SECTION THREE: INSTALLATION

INTRODUCTION

Proper installation is key to producing a stable and robust system. If installation is not done correctly, the system will not perform well and may actually fail.

This section will cover all aspects of installation and will include joining methods, in ground and above ground installation methods, pipe supports, handling and storage, other installation considerations (such as entrapped air) and testing.

CAUTION: Do not use or test the products in this manual with compressed air or other gases including air-over-water boosters.

HANDLING AND STORAGE

PVC and CPVC are strong, lightweight materials, about one fifth the weight of steel or cast iron. Piping made of this material is easily handled and, as a result, there is a tendency for them to be thrown about on the jobsite. Care should be taken in handling and storage to prevent damage to the pipe.

PVC and CPVC pipe should be given adequate support at all times. It should not be stacked in large piles, especially in warm temperature conditions, as bottom pipe may become distorted and joining will become difficult.

For long-term storage, pipe racks should be used, providing continuous support along the length. If this is not possible, timber supports of at least 3" bearing width, at spacings not greater than 3' centers, should be placed beneath the piping. If the stacks are rectangular, twice the spacing at the sides is required. Pipe should not be stored more than seven layers high in racks. If different classes of pipe are kept in the same rack, pipe with the thickest walls should always be at the bottom. Sharp corners on metal racks should be avoided.

For temporary storage in the field when racks are not provided, care should be taken that the ground is level and free of sharp objects (i.e. loose stones, etc.). Pipe should be stacked to reduce movement, but should not exceed three to four layers high.

Most pipe is now supplied in crates. Care should be taken when unloading the crates; avoid using metal slings or wire ropes. Crates may be stacked four high in the field.

The above recommendations are for a temperature of approximately 80°F (27ºC). Stack heights should be reduced if higher temperatures are encountered, or if pipe is nested (i.e. pipe stored inside pipe of a larger diameter). Reduction in height should be proportional to the total weight of the nested pipe, compared with the weight of pipe normally contained in such racks.

Since the soundness of any joint depends on the condition of the pipe end, care should be taken in transit, handling and storage to avoid damage to these ends. The impact resistance and flexibility of both PVC and CPVC pipe are reduced by lower temperature conditions. The impact strength for both types of piping materials will decrease as temperatures approach 32°F (0°C) and below. Care should be taken when unloading and handling pipe in cold weather. Dropping pipe from a truck or forklift may cause damage. Methods and techniques normally used in warm weather may not be acceptable at the lower temperature range.

When loading pipe onto vehicles, care should be taken to avoid contact with any sharp corners (i.e. angle irons, nail heads, etc.), as the pipe may be damaged.

While in transit, pipe should be well secured and supported over the entire length and should never project unsecured from the back of a trailer.

Larger pipe may be off-loaded from vehicles by rolling them gently down timbers, ensuring that they do not fall onto one another or onto a hard, uneven surface.

Prolonged Outdoor Exposure

Prolonged exposure of PVC and CPVC pipe to the direct rays of the sun will not damage the pipe. However, some mild discoloration may take place in the form of a milky film on the exposed surfaces. This change in color merely indicates that there has been a harmless chemical transformation at the surface of the pipe. A small reduction in impact strength could occur at the discolored surfaces but they are of a very small order and are not enough to cause problems in field installation.

Protection – Covering

Discoloration of the pipe can be avoided by shading it from the direct rays of the sun. This can be accomplished by covering the stockpile or the crated pipe with a light colored opaque material such as canvas. If the pipe is covered, always allow for the circulation of air through the pipe to avoid heat buildup in hot summer weather. Make sure that the pipe is not stored close to sources of heat such as boilers, steam lines, engine exhaust outlets, etc.

Protection – Painting

PVC and CPVC pipe and fittings can be easily protected from ultraviolet oxidation by painting with a heavily pigmented, exterior water-based latex paint. The color of the paint is of no particular importance; the pigment merely acts as an ultraviolet screen and prevents sunlight change. White or some other light color is recommended as it helps reduce pipe temperature. The latex paint must be thickly applied as an opaque coating on pipe and fittings that have been well cleaned and very lightly sanded.

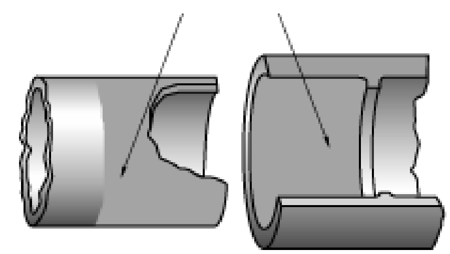
JOINING METHODS – SOLVENT CEMENT

Basic Principles

To make consistently tight joints, the following points should be clearly understood:

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

These areas must be softened and penetrated



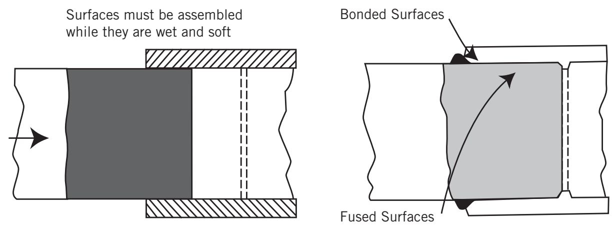
Penetration and softening can be achieved by the cement itself, by using a suitable primer, or by the use of both primer and cement. For certain materials and in certain situations, it is necessary to use a primer. A suitable primer will usually penetrate and soften the surfaces more quickly and effectively than cement alone. Additionally, the use of a primer can provide a safety factor for the installer, for he can know under various temperature conditions when he has achieved sufficient softening. For example, in cold weather more time and additional applications may be required.

Apply generous amounts of cement to fill the loose part of the joint. In addition to filling the gap, adequate cement layers will penetrate the surfaces and remain wet until the joint is assembled. To prove this, apply two separate layers of cement on the top surface of a piece of pipe. First, apply a heavy layer of cement; then alongside it, a thin, brushed-out layer. Test the layers every 15 seconds by gently tapping with your finger. You will note that the thin layer becomes tacky and then dries quickly (probably within 15 seconds); the heavy layer will remain wet much longer.

Check for penetration a few minutes after applying these layers by scraping them with a knife. The thin layer will have little or no penetration, while the heavy layer will have achieved much more penetration.

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

As the solvent dissipates, the cement layer and the softened surfaces will harden with a corresponding increase in joint strength. In the tight (fused) part of the joint, strength will develop quicker than in the looser (bonded) part of the joint.



Cement Types

The use of a reliable cement, specifically manufactured for industrial PVC or CPVC, is critical to a good, long-lasting system and must conform to applicable ASTM standards. Review Table 20 for guidelines on cement types.

Table 20 – Cement Types

Pipe Size	Pipe Schedule	Socket Type	Cement Type
up to 6" PVC up to 4" PVC	40 80	All types	Medium-bodied fast-setting cement Use primer to soften and prepare joining surfaces
up to 12" PVC	All	All types	Heavy-bodied medium-setting cement for all schedules through 12" diameter water lines, drain lines and DWV Use primer to soften and prepare joining surfaces
up to 30" PVC	All	All types	Extra heavy-bodied slow-setting cement Use primer to soften and prepare joining surfaces
up to 12" CPVC	All	All types	Heavy-bodied medium-setting cement for pressure and non-pressure service Use primer to soften and prepare joining surfaces
up to 16" CPVC	All	All types	Extra heavy-bodied slow-setting cement Use primer to soften and prepare joining surfaces

Handling

Solvent cements should be used as received in original containers. Adding thinners to change the viscosity of cement is not recommended. If cement is jelly-like and not free flowing, it should not be used. Containers should be kept tightly covered when not in use to stop the evaporation of the solvent.

