N/A
2	30	15	10	25	60	30	20	50
2-1/2	25	12	8	20	50	24	16	40
3	20	10	6	16	40	20	12	32
4	12	6	4	9	24	12	8	18
5	9	4.5	3	-	18	9	6	-
6	5	2.5	1.7	3	10	5	3.3	6
8	2.5	1	.8	2	5	2.1	1.6	4

Socket Joints

Size (in.)	Socket Depth (in.)	Cement* Quarts/Joint
10	8	.75
12	8-1/2	1.00
14	9	1.25
16	10	1.50
18	12	2.00
20	12	2.25
24	14	3.25

NOTE: GF Harvel recommends Weld-On 717 for all schedules and SDR's 1/8" - 5", and Weld-On 719 for all schedules and SDR's 6" - 24". Weld-On 717, 719 are registered trademarks of IPS Corporation.

Gasket Pipe (Lubricant)

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

Installation

Solvent Cement Assembly Instructions

General Instructions

CAUTION BEFORE APPLYING PRIMER AND CEMENT, appropriate safety precautions should be taken.

Primer and cement should be stored in the shade between 40˚F and 110˚F. Eliminate all ignition sources. Avoid breathing vapors. Use only with adequate ventilation; explosion-proof general mechanical ventilation or local exhaust is recommended to maintain vapor concentrations below recommended exposure limits. In confined or partially enclosed areas, a NIOSH-approved organic vapor cartridge respirator with full face-piece is recommended. Containers should be kept tightly closed when not in use, and covered as much as possible when in use. Avoid frequent contact with skin; wearing PVA-coated protective gloves and an impervious apron are recommended. Avoid any contact with eyes; splash proof chemical goggles are recommended. (Please refer to Safety, Basic Principles, and Getting Started sections on the preceeding pages prior to use). Verify expiration dates stamped on cements and primers prior to use.

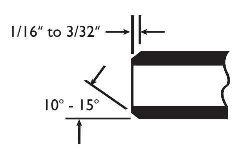
Component Preparation: Condition the pipe and fittings to the same temperature conditions prior to use. All pipe, fittings and tools used for joining must be clean and free of dirt, moisture, grease or other contamination prior to and during the joining process.

1. Cutting

Cut ends of pipe square using appropriate tools. To ensure the pipe is cut square, a miter box must be used when using a saw. Cutting the pipe as squarely as possible provides the surface of the pipe with a maximum bonding area. GF Harvel PVC and CPVC pipe can be easily cut with a wheel-type plastic tubing cutter, a power saw, or a fine toothed saw. Care must be taken not to split the pipe if a ratchet type cutter is used, especially in temperatures below 50˚F. If any indication of damage or cracking is evident, cut off at least two (2) inches beyond any visible crack. It is important that the cutting tools used are designed for use on plastic pipe; refer to plastic piping tools section.

2. Bevel/Debur

Burrs and filings can prevent contact between pipe and fitting during assembly, and must be removed from the outside and the inside of the pipe. A chamfering tool or file is suitable for this purpose. A slight bevel shall be placed at the end of the pipe to ease entry of the pipe into the socket and minimize the chances of wiping solvent cement from the fitting. Place a 10˚ to 15˚ bevel approximately 1/16" to 3/32" in width on the end of the pipe.



3. Joining Preparation

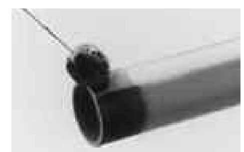
A. Inspect & Clean Components - Prior to assembly, all components shall be inspected for any damage or irregularities Mating components shall be checked to assure that tolerances and engagements are compatible. Do not use components that appear irregular or do not fit properly. Contact the appropriate manufacturer of the component product in question to determine usability. Using a clean, dry rag, wipe loose dirt and moisture from the fitting socket and pipe end. Moisture can slow the cure time, and at this stage of assembly, excessive water can reduce joint strength.

B. Check the dry fit - The pipe should enter the fitting socket easily one-quarter to three-quarters of the way. If the pipe bottoms in the fitting with little interference, use extra solvent cement in making the joint. If the pipe bottoms in the fitting with little interference, use extra solvent cement in making the joint.

C. Measure the socket depth - Measure the socket depth of the fitting and mark this distance on the pipe end. This reference mark can be used when joining to ensure the pipe is completely bottomed into the fitting during assembly.

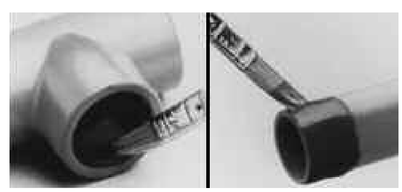
D. Position the pipe and fitting for alignment.

4. Primer Application



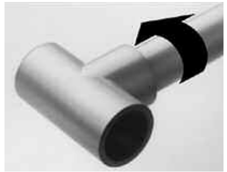
Primer must be used to prepare the bonding area for the addition of the solvent cement and subsequent assembly. It is important to use a proper applicator—a dauber, natural bristle brush, or roller approximately 1/2 the size of the pipe diameter is appropriate. A rag must NOT be used. Primer must be applied to both the pipe and fittings. Apply Primer to the fitting socket, then to the outside of the pipe end, then a second coating to the fittings socket, re-dipping applicator as necessary to ensure entire surface is wet. Repeated applications may be necessary.

5. Solvent Cement Application



The solvent cement shall be applied when the pipe and fittings are clean and free of any moisture and debris, and must be applied immediately while primer is still tacky. Cement shall be applied to the joining surfaces using a dauber, natural bristle brush, or roller approximately 1/2 the size of the pipe diameter. Apply a heavy, even coat of cement to the outside pipe end to equal to the depth of the fitting socket. The amount should be more than sufficient to fill any gap. Apply a medium coat to the fitting socket. Avoid puddling. If there was little or no interference when the dry fit was checked, a second application of cement should be made to the pipe end.

6. Assembly



While BOTH SURFACES are STILL WET with solvent cement, immediately insert the pipe into the fitting socket while rotating the pipe 1/4 turn. Pipe must bottom completely to the fitting stop. Properly align the fitting for installation at this time. Hold the assembly for approximately 30 seconds to ensure initial bonding. Due to the taper on the interference fit, the pipe can back-off the fitting stop if steady pressure is not held on the joint during initial bonding. A bead of cement should be evident around the pipe and fitting juncture. If this bead is not continuous around the socket shoulder, it may indicate that insufficient cement was applied. If insufficient cement is applied, the joint must be cut out, discarded and begun again. Cement in excess of the bead can be wiped of with a rag.

7. Set and Cure Times

Solvent Cement set and cure times are a function of: the cement type used, pipe size, temperature, relative humidity, and tightness of fit. Drying time is faster for drier environments, smaller pipe sizes, high temperatures and tighter fits. The assembly must be allowed to set, without any stress on the joint, for 1 to 5 minutes depending on the pipe size and temperature. Following the initial set period the assembly can be handled carefully avoiding stresses to the joint. **All solvent-cemented assemblies must be allowed to cure properly prior to pressure testing.** Refer to solvent cement manufacturers set and cure schedule prior to testing, and GF Harvel's suggested set and cure time, detailed solvent cementing information, and testing section for additional information.

! NOTE The general step by step instructions provided herein are based on the use of conventional Schedule 40 & Schedule 80 PVC & CPVC industrial piping products used under normal installation conditions and cannot be construed as covering every possible combination of field conditions. Specialty piping systems such as GF Harvel CPVC fire sprinkler piping products, GF Harvel LXT® UPW piping products, and other products have specific solvent cementing instructions that may vary from above. Follow appropriate solvent cementing procedures for the products being utilized.

Set and Cure Times

! NOTE The following set and cure times are average times based on the use of IPS Weld-On P-70 Primer and IPS Weld-On #717 and/or IPS Weld-On #719 Solvent cements as applicable for joining Schedule 40 & Schedule 80 PVC Piping, and the use of IPS Weld-On #714 as applicable for joining Schedule 40 & Schedule 80 CPVC Piping. Actual set and cure times are dependent on the pipe material and solvent cement system utilized, pipe size, temperature, relative humidity, pressure and tightness of fit.

SET TIME: The initial set times shown below are the recommended waiting periods before handling newly assembled joints. After initial set, the joints will withstand the stresses of normal installation. (A badly misaligned installation will cause excessive stresses in the joint, pipe and fittings.)

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.

CURE TIME: The cure time is the recommended waiting period before pressurizing newly assembled joints. These times depend on type of cement used, pipe size, fit, temperature, humidity and pressure. Follow appropriate cure times carefully. Allow longer cure periods for high humidity and/or cold weather – consult solvent cement manufacturer.

Avoid puddling of cement or primer on or within fitting and pipe that causes excess softening of the material and could cause damage to the product.

Installation

Hot Weather

There are many occasions when solvent cementing GF Harvel piping products in 95˚F temperatures and over cannot be avoided. If a few special precautions are taken, problems can be avoided. Solvent cements contain high-strength solvents that evaporate faster at elevated temperatures. This is especially true when there is a hot wind blowing. 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 and deeper, especially inside a joint. Thus, it is very important to avoid puddling inside sockets, and to wipe off excess cement outside.

Tips to Follow when 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. 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

Solvent Cement products 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 attack, therefore, it becomes more important to pre-soften surfaces. Because of slower evaporation, a longer cure time is necessary.

Tips to Follow when 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.

Follow appropriate set and cure times prior to pressure testing.

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 provided as a courtesy and 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. The above cure schedules are based on laboratory test data obtained on Net Fit Joints (NET FIT = in a dry fit, the pipe bottoms snugly in the fitting socket without meeting interference). Contact the appropriate solvent cement manufacturer for additional information. Installers should verify for themselves that they can make satisfactory joints under varying conditions and should receive training in installation and safety procedures.

Applicators

A wide variety of daubers, brushes, and rollers are available from the solvent cement manufacturer. Use the appropriate type and size applicator for the materials being joined. It is important to use a proper size applicator. A dauber, brush, or roller approximately one-half the size of the pipe diameter being joined is appropriate. Do not use daubers attached to the cement can lid on large diameter products (> 3"dia.) as sufficient cement cannot be applied. Generally daubers supplied on pint can lids are suitable for pipe sizes 1/2" – 1-1/4" diameters, and daubers supplied on quart can lids are suitable with pipe sizes from 1-1/2" – 3" diameters. Rollers are available for pipe sizes greater than 3".

Primers

The use of Primer is necessary to penetrate and dissolve the surface of the pipe and fitting prior to the application of cement. This is particularly true when working with large diameter pipe and conventional Schedule 40 and Schedule 80 piping for use in pressure applications. Primer must be applied to both the pipe and fittings. Apply primer to the fitting socket, then to the outside of the pipe end, than a second coat to the fitting socket; re-dipping the applicator as necessary to ensure entire surface is wet.

! NOTE Solvent cement should be applied immediately after primer while the surfaces are still tacky.

Solvent Cements

Select the appropriate solvent cement and primer for the type of products being joined.

The cement system used for joining PVC and CPVC plastic pipe is a solvent-based type. The solvent, typically tetra hydro furan (THF), dissolves the mating surfaces when properly applied to each surface. The PVC or CPVC resin filler contained in the cement assists in filling the gaps between pipe and fitting surfaces. An evaporation retardant, usually cyclohexanone, slows the rate of evaporation of the prime solvent (THF). Some cements are available clear, while most others contain pigments to match the pipe color. The most common color is gray, made from titanium dioxide and carbon black, which are considered inert pigments. Joining of the wet mating surfaces in one minute or less after starting to cement is essential to eliminate dry spots that will not bond. The bond interface will consist of a mixture of cement resin and dissolved PVC or CPVC from the attached pipe and fitting surfaces. As the solvent evaporates, the interface becomes homogeneous with the pipe and fitting surfaces except for residual solvent, which dissipates over a period of time. The resultant homogeneous bonded area has led to the term “solvent welded” although no heat is applied to melt and fuse the bonded areas as in metal welding.

A wide variety of different grades of solvent cements are available for different applications, pipe sizes and material types. They are usually classified as light or regular bodied, medium bodied, heavy bodied, extra heavy bodied and specialty cements. Different types of cements have different set and cure times.

1. **Light/Regular Bodied –** Cements for smaller diameters (i.e. < 4") and thin-wall classes and Schedule 40 piping with interference fits. They typically are called Schedule 40, quick-dry, regular body cement, or light-body cement. These cements are not designed to fill as much of a gap, tend to dry faster, do not bite into the pipe and fitting as much, and cure somewhat faster.

2. **Medium Bodied –** Cements for smaller diameters (i.e. < 4") for all classes, Schedule 40 and Schedule 80 pipe with interference fits. These cements have slightly better gap filler properties than regular bodied cement but are still considered fast setting cements.

3. **Heavy Bodied & Extra Heavy Bodied –** Cements for large diameters, and heavier-wall Schedule 80 and 120 products where the pipe is not as roundable. These cements are called heavy-weight, heavy-body, or Schedule 80 cements, and are designed to fill larger gaps, dry slower, bite into the pipe and fitting more, and have longer cure times.

4. **Specialty Cements -** Specialty cements have been formulated, developed, and tested for use with specific products and applications. Examples include Low VOC cements, transition cements, product specific, and one-step cements. One-step cements do not require the use of primer prior to the application of the cement, however their use is somewhat limited. Examples include one-step cements for use with CPVC fire sprinkler piping, CPVC hot and cold water plumbing pipe, and clean PVC cements for use in high purity applications (i.e. GF Harvel LXT®). Another example is specialty cements developed with improved chemical resistance to caustics. Specialty cements must be used in strict accordance with the manufacturers instructions for the intended application and should not be used to join conventional PVC/CPVC piping without investigating their suitability for use.

Contact GF Harvel or the solvent cement manufacturer for proper selection of primers, solvent cements, and applicators for various applications. Review the solvent cement manufacturers assembly instructions. Product training free of charge is available.

Installation

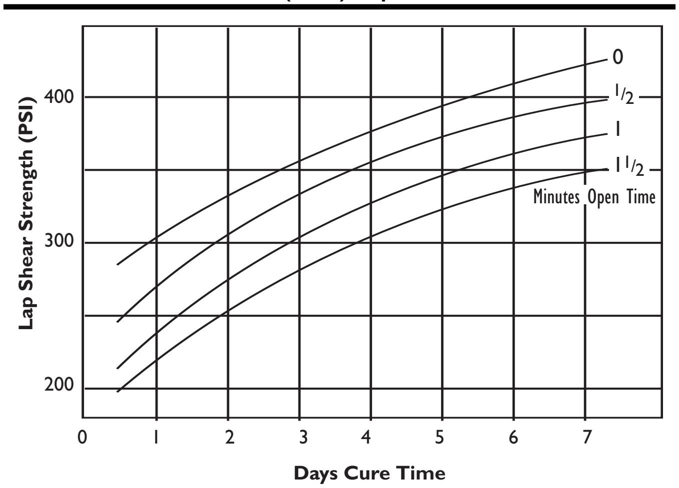
Joint Strength

Use of cements not designed for the system being installed or improper cementing techniques result in the majority of field problems with PVC and CPVC piping installations. Cements should be flowed on, not painted on, and brushes should not be trimmed as with oil based paints (apply like brushing on lacquers).

The drying time of the job cement supplied should be checked with a flowed-on coat on a piece of pipe. This time should not be less than a minute and preferably 1-1/2 minutes. A tacky wet surface (fingerprint impression marks not permanent) is desirable. This test indicates that the "open time" usually required is obtainable with that cement. It takes into account the obviously longer time required for assembly of larger sized pipe. The tabulations below are essentially 0 minute open time. They do reflect the effect of a .020" gap, which can be greater depending upon whether the pipe is in the horizontal or vertical plane during assembly. This gap, of course, could be appreciably less or greater depending upon the size of the pipe. The accompanying curve shows 1/2 minute, 1 minute, 1-1/2 minutes open times. This data is representative of cements with the 1 minute tacky-wet surface mentioned heretofore. Test conditions were similar to those employed for the tabulations on the left hand side, except the surfaces were joined as timed. They dramatically indicate the necessity of getting the pipe joint together as soon as possible after cement application is initiated. Joint failure normally does not occur with separation of the fitting from the pipe with application of test or working pressure. Failures are usually slight drip leaks, large drip leaks and pressurized spray leaks. The example below indicates the improbability of fitting separation from pipe. The only exceptions known are where lower temperatures and 100% humidity conditions occur.

Days Cure Time vs. Shear Strength & Open Time

Tests Conducted with 20 mil (.020") Gap



Test data courtesy Industrial Polychemical Service (IPS), Gardena, CA

Compressive Shear Strength PSI vs. Cure Time Using Heavyweight (HW) PVC Cement IPS #717or Extra Heavyweight (EHW) PVC Cement IPS #719

Cure Time	No Gap	.020" Gap
2 Hours		
HW 717	245	112
EHW 719	300	147
16 Hours		
HW 717	500	135
EHW 719	538	165
72 Hours		
HW 717	845	218
EHW 719	687	352
2 Weeks		
HW 717	913	362
EHW 719	1,287	563
30 Days		
HW 117	1,087	412
EWH 719	1,557	667

ASTM Test Method D-2564. Except Weld-On P-70 was used instead of MEK (Methyl Ethyl Ketone) to clean the area to be cemented

Example: 4" Schedule 80 PVC or CPVC Pipe. 4.5" O.D. 2.25" socket depth.

Cement surface area (in^2) = (O.D.)(π)(socket depth) = 31.81 in^2

Minimum cement shear strength = 300 PSI

Resistance to shear in pounds force = (31.81) (300) = 9543

Pounds force on cement shear area due to internal working pressure of 320 PSI for water at 73°F with average I.D.

3.786": $(3.786)^2$ $\pi/4$ x 320 = 3603 pounds force shear at working pressure.

Safety factor 9543/3603 = 2.65

It is obvious that in fitting design the safety factor is sufficient to prevent blow off, and with proper cementing, leakage should not occur. Nonetheless, cementing involves other intangibles in technique, humidity and other weather conditions. The data above does not take into consideration other variables. Some of which include: bending loads, movement due to cyclic temperature conditions, field trench construction and handling/installation techniques, and buried installations with heavy traffic or other types of loading. Proper cement selection, assembly techniques, and following proper set and cure times become more critical where these other variables exist. Channeling of fluid through the non-bonded areas is the usual failure mode. The longer socket depth of belled end pipe can help to alleviate such leakage problems.

Tolerances and Fits

PVC pipe and fittings are manufactured in accordance with applicable ASTM Standards to produce an interference fit when assembled. However, this condition can vary because of the minimum and maximum allowable tolerances permitted by the standards to which the pipe and fittings are produced.

In the case of a fitting with the maximum diameter and the pipe with the minimum diameter, a loose fit could result. Applying two coats of solvent cement under these conditions 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. to permit entrance may be necessary.

For these specific reasons, it is important to check dry fits prior to making a solvent welded joint. The Schedule 40 and lighter wall SDR pipe have a tendency to round themselves within the Schedule 40 fittings, thus permitting a greater degree of interference. However, in the case of Schedule 80 fittings, the heavy wall on the pipe will cause the pipe to be "non roundable". Interference can be less on large diameter Schedule 80 fittings (particularly fabricated fittings), which in many cases will allow the pipe to "bottom dry" with very little interference. It is under these conditions that it may be necessary to use a extra heavy bodied solvent cement and to apply more than one coat of solvent cement to the pipe and fitting if the "dry fit" seems loose. Prior to assembly, all piping system components should be inspected for damage or irregularities. Mating components should be checked to assure that tolerances and engagements are compatible. 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

The basic solvent cement instructions apply to all sizes of pipe, but when making joints 4" and above, the use of two men to apply the solvent cement simultaneously to pipe and fitting is recommended. Additional men should also be in a position to help "push" the pipe into the fitting socket while the cemented surfaces are still wet and ready for insertion. Alignment of large diameter pipe and fittings is much more critical than when working with small diameter pipe. Specialty large diameter joining tools developed specifically for joining large diameter PVC and CPVC piping products are available.

It is imperative to use the appropriate size applicator for the application of primer and cement when working with large diameter pipe. Use a roller approximately one-half the size of the diameter of pipe being joined. As the pipe diameters increase, the range of tolerances also increases, which can result in "out of round" and "gap" conditions. Speed in making the joint and applications of heavy coats of solvent cement in these cases is important. When working with pipe diameters such as 8" through 24", checking the dry fit of pipe and fittings again is more critical on these large sizes. In many cases where fabricated fittings are used, interference fits may not be present, and consequently it will be necessary to apply more than one coat of cement to the pipe and fitting. It is essential to use a heavy bodied, and/or extra heavy-bodied, slow drying cement on these large diameter sizes.

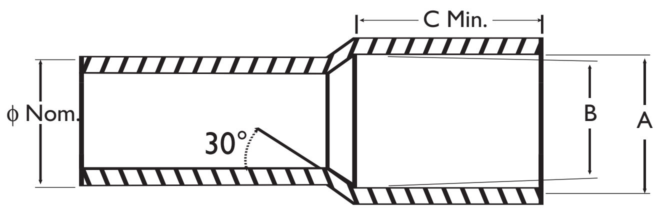
IPS Weld On 719 is a gray, extra heavy bodied, thixotropic (paste like), high strength PVC Solvent Cement. It provides thicker layers and has a higher gap filling property than regular heavyweight cement. It also allows slightly more open time before assembly. It is formulated for joining large size PVC pipe and fittings in all schedules and classes, including Schedule 80. It has excellent gap filling properties, which are particularly desirable where a sizeable gap exists between pipe and fitting. Under a damp or wet condition, this cement may absorb some moisture. Excessive moisture tends to slow down the cure and can reduce the ultimate bond strength. Contact GF Harvel or the solvent cement manufacturer for the proper selection of solvent cements when working with large diameter products.

Installation

Belled End Pipe

In many installations, 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 GF Harvel does not use silicone lubricants in the belling process. However, some manufacturers use a silicone release agent on the belling plug, and a residue of this agent can remain inside the bell. This residue must be removed in the cleaning process prior to solvent cementing.



GF Harvel Belled-End Pipe Dimensions

Nominal Size (in.)	A Min.	A Max	B 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

Techniques to Assure Strong Joints

Installers should verify for themselves that they can make satisfactory joints under varying conditions and should receive training in installation and safety procedures. Consult GF Harvel assembly instructions, Material Data Safety Sheet from the cement manufacturer, ASTM D2855 Standard Practice for Making Solvent cemented Joints with PVC Pipe and Fittings, and ASTM F402 Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings. **Follow appropriate cure times prior to pressure testing**– refer to Cure Schedules and Testing sections.

Heavy bodied cements can be and are successfully used in place of the lighter cements. There have probably been more field problems created by the use of the lighter and quicker drying cements with larger and heavier-wall pipe, than with heavy-weight cements and lighter-wall and small-diameter pipe. It is extremely difficult to get a satisfactory bond in the first case and quite easy with reasonable care in the second instance. More care should be used in cementing fitting sockets, especially smaller sizes, and avoiding puddling of cement or primer within the components being joined. Puddling causes excess softening of the material and could cause damage to the product. Maximum or somewhat extended cure times should also be followed with the heavy-bodied cements.

In the final analysis, the cement should be still wet when the surfaces are mated. In certain cases, difficult areas may extend cement-to-joining times to the upper one-minute limit. A check should be made with the cement supplied to insure it will provide a still-wet surface for at least one full minute with a normal full coat under the actual field conditions. This can be done by preparing a scrap piece of pipe with the primer and then applying a full, even coating stroke with the brush and checking to see if the cement is still wet after one minute.

Joint Evaluation

Good PVC solvent joints exhibit a complete dull surface on both surfaces when cut in half and pried apart. Leaky joints will show a continuous or an almost continuous series of un-fused areas (shiny spots) or channels from the socket bottom to the outer lip of the fitting. No bond occurred at these shiny spots. This condition can increase to the point where almost the entire cemented area is shiny, and fittings can blow off at this point.

Un-fused areas can be attributed to one or a combination of the following causes:

1. Use of wrong size applicator (insufficient cement application)
2. Use of a cement that has partially or completely dried prior to bottoming of the fitting
3. Use of a jelled cement that will not bite into the pipe and fitting surfaces due to loss of the prime solvent
4. Insufficient cement or cement applied to only one surface.
5. Excess gap, which cannot be satisfactorily filled.

6. Excess time taken to make the joint after start of the cement application. In many of these cases, as well as condition 1 or 2 above, examination will show that it was impossible to bottom the fitting, since the lubrication effect of the cement had dissipated.
7. Cementing with pipe surfaces above 110°F has evaporated too much of the prime solvent.
8. Cementing with cement, which has water added by one means or another, or excess humidity conditions coupled with low temperatures.
9. Joints that have been disturbed and the bond broken prior to a firm set, or readjusted for alignment after bottoming.
10. Cementing surface not properly primed and dissolved prior to applying solvent cement
11. Improper component preparation.
    a. Lack of a bevel on the pipe end, or an insufficient bevel, will cause the inserted pipe to scrape solvent from the socket wall of the fitting during assembly.
    b. Failure to debur. The presence of filings and shavings can create weak spots within the assembled components resulting in un-fused areas.
    c. Failure to cut the pipe end square will reduce surface area of the solvent cemented assembly in the critical area of the joint (socket bottom).

Joining Techniques

Threaded Connections

Georg Fischer Harvel LLC recommends the use of a quality PTFE (polytetrafluoroethylene) thread tape having a thickness of 0.0025" or greater that meets or exceeds military specification MIL-T-27730A for making-up threaded connections. Not more than 3 to 3-1/2 mil thickness is recommended.

! NOTE Some oil base pipe joint compounds and/or thread pastes contain ingredients that attack PVC or CPVC piping products. Assurances should be obtained from the manufacturer of the thread sealants that long-term tests with either material (PVC and/or CPVC) show no deleterious effects. Special examination should be made for environmental stress cracking. Suitability of thread paste compounds for use with plastics must be clearly established prior to use.

Assembly

Starting with the first full thread and continuing over the entire thread length, making sure that all threads are covered, wrap a PTFE thread tape in the direction of the threads. The tape should be started in a clockwise direction at the first or second full thread with a half width overlap over the effective thread length. It should be wrapped with enough tension so threads show through the single wrap area. Generally 2 to 3 wraps of tape are sufficient. Pipe sizes 2" and larger will benefit with not more than a second wrap due to the greater depth of thread.

Care must be used to avoid overtorquing during assembly. Generally 1 to 2 turns beyond finger tight is all that is required to obtain a leak-tight seal for most pipe sizes. GF Harvel recommends the use of a strap wrench when making up threaded connections as pipe wrenches, pliers and similar tools can cause damage to plastic pipe and fittings. Factory testing has indicated that 10–25 ft.-lbs. of torque is typically adequate to obtain a leak free seal. Sharp blows, dropping or straining of any kind should be avoided. The thread should not be forced. The larger sizes will usually not make up as much by hand and will require more wrench make up.

! NOTE **Use of threaded pipe requires a 50% reduction in pressure rating stated for plain end pipe @ 73°F.** Georg Fischer Harvel LLC does not recommend the use of PVC for threaded connections at temperatures above 110°F (>150°F for CPVC). Use specialty reinforced female adapters, flanges, socket unions, or grooved couplings where disassembly may be necessary on PVC or CPVC systems operating at elevated temperatures.

Plastic To Metal Threaded Joints

The American Standard Taper pipe thread was designed for metal pipe with appreciably higher tensile strengths than plastic. Occasionally it may be necessary to make a metal to plastic threaded joint. A male plastic thread can be inserted into a female metal thread if heat is not involved and both lines are anchored immediately adjacent to the joint. Male metal threads should not be connected to a female plastic pipe thread unless specialty reinforced plastic female adapters are used. Refer to "Transition To Other Materials" section for additional information.

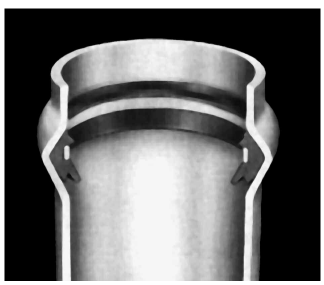
Joining Techniques

PVC Gasketed Pipe

Standards and Specifications

All GF Harvel piping products are manufactured in strict compliance with applicable industry standards and specifications to ensure consistent quality; GF Harvel gasket pipe is no exception. Since integral gasket bells are available on a variety of pipe dimensions, applicable standards are dependent on the pipe dimension chosen. All GF Harvel PVC pipe is manufactured from a Type I, Grade I PVC material per ASTM D1784. All GF Harvel gasket pipe utilizes flexible elastomeric seals for pressure pipe which, when properly assembled, meet the requirements of push-on joints per ASTM D3139. The gaskets used are manufactured in strict compliance with ASTM F477 requirements. GF Harvel SDR Series gasketed pipe is manufactured in strict compliance with ASTM D2241. GF Harvel PVC Schedule 40, 80 and 120 gasketed pipe is manufactured in strict compliance with ASTM D1785.

Rieber style gasket
2" through 8"



Retained Ring style gasket
10" through 24"

Gasket Design

GF Harvel gasketed pipe utilizes gaskets that are locked in place at the factory as part of the manufacturing process. Two styles of factory-installed gaskets are used. Pipe sizes 2" through 8" incorporate the Rieber style gasket; 10" through 24" diameter pipes utilize the Retained Ring style gasket. Both gasket styles are locked in place, and eliminate the need to install gaskets in the field. This technique also prevents fish mouthing or dislocation of the seal during assembly. The standard gasket material 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 available when necessary to meet demanding chemical resistance requirements.

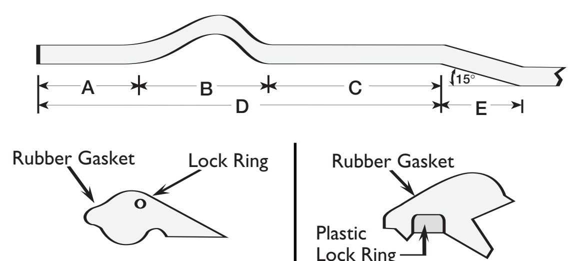
GF Harvel gasketed pipe offers low assembly force; flexibility to allow for variations in line pressure and changing working conditions; compensation for movement due to thermal expansion and contraction; a certain amount of allowable joint deflection; and positive, leak-free seals for both high- and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

Installation–Gasketed Pipe

Low assembly force enables fast and simple field installation without the risk of gasket dislocation. Each spigot end of GF Harvel gasket pipe contains a 15° bevel for easy insertion, as well as a factory-placed reference mark to indicate proper insertion depth. The reference marks also provide a visual means to verify proper insertion if lines are assembled above ground, and lowered into the trench after assembly. Field-cut lengths must be cut square, beveled to the same 15° taper, and marked to the proper insertion depth.

Dimensions

IPS (in.)	A	B	C	D	E (approx.)
Rieber Gasket					
2	0.590	1.329	2.820	4.739	0.474
2-1/2	0.670	1.489	2.860	5.019	0.566
3	0.708	1.587	2.940	5.235	0.688
4	0.867	1.723	3.020	5.610	0.874
6	1.063	2.076	3.200	6.339	1.274
8	1.260	2.073	3.500	6.833	1.500
Retained Ring Gasket					
10	1.875	2.417	4.750	9.042	1.500
12	2.000	2.619	5.500	10.119	1.500
14	2.125	3.375	6.000	11.500	1.500
16	2.250	2.875	6.500	11.625	1.500
18	2.500	3.062	7.000	12.562	1.500
20	2.750	3.375	7.375	13.500	1.500
24	2.203	3.781	8.000	13.984	1.500



Rieber gasket - 2"–8"
Laying length, 19'6" ± 2"

Retained Ring gasket - 10"–24"
Laying length, 19' ± 2"

Deflection

GF Harvel 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

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 devices are also used, but must be of design for use with PVC pipe.

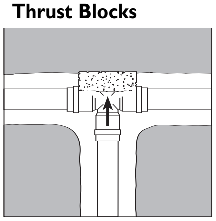
Thrust in lb. @ 100 psi Operating Pressure

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

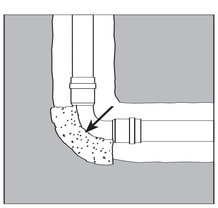
Safe Bearing Capacity

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

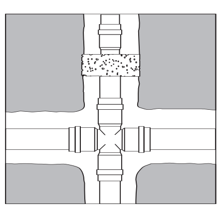
Thrust Blocks



Thru line connection, tee

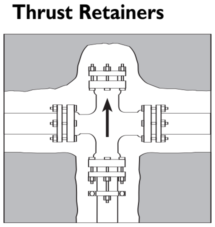


Direction change, elbow

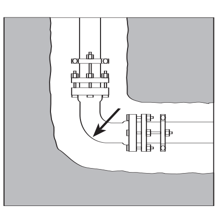


Change line size, reducer

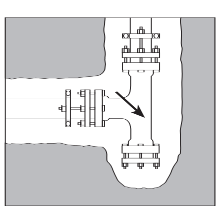
Thrust Retainers



Thru line connection, cross used as tee



Direction change, elbow



Direction change, tee used as elbow

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.

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 GF Harvel 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

Trenching–Initial Backfill

Trench depth is determined by the intended service and local conditions. GF Harvel 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.

Installation

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. The use of compressed air or gases for testing is not recommended.

GF Harvel suggests testing sections of pipe 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.

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 D2774 (Underground Installation of Thermoplastic Pressure Pipe), and ASTM D2321 (Underground Installation of Flexible Thermoplastic Sewer Pipe).

Water Volume Gallons Per 100 Feet

Pipe Size (in.)	Sch. 40	Sch. 80	Sch. 120	SDR. 21	SDR. 26	SDR. 41
2	17	15	14	19	20	–
2-1/2	25	22	21	28	29	–
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

Joining Techniques
Flanged Connections

When to Use Flange Connections

Flanged joints can be used in applications where frequent dismantling is required. PVC and CPVC flanges are available in both socket and threaded configurations in a variety of styles including one piece solid style flanges and two piece Van Stone style flanges where the bolt ring spins freely of the hub, easing bolt hole alignment during assembly. Most plastic flanges carry a maximum working pressure rating of 150-psi non-shock for water at 73˚F. Care should be taken to select the proper gasket material for compatibility with the fluid being conveyed

Flange Installation Instructions

Flange Gasket

A Class 150# rubber gasket must be used between the flange faces in order to ensure a good seal. For Schedule 80 flanges, GF Harvel recommends a 0.125" thick, full-face gasket with Shore A scale hardness of 70 ±5, and the bolt torque values shown on the table “Flange Bolt Torque” are based on this specification.

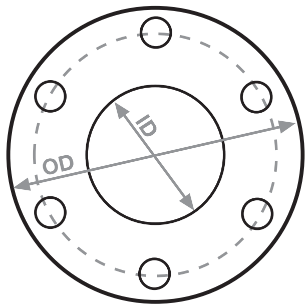
Contact GF Harvel for torque recommendations if other gasket hardness is required.

Select the gasket material based on the chemical resistance requirements of your system.

A full-face gasket should cover the entire flange-to-flange interface without extending into the flow path.

Flange Dimensions

Size (in.)	O.D. (in, min)	I.D. (in, max)
1/2	3.50	0.88
3/4	3.88	1.10
1	4.25	1.38
1-1/4	4.63	1.60
1-1/2	5.00	1.93
2	6.00	2.44
2-1/2	7.00	2.91
3	7.50	3.59
4	9.00	4.64
6	11.00	6.82
8	13.50	8.66
10	16.00	10.81
12	19.00	12.09



Fastener Specifications

Either the bolt or the nut, and preferably both, should be zinc-plated to ensure minimal friction. If using stainless steel bolt and nut, anti-seize lubricant must be used to prevent high friction and seizing.

The following fastener combinations are acceptable:

• zinc-on-zinc, with or without lube

• zinc-on-stainless-steel, with or without lube

• stainless-on-stainless, with lube only

Cadmium-plated fasteners are also acceptable with or without lubrication. Galvanized and carbon-steel fasteners are not recommended. Use a compatible antiseize lubricant to ensure smooth engagement and the ability to disassemble and reassemble the system easily.

CAUTION The chemical compatibility of the antiseize lubricant should be confirmed with the manufacturer prior to use with CPVC pipe and flanges. Certain types of lubricants can contain chemical additives that are incompatible with CPVC, and may result in failure if used.

Bolts must be long enough that two complete threads are exposed when the nut is tightened by hand.

A washer must be used under each bolt head and nut. The purpose of the washer is to distribute pressure over a wider area. Failure to use washers voids the GF Harvel warranty.

Flange Bolt Specifications

Pipe Size (in.)	No. of Bolts	Length[1] (in.)	Bolt Size (in.) & Type	Washer Size (in.) & Type[2]
1/2	4	2-1/2	1/2-UNC[5]	1/2
3/4	4	2-1/2	1/2-UNC	1/2 SAE[3]
1	4	2-3/4	1/2-UNC	1/2 SAE
1-1/4	4	2-3/4	1/2-UNC	1/2 SAE
1-1/2	4	3/1/4	1/2-UNC	1/2 SAE
2	4	3-1/2	5/8-UNC	5/8 SAE
2-1/2	4	4	5/8-UNC	5/8 SAE
3	4	4	5/8-UNC	5/8 SAE
4	8	4-1/4	5/8-UNC	5/8 SAE
6	8	4-1/2	3/4-UNC	3/4 F436[4]
8	8	6	3/4-UNC	3/4 F436
10	12	6	7/8-UNC	7/8 F436
12	12	6	7/8-UNC	7/8 F436

1: Suggested bolt length for flange-to-flange connection with 0.125" thick gasket. Adjust bolt length as required for other types of connections.

2: Minimum spec. Use of a stronger or thicker washer is always acceptable as long as published torque limits are observed.

3: Society of Automotive Engineers Compliant. Also known as Type A Plain Washers, Narrow Series.

4: ASTM F436, Standard Specification for Hardened Steel Washers, required for larger sizes to prevent warping at high torque.

5: Unified Coarse Threads

NOTE Verify customer spec is in compliance with manufactuters' recommendations.

Installation

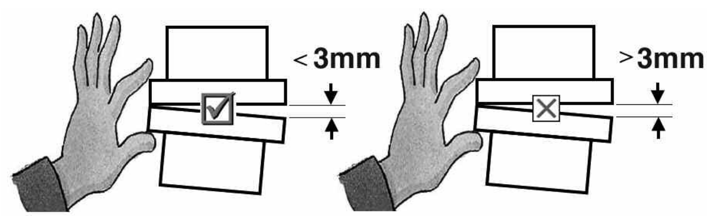
Checking System Alignment

Before assembling the flange, be sure that the two parts of the system being joined are properly aligned. GF Harvel has developed a “pinch test” that allows the installer to assess system alignment quickly and easily with minimal tools.

First check the gap between the flange faces by pinching the two mating components toward each other with one hand as shown below. If the faces can be made to touch, then the gap between them is acceptable

Check the angle between the flange faces. If the faces are completely flush when pinched together, then the alignment is perfect, and you may continue installation. Otherwise, pinch the faces together so that one side is touching, then measure the gap between the faces on the opposite side.

The gap should be no more than 3mm or 1/8"!



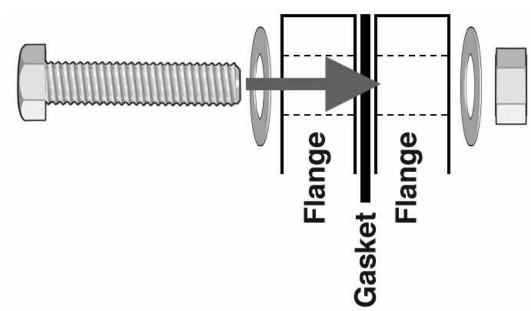
If the gap between the components cannot be closed by pinching them with one hand, or if the angle between them is too large, refit the system with proper alignment before bolting.

Assembly of the Flange

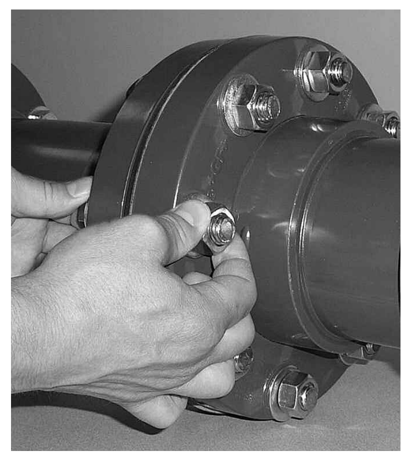
Center the gasket between the flange faces, with the bolt holes aligned with corresponding holes in the gasket. A full-face gasket cut to the specified dimensions (see table “Flange Dimensions”) should come just to the inner edge of the flange face near the flow path, or overlap the edge slightly.

If using a compatible antiseize lubricant as recommended, apply the lubricant evenly with a brush directly to the bolt threads, and to the nut if desired. Cover the bolt from its tip to the maximum extent to which the nut will be threaded.

Insert bolts through washers and bolts holes as shown:

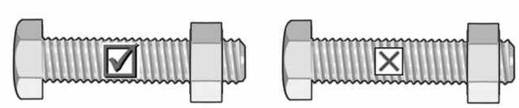


Tightening the Bolts



Tighten all nuts by hand. As you tighten each nut, the nuts on the other bolts will loosen slightly. Continue to hand-tighten all of the nuts until none remain loose.

Now the flange assembly will remain in place as you prepare to fully tighten it. When hand-tightened, at least two threads beyond the nut should be exposed in order to ensure permanent engagement. If fewer than two threads are exposed, disassemble the flange and use longer bolts.



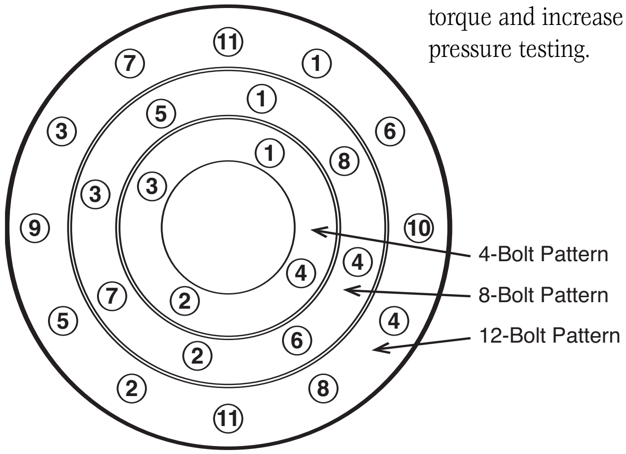
To ensure even distribution of stresses in the fully-installed flange, tighten the bolts in a star pattern then repeat the star pattern while tightening to the next torque value, and so on up to the maximum torque value.

For the installer's convenience, the pattern is also indicated by numbers molded into the vinyl flange next to each bolt hole. The torque required on each bolt in order to achieve the best seal with minimal mechanical stress is given on table below.

Vinyl flanges deform slightly under stress. Therefore, a final tightening after 24 hours is recommended, when practical. If a flange leaks when pressure-tested, re-tighten the bolts to the full recommended torque and retest. Do not exceed the recommended torque before consulting an engineer or GF Harvel representative.

Flange Bolt Torque

Size (in.)	Torque Sequence (ft-lb, lubed*)
1/2	5
3/4	5
1	5
1-1/4	5
1-1/2	5
2	8
2-1/2	12
3	15
4	20
6	30
8	40
10	60
12	72



Flange Connection to other Components

Note that the torques listed in the table are for flange-to-flange connections in which the full faces of the flanges are in contact.

For other types of connections, such as between a flange and a butterfly valve, where the full face of the flange is not in contact with the mating component, less torque will be required. Do not apply the maximum listed torque to the bolts in such connections, which may cause deformation or cracking, since the flange is not fully supported by the mating component.

Instead, start with approximately two-thirds of the listed maximum torque and increase as necessary to make the system leak-free after pressure testing.

Joining Techniques

Groove Style Connections

In many installations where transition to metal pipe, or where disassembly is a prime factor, metallic grooved style couplings 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. In order to prepare the plastic pipe for adapting the grooved style couplings, it is necessary to roll or cut a groove onto the end of the pipe without jeopardizing the wall thickness. Where shock loads from intermittent operation are probable, particularly with large diameter pipe, angular displacement should be avoided and the pipe aligned longitudinally to minimize high stress levels on the grooves. Grooved end pipe is available from GF Harvel.

Corrosion resistant grooved PVC piping in IPS sizes 2" through 24" is available as a fabrication option from the factory. Pressure rating of grooved end piping varies with schedule, pipe size, temperature, and the selected groove style coupling manufacturers' product specifications. As with all PVC piping, the maximum service temperature for grooved end PVC pipe is 140°F. The groove coupling manufacturer should be consulted for temperature and pressure limitations of the coupling used. This pipe is available from Georg Fischer Harvel LLC with grooved ends designed for use with Victaulic Style 75 or Style 77 or equivalent flexible style couplings. Only flexible style grooved couplings are recommended for use with GF Harvel grooved-end PVC pipe.

Groove Style (roll or cut)

Size (in.)	SCH 40 SCH 26 SDR 21[1] SDR 41[2]	SCH 80 SCH 120[1]
2	ROLL	ROLL
2-1/2	ROLL	ROLL
3	ROLL	ROLL
4	ROLL	ROLL
6	ROLL	ROLL[4]
8	ROLL	ROLL[4]
10	ROLL	CUT
12	ROLL	CUT
14	ROLL[3]	CUT
16	ROLL[3]	CUT
18	CUT	CUT
16	ROLL	CUT
18	CUT	CUT
20	ROLL	CUT
24	ROLL	CUT

1: SDR 21 and Schedule 120 PVC grooved pipe is available in the size ranges 2" to 8".
2: SDR 41 PVC grooved pipe is available in the size ranges 18" to 24".
3: 14" and 16" SDR 26 must be cut grooved.
4: 6" and 8" Schedule 120 must be cut grooved.

Installation

Rigid style couplings are not recommended for use on plastic pipe as they provide a compressive/shear load that can result in failure.

GF Harvel currently utilizes both the roll grooving method as well as the cut grooving method to provide grooved end pipe in the sizes below.

In addition to roll grooving pipe, injection molded PVC and CPVC grooved coupling adapters are also available for joining plastic pipe to metal pipe via the use of the grooved style couplings. Only flexible style metallic grooved couplings are recommended for use with plastic pipe. Rigid style couplings can provide a compressive/shear load to plastic pipe resulting in failure; as a result their use is not recommended. Care should be taken to investigate the compatibility of the grooved coupling gasket material for the intended application.

