CORZAN™
INDUSTRIAL SYSTEMS

Table of Contents

**Information presented within this report is based on test data and field experience of CPVC manufactured by Noveon and is not intended to reflect the properties found with other suppliers of CPVC materials. To determine if your supplier is using Corzan CPVC, call the Corzan Marketing Department at 888-234-2436.

Noveon, Inc. / 9911 Brecksville Road, Cleveland, Ohio 44141-3247

December 2002

What is Corzan® CPVC?

Chlorinated polyvinyl chloride (CPVC) has become an important engineering thermoplastic due to its relatively low cost, high glass transition temperature, high heat distortion temperature, chemical inertness, and outstanding mechanical, dielectric, and flame and smoke properties. CPVC was first commercialized by Noveon in the early 1960s and has since proven its value in a variety of industrial applications in which a high use temperature and excellent resistance to corrosive chemicals are desirable. Besides pipe and fittings, many other industrial fluid-handling products are available in Corzan® CPVC including pumps, valves, strainers, filters, tower packing, and duct, as well as sheet for fabrication into storage tanks, fume scrubbers, large diameter duct, and tank lining.

Conceptually, CPVC is a PVC homopolymer that has been subjected to a chlorination reaction. Typically, chlorine and PVC react according to a basic free radical mechanism. This can be brought about by various approaches using thermal and/or UV energy for initiation of the reaction. A generalized mechanism for the free radical chlorination of PVC can be schematically represented as follows, where RH denotes PVC:

Initiation: $Cl_2 \xrightarrow[\text{UV Energy}]{\text{Heat}} 2Cl\bullet$

Propagation: $RH + Cl\bullet \longrightarrow R\bullet + HCl$

$R\bullet + Cl_2 \longrightarrow RCl + Cl\bullet$

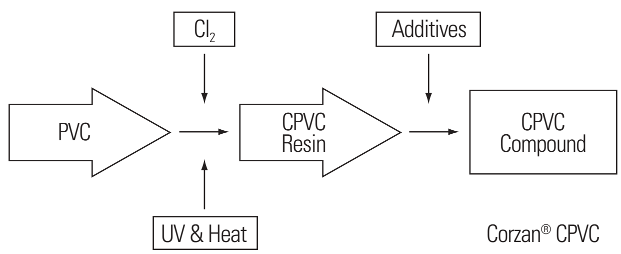
Termination: $R\bullet + Cl\bullet \longrightarrow RCl$

$Cl\bullet + Cl\bullet \longrightarrow Cl_2$

$R\bullet + R\bullet \longrightarrow R_2$

CPVC produced in such a manner can be quite varied structurally depending on the chlorination method, conditions, and the amount of chlorine reacted. The chlorine content of base PVC can be increased from 56.7 percent to as high as 74 percent, though typically most commercial CPVC resins have 63 to 69 percent chlorine. As the chlorine content in CPVC is increased, the glass transition temperature (T_g) of the polymer increases significantly. Also, as the molecular weight of base PVC is increased, there is a smaller proportionate increase in the T_g at an equivalent level of chlorine.

The CPVC resin manufactured from this free radical chlorination reaction is not processable without the addition of additives. These additives may include, but are not limited to, stabilizers (heat and UV), impact modifiers, pigments and lubricants. The quantity and combination of these additives enhances many of the CPVC resin's inherent properties, while easing its processability.



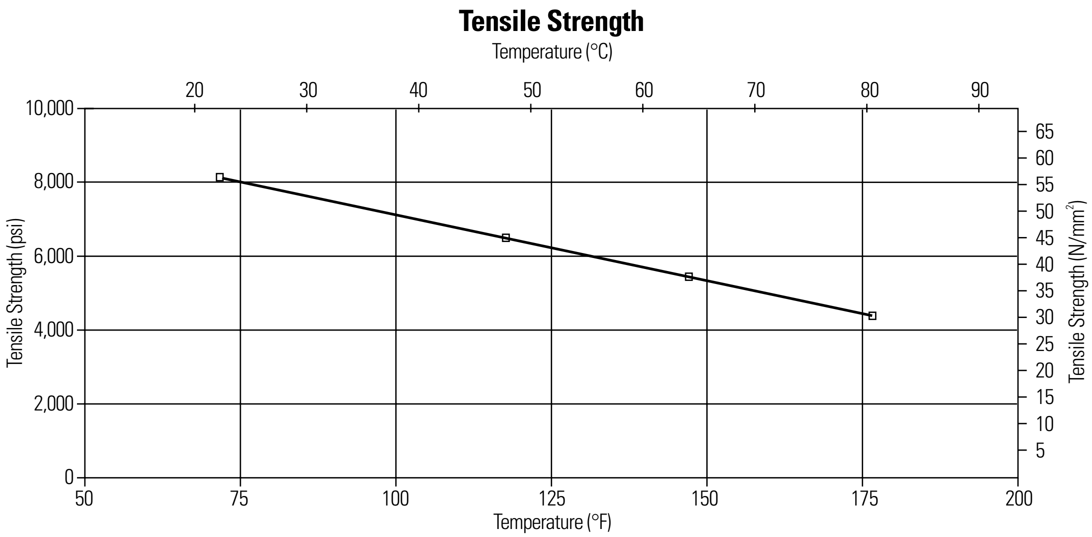
The family of these various compound formulations comprises Corzan® CPVC.

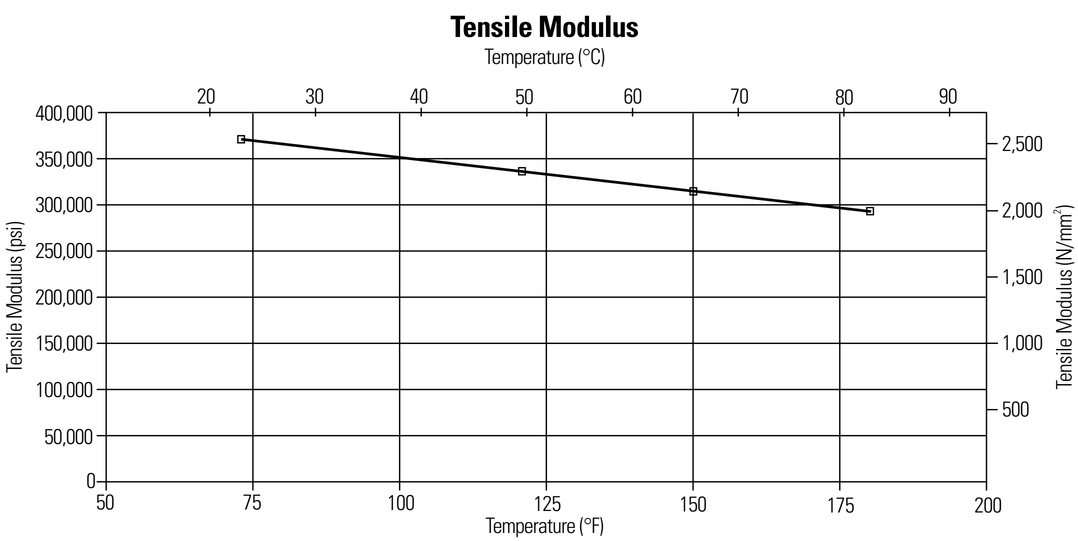
Basic Physical Properties

Property	Test	Condition	English Units	SI Units
GENERAL				
Specific Gravity	ASTM D792	73°F/23°C		1.55
Specific Volume		73°F/23°C	.0103 ft^3/lb	0.645 cm^3/g
Water Absorption	ASTM D570	73°F/23°C	+0.03%	+0.03%
		212°F/100°C	+0.55%	+0.55%
Rockwell Hardness	ASTM D785	73°F/23°C	119	
Cell class	ASTM D1784		23447	
MECHANICAL				
*Notched Izod Impact	ASTM D256	73°F/23°C	1.5 ft lb_f/in	80 J/m
*Tensile Strength	ASTM D638	73°F/23°C	8000 psi	55 N/mm^2
*Tensile Modulus	ASTM D638	73°F/23°C	360,000 psi	2500 N/mm^2
*Flexural Strength	ASTM D790	73°F/23°C	15,100 psi	104 N/mm^2
*Flexural Modulus	ASTM D790	73°F/23°C	415,000 psi	2860 N/mm^2
Compressive Strength	ASTM D695	73°F/23°C	10,100 psi	70 N/mm^2
Compressive Modulus	ASTM D695	73°F/23°C	196,000 psi	1350 N/mm^2
THERMAL				
Coefficient of Thermal Expansion	ASTM D696		$3.4x10^{-5}$ in/in/°F	$1.9x10^{-5}$ m/m/K
Thermal Conductivity	ASTM C177		0.95 BTU in/hr/ft^2/°F	0.066 Wm/K/m^2
Heat Distortion Temperature	ASTM D648		217°F	103°C
*Heat Capacity (Specific Heat)	DSC	73°F/23°C	0.21 BTU/lb_m °F	0.90 J/gK
		212°F/100°C	0.26 BTU/lb_m °F	1.10 J/gK
FLAMMABILITY				
Flammability Rating	UL 94	0.062 in/0.157 cm	V-O, 5VB, 5VA	
Flame Spread	ASTM E84		15	
Smoke Developed	ASTM E84		70-125	
Limiting Oxygen Index	ASTM D2863		60%	
ELECTRICAL				
Dielectric Strength	ASTM D147		1250 V/mil	492,000 V/cm
Dielectric Constant	ASTM D150	60 Hz, 30°F/-1°C	3.70	3.70
Power Factor	ASTM D150	1000 Hz	0.007%	0.007%
Volume Resistivity	ASTM D257	73°F/23°C	$3.4x10^{15}$ ohm/cm	$3.4x10^{15}$ ohm/cm

*Plots of these properties versus temperature follow this table.

Basic Physical Properties (cont.)





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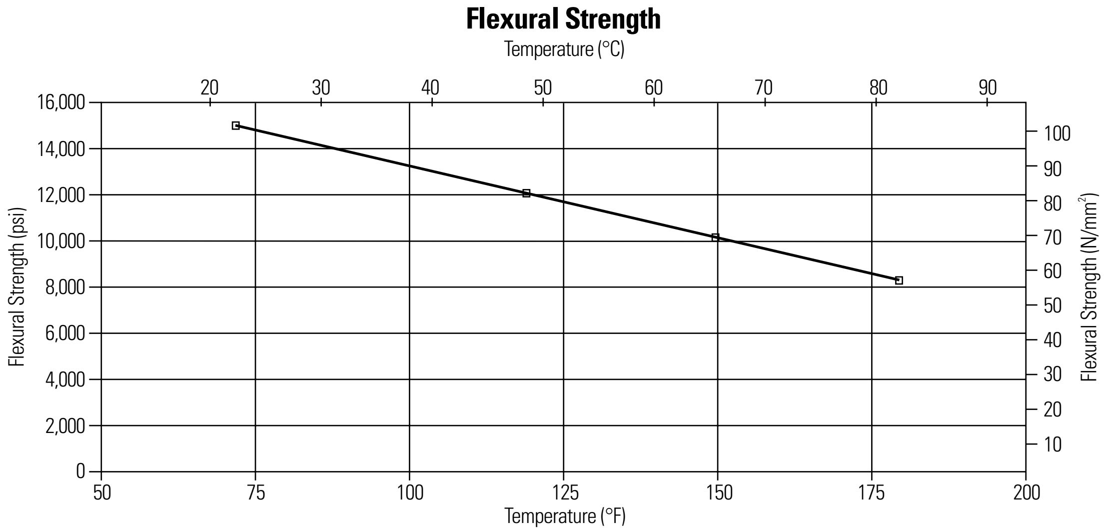
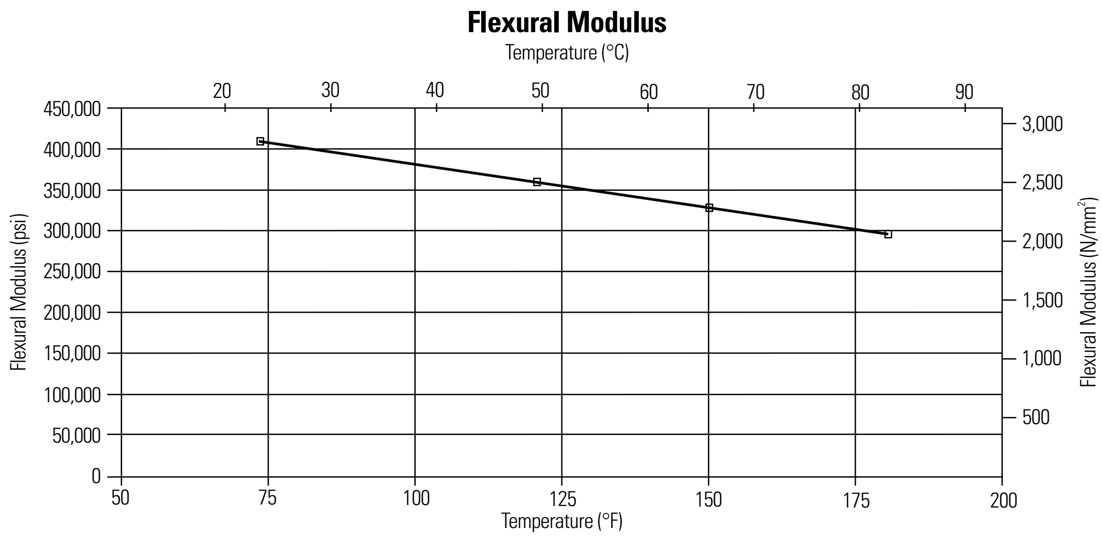
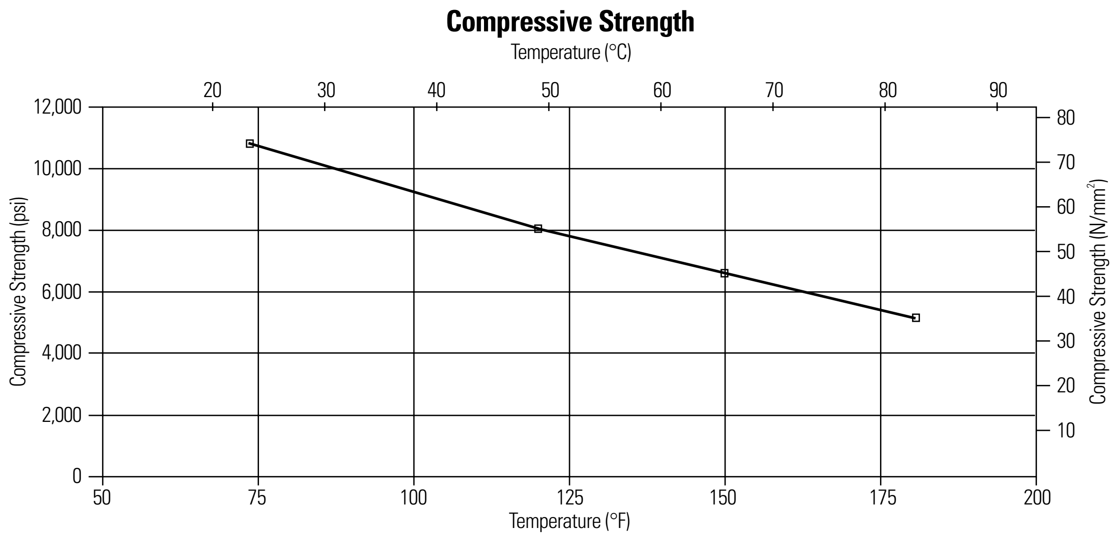
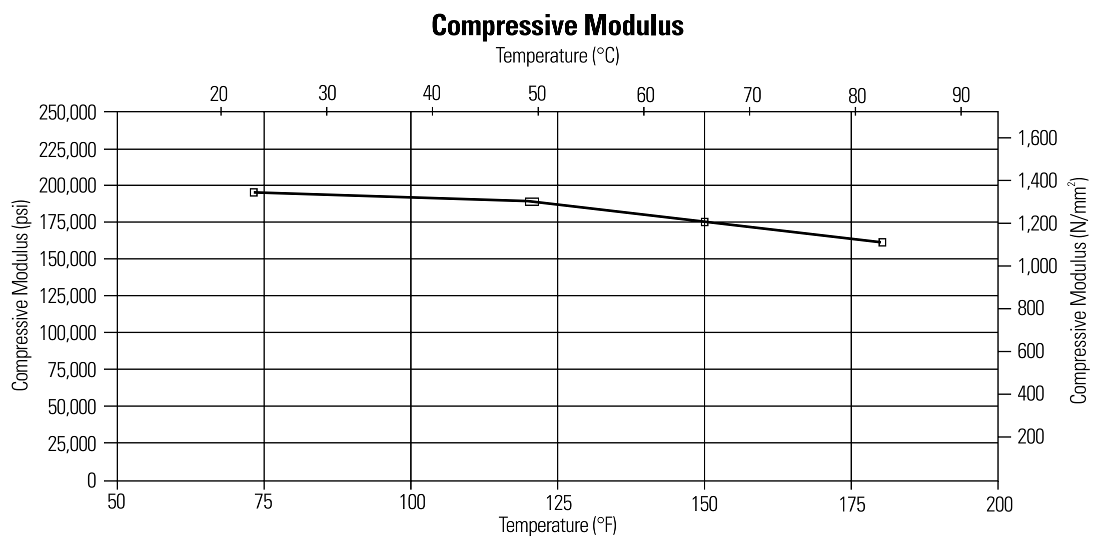


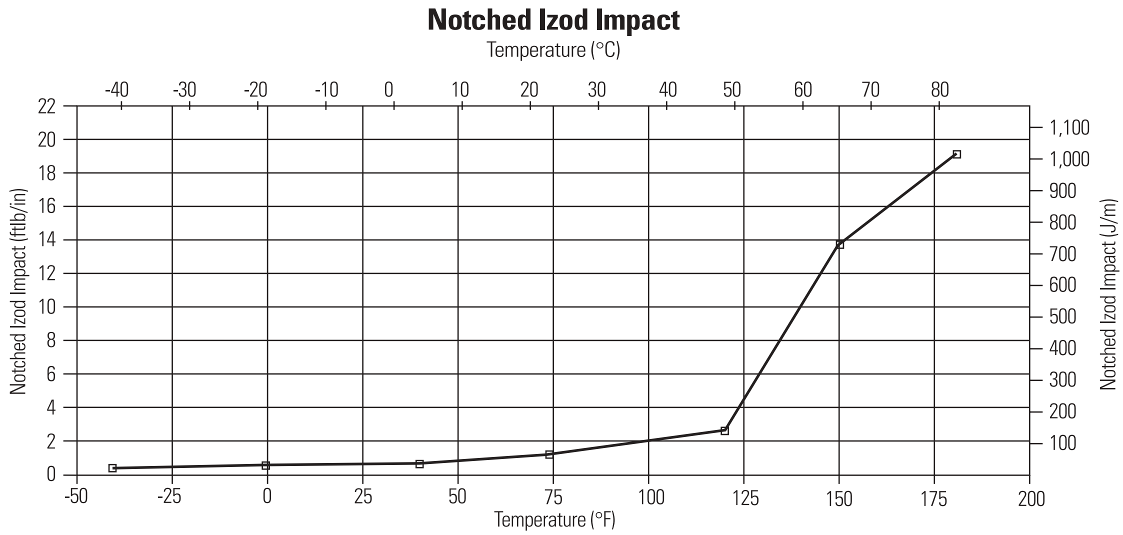


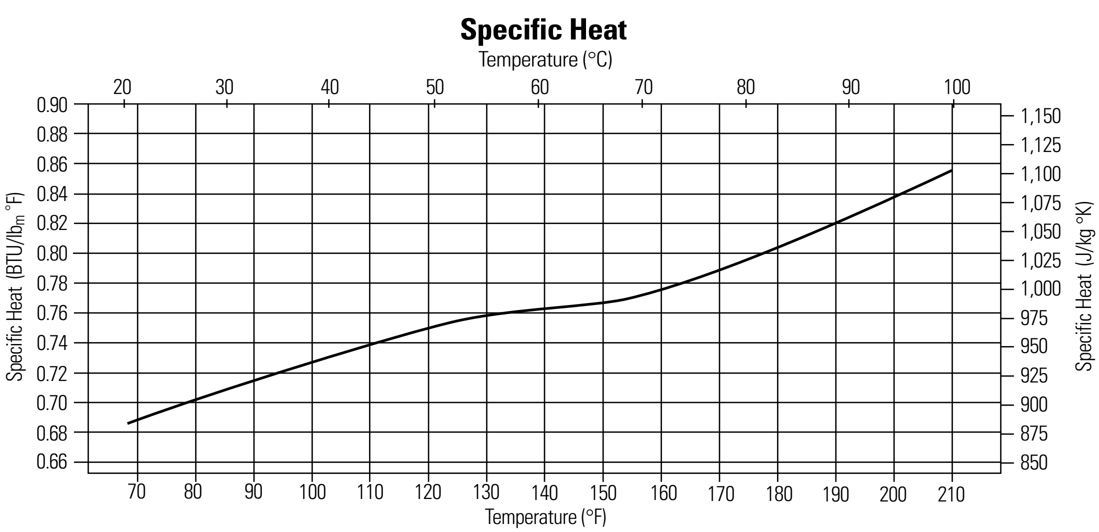
Basic Physical Properties (cont.)





Basic Physical Properties (cont.)





Fire Performance Characteristics

Corzan Industrial Systems are well suited for many process applications due to their outstanding resistance to many corrosive chemicals at temperatures up to 200°F. When thermoplastic piping materials are selected, consideration is often given to the fire performance characteristics of the material. Evaluating fire performance involves consideration of many factors such as resistance to ignition, heat of combustion, limiting oxygen index, flame spread and smoke generation characteristics.

Without the benefit of flame retardants and smoke inhibitors, Corzan CPVC inherently exhibits outstanding fire performance characteristics in terms of limited flame propagation and low smoke generation. When coupled with its excellent balance of mechanical strength, low thermal conductivity, improved hydraulics and outstanding corrosion resistance, Corzan CPVC provides excellent value in terms of safety and performance in a wide range of industrial process piping and ducting applications.

Ignition Resistance

Corzan CPVC has a flash ignition temperature of 900°F which is the *lowest* temperature at which sufficient combustible gas is evolved to be ignited by a small external flame. Many other ordinary combustibles, such as wood, ignite at 500°F or less.

FLASH IGNITION TEMPERATURE COMPARISON

Material	°C	°F
CPVC	482	900
PVC, rigid	399	750
Polyethylene	343	650
White Pine	204	400
Paper	232	450

Source: Hilado, C.J., "Flammability Handbook for Plastics", Table 2.5, Third Edition, Technomic Publishing, 1982.

Burning Resistance

Corzan CPVC will not sustain burning. It must be forced to burn due to its very high Limiting Oxygen Index (LOI) of 60. LOI is the percentage of oxygen needed in an atmosphere to support combustion. Since Earth's atmosphere is only 21% oxygen, Corzan CPVC will not burn unless a flame is constantly applied and stops burning when the ignition source is removed. Other materials will support combustion due to their low LOI.

LIMITING OXYGEN INDEX COMPARISON

Material	LOI
CPVC	60
PVC, rigid	45
PVDF	44
ABS	18
Polypropylene	17
Polyethylene	17

Source: Hilado, C.J., "Flammability Handbook for Plastics", Table 2.5, Third Edition, Technomic Publishing, 1982.

Heat of Combustion

Corzan CPVC has a significantly lower heat of combustion at 7,700 BTU/lb compared to Douglas fir at 9,040 BTU/lb and polypropylene at nearly 20,000 BTU/lb. Materials with a high heat of combustion generate more heat, and the burning process becomes self-sustaining.

Flame Spread/Smoke Generation

The flame spread and smoke generation characteristics of Corzan CPVC materials have been evaluated by Underwriters Laboratories, Inc. (ULI), Southwest Research Institute (SWRI), and Factory Mutual (FM) employing a number of recognized test methods. ULI evaluated Corzan CPVC for flammability in accordance with UL 94, which is used for determining the flammability of plastic materials used in the components and parts of finished products. This test measures a material's resistance to burning, dripping, glow emission and burn through. CPVC has achieved the highest rating available within the scope of this test of V0, 5VB and 5VA.

Southwest Research Institute (SWRI) tested water filled 1/2" & 4" schedule 80 Corzan pipe in accordance with UL 723/ASTM E84. Test results are shown below (contact Noveon for a copy of the test reports):

Nominal Pipe Diameter	FSI (flame spread index)	SDI (smoke developed index)
1/2"	0	20
4"	0	20

Fire Performance Characteristics (cont.)

Factory Mutual Clean Room Materials Flammability Testing Protocol (FM 4910)
Due to the growing concern in the semiconductor industry over safety and the high cost associated with fires and the subsequent cleanup, Factory Mutual developed a standard (FM 4910) for semiconductor clean room materials that requires that these materials provide greater resistance to flame and smoke development and therefore limit the damage that can be caused by fires. Several Corzan CPVC compounds have been evaluated and pass the FM 4910 test protocol for fire propagation & smoke development. These compounds include gray duct compound (for manufacture into seamless, round extruded duct), gray pipe compound, and the Corzan 4910 compounds, which are used to manufacture sheet for fabrication into cleanroom equipment.

Corzan 4910 CPVC sheet materials are a cost effective means for meeting the FM 4910 requirements for cleanroom tool construction. Compared to less expensive, non-fire safe materials such as polypropylene (PP) and flame-retardant polypropylene (FR-PP), Corzan 4910 CPVC may not require additional fire suppression equipment, lowering the overall cost of ownership of cleanroom tools.

Independent Listings
In some cases, the manufacturer of Corzan CPVC finished products will perform the testing required to obtain a product listing independent of Noveon. Consult the manufacturer to obtain these listings.

Weatherability

Weatherability is defined as a material's ability to maintain its basic physical properties after prolonged exposure to sunlight, wind, and rain/humidity. Over 40 years of experience with CPVC, including many long-standing outdoor installations, demonstrate that Corzan Industrial Systems will be able to withstand long-term exposure to the environment without significant adverse effects.