Storage Conditions

Solvent cements should be stored at temperatures between 40°F (4°C) and 110°F (43°C) away from heat or open flame. Cements should be used before the expiry date stamped on the container. If new cement is subjected to freezing temperatures, it may become extremely thick or gelled. This cement can be placed in a warm area where it will soon return to its original, usable condition. However, if hardening is due to actual solvent loss (when a container is left open too long during use or not sealed properly after use), the cement will not return to its original condition. Cement in this condition has lost its formulation and should be discarded in an environmentally safe manner.

Safety Precautions

Solvent cements are extremely flammable and should not be used or stored near heat or open flame including pilot lights. In confined or partially enclosed areas, a ventilating device should be used to remove vapors and minimize inhalation. Capping one end of a pipeline during construction may lead to an accumulation of flammable cement vapors inside the system. Nearby sparks may ignite these vapors and create a hazardous incident. If it is required to cover the pipe ends, use an air-permeable cloth that will prevent excessive amounts of dirt from entering the pipeline while permitting cement vapors to escape to the atmosphere. Alternatively, flushing the line with water will also remove all vapors after the cement has properly cured.

Containers should be kept tightly closed when not in use, and covered as much as possible when in use. Protective equipment such as gloves, goggles and an impervious apron should be used. Do not eat, drink or smoke while using these products. Avoid contact with skin, eyes or clothing. In case of eye contact, flush repeatedly with water. Keep out of the reach of children. Carefully read the Material Safety Data Sheets (MSDS) and follow all precautions.

⚠ WARNING

During the curing of the solvent cement joints, vapors may accumulate inside the pipeline, especially should one end of the line be capped. Nearby sparks from welders or torches may inadvertently ignite these vapors and create a hazardous incident. Attention should be given to removing all vapors using air-blowers or water flushing prior to capping one end of an empty pipeline.

⚠ CAUTION

Cement products are formulated for specific material types. To avoid potential joint failure, DO NOT USE PVC cement on CPVC components.

Solvent Welding Instructions for PVC & CPVC Pipe & Fittings

Solvent Welding with Primer

Step 1 Preparation

Assemble proper materials for the job. This includes the appropriate cement, primer and applicator for the size of piping system to be assembled. See Tables 23 and 24 for guidelines to estimate the amount of cement required.

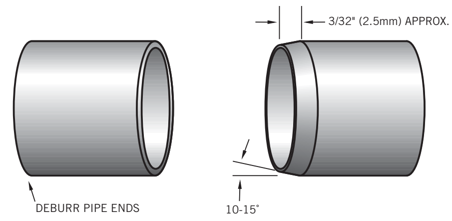
Step 2 Cut Pipe

Pipe must be cut as square as possible. (A diagonal cut reduces bonding area in the most effective part of the joint.) Use a handsaw and miter box or a mechanical saw.

Plastic tubing cutters may also be used for cutting plastic pipe; however, some produce a raised bead at the end of the pipe. This bead must be removed with a file or reamer, as it will wipe the cement away when pipe is inserted into the fitting.

Step 3 Deburr Pipe Ends

Use a knife, plastic pipe deburring tool, or file to remove burrs from the end of small diameter pipe. Be sure to remove all burrs from around the inside as well as the outside of the pipe. A slight chamfer (bevel) of about 15° should be added to the end to permit easier insertion of the pipe into the fitting. Failure to chamfer the edge of the pipe may remove cement from the fitting socket, causing the joint to leak. For pressure pipe systems of 2" and above, the pipe must be end-treated with a 15° chamfer cut to a depth of approximately 3/32" (2.5mm).



CAUTION: Do not use or test the products in this manual with compressed air or other gases including air-over-water boosters.

Step 4 Clean Pipe Ends

Remove all dirt, grease and moisture. A thorough wipe with a clean dry rag is usually sufficient. (Moisture will retard cure, dirt or grease can prevent adhesion).

Step 5 Check Fit

Check pipe and fittings for dry fit before welding together. For proper interference fit, the pipe must go easily into the fitting one quarter to three quarters of the way. Too tight a fit is not desirable; you must be able to fully bottom the pipe in the socket during assembly. If the pipe and fittings are not out of round, a satisfactory joint can be made if there is a “net” fit, that is, the pipe bottoms in the fitting socket with no interference, without slop.

All pipe and fittings must conform to ASTM and other recognized standards.

Step 6 Select Applicator

Ensure that the right applicator is being used for the size of pipe or fittings being joined. The applicator size should be equal to half the pipe diameter. It is important that a proper size applicator be used to help ensure that sufficient layers of cement and primer are applied.

Step 7 Priming

The purpose of a primer is to penetrate and soften pipe surfaces so that they can fuse together. The proper use of a primer provides assurance that the surfaces are prepared for fusion.

Check the penetration or softening on a piece of scrap before you start the installation or if the weather changes during the day. Using a knife or other sharp object, drag the edge over the coated surface. Proper penetration has been made if you can scratch or scrape a few thousandths of an inch of the primed surfaces away.

Weather conditions can affect priming and welding action, so be aware of the following:

- repeated applications to either or both surfaces may be necessary
- in cold weather, more time may be required for proper penetration
- in hot weather, penetration time may be shortened due to rapid evaporation

Step 8 Primer Application

Using the correct applicator, aggressively work the primer into the fitting socket, keeping the surface and applicator wet until the surface has been softened. More applications may be needed for hard surfaces and cold weather conditions. Re-dip the applicator in primer as required. When the surface is primed, remove any puddles of primer from the socket.

Step 9 Primer Application

Next, aggressively work the primer on to the end of the pipe to a point 1/2" beyond the depth of the fitting socket.

Immediately and while the surfaces are still wet, apply the appropriate IPEX cement.

Step 10 Cement Application

Stir the cement or shake can before using. Using the correct size applicator, aggressively work a full even layer of cement on to the pipe end equal to the depth of the fitting socket. Do not brush it out to a thin paint type layer, as this will dry within a few seconds.

Step 11 Cement Application

Aggressively work a medium layer of cement into the fitting socket.

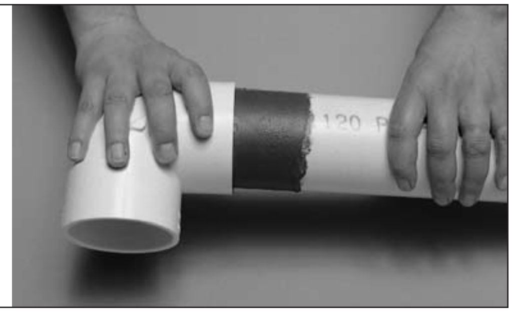
Avoid puddling the cement in the socket. On bell end pipe do not coat beyond the socket depth or allow cement to run down into the pipe beyond the spigot end.

Step 12 Cement Application

Apply a second full, even layer of cement on the pipe.

Step 13 Assembly

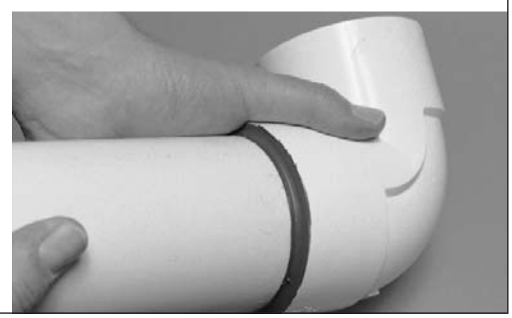
Without delay, while the cement is still wet, assemble the pipe and fittings. Use sufficient force to ensure that the pipe bottoms in the fitting socket. If possible, twist the pipe a quarter turn as you insert it.