Roll Groove Specifications (IPS)

Size (in.)	O.D.	A Gasket Seat +0.015, −0.030	B Groove Width +0.030, −0.015	C Groove Diameter Actual/Tolerance	D Nominal Groove Depth	T Min. Allowable Pipe Wall
2	2.375	0.625	0.344	2.250 +0.000, −0.015	0.063	0.065
2-1/2	2.875	0.625	0.344	2.720 +0.000, −0.015	0.078	0.083
3	3.500	0.625	0.344	3.344 +0.000, −0.015	0.078	0.083
4	4.500	0.625	0.344	4.334 +0.000, −0.015	0.083	0.083
6	6.625	0.625	0.344	6.455 +0.000, −0.015	0.085	0.109
8	8.625	0.750	0.469	8.441 +0.000, −0.020	0.092	0.109
10	10.750	0.750	0.469	10.562 +0.000, −0.025	0.094	0.134
12	12.750	0.750	0.469	12.531 +0.000, −0.025	0.109	0.156
14	14.000	0.938	0.469	13.781 +0.000, −0.025	0.109	0.156
16	16.000	0.938	0.469	15.781 +0.000, −0.025	0.109	0.165

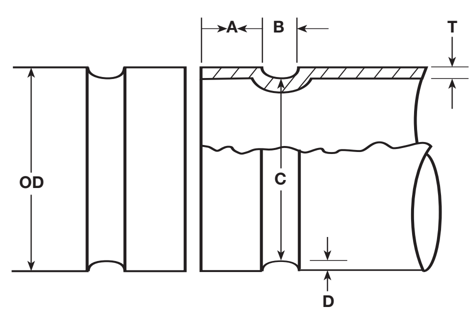
Roll Groove Specifications (IPS)

Size (in.)	O.D.	A Gasket Seat ±0.031	B Groove Width ±0.031	C Groove Diameter Actual/Tolerance	D Nominal Groove Depth	T Min. Allowable Pipe Wall
14	14.000	0.938	0.500	13.781 +0.000, −0.030	0.109	0.281
16	16.000	0.938	0.500	15.781 +0.000, −0.030	0.109	0.312
18	18.000	1.000	0.500	17.781 +0.000, −0.030	0.109	0.312
20	20.000	1.000	0.500	19.781 +0.000, −0.030	0.109	0.312
24	24.000	1.000	0.344	23.656 +0.000, −0.030	0.172	0.375

Specifications applicable to Schedule 40, 80, and 120 PVC piping are described in ASTM D1785
Specifications applicable to SDR 21, 26, and 41 PVC piping are described in ASTM D2241

NOTE Temperature and Pressure ratings and limitations are dependant on the grooved coupling manufacturer's specifications.

NOTE 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. HARVEL PLASTICS, INC. suggests verifying the suitability for use of the selected lubricant with the lubricant manufacturer prior to use.



Joining Techniques

Specialty Adapters

Specialty reinforced molded female adapters are available in PVC and CPVC for use as transition fittings to alternate materials. 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. In addition, this style of fitting also helps to compensate for stresses that may be generated as the result of differences in dissimilar material thermal expansion/contraction rates and related stresses.

Underground Installation

Underground piping must be installed in accordance with any applicable regulations, ordinances and codes. Since piping is installed in a wide range of sub soils attention should be given to local pipe laying techniques which may provide a solution to a particular pipe bedding issue. The following information is applicable to PVC and CPVC piping joined via the solvent cementing method and may be considered as a general guide. Refer to Gasketed Pipe section for additional information pertaining to installation of gasketed pipe.

Storage & Handling: Thermoplastic pipe must not be exposed to elevated temperatures during shipping and/or storage. Exposure to excessive temperatures will result in distortion/deformation of the pipe. PVC and CPVC pipe should not be dropped, have objects dropped on them, nor subjected to external loads. Thermoplastics can be damaged by abrasion and gouging. Pipe must not be dragged across the ground or over obstacles. Impacts such as dropping from sizable heights and/or rough handling should be avoided, particularly in cold weather. The product shall be inspected for any scratches, splits or gouges that may have occurred from improper handling or storage. If found, these sections must be cut out and discarded. Refer to the "Storage & Handling" section of this 112/401 publication for additional information.

Inspection: Before installation, PVC and CPVC piping products should be thoroughly inspected for cuts, scratches, gouges or split ends which may have occurred to the products during shipping and handling. Do not use damaged sections. Damaged sections found must be cut-out and discarded.

Trench Construction: For buried non-pressure applications trench construction, bedding, haunching, initial backfill, compaction, and final backfill shall be conducted as required by the project engineer or by following the Standard Practice for Underground Installation of Thermoplastic Pipe Sewers and Other Gravity-Flow Applications (ASTM D2321). For pressure applications, the Standard Practice for Underground Installation of Thermoplastic Pressure Piping (ASTM D2774) shall be followed in conjunction with this information when details are not provided by the project engineer.

The trench should be of adequate width to allow convenient installation, while at the same time be as narrow as possible. Minimum trench widths may be utilized by joining pipe outside the trench and lowering it into the trench after adequate joint strength has been achieved. Trench widths will have to be wider where pipe is joined in the trench or where thermal expansion and contraction is a factor.

Refer to manufacturer's instructions for recommended set and cure times for solvent cemented joints – do not lower into trench until adequate joint strength is achieved.

Trench depth is determined by intended service and 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. Reliability and safety should always be considered, as well as local, state, and national codes.

Water filled pipe should be buried at least 12" below the maximum expected frost line.

It is recommended that thermoplastic piping be run within a metal or concrete casing when it is installed beneath surfaces that are subject to heavyweight or constant traffic such as roadways and railroad tracks. Piping systems must be designed and installed to ensure they can handle anticipated loads. Refer to Critical Collapse Pressure Ratings under Engineering & Design Data 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.

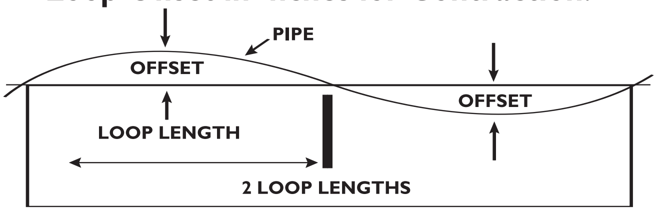
Snaking of Pipe: For small diameter piping systems (typically < 3" diameter), snaking of pipe is particularly important to compensate for thermal expansion and contraction of the piping when installing pipe in hot weather. This may also apply to larger diameter piping under specific applications and site conditions. After the pipe has been solvent welded and allowed to set properly, it is advisable to snake the pipe according to the following recommendations beside the trench during its required drying time (cure time). **BE ESPECIALLY CAREFUL NOT TO APPLY ANY STRESS THAT WILL DISTURB THE UNDRIED JOINT.** This snaking is necessary in order to allow for any anticipated thermal contraction that will take place in the newly joined pipeline. Refer to the section on Thermal Expansion & Contraction for additional information.

Installation

Snaking is particularly necessary on the lengths that have been solvent welded during the late afternoon or a hot summer's day, because their drying time will extend through the cool of the night when thermal contraction of the pipe could stress the joints to the point of pull out. This snaking is also especially necessary with pipe that is laid in its trench (necessitating wider trenches than recommended) and is backfilled with cool earth before the joints are thoroughly dry.

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 Feet	3"	4"	5"	5"	6"	6"	7"	7"	8"	8"
50 Feet	7"	9"	11"	13"	14"	16"	17"	18"	19"	20"
100 Feet	13"	18"	22"	26"	29"	32"	35"	37"	40"	42"

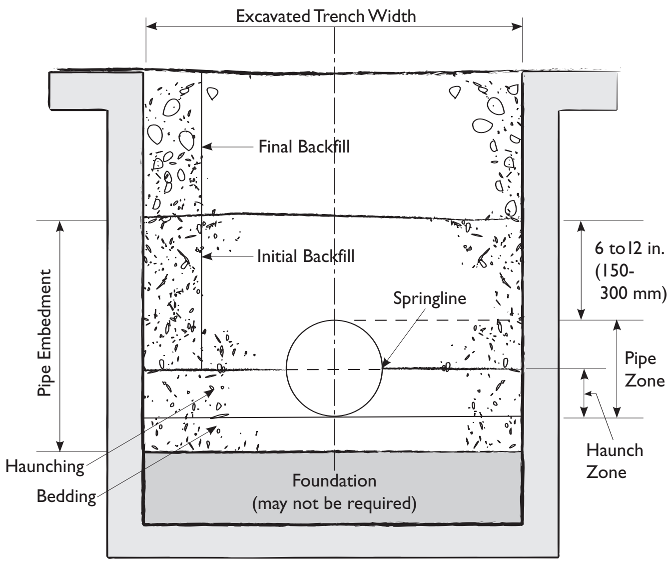
! NOTE Expansion and contraction could become excessive in systems operating at near or at the maximum allowable temperature ranges with intermittent flow and buried lines. In these cases the lines should not be snaked. The use of properly installed expansion joints installed within suitable concrete pit is recommended for PVC and CPVC systems operating at or near upper temperature limits. 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. This will minimize the potential for damage (scratching & scarring) to the carrier pipe 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.

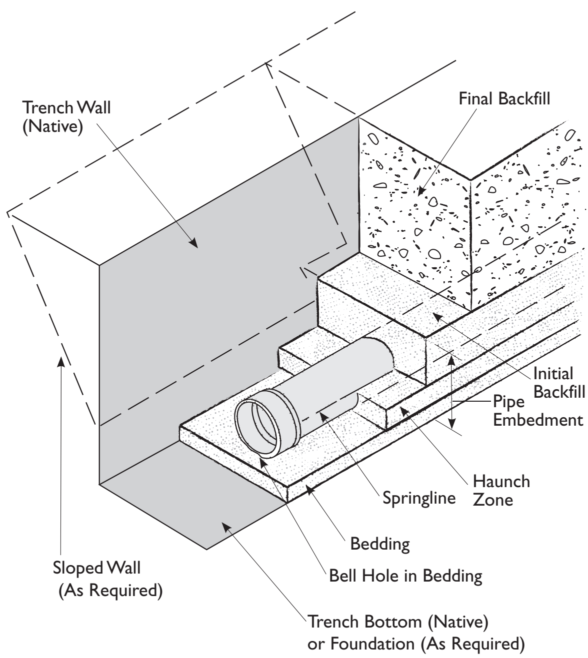
Bedding and Haunching: The pipe must be uniformly and continuously supported over its entire length on firm, stable material. Proper bedding and haunching materials are dependent on local soil conditions and type. Follow classes of embedment and backfill materials called-out in Table 1 "Pipe Stiffness Values for PVC Pipe" ASTM D2321. **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 with proper bedding using a minimum of six (6) inches of suitable bedding beneath the pipe as a cushion and for protection of the pipe from damage.** For belled-end pipe, provide bell holes in bedding no larger than necessary to ensure uniform pipe support. Embedment materials (initial backfill) shall be placed by methods that will not disturb or damage the pipe. The haunching material placed in the area between the bedding and the underside of the pipe shall be worked-in and hand tamped prior to placing and compacting the remainder of the embedment material in the pipe zone. Install and compact bedding materials in 6-inch maximum layers within the pipe zone. Refer to the diagrams on the following page for clarification. **Compaction techniques and equipment used must not contact or damage the pipe.**

Backfilling: Where possible underground pipe should be thoroughly inspected and tested for leaks prior to backfilling. 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. These soils should not only be stable, but applied in such a manner so as to physically shield the pipe from damage. Attention should be given to local pipe laying experience that may indicate particular pipe bedding problems. Initial backfill materials free of rocks with particle sizes 1/2" or less should be used to surround the pipe, and should be placed and compacted in layers. Each layer should be sufficiently compacted to uniformly develop lateral passive soil forces during the backfill operations. It may be advisable to have the pipe under water pressure (15 to 25 psi) during backfilling. Final backfill should be placed and spread in uniform layers in such a manor to fill the trench completely so that there will be no unfilled spaces under or about rocks or lumps of earth in the backfill. Large or sharp rocks, frozen clods and other debris greater than 3" diameter should be removed.

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. Rolling equipment or heavy tampers should only be used to consolidate the final backfill. Attention should be given to local pipe laying experience that may indicate particular pipe bedding problems. Local, state and national codes may also govern.

Cold Temperature Underground Installation of PVC and CPVC Piping: PVC and CPVC are rigid thermoplastic materials, as such, pipe stiffness increases and impact resistance decreases in colder temperature environments. PVC and CPVC can become more susceptible to physical damage when exposed to cold temperatures. Following the guidelines below will minimize the potential for damage. Impact resistance and ductility decrease at colder temperatures. In addition, a drop in temperature will cause the piping to contract, which must be addressed with proper system design. Due to PVC and CPVC's coefficient of thermal expansion, a 20-foot length of pipe will contract approximately 3/4" and 7/8", respectively, when cooled from 95F to -5F. Since pressure bearing capacity is not reduced with a decrease in temperature, PVC and CPVC piping are suitable for use at colder temperatures provided the fluid medium is protected from freezing, consideration is given to the effects of expansion and contraction, and additional care and attention are given during handling, installation and operation of the system to prevent physical damage caused by impact or other mechanical forces.





! NOTE Use of threaded connections should be avoided 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 D2774 "Underground Installation of Thermoplastic Pressure Piping", ASTM F645, Standard Guide For "Selection Design and Installation of Thermoplastic Water Pressure Piping Systems", and ASTM D2321 "Underground Installation of Flexible Thermoplastic Sewer Pipe."

Depth of Burial for GF Harvel PVC Pipe: When installed underground an external load is placed on a PVC Pipe, its diameter will begin to deflect, meaning its sides will move outward and slightly downward. If GF Harvel PVC pipe is buried in supportive soil, the stiffness of the soil will help support the pipe. This action and reaction is the key to how a PVC pipe carries external loads while buried.

The support from the embedded soil and the pipe stiffness form a combination to resist deflection from external loads. PVC Pipe's resistance to deflection in an unburied state is measured by its pipe stiffness. Due to the excellent quality of GF Harvel PVC Piping, it has a high pipe stiffness value. In general, the greater the pipe stiffness values the higher the load capacity.

Calculating Burial Depth Limitations

Due to the ability of GF Harvel PVC to flex before it breaks, a limit is placed on pipe diametric deflection. This limit is expressed in terms of percentage reduction in diameter due to external loading. The maximum allowable diametric deflection for GF Harvel PVC Piping is 5%. Any deflection greater then 5% could lead to the failure of a piping system.

One method that is commonly used to estimate pipe deflection based on its burial depth is the Modified Iowa Equation. A simplified, version of the equation is presented below where 5% deflection is the limiting factor:

Modified Iowa Equation

$$\%\ \text{Deflection} = \frac{0.1\,(P + L)\,100}{0.149\,(PS) + 0.061E'}$$

Where:

% Deflection = Predicated percentage of deflection of the buried pipe's outside diameter (5% is the maximum allowable deflection per ASTM D2665)

P = Prism Load Soil Pressure in lbs/in^2 = Pressure on the buried pipe from the weight of the soil column above it (Prism Loads values can be found in Table 2).

L = Live Load on Buried Pipe in lb/in^2 = Pressure transferred to the buried pipe from traffic on the surface above it (Live Load values can be found in Table 3).

PS = Pipe Stiffness in lb/in^2 = The inherent strength of pipe to resist deflection in an unburied state, per ASTM D2412 (Pipe Stiffness values for GF Harvel PVC Pipe can be found in Table 1).

E' = Modulus of Soil Reaction in lb/in2 = Stiffness of soil column on top of buried pipe. (Average Values of Modulus of Soil Reaction can be found in Table 4).

HARVEL

Installation

Table 1
Pipe Stiffness Values for PVC Pipe in lb/in²

Sch 40 PVC Pipe Size (in.)	Sch 40 Pipe Stiffness (PS)	Sch 80 PVC Pipe Size (in.)	Sch 80 Pipe Stiffness (PS)
1/8	15424	1/8	54031
1/4	13854	1/4	42399
3/8	7103	3/8	22696
1/2	6224	1/2	17919
3/4	3293	3/4	9532
1	2675	1	7345
1-1/4	1467	1-1/4	4127
1-1/2	1059	1-1/2	3057
2	626	2	1938
2-1/2	823	2-1/2	2248
3	534	3	1547
3-1/2	403	3-1/2	1209
4	323	4	996
5	216	5	709
6	161	6	637
8	110	8	438
10	82	10	374
12	67	12	347
14	63	14	340
16	63	16	323
18	63	18	311
20	54	20	301
24	48	24	287

SDR Series PVC Pipe Size (in.)	SDR Pipe Stiffness (PS)	Sch 120 PVC Pipe Size (in.)	Sch 120 Pipe Stiffness (PS)
SDR 13.5	950	1/2	30668
SDR 21	235	3/4	13535
SDR 26	120	1	10835
SDR 41	29	1-1/4	6184
		1-1/2	4551
		2	3057
		2-1/2	2969
		3	2575
		4	2336
		6	1495
		8	1406

In order to determine the allowable pipe burial depth, the pipe dimension, soil density, traffic load, soil type, and compaction density of embedment soil will be obtained from the tables provided. The values obtained would then be used the Modified Iowa Equation in order to determine the predicated percentage of pipe deflection. Georg Fischer Harvel LLC does not recommend the use of GF Harvel PVC Piping when the pipe diameter is deflected more then 5% due to the possibility of pipe failure. Therefore, it would not be recommended to use GF Harvel PVC Piping when the percentage of deflection, obtained through the Modified Iowa Equation, is greater than 5%. See the examples provided below.

Example 1:

4" Schedule 80 GF Harvel PVC Pipe is to be buried 10 feet under E80 railway traffic. The soil is coarse grained with little to no fines with a high proctor and 110 pounds per cubic foot soil density. Will this be an appropriate application for 4" Schedule 80 GF Harvel PVC Pipe?

Using the Modified Iowa Equation:

$$\%\ \text{Deflection} = \frac{0.1\ (P + L)\ 100}{0.149\ (PS) + 0.061E'}$$

$$\%\ \text{Deflection} = \frac{0.1\ (7.64 + 18.4)\ 100}{0.149\ (996) + 0.061(3000)}$$

$\%$ Deflection = $0.78 \pm 1\%$

The maximum predicted pipe deflection is $0.78 \pm 1\%$, this is below the maximum recommended deflection for GF Harvel PVC pipe of 5%. Therefore, with proper trench construction the pipe would be able to withstand the external load when buried in this application.

Example 2:

GF Harvel SDR 26 PVC Pipe is to be buried 30 feet underground with negligible foot traffic. The soil is crushed rock with a slight proctor and 140 pounds per cubic foot soil density. Will this be an appropriate application for GF Harvel SDR 26 PVC Pipe?

Using the Modified Iowa Equation:

$$\%\ \text{Deflection} = \frac{0.1\ (P + L)\ 100}{0.149\ (PS) + 0.061E'}$$

$$\%\ \text{Deflection} = \frac{0.1\ (29.17 + 0)\ 100}{0.149\ (120) + 0.061(3000)}$$

$\%$ Deflection = $1.45 \pm 1\%$

The maximum predicted pipe deflection is $1.45 \pm 1\%$, this is below the maximum recommended deflection for GF Harvel PVC pipe of 5%. Therefore, with proper trench construction the pipe would be able to withstand the external load when buried in this application.

Table 2
Prism Load Soil Pressure in lbs/in² (Soil Density)

Height of Soil Cover (ft)	Soil Unit Weight in lbs/ft³ 100	110	120	130	140	150
1	0.69	0.76	0.83	0.90	0.97	1.04
2	1.39	1.53	1.67	1.81	1.94	2.08
3	2.08	2.29	2.50	2.71	2.92	3.13
4	2.78	3.06	3.33	3.61	3.89	4.17
5	3.47	3.82	4.17	4.51	4.86	5.21
6	4.17	4.58	5.00	5.42	5.83	6.25
7	4.86	5.35	5.83	6.32	6.81	7.29
8	5.56	6.11	6.67	7.22	7.78	8.33
9	6.25	6.88	7.50	8.13	8.75	9.38
10	6.94	7.64	8.33	9.03	9.72	10.42
11	7.64	8.40	9.17	9.93	10.69	11.46
12	8.33	9.17	10.00	10.83	11.67	12.50
13	9.03	9.93	10.83	11.74	12.64	13.54
14	9.72	10.69	11.67	12.64	13.61	14.58
15	10.42	11.46	12.50	13.54	14.58	15.63
16	11.11	12.22	13.33	14.44	15.56	16.67
17	11.81	12.99	14.17	15.35	16.53	17.71
18	12.50	13.75	15.00	16.25	17.50	18.75
19	13.19	14.51	15.83	17.15	18.47	19.79
20	13.89	15.28	16.67	18.06	19.44	20.83
21	14.58	16.04	17.50	18.96	20.42	21.88
22	15.28	16.81	18.33	19.86	21.39	22.92
23	15.97	17.57	19.17	20.76	22.36	23.96
24	16.67	18.33	20.00	21.67	23.33	25.00
25	17.36	19.10	20.83	22.57	24.31	26.04
26	18.06	19.86	21.67	23.47	25.28	27.08
27	18.75	20.63	22.50	24.38	26.25	28.13
28	19.44	21.39	23.33	25.28	27.22	29.17
29	20.14	22.15	24.17	26.18	28.19	30.21
30	20.83	22.92	25.00	27.08	29.17	31.25
31	21.53	23.68	25.83	27.99	30.14	32.29
32	22.22	24.44	26.67	28.89	31.11	33.33
33	22.92	25.21	27.50	29.79	32.08	34.38
34	23.61	25.97	28.33	30.69	33.06	35.42
35	24.31	26.74	29.17	31.60	34.03	36.46
36	25.00	27.50	30.00	32.50	35.00	37.50
37	25.69	28.26	30.83	33.40	35.97	38.54
38	26.39	29.03	31.67	34.31	36.94	39.58
39	27.08	29.79	32.50	35.21	37.92	40.63
40	27.78	30.56	33.33	36.11	38.89	41.67
41	28.47	31.32	34.17	37.01	39.86	42.71
42	29.17	32.08	35.00	37.92	40.83	43.75
43	29.86	32.85	35.83	38.82	41.81	44.79
44	30.56	33.61	36.67	39.72	42.78	45.83
45	31.25	34.38	37.50	40.63	43.75	46.88
46	31.94	35.14	38.33	41.53	44.72	47.92
47	32.64	35.90	39.17	42.43	45.69	48.96
48	33.33	36.67	40.00	43.33	46.67	50.00
49	34.03	37.43	40.83	44.24	47.64	51.04
50	34.72	38.19	41.67	45.14	48.61	52.08

Table 3
Live Load on Buried Pipe in lb/in2 (Traffic Load)

Height of Cover in ft.	Highway H201	Railway E802	Airport3
1	12.5		
2	5.56	26.39	13.14
3	4.17	23.61	12.28
4	2.78	18.4	11.27
5	1.74	16.67	10.09
6	1.39	15.63	8.79
7	1.22	12.15	7.85
8	0.69	11.11	6.93
10	N	7.64	6.09
12	N	5.56	4.76
14	N	4.17	3.06
16	N	3.47	2.29
18	N	2.78	1.91
20	N	2.08	1.53
22	N	1.91	1.14
24	N	1.74	1.05
26	N	1.39	N
28	N	1.04	N
30	N	0.69	N
35	N	N	N
40	N	N	N

1-Simulates 20 ton truck traffic plus impact.
2-Simulates 80,000 lb/ft railway load plus impact.
3-180,000 lbs. dual tandem gear assembly; 26-inch spacing between tires and 66-inch center-to-center spacing between fore and aft tires under a rigid pavement 12 inches thick + impact.
N= Negligible live load influence. L = 0

Table 4
Average Values of Modulus of Soil Reaction, E' (Soil Type)

Pipe Bedding Materials		E' For Degree of Compaction of Pipe Zone Backfill, psi			
Soil Class	Soil Type (United Classification System per ASTM D2487)	Loose or Dumped	Slight <85% Proctor, <40% Relative Density	Moderate 85%-95% Proctor, 40%-70% Relative Density	High >95% Proctor, >70% Relative Density
Class V	Fine-grained Soils (LL>50b) Soils with medium to high plasticity CH, MH, CH-MH	No data available; consult a competent soils engineer; Otherwise use E'=0			
Class IV	Fine-grained Soils (LL<50) Soils with medium to no plasticity, CL, ML, ML-CL, with less than 25% coarse-grained particles	50	200	400	1000
Class III	Fine-grained Soils (LL<50) Soils with medium to no plasticity, CL, ML, ML-CL,with more than 25% coarse-grained particles	100	400	1000	2000
Class II	Coarse-grained Soils with Little or no Fines GW, GP, SW, SPc contains less than 12% fines	200	1000	2000	3000
Class I	Crushed Rock	1000	3000	3000	3000
	Accuracy in Terms of Percentage Deflection	±2	±2	±1	±0.5

ASTM Designation D 2487, USBR Designation E-3.

LL = Liquid limit.

Note: Values applicable only for fills less than 50 ft (15m). Table does not include any safety factor. For use in predicting initial deflections only; appropriate Deflection Lag Factor must be applied for long-term deflections. If bedding falls on the borderline between two compaction categories, select lower E1 value or average the two values. Percentage Proctor based on laboratory maximum dry density from test standards using about 12,500 ft-lb/cu ft (598,000 J/m3) (ASTM D 698, AASHTO T-99, USBR Designation E-11). 1psi = 6.9kN/m2.

Sources: UniBell- : "Soil Reaction for Buried Flexible Pipe" by Amster K. Howard, U.S. Bureau of Reclamation, Denver, Colorado. Reprinted with permission from American Society of Civil Engineers.

Above Ground Installation

Thermal Expansion & Contraction

The system must be designed and installed to compensate for movement as a result of thermal expansion and contraction. This is particularly true for above ground applications installed outdoors and within unoccupied buildings where ambient temperature swings can be significant. For example, a system installed in an unoccupied (i.e. un-heated) building during the winter months will expand considerably when temperatures rise. The direct opposite is true for systems installed at higher ambient temperatures where temperatures may fall considerably after installation. This fact must be addressed with proper system design to compensate for movement generated as the result of the effects of thermal expansion and/or contraction of the piping. Refer to Thermal Expansion & Contraction for additional information.

Outdoor Applications

PVC and CPVC piping products have been used successfully in outdoor applications when proper recommendations are followed. As with any other piping, the system must be protected from freezing in applications subject to colder temperatures. 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 manufacturers of these products should be consulted for suitability and compatibility of their products for use with PVC and CPVC products prior to use.

GF Harvel recommends that PVC and CPVC piping products exposed to the effects of sunlight (UV radiation) be painted with a light colored acrylic or latex paint that is chemically compatible with the PVC/CPVC products. Compatibility information should be confirmed with the paint manufacturer. The use of oil - based paints is not recommended. When painted the effects of exposure to sunlight are significantly reduced, however, consideration should be given to the effects of expansion/contraction of the system caused by heat absorption in outdoors applications. The use of a light colored, reflective paint coating will reduce this affect, however, the system must also be designed and installed in such a manner to reduce the effects of movement due to thermal expansion. Refer to Temperature Limitations and Thermal Expansion & Contraction for additional information.

Hangers and Supports

Hanger Support Spacing

Proper support selection and spacing is critical to prevent stress concentration areas as the result of weight loading, bending stress, the effects of thermal expansion/contraction, and to limit pipe displacement (sag). As with all thermoplastic materials, proper pipe support spacing is dependent on pipe size, the location and magnitude of any concentrated weight loads, and the operating temperatures of the system due to the effects that temperature has on the tensile and compressive strength of the material. Increases in temperature require additional supports. Piping should not be exposed to excessive heat producing sources such as light fixtures, ballasts and steam lines that could negatively affect its tensile strength. When operating at or near maximum recommended temperature limits, it may be more economical to provide continuous support for the system via structural angle or channel that is free from rough or sharp edges. Local building codes should also be consulted for applicable requirements prior to installation.

Proper support spacing can be calculated similarly to that of metallic 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.

Hanger Selection

Many hangers designed for metallic pipe are suitable for thermoplastics; however, hangers and supports used must provide an adequate load-bearing surface, which is smooth and free of rough or sharp edges that could damage the pipe. The use of improper supports can generate excessive sag resulting in failure. Movement caused by the effects of thermal expansion and contraction of the system due to temperature variations, as well as movement as the result of pressure fluctuations must be considered to ensure proper hanger selection and placement. Hangers and supports used must permit axial movement of the system; they should not compress the pipe or otherwise restrict this movement.

Placement

Common practice is to install suitable hangers within two feet (2 ft) of each side of a pipe joint; changes in direction should be supported as close as possible to the fitting to reduce tensional stress. Heavy system components such as valves, flanged assemblies, tees and other forms of concentrated stress loads must be independently supported. In addition, valves should be braced adequately to prevent movement/stress loads as the result of operational torque. Consideration should also be given for certain processes where solids accumulation within the line is a possibility.

Precautions

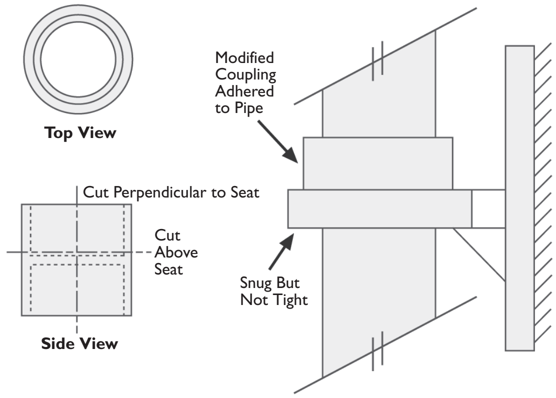
The use of protective sleeves or pads between the pipe and the hanger may be desirable in certain applications, as their use will distribute stress loads over a greater surface area, particularly when using U-bolt or roller type hangers. Piping should not be permitted to contact abrasive surfaces that could cause damage during axial movement of the system. Protective sleeves or pads should be used when pipe is resting on concrete or other abrasive support structures. Contact with localized heat producing sources must also be avoided. Plastic piping systems shall not be installed in close proximity to steam lines or other high temperature equipment without providing appropriate protection to prevent damage from distortion and/or forces generated by the effects of thermal expansion or contraction.

Vertical Support

Vertical lines (risers) must be supported properly at intervals that will prevent excessive loading on the fitting at the lower end of the riser (or other stress concentration areas). 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 (i.e. floating system). **Clamps and hangers used must not compress, distort, cut, or abrade the piping. Clamps used must not exert compressive stresses on the pipe; the use of riser clamps that utilize compression to support the pipe weight are not recommended.** If possible, the riser clamps should be located just below a fitting so that the shoulder of the fitting rests against the clamp to support the weight of the vertical column. Horizontal take-offs from the riser should be independently supported, and located as close to the riser clamp as possible. Offset configurations utilizing at least one change in direction should be used to tie horizontal runs into the riser in close proximity to the riser clamp. Offset configurations used between the riser tee and the wall entry will minimize stress on the horizontal connection should movement of the riser occur. The use of a single horizontal run from the riser tee through the wall should not be used on systems conveying fluids at elevated temperatures (i.e. CPVC hot water lines).

Thermal Expansion of Vertical Risers: Compared to horizontal runs, the affects of thermal expansion on fluid filled vertical risers is typically minimized due to the weight of the fluid column, in combination with the restraint provided at horizontal take-offs. The rate of thermal expansion must be calculated based on the temperature change anticipated. Refer to Thermal Expansion and Contraction section for additional information. Vertical piping should be maintained in straight alignment with supports at proper intervals plus a mid story guide, as specified by the design engineer, to allow for movement caused by thermal expansion and contraction of the piping. Mid story guides should always be used on small diameter pipe (2" diameter), particularly on CPVC hot

Installation



water lines, to minimize deflection caused by thermal expansion. The guidelines provided herein for vertical risers do not apply to horizontal runs. For horizontal runs, the use of expansion loops, offsets, bends, and other means are recommended to compensate for movement due to changes in temperature. Refer to Thermal Expansion and Contraction section for additional information. Contact GF Harvel Technical Services for additional information if necessary.

For vertical risers requiring support where horizontal take-offs may not be present; one common approach is to install clamps just below a modified 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 once the joint is allowed to cure properly. Note: A modified coupling must only be used to provide support to the riser, and must not be used to join two pieces of pipe. The load bearing strength of a modified coupling used for riser support is directly related to the surface area of the coupling and the integrity of the solvent weld (Lap Shear strength).

Anchors and Guides

Anchors are utilized to direct movement of the piping by providing restraint at key points in the system. Their use may be required to control the effects of movement caused by expansion and contraction, forces generated by pressure surges, vibration, and other transient conditions. Anchors and guides are typically installed on long straight runs, at changes in direction of the system, and where expansion joints and other methods of thermal compensation are utilized. Guides are necessary to help direct this movement between anchors by allowing longitudinal movement while restricting lateral movement. Since guides act as supports, they 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 in such a manor to perform adequately without point loading the system. Reference should be made to the section concerning Thermal expansion and contraction for additional information.

Hanger Support Recommendations

Horizontal pipe system support spacing is greatly influenced by operating temperature. The charts show the recommended support spacing 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. Charts are based on liquids up to 1.00 specific gravity, but do not include concentrated loads, nor do they include allowance for aggressive reagents.

The following hanger support spacing recommendations are considered conservative in nature and are based on straight runs of un-insulated lines with fluids being conveyed that have 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	12	11-1/2	10	7	6-1/2
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	11-1/2	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 either 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.

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	31/2	3
1-1/4	5-1/2	5-1/2	5-1/2	5	3	3	6-1/2	6	6	5-1/2	31/2	3
1-1/2	6	6	5-1/2	5	3-1/2	3	7	6-1/2	6	5-1/2	31/2	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	41/2	4
3	7	7	7	6	4	3-1/2	8	8	7-1/2	7	41/2	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	9	8-1/2	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	51/2	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	61/2	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	71/2	6-1/2
14	12	11	10	9	8	6	15	13-1/2	12-1/2	11	91/2	8
16	13	12	11	9-1/2	8-1/2	7	16	15	13-1/2	12	10	8-1/2
18	13	12-1/2	11	10	9	7-1/2	16	15-1/2	14	12-1/2	10-1/2	9
20	14	13	11-1/2	10-1/2	9	7-1/2	17	16	14-1/2	13	11	9-1/2
24	15	14	12-1/2	11	9-12	8	17-1/2	16-1/2	15	13-1/2	11-1/2	10

! 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 either 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.

GF Harvel Clear™ PVC

GF Harvel Clear™ Rigid Schedule 40 & 80 PVC piping provides a versatile, cost-effective alternative for many piping applications, particularly those where visual monitoring of processes is critical.

The benefits of rigid PVC piping are well recognized: exceptional corrosion resistance; smooth interior walls for unimpeded flow and reduced sediment buildup; non-contaminating for purity applications; fast, reliable solvent-welded connections; good pressure-bearing capability; and ease of handling and installation, to name a few.

All of these important benefits are now available in a unique product with optimum clarity. This clarity provides the all-round visibility that specialized applications demand—whether it be clean room applications, sight glass, dual-containment or various other processing applications where continuous monitoring is necessary.

- Manufactured to Schedule 40 and Schedule 80 IPS dimensions
- Full line of 1/4" through 8" GF Harvel Clear™ fittings
- Simple solvent-welded joining techniques
- Fully compatible with standard PVC pipe, fittings and valves
- Corrosion resistant
- Non-conductive
- Resists bacterial and biological activity
- Wide range of chemical resistance
- Lightweight, easy to handle and install
- Neatly boxed and packaged on-line, providing clean, scratch-free quality with every order
- Standard plain-end 10-foot lengths; belling and custom lengths available
- Lower overall installed cost than other alternatives

Material

GF Harvel Clear™ PVC piping is produced from a rigid, virgin Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784. This material enables GF Harvel Clear piping to safely carry a maximum service temperature of 140˚F when appropriate temperature/pressure de-rating factors are applied. In addition to exhibiting desirable physical properties and optimum transparency, this material is listed by the National Sanitation Foundation as being safe for use with potable water (NSF International Standard 61), 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. Due to the non-contaminating nature of GF Harvel Clear PVC piping products, extensive chemical extraction testing has been conducted to evaluate their use in critical applications. Details pertaining to extractable analysis is available from GF Harvel upon request.

GF Harvel Clear™ provides similar reliable chemical resistance properties that conventional PVC piping has demonstrated over the years. In general, it is resistant to most acids, bases, salts and oxidants; detailed chemical resistance data is available and should be referenced for proper material selection.

Clear PVC Pipe Physical Properties

GENERAL	Value	Test Method
Cell Classification	12454	ASTM D1784
Maximum Service Temp.	140°F	
Color	Transparent	
Specific Gravity, (g/cu.cm @ 73°F)	1.33	ASTM D792
Hardness, Shore D	84	ASTM D2240
Hazen-Williams Factor	C = 150	
MECHANICAL		
Tensile Strength, psi @ 73°F	7,260	ASTM D638
Tensile Modulus of Elasticity, psi @ 73°F	392,000	ASTM D638
Flexural Strength, psi @ 75°F	12,000	ASTM D790
Flexural Modulus, psi @ 75°F	389,000	ASTM D790
Compressive Strength, psi @ 75°F	8,300	ASTM D695
Compressive Modulus, psi @ 75°F	307,000	ASTM D695
Izod Impact notched - Method A, with Grain-Comp. Molded, .125 in. bars, 73°F	8.0 ft-lbs./in.	ASTM D256
Izod Impact notched - Method A, against Grain-Comp. Molded, .125 in. bars, 73°F	2.0 ft-lbs./in.	ASTM D256
THERMAL		
Coefficient of Linear Expansion (in/in/°F)	4.1×10^{-5}	ASTM D696
Heat Distortion Temp., Unannealed, 264 psi, .125 in. Bars	154°F	ASTM D648
Glass Transition Temp.	176°F	
FIRE PERFORMANCE		
Flammability Rating	V-0	UL-94

Since this material is a nonconductor, GF Harvel pipe is not subject to electrolytic or galvanic corrosion.

This material is compatible with conventional PVC pipe, fittings and valves, and can be incorporated into existing PVC systems via the solvent cement joining process. In addition to a full line of Schedule 40 clear fittings for most applications, an endless array of standard PVC components and accessories are readily available. GF Harvel Clear™ PVC exhibits excellent flammability characteristics as well.

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
5	5.563	5.016	0.258	2.874	100
6	6.625	6.031	0.280	3.733	90
6 x 1/8	6.625	6.335	0.110	1.647	45
8	8.625	7.942	0.322	5.619	80
10	10.750	9.976	0.365	7.966	70
12	12.750	11.889	0.406	10.534	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
2-1/2	2.875	2.289	0.276	1.419	210
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	-
12	35	-

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

Solvent cemented joints should be utilized when working at or near maximum temperatures. GF Harvel Plastics does not recommend the use of PVC for threaded connections at temperatures above 110°F; use flanged joints, unions, or roll grooved couplings where disassembly is necessary at elevated temperatures.

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

NOTE Although GF Harvel Clear maintains its physical properties when exposed to many substances, exposure to certain chemicals can affect the clarity of the product overtime. Certain nitrogen containing organics, bleaches, oxidative agents and acids may result in discoloration. Testing under actual use conditions is recommended.

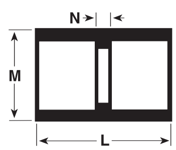
Exposure to sunlight (U.V.R.) will also affect clarity. Clear products do not contain U.V. stabilizers and are not recommended for outdoor use unless adequate protection is applied.

System Components

GF Harvel Clear PVC fittings incorporate state-of-the-art design using computer-generated stress analysis for optimum strength and performance. GF Harvel Clear fittings are manufactured to Schedule 40 dimensions from the same material to provide system uniformity and consistency in clarity. Socket-style fittings are manufactured in strict dimensional compliance with ASTM D2466 to Schedule 40 requirements. Specialty transition fittings are manufactured to Schedule 80 dimensions per the applicable requirements of ASTM D2464 (threaded) and D2467 (socket). Refer to dimensional and weight data for available sizes and configurations.

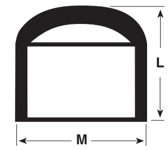
Weights & Dimensions

(Schedule 40 Clear Fittings)



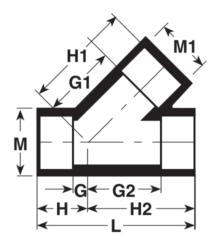
COUPLING (Slip x Slip)

Part #	Nominal Pipe Size (in.)	M	N	L	Weight (lbs.)
429-002L	1/4	27/32	1/16	1-3/8	0.02
429-003L	3/8	1	3/16	1-5/8	0.04
429-005L	1/2	1-3/32	3/32	1-19/32	0.03
429-007L	3/4	1-5/16	3/32	2-3/32	0.05
429-010L	1	1-5/8	3/32	2-11/32	0.08
429-012L	1-1/4	2	3/32	2-19/32	0.12
429-015L	1-1/2	2-1/4	1/8	2-11/16	0.15
429-020L	2	2-3/4	3/32	2-27/32	0.20
429-025L	2-1/2	3-5/16	5/32	4-5/32	0.46
429-030L	3	3-31/32	1/32	4-1/32	0.55
429-040L	4	5-1/16	1/4	4-1/4	0.82
429-060L	6	7-3/16	1/4	7-3/16	2.39
429-080L	8	9-5/16	7/16	9-3/16	4.61



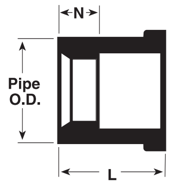
CAP (Slip)

Part #	Nominal Pipe Size (in.)	M	L	Weight (lbs.)
447-002L	1/4	13/16	15/16	0.01
447-003L	3/8	7/8	1	0.01
447-005L	1/2	1-3/32	1-1/32	0.02
447-007L	3/4	1-5/16	1-5/16	0.04
447-010L	1	1-5/8	1-9/16	0.06
447-012L	1-1/4	1-31/32	1-3/4	0.09
447-015L	1-1/2	2-1/4	1-7/8	0.11
447-020L	2	2-23/32	2-1/32	0.16
447-025L	2-1/2	3-11/32	2-3/4	0.35
447-030L	3	4	2-29/32	0.47
447-040L	4	5-1/32	3-3/16	0.75
447-060L	6	7-1/4	5	2.17
447-080L	8	9-5/16	6-3/8	4.35



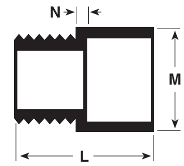
WYE (Slip x Slip x Slip)

PART #	Nom. Pipe Size (in.)	M	M1	H	H1	H2	G	G1	G2	L	WEIGHT (lbs.)
475-015L	1-1/2	2-11/32	2-11/32	1-7/8	3-31/32	3-15/16	1/2	2-19/32	2-9/16	5-13/16	0.69
475-020L	2	2-7/8	2-7/8	2-1/8	4-3/4	4-3/4	19/32	3-7/32	3-7/32	6-7/8	1.20
475-030L	3	4-5/32	4-5/32	2-19/32	6-17/32	6-3/32	11/16	4-5/8	4-3/16	8-11/16	2.59
475-040L	4	5-9/32	5-9/32	3-1/8	8-1/4	7-5/8	7/8	6	5-3/8	10-3/4	4.57
475-060L	6	7-9/16	7-9/16	4-5/16	11-21/32	11-1/16	1-5/16	8-21/32	8-1/16	15-3/8	12.09
475-532L	6 x 6 x 4	7-9/16	5-7/16	3-1/32	9-29/32	9-21/32	1/32	7-5/8	6-21/32	12-11/16	6.71



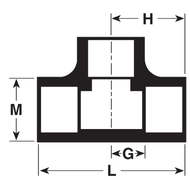
REDUCER BUSHING
(Spigot x Slip)

Part #	Nominal Pipe Size (in.)	N	L	Weight (lbs.)
437-101L	3/4 x 1/2	1/2	1-1/4	0.03
437-131L	1 x 3/4	5/32	15/32	0.03
437-168L	1-1/4 x 1	1-3/32	1-17/32	0.07
437-211L	1-1/2 x 1	1-9/32	1-23/32	0.14
437-212L	1-1/2 x 1-1/4	3/8	1-5/8	0.07
437-251L	2 x 1-1/2	3/8	1-3/4	0.16
437-292L	2-1/2 x 2	2-5/32	2-5/32	0.28
437-338L	3 x 2	7/8	2-1/4	0.46
437-339L	3 x 2-1/2	3/8	2-3/8	0.41
437-422L	4 x 3	3/8	2-3/8	0.80
437-532L	6 x 4	1-9/16	3-9/16	2.10
437-585L	8 x 6	1-15/32	4-31/32	4.02



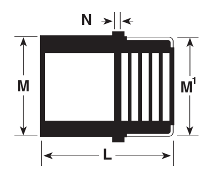
MALE ADAPTER
(Mipt x Slip)

Part #	Nominal Pipe Size (in.)	M	N	L	Weight (lbs.)
436-003L	3/8	7/8	7/32	1-3/8	0.02
436-005L	1/2	1-3/32	3/16	1-19/32	0.03
436-007L	3/4	1-5/16	3/16	1-15/16	0.04
436-010L	1	1-5/8	1/4	2-1/8	0.07
436-012L	1-1/4	1-31/32	9/32	2-11/32	0.11
436-015L	1-1/2	2-7/32	1/4	2-3/8	0.13
436-020L	2	2-23/32	3/8	2-1/2	0.19
436-025L	2-1/2	3-5/16	9/32	3-13/16	0.44
436-030L	3	4	9/32	3-29/32	0.56
436-040L	4	5	9/16	3-15/16	0.84



TEE
(Slip x Slip x Slip)

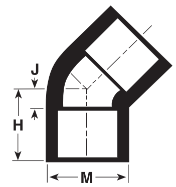
Part #	Nominal Pipe Size (in.)	M	H	G	L	Weight (lbs.)
401-002L	1/4	27/32	31/32	5/16	1-15/16	0.04
401-003L	3/8	7/8	1-3/16	7/16	2-3/8	0.04
401-005L	1/2	1-1/16	1-1/4	1/2	2-1/2	0.10
401-007L	3/4	1-5/16	1-9/16	9/16	3-1/8	0.09
401-010L	1	1-5/8	1-13/16	11/16	3-5/8	0.17
401-012L	1-1/4	1-15/16	2-1/8	7/8	4-1/4	0.28
401-015L	1-1/2	2-1/4	2-5/16	1	4-5/8	0.32
401-020L	2	2-11/16	2-5/8	1-1/4	5-1/4	0.48
401-025L	2-1/2	3-5/16	3-9/32	1-17/32	6-9/16	0.92
401-030L	3	4	3-15/16	1-15/16	7-7/8	1.39
401-040L	4	5	4-7/16	2-3/8	8-7/8	2.18
401-060L	6	7-13/16	6-31/32	3-15/32	13-15/16	6.33
401-080L	8	9-3/16	8-1/2	4-1/2	17	11.43



FEMALE ADAPTER
(Fipt x Slip) Stainless Steel Reinforced

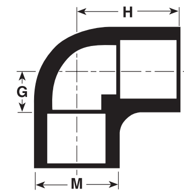
Part #	Nominal Pipe Size (in.)	M	M[1]	N	L	Weight (lbs.)
435-002SRL	1/4	13/16	13/16	1/8	1-5/16	0.03
435-003SRL	3/8	15/16	15/16	1/16	1-7/16	0.04
435-005SRL	1/2	1-3/16	1-3/16	3/16	1-3/4	0.06
435-007SRL	3/4	1-13/32	1-13/32	3/16	1-7/8	0.08
435-010SRL	1	1-3/4	1-3/4	1/8	2-1/8	0.13
435-012SRL	1-1/4	2-3/32	3/32	1/8	2-5/16	0.19
435-015SRL	1-1/2	2-7/16	2-7/16	1/8	2-7/16	0.27
435-020SRL	2	3	3	1/4	2-11/16	0.43
435-025SRL	2-1/2	3-9/16	3-9/16	1/4	3-1/4	0.68
435-030SRL	3	4-9/32	4-5/16	5/16	3-1/2	0.95
435-040SRL	4	5-7/32	5-7/32	3/16	3-15/16	1.29

Clear PVC



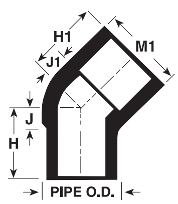
45° ELL
(Slip x Slip)

Part #	Nominal Pipe Size (in.)	M	H	J	Weight (lbs.)
417-002L	1/4	27/32	13/16	5/32	0.03
417-003L	3/8	1	31/32	7/32	0.04
417-005L	1/2	1-1/16	1	1/4	0.04
417-007L	3/4	1-5/16	1-11/32	11/32	0.06
417-010L	1	1-5/8	1-15/32	11/32	0.10
417-012L	1-1/4	1-31/32	1-5/8	3/8	0.14
417-015L	1-1/2	2-7/32	1-3/4	7/16	0.20
417-020L	2	2-23/32	2	5/8	0.28
417-025L	2-1/2	3-3/8	2-11/16	11/16	0.66
417-030L	3	3-31/32	2-7/8	7/8	0.81
417-040L	4	5	3-3/32	1-3/32	1.24
417-060L	6	7-7/32	5-7/32	1-25/32	3.80
417-080L	8	9-9/32	6-7/16	2	6.60



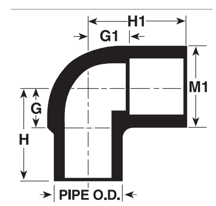
90° ELL
(Slip x Slip)

Part #	Nominal Pipe Size (in.)	M	H	G	Weight (lbs.)
406-002L	1/4	13/16	1	11/32	0.03
406-003L	3/8	7/8	1-1/8	3/8	0.03
406-005L	1/2	1-1/16	1-1/4	1/2	0.04
406-007L	3/4	1-5/16	1-9/16	9/16	0.07
406-010L	1	1-19/32	1-13/16	11/16	0.12
406-012L	1-1/4	1-31/32	2-1/8	7/8	0.19
406-015L	1/2	2-1/4	2-7/16	1-1/8	0.25
406-020L	2	2-11/16	2-5/8	1-1/4	0.35
406-025L	2-1/2	3-5/16	3-1/4	1-1/2	0.70
406-030L	3	3-31/32	3-23/32	1-27/32	1.01
406-040L	4	5	4-5/16	2-5/16	1.71
406-060L	6	7-3/16	6-29/32	3-13/32	4.81
406-080L	8	9-1/4	8-7/16	4-7/16	8.67



45° STREET ELL
(Spig x Soc)

Part #	Nom. Pipe Size (in.)	M^1	H	H^1	J	J^1	Weight (lbs.)
427-005L	1/2	1-3/16	1-9/32	1-9/32	11/32	13/32	.06
427-007L	3/4	1-13/32	1-1/2	1-17/32	7/16	17/32	.09
427-010L	1	1-23/32	1-19/32	1-21/32	13/32	17/32	.15
427-012L	1-1/4	2-3/32	1-25/32	1-29/32	1/2	21/32	.22
427-015L	1-1/2	2-11/32	2-1/32	2-3/32	19/32	23/32	.20
427-020L	2	2-27/32	2-5/16	2-1/8	11/16	21/32	.30
427-030L	3	4-5/32	2-31/32	3-1/32	1	1-7/32	1.19
427-040L	4	5-3/16	3-21/32	3-13/16	1-9/32	1-9/16	2.07



90° STREET ELL
(Spig x Soc)

Part #	Nom. Pipe Size (in.)	M^1	H	H^1	G	G^1	Weight (lbs.)
409-005L	1/2	1-5/32	1-7/16	1-5/32	11/16	13/32	0.05
409-007L	3/4	1-5/16	1-27/32	1-1/2	27/32	1/2	0.08
409-010L	1	1-19/32	2-1/8	1-13/16	1	11/16	0.12
409-012L	1-1/4	1-31/32	2-15/32	2-3/32	1-7/32	27/32	0.19
409-015L	1-1/2	2-1/4	2-5/8	2-13/32	1-3/8	1-1/4	0.25
409-020L	2	2-23/32	3-1/32	2-5/8	1-21/32	1-1/4	0.35
409-025L	2-1/2	3-11/32	3-23/32	3-3/8	1-15/32	1-17/32	0.77

Joining Techniques

GF Harvel PVC Clear pipe is easily joined by the solvent cementing process, providing a quick, strong, leak-tight seal for pressure applications. To maintain the system's clarity, Georg Fischer Harvel LLC recommends the use of a clear, medium-bodied, fast-setting cement in conjunction with a clear primer for optimum joint integrity, such as IPS Weld-on 705 Clear cement and IPS Weld-on P-70 Clear primer. As an added advantage due to the product's transparency, joint integrity is readily identified during the solvent cement joining process. Details on proper solvent cementing techniques are available and must be reviewed for proper assembly and joint integrity.