Corzan CPVC has been blended with a significant concentration of both carbon black and titanium dioxide (TiO_2). Both carbon black and TiO_2 are widely recognized as excellent ultraviolet blocking agents and help to protect the polymer backbone from the effects of ultraviolet radiation.

In fact, Noveon experience verifies that the pressure bearing capability of Corzan piping systems is maintained after extended exposure. Depending on the specific installation, there has been some gradual reduction in impact properties with prolonged exposure. If the specific installation requires additional protection from UV exposure, Corzan piping systems can be painted with common acrylic latex paint. Priming of the piping is not necessary prior to painting.

Abrasion Resistance

A piping system's resistance to abrasion is a function of many factors:

- Particle size and shape
- Hardness of particles
- Particle concentration
- Densities (fluid, particle, and pipe)
- Velocities
- Properties of piping materials
- Design of the piping system

While all piping systems will exhibit some degree of wear over time, the actual erosion will depend on the specific combination of these factors. Excluding the piping material itself, the system conditions which will minimize abrasion include:

- Lower velocities (<5 ft/sec)
- Large, round particles
- Uniform particle distribution
- Minimum changes in direction

When these ideal slurry conditions do not exist, the selection of the piping material becomes important. Corzan piping systems will usually outperform metal when transporting abrasive media and have been used successfully in many abrasive industrial applications.

No single test method exists which can consistently predict the abrasion resistance of a material to the broad range of potentially abrasive conditions. As a result, the best guide in selecting materials for abrasive service is past experience. In lieu of such case histories, attention should be directed towards approaching the ideal system conditions mentioned above, particularly minimizing changes in direction. At the same time, changes in direction can be designed to minimize abrasion potential. Large radius elbows and capped tee bends are usually specified to reduce particle impingement on the pipe wall.

One widely referenced test method is the Taber Abrasion Test, in which the weight loss of a material is measured after being exposed to an abrasive wheel for 1000 cycles. While the Taber test cannot predict actual performance of a material to a given application, it does provide a relative measure to compare materials.

TABER ABRASION TESTER
(Abrasion Ring CS-10, Load 1 kg)

Nylon 6-10	5mg/1000 cycles
UHMW PE	5
PVDF	5-10
PVC (rigid)	12-20
PP	15-20
CPVC	20
CTFE	13
PS	40-50
Steel (304 SS)	50
ABS	60-80
PTFE	500-1000

Source: Industrial and High Purity Piping Systems Engineering Handbook, George Fischer +GF+, 2002.

Biological Resistance

Corzan piping systems are resistant to attack from fungi. Fungus growth on plastics is supported when plasticizers or other additives are present for the fungus to feed on. Corzan CPVC contains no additives which would provide a nutrient source for fungi.

Bacteria are encountered in nearly all situations where water is present. The smooth interior surface of Corzan piping provides fewer footholds for bacteria to take hold and multiply. Corzan piping systems are resistant to the action of all forms of bacteria, many of which are known to cause corrosion in metal piping systems, such as iron-oxidizing bacteria, sulfate-reducing bacteria, and acid-producing bacteria.

Corzan CPVC is also resistant to most commonly used biocidal chemicals.

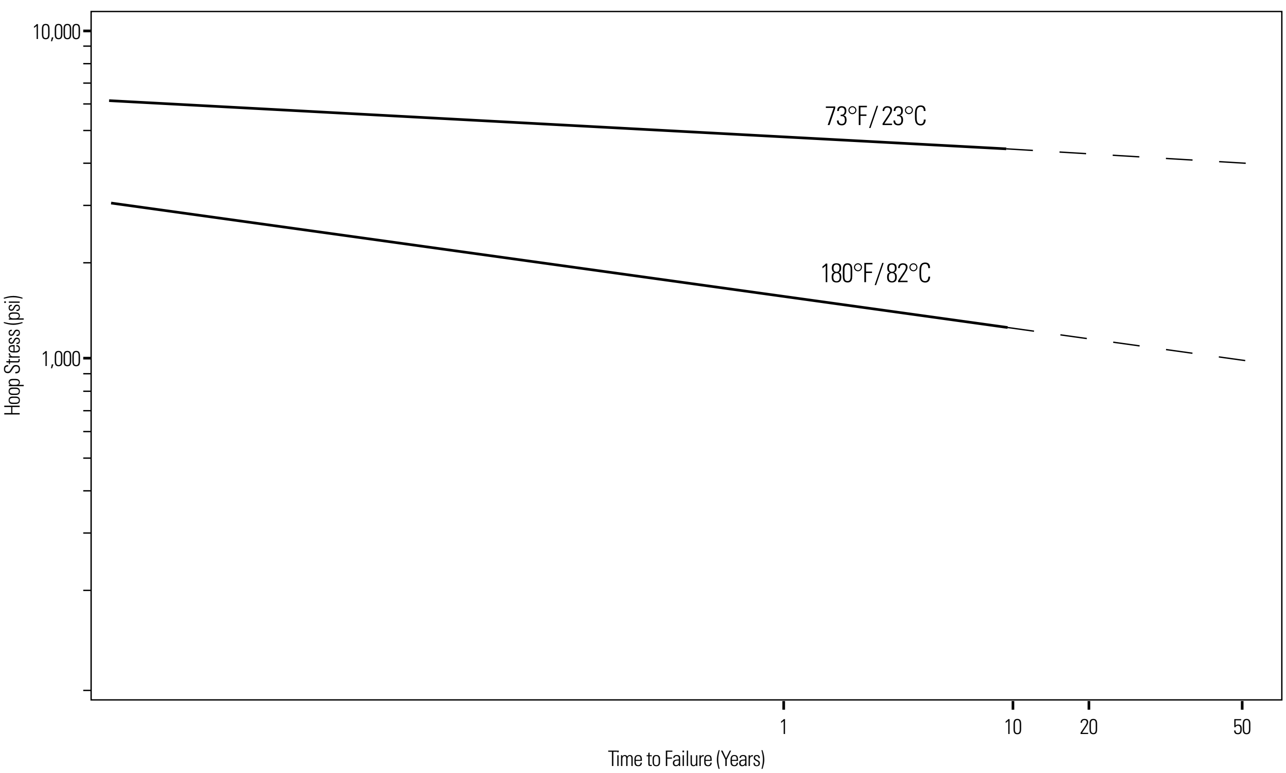
Long-Term Performance of Corzan Piping Systems Under Pressure

The long term performance of Corzan piping systems under pressure is tested in accordance with ASTM D 1598, Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure. Typical data obtained from pipe made from Corzan CPVC is shown below. Data is obtained up to 16,000 hours. The data is evaluated in accordance with ASTM D 2837, Standard Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials. The hydrostatic design basis (HDB) is the extrapolated value of the hoop stress at 100,000 hours. The hydrostatic design stress (HDS) is taken as 50% of the HDB. The pressure ratings for specific pipe sizes are calculated from the HDS with the following formula:

$$P = \frac{2St}{D-t}$$

where: P = pipe pressure rating
S = hydrostatic design stress (HDS)
t = pipe wall thickness
D = pipe outside diameter

Long-Term Performance of Corzan CPVC



Design Properties of Pipe

The data in the following tables can be used by piping design engineers to estimate loads, stresses, torques, and other mechanical data.

Definitions and Derivations

t: Minimum wall thickness of the pipe in inches as specified by ASTM F441 – Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

D: Outside diameter of the pipe in inches as specified by ASTM F441

d: Average inside diameter of the pipe in inches calculated by considering the average wall thickness to be the minimum wall thickness plus half the tolerance allowed by ASTM F441. All the values in the following tables are calculated with the average inside diameter, not the minimum wall thickness.

A_o: Outside surface area of the pipe in square feet per foot:

$$A_o = \frac{\pi D}{12}$$

A_i: Inside surface area of the pipe in square feet per foot:

$$A_i = \frac{\pi D}{12}$$

A_w: Cross-sectional area of the pipe wall in square inches:

$$A_w = \frac{\pi(D^2 - d^2)}{4}$$

A_f: Cross-sectional area of flow in pipe in square inches:

$$A_f = \frac{\pi d^2}{4}$$

W: Average weight of pipe in pounds per foot:

$$W = 0.671 A_w$$

W_w: Average weight of water in pipe in pounds per foot:

$$W_w = 0.433 A_f$$

K_A: Radius of gyration about the longitudinal axis of the pipe, in inches:

$$K_A = \frac{\sqrt{D^2 + d^2}}{4}$$

I_A: Moment of inertia in inches to the fourth power, (in^4):

$$I_A = \frac{\pi(D^4 - d^4)}{64}$$

Design Properties of Pipe (cont.)

Schedule 80

Nominal Pipe Size (in)	t Minimum Wall Thickness (in)	d Average Inside Diameter (in)	D Outside Diameter (in)	A_o Outside Surface Area (ft²/ft)	A_i Inside Surface Area (ft²/ft)	A_w Cross Sectional Area of Pipe Wall (in²)	A_f Cross Sectional Area of Flow (in²)	W Average Weight of Pipe (lb/ft)	W_w Average Weight of Water (lb/ft)	K_A Axial Radius of Gyration (in)	I_A Moment of Inertia (in⁴)
1/4	0.119	0.288	0.540	0.141	0.075	0.164	0.065	0.110	0.028	0.153	0.003834
3/8	0.126	0.407	0.675	0.177	0.106	0.228	0.130	0.153	0.056	0.197	0.00884
1/2	0.147	0.528	0.840	0.220	0.138	0.335	0.219	0.225	0.095	0.248	0.0206
3/4	0.154	0.724	1.050	0.275	0.189	0.454	0.411	0.305	0.178	0.319	0.0462
1	0.179	0.935	1.315	0.344	0.245	0.671	0.686	0.450	0.297	0.403	0.109
1 1/4	0.191	1.256	1.660	0.434	0.329	0.925	1.238	0.621	0.536	0.520	0.250
1 1/2	0.200	1.476	1.900	0.497	0.386	1.124	1.710	0.754	0.741	0.601	0.407
2	0.218	1.913	2.375	0.621	0.501	1.555	2.873	1.043	1.244	0.762	0.904
2 1/2	0.276	2.289	2.875	0.752	0.599	2.375	4.113	1.594	1.781	0.919	2.005
3	0.300	2.864	3.500	0.916	0.749	3.177	6.439	2.132	2.788	1.131	4.061
4	0.337	3.786	4.500	1.178	0.991	4.644	11.252	3.116	4.872	1.470	10.038
6	0.432	5.709	6.625	1.734	1.494	8.869	25.585	5.951	11.078	2.186	42.40
8	0.500	7.565	8.625	2.257	1.980	13.472	44.925	9.040	19.452	2.868	110.8
10	0.593	9.492	10.750	2.813	2.484	19.990	70.727	13.413	30.625	3.585	256.9
12	0.687	11.294	12.750	3.336	2.955	27.481	100.130	18.440	43.356	4.258	498.3
14	0.750	12.410	14.000	3.663	3.247	32.964	120.896	22.119	52.348	4.677	721.1
16	0.843	14.214	16.000	4.187	3.719	42.360	158.600	28.424	68.674	5.350	1212.7

Schedule 40

Nominal Pipe Size (in)	t Minimum Wall Thickness (in)	d Average Inside Diameter (in)	D Outside Diameter (in)	A_o Outside Surface Area (ft²/ft)	A_i Inside Surface Area (ft²/ft)	A_w Cross Sectional Area of Pipe Wall (in²)	A_f Cross Sectional Area of Flow (in²)	W Average Weight of Pipe (lb/ft)	W_w Average Weight of Water (lb/ft)	K_A Axial Radius of Gyration (in)	I_A Moment of Inertia (in⁴)
1/4	0.088	0.354	0.540	0.141	0.093	0.131	0.098	0.088	0.043	0.161	0.00340
3/8	0.091	0.483	0.675	0.177	0.126	0.175	0.183	0.117	0.079	0.208	0.00751
1/2	0.109	0.608	0.840	0.220	0.159	0.264	0.290	0.177	0.126	0.259	0.01772
3/4	0.113	0.810	1.050	0.275	0.212	0.350	0.515	0.235	0.223	0.332	0.03852
1	0.133	1.033	1.315	0.344	0.270	0.520	0.838	0.349	0.363	0.418	0.09084
1 1/4	0.140	1.364	1.660	0.434	0.357	0.703	1.460	0.471	0.632	0.537	0.20272
1 1/2	0.145	1.592	1.900	0.497	0.417	0.844	1.990	0.567	0.861	0.620	0.32423
2	0.154	2.049	2.375	0.621	0.536	1.132	3.296	0.760	1.427	0.784	0.6962
2 1/2	0.203	2.445	2.875	0.752	0.640	1.796	4.693	1.205	2.032	0.944	1.5986
3	0.216	3.042	3.500	0.916	0.796	2.352	7.264	1.578	3.145	1.159	3.1611
4	0.237	3.998	4.500	1.178	1.046	3.349	12.547	2.247	5.433	1.505	7.5838
6	0.280	6.031	6.625	1.734	1.578	5.901	28.553	3.960	12.363	2.240	29.604
8	0.322	7.943	8.625	2.257	2.078	8.870	49.527	5.952	21.445	2.931	76.22
10	0.365	9.976	10.750	2.813	2.610	12.593	78.124	8.450	33.828	3.666	169.28
12	0.406	11.890	12.750	3.336	3.111	16.634	110.977	11.162	48.053	4.358	315.99
14	0.437	13.072	14.000	3.663	3.421	19.721	134.139	13.233	58.082	4.789	452.21
16	0.500	14.940	16.000	4.187	3.909	25.745	175.215	17.275	75.868	5.473	771.07

General Specification

Corzan® CPVC Pipe and Fittings
1.0 Product Description
Corzan® CPVC pipe and fittings are extruded/molded from CPVC compounds manufactured by Noveon, Inc. The compounds shall meet cell class 23447 as defined by ASTM D1784, and the pipe shall be certified by NSF International for use with potable water. Corrosion resistant Corzan pipe and fittings are available in iron pipe sizes (IPS) for use in both pressure bearing and drain applications at temperatures up to and including 200°F. Pressure rating varies with schedule, pipe size, and temperature. See temperature derating chart for derating factors. Chemical resistance data is available and should be referenced for proper material selection.

1.1 Pipe and Fittings Dimensions and Tolerances
A. Schedules 40 and 80 pipe shall meet or exceed the requirements of ASTM F441.
B. Fittings shall meet or exceed the requirements of ASTM F437 (schedule 80 threaded), ASTM F438 (schedule 40 socket) and ASTM F439 (schedule 80 socket).

1.2 Solvent Cement
All socket type joints shall be made employing solvent cements that meet or exceed the requirements of ASTM F493 and primers that meet or exceed the requirements of ASTM F656. The standard practice for safe handling of solvent cements shall be in accordance with ASTM F402. Solvent cement and primer shall be listed by NSF for use with potable water, and approved by the Corzan CPVC pipe and fitting manufacturers.

2.0 Manufacturers
The piping systems shall be constructed from materials extruded/molded/fabricated by manufacturers using Corzan CPVC compounds.

A. Pipe

Charlotte Pipe & Foundry Co.
P.O. Box 35430
Charlotte, NC 28235
Phone: (800) 438-6091
Fax: (800) 553-1605

Harvel Plastics, Inc.
P.O. Box 757
Easton, PA 18044-0757
Phone: (610) 252-7355
Fax : (610) 253-4436

IPEX: (US inquiries)
PO Box 240696-0696
10100 Rodney Street
Pineville, NC 28134
Phone: (800) 463-9572
Fax: (905) 403-9195

IPEX (Canadian inquiries)
6810 Invader Crescent
Mississauga, ON L5T 2B6
Canada
Phone: (866) 473-9472
Fax: (905) 670-5295

IPEX (US inquiries)
2441 Royal Windsor Drive
Mississauga, ON L5J 4C7
Canada
Phone: (800) 463-9572
Fax: (905) 403-9195

B. Fittings

Charlotte Pipe & Foundry Co.
P.O. Box 35430
Charlotte, NC 28235
Phone: (800) 438-6091
Fax: (800) 553-1605

Colonial Engineering
8132 Merchants Place
Kalamazoo, MI 49002
Phone: (800) 374-0234
Fax: (616) 323-0630

IPEX (US inquiries)
PO Box 240696-0696
10100 Rodney Street
Pineville, NC 28134
Phone: (800) 463-9572
Fax: (905) 403-9195

IPEX (Canadian inquiries)
6810 Invader Crescent
Mississauga, ON L5T 2B6
Canada
Phone: (866) 473-9472
Fax: (905) 670-5295

Nibco, Inc.
1516 Middlebury Street
P.O. Box 1167
Elkhart, IN 46516-4740
Phone: (800) 642-5463
Fax: (219) 295-3307

General Specification (cont.)

C. Valves

CEPEX USA, Inc.
8003 Westside Industrial Dr.
Jacksonville, FL 32219
Phone: (904) 695-1441
Fax: (904) 695-1442

Hayward Industrial Products
One Hayward Industrial Dr.
Clemmons, NC 27012-5100
Phone: (800) 910-2536
Fax: (336) 712-9523

IPEX (Canadian inquiries)
6810 Invader Crescent
Mississauga, ON L5T 2B6
Canada
Phone: (866) 473-9472
Fax: (905) 670-5295

Plast-O-Matic Valves, Inc.
1384 Pompton Avenue
Cedar Grove, NJ 07009
Phone: (973) 256-3000
Fax: (973) 256-4745

Colonial Engineering
8132 Merchants Place
Kalamazoo, MI 49002
Phone: (800) 374-0234
Fax: (616) 323-0630

IPEX (US inquiries)
PO Box 240696-0696
10100 Rodney Street
Pineville, NC 28134
Phone: (800) 463-9572
Fax: (905) 403-9195

IPEX (US inquiries)
2441 Royal Windsor Drive
Mississauga, ON L5J 4C7
Canada
Phone: (800) 463-9572
Fax: (905) 403-9195

Nibco, Inc.
1516 Middlebury Street
P.O. Box 1167
Elkhart, IN 46516-4740
Phone: (800) 642-5463

D. Solvent Cement

IPS Corporation
455 W. Victoria Street
Compton, CA 90220
Phone: (800) 421-2677
Fax: (310) 898-3390

E. Fabricated Fittings

Fabricated fittings shall be manufactured by heat fusion (hot plate or hot gas welding) and fiberglass over wrapped. Fabricated fittings shall be manufactured from pipe supplied by the manufacturers listed in section 2.0A. Parts shall be manufactured by:

Plastinetics
439 Main Road (Rt. 202)
Towaco, NJ 07082
Phone (800) 627-7473
Fax (973) 316-0300

New Plastics Fitting
20W267 101st Street Unit B
Lemont, IL 60439
Phone (630) 739-2600
Fax (630) 739-2727

Harrison Machine & Plastics
11614 State Route 88
Garrettsville, OH 44231
Phone (330) 527-5641
Fax (330) 527-5640

General Specification (cont.)

3.0 SYSTEM DESIGN

A. System design shall be in accordance with the manufacturer's instructions. The design shall take into consideration such factors as pressure and flow requirements, friction loss, operating temperatures, support spacing, anchoring, bracing and thrust blocking, joining methods, and thermal expansion and contraction.

B. Maximum design pressure ratings shall not exceed those listed in the tables below. Pressure ratings apply to water at 73°F. For temperatures greater than 73°F, see derating factors listed. For fluids other than water, the full pressure rating may not apply; see the chemical resistance table for guidelines.

C. Schedule 80 pipe operating above 130°F shall NOT be threaded.

D. Threaded systems shall be derated to 50% of the pressure rating for the piping at the system operating temperature.

E. Flanged systems of any size shall not exceed 150 psi working pressure at 73°F. Follow the manufacturer's recommendations for temperature derating factors for services greater than 73°F.

F. Corzan valves are typically rated at 150 psi up to 240 psi at 73°F (pressure rating varies with valve type and manufacturer). Consult the valve manufacturer for pressure ratings and temperature derating schedules.

G. A Hazen-Williams friction factor of 150 shall be used in all hydraulic calculations.

TEMPERATURE DERATING FACTORS (PIPE)

Working Temperature (°F)	Pipe Derating Factor
73-80	1.00
90	0.91
100	0.82
120	0.65
140	0.50
160	0.40
180	0.25
200	0.20

Corzan Pipe Dimensions and Pressure Ratings

Schedule 80

Nominal Pipe Size (in)	O.D.	Minimum wall	Ave I.D.	Nominal Weight (lbs/ft)	Maximum Water P @73°F
¼″	0.540	0.119	0.288	0.110	1130
⅜″	0.675	0.126	0.407	0.153	920
½″	0.840	0.147	0.528	0.225	850
¾″	1.050	0.154	0.724	0.305	690
1″	1.315	0.179	0.935	0.450	630
1¼″	1.660	0.191	1.256	0.621	520
1½″	1.900	0.200	1.476	0.754	470
2″	2.375	0.218	1.913	1.043	400
2½″	2.875	0.276	2.289	1.594	420
3″	3.500	0.300	2.864	2.132	370
4″	4.500	0.337	3.786	3.116	320
6″	6.625	0.432	5.709	5.951	280
8″	8.625	0.500	7.565	9.040	250
10″	10.750	0.593	9.492	13.413	230
12″	12.750	0.687	11.294	18.440	230
14″	14.000	0.750	12.410	22.119	220
16″	16.000	0.843	14.214	28.424	220

Schedule 40

Nominal Pipe Size (in)	O.D.	Minimum Wall	Average I.D.	Nominal Weight (lbs/ft)	Maximum Water P @ 73°F
¼″	0.540	0.088	0.354	0.088	780
⅜″	0.675	0.091	0.483	0.117	620
½″	0.840	0.109	0.608	0.177	600
¾″	1.050	0.113	0.810	0.235	480
1″	1.315	0.133	1.033	0.349	450
1¼″	1.660	0.140	1.364	0.471	370
1½″	1.990	0.145	1.592	0.567	330
2″	2.375	0.154	2.049	0.760	280
2½″	2.875	0.203	2.445	1.205	300
3″	3.500	0.216	3.042	1.578	260
4″	4.500	0.237	3.998	2.247	220
6″	6.625	0.280	6.031	3.960	180
8″	8.625	0.322	7.943	5.952	160
10″	10.750	0.365	9.976	8.450	140
12″	12.750	0.406	11.890	11.162	130
14″	14.000	0.437	13.072	13.233	130
16″	16.000	0.500	14.940	17.275	130

General Specification (cont.)

4.0 JOINING SYSTEMS

A. Assembly of pipe and fittings shall be done by solvent cementing, threading, or flanging.

B. Solvent cement that meets or exceeds the requirements of ASTM F493 shall be used in conjunction with a primer manufactured by companies listed under section 2.0D.

C. Flanges shall be installed on pipe ends with primer and solvent cement and then bolted together per the manufacturer's instructions and torque ratings.

D. Threading shall be performed on Schedule 80 pipe 4" and smaller, per the manufacturer's instructions. Only water soluble oil or water shall be used when threading pipe. Degreasing type solvents shall never be used to clean threads.

E. Only Teflon tape or **CPVC *compatible* pipe dope** shall be used when making plastic threaded connections. Noveon maintains a list of products that have been shown to be incompatible with CPVC piping systems. Chemically incompatible products are added to this list as they are brought to Noveon's attention. For the most current list of chemically incompatible products, contact Noveon or refer to the website, www.corzancpvc.com. **A product's absence from this list does not imply or ensure CPVC chemical compatibility.** Always confirm chemical compatibility with CPVC with the manufacturer of the product in contact with the CPVC piping system.

MAXIMUM SUPPORT SPACING (FEET) SCHEDULE 80

Support spacing recommendations are based on straight runs of uninsulated lines conveying fluids with specific gravities up to 1.0. Heavy system components such as valves, flanged assemblies, tees and other forms of concentrated stress loads must be independently supported. For specific gravities greater than 1.0, the support spacing from the table provided should be multiplied by the following correction factors:

Specific Gravity	1.0	1.1	1.2	1.4	1.6	2.0	2.5
Correction Factor	1.00	0.98	0.96	0.93	0.90	0.85	0.80

Temp (F)	**½″**	**¼″**	**1″**	**1¼″**	**1½″**	**2″**	**2½″**	**3″**	**4″**	**6″**	**8″**	**10″**	**12″**	**14"**	**16"**
73	5½	5½	6	6½	7	7	8	8	9	10	11	11½	12½	15	16
100	5	5½	6	6	6½	7	7½	8	9	9½	10½	11	12½	13½	15
120	4½	5	5½	6	6	6½	7½	7½	8½	9	10	10½	11	12½	13½
140	4½	4½	5	5½	5½	6	6½	7	7½	8	9	9½	10½	11	12
160	3	3	3½	3½	3½	4	4½	4½	5	5½	6	6½	7½	9½	10
180	2½	2½	3	3	3½	3½	4	4	4½	5	5½	6	6½	8	8½

MAXIMUM SUPPORT SPACING (FEET) SCHEDULE 40

Temp (F)	**½″**	**¼″**	**1″**	**1¼″**	**1½″**	**2″**	**2½″**	**3″**	**4″**	**6″**	**8″**	**10″**	**12″**	**14"**	**16"**
60	5	5½	6	6	6½	6½	7½	8	8½	9½	9½	10	10½	12	13
80	5	5	5½	5½	6½	6	7	7	7½	8½	8½	9½	10½	11	12
100	4½	5	5½	5½	6½	6	7	7	7½	8	8	9	10	10	11
120	4½	4½	5	5½	5½	5½	6½	7	7	7½	7½	8	9	9	9½
140	4	4	4½	5	5	5	6	6	6½	7	7	7½	8	8	8½
180	2½	2½	2½	3	3	3	3½	3½	4	4½	5	5½	6	6¼	7

General Specification (cont.)