Step 14 Assembly

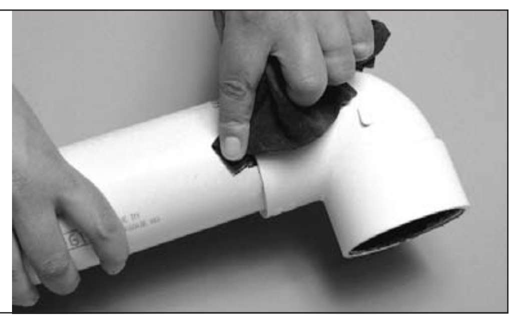
Hold the pipe and fitting together for approximately 30 seconds to avoid push out.

After assembly, a joint should have a ring or bead of cement completely around the juncture of the pipe and fitting. If voids in this ring are present, sufficient cement was not applied and the joint may be defective.



Step 15 Joint Cleaning

Using a rag, remove the excess cement from the pipe and fitting, including the ring or bead, as it will needlessly soften the pipe and fitting and does not add to joint strength. Avoid disturbing or moving the joint.



Step 16 Joint Setting & Curing

Handle newly assembled joints carefully until initial set has taken place. Allow curing to take place before pressurizing the system. (Note: in humid weather allow for 50% more curing time.)

For initial set and cure times for IPEX cements, refer to Tables 21 and 22.

Solvent Welding without Primer / One Step Cements

If local codes permit, successful joints can be made without a primer using cement alone, but extra care must be given to the installation. It is important that a good interference fit exists between the pipe and fittings. It is for this reason we recommend that joints being made without a primer be limited to systems 2" and smaller for pressure applications or 6" and smaller for DWV or non-pressure applications. Extra care must also be given in applying cements to make sure proper penetration and softening of the pipe and fitting surfaces is achieved. Note that one step cements are not recommended at temperatures at or below 32°F (0°C).

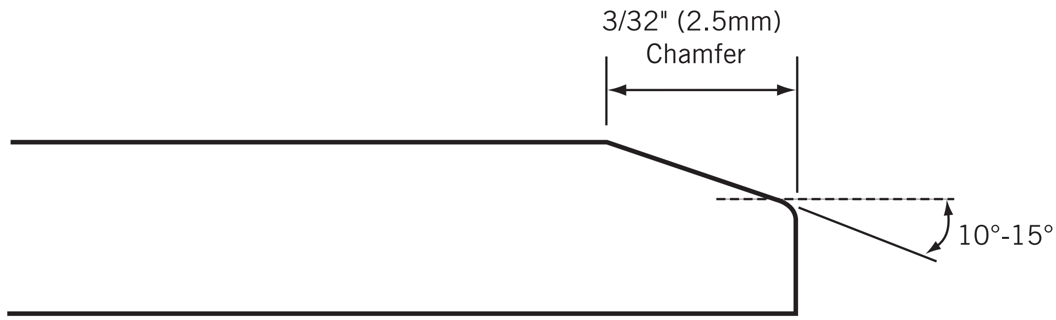
Joining Large Diameter Pipe and Fittings

As pipe diameter increases so does the difficulty in installing it. For large diameter pipe, the following recommendations apply.

- Select the proper size of applicator. The use of proper size applicators is even more important for large pipe to ensure that enough cement is applied to fill the larger gap that exists between the pipe and fittings.
- Ensure the proper selection of cement and primer (refer to Xirtec cement product catalog or your supplier of cements and primers).
- The size of the joining crew should be increased

  6" - 8" pipe: 2-3 people per joint

  10" - 24" pipe: 3-4 people per joint
- The end of the pipe must be chamfered as per the diagram below.
- The primer and cement should be applied simultaneously to the pipe and fittings.
- Make sure to apply a second full layer of cement to the pipe.
- Because of the short sockets in many large diameter fittings, it is very important to have pipe bottomed into the fitting. It is for this reason that above 6" diameter we recommend the use of a "come-a-long".
- Large diameter pipe and fittings will require longer set and cure times. (In cold weather, a heat blanket may be used to speed up the set and cure times.)
- Prefabricate as many joints as possible.
- If pipe is to be buried, make as many joints as possible above ground, then after the joints have cured, carefully lower the piping system into the trench.



INSTALLATION

CAUTION: Do not use or test the products in this manual with compressed air or other gases including air-over-water boosters.

Cold Weather

Although normal installation temperatures are between 40°F (4°C) and 110°F (43°C), high strength joints have been made at temperatures as low as –15°F (–26°C).

In cold weather, solvents penetrate and soften the plastic pipe and fitting surfaces more slowly than in warm weather. In this situation, the plastic is more resistant to solvent attack and it becomes even more important to pre-soften surfaces with an aggressive primer. Be aware that because of slower evaporation, a longer cure time is necessary.

Tips for solvent welding in cold weather

- Prefabricate as much of the system as is possible in a heated work area.
- Store cements and primers in a warmer area when not in use and make sure they remain fluid.
- Take special care to remove moisture including ice and snow from the surfaces to be joined.
- Ensure that the temperature of the materials to be joined (re: pipe and fittings) is similar.
- Use an IPEX Primer to soften the joining surfaces before applying cement. More than one application may be necessary.
- Allow a longer cure period before the system is used. Note: A heat blanket may be used to speed up the set and cure times.

Hot Weather

There are many occasions when solvent welding plastic pipe at 95ºF (35ºC) temperatures and above cannot be avoided. If special precautions are taken, problems can be avoided.

Solvent cements for plastic pipe contain high-strength solvents which evaporate faster at elevated temperatures. This is especially true when there is a hot wind blowing. If the pipe is stored in direct sunlight, the pipe surface temperatures may be 20ºF to 30ºF (10ºC to 15ºC) higher than the ambient temperature. In this situation, the plastic is less resistant to attack and the solvents will attack faster and deeper, especially inside a joint. It is therefore very important to avoid puddling the cement inside the fitting socket and to ensure that any excess cement outside the joint is wiped off.

Tips for solvent welding in hot weather:

- Store solvent cements and primers in a cool or shaded area prior to use.
- If possible, store fittings and pipe or at least the ends to be solvent welded, in a shady area before welding.
- Try to do the solvent welding in cooler morning hours.
- Cool surfaces to be joined by wiping with a damp rag.
- Make sure that the surface is dry prior to applying solvent cement.
- Make sure that both surfaces to be joined are still wet with cement when putting them together. With large size pipe, more people on the crew may be necessary.
- Using a primer and a heavier, high-viscosity cement will provide a little more working time.

Note: During hot weather the expansion-contraction factor may increase. Refer to the expansion-contraction design criteria in this manual.

Table 21 – Initial Set Schedule for IPEX and IPEX Recommended PVC/CPVC Solvent Cements *

Temperature Range (°F)	Temperature Range (°C)	Pipe Size (in)				
		½ to 1¼	1½ to 2	2½ to 8	10 to 14	≥ 16
60 to 100	16 to 38	2 minutes	5 minutes	30 minutes	2 hours	4 hours
40 to 60	4 to 16	5 minutes	10 minutes	2 hours	8 hours	16 hours
0 to 40	–18 to 4	10 minutes	15 minutes	12 hours	24 hours	48 hours

* The figures in the table are estimates based on laboratory tests for water applications (chemical applications may require different set times). In damp or humid weather allow 50% more set time.

Note 1: Due to the many variables in the field, these figures should be used as a general guideline only.

Note 2: Initial set schedule is the necessary time needed before the joint can be carefully handled.