Specialty clear female threaded transition fittings, incorporating a stainless steel retaining ring, reduce problems associated with overtightening and provide a strong, leak-tight seal for plastic-to-metal transitions. When used with clear male adapters, the reinforced female adapters provide an excellent threaded connection for disassembly while maintaining system transparency. The reinforced design reduces radial stress encountered with typical threaded connections, and eliminates the need for system pressure de-rating traditionally associated with non-reinforced plastic threaded joints. GF Harvel recommends the use of PTFE (polytetrafluoroethylene) thread tape for making reliable threaded connections. Generally, two to three wraps of tape in the direction of the threads on the male end, followed by one to two turns beyond finger tight is all that is required to make a leak-free connection.

! NOTE Certain thread paste compounds may contain stress cracking agents; contact the paste manufacturer for compatibility with PVC prior to use.

Where disassembly is required, GF Harvel Clear can be easily joined in the field using standard rigid thermoplastic pipe fittings and joining techniques such as flanges, molded grooved coupling adapters and unions. Joining options are limitless when overall system clarity is not a necessity.

Thermal Expansion and Contraction

As with other thermoplastic materials, consideration must be given to the effects of thermal expansion and contraction during the design and installation of the system. The coefficient of linear expansion for GF Harvel Clear pipe is 4.1 x 10^{-5} in./in./°F. The rate of expansion or contraction can be calculated as follows:

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

Where:
ΔL = expansion or contraction in inches
y = 4.1 x 10^{-5} (coefficient of linear expansion)
l = length of piping run in feet
T = temperature change °F
(T max. - T@ installation)

Refer to the engineering and design section under industrial pipe for additional information concerning thermal expansion and contraction.

Heat Bending

Bending of Clear PVC pipe may be desirable under certain conditions where long-radius bends and unusual configurations are required. Various sizes and wall thicknesses of rigid PVC pipe have been successfully heat-formed for many years into numerous angles, long-radius sweeps for conduit and flow conditions, U-bends for thermal compensation, and offsets in congested areas.

The following information is provided as a general guide for a better understanding of heat bending techniques commonly used in the field, and does not attempt to address specialized shop fabrication methods or procedures.

Successful bending requires that the appropriate amount of heat be applied uniformly to the required length of pipe to be bent. This presents the greatest challenge for field bending, as the heating method used must provide the necessary amount of heat over the required length of pipe in a reasonable amount of time. Several common pipe heating methods used in the field involve the use of hot air ovens, electric box heaters, electric pipe heating blankets, and flameless hot gas torches. Temperatures necessary to heat the pipe are dependent on pipe size and the severity of the desired bend radius. In general, PVC pipe should be heated from 225°F to 275°F for the minimum amount of time necessary to achieve uniform softening. Care should be taken to avoid exposing the pipe to bending temperatures for an excessive length of time, as irreparable distortion and deformation will occur. Localized overheating must be avoided. Successful minor bends (< 30°) can be achieved with minimum distortion in the lower temperature range (225°F) without internal support. Sharp bends (> 30°) require higher temperatures (250°-275°F) as well as internal support to prevent wall distortion/collapse.

Common methods used to provide internal support to the pipe during the bending process include using a filling medium such as sand or perlite (cat litter), inserting a coiled spring into the pipe, or in some cases providing internal pressure. Filling the pipe with fine grain sand or perlite prior to heating furnishes the internal support necessary to prevent collapse, while at the same time provides an excellent medium for uniform heat distribution during the heating process.

The filling medium used should be packed tightly into the pipe to achieve the desired bend radius with minimum distortion.

During this process, the pipe ends are capped or plugged and the filling medium is compacted as much as possible to remove any air pockets prior to heating. Once the bend is formed and cooled, the sand is emptied from the pipe and any remaining particles can be easily removed by rinsing with water.

To provide fabrication consistency in the field, standard pipe bending forms which provide the required radius and are sized (grooved) for the proper diameter can be used to bend plastic pipe. Plywood jigs constructed on site have also been used successfully in many applications. The minimum radius at bend should not be less than five times the pipe outside diameter to prevent flattening. Due to the recovery characteristics of the material, the pipe should

Clear PVC

be bent slightly beyond the desired radius and allowed to spring back to the required angle once uniformly heated at the correct temperature. When the bend is obtained, the pipe should be held in place and cooled quickly using a wet sponge or other application of water.

It should be noted that most bending procedures will induce stress into the pipe wall which can be retained in the material after the bend radius is formed. The amount of stress induced is dependent on the severity of the bend, the diameter and wall thickness of the pipe bent, and the bending method used. This residual stress will be added to the normal stresses created by internal pressure, installation procedures, and the effects of temperature. Therefore, pipe bending should be limited to applications for use at ambient temperatures or lower where maximum operating pressures are not utilized. It should also be noted that during the bending process of clear PVC pipe, the material will become cloudy during the heating process but will regain clarity when cooled, provided excessive bending stresses are not retained. The use of a filling medium during the bending process can also cause slight pitting and other interior surface blemishes depending on the method used.

Attempting to form bends in rigid thermoplastic piping at temperatures too low (below 200˚F) can induce excessive stress into the pipe, thereby jeopardizing its physical performance.

WARNING

Georg Fischer Harvel LLC does not recommend the use of this product or other rigid PVC/CPVC piping products for the transportation or storage of compressed air or gases, nor the testing of these systems using compressed air or gases.

CAUTION Although GF Harvel Clear 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 (U.V.R.) will also affect clarity. This can be addressed in sight glass applications exposed outdoors by simply providing an opaque cover attached to the pipe exterior such as a rubber flap or sleeve. These facts should be considered if optimum clarity is required for the system by testing under actual use conditions at the initial design phase of the project.

Standard threading or grooving can be conducted with GF Harvel Schedule 80 Clear pipe. Threading or grooving of GF Harvel Schedule 40 Clear pipe is not recommended due to insufficient wall thickness. Use specialty clear transition fittings for threaded assemblies or standard PVC transition fittings where applicable.

Hangers and Supports

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, and any other heavy system components). Proper support spacing is critical to ensure that deflection is kept to a minimum. 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; overtightening must be avoided.

Schedule 40—Support Spacing

Nominal	Maximum Support Spacing in Feet				
Pipe Size (in.)	60˚F	80˚F	100˚F	120˚F	140˚F
1/4	4	3-1/2	3-1/2	2	2
3/8	4	4	3-1/2	2-1/2	2
1/2	4-1/2	4-1/2	4	2-1/2	2-1/2
3/4	4	4-1/2	4	2-1/2	2-1/2
1	5-1/2	5	4-1/2	3	2-1/2
1-1/4	5-1/2	5-1/2	5	3	3
1-1/2	6	5-1/2	5	3-1/2	3
2	6	5-1/2	5	3-1/2	3
2-1/2	7	6-1/2	6	4	3-1/2
3	7	7	6	4	3-1/2
3-1/2	7-1/2	7	6-1/2	4	4
4	7-1/2	7	6-1/2	4-1/2	4
6	8-1/2	8	7-1/2	5	4-1/2
6 x 1/8	7-1/2	7	6-1/2	4-1/2	4
8	9	8-1/2	8	5	4-1/2
10	10	9	8-1/2	5-1/2	5
12	11-1/2	10-1/2	9-1/2	6-1/2	5-1/2

Schedule 80—Support Spacing

Nominal	Maximum Support Spacing in Feet				
Pipe Size (in.)	60˚F	80˚F	100˚F	120˚F	140˚F
1/4	4	4	3-1/2	2-1/2	2
3/8	4-1/2	4-1/2	4	2-1/2	2-1/2
1/2	5	4-1/2	4-1/2	3	2-1/2
3/4	5-1/2	5	4-1/2	3	2-1/2
1	6	5-1/2	5	3-1/2	3
1-1/4	6	6	5-1/2	3-1/2	3
1-1/2	6-1/2	6	5-1/2	3-1/2	3-1/2
2	7	6-1/2	6	4	3-1/2
2-1/2	7-1/2	7-1/2	6-1/2	4-1/2	4
3	8	7-1/2	7	4-1/2	4
4	9	8-1/2	7-1/2	5	4-1/2
6	10	9-1/2	9	6	5

Refer to the engineering and design section under industrial pipe for additional information concerning hangers and supports

FlameTech™

Low Flame and Smoke Translucent Containment Piping

A recent breakthrough in material technology has resulted in unique piping with good optical properties and exceptional fire performance characteristics.

GF Harvel FlameTech 25/50 Containment Piping Offers the Following Benefits:

- Good Fire Performance Characteristics – low flame spread and low smoke generation during fire exposure
- Chemical distribution tubing can be continually monitored for leaks by visual inspection
- Requires fewer monitoring sensors and other costly equipment compared to conventional "opaque" systems
- Good chemical resistance
- Heat-formable for on-site fabrication of belled ends, sweeps and bends
- Joined using conventional solvent cement joining techniques
- Installs quickly and reliably using inexpensive joining tools
- Compatible with conventional GF Harvel Clear PVC piping products
- Lower overall installed costs compared to alternative materials where fire performance requirements are a concern

Applications

GF Harvel FlameTech 25/50 has been developed for use as a non-pressure containment piping in visual leak detection systems in areas where flame spread and smoke generation are of concern (i.e., containment piping installed in return air plenum applications). Major building and mechanical codes require that combustible piping installed within an air plenum must have a maximum flame spread rating of 25 and a maximum smoke development rating of 50. Based on large-scale burn testing of finished piping products conducted by ULC, GF Harvel FlameTech 25/50 piping meets this fire performance requirement and is Listed by ULC for surface burning characteristics.

In addition to excellent fire performance properties, GF Harvel FlameTech 25/50 translucent piping offers good optical qualities. This enables its use as containment piping for high-purity piping runs where quick identification of primary tubing and visual leak detection are critical. Primary tubing can be readily identified and inspected visually through the pipe wall. Utilizing a flashlight or alternate light source greatly enhances this unique attribute.

Dimensions

GF Harvel FlameTech 25/50 piping is available in sizes from 1/2" through 2" diameters and is produced to IPS Schedule 40 dimensions per ASTM D1785 as follows:

Schedule 40 Dimensions

Nom. Pipe Size (in.)	O.D.	Min. Wall	Average I.D.	Nom. Wt./Ft.
1/2	.840	.109	.602	.190
3/4	1.050	.113	.804	.253
1	1.315	.133	1.029	.371
1-1/4	1.660	.140	1.360	.502
1-1/2	1.900	.145	1.590	.599
2	2.375	.154	2.047	.803

Fire Performance

GF Harvel FlameTech 25/50 piping has been evaluated and Listed for Surface Burning Characteristics by Underwriters Laboratories of Canada (CAN/ULC Standard S102.2). This is a large-scale test conducted on 24-foot lengths of dry piping to evaluate flammability characteristics compared to known non-combustibles (asbestos cement board) and known combustibles (red oak). GF Harvel FlameTech 25/50 piping has a maximum flame spread rating of 0 and a maximum smoke development rating of 25 when tested in accordance with this standard. Testing has shown that GF Harvel FlameTech 25/50 piping meets the maximum flame spread (25) and maximum smoke generation (50) values for combustible materials installed within an air plenum as called out by major building codes. GF Harvel FlameTech 25/50 out-performs the fire performance characteristics of alternate plastic piping materials typically used for visual leak detection.

Material	Flame Spread	Smoke Generation
Asbestos Cement Board	0	0
GF Harvel HFS 25/50	0	25
Conventional PVC	0-25	80-225
Red Oak	100	100

As a listed product, each pipe length is marked with the flame spread and smoke generation values for easy identification in the field.

Contact Georg Fischer Harvel LLC Technical Services Department at 610-252-7355 for additional information concerning the fire performance properties of GF Harvel piping products.

FlameTech™

Physical Performance

GF Harvel FlameTech 25/50 piping is produced from a new version of clear PVC material that has been optimized to address fire performance issues. As a result, this product exhibits characteristics similar to those of conventional GF Harvel Clear piping with regard to joining techniques, field fabrication, chemical resistance, and other beneficial physical properties. GF Harvel FlameTech 25/50 piping is heat-formable for on-site fabrication of belled ends, sweeps and bends. The maximum service temperature of this product is 140˚F. Refer to GF Harvel HPB-115 bulletin for basic physical properties, fabrication guidelines and additional information.

Joining Techniques

GF Harvel FlameTech piping is joined using conventional solvent cement joining techniques, providing a quick, strong, leak-tight seal. This product is intended for use in non-pressure applications only, therefore either conventional Schedule 40 PVC (clear) and/or conventional Schedule 80 CPVC (opaque) molded fittings can be solvent cemented to GF Harvel FlameTech piping using existing solvent cementing techniques. Clear PVC solvent cement and primer must be applied when using clear PVC fittings to join GF Harvel FlameTech. CPVC solvent cement (such as IPS 713) and primer (such as P-70) must be applied when joining Schedule 80 CPVC molded fittings to GF Harvel FlameTech pipe. Details on proper solvent cementing techniques are available and must be referenced for proper assembly and optimum joint integrity.

Hangers and Supports

Support location and spacing are dependent on the pipe diameter, operating temperature of the system and the location of any concentrated stress loads (i.e., valves, and any other heavy system components). Proper support location is critical to ensure deflection is kept to a minimum. Hangers used must have an adequate load-bearing surface free of any rough or sharp edges that could damage the pipe. They must also not restrict linear movement of the system due to the effects of thermal expansion and contraction.

Pipe Size (in.)	60°F	80°F	100°F	120°F	140°F
1/2	4-1/2	4-1/2	4-1/2	4	2-1/2
3/4	4-1/2	4-1/2	4	2-1/2	2-1/2
1	5-1/2	5	4-1/2	3	2-1/2
1-1/4	5-1/2	5-1/2	5	3	3
1-1/2	6	5-1/2	5	3-1/2	3
2	6	5-1/2	5	3-1/2	3

System Design

Systems utilizing GF Harvel FlameTech 25/50 piping are to be designed and installed using existing industry standards for the installation of rigid thermoplastic piping. Factors such as operating temperatures, proper support spacing, chemical resistance, thermal expansion and contraction, handling and storage, and joining must be taken into consideration and addressed with appropriate design techniques. The use of this product to address code compliance issues regarding any local, state, or national code requirements concerning its use is the responsibility of the end user. Additional information is available from GF Harvel.

⚠CAUTION Although GF Harvel FlameTech 25/50 maintains its physical properties when exposed to many substances, exposure to certain chemicals can affect the clarity of the pipe over time. Certain nitrogen-containing organics, bleaches, oxidative agents and acids may result in discoloration. Exposure to sunlight (U.V.R.) will also affect clarity. These facts should be considered and testing under actual use conditions is recommended. Georg Fischer Harvel LLC does not recommend the use of this product for pressurized fluid applications or for the transportation or storage of compressed air or gases. Standard threading or grooving of GF Harvel FlameTech 25/50 is not recommended due to insufficient wall thickness.

GF Harvel LXT® Ultra-pure Water Piping

Low Extractable Piping for High-Purity Systems

GF Harvel LXT® piping systems provide a cost-effective alternative to other piping materials typically used for ultra-pure water applications in the semiconductor, electronics, biotechnology, laboratory and other industries. Lower material costs combined with fast, reliable installation greatly reduce installation costs – resulting in significant savings without jeopardizing water quality.

In addition to significant cost savings, Harvel LXT® piping systems offer several other advantages for ultra-pure water applications. These include: non-contaminating material with extremely low-extractable contaminants (particularly Total Oxidizable Carbon and trace metals), ultra-smooth interior walls, strong Schedule 80 dimensions, specialty one-step solvent-cement joining system that cures fast, and unique translucency for visual inspection of joint integrity.

GF Harvel LXT® 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 GF Harvel LXT® (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

Materials

GF Harvel LXT® 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.

GF Harvel LXT® 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.

Processing

Processing conditions for converting this material into pipe form are as critical as the selection of the material itself to ensure that the physical properties of the finished product are optimized. Correct processing techniques ensure proper dispersion and fusion of the compound, resulting in a homogeneous melt with uniform properties. Great care is also taken during this process using proprietary techniques to address surface finish characteristics. Optimizing processing conditions and providing smooth internal surfaces greatly reduce the potential for extractable and particle contaminants.

GF Harvel LXT® pipe is cut square, purged to remove shavings, sealed in polybags and boxed on-line at time of manufacture to minimize contamination.

Joining

The GF Harvel LXT® system utilizes a one-step solvent-cementing system specifically formulated for use with this product. (GF Harvel LXT® One-Step Cement). Unlike conventional PVC solvent cements, this system contains fewer contaminants and cures quickly, reducing the potential for TOC contamination. Joining is accomplished quickly and efficiently utilizing inexpensive tools, thereby greatly reducing labor and installation costs.

GF Harvel LXT® Ultra-pure Water Piping

Physical Properties

Although the extractable contaminants of GF Harvel LXT® are much lower than common PVC piping, GF Harvel LXT® has physical properties very similar to those of conventional PVC piping. As a result, GF Harvel LXT® 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.

GF Harvel LXT® Physical Properties	Value	Test Method
Cell Classification	12343	ASTM D1784
Specific Gravity	1.327 (g/cu.Cm @ 73°F)	ASTM D792
Tensile Strength, @ yield	6720 psi	ASTM D638
Tensile Modulus of Elasticity	384,200 psi	ASTM D638
Flexural Strength, @ yield	11,440 psi	ASTM D790
Flexural Modulus of Elasticity	378,000 psi	ASTM D790
Izod Impact		
(avg 2 complete breaks)	1.3 ft-lbs /inch	
(avg 3 partial & 2 complete breaks)	10.9 ft-lbs /inch	ASTM D256
Coefficient of Linear Expansion	3.89×10^{-5} in/in°F	ASTM D696
Compressive Strength	8732 psi	ASTMD695
Heat Distortion Temperature	152°F	ASTM D648
Hardness, Shore D	82.2 ± 3	ASTM D2240
Maximum Temperature Use	140°F	

Fittings & Valves

All fittings shall be manufactured from the same virgin, low extractable material as specified in the material section. All fittings shall be manufactured to Schedule 80 dimensions and tolerances in strict accordance to the dimensional requirements of ASTM D2467. Socket style fittings shall have tapered sockets manufactured in accordance to the requirements of ASTM D2467 to create an interference type fit. Threaded fittings shall be manufactured in accordance with ASTM F1498 to tapered pipe thread dimensions. All fittings and valves shall be 100% visually inspected for cleanliness and imperfections as specified by the manufacturer. Upon final inspection, all fittings and valves are to be double bagged immediately in FDA approved anti-static polyethylene sleeves that are heat-sealed. All flanges shall have ANSI Class 150 bolt patterns, and carry a maximum pressure rating of 150 psi non-shock @ 73˚F.

All valves shall be true union Weir-style diaphragm or true union style quarter turn ball valves manufactured from the same virgin, low extractable material. All diaphragms and seats shall be PTFE; valve o-rings shall be EPDM or Viton as specified. All valve union nuts shall have buttress style threads. All valve components shall be replaceable. True union diaphragm valves sizes 1/2"–2" shall carry a maximum working pressure rating of 150 psi non-shock @ 73˚F. True union ball valves sizes 1/2"–2" carry a maximum working pressure rating of 235 psi, non-shock @ 73˚F. 3" and 4" shall carry a maximum working pressure rating of 150 psi non-shock @ 73˚F.

Joining

All GF Harvel LXT® UPW piping shall be joined utilizing GF Harvel LXT® One-Step UPW Grade Solvent Cement specifically formulated for joining this material. All solvent cemented welds shall be made-up in strict accordance with the written assembly procedures for the product as stated in the Georg Fischer Harvel LLC GF Harvel LXT® product
bulletin (HPB-114). Installers must become familiar with these procedures prior to assembly. The use of solvent cements and/or primers other than GF Harvel LXT® One-Step is not acceptable. Joint integrity on solvent welded connections shall be confirmed with visual inspection utilizing a light source to inspect the cemented surfaces for uniformity. All solvent cemented connections shall be allowed to set and cure properly prior to pressure testing/rinsing procedures per the joint cure schedules as stated in the Georg Fischer Harvel LLC GF Harvel LXT® product bulletin (HPB-114.)

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	GF Harvel LXT	High Purity PVDF	High Purity PP	Brand X Clean PVC	Conv. PVC	CPVC
TOC	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)

Dynamic Leach Analysis

GF Harvel LXT® 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. GF Harvel LXT® Flanges were assembled utilizing GF Harvel LXT® One-Step Cement and allowed to cure 24 hours prior to testing. Dynamic testing revealed that GF Harvel LXT® 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 GF Harvel.

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 GF Harvel LXT® 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.

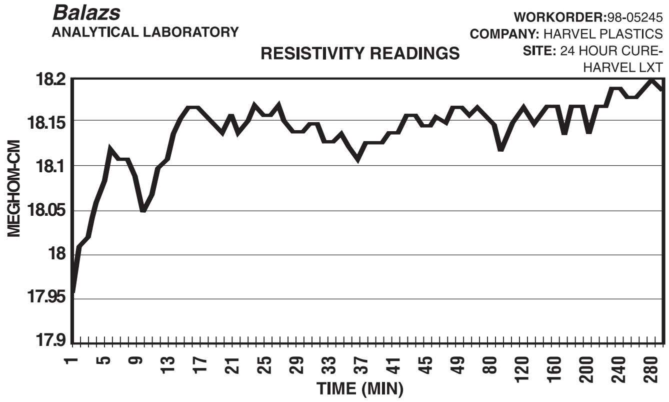
Leachable Contamination

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 (0.07ppb) 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.

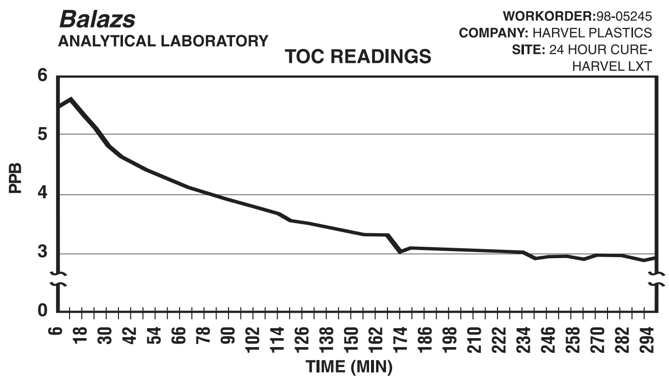
Resistivity

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.



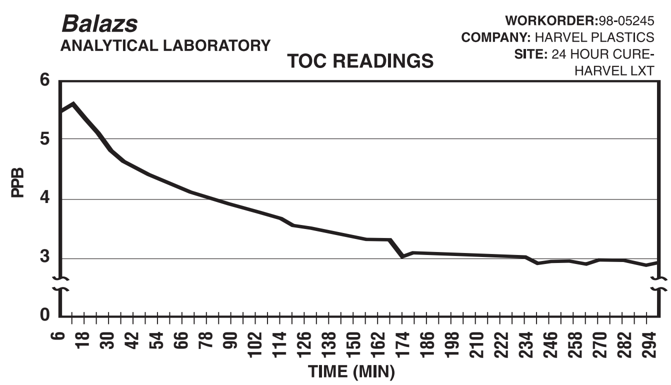
Total Oxidizable Carbon (TOC)

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 GF Harvel LXT® 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.

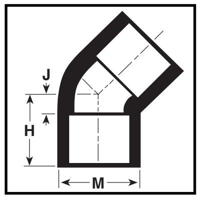


Surface Analysis

GF Harvel LXT® piping has a non-porous, exceptionally smooth interior surface that greatly reduces the potential for extractable and particle contamination while impeding bacterial growth. GF Harvel LXT® components (pipe and fittings) exhibit an average Roughness Analysis value of: ≤.25 μm (≤10 μ inch) and has been evaluated side-by-side with other common piping materials at various magnifications for surface roughness comparison.

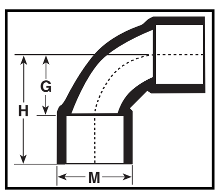
Components

GF Harvel LXT® fitting and valve components are manufactured from the same low extractable material. This provides entire system consistency and compatibility, while ensuring that extractable contamination is kept to a minimum. Leading-edge stress analysis technology is applied in the design of GF Harvel LXT® fitting and valve components to optimize strength and performance in critical applications.



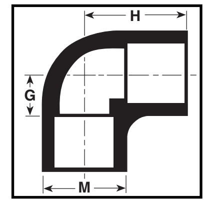
45° Ell (Soc x Soc)

Part #	Size (in.)	H	J	M	Wt. (lbs.)
817-005BL	1/2	1-1/8	1/4	1-3/16	0.06
817-007BL	3/4	1-11/32	11/32	1-13/32	0.09
817-010BL	1	1-7/16	11/32	1-23/32	0.15
817-012BL	1-1/4	1-11/16	13/32	2-3/32	0.21
817-015BL	1-1/2	1-27/32	7/16	2-3/8	0.30
817-020BL	2	2-5/32	21/32	2-7/8	0.48
817-030BL	3	2-27/32	31/32	4-1/8	1.13
817-040BL	4	3-3/8	1-3/32	5-1/4	2.24
817-060BL	6	4-7/8	1-7/8	7-9/16	5.37



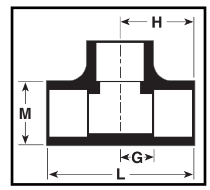
90° Sweep Elbow (Soc x Soc)

Part #	Size (in.)	G	H	M	Wt. (lbs.)
806-005SBL	1/2	27/32	1-23/32	1-3/16	0.07
806-007SBL	3/4	1-1/32	2-1/16	1-13/32	0.11
806-010SBL	1	1-5/16	2-7/16	1-23/32	0.19
806-012SBL	1-1/4	1-9/16	2-13/16	2-3/32	0.27
806-015SBL	1-1/2	1-3/4	3-1/8	2-11/32	0.36
806-020SBL	2	2-5/16	3-13/16	2-7/8	0.61



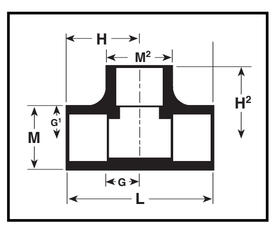
90° Ell (Soc x Soc)

Part #	Size (in.)	G	H	M	Wt. (lbs.)
806-005BL	1/2	9/16	1-15/32	1-3/16	0.08
806-007BL	3/4	11/16	1-11/16	1-7/16	0.12
806-010BL	1	13/16	1-31/32	1-23/32	0.19
806-012BL	1-1/4	1-1/32	2-5/16	1-31/32	0.33
806-015BL	1-1/2	1-3/32	2-15/32	2-11/32	0.54
806-020BL	2	1-7/16	2-15/16	2-7/8	0.61
806-030BL	3	2-1/16	3-31/32	4-5/32	1.57
806-040BL	4	2-19/32	4-27/32	5-1/4	2.80
806-060BL	6	3-23/32	6-3/4	7-19/32	8.59



Tee (Soc x Soc x Soc)

Part #	Size (in.)	G	H	L	M	Wt. (lbs.)
801-005BL	1/2	9/16	1-1/2	2-15/16	1-3/16	0.11
801-007BL	3/4	11/16	1-11/16	3-3/8	1-13/32	0.17
801-010BL	1	27/32	2	4	1-11/16	0.28
801-012BL	1-1/4	7/8	2-1/8	4-1/4	2-3/32	0.39
801-015BL	1-1/2	1-5/32	2-9/16	5-1/8	2-5/16	0.55
801-020BL	2	1-7/16	2-15/16	5-7/8	2-7/8	0.90
801-030BL	3	2-1/16	3-31/32	7-15/16	4-7/32	2.38
801-040BL	4	2-5/8	4-7/8	9-3/4	5-1/4	3.43
801-060BL	6	3-13/16	6-13/16	13-5/8	7-5/8	10.79

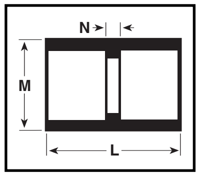


Reducing Tee (Soc x Soc x Soc)

Part #	Size (in.)	G	G¹	H	H¹	L	M	M¹	Wt. (lbs.)
801-131BL	1 x 1 x 3/4	23/32	27/32	1-27/32	1-27/32	3-11/16	1-11/16	1-3/8	0.23
801-211BL	1-1/2 x 1-1/2 x 1	7/8	1-3/16	2-1/4	2-5/16	4-1/2	2-3/8	1-11/16	0.46
801-249BL	2 x 2 x 1-1/2	7/8	1-7/16	2-3/8	2-9/16	4-3/4	2-7/8	1-3/4	0.58
801-251BL	2 x 2 x 3/4	1-3/16	1-7/16	2-11/16	2-13/16	5-3/8	2-7/8	2-3/8	0.80
801-338BL	3 x 3 x 2	1-1/2	1-15/32	3-5/16	3-11/32	6-5/8	4-3/16	2-7/8	1.56
801-422BL	4 x 4 x 3	2-1/16	2-21/32	4-11/32	4-15/32	8-11/16	5-7/32	4-3/16	3.09
801-530BL	6 x 6 x 3	2-11/16	4-9/16	5-9/16	6-3/8	11-1/8	7-1/2	5-3/16	6.34
801-532BL	6 x 6 x 4	2-11/16	3-3/4	5-9/16	5-15/16	11-1/8	7-1/2	5-1/4	7.43

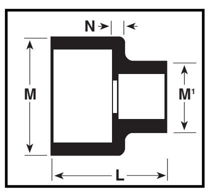
Fittings

High-quality GF Harvel LXT® components are designed to yield optimum performance for each fitting. Material reinforcement is uniformly placed in stress-concentration areas for substantially improved pressure-handling capability. Specialty transition fittings incorporate a stainless steel retaining ring that provides a strong, leak-tight seal for plastic-to-metal transitions while reducing problems associated with overtightening. The reinforced design reduces radial stress encountered with typical threaded connections, thereby eliminating the need for system pressure de-rating traditionally associated with non-reinforced plastic threaded joints. All GF Harvel LXT® fittings are produced in strict dimensional compliance with ASTM D2467 to Schedule 80 dimensions. GF Harvel components produced to these dimensions ensure that strong, leak-tight connections with exceptional pressure-bearing capability can be assembled quickly using inexpensive joining tools.



Couplings (Soc x Soc)

Part #	Size (in.)	L	M	N	Wt. (lbs.)
829-005BL	1/2	1-7/8	1-13/16	1/8	0.07
829-007BL	3/4	2-1/8	1-13/32	1/8	0.10
829-010BL	1	2-3/8	1-23/32	1/8	0.12
829-012BL	1-1/4	2-23/32	2-7/32	7/32	0.22
829-015BL	1-1/2	2-7/8	2-11/32	3/32	0.31
829-020BL	2	3-1/8	2-7/8	1/16	0.31
829-030BL	3	4	4-3/16	3/16	0.82
829-040BL	4	4-3/4	5-5/16	1/4	1.51
829-060BL	6	6-1/4	7-11/16	1/4	3.45



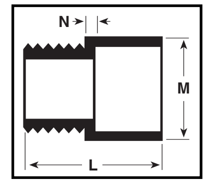
Reducer Couplings (Soc x Soc)

Part #	Size (in.)	L	M	M¹	N	Wt. (lbs.)
829-101BL	3/4 x 1/2	1-13/32	1-13/32	1-3/16	7/32	0.06
829-131BL	1 x 3/4	2-13/32	1-23/32	1-13/32	1/4	0.10
829-168BL	1-1/4 x 1	2-23/32	2-3/32	1-23/32	3/8	0.17
829-211BL	1-1/2 x 1	2-7/8	2-11/32	1-15/16	3/8	0.23
829-212BL	1-1/2 x 1-1/4	2-13/16	2-3/8	2-3/32	5/32	0.21
829-249BL	2 x 1	3-1/8	2-7/8	1-23/32	17/32	0.28
829-251BL	2 x 1-1/2	3-7/32	2-27/32	2-11/32	7/32	0.30
829-338BL	3 x 2	4	4-5/32	2-27/32	11/16	0.68
829-420BL	4 x 2	4-5/8	5-9/32	2-7/8	13/16	1.20
829-422BL	4 x 3	4-5/8	5-1/4	4-1/8	1/2	1.25
829-532BL	6 x 4	6-5/8	7-5/8	5-5/16	1-7/16	3.20

Threaded Connections

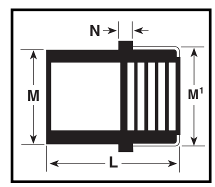
Use only a quality grade PTFE (polytetrafluoroethylene) tape as a thread sealant for GF Harvel LXT® applications.

⚠ WARNING Some pipe joint compounds or thread pastes may contain substances that could cause stress cracking to plastics and increase the potential for system contamination. 1 to 2 full turns beyond finger tight is generally all that is required to make a sound plastic threaded connection. Unnecessary over-tightening will cause damage to both pipe and fitting.



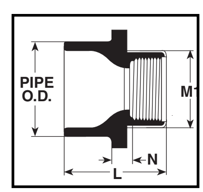
Male Adapter (Mipt x Soc)

Part #	Size (in.)	L	M	N	Wt. (lbs.)
836-005BL	1/2	1-13/16	1-3/16	3/16	0.04
836-007BL	3/4	1-29/32	1-13/32	1/4	0.06
836-010BL	1	2-1/4	1-3/4	7/32	0.10
836-012BL	1-1/4	2-1/2	2-1/8	9/32	0.15
836-015BL	1-1/2	2-9/16	2-13/32	1/4	0.19
836-020BL	2	2-23/32	2-29/32	9/32	0.27
836-030BL	3	3-23/32	4-7/32	3/8	0.75
836-040BL	4	4-3/8	5-3/16	1/2	1.13



Female Adapter (Fipt x Soc)
Special Stainless Steel Reinforced

Part #	Size (in.)	L	M	M¹	N	Wt. (lbs.)
835-005SRBL	1/2	1-3/4	1-5/32	1-3/16	3/16	0.07
835-007SRBL	3/4	1-7/8	1-13/32	1-3/8	1/8	0.08
835-010SRBL	1	2-5/32	1-23/32	1-23/32	3/32	0.12
835-012SRBL	1-1/4	2-5/16	2-1/8	2-1/16	3/16	0.19
835-015SRBL	1-1/2	2-7/16	2-13/32	2-7/16	7/32	0.26
835-020SRBL	2	2-11/16	3	3-3/32	9/32	0.43
835-030SRBL	3	3-1/2	4-1/4	4-9/32	7/32	0.89
835-040SRBL	4	3-31/32	5-7/32	5-7/32	1/4	1.29

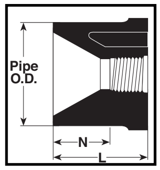


Reducing Female
Spigot Adapter (Spig x SR Fipt)
Special Stainless Steel Reinforced

Part #	Size (in.)	L	M¹	N	Wt. (lbs.)
878-072SRBL	1/2 x 1/4	1-13/32	27/32	3/16	0.03
878-098SRBL	3/4 x 1/4	1-27/32	27/32	9/32	0.05
878-128SRBL	1 x 1/4	2-3/8	27/32	21/32	0.08

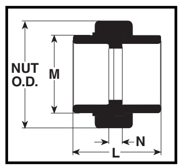
NOTE Additional components and configurations may be added periodically due to our continued commitment to product line improvements. Please contact GF Harvel Technical Services at 610-252-7355 for the latest component availability, verification of technical data, or additional information not contained herein. The dimensional information contained in this publication is based on current data and product design at time of publication and may be subject to change.

GF Harvel LXT® Ultra-pure Water Piping



Reducer Bushings (Spigot x Fipt) Flush Style

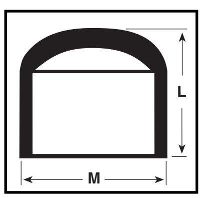
Part #	Size (in.)	L	N	Wt. (lbs.)
838-072BL	1/2 x 1/4	1	7/8	0.02
838-073BL	1/2 x 3/8	1-3/32	17/32	0.02
838-098BL	3/4 x 1/4	1-7/32	5/8	0.04
838-101BL	3/4 x 1/2	1-1/4	7/16	0.03
838-129BL	1 x 3/8	1-13/32	19/32	0.07
838-130BL	1 x 1/2	1-5/32	21/32	0.06
838-131BL	1 x 3/4	1-3/8	21/32	0.05
838-210BL	1-1/2 x 3/4	1-3/4	31/32	0.15



Union (Soc x Soc)

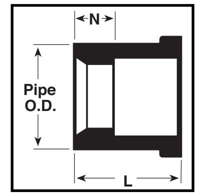
Part # *EPDM O-Ring Seal	Size (in.)	L	M	N	Nut O.D.	Wt. (lbs.)
897-005BL	1/2	2-3/32	1-9/32	11/32	1-31/32	0.12
897-007BL	3/4	2-3/8	1-17/32	11/32	2-1/2	0.17
897-010BL	1	2-9/16	1-27/32	3/8	2-7/8	0.28
897-012BL	1-1/4	2-7/8	2-7/32	3/8	3-5/16	0.36
897-015BL	1-1/2	3-3/32	2-9/16	15/32	3-9/16	0.50
897-020BL	2	3-5/8	3-1/32	9/16	4-3/16	0.86
897-030BL	3	4-1/4	4-3/16	1/2	6-5/32	2.16
897-040BL	4	5-1/8	5-1/4	5/8	7-3/4	3.75

*For (socket x socket) Unions equipped with Vitron® O-Ring, replace the 897 with an 857 before the dash.



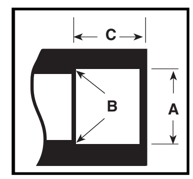
Caps (Soc)

Part #	Size (in.)	L	M	Wt. (lbs.)
847-005BL	1/2	1-7/32	1-3/16	0.03
847-007BL	3/4	1-13/32	1-3/8	0.05
847-010BL	1	1-19/32	1-11/16	0.08
847-012BL	1-1/4	1-27/32	2-3/32	0.16
847-015BL	1-1/2	2	2-11/32	0.16
847-020BL	2	2-9/32	2-27/32	0.35
847-030BL	3	3-1/32	4-5/32	0.84
847-040BL	4	3-9/16	5-7/32	1.43
847-060BL	6	4-7/8	7-1/2	3.17



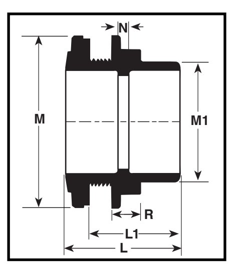
Reducer Bushings (Spigot x Soc) Flush Style

Part #	Size (in.)	L	N	Wt. (lbs.)
837-101BL	3/4 x 1/2	1-1/8	3/8	0.02
837-130BL	1 x 1/2	1-5/8	13/32	0.06
837-131BL	1 x 3/4	1-1/4	1/4	0.04
837-166BL	1-1/4 x 1/2	1-9/16	21/32	0.11
837-168BL	1-1/4 x 1	1-19/32	15/32	0.08
837-210BL	1-1/2 x 3/4	1-3/4	11/16	0.19
837-211BL	1-1/2 x 1	1-17/32	13/32	0.14
837-212BL	1-1/2 x 1-1/4	1-9/16	5/16	0.07
837-249BL	2 x 1	1-29/32	13/16	0.26
837-251BL	2 x 1-1/2	1-3/4	11/32	0.17
837-338BL	3 x 2	2-27/32	9/16	0.62
837-422BL	4 x 3	2-21/32	25/32	0.82
837-532BL	6 x 4	4	1-23/32	2.86



ASTM D2467 Standard Schedule 80 Socket Dimensions

Size (in.)	Entrance A	Bottom B	Min. Socket Length C	Tolerance (in.)
1/2	0.848	0.836	0.875	±.004
3/4	1.058	1.046	1.000	±.004
1	1.325	1.310	1.125	±.005
1-1/4	1.670	1.655	1.250	±.005
1-1/2	1.912	1.894	1.375	±.006
2	2.387	2.369	1.500	±.006
3	3.516	3.492	1.875	±.008
4	4.518	4.491	2.250	±.009
6	6.647	6.614	3.000	±.011



Tank Adapter (Soc x Soc)

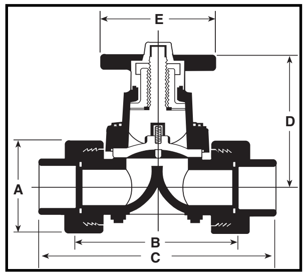
Part #	Size (in.)	Hole Size (in.)	L	L1	M	M1	N	R	Wt. (lbs.)
8710E-005BL	1/2	1.31	2-15/16	2-3/16	2	1-3/16	1-1/8	5/8	0.20
8710E-007BL	3/4	1.69	2-15/16	2-3/16	2-1/4	1-5/8	15/16	5/8	0.24
8710E-010BL	1	1.94	3-5/16	2-9/16	2-5/8	2	1-1/16	5/8	0.35
8710E-012BL	1-1/4	2.39	3-7/16	2-5/8	3-1/8	2-5/16	15/16	5/8	0.42
8710E-015BL	1-1/2	2.39	3-5/8	2-13/16	3-5/8	2-11/16	13/16	5/8	0.93
8710E-020BL	2	3.51	4-1/8	3-1/4	4-7/8	3-1/4	1-1/16	3/4	1.30
8710E-030BL	3	4.49	5-1/2	4-1/2	6	4-9/16	1-11/16	1	2.50
8710E-040BL	4	5.50	5	4	7-1/2	5-1/2	7/16	1-1/4	3.40

EPDM Gasket – 150 psi maximum working pressure @73°F. For Viton® O-ring, replace the E with V.