5.0 APPLICABLE STANDARDS

A. ASTM D1784, Specification for Rigid Poly(Vinyl Chloride) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

B. ASTM D2855, Standard Practice for Making Solvent Cemented Joints and Poly(Vinyl Chloride) (PVC) Pipe and Fittings.

C. ASTM F402, Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings.

D. ASTM F437, Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

E. ASTM F438, Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.

F. ASTM F439, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

G. ASTM F441, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 & 80.

H. ASTM F493, Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.

I. ASTM F656, Standard Specification for Primers for Use in Solvent Cement Joints in Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

J. NSF Standard 14, Plastic Piping Components and Related Materials.

K. NSF Standard 61, Drinking Water System Components – Health Effects.

L. ASTM F493, Standard Specification for Solvent

M. FM4910, Factory Mutual Research Clean Room Materials Flammability Test Protocol

6.0 TESTING

After the system is installed and any solvent cement is cured, the system shall be hydrostatically tested. **Air or compressed gas shall NEVER be used for pressure testing Corzan® CPVC piping systems.**

Corzan Pressure Ratings

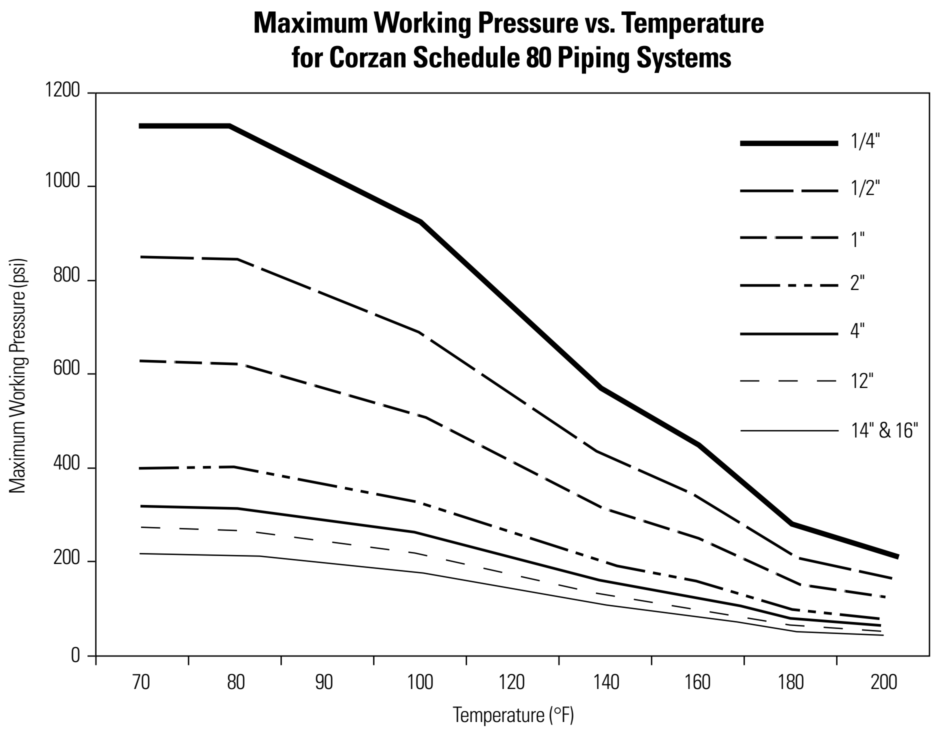
Schedule 80 CPVC (with socket fittings): Water Pressure Rating (psi)

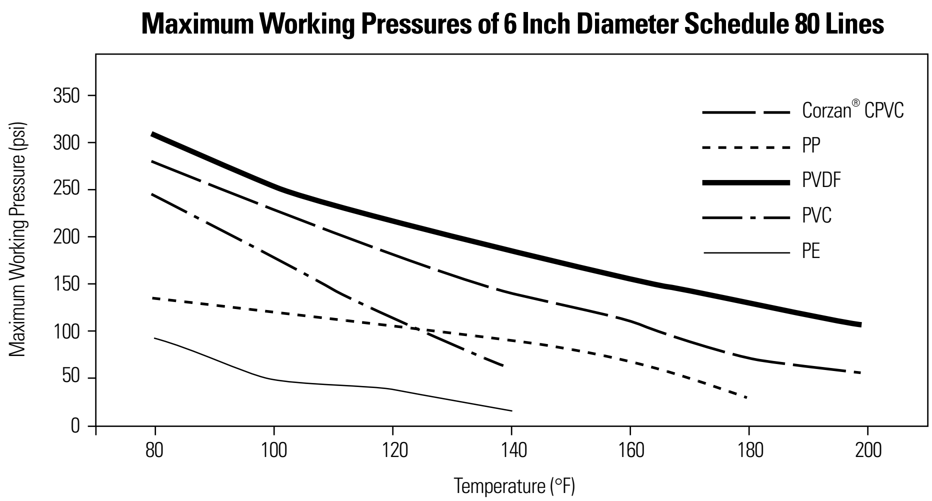
Pipe Size	70°F	80°F	90°F	100°F	120°F	140°F	160°F	180°F	200°F
¼"	1,130	1,130	1,028	927	735	565	452	283	226
⅜"	920	920	837	754	598	460	368	230	184
½"	850	850	774	697	553	425	340	213	170
¾"	690	690	628	566	449	345	276	173	138
1"	630	630	573	517	410	315	252	158	126
1¼"	520	520	473	426	338	260	208	130	104
1½"	470	470	428	385	306	235	188	118	94
2"	400	400	364	328	260	200	160	100	80
2½"	420	420	382	344	273	210	168	105	84
3"	370	370	337	303	241	185	148	93	74
4"	320	320	291	262	208	160	128	80	64
5"	290	290	264	238	189	145	116	73	58
6"	280	280	255	230	182	140	112	70	56
8"	250	250	228	205	163	125	100	63	50
10"	230	230	209	189	150	115	92	58	46
12"	230	230	209	189	150	115	92	58	46
14"	220	220	200	180	143	110	88	55	44
16"	220	220	200	180	143	110	88	55	44

Schedule 40 CPVC (with socket fittings): Water Pressure Rating (psi)

Pipe Size	70°F	80°F	90°F	100°F	120°F	140°F	160°F	180°F	200°F
¼"	780	780	710	640	507	390	312	195	156
⅜"	620	620	564	508	403	310	248	155	124
½"	590	590	537	484	384	295	236	148	118
¾"	480	480	437	394	312	240	192	120	96
1"	450	450	410	369	293	225	180	113	90
1¼"	365	365	322	299	237	183	146	91	73
1½"	330	330	300	271	215	165	132	83	66
2"	275	275	250	226	179	138	110	69	55
2½"	300	300	273	246	195	150	120	75	60
3"	260	260	237	213	169	130	104	65	52
4"	220	220	200	180	143	110	88	55	44
6"	180	180	164	148	117	90	72	45	36
8"	160	160	146	131	104	80	64	40	32
10"	140	140	127	115	91	70	56	35	28
12"	130	130	118	107	85	65	52	33	26
14"	130	130	118	107	85	65	52	33	26
16"	130	130	118	107	85	65	52	33	26

Corzan Pressure Ratings (cont.)





Corzan Pressure Ratings (cont.)

Collapse Pressure Rating (PSI)

Schedule 40

Nominal Pipe Size (in)	73°F	100°F	120°F	140°F	160°F	180°F	200°F
½	1,605	1,386	1,167	1,021	876	803	584
¾	1,219	1,153	993	869	745	683	496
1	948	896	859	814	698	640	465
1¼	511	484	463	443	429	411	395
1½	366	346	331	317	307	294	282
2	213	201	193	184	179	171	164
2½	276	261	250	238	231	221	213
3	179	169	162	155	150	144	138
4	108	102	97	93	90	86	83
6	54	51	49	47	45	43	42
8	37	35	33	32	31	29	28
10	27	26	25	24	23	22	21
12	22	21	20	19	19	18	17

Schedule 80

Nominal Pipe Size (in)	73°F	100°F	120°F	140°F	160°F	180°F	200°F
½	2,006	1,732	1,459	1,277	1,094	1,003	729
¾	1,740	1,502	1,265	1,107	949	870	633
1	1,628	1,406	1,184	1,036	888	814	592
1¼	1,399	1,221	1,028	900	771	707	514
1½	1,034	978	937	833	714	654	476
2	653	617	591	565	548	524	421
2½	758	717	687	656	636	603	439
3	521	493	472	451	437	418	396
4	334	316	303	289	280	268	258
6	214	202	194	185	179	172	165
8	146	139	133	127	123	118	113
10	125	118	113	108	105	100	96
12	116	110	105	100	97	93	89

Fluid Handling Characteristics of Corzan Pipe

Linear Fluid Flow Velocity

The linear velocity of a flowing fluid in a pipe is calculated from:

$$V = \frac{0.4085g}{d^2}$$

where V = linear fluid flow velocity in feet per second
g = flow rate in gallons per minute
d = inside diameter of pipe in inches

The values in the following tables are based on this formula. These values are accurate for all fluids.

Linear fluid flow velocity in a system should generally be limited to 5 ft/s, particularly for pipe sizes 6" and greater. Following this guideline will minimize risk of hydraulic shock damage due to water hammer surge pressures.

Friction Loss in Pipe

A great advantage that Corzan pipe enjoys over its metallic competitors is a smooth inner surface which is resistant to scaling and fouling. This means that friction pressure losses in the fluid flow are minimized from the beginning and do not significantly increase as the system ages, as can be the case with metal pipes subject to scaling.

The Hazen-Williams formula is the generally accepted method of calculating friction head losses in piping systems. The values in the following fluid flow tables are based on this formula and a surface roughness constant of C=150 for Corzan pipe. Surface roughness constants for other piping materials are given below:

$$f = 0.2083 \times \left(\frac{100}{C}\right)^{1.852} \frac{g^{1.852}}{d^{4.8655}}$$

where f = friction head in feet of water per 100 feet of pipe
d = inside diameter of pipe in inches
g = flow rate in gallons per minute
C = pipe surface roughness constant

Constant (C)	Type of Pipe
150	CPVC pipe, new-40 years old
130-140	steel/cast iron pipe, new
125	steel pipe, old
120	cast iron, 4-12 years old
110	galvanized steel; cast iron, 13-20 years old
60-80	cast iron, worn/pitted

Friction Loss in Fittings

Friction losses through fittings are calculated from the equivalent length of straight pipe which would produce the same friction loss in the fluid. The equivalent lengths of pipe for common fittings are given below.

EQUIVALENT LENGTH OF PIPE (FEET)*

Nominal Size (in)	90° Standard Elbow	45° Standard Elbow	Standard Tee Run Flow	Standard Tee Branch Flow
½	1.5	0.8	1.0	4.0
¾	2.0	1.1	1.4	5.0
1	2.6	1.4	1.7	6.0
1¼	3.8	1.8	2.3	7.0
1½	4.0	2.1	2.7	8.1
2	5.7	2.7	4.3	12.0
2½	6.9	3.3	5.1	14.7
3	7.9	4.1	6.2	16.3
4	11.4	5.3	8.3	22.0
6	16.7	8.0	12.5	32.2
8	21.0	10.6	16.5	39.7
10	25.1	13.4	19.1	50.1
12	29.8	15.9	22.4	63.0

*The data provided in this table is for reference only. Consult the fitting manufacturer's literature for additional information.

Fluid Handling Characteristics of Corzan Pipe (cont.)

Pressure Drop in Valves and Strainers

Pressure drop in valves and strainers is calculated using flow coefficient values which are published by the valve manufacturer. The equation for calculating pressure drop in this manner is:

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

where P = pressure drop in PSI
G = flow rate in gallons per minute
C_v = the valve flow coefficient

Typical flow coefficients for different valves and strainers can be found in the valve/strainer manufacturer's literature. Pressure drops for fluids other than water may be calculated by multiplying the value calculated from the above equation by the specific gravity of the fluid.

Water Hammer Surge Pressure

Whenever the flow rate of fluid in a pipe is changed, there is a surge in pressure known as water hammer. The longer the line and the faster the fluid is moving, the greater the hydraulic shock will be. Water hammer may be caused by opening or closing a valve, starting or stopping a pump, or the movement of entrapped air through the pipe. The maximum water hammer surge pressure may be calculated from:

$$P_{wh} = \frac{\rho \Delta V}{g_c}\left[\frac{\rho}{g_c}\left(\frac{1}{K} + \frac{d}{bE}\right)\right]^{-1/2}$$

where: P_{wh} = maximum surge pressure, psi
ρ = fluid density
ΔV = change in fluid velocity
g_c = gravitational constant
K = bulk modulus of elasticity of fluid
d = pipe inside diameter
b = pipe wall thickness
E = pipe material bulk modulus of elasticity

The values in the following tables are based on this formula at 73°F and the assumption that water flowing at a given rate of gallons per minute is suddenly completely stopped. At 180°F, the surge pressure is approximately 15% less. The value for fluids other than water may be approximated by multiplying by the square root of the fluid's specific gravity.

THE WATER HAMMER SURGE PRESSURE PLUS THE SYSTEM OPERATING PRESSURE SHOULD NOT EXCEED 1.5 TIMES THE RECOMMENDED WORKING PRESSURE RATING OF THE SYSTEM.

In order to minimize hydraulic shock due to water hammer, linear fluid flow velocity should generally be limited to 5 ft/s, particularly for pipe sizes of 6" or larger. Velocity at system start-up should be limited to 1 ft/s during filling until it is certain that all air has been flushed from the system and the pressure has been brought up to operating conditions. Air should not be allowed to accumulate in the system while it is operating. Pumps should not be allowed to draw in air.

Where necessary, extra protective equipment may be used to prevent water hammer damage. Such equipment might include pressure relief valves, shock absorbers, surge arrestors, and vacuum air relief valves.

Carrying Capacity and Friction Loss for Schedule 80 Thermoplastic Pipe

Independent variables: Volumetric flow rate and average pipe ID
Dependent variables: Linear velocity, friction head loss and pressure drop

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
	1/2 in.		
1	1.465	2.198	0.953
3	4.395	16.816	7.290
5	7.325	43.310	18.775
7	10.255	80.763	35.011
	4 in.		
20	0.570	0.039	0.017
25	0.713	0.059	0.025
30	0.855	0.082	0.036
35	0.998	0.109	0.047
40	1.141	0.140	0.061
45	1.283	0.174	0.076
50	1.426	0.212	0.092
60	1.711	0.297	0.129
70	1.996	0.395	0.171
80	2.281	0.506	0.219
90	2.566	0.629	0.273
100	2.851	0.765	0.331
125	3.564	1.156	0.501
150	4.277	1.620	0.702
175	4.990	2.155	0.934
200	5.703	2.760	1.197
250	7.128	4.173	1.809
300	8.554	5.849	2.535
350	9.980	7.781	3.373
400	11.405	9.964	4.320

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
	3/4 in.		
1	0.781	0.473	0.205
3	2.342	3.619	1.569
5	3.903	9.322	4.041
7	5.464	17.383	7.536
10	7.806	33.652	14.588
15	11.709	71.307	30.912
	6 in.		
50	0.627	0.029	0.012
60	0.752	0.040	0.017
70	0.878	0.054	0.023
80	1.003	0.069	0.030
90	1.129	0.085	0.037
100	1.254	0.104	0.045
125	1.567	0.157	0.068
150	1.881	0.220	0.095
175	2.194	0.292	0.127
200	2.508	0.374	0.162
250	3.135	0.566	0.245
300	3.762	0.793	0.344
350	4.389	1.055	0.457
400	5.016	1.351	0.586
450	5.643	1.680	0.728
500	6.270	2.042	0.885
750	9.405	4.327	1.876
1000	12.540	7.371	3.195

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
	1 in.		
3	1.403	1.043	0.452
5	2.338	2.686	1.164
7	3.274	5.008	2.171
10	4.677	9.696	4.203
15	7.015	20.545	8.906
20	9.354	35.002	15.173
25	11.692	52.914	22.938
30	14.031	74.167	32.152
	8 in.		
100	0.714	0.026	0.011
125	0.893	0.040	0.017
150	1.071	0.056	0.024
175	1.250	0.074	0.032
200	1.428	0.095	0.041
250	1.785	0.144	0.062
300	2.142	0.202	0.087
350	2.500	0.268	0.116
400	2.857	0.343	0.149
450	3.214	0.427	0.185
500	3.571	0.519	0.225
750	5.356	1.100	0.477
1000	7.142	1.874	0.812
1250	8.927	2.833	1.228
1500	10.712	3.970	1.721
2000	14.283	6.764	2.932

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
	1 1/4 in.		
3	0.777	0.248	0.108
5	1.296	0.639	0.277
7	1.814	1.191	0.516
10	2.592	2.306	1.000
15	3.887	4.887	2.119
20	5.183	8.326	3.609
25	6.479	12.587	5.456
30	7.775	17.643	7.648
35	9.070	23.472	10.175
40	10.366	30.057	13.030
45	11.662	37.384	16.206
50	12.958	45.439	19.698
	10 in.		
200	0.907	0.032	0.014
250	1.134	0.048	0.021
300	1.361	0.067	0.029
350	1.588	0.089	0.039
400	1.814	0.114	0.049
450	2.041	0.142	0.061
500	2.268	0.172	0.075
750	3.402	0.365	0.158
1000	4.536	0.621	0.269
1250	5.670	0.939	0.407
1500	6.804	1.316	0.571
2000	9.072	2.243	0.972
2500	11.341	3.390	1.470
3000	13.609	4.752	2.060
3500	15.877	6.322	2.741
4000	18.145	8.096	3.509

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
	1 1/2 in.		
3	0.563	0.113	0.049
5	0.938	0.291	0.126
7	1.313	0.543	0.235
10	1.876	1.052	0.456
15	2.814	2.228	0.966
20	3.752	3.797	1.646
25	4.691	5.739	2.488
30	5.629	8.045	3.487
35	6.567	10.703	4.640
40	7.505	13.705	5.941
45	8.443	17.046	7.390
50	9.381	20.719	8.982
60	11.257	29.041	12.589
70	13.134	38.637	16.749
	12 in.		
350	1.121	0.038	0.017
400	1.282	0.049	0.021
450	1.442	0.061	0.026
500	1.602	0.074	0.032
750	2.403	0.157	0.068
1000	3.204	0.267	0.116
1250	4.005	0.403	0.175
1500	4.806	0.565	0.245
2000	6.408	0.963	0.417
2500	8.010	1.455	0.631
3000	9.613	2.040	0.884
3500	11.215	2.714	1.176
4000	12.817	3.475	1.506
4500	14.419	4.322	1.874
5000	16.021	5.253	2.277
5500	17.623	6.267	2.717
6000	19.225	7.363	3.192

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
	2 in.		
5	0.558	0.082	0.036
7	0.782	0.154	0.067
10	1.117	0.298	0.129
15	1.675	0.631	0.274
20	2.233	1.075	0.466
25	2.792	1.625	0.704
30	3.350	2.278	0.987
35	3.909	3.030	1.314
40	4.467	3.881	1.682
45	5.025	4.827	2.092
50	5.584	5.866	2.543
60	6.700	8.223	3.565
70	7.817	10.940	4.742
80	8.934	14.009	6.073
90	10.050	17.424	7.553
100	11.167	21.178	9.181
125	13.959	32.016	13.879
	14 in.		
500	1.327	0.047	0.020
750	1.990	0.099	0.043
1000	2.654	0.169	0.073
1250	3.317	0.255	0.110
1500	3.981	0.357	0.155
2000	5.308	0.609	0.264
2500	6.635	0.920	0.399
3000	7.961	1.290	0.559
3500	9.288	1.716	0.744
4000	10.615	2.197	0.952
4500	11.942	2.733	1.185
5000	13.269	3.321	1.440
5500	14.596	3.963	1.718
6000	15.923	4.655	2.018
6500	17.250	5.399	2.341
7000	18.577	6.194	2.685

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
	2 1/2 in.		
5	0.390	0.034	0.015
7	0.546	0.064	0.028
10	0.780	0.124	0.054
15	1.170	0.264	0.114
20	1.560	0.449	0.195
25	1.950	0.679	0.294
30	2.340	0.951	0.412
35	2.730	1.266	0.549
40	3.120	1.621	0.703
45	3.510	2.016	0.874
50	3.900	2.450	1.062
60	4.680	3.434	1.489
70	5.460	4.569	1.981
80	6.240	5.851	2.536
90	7.020	7.277	3.155
100	7.800	8.845	3.834
125	9.751	13.372	5.797
150	11.701	18.743	8.125
175	13.651	24.936	10.810
200	15.601	31.931	13.842
	16 in.		
1000	2.023	0.087	0.038
1250	2.529	0.132	0.057
1500	3.034	0.185	0.080
2000	4.046	0.314	0.136
2500	5.057	0.475	0.206
3000	6.069	0.666	0.289
3500	7.080	0.886	0.384
4000	8.092	1.135	0.492
4500	9.103	1.412	0.612
5000	10.115	1.716	0.744
5500	11.126	2.047	0.887
6000	12.137	2.405	1.043
6500	13.149	2.790	1.209
7000	14.160	3.200	1.387
7500	15.172	3.636	1.576
8000	16.183	4.098	1.776
9000	18.206	5.097	2.209
10000	20.229	6.195	2.685

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
	3 in.		
5	0.249	0.012	0.005
7	0.349	0.022	0.009
10	0.498	0.042	0.018
15	0.747	0.089	0.038
20	0.997	0.151	0.065
25	1.246	0.228	0.099
30	1.495	0.320	0.139
35	1.744	0.425	0.184
40	1.993	0.545	0.236
45	2.242	0.678	0.294
50	2.491	0.823	0.357
60	2.990	1.154	0.500
70	3.488	1.536	0.666
80	3.986	1.966	0.852
90	4.484	2.446	1.060
100	4.983	2.973	1.289
125	6.228	4.494	1.948
150	7.474	6.299	2.731
175	8.720	8.381	3.633
200	9.965	10.732	4.652
250	12.457	16.224	7.033
300	14.948	22.740	9.858

CORZAN™ INDUSTRIAL SYSTEMS

Carrying Capacity and Friction Loss for Schedule 40 Thermoplastic Pipe

Independent variables: Volumetric flow rate and average pipe ID

Dependent variables: Linear velocity, friction head loss and pressure drop

1/2 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
1	1.106	1.107	0.480
3	3.319	8.465	3.669
5	5.532	21.801	9.451
7	7.744	40.654	17.624

4 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
20	0.511	0.030	0.013
25	0.639	0.045	0.020
30	0.767	0.063	0.027
35	0.895	0.084	0.036
40	1.023	0.107	0.047
45	1.151	0.134	0.058
50	1.279	0.162	0.070
60	1.534	0.228	0.099
70	1.790	0.303	0.131
80	2.046	0.388	0.168
90	2.301	0.483	0.209
100	2.557	0.587	0.254
125	3.196	0.887	0.384
150	3.836	1.243	0.539
175	4.475	1.654	0.717
200	5.114	2.117	0.918
250	6.393	3.201	1.388
300	7.671	4.487	1.945
350	8.950	5.969	2.588
400	10.228	7.644	3.314

3/4 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
1	0.623	0.274	0.119
3	1.869	2.096	0.909
5	3.115	5.399	2.341
7	4.361	10.068	4.365
10	6.230	19.491	8.449
15	9.345	41.301	17.904

6 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
50	0.562	0.022	0.010
60	0.674	0.031	0.013
70	0.787	0.041	0.018
80	0.899	0.052	0.023
90	1.011	0.065	0.028
100	1.124	0.079	0.034
125	1.405	0.120	0.052
150	1.685	0.168	0.073
175	1.966	0.224	0.097
200	2.247	0.286	0.124
250	2.809	0.433	0.188
300	3.371	0.607	0.263
350	3.933	0.808	0.350
400	4.495	1.034	0.448
450	5.056	1.286	0.558
500	5.618	1.563	0.678
750	8.427	3.313	1.436
1000	11.236	5.644	2.447

1 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
3	1.149	0.642	0.278
5	1.914	1.654	0.717
7	2.680	3.084	1.337
10	3.829	5.970	2.588
15	5.743	12.650	5.484
20	7.657	21.551	9.342
25	9.571	32.580	14.123
30	11.486	45.666	19.796

8 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
100	0.648	0.021	0.009
125	0.810	0.031	0.014
150	0.972	0.044	0.019
175	1.134	0.059	0.025
200	1.296	0.075	0.033
250	1.619	0.113	0.049
300	1.943	0.159	0.069
350	2.267	0.211	0.092
400	2.591	0.271	0.117
450	2.915	0.337	0.146
500	3.239	0.409	0.177
750	4.858	0.868	0.376
1000	6.478	1.478	0.641
1250	8.097	2.234	0.969
1500	9.717	3.132	1.358
2000	12.956	5.336	2.313

1 1/4 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
3	0.659	0.166	0.072
5	1.099	0.428	0.185
7	1.538	0.798	0.346
10	2.197	1.544	0.669
15	3.296	3.272	1.418
20	4.395	5.574	2.416
25	5.494	8.426	3.653
30	6.592	11.810	5.120
35	7.691	15.712	6.811
40	8.790	20.121	8.722
45	9.889	25.025	10.848
50	10.987	30.417	13.186

10 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
200	0.821	0.025	0.011
250	1.027	0.037	0.016
300	1.232	0.052	0.023
350	1.437	0.070	0.030
400	1.643	0.089	0.039
450	1.848	0.111	0.048
500	2.053	0.135	0.059
750	3.080	0.286	0.124
1000	4.107	0.488	0.211
1250	5.133	0.737	0.320
1500	6.160	1.033	0.448
2000	8.213	1.761	0.763
2500	10.267	2.662	1.154
3000	12.320	3.731	1.617
3500	14.374	4.963	2.152
4000	16.427	6.356	2.755

1 1/2 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
3	0.484	0.078	0.034
5	0.806	0.202	0.087
7	1.129	0.376	0.163
10	1.612	0.728	0.316
15	2.418	1.542	0.669
20	3.224	2.627	1.139
25	4.031	3.972	1.722
30	4.837	5.567	2.413
35	5.643	7.407	3.211
40	6.449	9.485	4.112
45	7.255	11.797	5.114
50	8.061	14.339	6.216
60	9.673	20.098	8.712
70	11.286	26.738	11.591

12 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
350	1.012	0.030	0.013
400	1.156	0.038	0.016
450	1.301	0.047	0.021
500	1.445	0.058	0.025
750	2.168	0.122	0.053
1000	2.891	0.208	0.090
1250	3.614	0.314	0.136
1500	4.336	0.440	0.191
2000	5.782	0.750	0.325
2500	7.227	1.133	0.491
3000	8.673	1.588	0.688
3500	10.118	2.113	0.916
4000	11.564	2.706	1.173
4500	13.009	3.365	1.459
5000	14.455	4.090	1.773
5500	15.900	4.880	2.115
6000	17.346	5.733	2.485

2 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
5	0.487	0.059	0.026
7	0.681	0.110	0.048
10	0.973	0.213	0.092
15	1.460	0.452	0.196
20	1.947	0.770	0.334
25	2.434	1.163	0.504
30	2.920	1.631	0.707
35	3.407	2.170	0.941
40	3.894	2.778	1.204
45	4.380	3.455	1.498
50	4.867	4.200	1.821
60	5.840	5.887	2.552
70	6.814	7.832	3.395
80	7.787	10.030	4.348
90	8.761	12.474	5.408
100	9.734	15.162	6.573
125	12.168	22.921	9.936

14 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
500	1.196	0.036	0.016
750	1.794	0.077	0.033
1000	2.392	0.131	0.057
1250	2.990	0.198	0.086
1500	3.588	0.277	0.120
2000	4.784	0.473	0.205
2500	5.980	0.714	0.310
3000	7.175	1.001	0.434
3500	8.371	1.332	0.578
4000	9.567	1.706	0.740
4500	10.763	2.122	0.920
5000	11.959	2.579	1.118
5500	13.155	3.077	1.334
6000	14.351	3.615	1.567
6500	15.547	4.193	1.818
7000	16.743	4.810	2.085

2 1/2 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
5	0.342	0.025	0.011
7	0.479	0.047	0.020
10	0.684	0.090	0.039
15	1.025	0.191	0.083
20	1.367	0.326	0.141
25	1.709	0.492	0.213
30	2.051	0.690	0.299
35	2.393	0.918	0.398
40	2.735	1.176	0.510
45	3.076	1.463	0.634
50	3.418	1.778	0.771
60	4.102	2.492	1.080
70	4.786	3.315	1.437
80	5.469	4.245	1.840
90	6.153	5.280	2.289
100	6.836	6.418	2.782
125	8.546	9.702	4.206
150	10.255	13.599	5.895
175	11.964	18.093	7.843
200	13.673	23.169	10.044

16 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
1000	1.831	0.068	0.030
1250	2.289	0.103	0.045
1500	2.747	0.145	0.063
2000	3.662	0.247	0.107
2500	4.578	0.373	0.162
3000	5.493	0.523	0.227
3500	6.409	0.696	0.302
4000	7.324	0.891	0.386
4500	8.240	1.108	0.480
5000	9.155	1.347	0.584
5500	10.071	1.607	0.696
6000	10.987	1.888	0.818
6500	11.902	2.189	0.949
7000	12.818	2.511	1.089
7500	13.733	2.854	1.237
8000	14.649	3.216	1.394
9000	16.480	4.000	1.734
10000	18.311	4.861	2.107

3 in.