Table 22 – Joint Cure Schedule for IPEX and IPEX Recommended PVC/CPVC Solvent Cements *

Temperature Range (°F)	Temperature Range (°C)	Pipe Size (in) & system operating pressure							
		½ to 1¼		1½ to 2		2½ to 8		10 to 14	> 16
		<160 psi	160 - 370 psi	<160 psi	160 - 315 psi	<160 psi	160 - 315 psi	<100 psi	<100 psi
60 to 100	16 to 38	15 min	6 hr	30 min	12 hr	1½hr	24 hr	48 hr	72 hr
40 to 60	4 to 16	20 min	12 hr	45 min	24 hr	4 hr	48 hr	96 hr	6 days
0 to 40	–18 to 4	30 min	48 hr	1 hr	96 hr	72 hr	8 days	8 days	14 days

* The figures in the table are estimates based on laboratory tests for water applications (chemical applications may require different set times). In damp or humid weather allow 50% more cure time (relative humidity over 60%).

Note 1: Due to the many variables in the field, these figures should be used as a general guideline only.

Note 2: Joint cure schedule is the necessary time needed before pressurizing the system.

Table 23 – Average Number of Joints per quart of IPEX and IPEX Recommended Cement *

Pipe Size (in)	No. of Joints / Qt.
½	300
¾	200
1	125
1½	90
2	60
3	40
4	30
6	10
8	5
10	2 - 3
12	1 - 2
14	1

* The figures in the table are estimates based on laboratory tests

Note: Due to the many variables in the field, these figures should be used as a general guideline only.

Table 24 – Average Number of Joints per US gallon of IPEX and IPEX Recommended Cement *

Pipe Size (in)	No. of Joints / Gal.
16	3
18	2
20	1 - 2
24	1

* The figures in the table are estimates based on laboratory tests

Note: Due to the many variables in the field, these figures should be used as a general guideline only.

JOINING METHODS – THREADING

Characteristics

Threading of PVC or CPVC pipe is only recommended for Schedule 80. The wall thickness is diminished at the point of threading and thereby reduces the maximum working pressure by 50%. Because of this, threaded pipe should not be used in high pressure systems nor in areas where a leak might endanger personnel. Threaded joints will not withstand constant or extreme stress and strain and must be supported or hung with this in mind. The threading of pipe sizes above 4" is not recommended.

Note: Using threaded PVC or CPVC products at or near the maximum temperature range should be avoided. Consult IPEX for specific details.

Tools & Equipment

- Power threading machine
- Threading ratchet and pipe vise (if hand pipe stock is used)
- Pipe dies designed for plastic
- Strap wrench
- Teflon* tape (PTFE)
- Cutting and de-burring tool
- Ring gauge (L-1)

*Trademark of the E.I. DuPont Company

CAUTION: Do not use or test the products in this manual with compressed air or other gases including air-over-water boosters.

Making the Pipe Thread

1. Cutting and Deburring

PVC or CPVC pipe should be cut square and smooth for easy and accurate threading. A miter box or similar guide should be used when sawing is done by hand. Burrs should be removed inside and out using a knife or plastic pipe deburring tool.

2. Threading

Threading Schedule 80 PVC and CPVC pipe can be easily accomplished using either a standard hand pipe stock or a power operated tool. Cutting dies should be clean and sharp.

Power-threading machines should be fitted with dies having a 5º negative front rake and ground especially for plastic pipe. Self opening die heads, and a slight chamfer to lead the dies will speed the operation; however, dies should not be driven at high speeds or with heavy pressure.

When using a hand-held cutter, the pipe should be held in a pipe vise. To prevent crushing or scoring of the pipe by the vise jaws, some type of protective wrap such as canvas, emery paper, rubber or light metal sleeve should be used.

For hand stocks, the dies should have a negative front rake angle of 5° to 10°. PVC and CPVC is readily threaded and caution should be taken not to over-thread. This procedure is best done in a shop or fabricating plant. Thread dimensional specifications can be found in Table 25, American National Standard Taper Pipe Threads (NPT).

Installation Guidelines

1. Preparing the Threaded Pipe

A ring gauge should be used to check the accuracy of the threads.

Tolerance = ±1½ turns.

The threads should be cleaned by brushing away cuttings and ribbons. After cleaning, apply an IPEX recommended thread lubricant such as Teflon® tape (PTFE) or IPEX Thread Sealant to the threaded portion of the pipe.

If tape is used, wrap the tape around the entire length of threads beginning with number two thread from the end. The tape should slightly overlap itself going in the same direction as the threads. This will prevent the tape from unraveling when the fitting is tightened on the pipe. Overlapping in the wrong direction and the use of too much tape can affect tolerances between threads. This can generate stress in the wall of female fittings resulting in failure during operations.

If IPEX Thread Sealant is to be used, brush on a generous amount of sealant, using the correctly sized applicator, onto the threads beginning with the number two thread from the end.

Note: IPEX strongly recommends the use of IPEX Pipe Thread Compound (or other IPEX approved sealants) when connecting threaded fittings to other materials.

IPEX Pipe Thread Compound has been specifically formulated for use with thermoplastic piping systems. Use of other sealants may contain substances harmful to thermoplastics.

2. Assembly of Threaded Joints and Unions

After applying thread lubricant, screw the threaded fitting onto the pipe. Screwed fittings should be started carefully and hand tightened. Threads must be properly cut and a good quality thread lubricant/tape must be used. If desired, the joint may be tightened with a strap wrench. In NO INSTANCE should a pipe or chain wrench be used as the jaws of this type of wrench will scar and damage the pipe wall.

Fittings should be threaded together until hand tight with an additional ½ to 1 turns more. Avoid stretching or distorting the pipe, fittings or threads by over tightening.

Note 1: Never apply solvent cement to threaded pipe or threaded fittings. Do not allow cleaners, primers, or solvent cements to "run" or drip into the threaded portion of the fitting.

Note 2: Avoid screwing metallic male threads into plastic female threads, except those that have metal reinforcement. Consult the factory or your IPEX sales representative for the availability of these metal reinforced fittings.

Note 3: It is recommended that pipe tape/lubricant be used when connecting union ends to threaded pipe. However, pipe tape/lubricant is not needed on the union threaded interface assembly.

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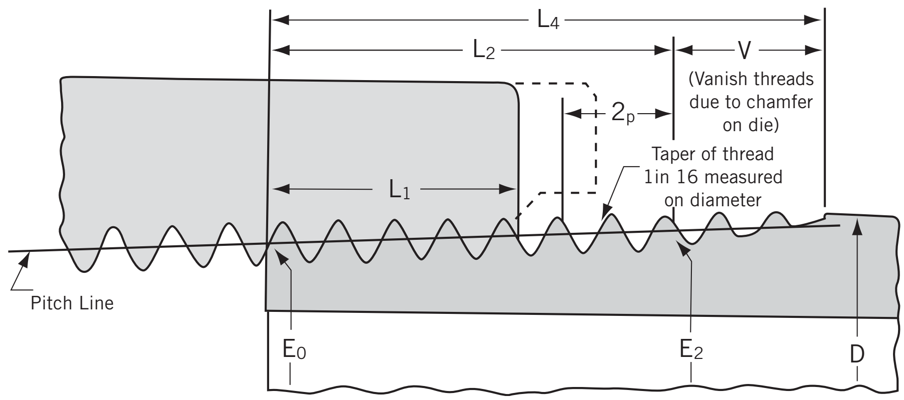


Table 25 - American National Standard Taper Pipe Threads (NPT)