Valves

Diaphragm Valves

GF Harvel LXT® diaphragm valves are engineered to provide accurate throttling control and shut-off, utilizing a positive-stop, non-rising stem. The Weir-type design incorporates a PTFE diaphragm for maintaining purity, and uses EPDM O-ring seals on the union connections. Low-profile True Union design minimizes space while allowing for ease of installation and maintenance. Valves are supplied with both socket and threaded-end connectors for versatility. They incorporate a built-in position indicator, and are operated with a high-impact, hand-wheel-style handle for easy operation.



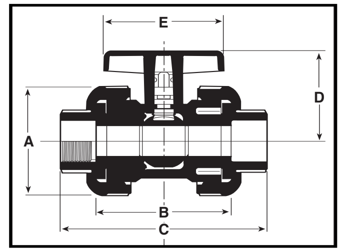
T.U. Diaphragm Valves

Part #	Size (in.)	A	B	C	D	E	Wt. (lbs.)
2729T-005BL	1/2	1-15/16	3-7/8	5-3/16	3-11/32	2-7/8	0.8
2729T-007BL	3/4	2-1/2	4-1/2	5-15/16	3-3/4	3-1/8	1.3
2729T-010BL	1	2-9/16	4-15/16	6-13/16	4-7/16	3-3/8	2.2
2729T-012BL	1-1/4	3-5/16	5-1/2	8-1/4	5-5/8	3-7/8	2.8
2729T-015BL	1-1/2	3-17/32	6-5/16	8-7/16	5-5/8	4-5/8	3.7
2729T-020BL	2	4-7/32	7-1/2	9-1/2	7	6-5/8	6.7

NOTE GF Harvel LXT® True Union diaphragm valves sizes 1/2" – 2" carry a maximum pressure rating of 150 psi for water, non-shock, @73°F.

Ball Valves

GF Harvel LXT® quarter-turn True Union ball valves incorporate the same high degree of unique engineering design characteristics. Among these characteristics are heavy-bodied construction with strong buttress threads, full Schedule 80 bore to minimize pressure drop, PTFE floating seat design to minimize seat wear, EPDM or Viton® O-ring seals, Safe-T-Shear® stem, socket and threaded-end connectors, and True Union design for ease of installation and maintenance.



T.U. Ball Valves

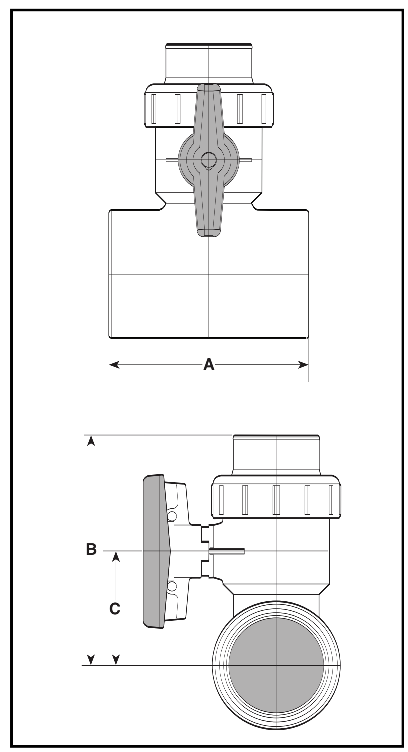
Part # *EPDM O-rings	Size (in.)	A	B	C	D	E	Wt. (lbs.)
1829-005BL	1/2	1-7/8	2-3/8	4-3/16	2-9/16	2-13/16	0.36
1829-007BL	3/4	2-1/4	2-3/4	4-3/4	2-7/8	3-3/8	0.56
1829-010BL	1	2-1/2	2-7/8	5-1/8	3-1/8	3-7/16	0.74
1829-012BL	1-1/4	3-1/16	3-1/4	5-3/4	3-5/8	3-7/8	1.13
1829-015BL	1-1/2	3-1/2	3-1/2	6-1/4	4	4-3/16	1.54
1829-020BL	2	4-1/4	4-3/4	7-3/4	4-1/2	5-1/8	2.72
1822-030BL	3	6-3/16	7	10-11/16	5-7/8	7-5/8	7.46
1822-040BL	4	7-5/8	7-5/16	11-7/8	6-3/4	9-3/16	12.35

NOTE GF Harvel LXT® True Union ball valves sizes 1/2" – 2" carry a maximum pressure rating of 235 psi for water, non-shock, @73°F. GF Harvel LXT® T.U. ball valves sizes 3" & 4" carry a maximum pressure rating of 150 psi, non-shock @ 73°F.

*For T.U. ball valves equipped with Viton® O-ring seals, replace the 1829 with 1839 in the Part #.

Tee-Style Ball Valves

Size (in.)	Dimension Reference (inches, ± 1/16) A	B-Socket	B-Threaded	C	Wt. (lbs.)	Oper.[1] Torque (in.lbs.)	Cv[2] (ValueOnly)
1/2	2-15/16	3-3/4	3-9/16	1-5/8	.48	16	29
3/4	3-7/16	4-1/4	4	1-7/8	.70	17	63
1	4	4-11/16	4-7/16	2-1/16	1.10	22	120
1-1/4	4-1/4	5-5/16	5	2-7/16	1.64	28	243
1-1/2	5-1/8	6-1/8	5-11/16	3	2.26	61	357
2	5-7/8	7-5/16	6-13/16	3-7/16	3.72	77	599
3/4 x 1/2	3-3/16	3-7/8	3-11/16	1-3/4	.51	16	29
1 x 1/2	3-7/16	4	3-13/16	1-7/8	.58	16	29
1 X 3/4	3-11/16	4-3/8	4-1/2	2	.78	17	63
1-1/4 x 1/2	4-1/4	4	3-13/16	1-7/8	.77	16	29
1-1/4 x 3/4	4-1/4	4-1/4	4	1-7/8	.90	17	63
1-1/4 x 1	4-1/4	4-13/16	4-5/8	2-3/16	1.78	22	120
1-1/2 x 1/2	4-3/8	4-1/4	4-1/16	2-1/8	.86	16	29
1-1/2 x 3/4	4-1/8	4-5/8	4-3/8	2-3/16	.91	16	63
1-1/2 x 1	4-1/2	5	4-13/16	2-3/8	1.37	16	120
2 x 1/2	4-3/16	4-9/16	4-3/8	2-7/16	1.06	16	29
2 x 3/4	4-3/8	4-15/16	4-11/16	2-9/16	1.23	17	63
2 x 1	4-3/4	5-1/4	5-1/16	2-5/8	1.38	22	120
2 x 1-1/2	5-7/8	6-1/16	5-7/8	2-15/16	2.33	61	39
3 x 1/2	5-1/2	5-1/8	4-15/16	3	1.60	16	39
3 x 1	5-1/2	5-7/8	5-11/16	3-1/4	2.19	22	120
3 x 1-1/2	7-1/4	6-9/16	6-3/8	3-7/16	3.66	61	357
3 x 2	6-11/16	7-11/16	7-3/16	3-13/16	4.61	77	599
4 x 1	7-7/16	6-5/16	6-1/8	3-11/16	3.25	22	120
4 x 1-1/2	7-3/8	7-5/16	7-1/8	4-3/16	4.01	61	357
4 x 2	7-3/4	8-5/16	7-3/4	4-7/16	5.20	77	599
6 x 2	10-3/16	9-5/8	9-1/8	5-3/4	9.26	77	599
6 x 2	10-3/16	9-5/8	9-1/8	5-3/4	9.26	77	599

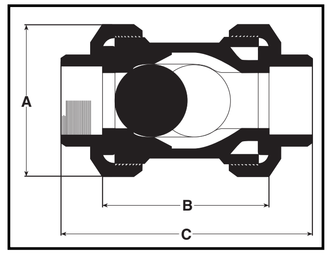


1: Torque required at valve maximum internal pressure rating, 5ft/sec. Flow velocity; due to adjustment differences during installation, actual values may vary.
2: Gallons per minute at 1 psi pressure drop. Values calculated from laying length, based on derivative of Hazen-Williams equation with surface roughness factor C=150. Cv values are for basic Ball Valve only, excluding Tee connection.

GF Harvel LXT® Ultra-pure Water Piping

T.U. Ball Check Valve

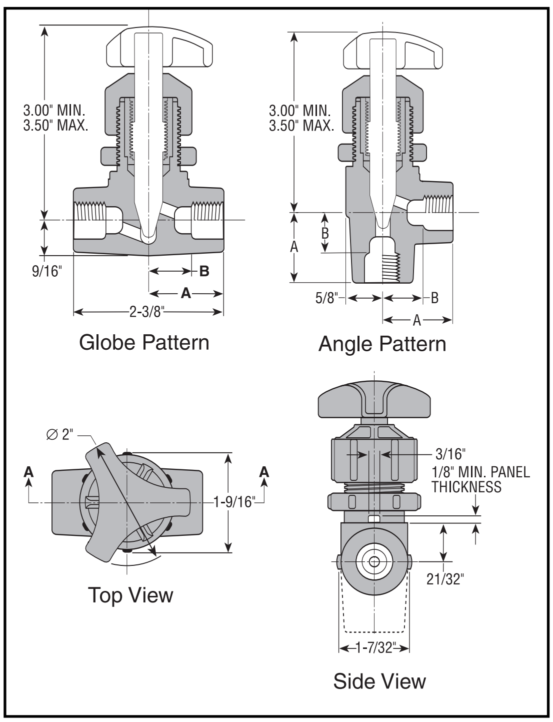
Part # *EPDM O-rings	Size (in.)	Dimension Reference (inches, ± 1/16) A	B[1]	C	Approx Wt. (lbs.) PVC	Cv[2] Threaded/ Socket	Horizontal Closing Feet of Head (water)	GPM (minimum)
4529-005BL	1/2	1-7/8	2-7/16	4-3/16	0.72	6.3	1.6	0.30
4529-007BL	3/4	2-1/4	2-3/4	4-3/4	1.19	17	1.6	0.46
4529-010BL	1	2-1/2	2-7/8	5-1/8	1.53	25	1.6	0.70
4529-012BL	1-1/4	3-1/16	3-1/4	5-3/4	1.85	65	1.6	1.04
4529-015BL	1-1/2	3-1/2	3-1/2	6-1/4	2.97	86	1.6	1.37
4529-020BL	2	4-1/4	4-3/4	7-3/4	4.55	130	1.6	2.47
4529-030BL	3	6-3/16	6-7/8	10-11/16	11.15	275	1.0	6.98
4529-040BL	4	7-1/2	7-1/4	11-13/16	16.58	500	1.0	12.13



1: Valve Lay Length 2: Gallons per minute at 1 psi pressure drop. Values based on independent testing by California State Polytechnic University.
NOTE GF Harvel LXT® True Union ball check valves sizes 1/2" - 2" carry a maximum pressure rating of 235 psi for water, non-shock, @73°F.
GF Harvel LXT® T.U. ball check valves sizes 3" & 4" carry a maximum pressure rating of 150 psi for water, non-shock, @73°F.
*For T.U. ball check valves equipped with Viton® O-ring seals, replace the 4529 with 4539 in the Part #.

Needle Valves

Needle valves (globe and angle) are available in 1/4", 3/8" and 1/2" size range with a variety of options. Contact GF Harvel for options and additional detailed information.

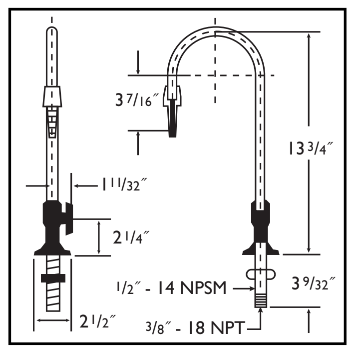


Needle Valves (Globe and Angle)

Size (in.)	End Connection	A	B
1/4	Thd	1-3/16	21/32
1/4	Soc	1-3/16	9/16
3/8	Thd	1-3/16	9/16
3/8	Soc	1-3/16	7/16
1/2	Thd	1-3/8	21/32
1/2	Soc	1-3/8	1/2

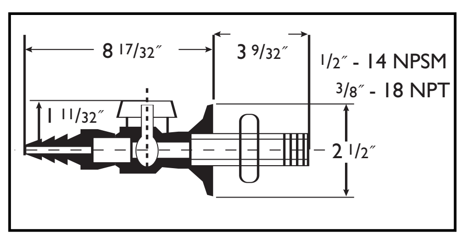
GF Harvel LXT® Lab Fixtures

Both gooseneck and turret style units are available in deck mount (horizontal surface mounting) and panel mount (vertical surface mounting) configurations. Options include metered flow (needle valve), direct flow (ball valve), deck mount recirculating units (continuous flow to reduce dead legs), and remote valve units. All lab fixture units include serrated tip and base with mounting nut. Contact GF Harvel for various options and availability.



3/8" Gooseneck - Deck Mount Lab Fixture

Part #	Description
LF1002-BL	3/8" standard deck mount with direct flow ball valve (EPDM o-rings)

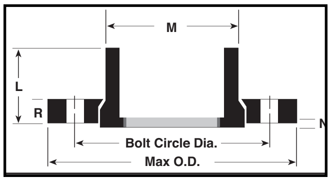


3/8" Turret - Panel Mount Lab Fixture

Part #	Description
LF3002-BL	3/8" standard panel mount turret with direct flow ball valve (EPDM o-rings)

Flanges

GF Harvel LXT® Van Stone-style flanges are also available for transition to alternate materials or where disassembly may be required. This unique two-piece design incorporates a rotating flange ring that greatly simplifies bolthole alignment during installation.



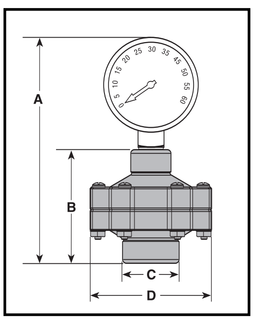
Van Stone-Style Flange (Soc - Two Piece)

Part #	Size (in.)	Max O.D.	L	M	N	R	Weight (lbs.)
854-005BL	1/2	3-1/2	1-1/32	1-7/32	5/32	17/32	0.19
854-007BL	3/4	3-7/8	1-1/8	1-7/16	5/32	9/16	0.26
854-010BL	1	4-1/4	1-9/32	1-3/4	5/32	5/8	0.36
854-012BL	1-1/4	4-5/8	1-13/32	2-5/32	5/32	11/16	0.46
854-015BL	1-1/2	5	1-17/32	2-7/16	3/16	3/4	0.56
854-020BL	2	6	1-11/16	2-15/16	3/16	13/16	0.85
854-030BL	3	7-1/2	2-1/8	4-1/4	1/4	1-1/16	1.66
854-040BL	4	9	2-1/2	5-1/4	1/4	1-1/8	2.68
854-060BL	6	11	3-3/8	7-9/16	7/16	1-9/32	4.54

GF Harvel LXT® flanges maximum working pressure 150 psi non-shock @ 73°F.

Gauge Guard

Gauge guards are available in 1/4" and 1/2" size range with a variety of options. Contact GF Harvel for options and additional detailed information.



Gauge Guard

Size (in.)	A	B	C	D
1/4 X 1/4	4-13/16	2-7/16	7/8	2-1/2 HEX
1/4 X 1/2	4-7/8	2-7/16	1-3/16	2-1/2 HEX

Design and Installation

GF Harvel LXT® piping is produced to Schedule 80 dimensions in strict accordance with ASTM D1785, and exhibits a Type II pressure rating. GF Harvel LXT® fittings are produced to Schedule 80 dimensions per ASTM D2467. 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.

Utilizing these dimensions provides a higher pressure-bearing capacity compared to other "clean" systems on the market, and permit the use of standard socket dimensions.

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.

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

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.

Hangers and Supports

Proper support spacing is critical to ensure that deflection is kept to a minimum. 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. Hangers also must not restrict linear movement of the system due to the effects of thermal expansion and contraction as a result of temperature changes; over-tightening must be avoided.

Hanger Support Spacing

Pipe Size (in.)	Maximum Support (Spacing in Feet) 73°F	80°F	100°F	120°F	140°F
1/2	5	4-1/2	4-1/2	3	2-1/2
3/4	5-1/2	5	4-1/2	3	2-1/2
1	6	5-1/2	5	3-1/2	3
1-1/4	6	6	5-1/2	3-1/2	3
1-1/2	6-1/2	6	5-1/2	3-1/2	3-1/2
2	7	6-1/2	6	4	3-1/2
3	8	7-1/2	7	4-1/2	4
4	9	8-1/2	7-1/2	5	4-1/2
6	10	9-1/2	9	6	5

NOTE Additional components and configurations may be added periodically due to our continued commitment to product line improvements. Please contact GF Harvel Technical Services at 610-252-7355 for the latest component availability, verification of technical data, or additional information not contained herein. The dimensional information contained in this publication is based on current data and product design at time of publication and may be subject to change.

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 GF Harvel LXT® pipe is 3.89 x 10^{-5} in./in./˚F. The rate of expansion or contraction can be calculated as follows:

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

Where:
ΔL = amount of expansion or contraction in inches
y = 3.89 x 10^{-5} in/in/˚F
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.)

Storage and Handling

Reasonable care and common sense should be used when handling and storing GF Harvel LXT® piping products. GF Harvel LXT® products are tough and corrosion resistant, but they should not be dropped or have objects dropped on them. Care should be used when transporting and storing the product to prevent physical damage. GF Harvel LXT® products should not be stored or installed close to heat-producing sources, subjected to external loads or overstacked when stored. The product should be inspected for any scratches, splits or gouges. Damaged sections must be cut out and discarded.

Joining Techniques

GF Harvel LXT® piping products are easily joined by the solvent-cementing process. Unlike conventional PVC solvent-cementing techniques, this product utilizes a one-step solvent-cement system specifically formulated for "clean" applications. This solvent cement exhibits extremely fast set and cure times. 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. A thorough understanding of the solvent cement joining process and proper assembly techniques must be used during assembly of these products to ensure the highest system integrity. Installers must become familiar with this process prior to use.

Basic Principles of Solvent Cementing

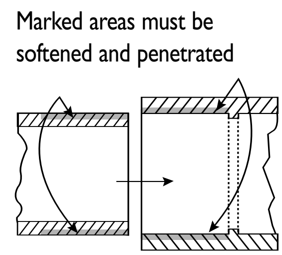
GF Harvel LXT® components are manufactured to the dimensional tolerances for Schedule 80 pipe per ASTM D1785, and Schedule 80 socket-type fittings per ASTM D2467. When fittings are produced to these dimensions, the ID of the fitting at the entrance of the socket is larger than the ID of the fitting at the socket bottom. The taper created by fitting socket dimensions provides an interference fit during assembly of the components. This provides a proven means for proper mating of components, ensuring adequate joint strength when properly assembled.

The following points must be clearly understood to ensure satisfactory joints are obtained consistently.

1. The joining surfaces must be softened and made semifluid.
2. Sufficient cement must be applied to fill the gap between the pipe and fitting.
3. Assembly of pipe and fitting must be made immediately while the surfaces are still wet and the cement is fluid.
4. Joint strength develops quickly as the cement dries. In the tight part of the joint, the surfaces will tend to fuse together; in the loose part of the joint the cement will bond to both surfaces.

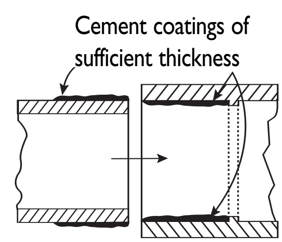
Softening and Penetration

These areas must be softened and penetrated. (This can be achieved by the cement itself.)



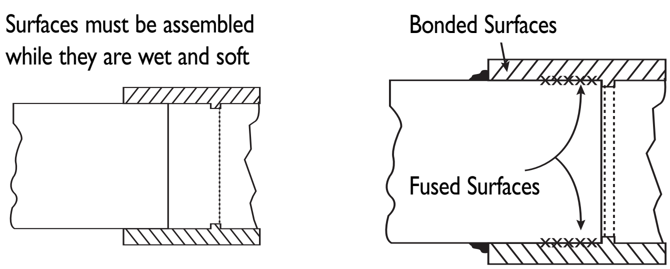
Sufficient Application of Cement

More than sufficient cement to fill the gap in the loose part of the joint must be applied. In addition to filling the gap, adequate cement layers will penetrate the joining surfaces and remain fluid until the joint is assembled.



Joint Integrity

When the cement coating on the pipe and fittings are fluid during assembly, they will tend to flow together and become one cement layer. In addition, the surfaces beneath the cement coating will be soft from surface penetration of the cement. The softened surface areas in the tight part of the joint will tend to fuse together. As the solvent dissipates, the cement layer and the softened surfaces will harden with a corresponding increase in joint strength. The dissipation of the solvent from GF Harvel LXT® One-Step Cement occurs very quickly due to its high evaporation rate. Joint strength develops more quickly in the tight (fused) part of the joint than in the looser (bonded) part of the joint. A properly assembled joint will take the required working pressure before the joint is fully dry and final joint strength is obtained.



GF Harvel LXT® One-Step Cement

Use only GF Harvel LXT® One-Step Cement formulated for GF Harvel LXT® applications using the appropriate size applicator. Carefully read and follow the label on the cement can, and application and cure time instructions thoroughly. NOTE: Dauber is supplied in pint-can lid (suitable for pipe sizes 1-1/2" – 3"). For pipe sizes 4" thru 6" use a roller equal in size to one half the pipe diameter.

Safety Precautions

Before applying cement, appropriate safety precautions should be taken. Solvent cement should be stored in the shade between 40°F and 110°F. Eliminate all ignition sources. Avoid breathing of vapors. Use only with adequate ventilation; mechanical ventilation or local exhaust is recommended to maintain vapor concentrations below exposure limits. In confined or partially enclosed areas an organic vapor respirator is recommended. Containers should be kept tightly closed when not in use, and covered as much as possible when in use. Avoid frequent contact with skin. Wear clean rubber gloves; do not perform work with bare hands.

1. **Cutting**
   Cutting the pipe as squarely as possible (90°) is required, as it maximizes the bonding area of the joint. Only sharp wheel-type cutters with blades specifically designed for cutting plastic shall be used. Cutters should be rotated slowly to provide optimum cut. Cutting speeds should be further reduced at lower temperatures. The use of a saw is not recommended as filings and shavings will cause particulate contamination.

2. **Deburring**
   All pipe ends shall be properly chamfered by providing a 10° to 15° bevel (1/16" to 3/32" in width). A chamfering tool designed for this purpose shall be used. A proper bevel will aid in assembly and prevent solvent cement being pushed from the wall of the fitting during assembly. Burrs and filings can prevent contact between the pipe and fitting and must be removed from the outside and inside of the pipe during this process. A common practice is to place sterile gauze in the pipe end to prevent shavings from entering the pipe. The gauze is then removed prior to cement application.

3. **Joining Preparation**
   Prior to assembly, all components shall be inspected for any damage or irregularities. Mating components shall be checked to assure that tolerances and engagements are compatible. Do not use components that appear irregular or do not fit properly. Check the dry fit – the pipe should enter the fitting socket easily one-quarter to three-quarters of the way. If the pipe bottoms in the fitting with little interference, use extra solvent cement in making the joint. Measure the socket depth of the fitting and mark this distance on the pipe end. This reference mark can be used when joining to ensure the pipe is completely bottomed into the fitting during assembly.

4. **Solvent Cement Application**
   GF Harvel LXT® One-Step Cement shall be applied to the joining surfaces using a dauber or natural-bristle brush approximately half the diameter of the pipes being joined. Working quickly, apply a heavy, even coat of solvent cement to the pipe end on the surface equal to the depth of the fitting socket. Apply a light coat to the fitting socket. If there was little interference during the dry fit, apply a second coat of cement to the pipe end at this time. Great care must be used to prevent cement from coming into contact with the interior waterway of the fitting or pipe.

5. **Assembly**
   Immediately insert the pipe into the fitting socket while rotating one-quarter turn. Properly align the fitting for the installation at this time. The pipe must bottom completely to the fitting stop. Hold the assembly for approximately 30 seconds to ensure initial bonding. Due to the taper on the interference fit, the pipe can back off the fitting stop if steady pressure is not held on the joint during initial bonding. A bead of cement should be evident around the pipe and fitting juncture. If the bead is not continuous, it may indicate that insufficient cement was applied. Due to the unique translucency of GF Harvel LXT®, visual inspection of the cemented joint can be conducted utilizing a flashlight or alternate light source. Joint integrity can be readily verified by visually inspecting the cemented surfaces for uniformity. If insufficient cement is applied, the joint must be cut out, discarded and begun again. Excess cement must be wiped off from the pipe O.D. using a clean rag at this time.

GF Harvel LXT® Ultra-pure Water Piping

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. (Misalignment of components during assembly will cause excessive stress in the joint, which can affect joint integrity). 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	96hrs	72 hrs

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

Flange Installation

1. Solvent cement flange to pipe.
2. Piping runs joined must be installed in straight-line position to the flange and supported to avoid stress and damage.
3. Rotate ring into position with gasket in place to align holes.
4. Insert all bolts, washers and nuts.
5. Mating surfaces of flanges must be flush against gasket prior to bolting.
6. Tighten by hand until snug. Tighten bolts in 5 ft.-lb. increments according to opposing sequence shown below.
7. Do not use bolts to bring improperly mated flanges together.

Flange Size (in.)	Recommended Torque
1/2 - 2	12 ft.-pounds
2 - 4	25 ft.-pounds
6	40 ft.-pounds

Installation Notes

Installers should verify for themselves that they can make satisfactory joints under varying conditions.

Use the appropriate size applicator. Avoid puddling of solvent cement on or within fittings and pipe. This will cause excessive softening of materials, resulting in damage to the product and excessive system contamination.

GF Harvel LXT® solvent-cemented assemblies cure very quickly when properly constructed, enabling pressure-bearing capability in a short time. This is a positive attribute of the system for scheduling pressure tests and repair work. However, Georg Fischer Harvel LLC recommends that newly assembled systems be allowed to cure for a minimum period of 24 hours prior to system rinsing/activation procedures. This reduces the potential for TOC contamination.

GF Harvel LXT® piping products should not be connected directly to UV light sources that can expose system components to ultraviolet radiation.

Other Design Considerations

Proper system engineering, design, construction practices and operation are the responsibility of the design authority. Consideration must be given to ensure the GF Harvel LXT® system is not exposed to any conditions that will exceed the product limitations regarding temperature, pressure, chemical compatibility, and mechanical strength. Detailed chemical resistance and other design information is available from Georg Fischer Harvel LLC

Georg Fischer Harvel LLC does not recommend the use of this product for the transportation or storage of compressed air or gases, nor the testing of these systems using 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. GF Harvel does not recommend flow velocities in excess of five feet per second.

GF Harvel LXT® piping systems are not formulated for outdoor use. Prolonged exposure to ultraviolet radiation (UVR) will affect physical properties.

WARNING Georg Fischer Harvel LLC 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.

NOTE GF Harvel LXT® piping is compatible with hydrogen peroxide at concentrations up to 30% at 73°F. Contact GF Harvel for additional chemical compatibility information concerning the use of GF Harvel LXT® products with various substances prior to use.

GF Harvel EnviroKing®UV Clear PVC Piping

EnviroKing®UV has been developed as a clear PVC piping that is suitable for exposure to sunlight. Unique UV blocking technology reduces harmful ultraviolet light wavelengths from penetrating the plastic while allowing beneficial wavelengths through.

These unique attributes provide a durable containment vessel that has been optimized to improve light transmission through the pipe without jeopardizing product integrity. This enables GF Harvel EnviroKingUV to provide a cost-effective solution for photobioreactor tubing used in the renewable energy industry and other outdoor applications.

Materials

GF Harvel EnviroKingUV piping is produced from a unique, rigid, transparent PolyVinyl Chloride (PVC) compound with a Cell Classification of 11553 per ASTM D1784. This material, which shows a slight blue tint, has been specifically formulated to block damaging UV light. GF Harvel EnviroKingUV is compatible with conventional IPS size PVC pipe, fittings, and valves and can be incorporated into existing PVC systems via the solvent cement joining process. It exhibits similar chemical resistance properties to conventional clear PVC, and in general is resistant to most acids, bases, salts, and oxidants. Chemical compatibility should be confirmed prior to use in chemical service environments. Please contact GF Harvel Technical Services at 610-252-7355 for additional information.

GF Harvel EnviroKingUV piping provides a versatile, cost-effective alternative for many piping applications where light transmission through the pipe is critical, or other applications where visual monitoring of processes is necessary (i.e., sight glass applications).

This product possesses the well-known benefits of rigid PVC such as: exceptional corrosion resistance; smooth interior walls for unimpeded flow and reduced sediment buildup; fast, reliable solvent-welded connections; good pressure-bearing capability; and ease of handling and installation, to name a few. All of these important attributes are now available in a unique transparent product with UV stability.

ThinWall™

GF Harvel EnviroKingUV is a low-pressure containment pipe which provides optimum dimensions for use as photobioreactor vessels and similar green technology applications. For example, when used in photobioreactors, the unique wall dimensions improve light transmission characteristics beneficial for enhanced algae growth, while maintaining product rigidity.

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI*
2	2.375	2.173	0.091	0.456	80
3	3.500	3.210	0.135	0.966	80
4	4.500	4.134	0.173	1.569	80
6	6.625	6.251	0.172	2.391	70
8	8.625	8.251	0.172	3.134	53
10	10.750	10.376	0.172	3.923	43
12	12.750	12.376	0.172	4.666	36

Schedule 40

GF Harvel EnviroKingUV is also manufactured in IPS sizes to Schedule 40 dimensions, which provide sufficient wall thickness for many pressure applications. It is suitable for use in both positive and negative pressure applications (i.e., vacuum service). As with all schedules of thermoplastic pipe, pressure rating is dependent on the pipe diameter selected as well as the operating temperature of the system. As temperatures rise, the pressure rating of the system decreases. Smaller diameter piping can withstand higher pressures than large diameter piping. Refer to the table below for dimensions, tolerances, and pressure ratings.

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P. PSI*
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	3.733	90

CPVC Fire Sprinkler Piping Systems

GF Harvel is dedicated to the manufacture and promotion of specialty CPVC plastic pipe for use in fire sprinkler systems. The use of specialty plastic pipe UL Listed for fire sprinkler applications has helped to promote the use of sprinklers by making many fire sprinkler systems more affordable. The following information pertaining to this important product line is considered introductory in nature. Additional comprehensive information is available separately by contacting GF Harvel, as its content is beyond the scope of this publication.

GF Harvel's experience with CPVC piping, and the companies proven dedication to quality, has been an integral part of CPVC's successful introduction to the fire sprinkler industry. Many of the first UL tests performed on CPVC fire sprinkler systems were conducted using pipe produced by GF Harvel. Today, GF Harvel remains committed to manufacturing the highest quality CPVC piping products for the fire sprinkler industry.

Materials

GF Harvel's specialty line of CPVC Fire Sprinkler Piping Products is chemically formulated for outstanding performance in fire sprinkler systems. The properties of the material (temperature capabilities, fire performance, etc.) and the pipe dimensions provide unique advantages in sprinkler applications such as:

- **Reduced installation time –** Light- weight, quick and easy to assemble and install using inexpensive tools, GF Harvel pipe reduces labor costs.
- **Reduced material costs –** Smaller diameter systems result in material savings and lower system design costs.
- **System longevity –** GF Harvel pipe yields long service life; it is not subject to microbiologically induced corrosion (MIC), and as a result it will not corrode or deteriorate like other piping materials

Product Characteristics

GF Harvel CPVC fire sprinkler pipe is produced to SDR-13.5 dimensions in accordance with ASTM F442 as shown in the following table. The use of CPVC produced to these dimensions provides a tough, smooth, large internal diameter piping which results in low friction loss. Exceptional hydraulic characteristics can allow the use of smaller diameter systems that still meet the water delivery needs of sprinkler service. Although classified as a rigid system, the pipe's inherent flexibility and light weight simplify installation; particularly in retrofit applications.

Approvals

GF Harvel CPVC fire sprinkler pipe is designed and Listed for a rated working pressure of 175 psi @150˚F for wet pipe fire sprinkler systems. It is listed by Underwriters Laboratories 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 GF Harvel's installation instructions for the product.

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

ASTM Standard D1784 Material Classification Equivalents: Cell Classification 23447 = CPVC Type IV Grade 1 = CPVC 4120

! NOTE Fire sprinkler systems must be designed and installed in accordance with all applicable National Fire Protection Association Standards. Georg Fischer Harvel LLC requires that all fire sprinkler systems using GF Harvel CPVC fire sprinkler products be installed in accordance with applicable NFPA Standards in conjunction with GF Harvel CPVC Fire Sprinkler Piping Products Installation Instructions and UL Listing Limitations. Georg Fischer Harvel LLC recommends that installers obtain proper installation training prior to working with the product.

Contact GF Harvel for additional detailed information on line at www.harvelsprinklerpipe.com or by calling 610-252-7355.

GF Harvel HydroKing® and GF Harvel FlowGuard Gold® CTS Plumbing Piping Systems

GF Harvel HydroKing® and GF Harvel FlowGuard Gold® CTS CPVC hot and cold water plumbing pipe provides exceptional corrosion resistance for hot and cold water plumbing applications. Easily installed using reliable solvent-welded joining techniques, GF Harvel plumbing pipe is the quality, cost-effective choice for long-term system service.

Product Ratings

GF Harvel CTS CPVC plumbing pipe is manufactured in strict compliance with ASTM D2846. This standard defines requirements for materials, workmanship, dimensions, tolerances, pressure-bearing capability, and thermocycling resistance. GF Harvel HydroKing® and GF Harvel FlowGuard Gold® pipe is manufactured to SDR 11 specifications in accordance with this standard. With SDR series pipe, the outside-diameter-to-wall- thickness ratio is constant regardless of pipe diameter; therefore all sizes of pipe carry the same pressure rating.

Performance Testing

In addition to GF Harvel's rigorous in-house testing, GF Harvel CTS CPVC pipe is regularly tested by independent third parties to verify the product's quality and safety. Stringent testing is conducted by the National Sanitation Foundation (NSF) to ensure GF Harvel pipe meets the requirements of NSF Standard 14 and NSF Standard 61 for quality and health effects. In addition to performance testing to ensure product quality, this testing ensures that the pipe does not contain nor contribute any harmful substances to the drinking water transported. As a result, GF Harvel CTS CPVC plumbing pipe contains the NSF stamp of approval for potable (drinking) water applications.

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 from the local code having jurisdiction prior to use.

Installation

Installation shall be in accordance with the requirements of the local code having jurisdiction, the solvent cement manufacturer recommendations, and Georg Fischer Harvel LLC published installation guidelines (HPB 108).

Dimensions

GF Harvel HydroKing® and GF Harvel FlowGuard Gold® plumbing pipe is manufactured in strict accordance to the requirements of ASTM D2846 to SDR 11 dimensions and tolerances. Each production run of pipe manufactured in compliance to this standard, also meets or exceeds the test requirements for materials, workmanship, burst pressure, flattening resistance, and extrusion quality and dimensions as defined in ASTM D2846.
This pipe is 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	Nominal 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 D2846 ASTM STANDARD D1784 MATERIAL EQUIVALENTS:
Cell Classification 23447 or 24448 = Type IV Grade I CPVC = CPVC 4120

Solvent Cement Joining Techniques

It is important to follow proper storage and handling, joining, assembly, and other installation techniques to ensure a quality system installation. A properly designed and installed CPVC plumbing system will provide years of trouble-free service, lasting much longer than metallic systems due to the products inherent corrosion resistance and other factors. The following information is provided as a general guide toward that end.

GF Harvel plumbing pipe is joined by the solvent cementing process; a reliable joining technique field-proven for more than 30 years. When properly conducted, this method provides a strong, homogenous joining area in which the mating surfaces are chemically fused together, producing a strong, leak-tight seal when cured. Prior to solvent cementing, appropriate safety precautions should be taken:

• Use only CPVC cement conforming to ASTM F493

• Follow the solvent cement manufacturer's instructions

CTS CPVC Hot and Cold Water Pipe

- Avoid breathing vapors
- Use only with adequate ventilation
- Avoid frequent contact with skin
- Avoid contact with eyes
- Eliminate all ignition sources
- Store primer and solvent cement in the shade between 40˚F and 110˚F
- Close containers tight when not in use, and cover as much as possible during use
- Follow all manufacturer-recommended precautions when using power tools
- Flush the system for a minimum of 10 minutes after pressure testing to remove trace amounts of solvents or other system components

Exercise special care when assembling GF Harvel plumbing pipe in extremely low temperatures (below 40˚F) or extremely high temperatures (above 80˚F). Extra set and handling times must be allowed in colder temperatures. Make certain cement has not "gelled" when cementing pipe and fittings in colder temperatures. Make certain both surfaces being joined are wet with cement during assembly when working in extremely hot temperatures.

1. Cutting

GF Harvel pipe must be cut square to obtain the proper insertion depth and to provide the maximum bonding area for solvent cementing. GF Harvel pipe can easily be cut with a wheel-type plastic tubing cutter, ratchet-style cutter, fine-toothed hand saw (hack saw), or power saws. A miter box should be used when working with saws to ensure a square cut. If ratchet-style cutters are used, their blades must be sharpened regularly. The use of ratchet cutters with dull blades, or their use in cold weather, will tend to compress the pipe prior to cutting which can result in hairline fracturing. The raised bead left on the pipe O.D. after cutting must be removed prior to solvent cementing—see step number 2 regarding beveling. Any cuts, fractures, splits, or other damaged areas must be removed prior to joining. Cut off at least 2" beyond any visible fracture.

2. Beveling/Deburring

Burrs, filings, shavings etc. caused by the cutting process must be removed from the outside and inside of the pipe. Shavings and other debris will prevent proper contact of the joining surfaces and can lead to joint failure. Chamfering tools are available for this purpose, however, pocket knives or files are also suitable. A slight bevel is required on the pipe end to help ease entry into the fitting socket, and to prevent solvent cement from being pushed ahead of the pipe during the assembly process. Many chamfering tools designed for use with plastic are readily available. These tools are specifically designed to remove burrs and provide a proper bevel simultaneously.

3. Fitting Preparation

Wipe dirt, debris, and moisture from the pipe end and fitting socket using a clean, dry rag. Moisture will slow the cure time and reduce joint strength. Inspect piping and components for damage or irregularities prior to assembly. Do not use components that appear irregular or that do not fit properly; contact the appropriate manufacturer of the product in question to determine usability. Check the dry fit of the pipe and fitting prior to assembly. The pipe should enter the fitting socket easily one-quarter to three-quarters of the way.

4. Solvent Cement Application

USE ONLY CPVC CEMENT that conforms to ASTM F493. The use of the wrong cement can result in failure. GF Harvel recommends the use of IPS 713 CPVC cement, P-68 primer or IPS Low VOC one-step CPVC cement or equivalent. Two solvent cementing processes are available; the two-step solvent cement and primer process, and the one-step process. The two-step process utilizes the application of primer to the outside of the pipe and the interior fitting socket prior to applying the solvent cement. When using primer, it must be applied to both the pipe and fittings using the appropriate size applicator. A dauber or paint brush approximately half the size of the pipe diameter is appropriate. A rag must not be used. Apply primer to the fitting socket, then to the outside of the pipe end, re-dipping the applicator as necessary to ensure the entire joining surfaces are wet; apply solvent cement immediately after primer application while primed surfaces are tacky. Cement application for one- or two-step process: Apply a heavy, even coat of cement to the outside pipe end. Apply a medium coat to the fitting socket. A second application of cement should be applied to the pipe end if there was little or no interference when the dry fit was checked. Do not allow excess cement to puddle in the pipe or fitting.

5. Assembly

Immediately insert the pipe into the fitting while rotating the pipe one-quarter turn to help distribute cement. Properly align the fitting for installation at this time. Pipe must bottom completely to the stop in the fitting. Hold the assembly for 10 to 15 seconds to ensure initial bonding. A continuous bead of cement should be evident around the pipe and fitting juncture. If the bead is not continuous, it may indicate that insufficient cement was applied. If insufficient cement is applied the fitting must be cut out, discarded and begun again. Cement in excess of the bead should be wiped off with a rag.

6. Set and Cure Times

Assembled joints must be allowed to set and cure properly prior to testing the system. Set and cure times are a function of type of cement used, pipe size, temperature, humidity, and tightness of fit. Drying time is faster for drier environments, smaller sizes, higher temperatures and tighter fits. The 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 150psi with Cold Water (based on proper use of IPS Weld-On One-Step Solvent Cement)

Pipe Size (in.)	Ambient Temperature During Cure Time >60°F	40°F - 60°F	<40°F
3/8	15 min.	20 min.	30 min.
1/2	15 min.	20 min.	30 min.
3/4	15 min.	20 min.	30 min.
1	15 min.	20 min.	30 min.
1-1/4	15 min.	20 min.	30 min.
1-1/2	30 min.	45 min.	1 hour
2	30 min.	45 min.	1 hour

NOTE In damp or humid weather allow 50% more cure time; test pressures greater than 150psi require additional cure times.
Exercise special care when assembling GF Harvel plumbing pipe in extremely low temperatures (below 40°F) or extremely high temperatures (above 80°F). Extra set and handling times must be allowed in colder temperatures. Make certain cement has not "gelled" when cementing pipe and fittings in colder temperatures. Make certain both surfaces being joined are wet with cement during assembly when working in extremely hot temperatures. Refer to cure schedule in the table above for minimum cure times after the last joint has been made before pressure testing can begin. Use of primer and/or the presence of hot water extend the cure time required before pressure testing can be conducted.

Hangers & Supports

Proper support spacing is critical to ensure that deflection is kept to a minimum. Hangers used must have an adequate load bearing surface free of any rough or sharp edges that could damage the pipe during use. They must also not restrict linear movement of the system due to the effects of expansion and contraction; overtightening must be avoided.

Pipe Size (in.)	Max. 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

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 CTS CPVC pumbing pipe to construct an appropriate UL Classified penetration system (fire-rated penetration system). When installed properly, these systems will provide a two-hour fire rating. Consult local building code requirements.

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.

Transition Connections

GF Harvel HydroKing® and GF Harvel FlowGuard Gold® plumbing pipe can be connected to copper, brass, valves, and other piping materials using transition unions, compression fittings, specialty reinforced male and female adapters, and other readily available transition fittings. Follow the fitting manufacturer's installation instructions for the specific connection being used to ensure a proper leak-free joint. When using compression fittings utilizing brass ferrules, it is recommended that a PTFE (polytetrafluoroethylene) thread tape be wrapped around the ferrule prior to assembly to help compensate for differences in expansion rates between CPVC and metallics. PTFE thread tape is also the recommended thread sealant for threaded connections.Certain pipe joint pastes and sealant compounds contain substances which could be damaging to CPVC and result in system failure. If joint sealant other than PTFE thread tape is used, contact the sealant manufacturer for compatibility with CPVC. Caution must be exercised to prevent overtightening of threaded connections and compression fittings.

Where water temperatures are 150˚F or higher, use transition fittings incorporating rubber seals or other approved specialty transition fittings at the plastic to metal changeover. Follow appropriate safety precautions and manufacturer's recommendations when working with or near open flame during soldering operations. Extreme care must be used when soldering to prevent flame contact with CPVC tubing.

Water Heater Connections

Care should be used to prevent contact of the CPVC pipe with heat-producing sources. Gas water heaters require the use of a metallic nipple or appliance connector at least six inches long to be installed above the flue piping as a transition piece to prevent damage to the CPVC by excessive heat build-up from the flue. CPVC can be installed directly onto electric water heaters with special transition fittings. Some codes require metal connectors on electric water heaters; consult applicable code requirements prior to installation.

CTS CPVC Hot and Cold Water Pipe

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. During sub-freezing temperatures, water should be blown out of the lines after testing to eliminate potential damage from freezing.

The use of compressed air or gases for pressure testing can result in system damage, serious bodily injury, or even death.

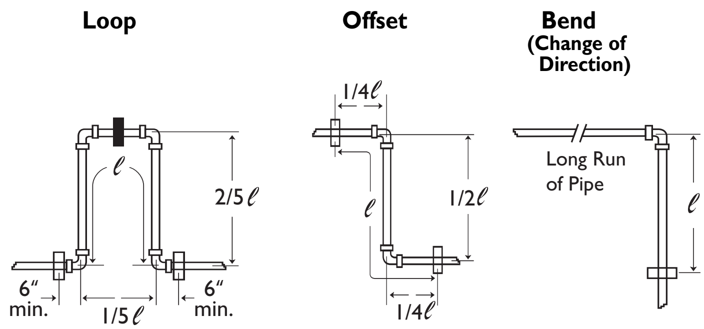
Handling and Storage

Care must be used when transporting, storing, and installing the pipe to prevent physical damage casued by impact, improper storage, or other forms of abuse. The pipe must not be dropped or have objects dropped on it. GF Harvel plumbing pipe should be kept in its original packaging to keep it free from dirt and debris and to reduce the possibility of damage. Product containing fractures, splits, gouges or other damage must not be used. If improper handling results in scratches, splits or gouges the damaged sections must be cut out and discarded prior to installation. When stored outdoors, GF Harvel plumbing pipe should be covered with a non-transparent material. Brief exposure to sunlight may cause the product's color to fade, but will not affect its physical properties.

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. GF Harvel CTS CPVC plumbing pipe will expand or contract approximately 1 inch per 50 feet of pipe with every 50˚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. Only one expansion loop, properly sized, is required in any single straight run, regardless of its total length. When more convenient due to space limitations, two or more smaller expansion loops, properly sized, can be used in a single run of pipe to compensate for thermal movement. The rate of expansion does not vary with pipe size. The effects of expansion/contraction are more pronounced on hot water lines. Generally the amount of temperature change experienced is no more than 80˚F. The chart below can be used to determine the size of an expansion joint needed to compensate for movement when a temperature change of 80˚F is experienced.

Pipe Size (in.)	Length of Run 40ft.	60ft.	80ft.	100ft.
1/2	22	27	31	34
3/4	26	32	36	41
1	29	36	41	46
1-1/4	32	40	46	51
1-1/2	35	43	50	56
2	40	49	57	64



Hangers or guides should be free of rough or sharp edges and should only be placed in the loop, offset, or change of direction as indicated above. Piping supports should restrict lateral movement and should direct axial movement into the expansion loop. Do not restrain "change in direction" configurations by butting up against joists, studs, walls or other structures.