Volumetric Flow (gal/min)	Linear Velocity (ft/s)	Friction Head Loss (ft water/100 ft)	Friction Pressure (psi/100 ft)
5	0.221	0.009	0.004
7	0.309	0.016	0.007
10	0.442	0.031	0.014
15	0.663	0.066	0.029
20	0.883	0.113	0.049
25	1.104	0.170	0.074
30	1.325	0.238	0.103
35	1.546	0.317	0.138
40	1.767	0.406	0.176
45	1.988	0.505	0.219
50	2.208	0.614	0.266
60	2.650	0.861	0.373
70	3.092	1.145	0.496
80	3.533	1.466	0.636
90	3.975	1.824	0.791
100	4.417	2.217	0.961
125	5.521	3.351	1.453
150	6.625	4.698	2.036
175	7.729	6.250	2.709
200	8.834	8.003	3.469
250	11.042	12.099	5.245
300	13.250	16.958	7.351

Thermal Expansion and Thermal Stresses

It is important to consider thermal expansion when designing a system with Corzan pipe. Most thermoplastics have a coefficient of thermal expansion which is significantly higher than those of metals. The thermal expansion of a piping system subject to a temperature change can therefore be significant, and may need compensation in the system design. The expansion or contraction of thermoplastic pipe may be calculated from the following formula:

Thermal Expansion Formula

$$\Delta L = L_p C \, \Delta T$$

Where: ΔL = Change in length due to change in temperature (in.)

L_p = Length of pipe (in.)

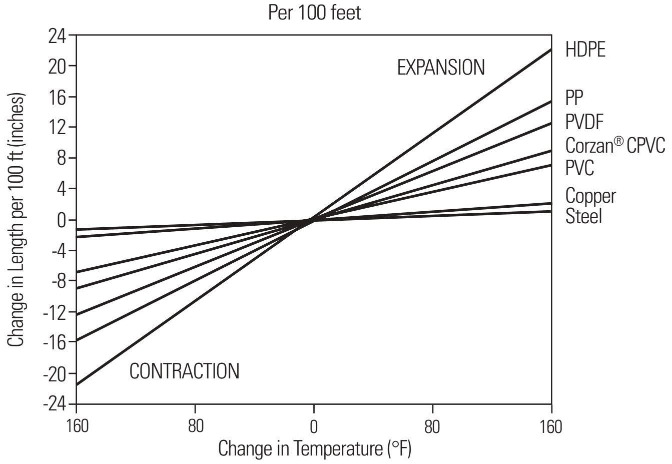
C = Coefficient of thermal expansion (in./in./°F)

= 3.4×10^{-5} in./in./°F for CPVC

ΔT = Change in temperature (°F)

The thermal expansion and contraction of CPVC and other piping materials is displayed below.

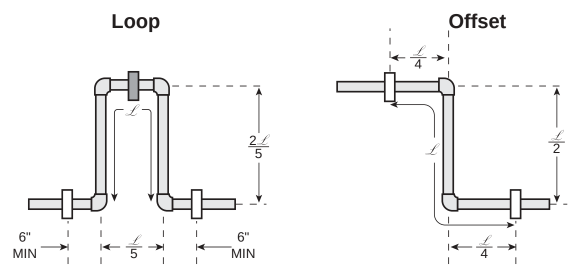
Thermal Expansion of Piping Materials



Expansion Loops and Offsets

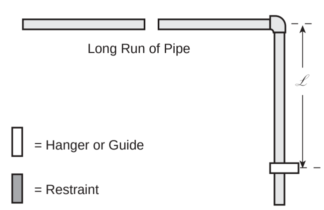
As a rule of thumb, if the total temperature change is greater than 30°F (17°C), compensation for thermal expansion should be included in the system design. The recommended method of accommodating thermal expansion is to include expansion loops, offsets, or changes in direction where necessary in the system design.

An expansion loop schematic is presented here.



Do not butt-up against fixed structure

Change of Direction



Expansion Loop and Offset Configuration

Thermal Expansion and Thermal Stresses (cont.)

Expansion Loop Formula

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

Where: $\mathcal{L}$ = Loop length (in.)
E = Modulus of elasticity at maximum temperature (psi)
S = Working Stress at maximum temperature (psi)
D = Outside diameter of pipe (in.)
ΔL = Change in length due to change in temperature (in.)

Modulus of Elasticity and Working Stress for CPVC

Temperature (°F)	Modulus, E (psi)	Stress, S (psi)
73	423,000	2000
90	403,000	1800
110	371,000	1500
120	355,000	1300
140	323,000	1000
160	291,000	750
180	269,000	500

Expansion loops and offsets should be constructed with straight pipe and 90° elbows which are solvent cemented together. If threaded pipe is used in the rest of the system, it is still recommended that expansion loops and offsets be constructed with solvent cement in order to better handle the bending stresses incurred during expansion. The expansion loop or offset should be located approximately at the midpoint of the pipe run and should not have any supports or anchors installed in it. Valves or strainers should not be installed within an expansion loop or offset.

Thermal Stresses

If thermal expansion is not accommodated, it is absorbed in the pipe as an internal compression. This creates a compressive stress in the pipe. The stress induced in a pipe which is restrained from expanding is calculated with the following formula:

$$S = E y \Delta T$$

where S = stress induced in the pipe
E = Modulus of elasticity at maximum temperature
y = coefficient of thermal expansion
ΔT = total temperature change of the system

Because the coefficient of thermal expansion of steel is five times lower than that of CPVC, dimensional changes due to thermal expansion will be five times less. However, as can be seen by the equation above, the stresses induced in the piping system due to restrained thermal expansion are dependent on the material's modulus as well as its coefficient of thermal expansion. Because the modulus of steel is approximately 80 times higher than that of CPVC, the stresses resulting from restrained expansion over a given temperature change will be approximately 16 times higher for steel than for CPVC.

For instance, restrained expansion over a 50°F temperature change will produce approximately 600 psi of stress in a CPVC system, but 9800 psi of stress in a steel system. CPVC's relatively more flexible nature will usually allow it to absorb its lower stresses in a buckling or snaking of the line if necessary. Because steel piping is too rigid to buckle, its higher stresses are often transferred to surrounding structures, resulting in damaged supports, anchors, or even abutting walls.

Typical Recommended Maximum Support Spacing (In Feet)*

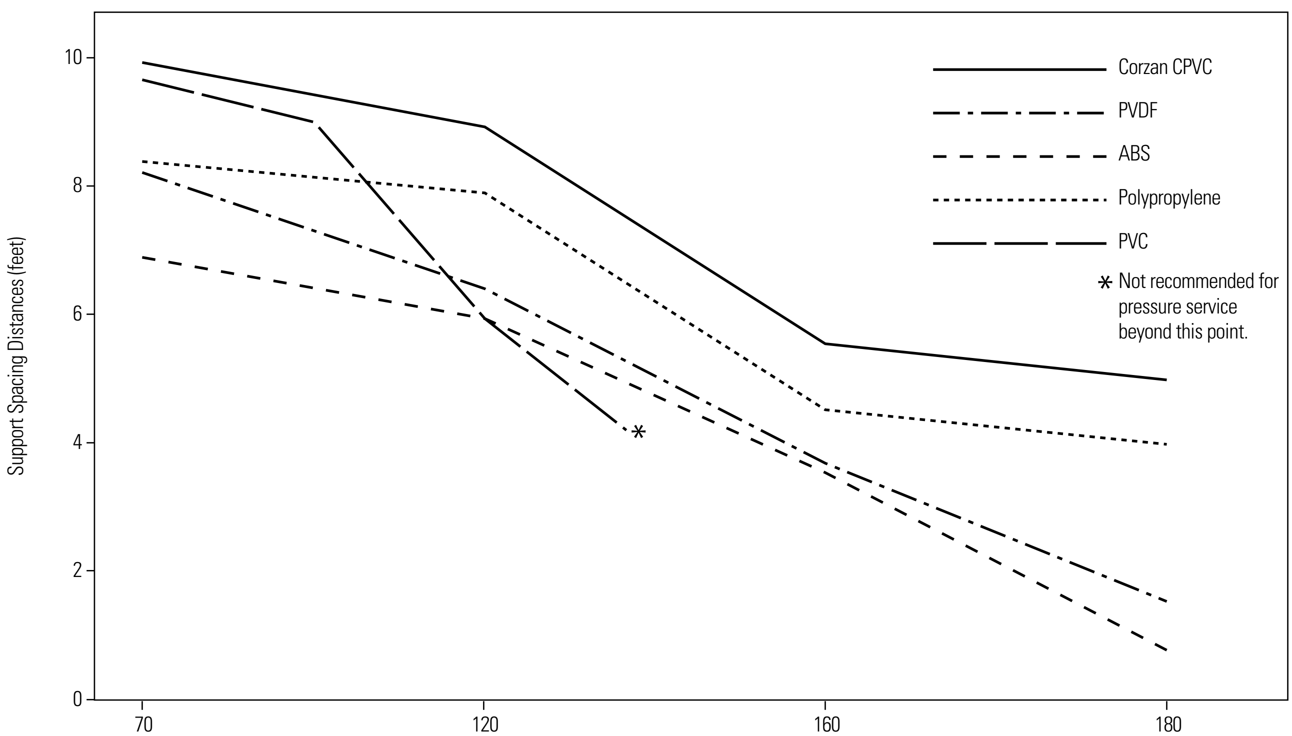
Schedule 80 Corzan Piping Nominal Pipe Size

Temp°F	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	6"	8"	10"	12"	14"	16"
73	5½	5½	6	6½	7	7	8	8	9	10	11	11½	12½	15	16
100	5	5½	6	6	6½	7	7½	8	9	9½	10½	11	12½	13½	15
120	4½	5	5½	6	6	6½	7½	7½	8½	9	10	10½	11	12½	13½
140	4½	4½	5	5½	5½	6	6½	7	7½	8	9	9½	10½	11	12
160	3	3	3½	3½	3½	4	4½	4½	5	5½	6	6½	7½	9½	10
180	2½	2½	3	3	3½	3½	4	4	4½	5	5½	6	6½	8	8½

*Chart based on spacing for continuous spans and for uninsulated lines conveying fluids of specific gravity up to 1.0. For specific gravities greater than 1.0, the support spacing from the table provided should be multiplied by the following correction factors:

Specific Gravity	1.0	1.1	1.2	1.4	1.6	2.0	2.5
Correction Factor	1.00	0.98	0.96	0.93	0.90	0.85	0.80

Support Spacing for 6 Inch Diameter, Schedule 80 Thermoplastic Systems



*Typical Recommended Maximum Support Spacing (In Feet)**

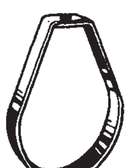
Schedule 40 Corzan Piping Nominal Pipe Size

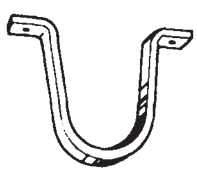
Temp°F	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"	6"	8"	10"	12"	14"	16"
60	5	5½	6	6	6½	6½	7½	8	8½	9½	9½	10	10½	12	13
80	5	5	5½	5½	6½	6	7	7	7½	8½	8½	9½	10½	11	12
100	4½	5	5½	5½	6½	6	7	7	7½	8	8	9	10	10	11
120	4½	4½	5	5½	5½	5½	6½	7	7	7½	7½	8	9	9	9½
140	4	4	4½	5	5	5	6	6	6½	7	7	7½	8	8	8½
180	2½	2½	2½	3	3	3	3½	3½	4	4½	5	5½	6	6¼	7

*Chart based on spacing for continuous spans and for uninsulated lines conveying fluids of specific gravity up to 1.0. For specific gravities greater than 1.0, the support spacing from the table provided should be multiplied by the following correction factors:

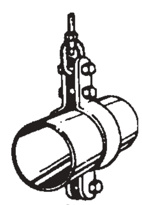
Specific Gravity	1.0	1.1	1.2	1.4	1.6	2.0	2.5
Correction Factor	1.00	0.98	0.96	0.93	0.90	0.85	0.80

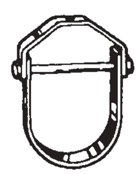
Pipe Hangers, Clamps, & Supports

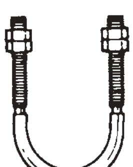

Band Hanger

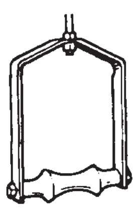

Anchor Strap

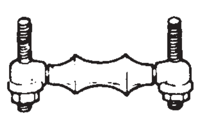

Pipe Clamp

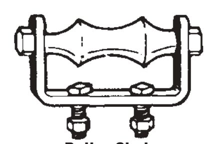

Pipe Clamp

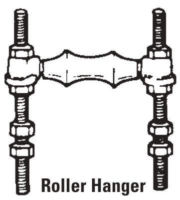

Clevis Hanger

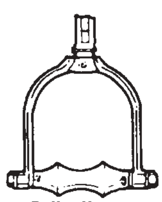

U-Bolt

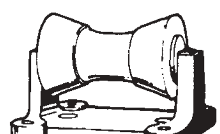

Roller Hanger


Roller Hanger


Roller Chair


Roller Hanger


Roller Hanger


Roller Stand

Source: Courtesy Piping Technology & Products, Inc., Houston, Texas

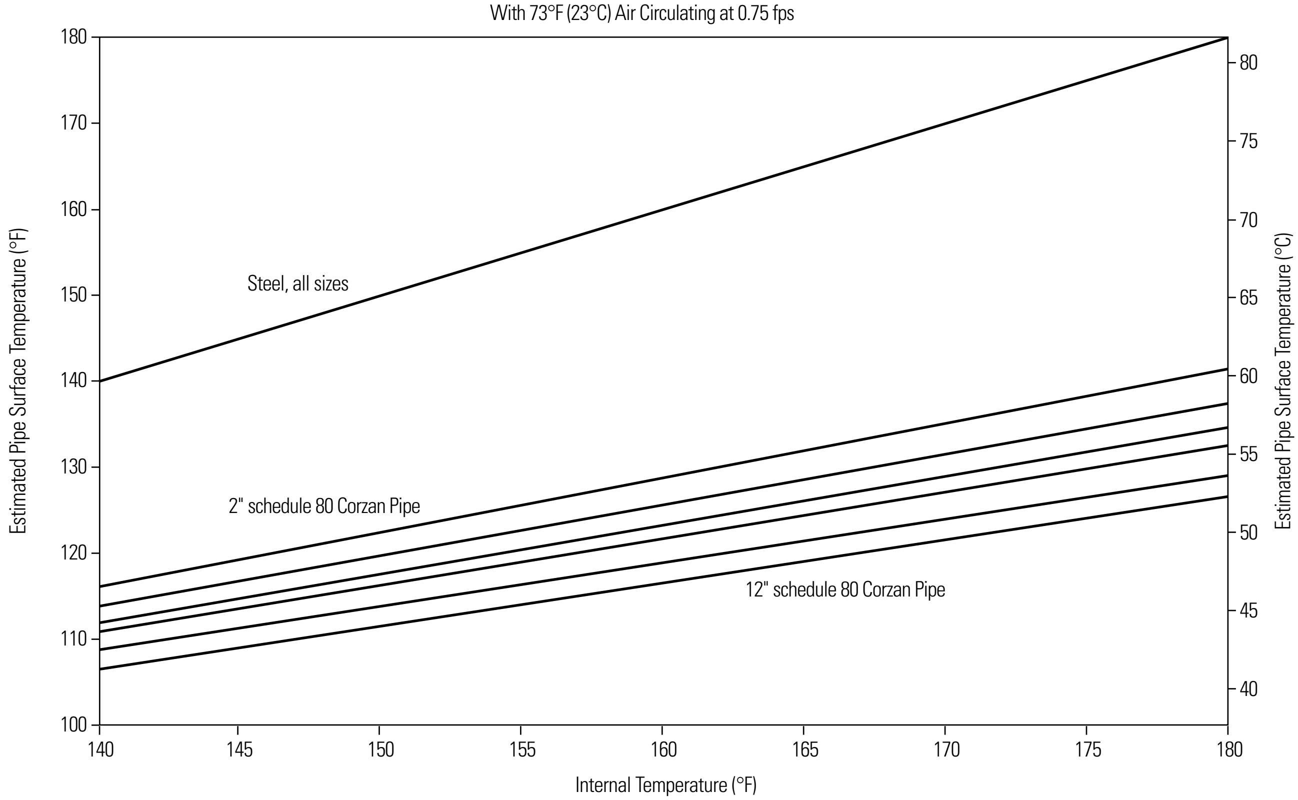
Thermal Conductivity of Corzan CPVC

Corzan CPVC has a very low thermal conductivity value, approximately 1/300th that of steel. A prudent practice to ensure worker safety is to insulate pipes which have exterior surface temperatures greater than 140°F. Because metal pipes have such a high thermal conductivity, the exterior surface temperature is approximately equal to the temperature of the fluid being conveyed. Therefore, pipes carrying fluids at temperatures of 140°F or more should be insulated if there is the possibility of worker contact. This generates more cost in the initial installation of a system and makes periodic inspections of the pipe more difficult. Because CPVC has a much lower thermal conductivity, the surface temperature of CPVC pipe is significantly lower than the internal fluid temperature. Insulation is therefore often not needed on Corzan pipe. The figure below shows the approximate pipe surface temperature as a function of internal fluid temperature for a piping system and with 73°F air circulating at 0.75 feet per second. Corzan pipe sizes of 2, 4, 6, 8, 10, and 12" Schedule 80 are represented. This figure is intended to demonstrate the significant difference between steel and CPVC pipe, but should not be used for system design. The actual surface temperature of pipe in a working system is dependent on many factors, including ambient temperature, air circulation velocity and direction, etc.

CPVC's low thermal conductivity also means that energy in the process stream is conserved. The rate of heat transfer through CPVC piping is typically 50-60% that of steel piping.

Estimated Pipe Surface Temperature vs. Internal Fluid Temperature

With 73°F (23°C) Air Circulating at 0.75 fps



General Installation Guidelines

Proper installation of Corzan piping systems is critical to the performance of the system. A few simple guidelines should be followed to ensure long service life and safe operation.

Handling

Proper care should be exercised when transporting or installing Corzan piping to prevent damage. Corzan piping should be stored and shipped only with other non-metallic piping. It should not be dropped or dragged during handling, especially during extremely cold weather. The same treatment should apply to the handling of Corzan fittings.

Prior to actual installation, the pipe and fittings should be thoroughly inspected for cracks, gouges, or other signs of damage. Particular attention should be given to the inside surface of the part. While the outside surface may not exhibit damage, improper handling can result in damage that appears only on the inside surface of the part.

Cutting

Lengths of pipe can be easily and successfully cut by following a few simple guidelines. Best results are obtained by using fine-toothed saw blades (16 to 18 teeth per inch) with little or no offset (0.025" max.). Circular power saws (6,000 rpm) or band saws (3,600 ft./min.) are recommended using ordinary hand pressure. Miter boxes or other guide devices are strongly recommended for manual operation to ensure square cuts. Burrs, chips, and dust should be removed following cutting to prevent contamination of the piping system and facilitate joining.

Joining Methods

Corzan piping can be installed using a number of joining techniques. Solvent welding, flanging, and threading are the more common methods and are covered in greater detail in this section. Back welding of joints using hot gas welders is also covered in some detail. Less common joining methods are also possible with Corzan piping and fittings, including butt fusion and Victaulic techniques. Contact Noveon or the Corzan piping manufacturers for assistance with less common joining methods.

Hanging/Laying of Pipe

Corzan piping can be installed above ground or buried underground. Methods to minimize stress on the piping as a result of installation are covered in detail below.

System Stress

Any metal or non-metal piping system is subject to stress-induced corrosion. As a result, special attention should be given to minimizing stress throughout the system. The total stress on a piping system includes not only the known pressure stress, but also stresses from sources such as expansion or installation. Expansion stresses can be minimized with expansion joints or loops. Installational stresses are minimized with careful installation techniques. Pipe and fittings should be properly prepared when joints are made up. Hangers and supports should be properly spaced to prevent sagging and should not cut into the pipe or clamp it tightly, preventing movement. System components should not be forced into place.

Thermal Expansion

Corzan piping has the lowest coefficient of thermal expansion of any thermoplastic piping. However, thermal expansion will be greater than that of metal piping. Typically, expansion loops or offsets in the piping are designed to account for any thermal expansion. These design methods are covered in detail in Section 4.8. Expansion joints can also be installed. Information on expansion joints can be obtained by contacting Noveon or Corzan piping manufacturers.

Testing the Piping System

After the piping system is installed and any solvent cement is fully cured, the system should be pressure tested and checked for leaks using water. Testing using compressed air or inert gas is not recommended. All entrapped air should be allowed to vent as the system is filled with water. Water filling should occur at a velocity not more than 1ft/sec. After filling, the system should be pressured to 125% of the maximum design pressure of the lowest rated part of the system. Pressure should be held for no more than one hour while the system is checked for leaks.

Joining Corzan Pipe and Fittings – Solvent Cementing

Cutting

Corzan pipe can be easily cut with a ratchet cutter, wheel-type plastic tubing cutter, power saw, or fine-toothed saw. To ensure the pipe is cut square, a mitre box must be used when cutting with a saw. Cutting the pipe as squarely as possible provides the maximum bonding surface area.

Chamfering and Deburring

Burrs and filings can prevent proper contact between the pipe and fitting and may put undue stress on the pipe and fitting assembly. Burrs and filings must be removed from the outside and inside of the pipe. A chamfering tool or file is suitable for this purpose. A slight bevel should 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. For pipe sizes 2 inches and larger a 10°-15° chamfer of 3/32" is recommended.

Fitting Preparation

Loose soil and moisture should be wiped from the fitting socket and pipe end with a clean, dry rag. Moisture can slow the curing, and at this stage of assembly excessive water can reduce the joint strength. The dry fit of the pipe and fitting should be checked. The pipe should enter the fitting socket easily 1/3 to 2/3 of the depth. If the pipe bottoms in the fitting with little interference, extra solvent cement should be used to prepare the joint.

Primer Application

Primer is needed to prepare the bonding area for the addition of the cement and subsequent assembly. It is important that a proper applicator be used. A dauber, swab or paintbrush approximately half the size of the pipe diameter is appropriate. A rag should not be used. Primer is applied to both the outside of the pipe end and inside of the fitting socket, redipping the applicator as necessary to ensure that the entire surface of both is tacky.