Nominal Pipe Size	O.D. of Pipe (D)	Threads per inch (n)	Pitch of Thread (P)	Pitch Diameter at Beginning of External Thread (E_0)	Handtight Engagement Length[2] (L_1)		Effective Thread, External Length[3] (L_2)		Vanish Thread (V)		Overall Length External Thread[4] (L_4)	Height of Thread (h)
					Inch	Threads	Inch	Threads	Inch	Thread		
1/8	0.405	27	0.03704	0.36351	0.1615	4.36	0.2639	7.12	0.1285	3.47	0.3924	0.02963
1/4	0.540	18	0.05556	0.47739	0.2278	4.10	0.4018	7.23	0.1928	3.47	0.5946	0.04444
3/8	0.675	18	0.05556	0.61201	0.240	4.32	0.4078	7.34	0.1928	3.47	0.6006	0.04444
1/2	0.840	14	0.07143	0.75843	0.320	4.48	0.5337	7.47	0.2478	3.47	0.7815	0.05714
3/4	1.050	14	0.07143	0.96768	0.339	4.75	0.5457	7.64	0.2478	3.47	0.7935	0.05714
1	1.315	11.5	0.08696	1.21363	0.400	4.60	0.6828	7.85	0.3017	3.47	0.9845	0.06957
1 1/4	1.660	11.5	0.08686	1.55713	0.420	4.83	0.7068	8.13	0.3017	3.47	1.0085	0.06957
1 1/2	1.900	11.5	0.08696	1.79609	0.420	4.83	0.7235	8.32	0.3017	3.47	1.0252	0.06957
2	2.375	11.5	0.08696	2.26902	0.436	5.01	0.7565	8.70	0.3017	3.47	1.0582	0.06957
2 1/2	2.875	8	0.12500	2.71953	0.682	5.46	1.1375	9.10	0.4337	3.47	1.5712	0.100000
3	3.500	8	0.12500	3.34062	0.766	6.13	1.2000	9.60	0.4337	3.47	1.6337	0.100000
3 1/2	4.000	8	0.12500	3.83750	0.821	6.57	1.2500	10.00	0.4337	3.47	1.6837	0.100000
4	4.500	8	0.12500	4.33438	0.844	6.75	1.3000	10.40	0.4337	3.47	1.7337	0.100000
5	5.563	8	0.12500	5.39073	0.937	7.50	1.4063	11.25	0.4337	3.47	1.8400	0.100000
6	6.625	8	0.12500	6.44609	0.958	7.66	1.5125	12.10	0.4337	3.47	1.9462	0.100000

NOTE:

1. The basic dimensions of the American National Standard Taper Pipe Thread are given in inches to four or five decimal places. While this implies a greater degree of precision than is ordinarily attained, these dimensions are the basis of gage dimensions and are so expressed for the purpose of eliminating errors in computations.
2. Also length of thin ring gage and length from gaging notch to small end of plug gage.
3. Also length of plug gage.
4. Reference dimension

JOINING METHODS – FLANGING

Introduction

Flanging is used extensively for plastic process lines that require periodic dismantling. Thermoplastic flanges and factory flanged fittings in PVC and CPVC are available in a full range of sizes and types for joining to pipe by solvent welding and threading. Gasket seals between the flange faces should be an elastomeric full-faced gasket with a hardness of 50 to 70 durometer A. Neoprene gaskets are commonly available in sizes from 1/2" through to 24" range having a 1/8" thickness. For chemical environments beyond the capabilities of neoprene, more resistant elastomers should be used.

Dimensions

IPEX PVC and CPVC flanges have the same bolt hole dimensions as Class 150 metal flanges per ANSI B16.5. Threads are tapered iron pipe size threads per ANSI B2.1. The socket dimensions conform to ASTM D 2467 which describes 1/2" through 8". Flanges 1/2" to 12" are third party tested by NSF according to ASTM F 1970. Flange bolt sets are listed in Table 28.

Maximum pressure for any flanged system is the rating of the pipe or up to 150 psi. Maximum operating pressures for elevated temperatures are shown in Table 26. To elevate the pressure rating above 150psi, a full-pressure flange kit is available. Details on page 58.

Blind flanges in sizes 14" – 24" have a maximum working pressure of 50 psi.

Table 26 - Maximum Pressures for Flanged Systems

Operating Temp.		Max. Operating Pressure (psi)	
°F	°C	PVC	CPVC
73	23	150	150
80	27	132	144
90	32	113	137
100	38	93	123
110	43	75	111
120	49	60	98
130	54	45	87
140	60	33	75
150	66	*	68
160	71	*	60
170	77	*	50
180	82	*	38
200	93	NR	30
210	99	NR	*

* intermittent drainage only
NR – not recommended

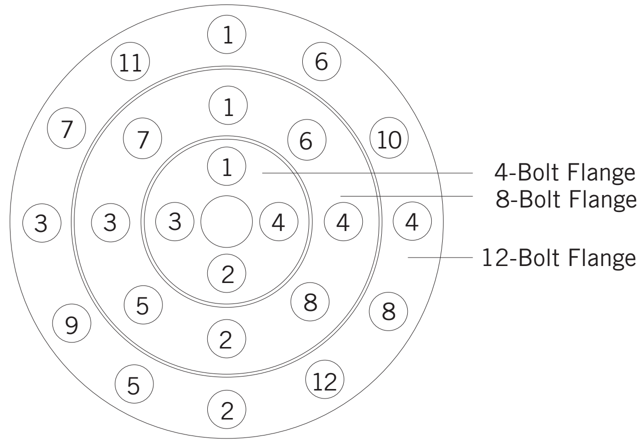
Installation Guidelines

The faces of IPEX flanges have a phonographic-grooved finish providing positive seal on the gasket when the bolts are properly tightened.

Once a flange is joined to pipe, use the following method to join two flanges together:

1) Make sure all bolt holes of the matching flanges are aligned.
2) Insert all bolts.
3) Make sure the faces of the mating flanges are not separated by excessive distance prior to bolting down the flanges.
4) The bolts on the plastic flanges should be tightened by pulling down the nuts diametrically opposite each other using a torque wrench. Complete tightening should be accomplished in stages using the final torque values in Table 27, Recommended Torque. Uniform stress across the flange will eliminate leaky gaskets.

   The following tightening pattern is suggested for the flange bolts.



5) If the flange is mated to a rigid and stationary flanged object or a metal flange, particularly in a buried situation where settling could occur with the plastic pipe, the plastic flange, and fitting or valve must be supported to eliminate potential stressing.

Table 27 – Recommended Torque

Flange Size (in.)	Recommended Maximum Torque Full Face/Heavy Duty Vanstone	PVC Vanstone
1/2– 1-1/2	15	15
2 – 4	30	30
6 – 8	50	50
10	70	65
12 – 24	100	75

* Based on using flat-faced PVC and CPVC flanges, a full-faced neoprene gasket, and well lubricated hardware, tightened in the proper sequence and applying torque in small increments. For vinyl-to-metal flange (or other materials), these torque recommendations may vary. Vanstone HD flanges should be tightened with the same torque as flat faced flanges.

Note: When thermoplastic flanges with PVC rings are used with butterfly valves or other equipment where a full-faced continuous support does not exist, a back-up ring or fiberloc ring should be used to prevent potential cracking of the flange face.