For temperature changes greater than 80˚F the actual amount of movement to be expected must be calculated based on the temperature changes anticipated. The rate of expansion or contraction can be calculated as follows:

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

Where: Δ = expansion or contraction in inches
$y = 3.8 \times 10^{-5}$ (coefficient of linear expansion)
l = length of piping run in feet
ΔT = temperature change ˚F
(Maximum temperature - temperature @Installation)

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

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

ℓ = Length of expansion loop in inches
E = Modulus of elasticity
D = Average outside diameter of pipe
ΔL = Change in length of pipe due to temperature change
S = Working stress at max. temperature

PVC & CPVC Corrosion Resistant Duct

GF Harvel PVC and CPVC duct, available in 6" through 24" diameters, provides long-lasting, cost-effective solutions for industrial and institutional corrosive fume exhaust and drain applications.

Physical Properties

GF Harvel PVC and CPVC Duct systems perform well in many aggressive environments that are not suitable for other types of materials. Due to the unique properties of the materials, GF Harvel Duct maintains high tensile strength and modulus over a moderate temperature range, low thermal conductivity, good electrical properties, and excellent chemical and corrosion resistance to a variety of aggressive substances. Well-balanced physical properties are crucial to ensure the material selected can handle anticipated system requirements. Appropriate construction practices are determined and applied based on the physical properties of the material selected. GF Harvel Duct provides construction advantages due to the material's inherent corrosion resistance, lightweight, ease of fabrication, and other labor saving characteristics. When combined with the longevity of a properly designed system, significant cost savings can be recognized.

NOTE The physical properties shown at right are considered general physical properties. Please contact GF Harvel technical services for additional information if necessary.

PVC & CPVC Duct Physical Properties

	VALUE		TEST
GENERAL	**PVC Duct**	**CPVC Duct**	**METHOD**
Cell Classification	12454	23447	ASTM D1784
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 D792
Water Absorption % increase 24 hrs @ 25°C	0.05	0.03	ASTM D570
Hardness, Rockwell	110 - 120	117	ASTM D785
Poisson's Ratio @ 73°F	0.410	0.386	
Hazen-Williams Factor	C = 150	C = 150	
MECHANICAL			
Tensile Strength, psi @ 73°F	7,450	7,750	ASTM D638
Tensile Modulus of Elasticity, psi @ 73°F	420,000	360,000	ASTM D638
Flexural Strength, psi @ 73°F	14,450	13,000	ASTM D790
Flexural Modulus, psi @ 73°F		360,000	ASTM D790
Compressive Strength, psi @ 73°F	9,600	10,000	ASTM D695
Compressive Modulus, psi @ 73°F		196,000	ASTM D695
Izod Impact, notched ft-lb/in @ 73°F	0.75	2.0	ASTM D256
THERMAL			
Coefficient of Linear Expansion (in/in/°F)	2.9×10^{-5}	3.7×10^{-5}	ASTM D696
Coefficient of Thermal Conductivity			ASTM C177
(Cal.)(cm) / (cm^2)(Sec.)(°C)	3.5×10^{-4}	3.27×10^{-4}	
BTU / in / hr / ft^2 / °F	1.02	0.95	
Watt/m/°K	0.147	0.137	
Heat Deflection Temperature Under Load (264psi, annealed)	170°F	226°F	ASTM D648
Specific Heat, Cal./°C/gm (BTU/lb/°F)	0.25	0.26	ASTM D2766
ELECTRICAL			
Dielectric Strength, volts/mil	1,413	1,250	ASTM D149
Dielectric Constant, 60Hz, 30°F	3.70	3.70	ASTM D150
Volume Resistivity, ohm/cm @ 95°C	1.2×10^{12}	3.4×10^{15}	ASTM D257
Power Factor, 1,000 Hz		0.007%	ASTM D150
GF Harvel PVC & CPVC Pipe is non-electrolytic			
FIRE PERFORMANCE			
Flammability Rating	V-0	V-0, 5VB, 5VA	UL-94
Flame Spread Index	<10	<10	ASTM E162
Flame Spread	0-25	<25	ASTM E-84/UL 723
		<25	ULC
Smoke Generation	80-225	≤50	ASTM E-84/UL 723
		<50	ULC
Flash Ignition Temp.	730°F	900°F	
Average Time of Burning (sec.)	<5	<5	ASTM D635
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 D2863
Clean Room Materials	N/A	FPI= 1.20	
Flammability Test		SDI = 0.09	FM 4910

PVC & CPVC Corrosion Resistant Duct

Materials

PVC

GF Harvel PVC duct is extruded from GF Harvel's own custom blend of dark-gray-colored Type I, Grade I, Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784 (PVC 1120). GF Harvel PVC duct can safely carry a maximum service temperature of 140˚F. GF Harvel PVC duct is chemically resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Unlike metallics, 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 is available and should be referenced for proper material selection.

CPVC

GF Harvel CPVC Duct is extruded from a light-gray-colored Chlorinated Polyvinyl Chloride (CPVC) compound with a Cell Classification of 23437 per ASTM D1784. This enables GF Harvel duct to safely carry a maximum service temperature of 200˚F. The use of CPVC duct offers a corrosive resistant material for hot fume service up to 60˚F over PVC's maximum temperature service. In addition to elevated temperature use, GF Harvel CPVC duct also has excellent fire performance properties. GF Harvel CPVC duct has been subjected to large-scale testing and is Listed by Underwriters Laboratories of Canada (ULC) for surface burning characteristics, having a flame spread rating of 5, and a smoke development rating of 25. This makes GF Harvel CPVC duct ideal for use in critical areas (such as air plenums) where fire performance issues are of a concern. GF Harvel 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 is available and should be referenced for proper material selection.

Flammability

In addition to chemical inertness and mechanical strength, GF Harvel duct also has good flammability properties when compared to many common building products. Unlike other types of plastics, GF Harvel duct will not independently support combustion; it will not burn unless a flame is constantly applied and stops burning once the flame is removed. GF Harvel CPVC duct has improved fire performance properties over PVC. In addition to burn resistance, GF Harvel CPVC duct has exceptionally low flame-spread and smoke-generation properties, and is listed by Underwriters Laboratories of Canada for surface burning characteristics.
Refer to the Fire Performance section of Table titled PVC & CPVC Duct Physical Properties for a list of fire performance properties and test methods.

Large Diameter Dimensions

GF Harvel seamless round duct is extruded in 6" through 24" sizes to Iron Pipe Size (IPS) dimensions. GF Harvel's unique precision extrusion technology produces duct with consistent proportional stability, assuring that the mechanical integrity of the duct remains uniform. Produced in IPS diameters, GF Harvel duct piping has large internal flow areas that can easily be adapted to other common IPS fittings, reducing fabrication and installation time. For space
considerations in congested areas such as pipe chases, additional ID sizes of PVC duct are available in 7", 9" and 11" diameters. GF Harvel Duct strictly conforms to the following dimensions:

PVC 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 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

Product Ratings and Capability

GF Harvel PVC duct performs well when exposed to harsh environments. GF Harvel duct has been taken to extremes under various negative and positive pressure conditions in applications as diverse as laboratory work and industrial metal finishing operations. The ratings shown in the following tables incorporate a 1.5:1 safety factor.

Positive Pressure

GF Harvel 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 GF Harvel PVC and CPVC duct at various temperatures.

Negative Pressure Ratings

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

	TEMPERATURE °F							
Size (in.)	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	60	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

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

	TEMPERATURE °F						
Size (in.)	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

Positive Pressure Ratings

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

	TEMPERATURE °F							
Size (in.)	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 Positive Pressure Rating
PSI @ Various Temperatures °F

	TEMPERATURE °F						
Size (in.)	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. The use of compressed air or gasses is not recommended for use with GF Harvel PVC/CPVC Duct piping.

System Design and Installation

Joining Techniques

GF Harvel duct can be easily assembled in the field using standard thermoplastic pipe-joining techniques. The most common methods involve thermal hot air welding or the solvent-cementing process. Both of these methods provide reliable, cost-effective joints. Other methods of joining and fabricating GF Harvel duct and system accessories include thermoforming, fusion welding, and hot plate welding.

Solvent Cementing

Belled-end duct, couplings, flanges and other socket-style fittings can be joined using the solvent-cementing process. This process involves the application of a primer and solvent cement to join system components. This joining method has been used successfully for over 30 years in tough corrosive pressure applications. When properly conducted, this method provides a strong, homogeneous joining area in which the mating surfaces are chemically fused together, producing a strong, leak-tight seal when cured. Detailed solvent cementing procedures are available and should be referenced for proper installation techniques. Adequate surface-to-surface contact of the parts being joined is necessary for reliable solvent-cemented joints. Generally, a minimum socket depth of 3" (all sizes) will provide sufficient joint strength for most systems. Since duct dimensional tolerances can be appreciable when compared to heavy wall pipe, the use of extra-heavy-bodied solvent cement (such as IPS 719 or equivalent for PVC and IPS 729 or equivalent for CPVC) is recommended due to the cement's excellent gap-filling properties. Care should be used when solvent cementing duct diameters 18" and larger to ensure tightness of fit of mating components. The solvent cementing method is not recommended for any type of end-to-end joining.

Thermal Welding

The hot-air welding technique utilizes clean hot air to preheat the duct material and PVC welding rod, while pressure is applied to the weld area as the rod is guided. This joining method results in the surface molecules of the parts being joined to fuse together at the weld seam. Only welding rod produced from the same material being joined (same Cell Classification) is recommended for this joining process to ensure the highest system integrity. Personnel adequately trained in the art of hot-air welding thermoplastics should conduct all welding.

Hangers and Supports

Proper support spacing is dependent on the duct diameter, the temperature parameters of the system, the location of concentrated stress loads, and the possibility of process solids accumulation within the system. As with all piping systems, proper support spacing is critical to ensure that deflection and sagging are kept to a minimum. This prevents unnecessary stress on the system, and reduces the possibility of creating fluid condensation/collection areas. Drains must be installed where accumulation of moisture is expected and at low points in the system; these locations shall be specified on the drawings. The values stated are based on actual testing of air-filled duct at various temperatures, and incorporate a reasonable safety factor. Depending on the type of system service, consideration must be given to the possibility of solids accumulation within the line, particularly where two separate process lines intersect. (Solids can be created within a system as the result of a chemical reaction of the fumes being extracted.) Stress loads can be generated by the additional weight of accumulated solids, and this fact should be addressed with adequate system support where required. 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.

As with any system, GF Harvel duct must be independently supported at fans, flexible connections, hoods, scrubbers, tanks, and other system components to ensure the highest system integrity. In the case where flexible connections are installed as expansion joints, a suitable support or hanger shall be provided at each end of the flexible connection. Other heavy system components such as dampers, filters, etc. must also be independently supported to prevent high-stress concentration areas. 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 shall have an adequate load-bearing surface free of rough or sharp edges, and shall not cause damage to the duct during use. The hangers and hanger hardware shall be of a corrosive-resistant material suitable for use in the system environment. Hangers are to be of a type that will not restrict linear movement of the system due to expansion and contraction. Overtightening must be avoided to prevent duct deformation and restriction of movement. Refer to the illustration on the following page for examples of typical hangers.

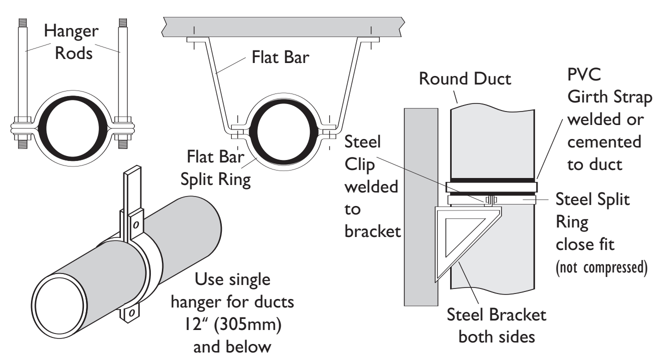
Hanger Support Spacing

PVC Duct Maximum Hanger Support Spacing In Feet

	TEMPERATURE °F							
Size (in.)	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

	TEMPERATURE °F						
Size (in.)	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



Reinforcement

Due to GF Harvel PVC duct's inherent rigidity, additional system reinforcements or flanges are not required for 6" through 24" sizes (.187" average wall or higher) up to 100°F and 10" of negative internal static pressure, (CPVC duct 6" thru 24" up to 160°F and 10" of negative internal static pressure) provided proper support spacing requirements are followed. Reinforcements are not required for systems under positive pressure when standard support spacing requirements are followed.

Thermal Expansion and Contraction

The coefficient of linear expansion (y) for GF Harvel duct can be found in the physical properties table (PVC = 2.9×10^{-5} in/in/°F; CPVC = 3.7×10^{-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 GF Harvel duct can be calculated as follows:

Thermal Expansion and Contraction for PVC Duct

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

Where:
ΔL = expansion or contraction of duct in inches
y = 2.9×10^{-5} in/in/°F (PVC duct material Coefficient of thermal expansion)
l = Length of duct run in feet
ΔT = Temperature change °F (T max. - T in.)
T max. = Maximum change in operating temperature (F)
T in. = temperature at time of installation (F)

Thermal Expansion and Contraction for CPVC Duct

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

Where:
ΔL = expansion or contraction of duct in inches
y = 3.7×10^{-5} in/in/°F (CPVC duct material Coefficient of thermal expansion)
l = Length of duct run in feet
ΔT = Temperature change °F (T max. - T in.)
T max. = Maximum change in operating temperature (F)
T in. = temperature at time of installation (F)

The most common means to compensate for changes in length is with the installation of in-line expansion joints, either flexible sleeve type or o-ring piston type being the most common. Using the inherent line flexibility of the system to construct expansion loops and offsets where required can also compensate the effects of thermal expansion and contraction. Additional detailed information concerning the effects and control of thermal expansion and contraction, and other information pertaining to the design and installation of PVC/CPVC piping products, is available from Georg Fischer Harvel LLC

PVC & CPVC Corrosion Resistant Duct

Other Design Considerations

Proper system engineering, design, construction practices, and operation are the responsibility of the design authority. Consideration must be given to ensure the duct system is not exposed to any conditions that will exceed the 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; particularly for solid particles as static electricity becomes a concern. Minimum exhaust volume requirements, usually expressed in cubic feet per minute (CFM), must be calculated based on the type and concentration of fumes being extracted. The system should also be designed and routed to provide sufficient access for inspection and future equipment maintenance. Size transition sections in mains and sub mains should be tapered appropriately to maintain optimum flow conditions. A general recommendation is to provide a minimum taper of 5" in length for each 1" change in duct diameter. Branches shall enter the main at the large end of the transition at angles not exceeding 45°. Branches shall not enter the main diametrically opposite one another. It is the responsibility of the design authority to ensure the system is designed in compliance with any applicable pollution control and/or building codes.

System Components

Fittings fabricated from GF Harvel duct are readily available in most configurations. To maintain system integrity, consistency, and compatibility, 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 D1784. Additional information concerning duct fittings and other system components can be obtained by contacting Georg Fischer Harvel LLC

Storage and Handling

Reasonable care and common sense should be used when handling and storing GF Harvel duct piping. Although GF Harvel duct is tough and corrosion resistant, it should not be dropped nor have objects dropped on it. Care should be used when transporting and storing duct to prevent physical distortion. The 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, GF Harvel duct must be covered with a non-transparent material to reduce the risk of heat absorption and discoloration. The product should be inspected for any scratches, splits or gouges that may have occurred from improper handling; if found, these sections must be cut out and discarded.

Refer to PVC Duct and CPVC Duct Product Specifications for additional information.

REFERENCES

Additional engineering and fabricating information can be obtained from:

1. Handbook for Welding and Fabricating Thermoplastic Materials; S.J. Kaminsky and J.A. Williams, Kamweld Products Co., Inc., 90 Access Road, PO Box 91 Norwood, MA 02062

2. Thermoplastic Duct (PVC) Construction Manual; SMACNA, 4201 Lafayette Center Drive, Chantilly, VA 22021

Machining Stock

Applications

An endless variety of finished parts and subcomponents can be readily produced using conventional machining methods such as cutting, boring, drilling, turning and threading. This provides a means to produce many custom assemblies and fixtures that are not available as extruded or molded items. Machined components and fixtures can then be incorporated into large assemblies or existing systems using standard solvent cementing, heat forming/ bending, or hot-air welding techniques, providing material consistency and integration for an entire system.

Typical products produced from extruded shapes include valve bodies and components, strainers, filters,pressure vessels, bulkhead fittings, pump components, bushings, compression fittings, flanges, hangers, headers, hooks, adapters, spacers, caps, sleeves, plugs, stiffeners, hubs, nuts, bolts, rollers, and numerous other mechanical components and appurtenances.

Physical Properties

GF Harvel PVC Shapes Physical Properties

GENERAL	Value	Test Method
Cell Classification	12454	ASTM D1784
Max. Service Temp.	140°F	
Color	White, Dark Gray, Black	
Specific Gravity, (g/cu.cm @ 73°F)	1.38 +/-2	ASTM D792
Hardness, Shore D	80 +/-3	ASTM D2240
MECHANICAL		
Tensile Strength, psi @ 73°F	7,300	ASTM D638
Tensile Modulus of Elasticity, psi @ 73°F	410,000	ASTM D638
Flexural Strength, psi @ 73°F	15,000	ASTM D790
Flexural Modulus, psi @ 73°F	420,000	ASTM D790
Izod Impact, notched, ft-lb/in @ 73°F	0.9	ASTM D256
THERMAL		
Coefficient of Linear Expansion (in/in/°F)	2.9×10^{-5}	ASTM D696
Heat Deflection Temperature Under Load (264psi, Annealed)	158°F	ASTM D648
FIRE PERFORMANCE		
Flammability Rating	V-0	UL-94

Clear PVC Shapes Physical Properties

GENERAL	Value	Test Method
Cell Classification	12454	ASTM D1784
Maximum Service Temp.	140°F	
Color	Transparent	
Specific Gravity, (g/cu.cm @ 73°F)	1.33	ASTM D792
Hardness, Shore D	84	ASTM D2240
MECHANICAL		
Tensile Strength, psi @ 73°F	7,260	ASTM D638
Tensile Modulus of Elasticity, psi @ 73°F	392,000	ASTM D638
Flexural Strength, psi @ 75°F	12,000	ASTM D790
Flexural Modulus, psi @ 75°F	389,000	ASTM D790
Compressive Strength, psi @ 75°F	8,300	ASTM D695
Compressive Modulus, psi @ 75°F	307,000	ASTM D695
Izod Impact notched - Method A with Grain-Comp. Molded, .125 in. bars, 73°F	8.0 ft-lbs./in.	ASTM D256
Izod Impact notched - Method A against Grain-Comp. Molded, .125 in. bars, 73°F	2.0 ft-lbs./in.	ASTM D256
THERMAL		
Coefficient of Linear Expansion (in/in/°F)	4.1×10^{-5}	ASTM D696
Heat Distortion Temp., Unannealed 264 psi, .125 in. Bars	154°F	ASTM D648
FIRE PERFORMANCE		
Flammability Rating	V-0	UL-94

GF Harvel Corzan CPVC Shapes Physical Properties

GENERAL	Value	Test Method
Cell Classification	23447	ASTM D1784
Max. Service Temp.	200°F	
Color	Medium Gray	
Specific Gravity, (g/cu.cm @ 73°F)	1.52	ASTM D792
Hardness, Rockwell	119	ASTM D785
MECHANICAL		
Tensile Strength, psi @ 73°F	7,100	ASTM D638
Tensile Modulus of Elasticity, psi @ 73°F	330,000	ASTM D638
Flexural Strength, psi @ 73°F	12,000	ASTM D790
Flexural Modulus, psi @ 73°F	350,000	ASTM D790
Izod Impact, notched, ft-lb/in @ 73°F	8.0	ASTM D256
THERMAL		
Coefficient of Linear Expansion (in/in/°F)	3.95×10^{-5}	ASTM D696
Heat Deflection Temperature Under Load (264psi, Annealed)	235°F	ASTM D648
FIRE PERFORMANCE		
Flammability Rating	V-0, 5VB, 5VA	UL-94

Materials

GF Harvel uses only the finest raw materials, which have been carefully evaluated to ensure consistency in the finished item. GF Harvel PVC material (white or gray) and GF Harvel Clear PVC materials are listed by NSF International to Standard 61 as being safe for use in potable water applications.

Polyvinyl Chloride (PVC)

Various shapes produced from PVC provide excellent machining and fabrication characteristics for components used in corrosive environments. The use of this material can provide a cost savings advantage with well-balanced physical properties for many applications. GF Harvel's standard PVC machining shapes are dark gray in color, signifying industrial grade product. PVC shapes are suitable for a maximum service temperature use of 140°F. PVC white is also inventoried, and a variety of custom colors are available upon request for specialty projects.

Clear PVC

Many unique and specialty items can be machined from GF Harvels' line of transparent PVC shapes. GF Harvel Clear PVC shapes provide the reliable chemical resistance of standard PVC, and are also fully compatible with standard PVC products with regard to machining characteristics, solvent cementing and other joining methods. In addition to exhibiting desirable physical properties and optimum transparency, this material complies with the provisions of Title 21 of the FDA Code of Federal Regulations as being safe for use in food-contact applications.

Chlorinated Polyvinyl Chloride (CPVC)

CPVC provides advantages in elevated temperature environments due to its high heat-distortion temperature. This enables the fabrication of end items or parts for use in applications with service temperatures up to 200°F. GF Harvel CPVC products also have exceptional fire resistance properties providing end products with low flame spread and smoke generation characteristics.

Various configurations of machining and joining shapes produced from specialty Corzan® 4910 CPVC are also available. GF Harvel Corzan® 4910 shapes offer exceptional fire performance characteristics, and can be used in the joining of duct, sheet and other components for use in the construction of wet benches and other units used in clean room work- stations. GF Harvel Corzan® 4910 products are off-white in color signifying cleanliness.

Industry Standard

More than 40 years of processing experience has enabled GF Harvel to refine the art of extruding machining shapes into an exacting science. This experience has made it possible to customize dedicated production equipment, addressing specific extrusion requirements.

Every aspect of the process, from raw material traceability through online testing, is continually monitored, and finalized with formal quality-control testing of finished product. Rigorous in-house TQM/SPC requirements and tough self-taught standards ensure consistency in product quality from start to finish. Key processing techniques that contribute to final product properties are carefully balanced during production to provide optimum quality.

In addition to maintaining tight dimensional tolerances, emphasis is placed on processing conditions that effect end product properties, performance, and overall quality. Focusing on and balancing the following quality requirements maximize product performance.

Degree of Fusion

Proper fusion of materials during the manufacturing process optimizes physical properties such as tensile strength, tensile modulus, flexural strength, impact resistance and other important properties that contribute to end product quality.

In addition, end-product performance in aggressive environments is dependent on the compatibility of the material selected with chemicals used during service. The degree of fusion and consistency of the melt during the manufacturing process greatly affects chemical compatibility. Product that is not properly fused during the extrusion process can result in substandard components with poor chemical resistance. This issue is addressed at GF Harvel with online and formal Q.C. tests to measure the degree of fusion throughout the entire product profile.

Porosity

Porosity and material contamination issues can create costly scrap and downtime when working with machine stock. GF Harvel uses only the finest raw materials and narrow, well-defined processing conditions for each type of product manufactured. This greatly reduces risks associated with material contamination related to substandard compound, and porosity caused by poor processing techniques.

Dimensional Stability

Laboratory tests show GF Harvel PVC solid rod outperforms other brands with significantly lower inherent stress levels.

GF Harvel has painstakingly developed methods without secondary annealing processes to reduce and monitor internal stress levels, addressing the dimensional stability characteristics of finished product when subjected to machining procedures. Residual stresses are inherent in all extruded profiles due to the nature of the extrusion process. The amount of inherent stress will affect the product's long-term stability, toughness, and machining characteristics. Stress created by the manufacturing process of GF Harvel profiles is minimized to ensure consistent machine stock with excellent dimensional stability.

Low inherent stress levels reduce the potential for fatigue and stress fracturing when products are subjected to heat cycling and various other physical demands caused by machining. Optimal product quality is achieved by producing machining shapes that can consistently withstand the vigorous demands and intricacies of complicated machining practices.

Camber and Bow

In addition to maintaining exacting tolerances on outside diameters, care is taken to ensure straightness of GF Harvel extruded products. Keeping close tolerances on camber and bow is second nature on all GF Harvel products. This enables successful machining of specialty products where overall length of a finished part is critical.

Traceability

Each finished product produced by GF Harvel is stamped and identified for tracking purposes. Careful handling, packaging and storage ensure quality is maintained from door to door.

Product Availability

GF Harvel offers quality-machining shapes in a wide variety of sizes and configurations to suit most application requirements. The following charts refer to standard stocking items. Other specialty materials such as static dissipative PVC, custom colors, additional sizes and special lengths are available upon request. Contact factory for details.

Hollow Bar

Substituting hollow bar for solid round can result in considerable savings where parts are bored. Only an internal finish cut is required, as close tolerances on O.D. dimensions are maintained.

O.D. Minimum (in.)	I.D. Material Maximum (in.)	(Weight Lbs./ft.) PVC	CPVC
1.625	0.562	1.154	1.288
1.900	0.562	1.647	-
1.900	0.906	1.410	-
2.000	1.250	1.285	-
2.125	0.750	2.010	2.243
2.250	1.125	2.025	2.260
2.250	1.500	1.625	-
2.375	1.000	2.393	2.671
2.500	1.000	2.680	-
2.500	1.500	2.209	-
2.625	1.500	2.511	2.802
2.750	1.000	3.299	3.682
2.875	1.500	-	3.525
3.000	1.000	3.976	-
3.000	1.250	3.770	4.207
3.000	1.500	3.375	-
3.000	2.000	2.798	-
3.250	1.250	4.506	-
3.500	1.500	5.037	-
3.563	1.500	5.245	5.853
3.563	2.125	4.324	-
4.000	2.500	5.153	5.751
4.000	3.000	3.845	-
4.250	1.750	7.452	8.316
4.250	3.000	4.948	-
4.500	2.000	8.099	-
4.750	3.000	7.069	7.899
5.000	3.000	8.217	9.170
5.563	4.000	7.954	-
6.000	2.437	15.200	-
6.000	4.000	11.190	-
6.625	2.875	18.030	20.121
6.625	4.000	14.910	16.640
8.625	5.750	21.400	-

Rod & Hollow Bar, Angle

SOLID ROUND BAR

GF Harvel's quality line of solid bar provides optimum machine stock for everything from thumbscrews to valve components and other items requiring complicated machining techniques.

Size (in.)	O.D.	Tol. -0; +	Camber & Bow	Material (Weight Lbs./ft.) Gray PVC	White PVC	Black PVC	CPVC	Clear
1/4	0.250	0.008	N/A	0.029	0.029	0.029	0.032	0.029
3/8	0.375	0.015	N/A	0.066	0.066	0.066	0.074	0.066
1/2	0.500	0.015	1-1/2	0.117	0.117	0.117	0.131	0.117
5/8	0.625	0.020	1-1/2	0.183	0.183	0.183	-	0.183
3/4	0.750	0.022	1-1/2	0.265	0.265	0.265	0.296	0.265
7/8	0.875	0.025	1-1/2	0.358	0.358	0.358	-	0.358
1	1.000	0.030	1-1/2	0.471	0.471	0.471	0.526	0.471
1-1/8	1.125	0.035	1-1/4	0.594	0.594	0.594	-	-
1-1/4	1.250	0.035	1-1/4	0.736	0.736	0.736	0.821	-
1-3/8	1.375	0.040	1-1/4	0.891	0.891	0.891	0.994	-
1-1/2	1.500	0.040	1-1/4	1.060	1.060	1.060	1.183	-
1-5/8	1.625	0.045	1-1/4	1.244	1.244	1.244	-	-
1-3/4	1.750	0.050	1	1.440	1.440	1.440	1.618	-
1-7/8	1.875	0.055	1	1.657	1.657	1.657	-	-
2	2.000	0.060	1	1.890	1.890	1.890	2.109	-
2-1/8	2.125	0.060	1/2	2.128	-	-	-	-
2-1/4	2.250	0.068	1/2	2.384	-	-	-	-
2-3/8	2.375	0.071	1/2	2.658	-	-	-	-
2-1/2	2.500	0.075	1/2	2.950	-	-	3.375	-
2-3/4	2.750	0.080	1/2	3.560	-	-	-	-
3	3.000	0.090	1/4	4.240	-	-	4.595	-
3-1/2	3.500	0.105	1/4	5.770	-	-	6.439	-
4	4.000	0.120	1/4	7.550	-	-	8.460	-
4-1/2	4.500	0.135	1/4	9.555	-	-	-	-
5	5.000	0.150	1/4	11.700	-	-	13.950	-
5-1/2	5.500	0.165	1/4	14.300	-	-	-	-
6	6.000	0.180	1/4	17.100	-	-	20.395	-
7	7.000	0.210	1/8	24.010	-	-	-	-
8	8.000	0.240	1/8	31.360				
9	9.000	0.270	1/8	39.690	-	-	-	-
10	10.000	0.300	1/8	49.000	-	-	-	-
11	11.000	0.330	1/16	59.290	-	-	-	-
12	12.000	0.360	1/16	74.000	-	-	-	-

Hexagonal Bar

Size (in.)	Tol. Across Flats (in.)	(Material Weight Lbs./ft.) Grey PVC	CPVC	Clear
7/16	±.030	0.108	0.121	–
1/2	±.030	0.142	0.159	–
9/16	±.030	0.180	0.202	–
5/8	±.030	0.222	0.249	–
3/4	±.030	0.320	0.359	–
13/16	±.030	0.375	0.421	–
7/8	±.030	0.435	0.489	–
1	±.030	0.569	0.639	–
1-1/8	±.030	0.721	0.810	–
1-1/4	+.0625 - 0	0.890	0.999	–
1-3/8	+.0625 - 0	1.080	1.213	–
1-1/2	+.0625 - 0	1.283	1.441	–
1-3/4	+.0625 - 0	1.746	–	–
2	+.0125 - 0	2.280	2.560	–

Square Bar

Size (in.)	Tol. Across Flats (in.)	(Material Weight Lbs./ft.) Grey PVC	CPVC	Clear
1/2	±.030	0.157	–	–
5/8	±.030	0.238	–	–
3/4	±.030	0.360	–	–
1	±.030	0.629	–	–
1-1/4	±.0625	1.033	–	–
1-1/2	±.0625	1.464	–	–
2	+.075 (-.020)	2.452	–	–

Rectangular Bar

Size (in.)	Tol. Across Flats (in.)	(Material Weight Lbs./ft.) Grey PVC	CPVC	Clear
1/2 x 3/4	1/2" flats ± .020 3/4" flats ± .030	0.225	–	–

PVC & CPVC Angle

GF Harvel's line of angle provides a reliable means for joining PVC and CPVC sheet to provide corrosion resistant tanks, cabinets, and other items. Joining is accomplished by the solvent cementing process or hot air welding methods.

Angle Bar

Size (in.)	(Material Weight Lbs./ft.) White or Grey PVC	CPVC	Clear PVC
1 x 1 x 1/8	0.141	0.180	0.141
1-1/4 x 1-1/4 x 3/16	0.262	0.325	0.262
1-1/2 x 1-1/2 x 3/16	0.316	0.395	0.316
1-1/2 x 1-1/2 x 1/4	–	–	0.415
2 x 2 x 1/4	0.563	0.645	0.563

Machining Recommendations

Certain machining practices, regardless of the material being machined (plastic or metal), can generate excessive stress. When induced stresses caused by the effects of machining are added to any residual stress, product failure can result. Causes of excessive stress induced by machining include:

- Excessive heat generation (frictional heat caused by improper speed and/or feed rates)
- Taking too much material at once
- Using worn, dull or improper tooling
- Improper support of product during machining

Speed and feed rates will be determined by the finish desired, the amount of stock removed, and the tool used.

The maximum speed that a cutting tool can be operated without generating excessive heat should be determined by actual testing. Machine vibration and way clearances must be kept to a minimum. The following machining recommendations will help minimize the amount of stress induced during the machining process.

1. **Heat Generation** should be kept to a minimum during all machining processes.

   a. Actual testing should be conducted to determine the maximum speed at which a particular tool can be used without generating excessive heat and/or chipping. All tools must be kept clean and sharp.

   b. Cutting solutions of water, soapy water, a suitable lubricant, or cool air jet should be considered for cooling during the machining process.

CAUTION Certain oils and lubricants typically used for machining of metallics contain stress-cracking agents that are not compatible with PVC or CPVC materials. Contact the lubricant manufacturer for compatibility prior to use.

2. **Turning and Boring -** High-speed steel and carbide tools are typically used for most plastics. A common practice is to follow the feed and speed rates that are typically used for machining brass. Speed rates for high-speed steel tools commonly vary between 250 - 500 ft./min.; speed rates for carbide tools can vary from 500 to 1500 ft./min. Tools used should have less clearance and more rake than those used for steel or other metals.

3. **Drilling -** Carbide-tipped bits are recommended for high volume production. Extra clearance at the back edges of the flutes is desirable to reduce heat generation caused by friction. Drill speeds can be as high as 12,000 to 15,000 rpm with carbide-tipped bits. Bit points should have an included angle of 55° to 60° for thin sections and 90° for thicker sections; clearance angle should be 15°. Lubrication or an air jet should be provided to avoid excessive heating and aid in chip removal. Commercial high-speed steel drill bits specifically designed for use with plastics are available; they have large flutes for easy chip removal.

4. **Tapping and Threading -** A high-speed, steel-nitrided, chromium-plated tap with a rake from 0° to -5° is recommended for tapping small holes. Tapping speeds usually vary from 40 to 55 ft./min. The size of the hole should allow for approximately three-quarters of the standard thread depth. When cutting a 60° thread (such as ANSI B1.2.1), the tool used should be ground to cut on one side only, and fed in at an angle of 30° by setting the compound rest at this angle.

NOTE The machining characteristics of different plastics vary somewhat. The recommendations given are general and may require modification to obtain the best results. The data furnished herein is provided as a courtesy and is based on past experience, limited testing, and other information believed to be reliable. This information may be considered as a basis for recommendation only, and not as a guarantee for its accuracy, suitability for particular applications, or the results to be obtained therefrom. Materials should be machined and tested under actual use conditions to determine suitability for a particular purpose.

PVC Industrial Pipe: Schedule 40

Application:

Corrosion resistant pressure pipe, IPS sizes 1/8" through 24", for use at temperatures up to and including 140°F. Pressure rating (120 psi to 810 psi) varies with schedule, pipe size, and temperature as stated in Georg Fischer Harvel LLC engineering bulletin (Product Bulletin 112/401). Pipe is also suitable for PVC plastic drain, waste, and vent (DWV) applications. Generally resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Chemical resistance data is available and should be referenced for proper material selection. Pipe exhibits excellent physical properties and flammability characteristics (independently tested flame and smoke characteristics-ULC). Typical applications include: chemical processing, plating, high purity applications, potable water systems, water and wastewater treatment, drainage, irrigation, agricultural, and other applications involving corrosive fluid transfer.

Scope:

This specification outlines minimum manufacturing requirements for Polyvinyl Chloride (PVC) Schedule 40 iron pipe size (IPS) pressure pipe. This pipe is intended for use in applications where the fluid conveyed does not exceed 140°F. This pipe meets and or exceeds the industry standards and requirements as set forth by the American Society for Testing and Materials (ASTM D1785 & D2665) and the National Sanitation Foundation (NSF International STD 61 & Std 14).

PVC Materials:

The material used in the manufacture of the pipe shall be domestically produced rigid polyvinyl chloride (PVC) compound, Type I Grade I, with a Cell Classification of 12454 as defined in ASTM D1784, trade name designation H707 PVC. This compound shall be white or gray in color as specified, and shall be approved by NSF International for use with potable water (NSF Std 61).

Dimensions:

All sizes of PVC Schedule 40 pipe shall be manufactured in strict accordance to the requirements of ASTM D1785 for physical dimensions and tolerances. PVC Sch 40 pipe sizes 1-1/4" through 24" diameters shall also meet the requirements of ASTM D2665 Standard Specification for PVC plastic drain, waste and vent (DWV) pipe and shall be dual marked as such. Each production run of pipe manufactured in compliance to the standard, shall also meet or exceed the test requirements for materials, workmanship, burst pressure, flattening, and extrusion quality defined in ASTM D1785 and ASTM D2665 as applicable. All belled-end pipe shall have tapered sockets to create an interference-type fit, which meet or exceed the dimensional requirements and the minimum socket length for pressure-type sockets as defined in ASTM D2672. All PVC Schedule 40 pipe must also meet the requirements of NSF Standard 14 and CSA Standard B137.3 rigid PVC pipe for pressure applications, and shall bear the mark of these Listing agencies. This pipe shall have a flame spread rating of 0-25 when tested for surface burning characteristics in accordance with CAN/ULC-S102-2-M88 or equivalent.

Marking:

Product marking shall meet the requirements of ASTM D1785 and ASTM D2665 as applicable and shall include: the manufacturer's name (or the manufacturer's trademark when privately labeled); the nominal pipe size; the material designation code; the pipe schedule and pressure rating in psi for water @ 73°F; the ASTM designation D1785; the ASTM designation D2665 (when dual marked); the independent laboratory's seal of approval for potable water usage; and the date and time of manufacture.

Sample Specification:

All PVC Schedule 40 pipe shall be manufactured from a Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM D1785 and D2665 (where applicable), consistently meeting and/or exceeding the Quality Assurance test requirements of these standards with regard to material, workmanship, burst pressure, flattening, and extrusion quality. The pipe shall be manufactured in the USA, using domestic materials, by an ISO 9001 certified manufacturer. Standard lengths of pipe sizes 6" and larger shall be beveled each end by the pipe manufacturer. All pipe shall be stored indoors after production at the manufacturing site until shipped from factory. This pipe shall carry the National Sanitation Foundation (NSF) seal of approval for potable water applications. All pipe shall be manufactured by Georg Fischer Harvel LLC.

PVC Industrial Pipe: Schedule 40

Schedule 40 Dimensions

	Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P.
	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

* Denotes these sizes are dual marked as being in compliance with both ASTM D1785 (pressure pipe) and ASTM D2665 (drain, waste & vent pipe- DWV).

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 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:
10" PVC SCH 40 @ 120°F = ?
140 psi x 0.40 = 56 psi max.
@ 120°F

THE MAXIMUM SERVICE TEMPERATURE FOR PVC IS 140°F.

Solvent-cemented joints should be utilized when working at or near maximum temperatures. GF Harvel does not recommend the use of PVC for threaded connections at temperatures above 110°F; use flanged joints, unions, or roll grooved couplings where disassembly is necessary at elevated temperatures.

Threading of Schedule 40 PVC pipe is not a recommended practice due to insufficient wall thickness. Thread only Schedule 80 or heavier walls. *Threading requires a 50% reduction in pressure rating stated for plain end pipe @ 73°F.*

Chemical resistance data should be referenced for proper material selection and possible de-rating when working with fluids other than water. Refer to GF Harvel 112/401 Product Bulletin for chemical resistance, installation data, and additional information.

ASTM STANDARD D1784 MATERIAL EQUIVALENTS:

Cell Classification 12454 = PVC Type I Grade I = PVC1120

Pipe sizes shown are manufactured in strict compliance with ASTM D1785 and ASTM D2665 where applicable.

Application:

Corrosion resistant pressure pipe, IPS sizes 1/8" through 24", for use at temperatures up to and including 140°F. Pressure rating (210 psi to 1230 psi) varies with schedule, pipe size, and temperature as stated in Georg Fischer Harvel LLC engineering bulletin (Product Bulletin 112/401). Generally resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Chemical resistance data is available and should be referenced for proper material selection. Pipe exhibits excellent physical properties and flammability characteristics (independently tested flame and smoke characteristics-ULC). Typical applications include: chemical processing, plating, high purity applications, potable water systems, water and wastewater treatment, irrigation, agricultural, and other industrial applications involving corrosive fluid transfer.

Scope:

This specification outlines minimum manufacturing requirements for Polyvinyl Chloride (PVC) Schedule 80 iron pipe size (IPS) pressure pipe. This pipe is intended for use in applications where the fluid conveyed does not exceed 140°F. This pipe meets and or exceeds the industry standards and requirements as set forth by the American Society for Testing and Materials (ASTM) and the National Sanitation Foundation (NSF International).

PVC Materials:

The material used in the manufacture of the pipe shall be domestically produced rigid polyvinyl chloride (PVC) compound, Type I Grade I, with a Cell Classification of 12454 as defined in ASTM D1784, trade name designation H707 PVC. This compound shall be gray in color as specified, and shall be approved by NSF International for use with potable water (NSF Std 61).

Dimensions:

PVC Schedule 80 pipe shall be manufactured in strict accordance to the requirements of ASTM D1785 for physical 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, and extrusion quality defined in ASTM D1785. All belled-end pipe shall have tapered sockets to create an interference-type fit, which meet or exceed the dimensional requirements and the minimum socket length for pressure-type sockets as defined in ASTM D2672. All PVC Schedule 80 pipe must also meet the requirements of NSF Standard 14 and CSA Standard B137.3 rigid PVC pipe for pressure applications, and shall bear the mark of these Listing agencies. This pipe shall have a flame spread rating of 0-25 when tested for surface burning characteristics in accordance with CAN/ULC-S102-2-M88 or equivalent.

Marking:

Product marking shall meet the requirements of ASTM D1785 and shall include: the manufacturer's name (or the manufacturer's trademark when privately labeled); the nominal pipe size; the material designation code; the pipe schedule and pressure rating in psi for water @ 73°F; the ASTM designation D1785; the independent laboratory's seal of approval for potable water usage; and the date and time of manufacture.

Sample Specification:

All PVC Schedule 80 pipe shall be manufactured from a Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM D1785, consistently meeting and/or exceeding the Quality Assurance test requirements of this standard with regard to material, workmanship, burst pressure, flattening, and extrusion quality. The pipe shall be manufactured in the USA, using domestic materials, by an ISO 9001 certified manufacturer. Standard lengths of pipe sizes 6" and larger shall be beveled each end by the pipe manufacturer. All pipe shall be stored indoors after production at the manufacturing site until shipped from factory. This pipe shall carry the National Sanitation Foundation (NSF) seal of approval for potable water applications. All pipe shall be manufactured by Georg Fischer Harvel LLC.

PVC Industrial Pipe: Schedule 80

Schedule 80 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P.
1/8	0.405	0.195	0.095	0.063	1230
1/4	0.540	0.282	0.119	0.105	1130
3/8	0.675	0.403	0.126	0.146	920
1/2	0.840	0.526	0.147	0.213	850
3/4	1.050	0.722	0.154	0.289	690
1	1.315	0.936	0.179	0.424	630
1-1/4	1.660	1.255	0.191	0.586	520
1-1/2	1.900	1.476	0.200	0.711	470
2	2.375	1.913	0.218	0.984	400
2-1/2	2.875	2.290	0.276	1.500	420
3	3.500	2.864	0.300	2.010	370
3-1/2	4.000	3.326	0.318	2.452	350
4	4.500	3.786	0.337	2.938	320
5	5.563	4.768	0.375	4.078	290
6	6.625	5.709	0.432	5.610	280
8	8.625	7.565	0.500	8.522	250
10	10.750	9.493	0.593	12.635	230
12	12.750	11.294	0.687	17.384	230
14	14.000	12.410	0.750	20.852	220
16	16.000	14.213	0.843	26.810	220
18	18.000	16.014	0.937	33.544	220
20	20.000	17.814	1.031	41.047	220
24	24.000	21.418	1.218	58.233	210

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 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:
10" PVC SCH 80 @ 120˚F = ?
230 psi x 0.40 = 92 psi max.
@ 120˚F

THE MAXIMUM SERVICE TEMPERATURE FOR PVC IS 140˚F.

Solvent-cemented joints should be utilized when working at or near maximum temperatures. GF Harvel does not recommend the use of PVC for threaded connections at temperatures above 110˚F; use flanged joints, unions, or roll grooved couplings where disassembly is necessary at elevated temperatures.

Thread only Schedule 80 or heavier walls. ***Threading requires a 50% reduction in pressure rating stated for plain end pipe @73˚F.*** Threading of Schedule 40 PVC pipe is not a recommended practice due to insufficient wall thickness.

Chemical resistance data should be referenced for proper material selection and possible de-rating when working with fluids other than water. Refer to GF Harvel 112/401 Product Bulletin for chemical resistance, installation data, and additional information.

ASTM STANDARD D1784 MATERIAL EQUIVALENTS:

Cell Classification 12454 = PVC Type I Grade I = PVC1120

Pipe sizes shown are manufactured in strict compliance with ASTM D1785.

PVC Industrial Pipe: Schedule 120

Application:

High pressure corrosion resistant, IPS sizes 1/2" through 8", for use at temperatures up to and including 140°F. Pressure rating (380 psi to 1010 psi) varies with pipe size and temperature as stated in Georg Fischer Harvel LLC engineering bulletin (Product Bulletin 112/401). Generally resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Chemical resistance data is available and should be referenced for proper material selection. Pipe exhibits excellent physical properties and flammability characteristics (independently tested flame and smoke characteristics-ULC). Typical applications include: chemical processing, plating, high purity applications, potable water systems, water and wastewater treatment, and other industrial applications involving corrosive fluid transfer where high pressures are encountered. Schedule 120 heavy wall dimensions provide sufficient wall thickness suitable for many drilling, tapping, and other custom machining/fabrication operations.

Scope:

This specification outlines minimum manufacturing requirements for Polyvinyl Chloride (PVC) schedule 120 iron pipe size (IPS) pressure pipe. This pipe is intended for use in industrial systems where the fluid conveyed does not exceed 140°F. This pipe meets and or exceeds the industry standards and requirements as set forth by the American Society for Testing and Materials (ASTM) and NSF International (NSF Std. 61 and NSF Std 14).

PVC Materials:

The material used in the manufacture of the pipe shall be domestically produced rigid polyvinyl chloride (PVC) compound, Type I Grade I, with a Cell Classification of 12454 as defined in ASTM D1784. This compound shall be gray in color, and shall be approved by the NSF International (NSF) for use with potable water.

Dimensions:

PVC Schedule 120 pipe shall be manufactured in strict accordance to the requirements of ASTM D1785 for physical 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, and extrusion quality defined in ASTM D1785. All belled-end pipe shall have tapered sockets to create an interference-type fit, which meet or exceed the dimensional requirements and the minimum socket length for pressure-type sockets as defined in ASTM D2672.

Marking:

Product marking shall meet the requirements of ASTM D1785 and shall include: the manufacturers name (or the manufacturers trademark when privately labeled); the nominal pipe size; the PVC 1120 material designation code; the pipe schedule and pressure rating in psi for water @ 73°F; the ASTM designation D1785; the independent laboratory's seal of approval for potable water usage (NSF-pw), and the date of manufacture.

Sample Specification:

All PVC Schedule 120 pipe shall be manufactured from a Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784, trade name H707 PVC. The pipe shall be manufactured in strict compliance to ASTM D1785, consistently meeting and/or exceeding the Quality Assurance test requirements of this standard with regard to material, workmanship, burst pressure, flattening, and extrusion quality. The pipe shall be manufactured in the USA, using domestic materials, by an ISO 9001 certified manufacturer. All pipe shall be stored indoors after production at the manufacturing site until shipped from factory. This pipe shall carry the National Sanitation Foundation (NSF) seal of approval for potable water applications. All pipe shall be manufactured by Georg Fischer Harvel LLC.