Solvent Cement Application

Solvent cement must be applied when the pipe surface is tacky, not wet, from primer. Joining surfaces must be penetrated and softened. Cement should be applied with a natural bristle brush or swab half the size of the pipe diameter. A dauber may be used to apply cement on pipe sizes below 2 inches. A heavy, even coat of cement should be applied to the outside of the pipe end, and a medium coat should be applied to the inside of the fitting socket. Pipe sizes greater than 2 inches should receive a second coat of cement on the pipe end.

Assembly

After cement application, the pipe should immediately be inserted into the fitting socket and rotated 1/8 to 1/4 turn until the fitting-stop is reached. The fitting should be properly aligned for installation at this time. The pipe must meet the bottom of the fitting socket. The assembly should be held in place for 10 to 30 seconds to ensure initial bonding and to avoid pushout. 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. In this case, the fitting should be discarded and the joint reassembled. Cement in excess of the bead may be wiped off with a rag.

Set and Cure Times

Solvent cement set and cure times are a function of 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 factors just discussed. Following the initial set period, the assembly can be handled carefully avoiding significant stresses to the joint. Refer to the following table for minimum cure times prior to testing.

Extra care should be exercised when systems are assembled in extreme temperature conditions. Extra set and cure times should be allowed when the temperature is below 40°F (4°C). When the temperature is above 100°F (38°C), the assembler should ensure that both surfaces to be joined are still wet with cement before joining them.

Joining Corzan Pipe and Fittings – Solvent Cementing (cont.)

Recommended Set Times

After a joint is assembled using solvent cement, it should not be disturbed for a period of time to allow for proper "setting" of the newly prepared joint. Recommended set times are as follows:

Ambient Temperature	to 1¼"	1½" to 3"	4" to 8"	10" to 12"
60° to 110°F	15 min	30 min	1 hr	2 hr
40° to 60°F	1 hr	2 hr	4 hr	8 hr
0° to 40°F	3 hr	6 hr	12 hr	24 hr

Recommended Cure Times

After a joint is assembled using solvent cement, the cement must be allowed to properly "cure" before the piping system is pressurized. Recommended minimum cure times are shown below. These recommendations should only serve as a guide since atmospheric conditions during installation will affect the curing process.

High humidity and/or colder weather will require longer cure times: typically add 50% to the recommended cure time if surroundings are humid or damp.

CURE TIME FOR OPERATING/ TEST PRESSURES TO 180 PSIG

Ambient Temperature	to 1¼"	1½" to 3"	4" to 8"	10" to 12"
60° to 110°F	1 hr	2 hr	6 hr	24 hr
40° to 60°F	2 hr	4 hr	12 hr	40 hr
0° to 40°F	8 hr	16 hr	48 hr	8 days

CURE TIME FOR OPERATING/ TEST PRESSURES ABOVE 180 PSIG**

Ambient Temperature	to 1¼"	1½" to 3"	4" to 8"	10" to 12"
60° to 110°F	6 hr	6 hr	24 hr	24 hr
40° to 60°F	12 hr	24 hr	48 hr	40 hr
0° to 40°F	48 hr	96 hr	8 days	8 days

**DO NOT exceed maximum working pressure of piping for given pipe size and operating temperature

Threading of Corzan Schedule 80 Pipe

Corzan Schedule 80 pipe up to and including 4" in diameter, and which will operate at 130°F or less, may be threaded. The threads should be in accordance with ANSI B1.20.1 Taper Pipe Thread. Threaded joints are derated to 50% of the pressure rating of the Schedule 80 pipe at the operating temperature. Schedule 40 pipe, Schedule 80 pipe larger than 4," or piping for systems which will operate at a temperature greater than 130°F should not be threaded. Flanges, unions, or Victaulic couplings may be used where occasional disassembly is required.

Pipe to be threaded should be squarely cut with a hand saw or power saw. A mitre box should be used when pipe is cut by hand. A fine-toothed blade (16-18 teeth per inch) works best for cutting plastics. Burrs should be removed from the cut end of the pipe with a knife or similar tool. A slight chamfer on the pipe end will speed threading. A tapered plug should be inserted into the pipe before threading to provide additional support and prevent distortion of the pipe or threads. The pipe should be held in a pipe vise, but saw-toothed jaws should not be used. A rubber sheet or some other type of material may be used to protect the pipe from the rough edges of the pipe vise.

The dies used for cutting threads on Corzan pipe should be clean, sharp, and in good condition. They should be reserved for use only on plastic materials. Pipe threading dies should have a 5° negative front rake when power threading machines are used, and a 5°-10° negative front rake when pipes are threaded by hand. When power threading equipment is used, the dies should not be driven at high speeds or with heavy pressure. Soap and water solutions or water soluble machine oils are suitable cutting lubricants for Corzan pipe.

The threads may be checked with a ring gauge to ensure accuracy. The gauging tolerance is +/- 1½ turns.

Threaded parts must be prepared for assembly by brushing away cutting debris from the threads. Degreasing solvents should never be used to clean CPVC threads.

Teflon tape is the recommended thread sealant for Corzan threaded parts. Many Teflon paste thread sealants are also suitable, although some contain components which may contribute to cracking of the pipe or fitting. The supplier of the paste should be consulted to determine its compatibility with Corzan CPVC. Solvent cement should never be applied to threaded joints.

After the thread tape has been applied, the threaded fitting may be screwed onto the pipe and tightened hand tight. If desired, a strap wrench may be used to tighten the joint an additional turn. Overtightening of threaded plastic joints will weaken the joint. When Corzan pipe or fittings are connected to metal with a threaded joint, the Corzan pipe or fittings should have male threads, and the metal should have female threads.

Flanging of Corzan Pipe

Flanging can be used to provide temporary disassembly of a piping system or when it is not possible to make up solvent cemented joints at the assembly site.

Flanges are joined to the pipe by solvent cement or threaded joints. Refer to the sections on solvent cementing or threading of Corzan pipe for the proper techniques.

Flanged joints incorporate an elastomeric gasket between the mating faces to provide for a seal. The gasket selected must be full-faced and have a hardness of 55-80 durometer A. Typically, gaskets are 1/8″ thick. The gasket material must be resistant to the chemical environment. Many manufacturers of gasketing materials supply this kind of information. If the piping system is for potable water service, the gasket must also be approved for potable water.

The flanges should be carefully aligned and the bolts inserted through matching holes. A flat washer should be used beneath each nut and bolt head. Each bolt should be partially tightened in the alternating sequence indicated in the patterns below. A torque wrench should be used for the final tightening of the bolts. The bolts should be tightened to the torque recommended in the table below in the same alternating sequence used previously.

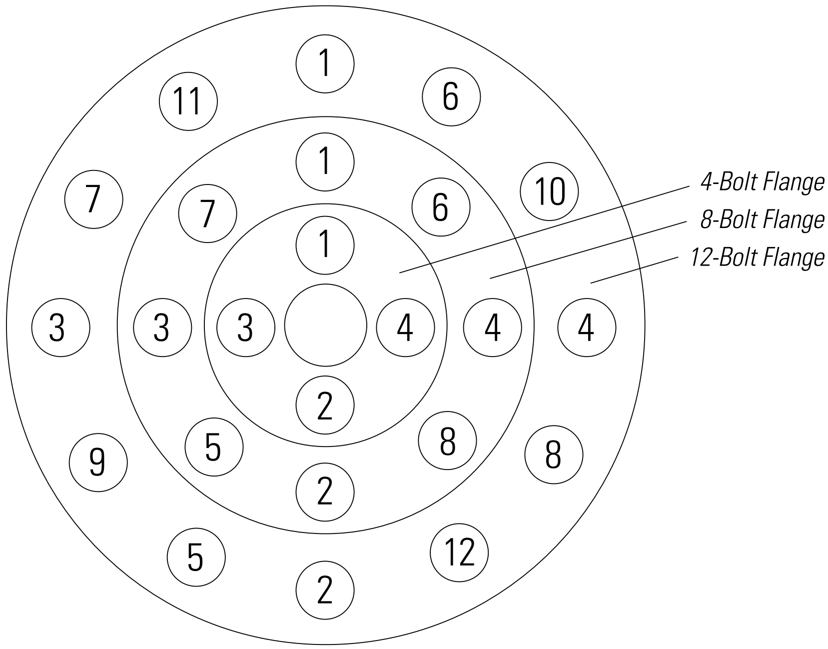
Flange joints are typically rated to 150 psi at 73°F. For systems operating at higher temperatures, the flange pressure rating should be derated per the manufacturer's recommendations.

RECOMMENDED BOLT TORQUE*

Nominal Pipe Size	Number of Bolt Holes	Bolt Diameter (in)	Recommended Torque (ft-lbs)
½ - 1½	4	1/2	10-15
2 - 3	4	5/8	20-30
4	8	5/8	20-30
6	8	3/4	33-50
8	8	3/4	33-50
10	12	7/8	53-75
12	12	1	80-110′

*Information given as guidelines only. Consult the manufacturer's literature for flange requirements.

Flange Bolt Tightening Patterns



Back-Welding of Pipe Joints

Back-welding may be used to repair minor leaks in solvent cemented or threaded joints. Back-welding is a hot-air welding technique which consists of forcing a welding rod to fuse in the joint fillet while both rod and fillet are softened with hot air.

Before hot-air welding begins, the section of piping where the repair will be made must be emptied. Joints should not be welded with fluid still in the pipe.

All dirt and moisture should be wiped away from the joint to be repaired. Excess dried solvent cement around the joint should be removed with an emery cloth. Residual solvent cement may tend to scorch and burn during welding. If the joint to be welded is a threaded joint, excess threads in the joint area should be removed with a file in order to provide a smooth surface for welding.

If a speed tip will be used for back-welding, refer to this manual's section on fabrication with high speed hot air welding for the proper conditions and techniques to use.

If welding will be done by feeding the rod manually, the following conditions and procedures should be used:

The welding temperature should be approximately 550-600°F. Only welding rod made of Corzan CPVC should be used for back welding CPVC joints.

The end of the welding rod should be inserted into the junction of the pipe and fitting, and the rod should be held at a 90° angle to the joint. The rod and base material should be preheated with the welding torch 1/4 to 3/4 inch away from both the rod and the base material and fanning back and forth in the immediate welding area. While preheating, the rod can be moved up and down until it is soft enough to stick to the base.

When the materials are softened enough to fuse, the rod should be advanced by the application of a slight pressure. The fanning motion of the torch should be continued throughout the welding process. When the weld is finished, another inch of rod material should be lapped over the bead.

When large diameter pipe is welded, three beads may be required to fill the joint adequately. The first bead should be laid directly into the joint fillet, and the subsequent beads on either side of the first bead.

Underground Installation Guidelines

References

These guidelines are based upon the following:

1. ASTM D2774: Standard Recommended Practice for Underground Installation of Thermoplastic Piping
2. Piping Manufacturer's Installation Instructions
3. Industry Experience

For additional information and data, consult ASTM standards D2774, D2321, or F645.

Installation Procedures

This procedure will cover the typical steps encountered in underground installations: trench design, trench preparation, piping assembly, laying of pipe, and backfilling.

Trench Design

Width: The trench should be of adequate width to allow for convenient installation, but as narrow as possible depending on whether the piping will be assembled inside or outside of the trench.

Depth: The trench depth should be sufficient to place the pipe deep enough to meet frost, above-ground load, and any trench bedding requirements.

Frost: Piping at least 12 inches below the frost line.

Loads: Piping should be deep enough to keep external stress levels below acceptable design stress. Design stress will be determined by pipe size and operating temperature and may be governed by various codes.

Bedding: 4 to 6 inches underneath piping, if necessary (see below)

Trench Preparation

The trench bottom should be continuous, relatively smooth and free of rocks. If ledge rock, hardpan, boulders, or rocks that are impractical to remove are encountered, it will be necessary to pad the trench bottom to protect the piping from damage. 4 to 6 inches of tamped earth or sand bedding will be sufficient in such situations.

Piping Assembly/Placement

Piping may be assembled using conventional solvent cementing techniques either inside or outside of the trench depending on the specific installation requirements. Solvent cement usually requires at least 12 to 24 hours for the cemented joint to cure properly. During this critical curing process, every effort should be made to minimize the stress on any joints. As a result, the piping should not be moved during the curing period, nor should the pipe be backfilled, or otherwise constrained during curing. See the recommendations on joint curing time to determine the exact curing requirements for a specific installation.

If the piping was assembled outside of the trench, the pipe may be placed into the trench after proper curing, but *MUST NOT* be rolled or dropped into place. Long lengths of joined piping should be properly supported as the piping is put into place to prevent excessive stress.

After proper curing and before backfilling, the piping should be brought to within 15°F of the expected operating temperature. Backfilling can proceed while the piping is maintained at this temperature in order to minimize stress on the system due to thermal expansion/contraction. If this step is impractical, then stress calculations must be done to determine the loads that will be created due to constrained thermal expansion/contraction.* These loads must then be compared to the design stress of the particular piping system.

*Refer to page 4.9 for the calculation for the stress developed when thermal expansion is constrained.

Underground Installation Guidelines (cont.)

Backfilling

Backfilling should only proceed after all solvent cement joints have been properly cured and the piping brought close to normal operating temperature, if operation will be more than 15°F different than the current ambient temperature. The piping should be uniformly supported over its entire length on firm, stable material.

Backfill material should be free of rocks and have a particle size no greater than 1/2." Piping should initially be surrounded with backfill to provide between 6" and 8" of cover. The backfill should be compacted using vibratory or water flooding methods. If water flooding is used, additional material should not be added until the water flooded backfill is firm enough to walk on. Backfill containing a significant amount of fine-grained material, such as silt or clay, should be hand or mechanically tamped.

The remainder of the backfill should be placed and spread in approximately uniform layers to completely fill the trench without voids. Particle size for this final fill should not exceed 3". Rolling equipment or heavy tampers should only be used to consolidate the final backfill.

Corzan Ducting Systems

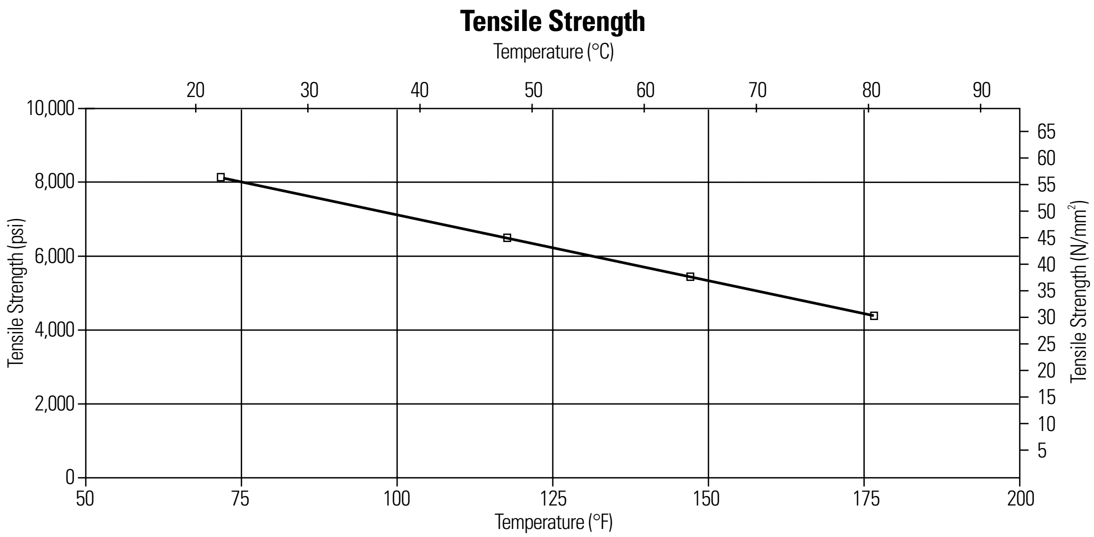
With increasing regulation of air emissions, the need for reliable fume handling systems, especially in corrosive environments, is growing rapidly. To meet this demand Corzan Industrial Systems offer the same outstanding balance of properties in round duct, fabricated duct fittings, industrial sheet, and welding rod. As a result, these properties can be designed and fabricated into entire fume handling systems.

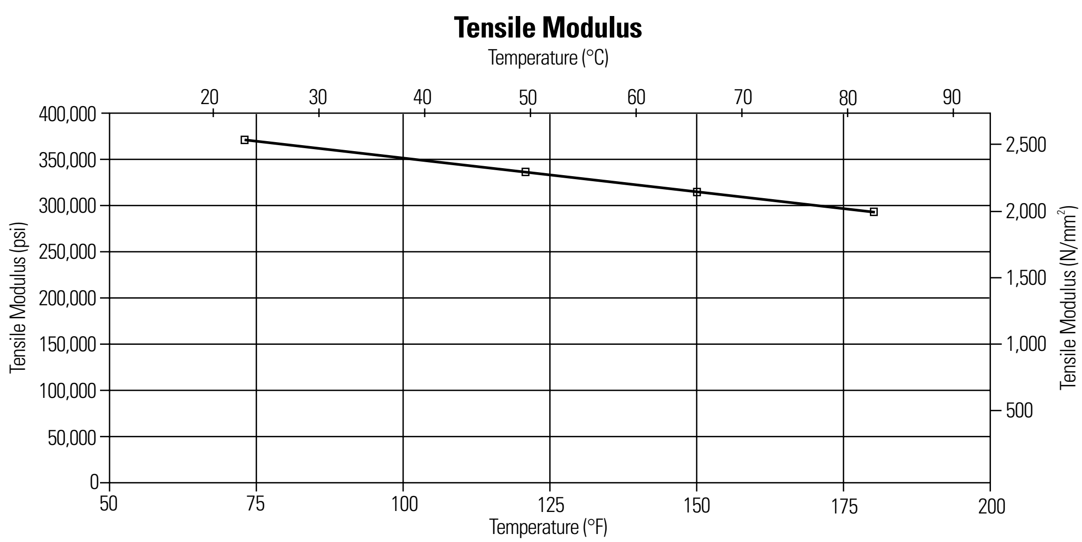
Round duct and fittings are available in sizes up to 24". For larger size systems, Corzan industrial sheet can be fabricated into square or round duct using techniques described in greater detail in the fabrication section of this manual. Corzan ducting systems can also be connected with fume scrubbers or other emission control equipment made of Corzan CPVC to ensure excellent corrosion resistance throughout the entire system.

Property	Test	Condition	English Units	SI Units
GENERAL				
Specific Gravity	ASTM D792	73°F/23°C		1.55
Specific Volume		73°F/23°C	.0103 ft^3/lb	0.645 cm^3/g
Water Absorption	ASTM D570	73°F/23°C	+0.03%	+0.03%
		212°F/100°C	+0.55%	+0.55%
Rockwell Hardness	ASTM D785	73°F/23°C	119	
Cell class	ASTM D1784		23437	
MECHANICAL				
*Notched Izod Impact	ASTM D256	73°F/23°C	1.5 ft lb_f/in	80 J/m
*Tensile Strength	ASTM D638	73°F/23°C	8000 psi	55 N/mm^2
*Tensile Modulus	ASTM D638	73°F/23°C	360,000 psi	2500 N/mm^2
*Flexural Strength	ASTM D790	73°F/23°C	15,100 psi	104 N/mm^2
*Flexural Modulus	ASTM D790	73°F/23°C	415,000 psi	2860 N/mm^2
Compressive Strength	ASTM D695	73°F/23°C	10,100 psi	70 N/mm^2
Compressive Modulus	ASTM D695	73°F/23°C	196,000 psi	1350 N/mm^2
THERMAL				
Coefficient of Thermal Expansion	ASTM D696		3.9×10^{-5} in/in/°F	2.2×10^{-5} m/m/K
Thermal Conductivity	ASTM C177		0.95 BTU in/hr/ft^2/°F	0.066 Wm/K/m^2
Heat Distortion Temperature	ASTM D648		217°F	103°C
*Heat Capacity (Specific Heat)	DSC	73°F/23°C	0.21 BTU/lb_m°F	0.90 J/gK
		212°F/100°C	0.26 BTU/lb_m°F	1.10 J/gK
FLAMMABILITY				
Flammability Rating	UL 94	0.062 in/0.157 cm	V-O, 5VB, 5VA	
Flame Spread	ASTM E84		15	
Smoke Developed	ASTM E84		300	
Limiting Oxygen Index	ASTM D2863		60%	
Burning Rate (in/mm)		Self extinguishing		
ELECTRICAL				
Dielectric Strength	ASTM D147		1250 V/mil	492,000 V/cm
Dielectric Constant	ASTM D150	60 Hz, 30°F/-1°C	3.70	3.70
Power Factor	ASTM D150	1000 Hz	0.007%	0.007%
Volume Resistivity	ASTM D257	73°F/23°C	3.4×10^{15} ohm/cm	3.4×10^{15} ohm/cm

*Plots of these properties versus temperature follow this table.

Basic Physical Properties





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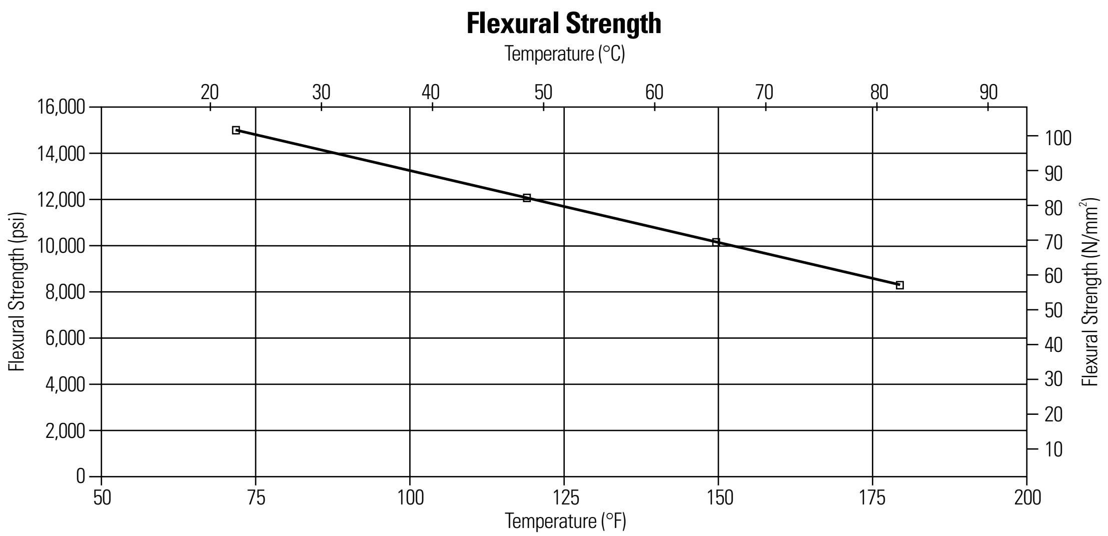

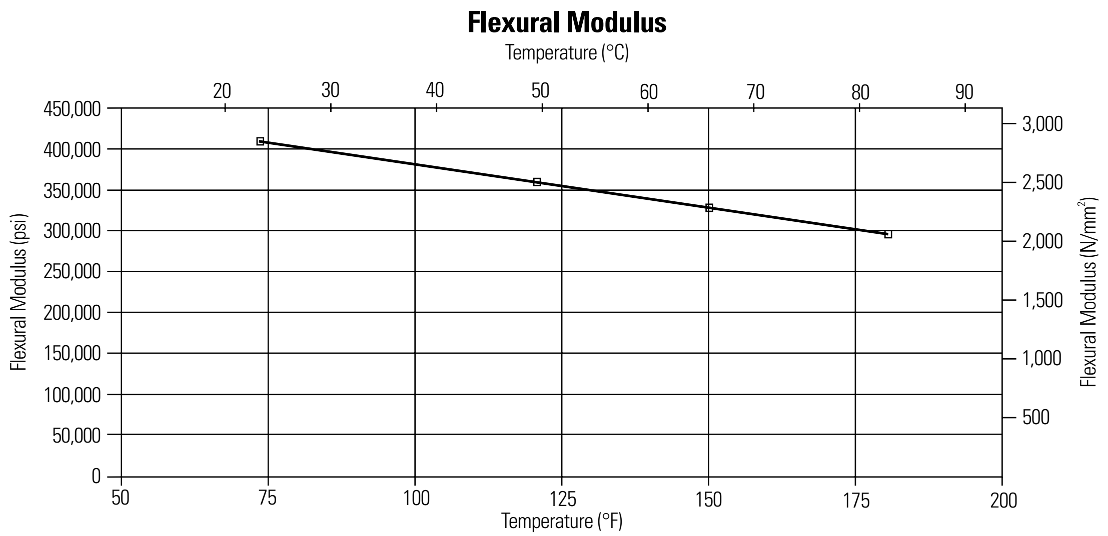

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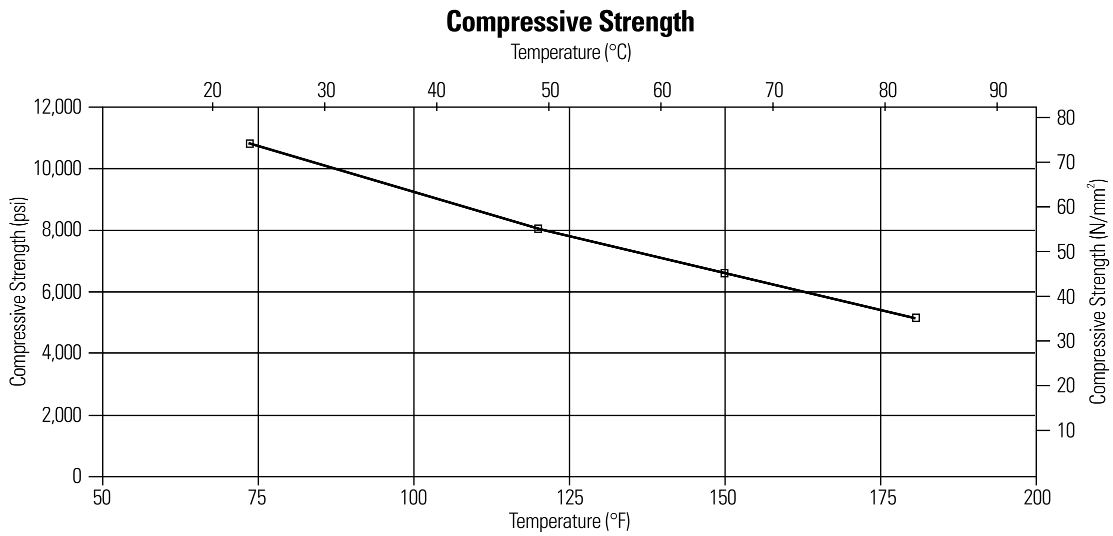