Table 28 - Recommended Flange Bolt Set

Pipe Size	No. of Holes	Bolt Diameter	Bolt Length
1/2	4	0.50	1.75
3/4	4	0.50	2.00
1	4	0.50	2.00
1-1/4	4	0.50	2.25
1-1/2	4	0.50	2.50
2	4	0.63	2.75
2-1/2	4	0.63	3.00
3	4	0.63	3.00
4	8	0.63	3.25
6	8	0.75	3.50
8	8	0.75	4.00
10	12	0.88	5.00
12	12	0.88	5.00
14	12	1.00	7.00
16	16	1.00	7.00
18	16	1.13	8.00
20	20	1.13	9.00
24	20	1.25	9.50

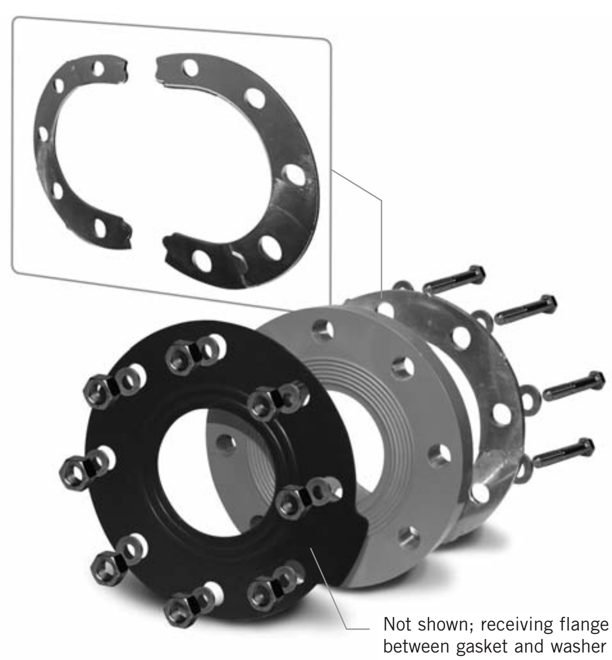
* Bolt length may vary depending on the style of flange and use of backing rings.

⚠ CAUTION

1. Do not over-torque flange bolts.
2. Use the proper bolt tightening sequence.
3. Make sure the system is in proper alignment.
4. Flanges should not be used to draw piping assemblies together.
5. Flat washers must be used under every nut and bolt head.

Corzan® Full Pressure Flange Kit

- One (1) Two-piece steel backing ring
- One (1) Stress-Saver XP gasket (75-80 durometer hardness)
- SAE J429 Grade 8 bolts with associated hex nut
- Two flat washers per bolt
- One (1) Corzan CPVC one-piece socket flange



CAUTION: Do not use or test the products in this manual with compressed air or other gases including air-over-water boosters.

IPEX is pleased to announce the launch of our new Corzan® Full Pressure (FP) Flange Kits, specifically developed to increase the pressure capability of a Schedule 80 Iron Pipe Size (IPS) Corzan CPVC one-piece flange. The Corzan FP Flange Kits have a pressure rating equal to that of Schedule 80 Corzan CPVC pipe in each of the 4 sizes offered (2-1/2" through 6"). The pressure rating is valid for connections to solid flat face metal flanges or to a second Corzan FP Flange Kit. The flange kit assembly is NSF 14 listed and meets the requirements set forth by the American Society of Testing Materials (ASTM) F1970. The special gasket and IPEX Corzan CPVC one-piece flange contained within this kit are certified to ANSI/NSF Standard 61.

Elevated Temperature Limitations

For IPEX Corzan CPVC Full-Pressure flange kits, the average pressure system operating temperature ranges from 40°F (4°C) to 200°F (93°C). At elevated temperatures the pressure capabilities of a Full-Pressure flange kit joint must not exceed the values as detailed below.

Pressure Capabilities of a Full-Pressure Flange Kit Joint

Operating Temperature		Size			
°F	°C	2-1/2"	3"	4"	6"
73	23	420	370	320	280
80	27	403	355	307	269
90	32	382	337	291	255
100	38	344	303	262	230
110	43	311	274	237	207
120	49	273	241	208	182
130	54	244	215	186	162
140	60	210	185	160	140
150	66	189	167	144	126
160	71	168	148	128	112
170	77	139	122	106	92
180	82	105	93	80	70
200	93	84	74	64	56
212	100	*	*	*	*

* Recommended for intermittent drainage only

Installation Instructions for Corzan Full-Pressure Flange Kits

Background

Proper installation of this product, for mating with a metal flange, requires the use of all the components supplied to achieve a pressure rating equal to that of the pipe.

Kit Contents

- Two-Piece steel backing ring
- Stress-Saver XP gasket (75-80 Durometer Hardness)
- SAE J429 Grade 8 bolts with associated hex nut*
- Two (2) flat washers per bolt
- Corzan CPVC one-piece socket flange

***Note:** the bolt length will vary for flange size and assembly configuration. The length of bolts supplied in this kit is assuming connection to a metal flange. For Corzan to Corzan flange connections, bolts should be 1/2" longer so that the bolts extend approximately 1/4" minimum beyond the nut after final assembly.

Installers will also need a torque wrench for proper assembly.

Installation Procedure

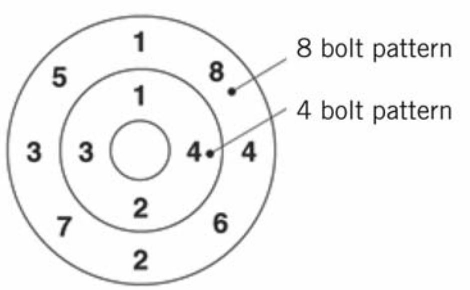
1. Assemble a Corzan flange to a Corzan pipe in a normal manner with proper solvent welding procedures in accordance with solvent cement installation procedures detailed in the Vinyl Process Piping Systems Technical Manual.
2. Allow the joint to fully cure set before installing the remaining components of the Full-Pressure Kit (refer to page 53 for recommended cure times versus temperature and size.
3. Begin kit installation by placing the backing ring over the back of the hub of the Corzan flange, ensuring that the bolt holes are aligned.
4. Slip the gasket provided between the two flanges and bring the Corzan and mating flanges together.
5. Insert the bolts through the matching holes of both the flanges and backing ring. Use only the bolts supplied or recommended above. A flat washer should be installed beneath each nut and the bolt head.
6. When the bolts are installed, a torque wrench should be placed over the nut (not on bolt head). Snug tighten the nut first, which is approximately 20 ft-lb of torque.

7. Next, tighten the nuts to the specified torque values indicated below (Table 1). A multi-step tightening process is recommended with each step requiring the installer to tighten the nuts in a star pattern (Figure 1).

Tableau 1: Torque (ft-lbs)

Size (inch)	Step 1	Step 2	Step 3	Step 4
2-1/2	20	40	70	–
3	20	40	70	–
4	20	40	80	110
6	20	40	80	110

Figure 1: Tightening Sequence



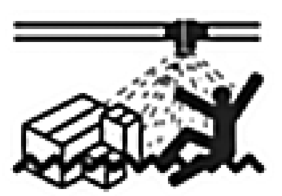
8. Once this assembly is complete, perform a check pass of the bolts by starting at one and going around in a clockwise direction ensuring each nut is tightened to the highest recommended torque level for that size.
9. **Do not use the flanged connection to support the weight of a metal system component such as a ball or butterfly valve. Those items should be supported independently.**

Notes:

1. After the piping is installed, and the solvent cement is fully cured, the system should be pressure-tested in accordance with local codes using water. Do not use compressed air or gases for testing. Refer to the Vinyl Process Piping Technical Manual for further instructions on testing.
2. **Flange kits cannot be installed against mating surfaces that include an integrated gasket, like wafer-style butterfly valves. The gasket provided in the Full-Pressure Flange Kit must be the only gasket used in the assembly.**
3. This Flange assembly has been certified to ASTM F 1970. As such, any components that are replaced must comply with the listing I order to maintain the certification. Replacement parts shall be: Stress-Saver XP gasket (75-80 Durometer Hardness), SAE J429 Grade 8 bolts with associated hex nut, two (2) flat washers per bolt.

Note: the bolt length will vary for flange size and assembly configuration. The length of bolts supplied in this kit is assuming connection to a metal flange. For Corzan to Corzan flange connections, bolts should be 1/2" longer so that the bolts extend approximately 1/4" minimum beyond the nut after final assembly.