PVC Industrial Pipe: Schedule 120

Schedule 120 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P.
1/2	0.840	0.480	0.170	0.236	1010
3/4	1.050	0.690	0.170	0.311	770
1	1.315	0.891	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
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

ASTM STANDARD D1784 MATERIAL EQUIVALENTS:
Cell Classification 12454 = PVC Type I Grade I = PVC1120

PIPE SIZES SHOWN ARE MANUFACTURED IN STRICT COMPLIANCE WITH ASTM D1785

The working pressure ratings (W.P.) given are for water, non-shock, @ 73°F. The following temperature de-rating factors are to be applied to the working pressure ratings (W.P.) 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 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: 6" PVC SCHEDULE 120
@ 130°F = ?
370 psi x 0.31 =
115 psi max. @ 130°F

THE MAXIMUM SERVICE TEMPERATURE FOR PVC IS 140°F.

Solvent cemented joints should be utilized when working at or near maximum temperatures. GF Harvel does not recommend the use of PVC for threaded connections at temperatures above 110°F; use flanged joints, unions, or roll grooved couplings where disassembly is necessary at elevated temperatures.

Threading requires a 50% reduction in pressure rating stated for plain end pipe @73°F.

Chemical resistance data should be referenced for proper material selection and possible de-rating when working with fluids other than water. Refer to GF Harvel 112/401 Product Bulletin for chemical resistance and installation data.

Reference GF Harvel Product Bulletin 112/401 for information pertaining to chemical resistance, physical properties, joining methods, hangers and supports, collapse pressure ratings, system components and other system design and installation related data.

PVC SDR Series: Pressure Rated Pipe

Application:

Corrosion resistant pressure pipe, IPS sizes 3/4" through 24", for use at temperatures up to and including 140 F. Pressure rating (100 psi to 200 psi) varies with SDR Series and temperature shown on page 2 of this specification, and as stated in Georg Fischer Harvel LLC engineering bulletin (Product Bulletin 112/401). Generally resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Chemical resistance data is available and should be referenced for proper material selection. Pipe exhibits excellent physical properties and flammability characteristics (independently tested flame and smoke characteristics-ULC,1993). Typical applications include: potable water systems, water and wastewater treatment, irrigation, agricultural, high purity applications, chemical processing, and other industrial applications involving corrosive fluid transfer.

Scope:

This specification outlines minimum manufacturing requirements for Polyvinyl Chloride (PVC) SDR Series iron pipe size (IPS) pressure pipe. This pipe is intended for use in piping systems where the fluid conveyed does not exceed 140F. This pipe meets and or exceeds the industry standards and requirements as set forth by the American Society for Testing and Materials (ASTM) and the National Sanitation Foundation (NSF).

PVC Materials:

The material used in the manufacture of the pipe shall be domestically produced rigid polyvinyl chloride (PVC) compound, Type I Grade I, with a Cell Classification of 12454 as defined in ASTM D1784, trade name designation H707 PVC. This compound shall be white or gray in color as specified, and shall be approved by NSF for use with potable water.

Dimensions:

PVC SDR Series pipe shall be manufactured in strict accordance to the requirements of ASTM D2241 for physical 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, impact resistance, flattening, and extrusion quality as defined in ASTM D2241. This pipe shall be produced in IPS diameters to either: SDR 21 (3/4"–8" sizes 200 psi @ 73°F); SDR 26 (1"–24" sizes 160 psi @ 73°F); or SDR 41 (18"–24" 100 psi @ 73°F) as specified. All belled end pipe shall have tapered sockets to create an interference type fit, which shall meet or exceed dimensional requirements and the minimum socket length for pressure-type belled sockets as defined in ASTM D2672.

Marking:

Product marking shall meet the requirements of ASTM D2241 and shall include: the manufacturers name (or the manufacturers trademark when privately labeled); the nominal pipe size; the outside diameter system; the material designation code; the applicable Standard thermoplastic pipe Dimension Ratio designation code (SDR number) and the corresponding pressure rating in psi for water @ 73°F; the ASTM designation D2241; and the independent laboratory's' seal of approval for potable water usage.

Sample Specification:

All PVC SDR Series pipe shall be manufactured from a Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM D2241, consistently meeting and/or exceeding the Quality Assurance test requirements of this standard with regard to pressure rating, material, workmanship, burst pressure, flattening, impact resistance, and extrusion quality. The pipe shall be manufactured in the USA, using domestic materials, by an ISO 9001 certified manufacturer. Standard lengths of pipe sizes 10" and larger shall be beveled each end by the pipe manufacturer. All pipe shall be stored indoors after production at the manufacturing site until shipped from factory. This pipe shall carry the National Sanitation Foundation (NSF) seal of approval for potable water applications. All pipe shall be manufactured by Georg Fischer Harvel LLC.

PVC SDR Series: Pressure Rated Pipe

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

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.
1/2	0.840	0.696	0.062	0.110

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

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. 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	1.168
3-1/2	4.000	3.597	0.190	1.520
4	4.500	4.046	0.214	1.927
5	5.563	5.001	0.265	2.948
6	6.625	5.955	0.316	4.185
8	8.625	7.756	0.410	7.069

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

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. 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	0.966
3-1/2	4.000	3.672	0.154	1.250
4	4.500	4.134	0.173	1.569
5	5.563	5.108	0.214	2.411
6	6.625	6.084	0.255	3.414
8	8.625	7.921	0.332	5.784
10	10.750	9.874	0.413	8.971
12	12.750	11.711	0.490	12.620
14	14.000	12.860	0.538	15.205
16	16.000	14.696	0.615	19.877
18	18.000	16.533	0.692	25.156
20	20.000	18.370	0.769	31.057
24	24.000	22.043	0.923	44.744

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

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.
18	18.000	17.061	0.439	16.348
20	20.000	18.956	0.488	20.196
24	24.000	22.748	0.585	29.064

*PRESSURE RATINGS GIVEN ARE FOR WATER, NON-SHOCK, @ 73°F

ASTM STANDARD D1784 MATERIAL EQUIVALENTS:
Cell Classification 12454 = PVC Type I Grade I = PVC 1120

PIPE SIZES SHOWN ARE MANUFACTURED IN STRICT COMPLIANCE WITH ASTM D1785

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

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 (W.P.) 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.

EX: SDR 21 @ 120°F = ?
200 psi x 0.40 = 80 psi max. @ 120°F

THE MAXIMUM SERVICE TEMPERATURE FOR PVC IS 140°F.

Solvent cemented joints should be utilized when working at or near maximum temperatures. GF Harvel does not recommend the use of PVC for threaded connections at temperatures above 110°F; use flanged joints, unions, or roll grooved couplings where disassembly is necessary at elevated temperatures.

Threading of SDR Series pipe is not a recommended practice due to insufficient wall thickness.

Chemical resistance data should be referenced for proper material selection and possible de-rating when working with fluids other than water. Refer to GF Harvel 112/401 Product Bulletin for chemical resistance and installation data.

CPVC Industrial Pipe: Schedule 40 & 80

Application:

Corrosion resistant pressure pipe, IPS sizes 1/8" through 24", for use at temperatures up to and including 200°F. Pressure rating (130 psi to 1130 psi) varies with schedule, pipe size, and temperature as shown on page 2 of this specification, and as stated in Georg Fischer Harvel LLC engineering bulletin (Product Bulletin 112/401). Generally resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Chemical resistance data is available and should be referenced for proper material selection. Pipe exhibits excellent flammability characteristics (ULC Listed for Surface Burning Characteristics) and other physical properties. Typical applications include: chemical processing, plating, high purity applications, hot and cold potable water systems, water and wastewater treatment, and other industrial applications involving hot corrosive fluid transfer.

Scope:

This specification outlines minimum manufacturing requirements for Chlorinated Polyvinyl Chloride (CPVC) schedule 40 and 80 iron pipe size (IPS) pressure pipe. This pipe is intended for use in industrial systems where the fluid conveyed does not exceed 200°F. This pipe meets and or exceeds the industry standards and requirements as set forth by the American Society for Testing and Materials (ASTM) and the National Sanitation Foundation (NSF).

CPVC Materials:

The material used in the manufacture of the pipe shall be a rigid chlorinated polyvinyl chloride (CPVC) compound, Type IV Grade I, with a Cell Classification of 23447 as defined in ASTM D1784. This compound shall be light gray in color, and shall be approved by NSF for use with potable water.

Dimensions:

CPVC Schedule 40 and Schedule 80 pipe shall be manufactured in accordance to the requirements of ASTM F441 for physical dimensions and tolerances. Each production run of pipe manufactured in compliance to this standard, shall also meet the test requirements for materials, workmanship, burst pressure, flattening, and extrusion quality defined in ASTM F441. All belled-end pipe shall have tapered sockets to create an interference-type fit, which meet or exceed the dimensional requirements, and the minimum socket length for pressure-type sockets, as defined in ASTM D2672.

Marking:

Product marking shall meet the requirements of ASTM F 441 and shall include: the manufacturers name (or the manufacturers trademark when privately labeled); the nominal pipe size; the material designation code; the pipe schedule and pressure rating in psi for water @ 73°F; the ASTM designation F 441; and the independent laboratory's seal of approval for potable water usage. Marking shall also include the flame spread rating and smoke development rating when tested and listed for surface burning characteristics per CAN/ULC S102.2 (Flame Spread (F.S.) of <25 and Smoke Development (S.D.) of <50).

Sample Specification:

All CPVC Schedule 40 and schedule 80 pipe shall be manufactured from a Type IV, Grade I Chlorinated Polyvinyl Chloride (CPVC) compound with a minimum Cell Classification of 23447 per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM F441, consistently meeting the Quality Assurance test requirements of this standard with regard to material, workmanship, burst pressure, flattening, and extrusion quality. The pipe shall be produced in the USA using domestic materials, by an ISO 9001 certified manufacturer, and shall be stored indoors after production, at the manufacturing site, until shipped from factory. This pipe shall carry the National Sanitation Foundation (NSF) seal of approval for potable water applications. The pipe shall have a Flame Spread rating < 25 and a Smoke Development rating < 50 when tested and listed for Surface Burning Characteristics in accordance with CAN/ULC-S102-2-M88 or equivalent. All pipe shall be manufactured by Georg Fischer Harvel LLC.

CPVC Industrial Pipe: Schedule 40 & 80

Schedule 40 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P
1/4	0.540	0.344	0.088	0.096	780
3/8	0.675	0.473	0.091	0.128	620
1/2	0.840	0.602	0.109	0.190	600
3/4	1.050	0.804	0.113	0.253	480
1	1.315	1.029	0.133	0.371	450
1-1/4	1.660	1.360	0.140	0.502	370
1-1/2	1.900	1.590	0.145	0.599	330
2	2.375	2.047	0.154	0.803	280
2-1/2	2.875	2.445	0.203	1.267	300
3	3.500	3.042	0.216	1.660	260
3-1/2	4.000	3.521	0.226	1.996	240
4	4.500	3.998	0.237	2.363	220
5	5.563	5.016	0.258	2.874	190
6	6.625	6.031	0.280	4.164	180
8	8.625	7.942	0.322	6.268	160
10	10.750	9.976	0.365	8.886	140
12	12.750	11.889	0.406	11.751	130
14	14.000	13.073	0.437	13.916	130
16	16.000	14.940	0.500	18.167	130
18	18.000	16.809	0.562	22.965	130
20	20.000	18.743	0.593	29.976	120
24	24.000	22.544	0.687	37.539	120

Schedule 80 Dimensions

Nom. Pipe Size (in.)	O.D.	Average I.D.	Min. Wall	Nom. Wt./Ft.	Max. W.P.
1/4	0.540	0.282	0.119	0.117	1130
3/8	0.675	0.403	0.126	0.162	920
1/2	0.840	0.526	0.147	0.238	850
3/4	1.050	0.722	0.154	0.322	690
1	1.315	0.936	0.179	0.473	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	37.419	220
20	20.000	17.814	1.031	45.879	220
24	24.000	21.418	1.218	64.959	210

ASTM STANDARD D1784 MATERIAL EQUIVALENTS:
Cell Classification 23447 = CPVC Type IV Grade I = CPVC 4120

PIPE SIZES SHOWN ARE MANUFACTURED IN STRICT COMPLIANCE WITH ASTM F441

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 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.

EX: 10" CPVC SCH 80
@ 120°F = ?
230 psi x 0.65 =
149.5 psi max. @ 120°F

De-Rating Factor

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

THE MAXIMUM SERVICE TEMPERATURE FOR CPVC IS 200°F.

Solvent-cemented joints should be utilized when working at or near maximum temperatures. GF Harvel does not recommend the use of CPVC for threaded connections at temperatures above 150°F; use flanged joints, unions, or roll grooved couplings where disassembly is necessary at elevated temperatures.

Threading of Sch 40 CPVC pipe is not a recommended practice due to insufficient wall thickness. Thread only Sch 80 or heavier walls. **Threading requires a 50% reduction in pressure rating stated for plain end pipe @73°F.**

Chemical resistance data should be referenced for proper material selection and possible de-rating when working with fluids other than water. Refer to GF Harvel 112/401 Product Bulletin for chemical resistance and installation data.

PVC Bar: Solid Round

Application:

Corrosion resistant solid round bar, sizes 1/4" through 12", for use at temperatures up to and including 140°F. Generally resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Chemical resistance data is available and should be referenced for proper material selection. Extruded bar exhibits excellent physical properties and flammability characteristics. Provides consistent machining stock for the production of corrosion resistant: valve and valve components, pump components, bushings, spacers, nuts, bolts, and many other custom components and subassemblies for use in corrosive environments. Standard methods for machining, joining, and fabricating PVC thermoplastics are applicable to this product including: drilling, threading, turning, solvent cementing, and thermal welding techniques. General machining recommendations stated on page 2 of this specification should be referenced as guidelines.

Scope:

This specification outlines minimum manufacturing requirements for Polyvinyl Chloride (PVC) solid round bar. This product is manufactured as machining stock for use to produce components for end use in systems where temperatures do not exceed 140°F.

PVC Materials:

The material used in the manufacture of the solid bar shall be domestically produced rigid, unfilled, general-purpose-grade polyvinyl chloride (PVC) compound, Type I Grade I, with a Cell Classification of 12454 as defined in ASTM D1784 as provided by the PolyOne Corporation. (Callout Designation S-PVC0111 per ASTM D6263). This compound shall be gray in color, and shall be approved by NSF International for use with potable water. This material shall not contain lead stabilizers.

Quality Assurance:

PVC solid round bar is manufactured in strict compliance with ASTM D6263, Standard Specification for Extruded Rods and Bars. This includes requirements for classification and material, physical properties, degree of fusion, dimensions, dimensional stability, voids, lengthwise camber, workmanship, finish and appearance. Each production run of solid bar shall be subjected to, and meet, the following test requirements established for material, workmanship, extrusion quality, and internal stress. All finished product shall be homogenous throughout, and shall be free of voids and foreign contamination.

Product Traceability:

- A record of each material lot, which contains physical analysis and conformance records of that lot, shall be maintained for material identification and tracking.
- Each standard length of product shall be traceable to the raw material lot and batch from which it was produced.

Physical Performance Testing:

- Finished product dimensions shall be monitored continuously for compliance to standards and tolerances.
- Physical samples shall be taken at start-up, and periodically from each production run, and subjected to destructive testing for:
- Degree of fusion by Acetone Immersion per Section 12.6 of ASTM D6263
- Voids - all product shall be porosity free, and shall not contain foreign inclusions or contamination per Section 8 of ASTM D6263.
- Stress - Internal stress levels throughout the product profile shall be measured, monitored, and kept to a minimum. This product shall also meet the dimensional stability requirements as published in Table S-PVC-II of ASTM D6263 when tested in accordance with Section 12.2 of that Standard.

Marking:

Each standard length of solid bar, sizes 1" and larger shall be permanently marked on each end with the production date and shift for tracking purposes.

Sample Specification:

All PVC Solid Round Bar shall be manufactured from a unfilled, general purpose grade PVC material with a Cell Classification of 12454 per ASTM D1784 (Callout Designation S-PVC0111 per ASTM D6263). The bar shall be manufactured in strict compliance to ASTM D6263 consistently meeting or exceeding the quality assurance test requirements of this standard with regard to material, physical properties, degree of fusion, dimensions, dimensional stability, lengthwise camber, workmanship, finish and appearance. All PVC solid bar shall be porosity free, and shall be tested for internal stress levels. The solid bar shall be manufactured in the USA, using domestic materials, by an ISO 9001 certified manufacturer. All solid round bar shall be stored indoors after production at the manufacturing site until shipped from factory. This product shall be produced from materials Listed by the National Sanitation Foundation (NSF) as approved for potable water applications. All PVC solid rod shall be manufactured by Georg Fischer Harvel LLC.

Solid Round Bar

Size (in.)	O.D.	Tol. -0; +	Camber & Bow	Nom. Weight (Lbs./ft.)
1/4	0.250	0.008	N/A	0.029
3/8	0.375	0.015	N/A	0.066
1/2	0.500	0.015	1-1/2	0.117
5/8	0.625	0.020	1-1/2	0.183
3/4	0.750	0.022	1-1/2	0.265
7/8	0.875	0.025	1-1/2	0.358
1	1.000	0.030	1-1/2	0.471
1-1/8	1.125	0.035	1-1/4	0.594
1-1/4	1.250	0.035	1-1/4	0.736
1-3/8	1.375	0.040	1-1/4	0.891
1-1/2	1.500	0.040	1-1/4	1.060
1-5/8	1.625	0.045	1-1/4	1.244
1-3/4	1.750	0.050	1	1.440
1-7/8	1.875	0.055	1	1.657
2	2.000	0.060	1	1.890
2-1/8	2.125	0.060	1/2	2.128
2-1/4	2.250	0.068	1/2	2.384
2-3/8	2.375	0.071	1/2	2.658
2-1/2	2.500	0.075	1/2	2.950
2-3/4	2.750	0.080	1/2	3.560
3	3.000	0.090	1/4	4.240
3-1/4	3.250	0.100	1/4	4.975
3-1/2	3.500	0.105	1/4	5.770
4	4.000	0.120	1/4	7.550
4-1/2	4.500	0.135	1/4	9.555
5	5.000	0.150	1/4	11.700
5-1/2	5.500	0.165	1/4	14.300
6	6.000	0.180	1/4	17.100
7	7.000	0.210	1/8	24.010
8	8.000	0.240	1/8	31.360
9	9.000	0.270	1/8	39.690
10	10.000	0.300	1/8	49.000
11	11.000	0.330	1/16	59.290
12	12.000	0.360	1/16	74.000

1/4" thru 2" stocked in 10 ft lengths; 2 1/8" thru 5 1/2" stocked in 5 ft and 10 ft lengths; 6" thru 10" stocked in 5 ft lengths; 11" and 12" stocked in 2 ft lengths. Tolerance on lengths = ±1". Custom lengths available on all sizes as requested.

ASTM STANDARD D1784 MATERIAL EQUIVALENTS:
Cell Classification 12454 = PVC Type I Grade I = PVC1120

Refer to Georg Fischer Harvel LLC Machining Shapes Bulletin (HPB-111) for additional information pertaining to materials, physical properties, machining recommendations and other technical data.

NOTE The machining characteristics of different plastics vary somewhat. The recommendations given are general and may require modification to obtain the best results. The data furnished herein is provided as a courtesy and is based on past experience, limited testing, and other information believed to be reliable. This information may be considered as a basis for recommendation only, and not as a guarantee for its accuracy, suitability for particular applications, or the results to be obtained there from. Materials should be machined and tested under actual use conditions to determine suitability for a particular purpose.

Recommended Machining Practices

Residual stresses are inherent in all extruded profiles due to the nature of the extrusion process. The amount of inherent stress will affect the product's long term stability, toughness, and machineability. Certain machining practices, regardless of the material being machined, can generate excessive stress. When induced stresses caused by the effects of machining are added to the existing residual stress, product failure can result.

Georg Fischer Harvel LLC has addressed this phenomena by refining its extrusion processes to reduce and continually monitor internal stress levels present within extruded bar to ensure consistent machine stock. The following machining recommendations will help minimize the amount of stress being induced during the machining process.

1. **Heat Generation** should be kept to a minimum during all machining processes.

   a. Actual testing should be conducted to determine the maximum speed a particular tool can be used without generating excessive heat.

   b. Cutting solutions of water, soapy water, a suitable lubricant, or cool air jet should be considered for cooling during the machining process. CAUTION: Certain oils and lubricants typically used for machining of metallics contain stress-cracking agents that are not compatible with PVC or CPVC materials. Contact the lubricant manufacturer for compatibility prior to use.

2. **Turning and Boring -** High-speed steel and carbide tools are typically used for most plastics. A common practice is to follow the feed and speed rates that are typically used for machining brass. Speed rates for high speed steel tools commonly vary between 250-500 ft./min.; rates for carbide tools can vary from 500 to 1500 ft./min. Tools used should have less clearance and more rake than those used for steel or other metals.

3. **Drilling -** Carbide tipped bits are recommended for high volume production. Extra clearance at the back edges of the flutes is desirable to reduce heat generation caused by friction. Drill speeds can be as high as 12,000 to 15,000 Rpm's with carbide tipped bits. Bit points should have an included angle of 55° to 60° for thin sections and 90° for thicker sections; with a clearance angle of 15°. Lubrication or an air jet should be provided for to avoid excessive heating and aid in chip removal. Commercial high speed steel drills specifically designed for use with plastics are available which have large flutes for easy chip removal.

4. **Tapping and Threading -** A high speed, steel nitride, chromium plated tap with a rake from 0 to -5° is recommended for tapping small holes. Tapping speeds usually vary from 40 to 55 ft./min. The size of the hole should allow for approx. 3/4 of the standard thread depth. When cutting a 60° thread (such as ANSI B1.2.1) the tool used should be ground to cut on one side only, and fed in at an angle of 30° by setting the compound rest at this angle.

HydroKing® CTS CPVC Pipe

Application:

Corrosion resistant hot and cold water plumbing pipe, CTS sizes 1/4" through 2", for use at temperatures up to and including 180˚F. All sizes carry a maximum working pressure of 400 psi @ 73˚F for cold water service, and a maximum working pressure of 100 psi @ 180˚F for hot water service. This product is manufactured to SDR 11 physical dimensions and tolerances per ASTM D 2846 as stated on page 2 of this specification, and as stated in Georg Fischer Harvel LLC Copper Tube Size CPVC Pipe Product Bulletin (HPB-108) which shall be referenced for proper handling, joining, and other installation recommendations. This product is intended for use in hot and cold water service lines for domestic plumbing applications and bears the NSF-pw stamp of approval for potable water use. Typical applications include water distribution systems in: apartments, condominiums, hotels/motels, high rises, single and multifamily homes, and various commercial systems. State and local codes must be referenced for proper application and restrictions prior to use.

Scope:

This specification outlines minimum manufacturing requirements for Chlorinated Polyvinyl Chloride (CPVC) SDR 11 Series copper tube size (CTS) plumbing pipe. This pipe is intended for use in piping systems where the fluid conveyed does not exceed 200˚F. This pipe meets and or exceeds the industry standards and requirements as set forth by the American Society for Testing and Materials (ASTM) and the National Sanitation Foundation (NSF).

CPVC Materials:

The material used in the manufacture of the pipe shall be a rigid chlorinated polyvinyl chloride (CPVC) compound, Type IV Grade I, with a Cell Classification of 23447 (CPVC4120) as defined in ASTM D1784. This compound shall be tan in color, and shall be approved by the National Sanitation Foundation (NSF) for potable water use.

Dimensions:

CPVC CTS Series pipe shall be manufactured in strict accordance to the requirements of ASTM D2846 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 D2846. This pipe shall be produced in CTS diameters (1/4" through 2" sizes) to SDR 11 specifications.

Marking:

Product marking shall meet the requirements of ASTM D2846 and shall include: the manufacturers name (or the manufacturers trademark when privately labeled); the nominal pipe size; the outside diameter system; the material designation code; the applicable Standard thermoplastic pipe Dimension Ratio designation code (SDR number) and the corresponding pressure rating in psi for water @ 180˚F; the ASTM designation D2846; and the independent laboratory's seal of approval for potable water usage.

Sample Specification:

All CPVC SDR 11 Series hot and cold water plumbing pipe shall be manufactured from a Type IV, Grade I Chlorinated Polyvinyl Chloride (CPVC) compound with a Cell Classification of 23447 (CPVC4120) per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM D2846, consistently meeting and/or exceeding the Quality Assurance test requirements of this standard with regard to pressure rating, material, workmanship, burst pressure, flattening resistance, and extrusion quality. The pipe shall be manufactured in the USA, by an ISO 9001 certified manufacturer. All pipe shall be packaged on-line immediately after its manufacture and stored indoors after production at the manufacturing site until shipped from factory. This pipe shall carry the National Sanitation Foundation (NSF) seal of approval for potable water applications. All HydroKing® pipe shall be manufactured by Georg Fischer Harvel LLC.

CTS CPVC Dimensions & Tolerances

Pipe Size (in.)	Average O.D.	O.D. TOL	Average I.D.	Min. Wall	Wall TOL	Pressure 73°F	Rating@ 180°F
1/2	0.625	±.003	0.469	0.068	±0.020	400	100
3/4	0.875	±.003	0.695	0.080	±0.020	400	100
1	1.125	±.003	0.901	0.102	±0.020	400	100
1-1/4	1.375	±.003	1.105	0.125	±0.020	400	100
1-1/2	1.625	±.004	1.309	0.148	±0.020	400	100
2	2.125	±.004	1.716	0.193	±0.023	400	100

PIPE SIZES SHOWN ARE MANUFACTURED IN STRICT COMPLIANCE WITH ASTM D2846
ASTM STANDARD D1784 MATERIAL EQUIVALENTS:
Cell Classification 23447 = Type IV Grade I CPVC = CPVC 4120

General Recommendations

Code Approvals

State and local codes must be referenced prior to installation for proper application and /or any restrictions applicable to the product prior to use. All CTS CPVC pipe shall be Listed by the National Sanitation Foundation (NSF) for conformance to ASTM D2846 and NSF Standard 14 and 61 requirements, which validate performance characteristics and health affects. These listings are required for, and accepted by, major model building codes.

Handling and Storage

All CTS CPVC pipe shall be provided boxed by the manufacturer, however, care shall be used when transporting, storing, and installing to prevent physical damage. Damaged sections must be cut out and discarded prior to installation.

Installation

Installation shall be in accordance with the requirements of the local code having jurisdiction, the solvent cement manufacturer recommendations, and Georg Fischer Harvel LLC published installation guidelines (HPB 108).

Solvent Cement Joining

Use only CPVC solvent cement that conforms to ASTM F493; the use of the wrong cement can result in joint failure. Prior to solvent cementing appropriate safety precautions shall be taken. Two solvent cement joining processes are approved for use with this product. The two-step solvent cement and primer process and one-step process. All solvent cemented joints shall be made up in accordance with the procedures outlined in GF Harvel HPB 108 HydroKing® CTS CPVC Pipe brochure and the solvent cement manufacturers instructions to ensure the highest system integrity.

Thermal Expansion

Consideration shall be given at the design and installation of the plumbing system to address the effects that thermal expansion/ contraction has on the piping system as a result of temperature variations. Refer to Harvel Plastics HPB 108 HydroKing® CTS CPVC Pipe brochure for additional information.

Chemical Compatibility

Care shall be taken by the end user to ensure that any substances coming into contact with the piping (thread pastes, sealants, fire stop materials, lubricants etc.) are chemically compatible with CPVC. The manufacturer of the product in question must be contacted for compatibility information.

System Components

All CTS CPVC fittings used in conjunction with this piping shall comply with the applicable requirements of ASTM D2846 and shall be Listed by the National Sanitation Foundation (NSF) to NSF Standard 14 and Standard 61 requirements, such as those manufactured by Spears Manufacturing Company or approved equal.

Application:

Corrosion resistant hot and cold water plumbing pipe, CTS sizes 1/4" through 2", for use at temperatures up to and including 180˚F. All sizes carry a maximum working pressure of 400 psi @ 73˚F for cold water service, and a maximum working pressure of 100 psi @ 180˚F for hot water service. This product is manufactured to SDR 11 physical dimensions and tolerances per ASTM D 2846 as stated on page 2 of this specification, and as stated in Georg Fischer Harvel LLC Copper Tube Size CPVC Pipe Product Bulletin (HPB-117) which shall be referenced for proper handling, joining, and other installation recommendations. This product is intended for use in hot and cold water service lines for domestic plumbing applications and bears the NSF-pw stamp of approval for potable water use. Typical applications include water distribution systems in: apartments, condominiums, hotels/motels, high rises, single and multifamily homes, and various commercial systems. State and local codes must be referenced for proper application and restrictions prior to use.

Scope:

This specification outlines minimum manufacturing requirements for Chlorinated Polyvinyl Chloride (CPVC) SDR 11 Series copper tube size (CTS) plumbing pipe. This pipe is intended for use in piping systems where the fluid conveyed does not exceed 200˚F. This pipe meets and or exceeds the industry standards and requirements as set forth by the American Society for Testing and Materials (ASTM) and the National Sanitation Foundation (NSF).

CPVC Materials:

The material used in the manufacture of the pipe shall be a rigid chlorinated polyvinyl chloride (CPVC) compound, Type IV Grade I, with a Cell Classification of 24448 (CPVC4120) as defined in ASTM D1784. This compound shall be tan in color, and shall be approved by the National Sanitation Foundation (NSF) for potable water use.

Dimensions:

CPVC CTS Series pipe shall be manufactured in strict accordance to the requirements of ASTM D2846 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 D2846. This pipe shall be produced in CTS diameters (1/4" through 2" sizes) to SDR 11 specifications.

Marking:

Product marking shall meet the requirements of ASTM D2846 and shall include: the manufacturers name (or the manufacturers trademark when privately labeled); the nominal pipe size; the outside diameter system; the material designation code; the applicable Standard thermoplastic pipe Dimension Ratio designation code (SDR number) and the corresponding pressure rating in psi for water @ 180˚F; the ASTM designation D2846; and the independent laboratory's seal of approval for potable water usage.

Sample Specification:

All CPVC SDR 11 Series hot and cold water plumbing pipe shall be manufactured from a Type IV, Grade I Chlorinated Polyvinyl Chloride (CPVC) compound with a Cell Classification of 24448 (CPVC4120) per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM D2846, consistently meeting and/or exceeding the Quality Assurance test requirements of this standard with regard to pressure rating, material, workmanship, burst pressure, flattening resistance, and extrusion quality. The pipe shall be manufactured in the USA, by an ISO 9001 certified manufacturer. All pipe shall be packaged on-line immediately after its manufacture and stored indoors after production at the manufacturing site until shipped from factory. This pipe shall carry the National Sanitation Foundation (NSF) seal of approval for potable water applications. All GF Harvel FlowGuard Gold® pipe shall be manufactured by Georg Fischer Harvel LLC.

CTS CPVC Dimensions & Tolerances

Pipe Size (in.)	Average O.D.	O.D. TOL	Average I.D.	Min. Wall	Wall TOL	Pressure 73°F	Rating@ 180°F
1/2	0.625	±.003	0.469	0.068	±0.020	400	100
3/4	0.875	±.003	0.695	0.080	±0.020	400	100
1	1.125	±.003	0.901	0.102	±0.020	400	100
1-1/4	1.375	±.003	1.105	0.125	±0.020	400	100
1-1/2	1.625	±.004	1.309	0.148	±0.020	400	100
2	2.125	±.004	1.716	0.193	±0.023	400	100

PIPE SIZES SHOWN ARE MANUFACTURED IN STRICT COMPLIANCE WITH ASTM D2846
ASTM STANDARD D1784 MATERIAL EQUIVALENTS:
Cell Classification 24448 = Type IV Grade I CPVC = CPVC 4120

General Recommendations

Code Approvals

State and local codes must be referenced prior to installation for proper application and /or any restrictions applicable to the product prior to use. All CTS CPVC pipe shall be Listed by the National Sanitation Foundation (NSF) for conformance to ASTM D2846 and NSF Standard 14 and 61 requirements, which validate performance characteristics and health affects. These listings are required for, and accepted by, major model building codes.

Handling and Storage

All CTS CPVC pipe shall be provided boxed by the manufacturer, however, care shall be used when transporting, storing, and installing to prevent physical damage. Damaged sections must be cut out and discarded prior to installation.

Installation

Installation shall be in accordance with the requirements of the local code having jurisdiction, the solvent cement manufacturer recommendations, and Georg Fischer Harvel LLC published installation guidelines (HPB 108).

Solvent Cement Joining

Use only CPVC solvent cement that conforms to ASTM F493; the use of the wrong cement can result in joint failure. Prior to solvent cementing appropriate safety precautions shall be taken. Two solvent cement joining processes are approved for use with this product. The two-step solvent cement and primer process and one-step process. All solvent cemented joints shall be made up in accordance with the procedures outlined in GF Harvel HPB 117 GF Harvel FlowGuard Gold® CTS CPVC Pipe brochure and the solvent cement manufacturers instructions to ensure the highest system integrity.

Thermal Expansion

Consideration shall be given at the design and installation of the plumbing system to address the effects that thermal expansion/ contraction has on the piping system as a result of temperature variations. Refer to GF Harvel HPB 117 FlowGuard Gold® CTS CPVC Pipe brochure for additional information.

Chemical Compatibility

Care shall be taken by the end user to ensure that any substances coming into contact with the piping (thread pastes, sealants, fire stop materials, lubricants etc.) are chemically compatible with CPVC. The manufacturer of the product in question must be contacted for compatibility information.

System Components

All CTS CPVC fittings used in conjunction with this piping shall comply with the applicable requirements of ASTM D2846 and shall be Listed by the National Sanitation Foundation (NSF) to NSF Standard 14 and Standard 61 requirements, such as those manufactured by Spears Manufacturing Company or approved equal.

Application:

Corrosion resistant CLEAR pressure pipe, IPS sizes 1/4" through 12", for use at temperatures up to and including 140˚F. Pressure rating (70 psi to 570 psi) varies with schedule, pipe size, and temperature as stated on page 2 of this specification and in Georg Fischer Harvel LLC Clear bulletin (Product Bulletin HPB-107). Generally resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Chemical resistance data should be referenced for proper material selection. Pipe exhibits excellent physical properties and optimum clarity. Typical applications include process, sight glass, and dual containment piping as found in chemical processing, high purity applications, food processing, pharmaceuticals, laboratory use, waste treatment, plating, and other applications involving fluid transfer where visual monitoring of process lines is warranted.

Scope:

This specification outlines minimum manufacturing requirements for CLEAR Polyvinyl Chloride (PVC) Schedule 40 and Schedule 80 iron pipe size (IPS) pressure pipe. This pipe is intended for use in systems where the fluid conveyed does not exceed 140˚F. This pipe meets and or exceeds applicable industry standards and requirements as set forth by the American Society for Testing and Materials (ASTM).

PVC Materials:

The material used in the manufacture of the pipe shall be a rigid polyvinyl chloride (PVC) compound, with a Cell Classification of 12454 as defined in ASTM D1784. This compound shall comply with the provisions of Title 21 United States FDA Code of Federal Regulations and shall be safe for use with food contact applications. This compound shall be transparent in color, and shall be approved by NSF International for use with potable water (NSF Std 61).

Dimensions:

PVC Clear Schedule 40 and Schedule 80 pipe shall be manufactured in strict accordance with the dimensional requirements of ASTM D1785 to Schedule 40 or Schedule 80 dimensions and tolerances as applicable. All PVC Clear pipe shall meet the minimum burst pressure requirements and water pressure rating requirements of PVC Type II, Grade I, established for PVC 2110 as defined in ASTM D1785. Each production run of pipe shall also meet or exceed the test requirements for materials, workmanship, flattening, and extrusion quality defined in ASTM D1785. All belled-end pipe shall have tapered sockets to create an interference-type fit, which meet or exceed the dimensional requirements and the minimum socket length for pressure-type sockets as defined in ASTM D2672.

Marking:

All Clear PVC Schedule 40 and Schedule 80 pipe shall be permanently embossed with the manufacturers name or (or the manufacturers trademark when privately labeled), pipe size, dimension (i.e. Sch 40 or Sch 80), and date and time of manufacture.

Sample Specification:

All PVC Schedule 40 & Schedule 80 CLEAR pipe shall be manufactured from a Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784. The pipe shall be manufactured in strict compliance to ASTM D1785, consistently meeting and/or exceeding the applicable Quality Assurance test requirements of this standard with regard to material, dimensions, workmanship, burst pressure, flattening, and extrusion quality. The pipe shall be manufactured in the USA by an ISO 9001 certified manufacturer. All PVC CLEAR pipe shall be packaged immediately after its manufacture to prevent damage, and shall then be stored indoors at the manufacturing site until shipped from factory. All pipe shall be manufactured by Georg Fischer Harvel LLC.

Clear PVC Piping: Schedule 40 & 80

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
5	5.563	5.016	0.258	2.874	100
6	6.625	6.031	0.280	3.733	90
* 6 x 1/8	6.625	6.335	0.125	1.647	45
8	8.625	7.942	0.322	5.619	80
10	10.750	9.976	0.365	7.966	70
12	12.750	11.889	0.406	10.534	70

*This size does not meet Schedule 40 criteria

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
2-1/2	2.875	2.290	0.276	1.500	210
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

Chemical resistance data should be referenced for proper material selection and possible de-rating when working with fluids other than water. Refer to GF Harvel 112/401 Product Bulletin for chemical resistance and installation data.

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 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

Clear PVC Pipe Physical Properties

GENERAL	Value	Test Method
Cell Classification	12454	ASTM D1784
Max. Service Temp.	140°F	
Color	Transparent	
Specific Gravity g/cu.cm @ 73°F	1.33	ASTM D792
Hardness, Shore D	84	ASTM D2240
Hazen Williams Factor	C = 150	
Tensile Strength, psi @ 73°F	7,260	ASTM D638
Tensile Modulus of Elasticity, psi @ 73°F	392,000	ASTM D638
Flexural Strength, psi @ 75°F	12,000	ASTM D790
Flexural Modulus, psi @ 75°F	389,000	ASTM D790
Compressive Strength psi @75°F	8,300	ASTM D695
Compressive Modulus psi @ 75°F	307,000	ASTM D695
Izod Impact notched – Method A, w/ Grain- comp. Molded, .125 in. bars @73°F	8.0 ft.-lbs./in.	ASTM D256
Izod Impact notched – Method A, against Grain- comp. Molded, .125 in. bars @73°F	2.0 ft.-lbs./in.	ASTM D256
Coefficient of Linear Expansion	4.10×10^{-5} in/in °F	ASTM D696
Heat Distortion Temp.	154°F	ASTM D648
Glass Transition Temperature	176°F	
Flammability Rating	V-0	UL-94

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

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

Solvent-cemented joints should be utilized when working at or near maximum temperatures. GF Harvel Plastics does not recommend the use of PVC for threaded connections at temperatures above 110˚F; use flanged joints, unions, or roll grooved couplings where disassembly is necessary at elevated temperatures.

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

NOTE Although GF Harvel Clear 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 (U.V.R.) will also affect clarity. Clear products do not contain U.V. stabilizers and are not recommended for outdoor use unless adequate protection is applied.

Application:

Intended for use in pressure piping systems for the conveyance of ultrapure water. IPS sizes 1/2" through 6", for use at ambient temperatures up to and including a maximum of 140 F. Pressure rating (140 psi to 420 psi) varies with pipe size, temperature, and component limitations as stated in the GF Harvel LXT® product bulletin (HPB-114). Pipe exhibits excellent surface finish characteristics, good physical properties and exceptional low extractable qualities that reduce the potential for micro contamination in UPW applications.

Scope:

This specification outlines minimum requirements for GF Harvel LXT® Schedule 80-iron pipe size (IPS) UPW pressure pipe. This piping system is intended for use in ambient temperature ultrapure water systems where the fluid conveyed does not exceed 140F.

Materials:

The material used in the manufacture of pipe, fittings and valves shall be a specialty, virgin, low-extractable rigid polyvinyl chloride (PVC) compound (trade name GF Harvel LXT®), with a Cell Classification of 12343 per ASTM D1784. This specialty compound shall be translucent blue in color, and shall be approved by NSF International for use with potable water (NSF Standard 61). This material 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. All GF Harvel LXT® raw material utilized for the production of pipe shall be procured, packaged, handled and stored utilizing controlled procedures to reduce the potential for external contamination. A record of each material lot shall be maintained for material identification and tracking. This material shall not contain lead stabilizers.

Pipe:

GF Harvel LXT® pipe shall be manufactured in strict accordance to the dimensional requirements of ASTM D1785 to Schedule 80 dimensions and tolerances. All pipe shall be extruded on dedicated equipment used for the production of GF Harvel LXT®. All pipe shall be continually monitored for dimensional tolerances and inspected for any visible scratches, bubbles, dirt, voids or other imperfections. All finished product shall be homogenous throughout, and shall be free of voids and foreign contamination. Each pipe length shall be purged with clean filtered air during production to remove shavings. All pipe shall be double bagged immediately after manufacture in FDA approved anti-static polyethylene sleeves that are heat-sealed upon final inspection. Each standard length of product shall be traceable to the raw material lot and batch from which it was produced. Each production run of pipe shall also meet or exceed the test requirements established by GF Harvel's Quality Assurance Program for materials, workmanship, burst pressure, flattening resistance, and extrusion quality.

Pipe Marking:

Pipe identification marking shall be provided on the exterior pipe surface at intervals not exceeding 5 feet in length. Marking identification shall include the material designation GF Harvel LXT®, pipe size, dimensions (Schedule 80) and production lot information for product traceability.

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 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

Fittings & Valves:

All fittings and valves shall be manufactured from the same virgin, low extractable material as specified in the material section. All fittings shall be manufactured to Schedule 80 dimensions and tolerances in strict accordance to the dimensional requirements of ASTM D2467. Socket-style fittings shall have tapered sockets manufactured in accordance to the requirements of ASTM D2467 to create an interference type fit. Threaded fittings shall be manufactured in accordance with ASTM F1498 to tapered pipe thread dimensions. All fittings and valves shall be 100% visually inspected for cleanliness and imperfections as specified by the manufacturer. Upon final inspection, all fittings and valves are to be double bagged immediately in FDA approved anti-static polyethylene sleeves that are heat-sealed. All flanges shall have ANSI Class 150 bolt patterns, and carry a maximum pressure rating of 150 psi non-shock @ 73F.

All valves shall be true union Weir-style diaphragm or true union style quarter turn ball valves manufactured from the same virgin, low extractable material. All diaphragms and seats shall be PTFE; valve o-rings shall be EPDM or Viton as specified. All valve union nuts shall have buttress style threads. All valve components shall be replaceable. True union diaphragm valves sizes 1/2"–2" shall carry a maximum working pressure rating of 150 psi non-shock @ 73°F. True union ball valves sizes 1/2"–2" shall carry a maximum working pressure rating of 235 psi non-shock @ 73°F. True union ball valves sizes 3" & 4" shall carry a maximum working pressure rating of 150 psi non-shock @ 73°F.

Joining:

All GF Harvel LXT® UPW piping shall be joined utilizing GF Harvel LXT® One-Step UPW Grade Solvent Cement specifically formulated for joining this material. All solvent cemented welds shall be made-up in strict accordance with the written assembly procedures for the product as stated in the Georg Fischer Harvel LLC GF Harvel LXT® product bulletin (HPB-114). Installers must become familiar with these procedures prior to assembly. The use of solvent cements and/or primers other than GF Harvel LXT® One-Step is not acceptable. Joint integrity on solvent welded connections shall be confirmed with visual inspection utilizing a light source to inspect the cemented surfaces for uniformity. All solvent cemented connections shall be allowed to set and cure properly prior to pressure testing/rinsing procedures per the joint cure schedules as stated in the Georg Fischer Harvel LLC GF Harvel LXT® product bulletin (HPB-114).

Sample Specification:

UPW process piping and fittings shall be manufactured from a specialty low-extractable, Polyvinyl Chloride (PVC) compound with a Cell Classification of 12343 per ASTM D1784. All pipe and fittings shall be produced to Schedule 80 dimensions, manufactured in strict compliance to ASTM D1785 (pipe), and ASTM D2467 (fittings). These products shall carry a Type II pressure rating and consistently meet or exceed the applicable Quality Assurance test requirements of these standards with regard to dimensions, workmanship, burst pressure, flattening resistance and end product quality. All UPW process valves shall be True Union style diaphragm or True Union style quarter turn ball valves produced from the same low-extractable PVC compound. All valve diaphragms and seats shall be PTFE; valve o-rings shall be EPDM or Viton® as applicable. All valve union nuts shall have buttress style threads. All valve components shall be replaceable. System components shall be joined utilizing GF Harvel LXT® One-Step specialty solvent cement specifically formulated for joining the system. All system components shall be manufactured in the USA by an ISO certified manufacturer. All UPW piping shall be bagged and sealed immediately after manufacture to maintain cleanliness, boxed and stored indoors at the manufacturing facility until shipped from the factory. UPW process pipe, components and cement shall be that as provided by GF Georg Fischer Harvel LLC, trade name GF Harvel LXT®.

PVC Duct: Extruded Round

Application:

Corrosion resistant duct, IPS sizes 6" through 24", for use in corrosive fume handling systems at temperatures up to and including 140°F. Positive and negative pressure ratings vary with duct diameter and temperature as stated in Georg Fischer Harvel LLC PVC Duct product bulletin (bulletin HPB-109). Generally resistant to most acids, bases, salts, aliphatic solutions, oxidants, and halogens. Chemical resistance data is available and should be referenced for proper material selection. Typical applications include: chemical processing, plating, water and wastewater treatment, laboratory, and other industrial applications involving corrosive fume collection, transfer, and reclamation.

Scope:

This specification outlines minimum manufacturing requirements for Polyvinyl Chloride (PVC) iron pipe size (IPS) seamless, extruded round duct. This duct is intended for use in industrial fume handling systems where temperatures encountered do not exceed 140°F.

PVC Materials:

The material used in the manufacture of the duct shall be a virgin, rigid polyvinyl chloride (PVC) compound, with a Cell Classification of 12454 as defined in ASTM D1784. This compound shall be dark gray in color or as specified, and shall be domestically produced PVC material designated as GF Harvel H707 compound, PVC 1120.

Dimensions:

All PVC extruded duct shall be manufactured in strict accordance to the requirements established by Georg Fischer Harvel LLC for the production of extruded duct piping; including the physical dimensions and tolerances as stated on Page 2 of this specification.