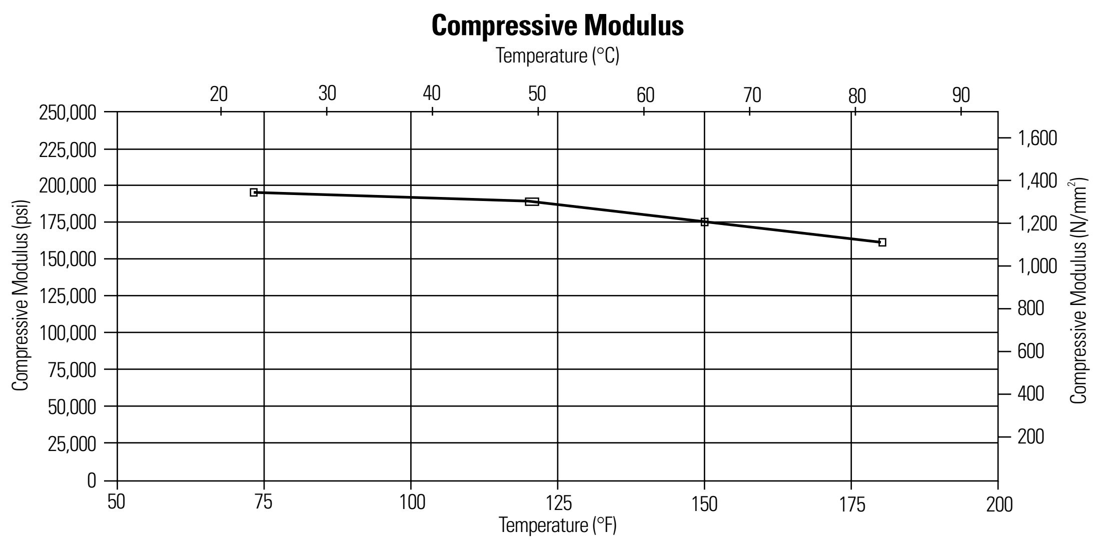

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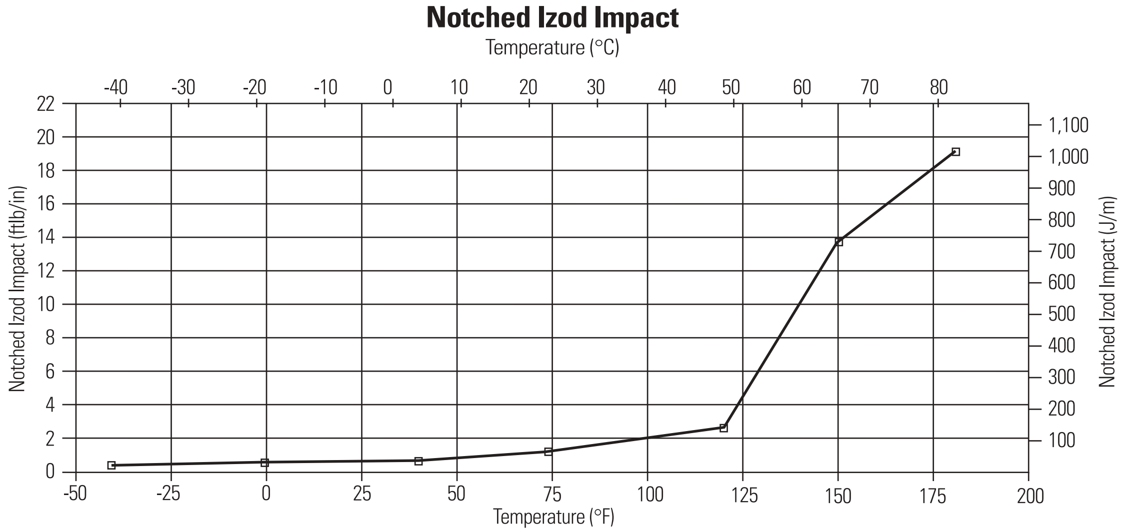

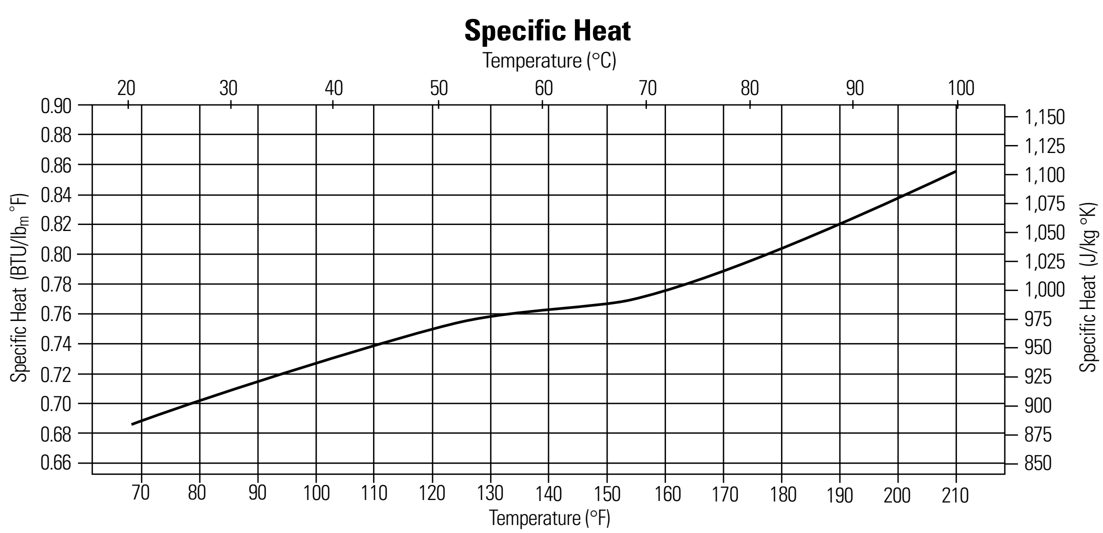

Dimensions

Extruded Duct

Extruded, seamless round duct is available in sizes up to 24" according to the following table:

Size	Avg. OD	Avg. OD Tol.	Out of Round	Min. Wall	Max. Wall	Lbs/ Ft
6"	6.625	+/-.020	+/-.050	.172	.202	2.555
8"	8.625	+/-.020	+/-.075	.172	.202	3.349
10"	10.750	+/-.025	+/-.075	.172	.202	4.192
12"	12.750	+/-.025	+/-.075	.172	.202	4.986
14"	14.000	+/-.030	+/-.075	.172	.202	5.485
16"	16.000	+/-.030	+/-.075	.172	.202	6.273
18"	18.000	+/-.040	+/-.080	.172	.202	7.580
20"	20.000	+/-.070	+/-.140	.199	.239	9.146
24"	24.000	+/-.090	+/-.180	.230	.270	12.536

Fabricated Duct

Round duct larger than 24" should be fabricated from Corzan industrial sheet and butt welded with longitudinal seams. Square duct can also be fabricated by thermal bending Corzan sheet and butt welding with longitudinal seams. Recommendations for butt welding are provided in the Fabrication section of this manual.

Fabricated duct should be made from Corzan sheet according to the following guidelines:

Duct Diameter	Wall Thickness
Up to 20"	1/8"
21" to 41"	3/16" to 1/4"
41" and Larger	1/4" Minimum

Fabricated Fittings

Elbows and bevels should have a minimum centerline radius of 1.5 times the duct diameter.

Product Ratings and Capability

The excellent mechanical properties of Corzan CPVC enable Corzan fume handling systems to withstand higher vacuum loadings and differential pressure conditions compared to traditional materials, especially at elevated temperatures. Testing of CPVC duct by Noveon indicates that Corzan duct will perform well in most conditions encountered in a typical fume handling application.

Negative Pressure

Corzan CPVC Duct performs well when exposed to harsh environments. This was demonstrated by testing conducted at an independent test facility to determine critical collapse pressures. Corzan CPVC Duct was taken to extremes under various negative pressure conditions to validate the product's structural integrity at elevated temperatures when exposed to severe conditions. The negative pressure ratings shown in Table 1 are based on actual testing of round seamless extruded CPVC Duct at various temperatures and incorporate a 1.5:1 safety factor.

Positive Pressure

Corzan CPVC Duct can endure greater levels of positive internal pressure than negative internal pressure. Table 2 shows the maximum recommended internal pressure rating in PSI for Corzan CPVC round seamless extruded Duct at various room temperatures.

TABLE 1
MAX. INTERNAL NEGATIVE PRESSURE RATING
INCHES OF WATER @ VARIOUS TEMPERATURES ˚F

Size	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

TABLE 2
MAX. INTERNAL POSITIVE PRESSURE RATING
PSI @ VARIOUS TEMPERATURES ˚F

Size	Temperature ˚F						
	73	**100**	**120**	**140**	**160**	**180**	**200**
6″	70	56	45	35	26	16	13
8″	53	43	33	26	20	13	10
10″	43	35	28	21	16	10	8
12″	36	30	23	18	15	8	6
14″	33	26	21	16	13	8	6
16″	28	23	18	13	11	6	5
18″	25	20	15	11	10	5	5
20″	26	21	16	13	10	6	5
24″	25	20	15	11	10	5	5

NOTE: Maximum values stated are for extruded duct pipe only, and incorporate a 1.5:1 safety factor. Consideration should be given to system design, method of fabrication, and joining which may require additional system derating. The use of compressed air or gases is not recommended for use with Corzan PVC/CPVC Duct piping.

Installation of Corzan Ducting Systems

Joining Methods

Corzan CPVC 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 Corzan CPVC Duct and system accessories include thermoforming, extrusion 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, homogenous 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 appreciable when compared to heavy wall pipe, the use of extra-heavy-bodied CPVC cement (such as IPS 3461 or equivalent) 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 matting components. The solvent-cementing method is not recommended for any type of end-joining.

Thermal Welding

The hot-air welding technique utilizes clean hot air to preheat the duct material and CPVC 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 Corzan CPVC material is recommended for this joining process to ensure the highest system integrity. All welding should be conducted by personnel adequately trained in the art of hot-air welding thermoplastics. Detailed information concerning Corzan CPVC welding and fabrication is available.

Flanged Systems

For flanged systems, the general recommendations for flange fabrication are as follows:

Flange Thickness	3/16" to 1/4"
Flange Width	1¼" to 2"
Distance Between Bolt Holes	3" to 4"
Bolt Hole Diameter	5/16" to 3/8"
Bolts	1/4" to 5/16"

Hangers and Supports

Corzan CPVC Duct requires fewer supports at elevated temperatures than other thermoplastic duct systems due to its exceptional heat resistance, a significant cost-savings advantage. 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 the 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 in Table 1 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 Table 1 for maximum support spacing of horizontal air-filled duct at various temperatures.

TABLE 1
MAXIMUM HANGER SUPPORT SPACING IN FEET

Size	Temperature °F						
	73	100	120	140	160	180	200
6"	10	10	10	10	10	8	8
8"	10	10	10	10	10	8	8
10"	10	10	10	10	10	10	10
12"	10	10	10	10	10	10	10
14"	12	12	12	12	10	10	10
16"	12	12	12	12	12	10	10
18"	12	12	12	12	12	12	12
20"	12	12	12	12	12	12	12
24"	12	12	12	12	12	12	12

As with any system, Corzan CPVC 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.

Reinforcement

Due to Corzan CPVC Duct's inherent rigidity and heat resistance, additional system reinforcements or flanges are not required for 6" through 24" sizes up to 160°F and 10" of negative internal static pressure, provided proper support spacing requirements are followed. Additional reinforcements are not required for systems under positive pressure.

Hangers and Supports (cont.)

Thermal Expansion and Contraction
The coefficient of linear expansion (y) for Corzan CPVC Duct is 3.9 x 10^{-5} in/in/°F, the lowest thermal expansion rate of commonly used thermoplastics. 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 Corzan CPVC Duct can be calculated as follows:

$\Delta L = L_d C \Delta T$

where: ΔL = expansion or contraction of duct in inches
L_d = Length of duct run in feet
C = 3.9 x 10^{-5} in/in/°F (coefficient of thermal expansion)
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. The effects of thermal expansion and contraction can also be compensated by using the inherent line flexibility of the system to construct expansion loops and offsets where required. Additional detailed information concerning the effects and control of thermal expansion and contraction, and other information pertaining to the design and installation of CPVC piping products, is available from Noveon, Inc.

Industrial Sheet/Lining

The superior corrosion resistance and high temperature performance of Corzan CPVC is available in 48″ x 96″ sheet. The excellent fire performance of Corzan CPVC will also be useful in many sheet applications. Sheet products are available in thicknesses ranging from 1/8″ to 3,″ and are either extruded or compression molded.

The ability to bend, shape, and weld sheet made from Corzan CPVC enables its use in a wide variety of process applications including tanks, scrubbers, and ventilation systems.

Recommendations for fabricating equipment using sheet are covered in the Fabrication section of the design manual. Sheet made from Corzan CPVC can readily be overwrapped with Fiber Reinforced Polyester (FRP), if necessary, and will not require fabric-backing to achieve proper adhesion between the CPVC and FRP.

Refer to the Product Availability section of the design manual for information on where to obtain sheet made from Corzan CPVC.

Property	Test	Condition	English Units	SI Units
GENERAL				
Specific Gravity	ASTM D792	73°F/23°C		1.55
Specific Volume		73°F/23°C	.0103 ft^3/lb	0.645 cm^3/g
Water Absorption	ASTM D570	73°F/23°C	+0.03%	+0.03%
		212°F/100°C	+0.55%	+0.55%
Rockwell Hardness	ASTM D785	73°F/23°C	119	
Cell class	ASTM D1784		23447	
MECHANICAL				
*Notched Izod Impact	ASTM D256	73°F/23°C	1.5 ft lb_f/in	80 J/m
*Tensile Strength	ASTM D638	73°F/23°C	8000 psi	55 N/mm^2
*Tensile Modulus	ASTM D638	73°F/23°C	360,000 psi	2500 N/mm^2
*Flexural Strength	ASTM D790	73°F/23°C	15,100 psi	104 N/mm^2
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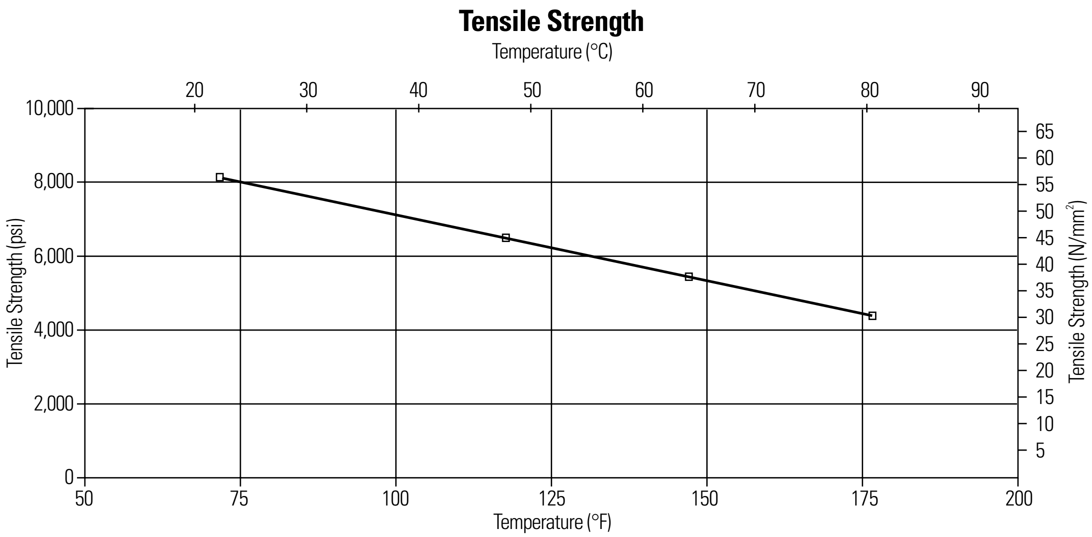
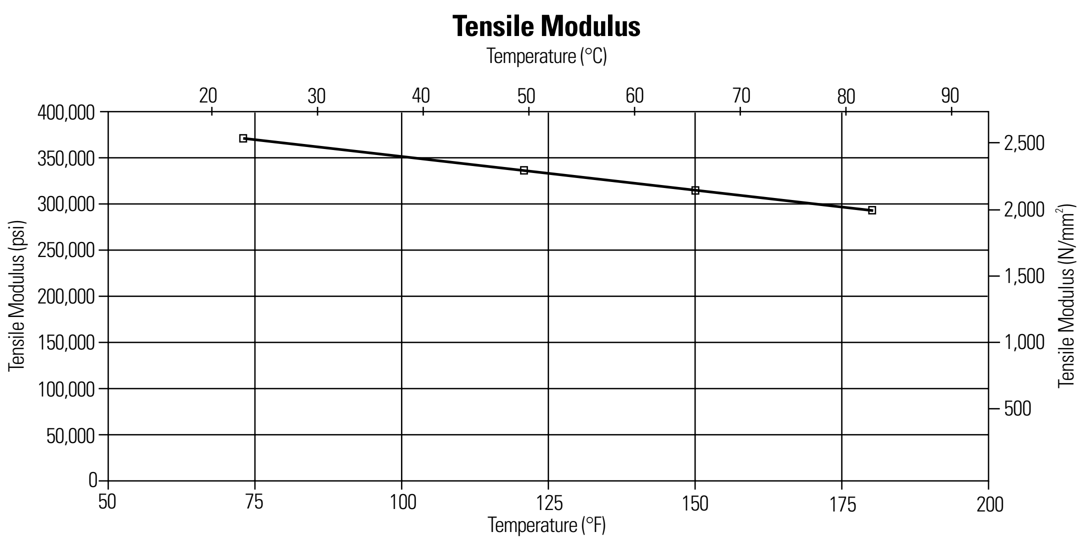
Compressive Strength	ASTM D695	73°F/23°C	10,100 psi	70 N/mm^2
Compressive Modulus	ASTM D695	73°F/23°C	196,000 psi	1350 N/mm^2
THERMAL				
Coefficient of Thermal Expansion	ASTM D696		3.4×10^{-5} in/in/°F	1.9×10^{-5} m/m/K
Thermal Conductivity	ASTM C177		0.95 BTU in/hr/ft^2/°F	0.066 Wm/K/m^2
Heat Distortion Temperature	ASTM D648		217°F	103°C
*Heat Capacity (Specific Heat)	DSC	73°F/23°C	0.21 BTU/lb_m °F	0.90 J/gK
		212°F/100°C	0.26 BTU/lb_m °F	1.10 J/gK
FLAMMABILITY				
Flammability Rating	UL 94	0.062 in/0.157 cm	V-O, 5VB, 5VA	
Flame Spread	ASTM E84		15	
Smoke Developed	ASTM E84		70-125	
Limiting Oxygen Index	ASTM D2863		60%	
ELECTRICAL				
Dielectric Strength	ASTM D147		1250 V/mil	492,000 V/cm
Dielectric Constant	ASTM D150	60 Hz, 30°F/-1°C	3.70	3.70
Power Factor	ASTM D150	1000 Hz	0.007%	0.007%
Volume Resistivity	ASTM D257	73°F/23°C	3.4×10^{15} ohm/cm	3.4×10^{15} ohm/cm

*Plots of these properties versus temperature follow this table.

Basic Physical Properties





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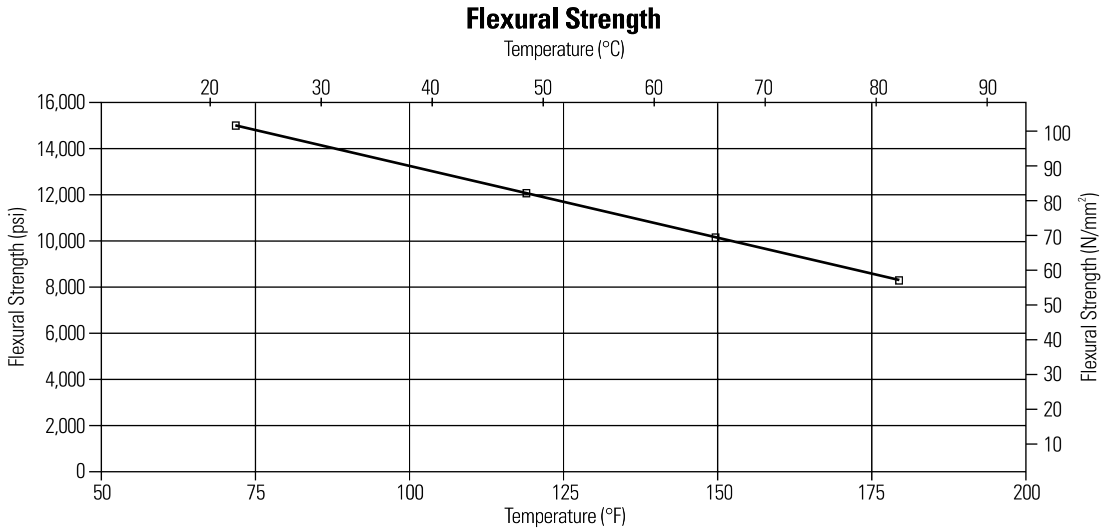

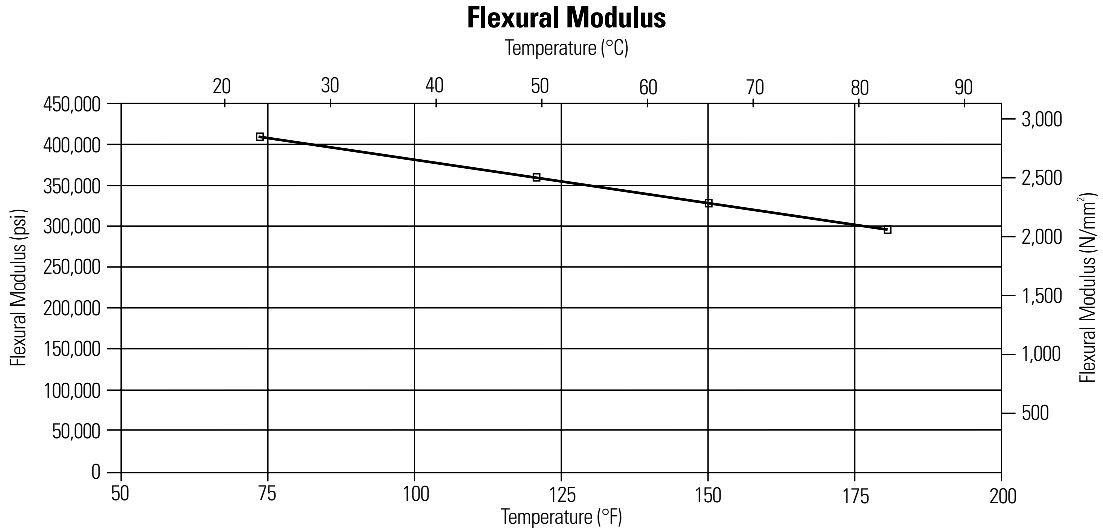

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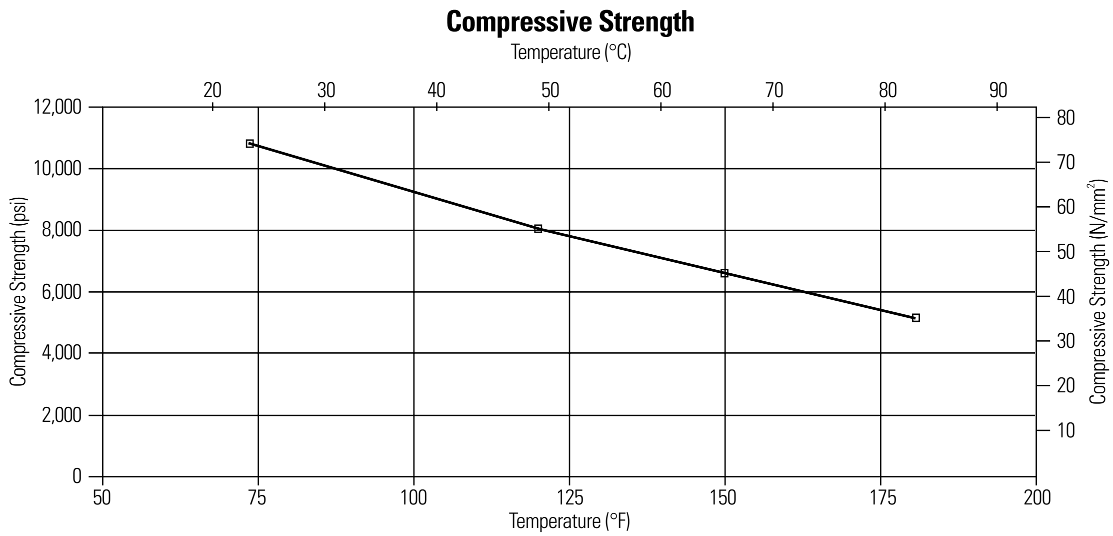