WARNING



Failure to install flange properly may result in joint leakage or joint failure which may cause severe injury and property damage.

CAUTION

1. Do not over-torque flange bolts.
2. Use the proper bolt tightening sequence.
3. Make sure the system is in proper alignment.
4. Flanges should not be used to draw piping assemblies together.
5. Flat washers must be used under every nut and bolt head.

JOINING METHODS – ROLL GROOVED OR RADIUS CUT GROOVED (PVC ONLY)

Introduction

IPEX PVC pipe can be roll or cut-grooved at each end for quick connection using mechanical couplings specifically designed for PVC pipe. This method can be used in any application where PVC pipe is acceptable and where it is desirable to have a means for quick assembly under adverse conditions.

Features

- Completely re-usable pressure system that does not require threading, solvent welding, or flanging.
- Joints are mechanically locked to produce a secure, leak-tight connection under pressure or vacuum. (See coupling manufacturer's product information for details on pressure capabilities.)
- A union at every joint allows for speed and ease of assembly and field maintenance.
- In abrasive applications, pipe can easily be rotated to distribute wear evenly.
- Flexible system permits laying on rough or uneven terrain.
- When using a gasket-type coupler, each joint will absorb some expansion and contraction due to temperature changes.
- Grooved systems facilitate fast add-ons, modifications or re-location of the pipe.

Table 29 – Recommended Piping for Roll or Radius Cut Grooved Joints

Piping Material	Recommended Grooved Joints
PVC Sch 40 (2" – 8")	Roll or radius cut
PVC Sch 80 (2" – 12")	Roll or radius cut
PVC SDR 26 (6" – 12")	Roll or radius cut
PVC SDR 21 (4" – 12")	Roll or radius cut
PVC 14"	* May be cut grooved
PVC 16"	* May be cut grooved
PVC 18"	* May be cut grooved
PVC 24"	* May be cut grooved

* Consult an IPEX representative for detailed design considerations

Installation Guidelines

1) Always use a grooved coupling that is designed and recommended for use with PVC pipe. Table 29 shows recommended piping systems for above ground assemblies.
2) The grooves are normally machined or rolled in the pipe end by IPEX before shipment. The dimensions of the groove will be as recommended by the grooved coupling manufacturer as shown in Table 30, Grooved Joint Dimensions.
3) The working pressure and/or test pressure in a grooved joint PVC piping system should not exceed the recommended maximum pressures shown in Table 31, Maximum Pressures for Grooved PVC Pipes, at temperatures at or below 73°F (23ºC).
4) The maximum recommended operating pressures in Table 31 should be multiplied by the factors in Table 32, Temperature De-rating Factors for Grooved Joints, when the system works at temperatures constantly above 73°F (23ºC). The maximum recommended operating temperature in grooved-jointed PVC pipe systems is 100°F (38ºC).
5) The installation of grooved-jointed PVC pipe should ensure that:
   a) Thrust reaction is restrained at points of deflection or dead ends by external supports or harnesses. Thrust forces should not be transferred to the joints by design.
   b) Straight alignment of pipe is maintained at the joints, using a suitable support system.
   c) Thermal expansion/contraction movement does not exceed .0625" per joint.

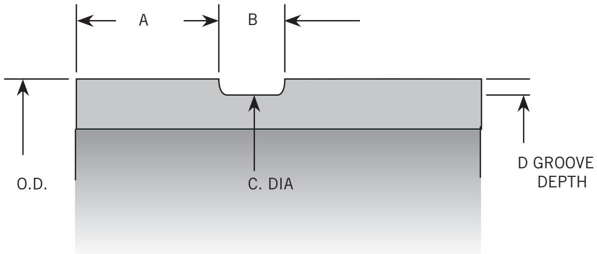


Table 30 – Grooved Joint Dimensions

Pipe Size (in.)	O.D. (in.)	A ± 0.031 (in.)	B ± 0.031 (in.)	C Average (in.)	D* (in.)
2	2.375	0.625	0.312	2.250 ± 0.015	0.062
2½	2.875	0.625	0.312	2.720 ± 0.018	0.078
3	3.500	0.625	0.312	3.344 ± 0.018	0.078
4	4.500	0.625	0.375	4.334 ± 0.020	0.083
6	6.625	0.625	0.375	6.455 ± 0.022	0.085
8	8.625	0.750	0.437	8.441 ± 0.025	0.092
10	10.750	0.750	0.500	10.562 ± 0.027	0.094
12	12.750	0.750	0.500	12.531 ± 0.030	0.109

* Dimension D is a convenient reference only, dimension C governs

Table 31 – Maximum Pressures (psi) for Cut Grooved PVC Pipes at 73°F

Pipe Size (in.)	SDR 26	SDR 21	SCH 40	SCH 80
2	-	-	100	170
2½	-	-	110	175
3	-	-	100	160
4	-	75	85	140
6	60	80	70	125
8	65	85	65	115
10	70	90	-	110
12	70	90	-	110

Table 32 – Temperature De-rating Factors for Grooved Joints

Operating Temp.		De-rating Factor
°F	°C	
73	38	1.00
80	27	0.90
90	32	0.75
*100	38	0.62

* Maximum recommended operating temperature for grooved PVC piping systems.

SUPPORTS AND RESTRAINTS

Thrust

Thrust forces can occur at any point in a piping system where the directional or cross-sectional area of the waterway changes or where additional structural loads such as valves are installed. These forces must be reduced by means of anchors, risers, restraining hangers, thrust blocks or encasement. The method chosen will depend on whether the system is buried or above ground. See also the section on installation of buried pipes in this manual.

The size or need for reinforcements should be based on the design engineer's evaluation of flow velocities and pressure increases due to the fluid's momentum. Note that the thrust created at unrestrained fittings can be considerable (as shown in Table 33) and should be addressed during installation. For more detail regarding estimating and compensating for thrust forces, refer to engineering textbooks such as the *Uni–Bell Handbook of PVC Pipe*.

Note that all valves must be anchored. This includes valves installed in line, in a chamber and those that are operated infrequently. It is recommended that anchor rods be installed around the valve body or through the mounting lugs. The rods should be embedded in concrete beneath the valve.

Table 33 - Thrust at Fittings in pounds Per 100 psi (internal pressure)

Pipe Size (in)	Blank ends & junctions	90° Bends	45° Bends	22½° Bends	11¼° Bends
½	60	85	50	25	15
¾	90	130	70	35	20
1	140	200	110	55	30
1¼	220	320	170	90	45
1½	300	420	230	120	60
2	450	630	345	180	90
2½	650	910	500	260	130
3	970	1,360	745	385	200
4	1,600	2,240	1,225	635	320
6	3,450	4,830	2,650	1,370	690
8	5,850	8,200	4,480	2,320	1,170
10	9,100	12,750	6,980	3,610	1,820
12	12,790	17,900	9,790	5,080	2,550
14	15,400	21,500	11,800	6,100	3,080
16	20,100	28,150	15,400	7,960	4,020
18	25,400	35,560	19,460	10,060	5,080
20	31,400	43,960	24,060	12,440	6,280
24	45,300	63,420	34,700	17,940	9,060

General Principles of Support

Adequate support for any piping system is a matter of great importance. In practice, support spacing is a function of pipe size, operating temperatures, the location of heavy valves or fittings and the mechanical properties of the pipe material.

To ensure satisfactory operation of a thermoplastic piping system, the location and type of hangers should be carefully considered. The principles of design for steel piping systems are generally applicable to thermoplastic piping systems, but with some notable areas where special consideration should be exercised.