Marking:

Product marking shall include the manufacturer's name (or the manufacturer's trademark when privately labeled); the nominal duct size; material designation; and the date of manufacture.

Sample Specification:

All exhaust duct piping, sizes 6" through 24", shall be PVC seamless extruded type, as manufactured by Harvel Plastics Inc. This duct pipe shall be extruded from a Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784, trade name H707 PVC. All extruded PVC duct shall have a maximum flame spread rating of 25 or less per ULC S102.2. All PVC extruded duct pipe shall meet Harvel Plastics Inc. published standards with regard to material and dimensions, and shall carry a maximum temperature rating of 140°F. All extruded duct pipe shall be manufactured in the USA, using domestic materials, by an ISO 9001 certified manufacturer, and shall be stored indoors at the manufacturing site until shipped from the factory. All extruded PVC duct pipe shall be marked with the manufacturer's name or identifying symbol.

General Recommendations

Joining

Thermal welding shall be performed by personnel adequately trained in the art of PVC welding utilizing the hot gas fusion welding method using virgin PVC filler welding rod as manufactured for this purpose.

When solvent cemented connections are utilized, the use of an extra heavy bodied PVC solvent cement and appropriate primer is recommended due to tolerance extremes that can be encountered when working with duct and fabricated duct fittings. Proper solvent cement joining procedures shall be followed.

Hangers and Supports

Hangers selected shall have an adequate load-bearing surface free of rough or sharp edges and shall not cause damage to the duct during use. Hangers and hanger hardware shall be of a corrosive-resistant material suitable for use in the system environment.

Ductwork is to be supported independently of hoods, scrubbers, fans, tanks or other equipment wherever possible. Where flexible connections are provided as expansion joints, a suitable hanger or support shall be provided at each end of the flexible connection. Consideration shall be given to the possibility of solids accumulation; adequate system support shall be provided where required.

Drains shall be installed where accumulation of moisture is expected at low points in the system as indicated on the drawings.

Handling and Storage

Care shall be used when transporting and storing duct to prevent physical distortion. Duct shall not be stored close to heat producing sources, subjected to external loads, or over stacked when stored. Damaged sections must be cut out and discarded.

System Components

All duct fittings, fume hoods, fans, blast gates and other system components shall be fabricated from PVC sheet or PVC duct material of the same wall thickness. The use of Type I Grade I (Cell Classification 12454 per ASTM D1784) PVC material is recommended to maintain system compatibility.

Reference Georg Fischer Harvel LLC Duct Bulletin HPB-109 and Product Bulletin 112/401 for information pertaining to chemical resistance, joining methods, hangers and supports, collapse pressure ratings, system components, and other installation related data.

The information provided herein is intended as a general guide based on common practice. This information may be considered as a basis for recommendation only, and not as a guarantee for its accuracy, suitability for particular applications, or the results to be obtained therefrom. Individual differences are a matter of design preference and shop practice.

PVC Duct Physical Properties

PROPERTY	VALUE	TEST METHOD
Cell Classification	12454	ASTM D1784
Specific Gravity (g/cu.cm @73°F)	1.40 +/- .02	ASTM D792
Tensile Strength, psi @73°F	7,450	ASTM D638
Modulus of Elasticity, psi @ 73°F	420,000	ASTM D638
Izod Impact, notched ft-lbs/in @ 73°F	.75	ASTM D256
Coefficient of Linear Expansion (in/in/°F)	2.9×10^{-5}	ASTM D696
Flame Spread	0-25	ULC
Flammability	V-O	UL 94
Hardness, Rockwell	110-120	ASTM D785

PVC 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	0.18	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 Duct: Extruded Round

Application:

Seamless, corrosion resistant exhaust duct, IPS sizes 6" through 24", for use in corrosive fume handling systems at temperatures up to 200˚F. Duct exhibits excellent fire resistance and is classified for Surface Burning Characteristics (independently tested flame and smoke characteristics ULC S102.2 Duct; and FM 4910 Duct Material). Positive and negative pressure ratings vary with duct diameter and temperature as stated on page 2 of this specification. Offers exceptional physical properties, and is generally resistant to most: acids, bases, salts, aliphatic solutions, oxidants, and halogens. Chemical resistance data is available and should be referenced for proper material selection. Typical applications include: chemical processing, plating, clean rooms, water and wastewater treatment, laboratory, and other industrial and institutional applications involving corrosive fume collection, transfer, and reclamation.

Scope:

This specification outlines minimum manufacturing requirements for Chlorinated Polyvinyl Chloride (CPVC) iron pipe size (IPS) seamless, extruded round duct. This duct is intended for use in industrial fume handling systems where temperatures encountered do not exceed 200˚F.

CPVC Materials:

The material used in the manufacture of the duct shall be a virgin, rigid chlorinated polyvinyl chloride (CPVC) compound, with a Cell Classification of 23447 as defined in ASTM D1784. This compound shall be light gray in color, and shall be domestically produced CPVC material, specifically formulated for the manufacturing of CPVC duct, tradename Corzan® CPVC as provided by Lubrizol Advanced Materials. This material meets FM 4910 Clean Room Materials Flammability Test protocol as outlined on page 2 of this specification.

Dimensions:

All CPVC extruded duct shall be manufactured in strict accordance to the requirements established by Georg Fischer Harvel LLC for the production of extruded duct piping; including the physical dimensions and tolerances as stated on Page 2 of this specification.

Marking:

Product marking shall include: the manufacturers name (or the manufacturers trademark when privately labeled); the nominal duct size; the Corzan® material designation, date of manufacture, and the independent laboratory's label stating flammability characteristics where applicable.

Sample Specification:

All exhaust duct piping, sizes 6" through 24", shall be CPVC seamless extruded type, as manufactured by Harvel Plastics Inc.; trade name GF Harvel Duct. Exhaust duct shall be extruded from a Type IV, Grade I Chlorinated Polyvinyl Chloride (CPVC) compound with a Cell Classification of 23447 per ASTM D1784; trade name Corzan® CPVC. All extruded duct shall have a maximum flame spread rating of 5 or less and a maximum smoke generation of 25 or less per ULC S102.2. All extruded duct shall meet Harvel Plastics Inc. published standards with regard to material and dimensions, and shall carry a maximum temperature rating of 200˚F. All extruded duct pipe shall be manufactured in the USA, using domestic materials, by an ISO 9001 certified manufacturer, and shall be stored indoors at the manufacturing site until shipped from the factory. All extruded CPVC duct pipe shall be marked with the manufacturer name or identifying symbol, and the Corzan® CPVC material trademark.

CPVC 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

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

FIRE PERFORMANCE

Test Protocol	Standard Test Results	Test Method
Flammability Rating	V-0, 5VB, 5VA	UL-94
Flame Spread Index	<10	ASTM E162
Flame Spread	<25	ASTM E-84/UL 723
	<25	ULC
Smoke Generation	≤50	ASTM E-84/UL 723
	<50	ULC
Flash Ignition Temp.	900°F	
Average Time of Burning (sec.)	<5	ASTM D635
Average Extent of Burning (mm)	<10	
Burning Rate (in/min)	Self Extinguishing	
Softening Starts (approx.)	295°F	
Material Becomes Viscous	395°F	
Material Carbonizes	450°F	
Limiting Oxygen Index (LOI)	60	ASTM D2863
Clean Room Materials	FPI= 1.20	
Flammability Test	SDI = 0.09	FM 4910

General Recommendations

Joining

Thermal welding shall be performed by personnel adequately trained in the art of CPVC welding utilizing the hot gas fusion welding method using Corzan® CPVC filler welding rod as manufactured for this purpose.

When solvent cemented connections are utilized, the use of an extra heavy bodied CPVC solvent cement (such as IPS 729) and appropriate primer is recommended due to tolerance extremes that can be encountered when working with duct and fabricated duct fittings. Proper solvent cement joining procedures shall be followed.

Hangers and Supports

Hangers selected shall have an adequate load-bearing surface free of rough or sharp edges and shall not cause damage to the duct during use. Hangers and hanger hardware shall be of a corrosive resistant material suitable for use in the system environment.

Ductwork is to be supported independently of hoods, scrubbers, fans, tanks or other equipment wherever possible. Where flexible connections are provided as expansion joints a suitable hanger or support shall be provided at each end of the flexible connection. Consideration shall be given to the possibility of solids accumulation; adequate system support shall be provided where required.

Drains shall be installed where accumulation of moisture is expected at low points in the system as indicated on the drawings.

Handling and Storage

Care shall be used when transporting and storing duct to prevent physical distortion. Duct shall not be stored close to heat producing sources, subjected to external loads, or over stacked when stored. Damaged sections must be cut out and discarded.

System Components

All duct fittings, fume hoods, fans, blast gates and other system components shall be fabricated from Corzan® sheet or duct material of the same wall thickness to maintain system compatibility and integrity.

Reference Georg Fischer Harvel LLC CPVC Duct product bulletin (Bulletin HPB-106) for additional information pertaining to joining methods, hangers and supports, system components, and other installation related data.

Grooved-End – PVC Pipe

Application:

Corrosion resistant grooved-end PVC pipe in IPS sizes 2" through 24" is available as an option from the factory. Pressure rating varies with schedule, pipe size, temperature, and the selected groove style coupling for PVC pipe as stated in Georg Fischer Harvel LLC engineering bulletin (Product Bulletin 112/401) and the manufacturers' groove coupling product specifications. The maximum service temperature for PVC pipe is 140°F, consult the groove coupling manufacturer for temperature limitations of their couplings for use in PVC pipe applications. Groove style connections are used where GF Harvel PVC pipe is joined to alternate IPS piping materials, or where disassembly is a prime factor. This pipe is available from Georg Fischer Harvel LLC with grooved ends designed for use with Victaulic Style 75 or Style 77 or equivalent flexible style couplings. Harvel currently utilizes both the roll grooving method as well as the cut grooving method to provide grooved-end pipe. Only flexible style grooved couplings are recommended for use with Harvel grooved-end PVC pipe. Rigid style couplings are not recommended for use on plastic pipe as they provide a compressive/shear load that can result in failure.

Scope:

This specification outlines manufacturing requirements for Polyvinyl Chloride (PVC) Groove Style Connection iron pipe size (IPS) pressure pipe. This pipe is intended for use in applications to join PVC pipe to alternate IPS piping materials, or where disassembly is a prime factor. This pipe meets and or exceeds the industry standards and requirements as set forth by the American Society for Testing and Materials (ASTM), the National Sanitation Foundation (NSF International), and Victaulic Standard Roll and Square Cut Groove Specifications (IPS) Pipe.

PVC Materials:

The material used in the manufacture of the pipe shall be domestically produced rigid polyvinyl chloride (PVC) compound, Type I Grade I, with a Cell Classification of 12454 as defined in ASTM D1784, trade name designation H707 PVC. This compound shall be white or gray in color as specified, and shall be approved by NSF International for use with potable water (NSF Std 61).

Dimensions:

PVC Schedule [40, 80, 120] and PVC SDR series pipe fitted with a groove style connection shall be manufactured in strict accordance to the requirements of ASTM D1785 or ASTM D2241 as applicable for physical dimensions and tolerances. Each production run of pipe manufactured in compliance to the applicable standard, and shall also meet or exceed the test requirements for materials, workmanship, burst pressure, flattening, and extrusion quality defined in ASTM D1785 or ASTM D2241as applicable. The groove dimensions for PVC Schedule and PVC SDR series grooved-end pipe shall meet the dimensional specifications called-out on Page 2 of this specification.

Marking:

Product marking shall meet the requirements of ASTM D1785 for Schedule [40, 80, 120] pipe or ASTM D2241 for SDR Series Pipe as applicable and shall include: the manufacturer's name (or the manufacturer's trademark when privately labeled); the nominal pipe size; the material designation code; the pipe schedule and pressure rating for plain end pipe in psi for water @ 73°F; the ASTM designation D1785 or D2241 as applicable; the independent laboratory's seal of approval for potable water usage; and the date and time of manufacture.

Sample Specification:

All PVC Schedule and SDR series pipe shall be manufactured from a Type I, Grade I Polyvinyl Chloride (PVC) compound with a Cell Classification of 12454 per ASTM D1784; trade name H707 PVC. The pipe shall be manufactured in strict compliance to ASTM D1785 or ASTM D2241 as applicable, consistently meeting and/or exceeding the Quality Assurance test requirements of this standard with regard to material, workmanship, burst pressure, flattening, and extrusion quality. The pipe shall be manufactured in the USA, using domestic materials, by an ISO 9001 certified manufacturer. The groove dimensions for grooved-end pipe shall meet GF Harvel's published roll groove or cut groove dimensional specifications as applicable. All pipe shall be stored indoors after production at the manufacturing site until shipped from factory. This pipe shall carry the National Sanitation Foundation (NSF) seal of approval for potable water applications. All pipe shall be manufactured by Georg Fischer Harvel LLC; No Equal.

Groove Style (roll or cut)

Size (in.)	SCH 40 SCH 26 SDR 21[1] SDR 41[2]	SCH 80 SCH 120[1]
2	ROLL	ROLL
2-1/2	ROLL	ROLL
3	ROLL	ROLL
4	ROLL	ROLL
6	ROLL	ROLL[4]
8	ROLL	ROLL[4]
10	ROLL	CUT
12	ROLL	CUT
14	ROLL[3]	CUT
16	ROLL[3]	CUT
18	CUT	CUT
16	ROLL	CUT
18	CUT	CUT
20	ROLL	CUT
24	ROLL	CUT

1: SDR 21 and Schedule 120 PVC grooved pipe is available in the size ranges 2" to 8".
2: SDR 41 PVC grooved pipe is available in the size ranges 18" to 24".
3: 14" and 16" SDR 26 must be cut grooved.
4: 6" and 8" Schedule 120 must be cut grooved.

Roll Groove Specifications (IPS)

Size (in.)	O.D.	A Gasket Seat +0.015, –0.030	B Groove Width +0.030, –0.015	C Groove Diameter Actual/Tolerance	D Nominal Groove Depth	T Minimum Allowable Pipe Wall
2	2.375	0.625	0.344	2.250 +0.000, –0.015	0.063	0.065
2-1/2	2.875	0.625	0.344	2.720 +0.000, –0.015	0.078	0.083
3	3.500	0.625	0.344	3.344 +0.000, –0.015	0.078	0.083
4	4.500	0.625	0.344	4.334 +0.000, –0.015	0.083	0.083
6	6.625	0.625	0.344	6.455 +0.000, –0.015	0.085	0.109
8	8.625	0.750	0.469	8.441 +0.000, –0.020	0.092	0.109
10	10.750	0.750	0.469	10.562 +0.000, –0.025	0.094	0.134
12	12.750	0.750	0.469	12.531 +0.000, –0.025	0.109	0.156
14	14.000	0.938	0.469	13.781 +0.000, –0.025	0.109	0.156
16	16.000	0.938	0.469	15.781 +0.000, –0.025	0.109	0.165

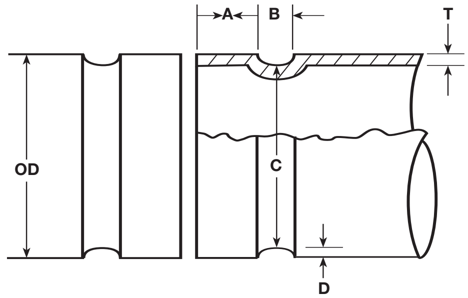
Cut Groove Specifications (IPS)

Size (in.)	O.D.	A Gasket Seat ±0.031	B Groove Width ±0.031	C Groove Diameter Actual/Tolerance	D Nominal Groove Depth	T Minimum Allowable Pipe Wall
14	14.000	0.938	0.500	13.781 +0.000, –0.030	0.109	0.281
16	16.000	0.938	0.500	15.781 +0.000, –0.030	0.109	0.312
18	18.000	1.000	0.500	17.781 +0.000, –0.030	0.109	0.312
20	20.000	1.000	0.500	19.781 +0.000, –0.030	0.109	0.312
24	24.000	1.000	0.344	23.656 +0.000, –0.030	0.172	0.375

Specifications applicable to Schedule 40, 80, and 120 PVC piping are described in ASTM D1785
Specifications applicable to SDR 21, 26, and 41 PVC piping are described in ASTM D2241

NOTE Temperature and Pressure ratings and limitations are dependant on the grooved coupling manufacturer's specifications.

NOTE 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. Georg Fischer Harvel LLC. suggests verifying the suitability for use of the selected lubricant with the lubricant manufacturer prior to use.



Additional chemical resistance data should be referenced for proper material selection and possible de-rating when working with fluids other than water. Refer to GF Harvel 112/401 Product Bulletin for chemical resistance, installation data, and additional information.

ASTM STANDARD D1784 MATERIAL EQUIVALENTS:
Cell Classification 12454 = PVC Type I Grade I = PVC1120

Design Properties of Pipe

The data in the following tables can be used by piping designers and the engineering community to calculate a variety of factors related to GF Harvel piping such as: working pressures, bending stresses for line expansion, weight loading, axial loads, capacity, support spacing, and other pertinent design related information. The weights shown are higher than minimum weights, as GF Harvel piping products are produced at or near the average wall thickness dimensions per applicable industry standards; not minimum wall thickness dimensions as some other products may be.

Symbols and Units:

D = outside diameter of pipe, inches

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

t = minimum wall thickness, inches

$A_O = \frac{D \times \pi}{12}$ = outside pipe surface, sq. ft per ft. length

$A_1 = \frac{d \times \pi}{12}$ = inside surface, sq. ft. per ft. length

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

$A_f = \frac{d^2 \times \pi}{4}$ = cross sectional flow area, sq.in.

$W_{pvc} = .632 \times A$ = weight of pipe, lb. per ft. length

$W_{cpvc} = .705 \times A$ = weight of pipe, lb. per ft. length

$W_w = 0.433\ A_f$ = weight of water filling, lb. per ft. length

$r_g = \sqrt{\frac{I}{A}} = \frac{\sqrt{D^4 + d^4}}{4}$ = radius of gyration, inches

$I = Ar_g^2 = .0491\ (D^4 - d^4)$ = moment of inertia, inches fourth

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

$W_{wfp} = W_{pvc}(\text{or } W_{cpvc}) + W_w$ = weight of water filled pipe, lb. per ft. length

$V_G = V \times 0.004329$ = Volume capacity, gallons per ft. length

$V = 0.7854 \times d^2 \times 12$ = Volume capacity, cubic inches per ft. length

SCH 40 PVC

Nominal Size (in.)	D	d	t	d_5	A_o	A_1	A	A_f	Wpvc	Ww	rg	I	Z	Wwfp	V	V_G	Wall Tol.
1/8	0.405	0.249	0.068	0.00096	0.106	0.065	0.080	0.049	0.051	0.021	0.119	0.001	0.006	0.072	0.584347	.003	.020
1/4	0.540	0.344	0.088	0.00482	0.141	0.090	0.136	0.093	0.086	0.040	0.160	0.003	0.013	0.126	1.115293	.005	.020
3/8	0.675	0.473	0.091	0.02368	0.177	0.124	0.182	0.176	0.115	0.076	0.206	0.008	0.023	0.191	2.108601	.009	.020
1/2	0.840	0.602	0.109	0.07906	0.220	0.158	0.270	0.285	0.170	0.123	0.258	0.018	0.043	0.294	3.415585	.015	.020
3/4	1.050	0.804	0.113	0.33595	0.275	0.211	0.358	0.508	0.226	0.220	0.331	0.039	0.075	0.446	6.092342	.026	.020
1	1.315	1.029	0.133	1.154	0.344	0.270	0.527	0.832	0.333	0.360	0.417	0.092	0.140	0.693	9.979365	.043	.020
1-1/4	1.660	1.360	0.140	4.653	0.435	0.356	0.712	1.453	0.450	0.629	0.536	0.205	0.247	1.079	17.43211	.075	.020
1-1/2	1.900	1.590	0.145	10	0.498	0.416	0.850	1.986	0.537	0.860	0.619	0.326	0.343	1.397	23.82684	.103	.020
2	2.375	2.047	0.154	36	0.622	0.536	1.140	3.292	0.720	1.426	0.784	0.700	0.590	2.146	39.49188	.171	.020
2-1/2	2.875	2.445	0.203	87	0.753	0.640	1.797	4.697	1.136	2.034	0.944	1.600	1.113	3.170	56.34169	.244	.024
3	3.500	3.042	0.216	260	0.917	0.797	2.354	7.271	1.488	3.148	1.159	3.164	1.808	4.636	87.21487	.378	.026
3-1/2	4.000	3.521	0.226	541	1.048	0.922	2.831	9.741	1.789	4.218	1.332	5.024	2.512	6.007	116.8434	.506	.027
4	4.500	3.998	0.237	1021	1.179	1.047	3.352	12.559	2.118	5.438	1.505	7.591	3.374	7.556	150.646	.652	.028
5	5.563	5.016	0.258	3175	1.457	1.314	4.547	19.769	2.874	8.560	1.873	15.944	5.732	11.433	237.1304	1.027	.031
6	6.625	6.031	0.280	7979	1.735	1.580	5.907	28.579	3.733	12.375	2.240	29.631	8.945	16.108	342.8079	1.484	.034
8	8.625	7.942	0.322	31597	2.259	2.080	8.891	49.559	5.619	21.459	2.931	76.384	17.712	27.078	594.4727	2.573	.039
10	10.750	9.976	0.365	98806	2.815	2.613	12.604	78.195	7.966	33.858	3.666	169.437	31.523	41.824	937.9615	4.060	.044
12	12.750	11.889	0.406	237534	3.339	3.114	16.668	111.059	10.534	48.089	4.358	316.604	49.663	58.623	1332.18	5.767	.049
14	14.000	13.073	0.437	381836	3.667	3.424	19.719	134.281	12.462	58.144	4.789	452.181	64.597	70.606	1610.73	6.973	.053
16	16.000	14.940	0.500	744309	4.190	3.913	25.769	175.374	16.286	75.937	5.473	771.775	96.472	92.223	2103.649	9.107	.060
18	18.000	16.809	0.562	1341867	4.714	4.402	32.574	221.998	20.587	96.125	6.157	1234.836	137.204	116.712	2662.906	11.528	.067
20	20.000	18.743	0.593	2313106	5.238	4.909	38.264	276.021	24.183	119.517	6.852	1796.746	179.675	143.700	3310.933	14.333	.071
24	24.000	22.544	0.687	5823108	6.286	5.904	53.246	399.325	33.652	172.908	8.232	3608.211	300.684	206.559	4789.984	20.736	.082

D = outside diameter of pipe, inches

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

t = minimum wall thickness, inches

$A_o = \frac{D \times \pi}{12}$ = outside pipe surface, sq. ft per ft. length

$A_1 = \frac{d \times \pi}{12}$ = inside surface, sq. ft. per ft. length

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

$A_f = \frac{d^2 \times \pi}{4}$ = cross sectional flow area, sq.in.

$W_{pvc} = .632 \times A$ = weight of pipe, lb. per ft. length

$W_{cpvc} = .705 \times A$ = weight of pipe, lb. per ft. length

$W_w = 0.433\ A_f$ = weight of water filling, lb. per ft. length

$r_g = \sqrt{\frac{I}{A}} = \sqrt{\frac{D^4 + d^4}{4}}$ = radius of gyration, inches

$I = Ar_g^2 = .0491\ (D^4 - d^4)$ = moment of inertia, inches fourth

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

$W_{wfp} = W_{pvc}(\text{or } W_{cpvc}) + W_w$ = weight of water filled pipe, lb. per ft. length

$V_G = V \times 0.004329$ = Volume capacity, gallons per ft. length

$V = 0.7854 \times d^2 \times 12$ = Volume capacity, cubic inches per ft. length

Design Properties of Pipe - Schedule 80 PVC

SCH 80 PVC

Nominal Size (in.)	D	d	t	d_5	A_o	A_1	A	A_f	Wpvc	Ww	r_g	I	Z	Wwfp	V	V_G	Wall Tol.
1/8	0.405	0.195	0.095	0.00028	0.106	0.051	0.099	0.030	0.063	0.013	0.112	0.001	0.006	0.076	0.358378	.002	.020
1/4	0.540	0.282	0.119	0.00178	0.141	0.074	0.167	0.062	0.105	0.027	0.152	0.004	0.014	0.132	0.749498	.003	.020
3/8	0.675	0.403	0.126	0.01063	0.177	0.106	0.230	0.128	0.146	0.055	0.197	0.009	0.026	0.201	1.530672	.007	.020
1/2	0.840	0.526	0.147	0.04027	0.220	0.138	0.337	0.217	0.213	0.094	0.248	0.021	0.049	0.307	2.607616	.011	.020
3/4	1.050	0.722	0.154	0.19619	0.275	0.189	0.457	0.410	0.289	0.177	0.319	0.046	0.088	0.466	4.912997	.021	.020
1	1.315	0.936	0.179	0.71842	0.344	0.245	0.670	0.688	0.424	0.298	0.404	0.109	0.166	0.722	8.25703	.036	.021
1-1/4	1.660	1.255	0.191	3.113	0.435	0.329	0.928	1.238	0.586	0.536	0.520	0.251	0.302	1.122	14.8443	.064	.023
1-1/2	1.900	1.476	0.200	7.005	0.498	0.387	1.125	1.712	0.711	0.741	0.601	0.407	0.428	1.452	20.53264	.089	.024
2	2.375	1.913	0.218	26	0.622	0.501	1.557	2.875	0.984	1.245	0.762	0.905	0.762	2.229	34.49071	.149	.026
2-1/2	2.875	2.290	0.276	63	0.753	0.600	2.374	4.120	1.500	1.784	0.919	2.005	1.394	3.285	49.42459	.214	.033
3	3.500	2.864	0.300	193	0.917	0.750	3.180	6.445	2.010	2.791	1.131	4.065	2.323	4.800	77.30688	.335	.036
3-1/2	4.000	3.326	0.318	407	1.048	0.871	3.880	8.692	2.452	3.764	1.301	6.562	3.281	6.215	104.2597	.451	.038
4	4.500	3.786	0.337	778	1.179	0.992	4.648	11.262	2.938	4.877	1.470	10.048	4.466	7.814	135.0932	.585	.040
5	5.563	4.768	0.375	2464	1.457	1.249	6.453	17.862	4.078	7.734	1.832	21.651	7.784	11.813	214.2617	.928	.045
6	6.625	5.709	0.432	6065	1.735	1.495	8.877	25.609	5.610	11.088	2.186	42.434	12.810	16.699	307.1795	1.330	.052
8	8.625	7.565	0.500	24777	2.259	1.981	13.484	44.966	8.522	19.470	2.868	110.922	25.721	27.992	539.374	2.335	.060
10	10.750	9.493	0.593	77093	2.815	2.486	19.993	70.806	12.635	30.659	3.585	257.008	47.815	43.295	849.3352	3.677	.071
12	12.750	11.294	0.687	183755	3.339	2.958	27.506	100.221	17.384	43.396	4.258	498.753	78.236	60.780	1202.175	5.204	.082
14	14.000	12.410	0.750	294347	3.667	3.250	32.994	121.006	20.852	52.396	4.677	721.752	103.107	73.248	1451.496	6.284	.090
16	16.000	14.213	0.843	580001	4.190	3.722	42.421	158.722	26.810	68.726	5.350	1214.332	151.791	95.537	1903.898	8.242	.101
18	18.000	16.014	0.937	1053172	4.714	4.194	53.076	201.495	33.544	87.247	6.023	1925.507	213.945	120.792	2416.973	10.463	.112
20	20.000	17.814	1.031	1793937	5.238	4.666	64.948	249.337	41.047	107.963	6.696	2911.868	291.187	149.010	2990.853	12.947	.124
24	24.000	21.418	1.218	4507073	6.286	5.609	92.140	360.431	58.233	156.067	8.042	5958.765	496.564	214.299	4323.445	18.716	.146

D = outside diameter of pipe, inches

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

t = minimum wall thickness, inches

$A_o = \frac{D \times \pi}{12}$ = outside pipe surface, sq. ft per ft. length

$A_1 = \frac{d \times \pi}{12}$ = inside surface, sq. ft. per ft. length

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

$A_f = \frac{d^2 \times \pi}{4}$ = cross sectional flow area, sq.in.

$W_{pvc} = .632 \times A$ = weight of pipe, lb. per ft. length

$W_{cpvc} = .705 \times A$ = weight of pipe, lb. per ft. length

$W_w = 0.433\ A_f$ = weight of water filling, lb. per ft. length

$r_g = \sqrt{\frac{I}{A}} = \sqrt{\frac{D^4 + d^4}{4}}$ = radius of gyration, inches

$I = Ar_g^2 = .0491\ (D^4 - d^4)$ = moment of inertia, inches fourth

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

$W_{wfp} = W_{pvc}(\text{or } W_{cpvc}) + W_w$ = weight of water filled pipe, lb. per ft. length

$V_G = V \times 0.004329$ = Volume capacity, gallons per ft. length

$V = 0.7854 \times d^2 \times 12$ = Volume capacity, cubic inches per ft. length

SCH 120 PVC

Nominal Size (in.)	D	d	t	d_5	A_o	A_1	A	A_f	Wpvc	Ww	rg	I	Z	Wwfp	V	V_G	Wall Tol.
1/2	0.840	0.480	0.170	0.02548	0.220	0.126	0.373	0.181	0.236	0.078	0.242	0.022	0.052	0.314	2.171474	.009	.020
3/4	1.050	0.690	0.170	0.15640	0.275	0.181	0.492	0.374	0.311	0.162	0.314	0.049	0.092	0.473	4.487147	.019	.020
1	1.315	0.891	0.200	0.56155	0.344	0.233	0.735	0.624	0.464	0.270	0.397	0.116	0.176	0.735	7.48217	.032	.024
1-1/4	1.660	1.204	0.215	2.530	0.435	0.315	1.026	1.139	0.649	0.493	0.513	0.270	0.325	1.142	13.66234	.059	.026
1-1/2	1.900	1.423	0.225	5.835	0.498	0.373	1.245	1.591	0.787	0.689	0.593	0.439	0.462	1.476	19.08455	.083	.027
2	2.375	1.845	0.250	21	0.622	0.483	1.757	2.675	1.111	1.158	0.752	0.993	0.837	2.269	32.08225	.139	.030
2-1/2	2.875	2.239	0.300	56	0.753	0.586	2.556	3.939	1.615	1.706	0.911	2.121	1.475	3.321	47.24766	.205	.036
3	3.500	2.758	0.350	160	0.917	0.722	3.648	5.977	2.306	2.588	1.114	4.528	2.587	4.894	71.69034	.310	.042
4	4.500	3.574	0.437	583	1.179	0.936	5.874	10.036	3.713	4.346	1.437	12.125	5.389	8.058	120.3875	.521	.052
6	6.625	5.434	0.562	4738	1.735	1.423	11.285	23.201	7.132	10.046	2.142	51.782	15.632	17.178	278.2988	1.205	.067
8	8.625	7.189	0.718	19202	2.259	1.883	17.843	40.607	11.277	17.583	2.807	140.592	32.601	28.859	487.0899	2.109	.086

D = outside diameter of pipe, inches

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

t = minimum wall thickness, inches

$A_o = \frac{D \times \pi}{12}$ = outside pipe surface, sq. ft per ft. length

$A_1 = \frac{d \times \pi}{12}$ = inside surface, sq. ft. per ft. length

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

$A_f = \frac{d^2 \times \pi}{4}$ = cross sectional flow area, sq.in.

$W_{pvc} = .632 \times A$ = weight of pipe, lb. per ft. length

$W_{cpvc} = .705 \times A$ = weight of pipe, lb. per ft. length

$W_w = 0.433\ A_f$ = weight of water filling, lb. per ft. length

$r_g = \sqrt{\frac{I}{A}} = \sqrt{\frac{D^4 + d^4}{4}}$ = radius of gyration, inches

$I = Ar_g^2 = .0491\ (D^4 - d^4)$ = moment of inertia, inches fourth

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

$W_{wfp} = W_{pvc}(\text{or } W_{cpvc}) + W_w$ = weight of water filled pipe, lb. per ft. length

$V_G = V \times 0.004329$ = Volume capacity, gallons per ft. length

$V = 0.7854 \times d^2 \times 12$ = Volume capacity, cubic inches per ft. length

Design Properties of Pipe - SDR 31.5 & 21 PVC

SDR 13.5 PVC

Nominal Size (in.)	D	d	t	d_5	A_o	A_1	A	A_f	Wpvc	Ww	rg	I	Z	Wwfp	V	V_G	Wall Tol.
1/2	0.840	0.696	0.062	0.16332	0.220	0.182	0.174	0.381	0.110	0.165	0.273	0.013	0.031	0.275	4.565524	.020	.020

SDR 21 PVC

Nominal Size (in.)	D	d	t	d_5	A_o	A_1	A	A_f	Wpvc	Ww	rg	I	Z	Wwfp	V	V_G	Wall Tol.
3/4	1.050	0.910	0.060	0.62403	0.275	0.238	0.216	0.651	0.136	0.282	0.347	0.026	0.050	0.418	7.804677	.034	.020
1	1.315	1.169	0.063	2.183	0.344	0.306	0.285	1.074	0.180	0.465	0.440	0.055	0.084	0.645	12.87956	.056	.020
1-1/4	1.660	1.482	0.079	7.149	0.435	0.388	0.439	1.726	0.278	0.747	0.556	0.136	0.164	1.025	20.69991	.090	.020
1-1/2	1.900	1.700	0.090	14	0.498	0.445	0.566	2.271	0.358	0.983	0.637	0.230	0.242	1.341	27.23767	.118	.020
2	2.375	2.129	0.113	44	0.622	0.558	0.871	3.561	0.550	1.542	0.797	0.554	0.466	2.092	42.71923	.185	.020
2-1/2	2.875	2.581	0.137	115	0.753	0.676	1.260	5.234	0.797	2.266	0.966	1.176	0.818	3.063	62.78388	.272	.020
3	3.500	3.146	0.167	308	0.917	0.824	1.849	7.776	1.168	3.367	1.177	2.559	1.462	4.535	93.28022	.404	.020
3-1/2	4.000	3.597	0.190	602	1.048	0.942	2.406	10.166	1.520	4.402	1.345	4.351	2.175	5.922	121.9419	.528	.023
4	4.500	4.046	0.214	1084	1.179	1.060	3.048	12.862	1.927	5.569	1.513	6.977	3.101	7.496	154.2851	.668	.026
5	5.563	5.001	0.265	3128	1.457	1.310	4.665	19.651	2.948	8.509	1.870	16.314	5.865	11.457	235.7143	1.020	.032
6	6.625	5.955	0.316	7489	1.735	1.560	6.622	27.863	4.185	12.065	2.227	32.844	9.915	16.250	334.2225	1.447	.038
8	8.625	7.756	0.410	28067	2.259	2.031	11.185	47.265	7.069	20.466	2.900	94.054	21.810	27.535	566.9539	2.454	.049

D = outside diameter of pipe, inches

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

t = minimum wall thickness, inches

$A_o = \frac{D \times \pi}{12}$ = outside pipe surface, sq. ft per ft. length

$A_1 = \frac{d \times \pi}{12}$ = inside surface, sq. ft. per ft. length

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

$A_f = \frac{d^2 \times \pi}{4}$ = cross sectional flow area, sq.in.

$W_{pvc} = .632 \times A$ = weight of pipe, lb. per ft. length

$W_{cpvc} = .705 \times A$ = weight of pipe, lb. per ft. length

$W_w = 0.433\ A_f$ = weight of water filling, lb. per ft. length

$r_g = \sqrt{\frac{I}{A}} = \sqrt{\frac{D^4 + d^4}{4}}$ = radius of gyration, inches

$I = Ar_g^2 = .0491\ (D^4 - d^4)$ = moment of inertia, inches fourth

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

$W_{wfp} = W_{pvc}(\text{or } W_{cpvc}) + W_w$ = weight of water filled pipe, lb. per ft. length

$V_G = V \times 0.004329$ = Volume capacity, gallons per ft. length

$V = 0.7854 \times d^2 \times 12$ = Volume capacity, cubic inches per ft. length

SDR 26 PVC

Nominal Size (in.)	D	d	t	d_5	A_o	A_1	A	A_f	Wpvc	Ww	rg	I	Z	Wwfp	V	V_G	Wall Tol.
1	1.315	1.175	0.060	2.240	0.344	0.308	0.274	1.085	0.173	0.470	0.441	0.053	0.081	0.643	13.01211	.056	.020
1-1/4	1.660	1.512	0.064	7.902	0.435	0.396	0.369	1.796	0.233	0.778	0.561	0.116	0.140	1.011	21.54645	.093	.020
1-1/2	1.900	1.734	0.073	16	0.498	0.454	0.474	2.362	0.300	1.023	0.643	0.196	0.206	1.322	28.33807	.123	.020
2	2.375	2.173	0.091	48	0.622	0.569	0.722	3.710	0.456	1.606	0.805	0.468	0.394	2.063	44.50324	.193	.020
2-1/2	2.875	2.635	0.110	127	0.753	0.690	1.039	5.455	0.657	2.362	0.975	0.988	0.687	3.019	65.43851	.283	.020
3	3.500	3.210	0.135	341	0.917	0.841	1.529	8.096	0.966	3.506	1.187	2.155	1.232	4.472	97.11408	.420	.020
3-1/2	4.000	3.672	0.154	668	1.048	0.962	1.977	10.594	1.250	4.587	1.357	3.643	1.822	5.837	127.0801	.550	.020
4	4.500	4.134	0.173	1207	1.179	1.083	2.483	13.428	1.569	5.814	1.528	5.794	2.575	7.383	161.0694	.697	.020
5	5.563	5.108	0.214	3477	1.457	1.338	3.815	20.501	2.411	8.877	1.888	13.600	4.889	11.288	245.9087	1.065	.027
6	6.625	6.084	0.255	8336	1.735	1.593	5.402	29.083	3.414	12.593	2.249	27.317	8.247	16.007	348.8595	1.510	.031
8	8.625	7.921	0.332	31182	2.259	2.075	9.152	49.297	5.784	21.346	2.928	78.443	18.190	27.130	591.3331	2.560	.040
10	10.750	9.874	0.413	93857	2.815	2.586	14.195	76.604	8.971	33.169	3.649	189.025	35.168	42.141	918.8791	3.978	.050
12	12.750	11.711	0.490	220277	3.339	3.067	19.969	107.759	12.620	46.660	4.328	374.055	58.675	59.280	1292.588	5.596	.059
14	14.000	12.860	0.538	351726	3.667	3.368	24.059	129.941	15.205	56.265	4.752	543.399	77.628	71.470	1558.67	6.747	.064
16	16.000	14.696	0.615	685481	4.190	3.849	31.450	169.693	19.877	73.477	5.431	927.728	115.966	93.353	2035.497	8.812	.074
18	18.000	16.533	0.692	1235260	4.714	4.330	39.804	214.767	25.156	92.994	6.110	1486.041	165.116	118.150	2576.176	11.152	.083
20	20.000	18.370	0.769	2091923	5.238	4.811	49.141	265.145	31.057	114.808	6.789	2264.961	226.496	145.865	3180.464	13.768	.092
24	24.000	22.043	0.923	5204194	6.286	5.773	70.798	381.774	44.744	165.308	8.147	4698.727	391.561	210.052	4579.452	19.824	.111

SDR 41 PVC

Nominal Size (in.)	D	d	t	d_5	A_o	A_1	A	A_f	Wpvc	Ww	rg	I	Z	Wwfp	V	V_G	Wall Tol.
18	18.000	17.061	0.439	1445514	4.714	4.468	25.868	228.704	16.348	99.029	6.200	994.408	110.490	115.377	2743.349	11.876	.061
20	20.000	18.956	0.488	2447561	5.238	4.965	31.955	282.331	20.196	122.249	6.889	1516.527	151.653	142.445	3386.613	14.661	.068
24	24.000	22.748	0.585	6091386	6.286	5.958	45.987	406.585	29.064	176.051	8.267	3142.820	261.902	205.115	4877.065	21.113	.082

D = outside diameter of pipe, inches

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

t = minimum wall thickness, inches

$A_o = \frac{D \times \pi}{12}$ = outside pipe surface, sq. ft per ft. length

$A_1 = \frac{d \times \pi}{12}$ = inside surface, sq. ft. per ft. length

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

$A_f = \frac{d^2 \times \pi}{4}$ = cross sectional flow area, sq.in.

$W_{pvc} = .632 \times A$ = weight of pipe, lb. per ft. length

$W_{cpvc} = .705 \times A$ = weight of pipe, lb. per ft. length

$W_w = 0.433\ A_f$ = weight of water filling, lb. per ft. length

$r_g = \sqrt{\frac{I}{A}} = \sqrt{\frac{D^4 + d^4}{4}}$ = radius of gyration, inches

$I = Ar_g^2 = .0491\ (D^4 - d^4)$ = moment of inertia, inches fourth

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

$W_{wfp} = W_{pvc}(\text{or } W_{cpvc}) + W_w$ = weight of water filled pipe, lb. per ft. length

$V_G = V \times 0.004329$ = Volume capacity, gallons per ft. length

$V = 0.7854 \times d^2 \times 12$ = Volume capacity, cubic inches per ft. length

Design Properties of Pipe - Schedule 40 & 80 Clear PVC

SCH 40 Clear PVC

Nominal Size (in.)	D	d	t	d_5	A_o	A_1	A	A_f	Wpvc	Ww	r_g	I	Z	Wwfp	V	V_G	Wall Tol.
1/4	0.540	0.344	0.088	0.00482	0.141	0.090	0.136	0.093	0.086	0.040	0.160	0.003	0.013	0.126	1.115293	.005	.020
3/8	0.675	0.473	0.091	0.02368	0.177	0.124	0.182	0.176	0.115	0.076	0.206	0.008	0.023	0.191	2.108601	.009	.020
1/2	0.840	0.602	0.109	0.07906	0.220	0.158	0.270	0.285	0.170	0.123	0.258	0.018	0.043	0.294	3.415585	.015	.020
3/4	1.050	0.804	0.113	0.33595	0.275	0.211	0.358	0.508	0.226	0.220	0.331	0.039	0.075	0.446	6.092342	.026	.020
1	1.315	1.029	0.133	1.154	0.344	0.270	0.527	0.832	0.333	0.360	0.417	0.092	0.140	0.693	9.979365	.043	.020
1-1/4	1.660	1.360	0.140	4.653	0.435	0.356	0.712	1.453	0.450	0.629	0.536	0.205	0.247	1.079	17.43211	.075	.020
1-1/2	1.900	1.590	0.145	10	0.498	0.416	0.850	1.986	0.537	0.860	0.619	0.326	0.343	1.397	23.82684	.103	.020
2	2.375	2.047	0.154	36	0.622	0.536	1.140	3.292	0.720	1.426	0.784	0.700	0.590	2.146	39.49188	.171	.020
2-1/2	2.875	2.445	0.203	87	0.753	0.640	1.797	4.697	1.136	2.034	0.944	1.600	1.113	3.170	56.34169	.244	.024
3	3.500	3.042	0.216	260	0.917	0.797	2.354	7.271	1.488	3.148	1.159	3.164	1.808	4.636	87.21487	.378	.026
3-1/2	4.000	3.521	0.226	541	1.048	0.922	2.831	9.741	1.789	4.218	1.332	5.024	2.512	6.007	116.8434	.506	.027
4	4.500	3.998	0.237	1021	1.179	1.047	3.352	12.559	2.118	5.438	1.505	7.591	3.374	7.556	150.646	.652	.028
5	5.563	5.016	0.258	3175	1.457	1.314	4.547	19.769	2.874	8.560	1.873	15.944	5.732	11.433	237.130	1.027	.031
6	6.625	6.031	0.280	7979	1.735	1.580	5.907	28.579	3.733	12.375	2.240	29.631	8.945	16.108	342.8079	1.484	.034
8	8.625	7.942	0.322	31597	2.259	2.080	8.891	49.559	5.619	21.459	2.931	76.384	17.712	27.078	594.4727	2.573	.039
10	10.750	9.976	0.365	98806	2.815	2.613	12.604	78.195	7.966	33.858	3.666	169.437	31.523	41.824	937.9615	4.060	.044
12	12.750	11.889	0.406	237534	3.339	3.114	16.688	111.059	10.534	48.089	4.358	316.604	49.663	58.623	1332.18	5.767	.049

SCH 80 Clear PVC

Nominal Size (in.)	D	d	t	d_5	A_o	A_1	A	A_f	Wpvc	Ww	r_g	I	Z	Wwfp	V	V_G	Wall Tol.
1/4	0.540	0.282	0.119	0.00178	0.141	0.074	0.167	0.062	0.105	0.027	0.152	0.004	0.014	0.132	0.749498	.003	.020
3/8	0.675	0.403	0.126	0.01063	0.177	0.106	0.230	0.128	0.146	0.055	0.197	0.009	0.026	0.201	1.530672	.007	.020
1/2	0.840	0.526	0.147	0.04027	0.220	0.138	0.337	0.217	0.213	0.094	0.248	0.021	0.049	0.307	2.607616	.011	.020
3/4	1.050	0.722	0.154	0.19619	0.275	0.189	0.457	0.410	0.289	0.177	0.319	0.046	0.088	0.466	4.912997	.021	.020
1	1.315	0.936	0.179	0.71842	0.344	0.245	0.670	0.688	0.424	0.298	0.404	0.109	0.166	0.722	8.25703	.036	.021
1-1/4	1.660	1.255	0.191	3.113	0.435	0.329	0.928	1.238	0.586	0.536	0.520	0.251	0.302	1.122	14.8443	.064	.023
1-1/2	1.900	1.476	0.200	7.005	0.498	0.387	1.125	1.712	0.711	0.741	0.601	0.407	0.428	1.452	20.53264	.089	.024
2	2.375	1.913	0.218	26	0.622	0.501	1.557	2.875	0.984	1.245	0.762	0.905	0.762	2.229	34.49071	.149	.026
2-1/2	2.875	2.290	0.276	63	0.753	0.600	2.374	4.120	1.500	1.784	0.919	2.005	1.394	3.285	49.42459	.214	.033
3	3.500	2.864	0.300	193	0.917	0.750	3.180	6.445	2.010	2.791	1.131	4.065	2.323	4.800	77.30688	.335	.036
3-1/2	4.000	3.326	0.318	407	1.048	0.871	3.880	8.692	2.452	3.764	1.301	6.562	3.281	6.215	104.2597	.451	.038
4	4.500	3.786	0.337	778	1.179	0.992	4.648	11.262	2.938	4.877	1.470	10.048	4.466	7.814	135.0932	.585	.040
6	6.625	5.709	0.432	6065	1.735	1.495	8.877	25.609	5.610	11.088	2.186	42.434	12.810	16.699	307.1795	1.330	.052

D = outside diameter of pipe, inches

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

t = minimum wall thickness, inches

$A_o = \frac{D \times \pi}{12}$ = outside pipe surface, sq. ft per ft. length

$A_1 = \frac{d \times \pi}{12}$ = inside surface, sq. ft. per ft. length

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

$A_f = \frac{d^2 \times \pi}{4}$ = cross sectional flow area, sq.in.