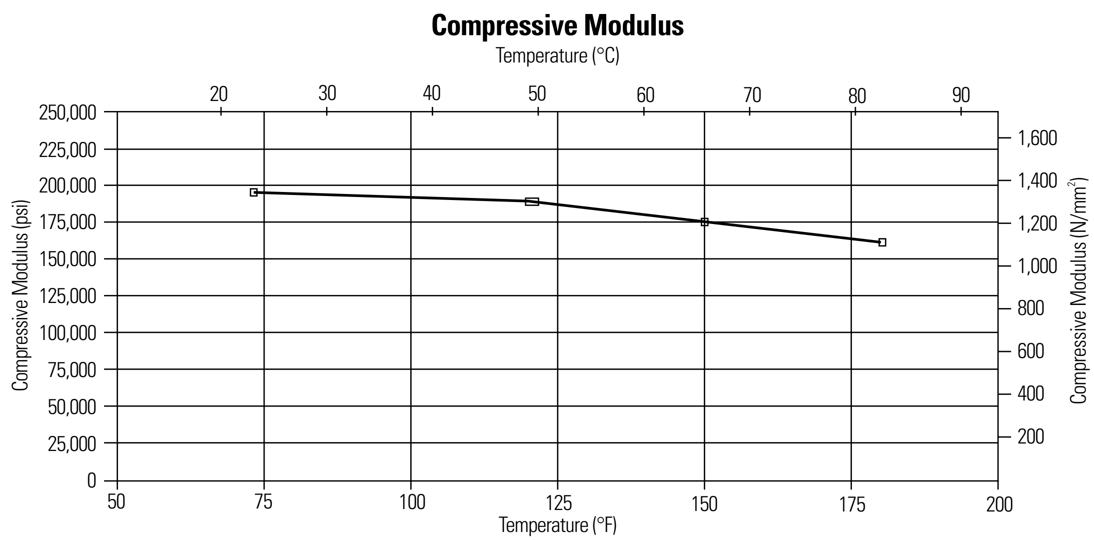

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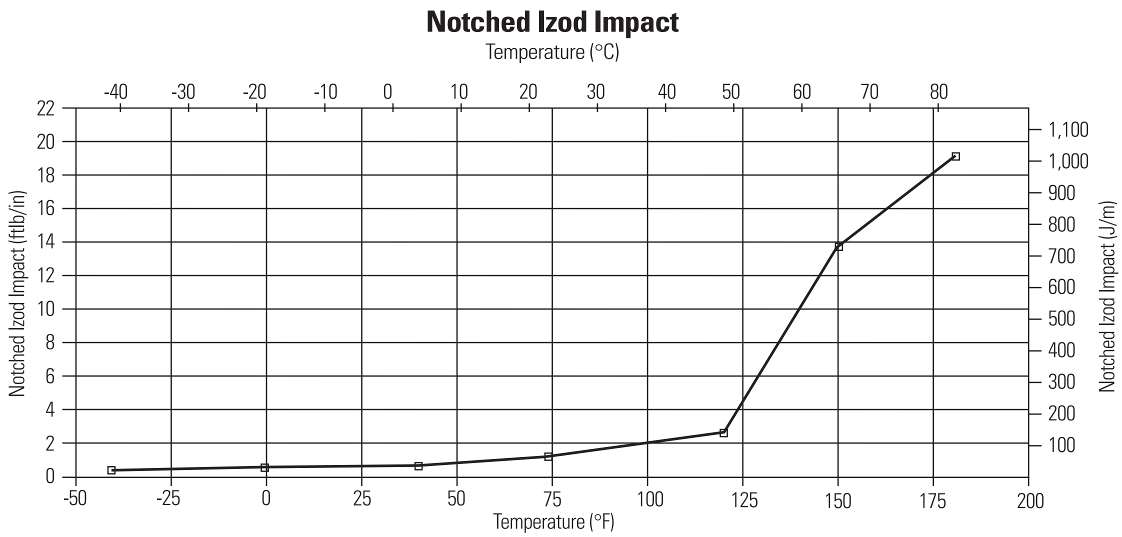
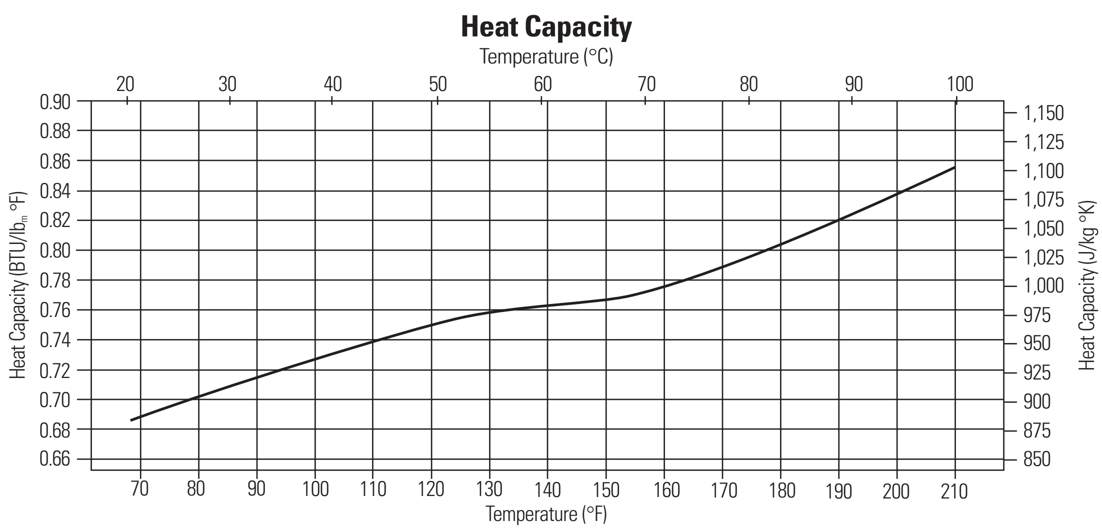




Recommendations for Fabrication

Introduction

CPVC offers a variety of advantages to the chemical process industries and has been successfully used in industrial applications for more than 40 years. Some of the outstanding features of Corzan CPVC products include: high temperature capabilities, excellent chemical resistance to a wide range of highly corrosive liquid and vapor environments, resistance to galvanic corrosion, low heat transfer, good electrical insulation properties, and lightness of weight for ease of installation. In addition to pipe, fittings, valves, pumps, tower packing, and other fluid handling products which are manufactured from CPVC, sheet and duct products are also available from which specialized parts such as tanks and tank linings, as well as ventilation and vapor scrubbing equipment, can be fabricated.

Corzan Industrial Systems components can be fabricated with all of the most common techniques for thermoplastic fabrication. This document addresses high speed hot gas welding and butt welding of Corzan system components. It will be amended at a later date to include extrusion welding and thermoforming, as information on those topics becomes available.

The Essentials of Hot Gas Welding Corzan CPVC

- clean, dry gas
- accurate temperature control
- beveled edges on base material
- buff or scrape welding surface & rod
- base material and rod both Corzan CPVC
- ideal rod diameter 1/8" - 5/32"
- optimum temperature range:
  710-800°F (375-425°C) – dial-selected – (*calibrated* Wegener Autotherm)
  680-770°F (360-410°C) – measured and adjusted – 3/16" (5mm) inside *main* opening *of welding tip*
- optimum air flow: 40-60 lpm

The Principle of Thermoplastic Welding

In order to weld thermoplastics, the material has to be heated to reach its melt state. The pieces to be welded must then be pressed together with a certain amount of pressure over a given amount of time. This will cause the surface molecules of the parts to interlock, fusing the parts together.

High Speed Hot Gas Welding

Corzan system components can be hot gas welded to give approximately 80% of the tensile strength of solid sheet. Actual performance will depend upon the equipment used, the welding conditions employed, and the individual technique of the person doing the welding. As a result, the recommendations given in this document are intended to be general guidelines and do not guarantee actual performance.

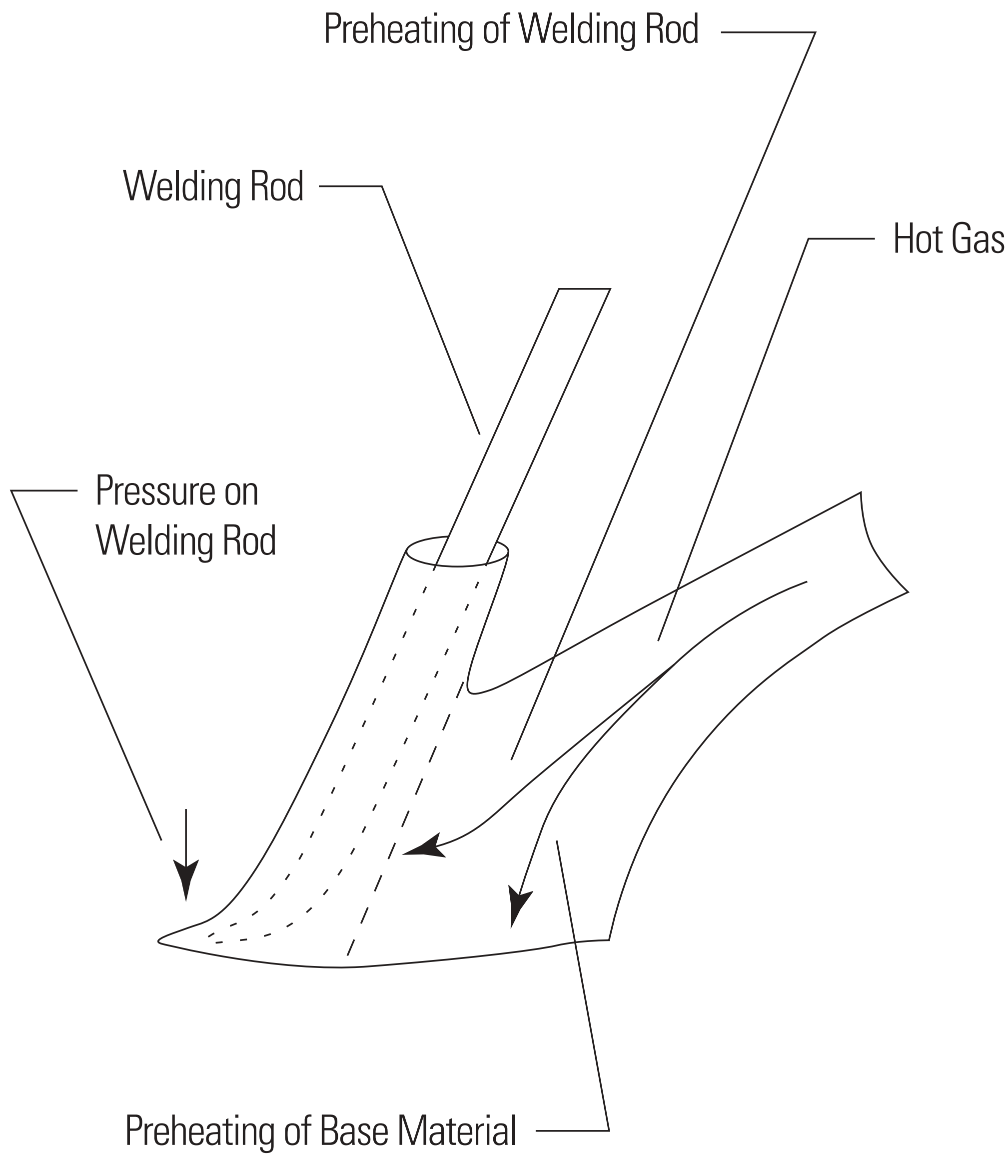
Equipment

When thermoplastics are being welded, the quality of the gas used as the heat transfer medium is a critical factor in the quality of the weld. High-speed hot gas welding requires the use of gas supplied at low pressure and high volume, which is free of oil and moisture. Common shop compressors generally do not supply air of adequate quality for use in high-speed hot gas welding. Many manufacturers of hot gas welding equipment also have blowers available that are specifically suited for this purpose.

When Corzan system components are being welded, the accuracy of the temperature controlling equipment is equally as important as the quality of the gas. The optimum temperature range for welding Corzan system components is typically somewhat narrower than for other thermoplastics such as polyolefins. The quality of the weld produced is therefore dependent on having a constant temperature at the welding tip. Welding equipment for use with Corzan system components preferably should control the temperature by regulating power to the heating element, not by varying the gas flow. The ideal temperature control arrangement for welding Corzan system components should incorporate closed loop controls which hold the temperature constant even while gas flow or supply voltages fluctuate.

A high speed welding tip is designed to perform three functions: preheating the base material, guiding and preheating the welding rod, and applying pressure to the weld area. A typical high-speed hot gas welding tip is shown in Figure 1.

Figure 1: A Typical High Speed Hot Gas Welding Tip



Recommendations for Fabrication (cont.)

Material Preparation

The ends of the pieces of material to be joined must be beveled in order to produce the best weld. The bevel may be produced with an adjustable saw, a router or other suitable tool. The angle between the bevels of the two pieces to be joined should be between 60 and 70 degrees, except when one piece is joined perpendicularly to another, in which case, the angle is reduced to 45 degrees.

The parts to be assembled must be very clean. To remove surface residue, slight grinding or scraping with a sharp blade at the area to be welded and the weld rod is strongly recommended. Acetone is the only solvent that is suitable for use to clean the area to be welded. Other solvents may have potentially negative effects on Corzan CPVC.

If the joint will not be tacked prior to welding, it is recommended to leave a gap of 0.5-1 mm wide between the two pieces to be joined so that the welding material may penetrate to the root of the bevel and overflow slightly on the other side. If the parts will first be tacked, they should be butted together with no gap. The parts to be joined should be mounted firmly in place with appropriate clamps as necessary.

Typical welded joint configurations are shown in Figure 2.

Welding Rod Selection

When Corzan CPVC parts are being joined, the welding rod selected should also be produced from Corzan CPVC. Triangular rod may be used where the appearance of the joint is the most important factor, but round welding rod should be used when structural integrity is desired.

While welding rod is commonly available in sizes up to 1/4" (6 mm) in diameter, the strongest joints are obtained by using rod in smaller diameters with multiple beads as necessary. In order to obtain the strongest weld with Corzan welding rod, it is recommended to use rod no larger than 5/32" (4 mm) in diameter.

It is important to match the diameter of the welding tip with the diameter of the rod selected. An oversized tip will negatively affect guidance and pressure applied to the rod and may also cut into the parts being welded.

Tack Welding

The initial step in the process is the "tack weld." The objective is to put the parts in place, align them, and prevent any slippage of the material during the structural welding process. Tacking is done with a pointed shoe tip. The operator places the tacking tip directly on the material to be welded and draws it along the joint. Hot gas from the welder softens the material, and pressure applied by the operator to the tip fuses the material together. Continuous or spot tack welding may be used as necessary. Larger structures or thick gauge materials may require additional clamping.

Any tank should be continuously tack welded to achieve a leak free connection. This prevents solutions from penetrating between the tank wall and the bottom in case of a problem with the filler weld.

The Welding Process

The optimum temperature range for hot gas welding of Corzan system components is dependent on the type of welding equipment being used and the way in which the temperature is measured. If the welding torch incorporates closed-loop controls which maintain the temperature selected on a dial setting, the optimum range is typically 710-800°F (375-425°C). If the temperature cannot be directly selected on a dial setting, it must be measured by the operator and then adjusted by varying power to the heating element or regulating the gas flow. The temperature should be measured with a pyrometer approximately 3/16" (5 mm) inside the main opening of the high speed welding tip. When the temperature is controlled in this manner, the optimum temperature for welding Corzan system components is typically 680-770°F (360-410°C). The actual temperature within the range that will produce the best weld will depend on a number of factors including diameter of rod, brand of rod, speed of welding, ambient temperature, etc., and must be adjusted accordingly.

To make it easier to initiate welding, a sharp angle may be cut on the lead end of the welding rod. The welding rod should not be inserted into the high speed-welding tip until immediately before the operator is ready to begin welding. Burning of the rod may otherwise result.

Recommendations for Fabrication (cont.)

To begin welding, the operator should grasp the welding torch like a dagger with the airline trailing away from his body or over the shoulder so that he will be able to operate quickly and smoothly once he has begun. Holding the welding tip approximately 8 cm above the area to be welded to prevent scorching the material before work begins, insert the welding rod into the preheating tube and then place the pointed tip of the shoe on the material at the starting point of the weld.

Holding the welder at roughly a 45 degree angle, push the rod through the tip until it contacts the base material. Continue to feed the rod with the other hand, using slight pressure. If the rod is not guided, the welding rod will stretch fully apart. The weight of the welder is the only pressure needed as the weld is pulled along the joint

As welding progresses, visual inspection of the weld may indicate its quality. Browned or charred edges occur when the welder is moving too slowly and/or overheating. If the rod has been softened too much by overheating, it will stretch and break or flatten out.

Once welding begins, it must be continued at a fairly constant rate of speed. The welding torch must not be held still or burning will result. To stop welding before the rod is used up, the operator should tilt the welder backward, cut the rod off with the tip of the shoe and immediately remove the remaining rod from the welding tip. Welding may also be terminated by pulling the welder tip up over the remaining rod and cutting the rod.

For best results, the welding tip should be cleaned occasionally with a wire brush.

Multiple beads should be applied as necessary until the joint is completely filled as shown in Figure 2. If the joint to be welded is a double V or a double half V joint, the best results are obtained if layers of beads are put down alternately on opposite sides of the joint. The table below presents recommendations for bead lay-up for different material thicknesses and joint configurations.

RECOMMENDATIONS FOR BEAD LAY-UP

	Material Thickness	Number of Beads x Rod Diameter
Single V Joint	1/8" (3mm)	3 x 1/8" (3mm)
	5/32" (4mm)	1 x 1/8" (3mm) + 2 x 5/32" (4mm)
	3/16" (5mm)	6 x 1/8" (3mm)
Double V Joint	5/32" (4mm)	2 @ 1 x 5/32" (4mm)
	3/16" (5mm)	2 @ 3 x 1/8" (3mm)
	1/4" (6mm)	2 @ 3 x 1/8" (3mm)
	5/16" (8mm)	2 @ 1 x 1/8" (3mm) + 2 x 5/32" (4mm)
	3/8" (10mm)	2 @ 6 x 1/8" (3mm)

Heat Stress Problems

During hot air welding, the material will expand while it is forced into position. When cooling, it will shrink back to its original volume. A welded sheet that was straight while still hot may be bent after cooling. Using a double V joint is one way to avoid this problem. Another way for an experienced operator to avoid this problem is to pre-bend the parts prior to welding as shown in Figure 3.

Weld Factor

When properly hot gas welded, Corzan CPVC sheet can be expected to perform to approximately 80% of its nominal tensile strength.

Figure 2: Typical Welded Joint Configuration

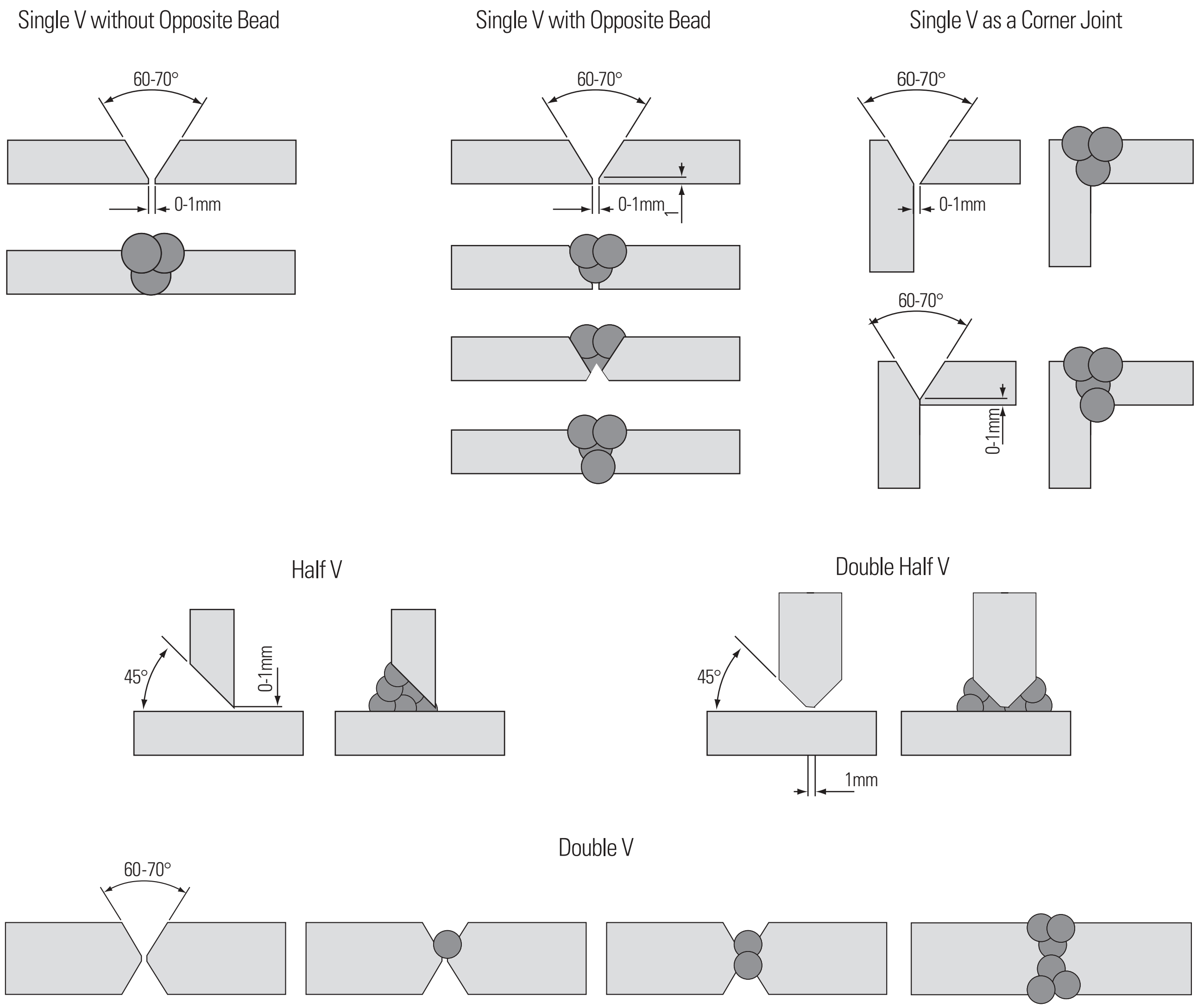
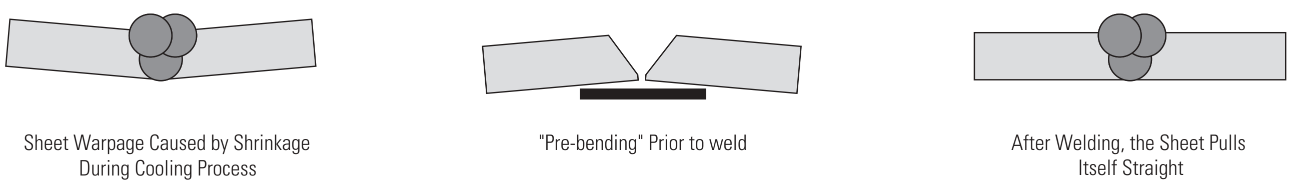


Figure 3: Typical Welded Joint Configuration



Source: Wegener North America

Recommendations for Fabrication (cont.)

Hot Plate (Butt) Welding

Butt welding of thermoplastics involves holding two pieces of the material with defined pressure against a heated plate element until the material melts. The two pieces are then brought together quickly and held with a defined pressure so that they fuse into one piece. Some of the most common uses for butt welding are to join two pieces of flat sheet, to join both ends of a rolled or bent sheet to form a round or rectangular shape, or to join segments of pipe together to form fabricated fittings. The following recommendations are based primarily on work with sheet, but could be modified by an experienced welder for work with pipe.

The Essentials of Hot Plate (Butt) Welding Corzan CPVC

- PTFE-coated heating element
- accurate temperature control
- changeover time: less than 3 sec.
- optimum temperature: 440-445°F (225-230°C)
- optimum melting pressure: 95-100 psi (65-70 N/cm^2)
- optimum heating pressure: 30 psi (20 N/cm^2)
- optimum welding pressure: 95-100 psi (65-70 N/cm^2)
- heating and welding/fusion times are dependent on material thickness (see Tables 1 & 2).

Equipment

The heating element should be PTFE-coated stainless steel in order to prevent sticking of the melted plastic to the element. The heating element should be kept very clean. If necessary, a clean cotton rag or paper towel can be used to wipe off any residue.

The control of the temperature of the heating element is very important when Corzan CPVC sheet is butt welded. Butt welding of Corzan CPVC sheet should be performed in an area free of drafts in order to maintain the best temperature control possible.

The changeover time, during which the element is removed and the two pieces of heated plastic are pressed together to form the weld, should be as short as possible. Ideally, the changeover time should be no more than three seconds.

Material Preparation

The edges of the pieces of material to be welded should be as square as possible so that they will contact the heating element and each other evenly. Cutting debris and any oil or dirt should be removed from the welding area. The pieces to be welded should be clean and dry. Solvents should not be used to clean the surfaces to be welded.

The Welding Process

The heating element should be set at the desired welding temperature. The optimum temperature for butt welding Corzan CPVC sheet is typically 437-446°F (225-230°C). With a microprocessor controlled machine, only the sheet thickness and length, as well as the melting/welding pressures have to be programmed; the machine will then make the necessary calculations and perform the necessary machine settings with respect to time and pressure. With a non-microprocessor controlled machine, the operator has to calculate the welding surface, then multiply the cross section with the optimum melting/fusing pressure and set the machine gauges accordingly. Here, as well, temperature and times have to be manually adjusted. Once the machine is set up, the sheets are inserted on either side of the table tightly against the setting bar and clamped.

The heating element should be brought into position and the pieces of material should be pressed against the heating plate with the desired melting pressure. The purpose for the higher pressure melting time is to assure that the material makes solid contact with the heating element. Once a bead has formed along the entire weld area, the pressure should be dropped to a nominal heating pressure. This pressure should be sufficient to hold the pieces against the element, but prevent excessively large beads from forming. The goal is to heat up the fusion area without pushing molten material out of the weld zone. With microprocessor controlled machines, the melting time is preset and can be extended, stopped, or reprogrammed, depending on the accuracy of the cut. The better the cut, the shorter the melting time. The optimum heating pressure for butt welding Corzan CPVC is approximately 30 psi (20 N/cm^2).

Recommendations for Fabrication (cont.)

The time that the plastic should be held against the element under the heating pressure is dependent on the thickness of the sheet. Typical optimum heating times for CPVC sheet are shown below.

Table 1

Thickness (in.)	Heating Time (sec.)
3/16	75
1/4	90
3/8	120
1/2	150

When the heating time is complete, the element should be removed and the pieces brought together as quickly as possible. The optimum changeover time is less than three seconds. The pressure should then be brought up to the desired fusion pressure, which should be maintained for a period of time which is dependent on the thickness of the sheet. The optimum welding pressure for Corzan CPVC sheet is typically 95-100 psi (65-70 N/cm^2). The optimum fusion times for CPVC sheet are given below.

Table 2

Thickness (in.)	Welding Time (min.)
3/16	5
1/4	6
3/8	9
1/2	11

Weld Factor

Corzan CPVC sheet, when properly butt welded, can be expected to perform to approximately 80% of its nominal tensile strength.

Welding Corzan Sheet and Pipe

It is possible to weld sheet and pipe together. It is important, however, to remember that the sheet and pipe will heat differently when welded at different speeds. As a result, it will appear that the adhesion to the pipe is not as good as it is to the sheet.

Recommendations to ensure a successful bond follow:

1. Solvent wipe the surface to be welded prior to heating using acetone. This will help to etch the surface to be welded.
2. Preheat the pipe surface to be welded, in addition to the tack welding to be performed.
3. Use a thicker welding rod (i.e. 4 mm) so that the heating time is longer.

Dual Laminate: Reinforcing Corzan Pipe with Fiberglass

In order to obtain the best adhesion when wrapping Corzan CPVC pipe with fiberglass, first rough up the surface of the pipe. Apply the appropriate bonding resin (this resin should be compatible with CPVC, as well as suitable for the intended end use application). After applying the resin, apply the first layer of fiberglass. Follow the glass layer with another coat of the bonding resin, then build up the glass and resin layers accordingly with the appropriate amount of each for the intended application.

Other Fabrication Reference Materials

AWS G1.10M:2001
Guide for the Evaluation of Hot Gas, Hot Gas Extrusion and Heated Tool Butt Thermoplastic Welds

ASTM C 1147
Standard Practice for Determining the Short Term Tensile Weld Strength of Chemical-Resistant Thermoplastics

DVS 2207-3
Hot-Gas welding of thermoplastics – Sheets and pipes

DVS 2207-3 Addendum
Hot-Gas welding of thermoplastics – Sheets and pipes – Welding Parameters

DVS 2208-1
Welding of thermoplastics – Machines and devices for the heated tool welding of pipes, pipeline components and sheets

Other System Components

There are a variety of products made from Corzan CPVC that can be used in various industrial applications. Some of these System Components include:

- Pumps
- Filters
- Tower Packing
- Rods and Shapes
- Special Valves
- Special Fittings
- Custom Molded Parts

Consult the manufacturer's literature for further information on these components

Economic Benefits – A Process Life-Cycle Approach

The material selection process will often consider much more than simply material cost. A process life-cycle analysis will include an evaluation of many factors, including the following:

- Material Cost
- Fabrication Labor
- Installation/Erection Labor
- Process Requirements/Layout
- Operating Cost
- Maintenance Cost
- Equipment Service Life
- Replacement Cost

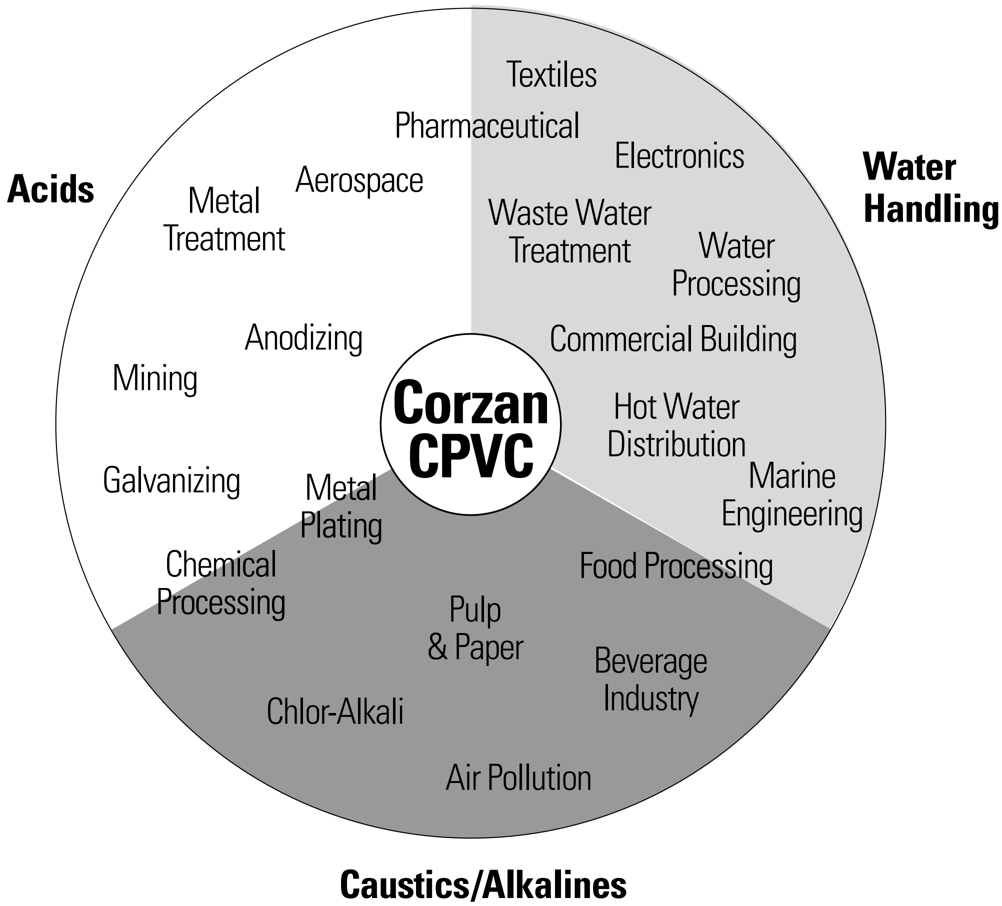
To quantify true life-cycle costs is nearly impossible due to the huge array of variables to be considered, especially after system installation. However, quantifying total installed cost of a system is possible using standard project estimating techniques. These estimates can be used to compare installed costs of a given system using different materials of construction. Beyond installed cost, a qualitative comparison can be done to evaluate the relative costs that are expected to be incurred throughout the life of the system.

A detailed study of the installed cost of model piping systems was published in *Chemical Engineering* in January, 1993. A reprint of that study follows on the next page for your reference in comparing different materials of construction for your process application. This study considers all of the key costs that will be incurred during project installation, including fabrication and labor costs. Corzan CPVC compares very favorably to all other materials of construction due partly to the reasonable material cost, but primarily because of its relative ease of fabrication and installation.

Qualitative factors that can be considered to compare other life-cycle costs include corrosion resistance, ease of repair/retrofit, and operating costs. The superior corrosion resistance of Corzan CPVC will compare favorably to other materials when considering the impact on service life and the need for future maintenance, including process down-time. The ability to solvent cement Corzan Industrial Systems enables labor-saving repairs and modifications with minimum impact on process up-time. Finally, the relatively low coefficient of friction of Corzan CPVC and its ability to avoid corrosive build-up will help minimize pumping and other fluid handling power costs.

Overall, Corzan Industrial Systems are an excellent choice for many process applications because of their excellent life-cycle economics.

Industries/Applications



CORZAN™
INDUSTRIAL SYSTEMS

Manufacturing Partners / Products

MANUFACTURERS	PIPE	FITTINGS	FABRICATED FITTINGS	VALVES	DUAL CONTAINMENT	BAR STOCK/SHAPES	PUMPS	FILTERS	STRAINERS	CARBON TREATMENT	SHEET	WELDING ROD	TOWER PACKING	FLOW DETECTORS/SENSOR HOUSING	CPVC CEMENT	DUCTING
CEPEX USA, INC				x												
CHARLOTTE PIPE & FOUNDRY CO.	x	x														
COLONIAL ENGINEERING		x		x												
COMPRESSION POLYMERS (CPG)/VYCOM											x					
GEHR PLASTICS						x										
HARVEL PLASTICS, INC.	x					x										x
HAYWARD INDUSTRIAL PRODUCTS/WEBSTER PUMPS				x			x		x							
IPEX	x	x	x	x	x				x							
IPS CORPORATION															x	
JAEGER PRODUCTS, INC.													x			
KOCH-GLITSCH													x			
NIBCO, INC.		x		x												
PENGUIN PUMPS, INC.							x	x		x						
PLAST-O-MATIC VALVES, INC.				x					x							
POLY-HI SOLIDUR											x					
PRIME PLASTICS, INC.												x				
RAUSCHERT INDUSTRIES, INC.													x			
SERFILCO, LTD.							x	x		x				x		
V&A PROCESS, INC.												x				
WESTLAKE PLASTICS COMPANY											x					

Manufacturers of Process Components made from Corzan® CPVC

Pipe (Per ASTM F441, Schedule 40 and 80)

Charlotte Pipe & Foundry Co.
P.O. Box 35430
Charlotte, NC 28235
Phone: (800) 438-6091
Fax: (800) 553-1605
www.charlottepipe.com

IPEX (US)
P.O. Box 240696-0696
10100 Rodney Street
Pineville, NC 28134
Phone: (800) 463-9572
Fax: (905) 403-9195
www.ipexinc.com

Harvel Plastics, Inc.
P.O. Box 757
Easton, PA 18044-0757
Phone: (610) 252-7355
Fax: (610) 253-4436
www.harvel.com

IPEX (Canada)
6810 Invader Crescent
Mississauga, ON L5T 2B6
Canada
Phone: (866) 473-9472
Fax: (905) 670-5295
www.ipexinc.com

Double Containment Pipe

IPEX (US)
P.O. Box 240696-0696
10100 Rodney Street
Pineville, NC 28134
Phone: (800) 463-9572
Fax: (905) 403-9195
www.ipexinc.com

IPEX (Canada)
6810 Invader Crescent
Mississauga, ON L5T 2B6
Canada
Phone: (866) 473-9472
Fax: (905) 670-5295
www.ipexinc.com

Manufacturers of Process Components made from Corzan® CPVC

Fittings
(Per ASTM F437 and 439, Schedule 80)

Charlotte Pipe & Foundry Co.
P.O. Box 35430
Charlotte, NC 28235
Phone: (800) 438-6091
Fax: (800) 553-1605
www.charlottepipe.com

IPEX (US)
P.O. Box 240696-0696
10100 Rodney Street
Pineville, NC 28134
Phone: (800) 463-9572
Fax: (905) 403-9195
www.ipexinc.com

NIBCO, Inc.
1516 Middlebury Street
P.O. Box 1167
Elkhart, IN 46516-4740
Phone: (800) 642-5463
Fax: (219) 295-3307
www.nibco.com

Colonial Engineering
8132 Merchants Place
Kalamazoo, MI 49002
Phone: (800) 374-0234
Fax: (616) 323-0630
www.colonialengineering.com

IPEX (Canada)
6810 Invader Crescent
Mississauga, ON L5T 2B6
Canada
Phone: (866) 473-9472
Fax: (905) 670-5295
www.ipexinc.com

Manufacturers of Process Components made from Corzan® CPVC

Valves

CEPEX USA, Inc.
8003 Westside Industrial Drive
Jacksonville, FL 32219
Phone: (904) 695-1441
Fax: (904) 695-1442
www.cepex.com

Colonial Engineering
8132 Merchants Place
Kalamazoo, MI 49002
Phone: (800) 374-0234
Fax: (616) 323-0630
www.colonialengineering.com

IPEX (US)
P.O. Box 240696-0696
10100 Rodney Street
Pineville, NC 28134
Phone: (800) 463-9572
Fax: (905) 403-9195
www.ipexinc.com

NIBCO, Inc.
1516 Middlebury Street
P.O. Box 1167
Elkhart, IN 46516-4740
Phone: (800) 642-5463
Fax: (219) 295-3307
www.nibco.com

Hayward Industrial Products
One Hayward Industrial Drive
Clemmons, NC 27012-5100
Phone: (800) 910-2536
Fax: (336) 712-9523
www.haywardindustrial.com

IPEX (Canada)
6810 Invader Crescent
Mississauga, ON L5T 2B6
Canada
Phone: (866) 473-9472
Fax: (905) 670-5295
www.ipexinc.com

Plast-O-Matic Valves, Inc.
1384 Pompton Avenue
Cedar Grove, NJ 07009
Phone: (973) 256-3000
Fax: (973) 256-4745
www.plastomatic.com

CPVC Solvent Cement (Per ASTM F493)

IPS Corporation
455 W. Victoria Street
Compton, CA 90220
Phone: (800) 421-2677
Fax: (310) 898-3392
www.ipscorp.com

Fabricated Fittings

Consult your Corzan CPVC Field Sales Representative for a list of manufacturers of fabricated fittings.

Manufacturers of Process Components made from Corzan® CPVC

Bar Stock & Shapes

Gehr Plastics
Naamans Creek Center
24 Creek Circle
Boothwyn, PA 19061
Phone: (800) 782-4347
Fax: (610) 497-8901
www.gehrplastics.com

Harvel Plastics, Inc.
P.O. Box 757
Easton, PA 18044-0757
Phone: (610) 252-7355
Fax: (610) 253-4436
www.harvel.com

Pumps

Hayward Industrial Products
One Hayward Industrial Drive
Clemmons, NC 27012-5100
Phone: (800) 910-2536
Fax: (336) 712-9523
www.haywardindustrial.com

Serfilco, Ltd.
2900 MacArthur
Northbrook, IL 60062
Phone: (800) 323-5431
Fax: (847) 559-1995
www.serfilco.com

Penguin Pumps, Inc.
7932 Ajay Drive
Sun Valley, CA 91352
Phone: (818) 504-2391
Fax: (818) 768-7590
www.penguinpumps.com

Filters

Hayward Industrial Products
One Hayward Industrial Drive
Clemmons, NC 27012-5100
Phone: (800) 910-2536
Fax: (336) 712-9523
www.haywardindustrial.com

Serfilco, Ltd.
2900 MacArthur
Northbrook, IL 60062
Phone: (800) 323-5431
Fax: (847) 559-1995
www.serfilco.com

Penguin Pumps, Inc.
7932 Ajay Drive
Sun Valley, CA 91352
Phone: (818) 504-2391
Fax: (818) 768-7590
www.penguinpumps.com

Manufacturers of Process Components made from Corzan® CPVC

Strainers

Hayward Industrial Products
One Hayward Industrial Drive
Clemmons, NC 27012-5100
Phone: (800) 910-2536
Fax: (336) 712-9523
www.haywardindustrial.com

IPEX (Canada)
6810 Invader Crescent
Mississauga, ON L5T 2B6
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Phone: (866) 473-9472
Fax: (905) 670-5295
www.ipexinc.com

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Fax: (905) 403-9195
www.ipexinc.com

Plast-O-Matic Valves, Inc.
1384 Pompton Avenue
Cedar Grove, NJ 07009
Phone: (973) 256-3000
Fax: (973) 256-4745
www.plastomatic.com

Ducting

Harvel Plastics, Inc.
P.O. Box 757
Easton, PA 18044-0757
Phone: (610) 252-7355
Fax: (610) 253-4436
www.harvel.com

CPVC Sheet

Compression Polymers (CPG)/Vycom
801 Corey Street
Moosic, PA 18507
Phone: (570) 346-8797
Fax: (570) 346-5080
www.cpg-vycom.com

Westlake Plastics Company
West Lenni Road
Lenni, PA 19052
Phone: (800) 999-1700
Fax: (610) 459-1084
www.westlakeplastics.com

Poly-Hi Solidur
2710 American Way
Fort Wayne, IN 46809
Phone: (800) 628-7264
Fax: (260) 478-1074
www.polyhi.com

Manufacturers of Process Components made from Corzan® CPVC

Welding Rod

Prime Plastics, Inc.
3782 Golf Course Drive
Norton, OH 44203
Phone: (330) 825-3451
Fax: (330) 825-3365
www.primeweld.com

V&A Process, Inc.
1230 Colorado Avenue
Lorain, OH 44052
Phone: (440) 288-8137
Fax: (440) 288-2323
www.vandaprocess.com

Tower Packing

Jaeger Products, Inc.
P.O. Box 1563
Spring, TX 77383
Phone: (800) 678-0345
Fax: (281) 449-9400
www.jaeger.com

Rauschert Industries, Inc.
351 Industrial Park Road
Madisonville, TN 37354
Phone: (423) 442-4471
Fax: (423) 442-6168
www.rauschertus.com

Koch-Glitsch
P.O. Box 30190
5385 Orchardview Drive
East Canton, Ohio 44730
Phone: (330) 488-1279
Fax: (330) 488-1656
www.koch-glitsch.com

Glossary

Adhesive
A substance capable of holding materials together by surface attachment.

Aging
1) The effect on materials of exposure to an environment for an interval of time.
2) The process of exposing materials to an environment for an interval of time.

Apparent Density
The weight per unit volume of a material including voids inherent in the material as tested.

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

Bell End
The enlarged portion of a pipe that resembles the socket portion of a fitting and is used to make a joint.

Burst Strength
The internal pressure required to cause a pipe or fitting to fail.
Note: This pressure will vary with the rate of buildup of the pressure and the time during which the pressure is held.

Chemical Resistance
The ability to resist chemical attack.
Note: The attack is dependent on the method of test, and its severity is measured by determining the changes in physical properties. Time, temperature, stress, and reagent may all be factors that affect the chemical resistance of a material.

Cleaner, Chemical
An organic solvent used to remove foreign matter from the surface of plastic pipe and fittings.

Cleaner, Mechanical
An abrasive material or device used to remove foreign matter and gloss from the surface of plastic pipe and fittings.
Note: Mechanical cleaners may be used prior to joining with a solvent cement or adhesive.

Code, Thermoplastic Pipe Materials Designation
A code for pressure pipe that consists of two or three letters that indicate the kind of thermoplastic followed by two numerals that designate the type and grade of thermoplastic and two numerals that designate the hydrostatic design stress in units of 100 psi with any decimal figures dropped.
Note: For example, CPVC 4120

Compound
A mixture of a polymer with other ingredients such as fillers, stabilizers, catalysts, processing aids, lubricants, modifiers pigments, or curing agents.

Compression Molding
The method of molding a material in a confined cavity by applying pressure and usually heat.

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

Contamination
The presence of a substance not intentionally incorporated in a product.

Crack
Any narrow opening or fissure in the surface that may or may not be visible to the naked eye.

Crazing
Apparent fine cracks at or under the surface of a plastic.

Deflection Temperature
The temperature at which a specimen will deflect a given distance at a given load under prescribed conditions of test. Formerly called heat distortion.

Degradation
A deleterious change in the chemical structure of a plastic.

Glossary (cont.)

Diffusion
The movement of a material such as a gas or liquid, in the body of a plastic.
Note: If the gas or liquid is absorbed on one side of a piece of plastic and given off on the other side, the phenomenon is called permeability. Diffusion and permeability are not due to holes or pores in the plastic.

Dimension Ratio
The average specified diameter of a pipe divided by the minimum specified wall thickness.

Elastomer
A polymer that returns to approximately its initial dimensions and shape after substantial deformation by a weak stress and release of the stress.

Elevated Temperature Testing
Tests on plastic pipe above 23°C (73°F).

Environmental Stress Cracking
The development of cracks in a material that is subjected to stress or strain in the presence of specific chemicals. The degree of cracking may be measured by visible crack evidence or by retention of mechanical properties in the exposed thermoplastic part.

Extrusion
A process whereby heated plastic forced through a shaping orifice becomes one continuously formed piece.

Fabricating
The manufacture of plastic products from molded parts, rods, tubes, sheeting, extrusions, or other forms by appropriate operations such as punching, cutting, drilling, and tapping including fastening plastic parts together or to other parts by mechanical devices, adhesives, heat sealing, or other means.

Filler
A relatively inert material added to a plastic to modify its strength, permanence, working properties or other qualities or to lower costs.

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

Fuse
1) To convert plastic powder or pellets into a a homogeneous mass through heat and pressure.
2) To make a plastic piping joint by heat and pressure.

Glass Transition
The reversible change in an amorphous polymer or in amorphous regions of a partially crystalline polymer from a hard condition to a rubbery condition as its temperature is increased.

Glass Transition Temperature (T_g):
The approximate midpoint of the temperature range over which the glass transition takes place. The glass transition temperature is the determining feature of the deflection temperature.

Heat Joining
Making a joint by heating the mating surfaces of the pipe components to be joined and pressing them together so that they fuse and become essentially one piece.
Note: Also known as heat fusion, thermal fusion, and fusion.

Hoop Stress
The tensile stress in the wall of the pipe in the circumferential orientation due to internal hydrostatic pressure.
Note: Hydrostatic means fluid and is not limited to water.

Hydrostatic Design Stress
The recommended maximum hoop stress that can be applied continuously with a high degree of certainty that failure of the pipe will not occur.

Impact, Izod
A specific type of impact test made with a pendulum type machine on a cantilever beam specimen and also the values obtained by this method.

Glossary (cont.)

Impact, Drop Weight
A falling weight (tup) impact test developed specifically for pipe and fittings.

Injection Molding
The process of forming a material by forcing it, under pressure, from a heated cylinder through a sprue (runner, gate) into the cavity of a closed mold.

Joint
The location at which two pieces of pipe or a pipe and fitting are connected together.
Note: The joint may be made by an adhesive, a solvent-cement, heat joining, or a mechanical device such as threads or a ring seal.

Long-Term Hydrostatic Strength (LTHS)
Hoop stress that when applied continuously will cause failure of the pipe at 100 000 h (11.43 years).
Note: These strengths are usually obtained by extrapolation of log-log regression equations or plots. Typical conditions are water at 23°C.

Lubricant
1) A material used to reduce the friction between two mating surfaces that are being joined by sliding contact.
2) An additive that is added to a plastic compound to lower the viscosity or otherwise improve the processing or product characteristics.

Monomer
A relatively simple organic compound which can react to form a polymer.

Plasticizer
A substance incorporated in a material to increase its workability, flexibility or extensibility.

Polymer
A substance consisting of very large molecules characterized by the repetition of one or more types of monomeric units.

Pressure Rating
The estimated maximum pressure that the medium in the pipe can exert continuously with a high degree of certainty that failure of the pipe will not occur.

Primer
An organic solvent, which enhances adhesion, applied to plastic pipe and fittings prior to application of a solvent cement.

Quick Burst Pressure
The internal pressure required to bring a piping component to failure when subjected to a quick burst test.

Resin
The powder form of a polymer.

Schedule
A pipe size system (outside diameters and wall thicknesses) originated by the iron pipe industry.

Solvent Cement
An adhesive made by dissolving a plastic resin or compound in a suitable solvent or mixture of solvents. The solvent cement dissolves the surfaces of the pipe and fittings to form a bond between the mating surfaces provided the proper cement is used for the particular materials and proper techniques are followed.

Strain
The change per unit of length in a linear dimension of a body, that accompanies a stress.

Strength
The stress required to break, rupture, or cause a failure. (flex strength is not a measure of a failure mode)

Stress Relaxation
The decrease in stress, at constant strain, with time.

Conversion Factors

TO CONVERT FROM	TO	MULTIPLY BY
	LENGTH	
Centimeters	Inches	0.39370079
Inches	Centimeters	2.54
Meters	Feet	3.2808399
Feet	Meters	0.3048
	MASS	
Kilograms	Pounds	2.2046226
Pounds	Kilograms	0.45359237
	FORCE	
Newtons	Pounds	0.22480894
	PRESSURE	
Atmospheres	Bars	1.01325
Atmospheres	PSI	14.6959488
Bars	Atmospheres	0.986923
Bars	PSI	14.5038
Feet of water (4C)	PSI	0.433515
Kilograms/sq. cm	Bars	0.980665
Kilograms/sq. cm	PSI	14.223343
PSI	Atmospheres	0.0680460
PSI	Bars	0.0689476
	AREA	
Square centimeters	Square inches	0.15500031
Square feet	Square meters	0.09290304
Square inches	Square centimeters	6.4516
Square meters	Square feet	10.763910
	VOLUME	
Cubic centimeters	Cubic inches	0.061023744
Cubic feet	Gallons	7.4805195
Cubic feet	Liters	28.316847
Cubic inches	Cubic centimeters	16.387064
Cubic inches	Cubic feet	0.0005787037
Cubic meters	Cubic feet	35.314667
Cubic meters	Gallons	264.17205
Gallons	Cubic feet	0.133680555
Gallons	Liters	3.7854118
Liters	Cubic feet	0.035314667
Liters	Gallons	0.26417205
	DENSITY	
Grams/cubic centimeter	Pounds/gallon	8.3454044
Pounds/gallon	Grams/cubic centimeter	0.11982643
	ENERGY	
BTU	Foot-pounds	777.649
BTU	Joules	1054.35
BTU	Kilowatt-hours	0.000292875
Foot-pounds	BTU	0.0012859
Foot-pounds	Joules	1.35582
	POWER	
BTU/min	Horsepower	0.0235651
BTU/min	Joules/second (Watts)	17.5725
Horsepower	BTU/min.	42.4356
Horsepower	Kilowatts	0.7457
Kilowatts	BTU/min.	56.9072
Kilowatts	Horsepower	1.34102

PLANTA

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