$W_{pvc} = .632 \times A$ = weight of pipe, lb. per ft. length

$W_{cpvc} = .705 \times A$ = weight of pipe, lb. per ft. length

$W_w = 0.433\ A_f$ = weight of water filling, lb. per ft. length

$r_g = \sqrt{\frac{I}{A}} = \sqrt{\frac{D^4 + d^4}{4}}$ = radius of gyration, inches

$I = A r_g^2 = .0491\ (D^4 - d^4)$ = moment of inertia, inches fourth

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

$W_{wfp} = W_{pvc}(\text{or } W_{cpvc}) + W_w$ = weight of water filled pipe, lb. per ft. length

$V_G = V \times 0.004329$ = Volume capacity, gallons per ft. length

$V = 0.7854 \times d^2 \times 12$ = Volume capacity, cubic inches per ft. length

SCH 40 CPVC

NOMINAL Size (in.)	D	d	t	d_5	A_o	A_1	A	A_f	Wcpvc	Ww	rg	I	Z	Wwfp	V	V_G	Wall Tol.
1/4	0.540	0.344	0.088	0.00482	0.141	0.090	0.136	0.093	0.096	0.040	0.160	0.003	0.013	0.136	1.115293	.005	.020
3/8	0.675	0.473	0.091	0.02368	0.177	0.124	0.182	0.176	0.128	0.076	0.206	0.008	0.023	0.205	2.108601	.009	.020
1/2	0.840	0.602	0.109	0.07906	0.220	0.158	0.270	0.285	0.190	0.123	0.258	0.018	0.043	0.313	3.415585	.015	.020
3/4	1.050	0.804	0.113	0.33595	0.275	0.211	0.358	0.508	0.253	0.220	0.331	0.039	0.075	0.473	6.092342	.026	.020
1	1.315	1.029	0.133	1.154	0.344	0.270	0.527	0.832	0.371	0.360	0.417	0.092	0.140	0.732	9.979365	.043	.020
1-1/4	1.660	1.360	0.140	4.653	0.435	0.356	0.712	1.453	0.502	0.629	0.536	0.205	0.247	1.131	17.43211	.075	.020
1-1/2	1.900	1.590	0.145	10	0.498	0.416	0.850	1.986	0.599	0.860	0.619	0.326	0.343	1.459	23.82684	.103	.020
2	2.375	2.047	0.154	36	0.622	0.536	1.140	3.292	0.803	1.426	0.784	0.700	0.590	2.229	39.49188	.171	.020
2-1/2	2.875	2.445	0.203	87	0.753	0.640	1.797	4.697	1.267	2.034	0.944	1.600	1.113	3.301	56.34169	.244	.024
3	3.500	3.042	0.216	260	0.917	0.797	2.354	7.271	1.660	3.148	1.159	3.164	1.808	4.808	87.21487	.378	.026
3-1/2	4.000	3.521	0.226	541	1.048	0.922	2.831	9.741	1.996	4.218	1.332	5.024	2.512	6.213	116.8434	.506	.027
4	4.500	3.998	0.237	1021	1.179	1.047	3.352	12.559	2.363	5.438	1.505	7.591	3.374	7.801	150.646	.652	.028
5	5.563	5.016	0.258	3175	1.457	1.314	4.547	19.769	3.205	8.560	1.873	15.944	5.732	11.765	237.130	1.027	.031
6	6.625	6.031	0.280	7979	1.735	1.580	5.907	28.579	4.164	12.375	2.240	29.631	8.945	16.539	342.8079	1.484	.034
8	8.625	7.942	0.322	31597	2.259	2.080	8.891	49.559	6.268	21.459	2.931	76.384	17.712	27.727	594.4727	2.573	.039
10	10.750	9.976	0.365	98806	2.815	2.613	12.604	78.195	8.886	33.858	3.666	169.437	31.523	42.744	937.9615	4.060	.044
12	12.750	11.889	0.406	237534	3.339	3.114	16.668	111.059	11.751	48.089	4.358	316.604	49.663	59.840	1332.18	5.767	.049
14	14.000	13.072	0.437	381689	3.667	3.424	19.739	134.261	13.916	58.135	4.789	452.620	64.660	72.051	1610.483	6.972	.053
16	16.000	14.940	0.500	744309	4.190	3.913	25.769	175.374	18.167	75.937	5.473	771.775	96.472	94.104	2103.649	9.107	.060
18	18.000	16.809	0.562	1341867	4.714	4.402	32.574	221.998	22.965	96.125	6.157	1234.836	137.204	119.089	2662.906	11.528	.067
20	20.000	18.743	0.593	2313106	5.238	4.909	38.264	276.021	26.976	119.517	6.852	1796.746	179.675	146.949	3310.933	14.333	.071
24	24.000	22.544	0.687	5823108	6.286	5.904	53.246	399.325	37.539	172.908	8.232	3608.211	300.684	210.466	4789.984	20.736	.082

D = outside diameter of pipe, inches

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

t = minimum wall thickness, inches

$A_o = \frac{D \times \pi}{12}$ = outside pipe surface, sq. ft per ft. length

$A_1 = \frac{d \times \pi}{12}$ = inside surface, sq. ft. per ft. length

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

$A_f = \frac{d^2 \times \pi}{4}$ = cross sectional flow area, sq.in.

$W_{pvc} = .632 \times A$ = weight of pipe, lb. per ft. length

$W_{cpvc} = .705 \times A$ = weight of pipe, lb. per ft. length

$W_w = 0.433\ A_f$ = weight of water filling, lb. per ft. length

$r_g = \sqrt{\frac{I}{A}} = \sqrt{\frac{D^4 + d^4}{4}}$ = radius of gyration, inches

$I = Ar_g^2 = .0491\ (D^4 - d^4)$ = moment of inertia, inches fourth

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

$W_{wfp} = W_{pvc}(\text{or } W_{cpvc}) + W_w$ = weight of water filled pipe, lb. per ft. length

$V_G = V \times 0.004329$ = Volume capacity, gallons per ft. length

$V = 0.7854 \times d^2 \times 12$ = Volume capacity, cubic inches per ft. length

Design Properties of Pipe - Schedule 80 CPVC

SCH 80 CPVC

NOMINAL Size (in.)	D	d	t	d_5	A_o	A_1	A	A_f	Wcpvc	Ww	rg	I	Z	Wwfp	V	V_G	Wall Tol.
1/4	0.540	0.282	0.119	0.00178	0.141	0.074	0.167	0.062	0.117	0.027	0.152	0.004	0.014	0.145	0.749498	.003	.020
3/8	0.675	0.403	0.126	0.01063	0.177	0.106	0.230	0.128	0.162	0.055	0.197	0.009	0.026	0.218	1.530672	.007	.020
1/2	0.840	0.526	0.147	0.04027	0.220	0.138	0.337	0.217	0.238	0.094	0.248	0.021	0.049	0.332	2.607616	.011	.020
3/4	1.050	0.722	0.154	0.19619	0.275	0.189	0.457	0.410	0.322	0.177	0.319	0.046	0.088	0.499	4.912997	.021	.020
1	1.315	0.936	0.179	0.71842	0.344	0.245	0.670	0.688	0.473	0.298	0.404	0.109	0.166	0.771	8.25703	.036	.021
1-1/4	1.660	1.255	0.191	3.113	0.435	0.329	0.928	1.238	0.654	0.536	0.520	0.251	0.302	1.190	14.8443	.064	.023
1-1/2	1.900	1.476	0.200	7.005	0.498	0.387	1.125	1.712	0.793	0.741	0.601	0.407	0.428	1.534	20.53264	.089	.024
2	2.375	1.913	0.218	26	0.622	0.501	1.557	2.875	1.097	1.245	0.762	0.905	0.762	2.342	34.49071	.149	.026
2-1/2	2.875	2.290	0.276	63	0.753	0.600	2.374	4.120	1.674	1.784	0.919	2.005	1.394	3.458	49.42459	.214	.033
3	3.500	2.864	0.300	193	0.917	0.750	3.180	6.445	2.242	2.791	1.131	4.065	2.323	5.033	77.30688	.335	.036
3-1/2	4.000	3.326	0.318	407	1.048	0.871	3.880	8.692	2.735	3.764	1.301	6.562	3.281	6.499	104.2597	.451	.038
4	4.500	3.786	0.337	778	1.179	0.992	4.648	11.262	3.277	4.877	1.470	10.048	4.466	8.154	135.0932	.585	.040
5	5.563	4.768	0.375	2464	1.457	1.249	6.453	17.862	4.549	7.734	1.832	21.651	7.784	12.284	214.262	.928	.045
6	6.625	5.709	0.432	6065	1.735	1.495	8.877	25.609	6.258	11.088	2.186	42.434	12.810	17.347	307.1795	1.330	.052
8	8.625	7.565	0.500	24777	2.259	1.981	13.484	44.966	9.506	19.470	2.868	110.922	25.721	28.976	539.374	2.335	.060
10	10.750	9.493	0.593	77093	2.815	2.486	19.993	70.806	14.095	30.659	3.585	257.008	47.815	44.754	849.3352	3.677	.071
12	12.750	11.294	0.687	183755	3.339	2.958	27.506	100.221	19.392	43.396	4.258	498.753	78.236	62.788	1202.175	5.204	.082
14	14.000	12.410	0.750	294347	3.667	3.250	32.994	121.006	23.261	52.396	4.677	721.752	103.107	75.656	1451.496	6.284	.090
16	16.000	14.214	0.843	580205	4.190	3.723	42.399	158.744	29.891	68.736	5.350	1213.768	151.721	98.627	1904.166	8.243	.101
18	18.000	16.014	0.937	1053172	4.714	4.194	53.076	201.495	37.419	87.247	6.023	1925.507	213.945	124.666	2416.973	10.463	.112
20	20.000	17.814	1.031	1793937	5.238	4.666	64.948	249.337	45.789	107.963	6.696	2911.868	291.187	153.752	2990.853	12.947	.124
24	24.000	21.418	1.218	4507073	6.286	5.609	92.140	360.431	64.959	156.067	8.042	5958.765	496.564	221.026	4323.445	18.716	.146

D = outside diameter of pipe, inches

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

t = minimum wall thickness, inches

$A_o = \frac{D \times \pi}{12}$ = outside pipe surface, sq. ft per ft. length

$A_1 = \frac{d \times \pi}{12}$ = inside surface, sq. ft. per ft. length

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

$A_f = \frac{d^2 \times \pi}{4}$ = cross sectional flow area, sq.in.

$W_{pvc} = .632 \times A$ = weight of pipe, lb. per ft. length

$W_{cpvc} = .705 \times A$ = weight of pipe, lb. per ft. length

$W_w = 0.433\ A_f$ = weight of water filling, lb. per ft. length

$r_g = \sqrt{\frac{I}{A}} = \sqrt{\frac{D^4 + d^4}{4}}$ = radius of gyration, inches

$I = Ar_g^2 = .0491\ (D^4 - d^4)$ = moment of inertia, inches fourth

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

$W_{wfp} = W_{pvc}(\text{or } W_{cpvc}) + W_w$ = weight of water filled pipe, lb. per ft. length

$V_G = V \times 0.004329$ = Volume capacity, gallons per ft. length

$V = 0.7854 \times d^2 \times 12$ = Volume capacity, cubic inches per ft. length

Industry Standards & Test Methods

GF Harvel's 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 D1784	Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D1785	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120
ASTM D6263	Standard Specification for Extruded Bars Made From Rigid Poly (Vinyl Chloride) (PVC) and Chlorinated Poly (Vinyl Chloride) (CPVC)
ASTM D2464	Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2467	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D2241	Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure Rated Pipe (SDR Series)
ASTM F441	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
ASTM F442	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)
ASTM D2672	Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement
ASTM D2846	Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems
ASTM D2466	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D3139	Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D2665	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM F437	Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F438	Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40
ASTM F439	Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
ASTM F477	Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F480	Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), Schedule 40 and Schedule 80
ASTM F493	Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
ASTM F656	Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
ASTM F913	Standard Specification for Thermoplastic Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM D1866	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Schedule 40 Drainage and DWV Fabricated Fittings

ASTM STANDARD TEST METHODS

ASTM D1598	Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
ASTM D1599	Standard Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe & Fittings
ASTM D2837	Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials
ASTM D2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D2444	Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
ASTM D2564	Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D2152	Standard Test Method for Adequacy of Fusion by Acetone Immersion
ASTM D2122	Standard Test Method for Determining Dimensions of Thermoplastic Pipe & Fittings
ASTM F610	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 D2855	Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D2774	Standard Practice for Underground Installation of Thermoplastic Pressure Piping
ASTM D2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM F402	Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastics Pipe and Fittings
ASTM F690	Standard Practice for Underground Installation of Thermoplastic Pressure Piping Irrigation System
ASTM F1057	Standard Practice for Evaluating the Quality of Extruded Poly (Vinyl Chloride) (PVC) Pipe by the Heat Reversion Technique
ASTM F645	Standard Guide for Selection, Design, and Installation of Thermoplastic Water Pressure Systems

Industry Standards & Test Methods

TOXILOGICAL

NSF International NSF Standard 061	Drinking Water System Components - Health Effects
NSF International NSF Standard 14	Plastics Piping System Components and Related Materials
United States FDA Code of Federal Regulations	Title 21

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 E84	Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM D635	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
ASTM E162	Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source
ASTM D2863	Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)

OTHER

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

Symbols & Units

D = outside diameter of pipe, inches

d = inside diameter of pipe, inches (Average based on mean wall)
t = average wall thickness, inches
P = pressure, psi
S = stress, psi

Useful Formulas

$A_o = D \times \pi/12$ = outside pipe surface, sq. ft per ft. length

$A_1 = d \times \pi/12$ = inside surface, sq. ft. per ft. length

$A = (D^2 - d^2) \times \pi/4$ = cross-sectional plastic area, sq.in

$A_f = d^2 \times \pi/4$ = cross sectional flow area, sq.in.

$W_{pvc} = .632 \times A$ = weight of pipe, lb. per ft. length

$W_{cpvc} = .705 \times A$ = weight of pipe, lb. per ft. length

$W_w = 0.433\ A_f$ = weight of water filling, lb. Per ft. length

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

$I = Ar_g^2 = .0491\ (D^4 - d^4)$ = moment of inertia, inches fourth

$Z = 2I/D = 0.0982 \times (D^4 - d^4)/D$ = section modulus, inches cube

$W_{wfp} = W_{pvc}\ (\text{or } W_{cpvc}) + W_w$ = weight of water filled pipe, lb. per ft. length

Capacity

$V_G = V \times 0.004329$ = Volume capacity, gallons per ft. length

$V = 0.7854 \times d^2 \times 12$ = Volume capacity, cubic inches per ft. length

Pressure Rating

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

Circle

Circumference $= 2\pi R$

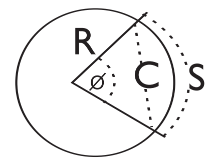
Area $= \pi R^2$

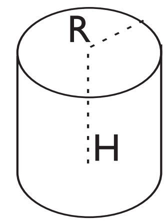
Length of Arc, $S = \text{Ø}\ R$

Length of Cord, $C = 2\ R \text{ sine } (\text{Ø} / 2)$

Area of Sector $= (R\ S) / 2$

Ø = Angle in Radians

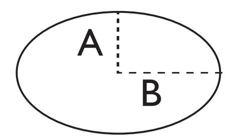




Cylinder

$V = \pi R^2 \times H$
$A = (2\pi R \times H) + (2\pi R^2)$

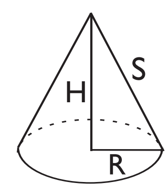
Ellipse



$A = \pi A \times B$

$C = \pi\sqrt{2(A^2 + B^2)}$

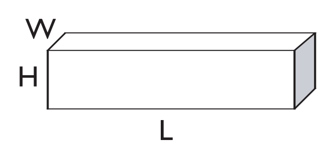
Cone



$A = \pi(R \times S) + \pi R^2$

$V = 1.047 \times R^2 \times H$

Rectangular Solid



$A = 2\ [W \times L + L \times H + H \times W]$

$V = W \times L \times H$

Conversion Factors

Length

	Equivalent					
Unit	**millimeters**	**inches**	**feet**	**meters**	**kilometers**	**miles**
millimeters	1	3.937×10^{-2}	3.281×10^{-3}	1×10^{-3}	1×10^{-6}	6.214×10^{-7}
inches	25.4	1	8.33×10^{-2}	2.54×10^{-2}	2.54×10^{-5}	1.578×10^{-5}
feet	304.8	12	1	0.3048	3.048×10^{-4}	1.894×10^{-4}
meters	1,000	39.37	3.281	1	1×10^{-3}	6.214×10^{-4}
kilometers	1×10^{6}	3.937×10^{4}	3,281	1,000	1	0.6214
miles	1.609×10^{6}	6.336×10^{4}	5,280	1,609	1.609	1

Useful Formulas

Area

Unit	Equivalent square inches	square feet	square meters	acres	square hectares	square kilometers	miles
square inches	1	6.944×10^{-3}	6.452×10^{-4}	1.594×10^{-8}	6.452×10^{-8}	6.452×10^{-10}	2.491×10^{-10}
square feet	144	1	9.29×10^{-2}	2.296×10^{-5}	9.29×10^{-9}	9.29×10^{-8}	3.587×10^{-8}
square meters	1,550	10.76	1	2.471×10^{-4}	1×10^{-4}	1×10^{-6}	3.861×10^{-7}
acres	6.273×10^{6}	4.356×10^{4}	4,047	1	0.4047	4.047×10^{-3}	1.563×10^{-3}
hectares	1.55×10^{7}	1.076×10^{5}	1×10^{4}	2.471	1	0.01	3.861×10^{-3}
square kilometers	1.55×10^{9}	1.076×10^{7}	1×10^{6}	247.1	100	1	0.3861
square miles	4.014×10^{9}	2.788×10^{7}	2.59×10^{6}	640	259	2.59	1

Volume

Unit	Equivalent cubic inches	liters	gallons	cubic feet	cubic yards	cubic meters	acre-ft
cubic inches	1	1.639×10^{-2}	4.329×10^{-3}	5.787×10^{-4}	2.143×10^{-5}	1.639×10^{-5}	1.329×10^{-8}
liters	61.02	1	0.2642	3.531×10^{-2}	1.308×10^{-3}	0.001	8.106×10^{-7}
gallons	231	3.785	1	0.1337	4.951×10^{-3}	3.785×10^{-3}	3.068×10^{-6}
cubic feet	1,728	28.32	7.481	1	3.704×10^{-2}	2.832×10^{-3}	2.296×10^{-5}
cubic yards	4.666×10^{4}	764.6	202	27	1	0.7646	6.198×10^{-4}
cubic meters	6.102×10^{4}	1,000	264.2	35.31	1.308	1	8.106×10^{-4}
acre-ft	7.527×10^{7}	1.233×10^{6}	3.259×10^{5}	4.356×10^{4}	1,613	1,233	1

Mass

Unit	Equivalent ounce	pound	kilogram	metric slug	slug	short ton	metric ton	long ton
ounce	1	6.25×10^{-2}	2.835×10^{-2}	2.891×10^{-3}	1.943×10^{-3}	3.125×10^{-5}	2.835×10^{-5}	2.79×10^{-5}
pound	16	1	0.4536	4.625×10^{-2}	3.108×10^{-2}	5×10^{-4}	4.536×10^{-4}	4.464×10^{-4}
kilogram	35.28	2.205	1	0.102	6.852×10^{-2}	1.102×10^{-3}	0.001	9.842×10^{-4}
metric slug	345.9	21.62	9.807	1	0.6721	92.51	9.807×10^{-4}	9.651×10^{-3}
slug	514.7	32.17	14.59	1.49	1	62.17	1.459×10^{-2}	1.436×10^{-2}
short ton	3.2×10^{4}	2,000	907.2	92.51	62.16	1	0.907	0.8929
metric ton	3.528×10^{4}	2,205	1,000	102	68.52	1.103	1	0.9842
long ton	3.584×10^{4}	2,240	1,016	103.7	69.63	1.12	1.016	1

Density

Unit	Equivalent pounds per cubic inch	pounds per cubic feet	pounds per gallon	grams per cubic centimeter	grams per liter
pounds per cubic inch	1	1,728	231	27.68	2.768×10^{4}
pounds per cubic feet	5.787×10^{-4}	1	0.1337	1.6×10^{-2}	16.02
pounds per gallon	4.33×10^{-3}	7.481	1	0.1198	119.8
grams per cubic centimeter	3.61×10^{-2}	62.43	8.345	1	1,000
grams per liter	3.61×10^{-5}	6.24×10^{-2}	8.35×10^{-3}	0.001	1

Force

Unit	Equivalent dyne	newton	poundforce	kilogramforce
dynes	1	1×10^{-5}	2.248×10^{-6}	1.02×10^{-6}
newtons	1×10^{5}	1	0.2248	0.102
poundforce	4.448×10^{5}	4.448	1	0.4536
kilogramforce	9.807×10^{5}	9.807	2.205	1

Useful Formulas

Energy

Unit	Equivalent: British thermal unit	foot-pound	horsepower-hour	joules	calorie	kilowatt_hour
British thermal unit	1	777.9	3.929×10^{-4}	1,055	252	2.93×10^{-4}
foot-pound	1.285×10^{-3}	1	5.051×10^{-7}	1.356	0.3239	3.766×10^{-7}
horsepower-hour	2,545	1.98×10^{6}	1	2.685×10^{6}	6.414×10^{5}	0.7457
joules	9.481×10^{-4}	0.7376	3.725×10^{-7}	1	0.2389	2.778×10^{-7}
calorie	3.968×10^{-3}	3.087	1.559×10^{-6}	4.186	1	1.163×10^{-6}
kilowatt-hour	3,413	2.655×10^{6}	1.341	3.6×10^{6}	8.601×10^{5}	1

Velocity

Unit	Equivalent: feet per day	kilometers per	hourfeet per second	miles per hour	meters per second
feet per day	1	1.27×10^{-5}	1.157×10^{-5}	7.891×10^{-6}	3.528×10^{-6}
kilometers per hour	7.874×10^{4}	1	0.9113	0.6214	0.2778
feet per second	8.64×10^{4}	1.097	1	0.6818	0.3048
miles per hour	1.267×10^{5}	1.609	1.467	1	0.447
meters per second	2.835×10^{5}	3.6	3.281	2.237	1

Discharge (flow rate, volume/time)

Unit	Equivalent: gallons per minute	liters per second	acre-feet per day	cubic feet per second	cubic meters per day
gallons per minute	1	6.309×10^{-2}	4.419×10^{-3}	2.228×10^{-3}	5.45
liters per second	15.85	1	7.005×10^{-2}	3.531×10^{-2}	86.4
acre-feet per day	226.3	14.28	1	0.5042	1,234
cubic feet per second	448.8	28.32	1.983	1	2,447
cubic meters per day	1.369×10^{9}	8.64×10^{7}	6.051×10^{6}	3.051×10^{6}	1

Pressure

Unit	Equivalent: lb. per square inch	lb. per square feet	atmos-pheres	kg. per square centimeter	kg. per square meter	inches of water (68°F)	feet of water (68°F)	inches of mercury (32°F)	mm. of mercury (32°F)	bars	kilo Pascals
pounds per square inch	1	144	6.805×10^{-2}	7.031×10^{-2}	703.1	27.73	2.311	2.036	51.72	6.895×10^{-2}	6.895
pounds per square feet	6.945×10^{-3}	1	4.73×10^{-4}	4.88×10^{-4}	4.882	0.1926	1.605×10^{-2}	1.414×10^{-2}	0.3591	4.79×10^{-4}	4.79×10^{-2}
atmospheres	14.7	2,116	1	1.033	1.033×10^{4}	407.5	33.96	29.92	760	1.013	101.3
kilograms per square cm.	14.22	2,048	0.9678	1	1×10^{4}	394.4	32.87	28.96	735.6	0.9807	98.07
kilograms per square meter	1.422×10^{-3}	0.2048	9.678×10^{-5}	0.001	1	3.944×10^{-2}	3.287×10^{-3}	2.896×10^{-3}	7.356×10^{-2}	9.807×10^{-5}	9.807×10^{-3}
inches of water (68°F)	3.609×10^{-2}	5.197	2.454×10^{-3}	2.53×10^{-3}	25.38	1	8.333×10^{-2}	7.343×10^{-2}	1.865	2.49×10^{-3}	0.249
feet of water (68°F)	0.4328	62.32	2.945×10^{-2}	3.043×10^{-2}	304.3	12	1	0.8812	22.38	2.984×10^{-2}	2.984
inches of mercury (32°F)	0.4912	70.73	3.342×10^{-2}	3.453×10^{-2}	345.3	13.62	1.135	1	25.4	3.386×10^{-2}	3.386
millimeters of mercury (32°)	1.934×10^{-2}	2.785	1.316×10^{-3}	1.36×10^{-3}	13.6	0.5362	4.468×10^{-2}	3.937×10^{-2}	1	1.333×10^{-3}	0.1333
bars	14.5	2,089	0.9869	1.02	1.02×10^{4}	402.2	33.51	29.53	750.1	1	100
kilo Pascals	0.145	20.89	9.869×10^{-3}	1.02×10^{-2}	102	4.022	0.3351	0.2953	7.501	0.01	1

Glossary

Words, Terms, & Phrases Used in the Plastic Industry

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

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.

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.

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

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.

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.

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

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

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.

COPOLYMER: The product of simultaneous polymerization of two or more polymerizeable 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.

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.

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.

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.

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

ESTER: A compound formed by the elimination of waste 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: Method of processing plastic in a continuous or extended form by forcing heat softened plastic through an opening shaped like the cross section of the finished product.

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.

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.

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.

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.

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.

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 kilograms 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.

Glossary

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.

POLYVINYL CHLORIDE: 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.

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 asses 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.

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.

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.

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.

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.

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.

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: Materials, which soften when, heated to normal processing temperatures without the occurrence of appreciable chemical change, but are quickly hardened by cooling. Unlike the thermosetting materials they can be reheated to soften, and retooled to "set", almost indefinitely; they may be formed and reformed many times by heat and pressure.

THERMOSETTING: 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. RO, DI, 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 agressive cleaning agent and is used in a variety of industries (semiconductor, pharmacuetical, 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.

VISCOSITY: Internal friction of a liquid because of its resistance to shear, agitation, or flow.

VOLATILE: Property of liquids to pass away by evaporation.

VOLUME RESISTIVITY: The electrical resistance of a 1 centimercube 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: Ability of a plastic to retain its original physical properties and appearance upon 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.

Testing

WARNING

Use of compressed air or gas in PVC/CPVC pipe and fittings can cause explosive failures resulting in system damage, severe bodily injury, or death.

Hydrostatic pressure testing (testing with water filled lines) is the only test method recommended and approved for pressure testing GF Harvel PVC and CPVC piping products. During pressure testing appropriate safety precautions must be taken to protect personnel and property from damage should a failure occur. The test pressure and duration of the pressure test performed should meet requirements of any local, state, or federal regulations as applicable. In the absence of any such requirements or regulations the following procedures can be used to properly conduct a hydrostatic pressure test on newly installed PVC and CPVC piping systems.

Strict adherence to proper solvent cementing instructions and set and cure times is essential to ensure the highest system integrity prior to pressure testing. Particular attention should be paid to pipe sizes, temperature at time of installation and any temperature variations over the set and cure period.

- All solvent-cemented connections in the system must be fully cured properly prior to filling the system with water.
- Pipe must be adequately anchored/restrained to prevent movement during testing.
- The system should not be tested until authorized and subsequently witnessed by the responsible engineer.
- Extreme care shall be used to ensure complete venting of all entrapped air when filling the system with water. Entrapped air is a major cause of excessive surge pressures that result in burst failures of rigid plastic piping systems.
- Air must be removed from the system to prevent it from being locked in the system when pressure is applied.
- The system should include the use of air release and air/vacuum relief valves located at high points in the system to vent air during filling, as well as during normal operation of the system.
- The system must be filled slowly with water, venting air from valves at piping run ends and at elevations during the filling process. Whether a hydraulic hand pump or available water line pressure is used, any slow build-up of gauge pressure or any rapidly fluctuating gauge needle on a completely liquid filled system is a strong indication that entrapped air is present within the system. Should this occur, pressure should be immediately released and the line re-bled. Failure to do so can lead to a catastrophic failure when the water column is suddenly accelerated by the rapidly decompressing air should a faulty joint separate or other failure occur.
- A maximum test pressure of 150% of the maximum stated system design operating pressure is considered satisfactory. The test pressure selected must not exceed the working pressure rating of the lowest pressure rated component in the system (i.e. threaded components, flanges, unions, valves etc.). Reduced test pressures must be used for any elevated temperature testing due to field conditions affecting temperatures. Appropriate temperature de-rating factors must be applied to determine a suitable test pressure at elevated temperatures (>73°F).
- A test period of two (2) hours is usually considered satisfactory to demonstrate the integrity of the system.
- If a leak is found the pressure must be relieved, the failed section cut-out, replaced, and allowed to cure properly prior to recharging and retesting the system.

GF Harvel recommends that large and/or complex systems be tested in segments as they are installed to permit evaluation and correction of improper installation techniques or other deficiencies as the project progresses. In buried applications the system should be hydrostatically tested prior to backfilling operations. During testing of buried lines, fittings and joints should be left exposed to aid in visual inspection for leakage. Sufficient earth cover should be placed over the pipe sections located between the fittings/joints to help prevent movement during testing. Any concrete anchors and/or thrust blocks must be allowed to cure completely prior to pressure testing.

WARNING

Compressed air or gases must never be used for testing of rigid PVC and CPVC piping systems (refer to Caution Areas section for additional information). Improper installation, especially poor workmanship in solvent cementing techniques, can lead to an abrupt release of tremendous stored energy in the presence of compressed air or gas. This abrupt release of energy creates a "whipping action" of the piping where shattering of pipe and fittings is then apt to occur at directional changes and at points where the system is rigidly restrained. This scenario creates a substantial safety hazard to personnel. In addition, secondary hairline stress fractures caused by this effect can also be initiated which will tend to propagate over time resulting in additional failures. It is also known that certain additives present in air compressor lubricants are not chemically compatible with PVC/CPVC materials and will initiate stress cracking of the plastic, further increasing the potential for additional failures. Refer to caution areas for additional information.

Safety & Cautions

Safety - MSDS

FINISHED PROFILE, BAR STOCK, DUCT, ANGLE, JOINING STRIP, and PIPE MADE FROM RIGID PVC and CPVC THERMOPLASTIC SECTION I

Manufacturer's Name: Georg Fischer Harvel LLC

Telephone Number: (610) 252-7355 FAX: (610) 253-4436

Address: PO. Box 757, Easton, PA 18044-0757

Chemical Family: Ethene, chloro-(homopolymer and chlorinated)

Formula: Mixture of PVC or CPVC polymer with functional additives.

TRADE DESIGNATION

Chemical Name/Synonyms: Polyvinyl chloride, PVC and chlorinated polyvinyl chloride CPVC.

NFPA 704[1]: Health: 2 / Flammability: 1 / Reactivity: 0 / Special: None

HMIS[2]: Health: 0 / Flammability: 1 / Reactivity: 0

Hazard Code Key: 0 = Insignificant; 1 = Slight; 2 = Moderate; 3 = High; 4 = Extreme, 1 National Fire Protection Association, 2 National Paint and Coatings Association.

SECTION II- HAZARDOUS INGREDIENTS

All ingredients are bound-up in the manufacturing process and are not expected to create any hazard in handling or use. Finished goods (e.g., rigid pipe, bar stock, duct, angle, joining strip, or profile) are inert.

SECTION III- PHYSICAL DATA (Typical data, not specifications)

Boiling Point: Not applicable (NA)

Melting Point: NA

Specific Gravity: (H_2O = 1) 1.35-1.55

Solubility in Water: Insoluble

% Volatile by Weight: NA

Vapor Density: (Air = 1) NA

Vapor Pressure: (mm Hg) NA

Particle Size: NA

pH: NA

Appearance and Odor: Rigid pipe, bar stock, duct, angle, joining strip, or profile. No odor.

SECTION IV-FIRE AND EXPLOSION HAZARD DATA

Flashpoint: Not applicable to solid products

Ignition Temperature:

PVC: >730°F (>388°C) CPVC: >830°F (>433°C)

Flammable Limits in Air: (% by volume) Lower: NA Upper: NA

Extinguishing Media: Water. ABC dry chemical. AFFF. Protein type air foams. Carbon Dioxide may be ineffective on larger fires due to a lack of cooling capacity, which may result in re-ignition.

Special Firefighting Procedure: Wear positive pressure self-contained breathing apparatus (SCBA). Personnel not having suitable respiratory protection must leave the area to prevent significant exposure to toxic combustion gases from any source. In enclosed or poorly ventilated areas, wear SCBA during cleanup immediately after a fire as well as during the attack phase of firefighting operations.

Unusual Fire and Explosion Hazards: None known.

SECTION V-HEALTH HAZARD DATA

Threshold Limit Value: None established.

Effects of Overexposure: There are no significant health hazards from vinyl compound at ambient temperature. Inhalation of decomposition or combustion products, especially hydrogen chloride, will cause irritation of the respiratory tract, eyes and skin. Depending on the severity of exposure, physiological response will be coughing, pain and inflammation. Individuals with bronchial asthma and other types of chronic obstructive respiratory diseases may develop bronchspasm if exposure is prolonged.

Emergency and First Aid Procedure: If irritation persists from exposure to decomposition products, remove the affected individual from the area. Provide protection before reentry.

SECTION VI-REACTIVITY DATA

Stability: Stable

Hazardous Polymerization: Will not occur.

Hazardous Decomposition Products: CO, CO_2, hydrogen chloride, and small amounts of benzene and aromatic and aliphatic hydrocarbons. CPVC may also contribute small amounts of chloroform and carbon tetrachloride.

Incompatibility (materials to avoid): Refer to GF Harvel Chemical Resistance Guide for chemical resistance information about GF Harvel thermoplastic pipe.

SECTION VII-SPILL OR LEAK PROCEDURE

Steps to be taken in case material is released or spilled: Material is inert. Place into a container for reuse or disposal.

Waste Disposal Method: Dispose of waste in accordance with federal, state and local regulations. For waste disposal purposes these products are not defined or designated as hazardous by current provisions of the Federal Resources Conservation and Recovery Act (RCRA) 40CFR261.

SECTION VIII-SPECIAL PROTECTION INFORMATION

Ventilation: Provide efficient exhaust at all operations capable of creating fumes or vapors. Cutting or sawing, machining, heat welding, thermoforming and other operations involving heat sufficient to result in degradation should be examined to ensure adequate ventilation.

Respiratory Protection: Not normally required. If overheating results in decomposition resulting in smoke or fumes, a NIOSH/MSHA approved combination high efficiency particulate filter with organic vapor cartridge can be used. Gross decomposition may require the use of a positive pressure self-contained breathing apparatus.

Protective Equipment: Wear safety glasses.

SECTION IX-SPECIAL PRECAUTIONS

Certain operations, such as the installation of piping systems, may require the use of solvent cements. The user must obtain and comply with all safety precautions recommended by solvent cement manufacturers. Avoid continued or prolonged breathing vapors produced by overheating.

SECTION X-TRANSPORTATION

For domestic transportation purposes, these pro-ducts are not defined or designated as a hazardous material by the U.S. Department of Transportation under Title 49 of the Code of Federal Regulations, 1983 Edition.

DOT Proper Shipping Name: Not applicable

DOT Hazard Class: Not hazardous

DOT Label: None required

UN/NA Hazard No.: Not applicable

Disclaimer of Liability

As the conditions or methods of use are beyond our control, we do not assume any responsibility and expressly disclaim any liability for any use of this material. Information contained herein is believed to be true and accurate but all statements or suggestions are made without warranty, expressed or implied, regarding accuracy of the information, the hazards connected with the use of the material or the results to be obtained from the use thereof. Compliance with all applicable federal, state and local laws and regulations remains the responsibility of the user.

General Safety Information

Thermoplastic piping is a general term applied to a variety of different plastics. A user of plastic piping should select the kind of plastic best suited for his use. Special care must be used to apply proper engineering, design and installation procedures.

GF Harvel recommends against the use of its thermoplastic piping systems for transport or storage of compressed air or gases. Entrapped air must be removed from liquid piping systems so that no air remains locked in the system when pressure is applied to the liquid. Excessive surge pressure must be avoided. Surge pressure can develop if liquid movement through the pipe is near maximum velocities and valves are closed abruptly. Maximum velocity is generally considered to be five feet per second.

Failures can occur at the joints connecting the pipe and the fittings. For example, threaded joints have a diminished wall thickness because of the cut of the thread into the wall. Also, improperly cemented joints will leave the strength of the joint impaired.

Temperature extremes, both hot and cold or changes in temperature can result in failures of plastic pipe in the following cases:

(1) Breakage or other damage on the job site in cold weather can be caused by impact with tools, vehicles or rocks.

(2) Heat of solution of chemicals or heat from other sources can cause failure because the piping systems will be distorted.

(3) Wide variations in temperature when the pipe is restrained as in concrete or is otherwise anchored can lead to cracking and breakage.

(4) Freezing of pipe contents when the line is full can lead to breakage.

(5) When heat is introduced by a pump especially when on recirculation, the pipe or joints can fail.

(6) Expansion and contraction can cause leakage or breaks at joints.

Crush strength of the plastic pipe and fittings should not be exceeded. Similarly, excessive suction or vacuum must be avoided. Since plastics are relatively soft they can be damaged using pipe wrenches on threaded connections. Pipe should not be used as a "ground" for electrical systems and conditions of "static electricity" should not be created through excessive friction. Welding or torch cutting operations near plastic pipe can cause damage to the pipe due to burning by sparks or overheating. High chromic acid solutions and high nitric acids can lead to stress cracking; also, when certain chemicals and solvents are absorbed into the pipe and fittings surfaces, a softness will develop in the plastic which can lead to weeping or rupture.

Proper trenching and backfilling procedures will provide a level and clean bed and will avoid impact and cutting from large or sharp rocks.

When using cement in making pipe joints, follow in detail the instructions in the solvent cement pamphlet.

SAFETY INFORMATION ON PRIMERS AND SOLVENTS

Over a period of 30 years, millions of solvent cemented joints have been made with only rare cases of mishap. However, since these products are flammable and contain chemical solvents, appropriate safety precautions should be taken.

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. Cement should be stored in closed containers at temperatures between 40˚F and 110˚F. They should be used only with adequate ventilation. In confined or partially enclosed areas, a ventilating device should be used to remove vapors and minimize their inhalation.

Respirators especially designed to minimize the inhalation of organic vapors can also be used, They are commercially available.

Containers should be kept tightly closed when not in use and covered as much as possible when in use. Use of an applicator can with applicator attached to a lid is especially recommended.

Avoid frequent contact with skin and eyes. May be absorbed through the skin. May cause eye injury. 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.

⚠ WARNING

USE CAUTION WITH WELDING TORCHES

At construction sites where plastic pipe is being installed or has recently been solvent welded, special caution should be taken where using welding torches or other equipment where sparks might be involved. Flammable vapors from cemented joints sometimes linger within or around a piping system for some time.

Special care must be taken when using a welding torch in these application:

- Well casing installations
- Installing pumps in irrigation water lines
- Installation of plastic pipe systems in industrial plants

In all cases, lines should be purged to remove solvent vapors before welding.

USE CAUTION WITH CALCIUM HYPOCHLORITE

WARNING Do not use a dry granular calcium hypochlorite as a disinfecting material for water purification in potable water piping systems. The introductions of granules or pellets of calcium hypochlorite with solvent cements and primers (including their vapors) may result in violent chemical reactions if a water solution is not used. It is advisable to purify lines by pumping chlorinated water into the piping system—this solution will be nonvolatile.

Furthermore, 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. People have learned they must be careful with gasoline. Although solvent cements are not as flammable as gasoline—users must learn to be careful. Again, accidents and injuries have seldom occurred in the use of our products. Help maintain and improve this excellent record by following the above recommendations.

USE OF COMPRESSED AIR OR GAS WITH HARVEL PVC/CPVC PIPING PRODUCTS

WARNING

The use of plastic piping in these types of devices can result in severe bodily injury or death.

GF Harvel's PVC and CPVC piping products are "rigid" thermoplastic materials. Georg Fischer Harvel LLC does not recommend the use of PVC or CPVC piping products for the testing, transport, or storage of compressed air or gases. The compressibility of air and/or other gases result in tremendous amounts of stored energy, even at lower pressures. Should a failure occur in a compressed air or gas system for any reason (i.e. improper assembly, mechanical damage etc.) the failure mode will be very dramatic in nature due to the physical characteristics of the rigid piping in combination with the immediate release of this stored energy. Under these conditions, the velocity created by rapidly escaping air and the resultant failure mode can throw shards of plastic in multiple directions (i.e. shrapnel/projectiles). This scenario creates a substantial hazard to personnel and property within the vicinity of the piping should a failure occur. Several cautionary statements and alerts against the use of rigid PVC/CPVC piping for use with compressed air or gases are available through the Plastic Pipe Institute (PPI), American Society for Testing and Materials (ASTM), various other trade organizations, manufacturers, safety codes, as well as several State and Federal Agencies (i.e. OSHA).

Compressed air or other gases should never be used in testing. Extreme care should be used to assure complete venting of all entrapped air when filling the system with water or other liquids used in testing. Whether a hydraulic hand pump or available water line pressure is used, any slow build-up of gauge pressure on a completely liquid filled line shows some entrapped air in the system. Pressure should be immediately released and the line re-bled. Failure to do this can lead to a catastrophic failure when the decompressing gas suddenly accelerates the solid water column if a faulty joint separates.

PVC and CPVC piping systems are not recommended for compressed air lines. Improper installation, especially poor cementing techniques can lead to an abrupt release of tremendous stored energy. Shattering of pipe and fittings is then apt to occur at directional changes and at points where the system is rigidly restrained due to the instantaneous whipping action imparted by the escaping air. Internal surface cracks, due to the stress, can be initiated which will tend to propagate and cause shattering, hairline or pinhole cracks over a period of time. There is also evidence that certain additives to system lubricants will initiate internal stress cracking which will again lead to similar failure over extended periods of time.

USE OF PLASTIC PIPE TO CONSTRUCT LAUNCHING DEVICES

⚠ WARNING

The use of plastic piping in these types of devices can result in severe bodily injury or death.

It has been brought to our attention that plastic piping products are being used to construct launching devices commonly known as "Spud Guns". Georg Fischer Harvel LLC does not recommend nor approve these or similar devices. Devices of this type are extremely dangerous regardless of the type of piping materials used to build them.

Georg Fischer Harvel LLC does not recommend the use of our PVC or CPVC piping products for the testing, transport, or storage of compressed air or gases. The compressibility of air and gas results in tremendous amounts of stored energy, even at lower pressures. Should a failure occur in a compressed air or gas system, the failure mode will be very dramatic in nature due to the physical characteristics of the rigid plastic piping in combination with the immediate release of this stored energy. Under these conditions, the velocity created by rapidly escaping air and the resultant failure mode can throw shards of plastic in multiple directions (i.e. projectiles). This scenario creates a substantial hazard to personnel and property within the vicinity of the piping should a failure occur. Several cautionary statements and alerts against the use of rigid PVC/CPVC piping for use with compressed air or gases are available through the Plastic Pipe Institute (PPI), American Society for Testing and Materials (ASTM), various manufacturers, safety codes, as well as several State and Federal Agencies (i.e. OSHA). It should also be noted that these types of devices are considered illegal by many State laws.

In addition to the obvious risk of bodily harm involved with the handling of flammable/explosive materials of combustion, plastic pipe utilized in this application is subject to failure for the following reasons:

- The failure mode of rigid thermoplastic piping under these use conditions will be very dramatic. The rapid release of the pressure build-up associated with the combustion gases can result in the instantaneous rupture of the pipe wall and/or attached components. This will result in shards of plastic (shrapnel) rapidly escaping at high velocity.
- Temperatures created as the result of the ignition of flammable substances can quickly exceed the thermal properties of the piping, thereby greatly reducing its physical properties and making it more susceptible to failure.
- Shock loads associated with the combustion of the flammable substance can quickly exceed the design capabilities of the plastic piping.
- The sudden pressure rise associated with combustion can quickly exceed the pressure bearing capacity of the piping.
- Chemical compatibility issues with certain flammable substances can cause stress cracking and premature failure of the plastic.

About GF Harvel Safety Alerts

Several varieties of safety alerts and related messages appear in this catalog. Please be sure you understand the meaning of the keywords that identify each type of alert.

⚠ WARNING

"WARNING" signifies hazards or unsafe practices that can cause severe personal injury or death if instructions, including recommended precautions, are not followed.

⚠ CAUTION

"CAUTION" signifies hazards or unsafe practices that can cause minor injury or product or property damage if instructions, including recommended precautions, are not followed.

! NOTE

Use of the word "NOTE" signifies important special instructions.

⚠ WARNING

Use of compressed air or gas in PVC/CPVC pipe and fittings can result in explosive failures and cause severe injury or death.

The data furnished herein is provided as a courtesy and is based on past experience, limited testing, and other information believed to be reliable. This information may be considered as a basis for recommendation only. No guarantee is made as to its accuracy, suitability for particular applications, or the results to be obtained therefrom. Materials should be tested under actual service conditions to determine suitability for a particular purpose.

A commitment to excellence.

In a world of constant technological change, outstanding PVC and CPVC pipe extrusions can only be produced by a company with unique skills. Technical mastery, persistent dedication and testing without compromise – these are the elements that make GF Harvel an international leader in thermoplastic extrusions.

Key to GF Harvel's technological advantage are superbly equipped on-site laboratories at each of two manufacturing plants. These innovative facilities are in the forefront of product development; they also evolve the most careful, vigilant standards of product testing.

This means constant checking and rechecking of the blended materials that go into GF Harvel products. It also means applying a range of tests to completed products – tough trials that prove excellence beyond a doubt.

From the start, GF Harvel has been devoted to the quality of its products. Its comprehensive quality program has always been based on the continuous improvement tools of Total Quality Management (TQM) and Statistical Process Control (SPC). GF Harvel was the first in its industry to achieve ISO 9001 quality certification. ISO certification represents just one more benchmark for GF Harvel products – known throughout the industry for reliable quality.

GF Harvel's original headquarters factory was built more than 40 years ago in Easton, Pennsylvania and has since expanded to encompass a quarter of a million square feet. In Bakersfield, California, the plant, warehouse and distribution center, serve the US West and Pacific Rim, affirming the company's position as a worldwide leader. Wherever produced, GF Harvel pipe and extrusions embody the highest standards of quality. Today continuous dedication to those standards reinforces GF Harvel's reputation as "The Quality Line".

+GF+

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PIPING SYSTEMS

HARVEL®

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