1) Concentrated loads (i.e. valves, flanges, etc.) should be supported directly to eliminate high stress concentrations on the pipe. Should this be impractical, the pipe must then be supported immediately adjacent to the load.
2) In systems where large fluctuations in temperature occur, allowance must be made for expansion and contraction of the piping system. Since changes in direction in the system are usually sufficient to allow expansion and contraction, hangers must be placed so movement is not restricted. (See also Expansion-Contraction in the Design section in this manual). Note that in some instances it may be desirable to use a clamp-type hanger to direct thermal expansion or contraction in a specific direction. When using a clamp-type hanger, the hanger should not deform the pipe when it has been tightened. (See Figure 9, Recommended Pipe Hangers)
3) Changes in direction (e.g. 90° elbows) should be supported as close as practical to the fitting to avoid introducing excessive torsional stresses into the system.
4) Since PVC and CPVC pipe are somewhat notch sensitive, hangers should provide as much bearing surface as possible. Sharp supports or sharp edges on supports should not be used with these materials since they will cause mechanical damage if the pipe moves.
5) Valves should be braced against operating torque. Heavy metal valves should be supported so as not to induce additional stress on the thermoplastic piping system.

Tables 34 and 35 give recommended maximum support spacing for PVC and CPVC pipe at various temperatures. The data is based on fluids with a specific gravity of 1.0. For heavier fluids, the support spacing from the graphs should be multiplied by the correction factors shown in Table 36.

These maximum recommendations should always be referenced against local plumbing and mechanical codes as well as the local authority having jurisdiction.

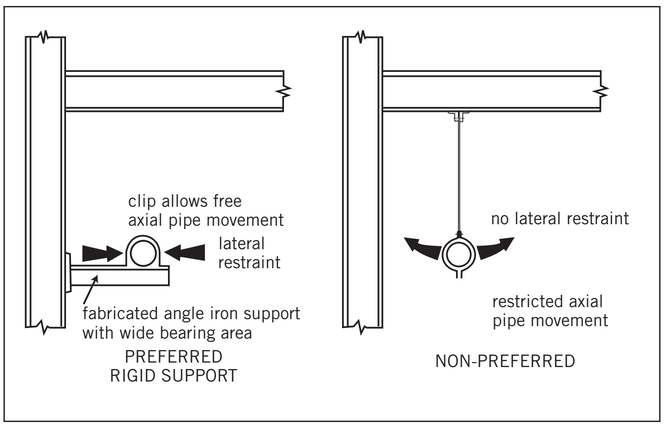
Supporting Pipes

The high coefficient of thermal expansion of plastic compared with metals may result in considerable expansion and contraction of the pipe runs as the temperature changes.

The principle is to control expansion by restraining the pipe in the lateral direction while allowing free axial movement.

A hanger-type support does not provide lateral restraint to the pipe, but it does encourage snaking and should be avoided whenever possible.

The diagram below illustrates preferred and non-preferred support arrangements.



In some cases, it may be physically impossible or impractical to install a rigid support in between two widely spaced columns. In this event hanger rods with loose fitting clips should be used.

The frequency of supports for plastic pipes is greater than for metal pipes. The recommended maximum distance between supports for pipes filled with water is given in Table 34 (See Recommended Maximum Support Spacing) and applies to pipes and contents at the temperature stated.

Pipe supports should be installed so that the horizontal piping is in uniform alignment and with a uniform slope of at least 1/8" per foot, or in accordance with the local plumbing codes or authority having jurisdiction.

Calculation of Support Spacing Based on Sag Limit

$$L = \frac{[(SL \times E \times I) / (1.302 \times Wt)]^{0.333}}{12}$$

Where:

L = Length between supports, 'Span Length', Ft.

SL = Sag Limit, the maximum permitted vertical deflection allowed across a span, expressed as a percentage of the span length for 0.2% SL = 0.2

E = Modulus of elasticity of the pipe material, psi (see Table 15)

OD = Outside Diameter of the pipe, ins.

$I = \frac{\pi}{64} \times (OD^4 - ID^4)$

$Wt = 0.02837 \times (\delta\text{-pipe} \times (OD^2 - ID^2) + \delta\text{-fluid} \times ID^2)$

δ-pipe = Density of pipe material, g/cc = Specific Gravity x 0.9975

δ-fluid = Density of the fluid, g/cc

ID = Inside diameter of the pipe, ins

Example 17

For a 1½" Schedule 40 PVC pipe operating at 140ºF (60ºC), calculate the maximum allowable support spacing with a sag limit of 0.2% (System fluid density = 1.0 g/cc)

Step 1: Calculate the weight of the piping system

$Wt = 0.02837 \times (\delta\text{-pipe} \times (OD^2 - ID^2) + \delta\text{-fluid} \times ID^2)$

Known:

Specific gravity of PVC = 1.42 (from Table 1)

E = Modulus of elasticity = 280,000 psi

OD = 1.900" (from Table A-14)

δ-pipe = 1.42 x 0.9975 = 1.416 g/cc

ID = 1.590" (from Table A-14)

$wt = 0.02837 \times (1.416 \times (1.900^2 - 1.590^2) + 1.0 \times 1.590^2)$

wt = 0.11518

Step 2: Calculate the moment of inertia

$I = \frac{\pi}{64} \times (1.900^4 - 1.590^4)$

I = 0.326

Step 3: Calculate the maximum allowable support spacing

$$L = \frac{[(0.2 \times 280{,}000 \times 0.326) / (1.302 \times 0.11518)]^{0.333}}{12}$$

L = 4.114 ft.

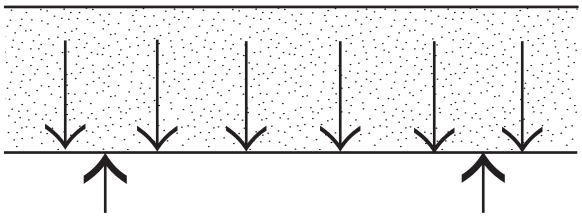
Table 34 – Recommended Maximum Support Spacing in feet for Xirtec140 PVC *

Pipe Size (in.)	Schedule 40 PVC			Schedule 80 PVC		
	60°F (15°C)	100°F (38°C)	140°F (60°C)	60°F (15°C)	100°F (38°C)	140°F (60°C)
1/2	3.0	2.9	2.6	3.1	3.0	2.7
3/4	3.4	3.2	3.0	3.5	3.4	3.1
1	3.9	3.7	3.4	4.0	3.9	3.6
1 1/4	4.3	4.2	3.9	4.6	4.4	4.1
1 1/2	4.7	4.5	4.1	5.0	4.8	4.4
2	5.2	5.0	4.6	5.6	5.4	5.0
3	6.7	6.4	5.9	7.2	6.9	6.4
4	7.6	7.3	6.7	8.2	7.9	7.3
6	9.2	8.9	8.2	10.3	9.9	9.2
8	10.7	10.2	9.5	12.0	11.5	10.6
10	12.0	11.5	10.7	13.7	13.1	12.1
12	13.2	12.7	11.8	15.2	14.6	13.5
14	14.0	13.5	12.4	16.2	15.6	14.4
16	15.3	14.7	13.6	17.6	16.9	15.7
18	16.6	15.9	14.7	19.0	18.3	16.9
20	17.5	16.8	15.5	20.0	19.5	18.1
24	19.6	18.8	17.4	20.0	20.0	20.0

* based on a sag limit of 0.2% of span length that is well within the bending stress limits of the material. This conservative calculation is also intended to accommodate expansion and contraction, pressure surges and entrapped air.

Note 1: A maximum span of 20 ft. is recommended.

Note 2: Bearing surface of supports should be at least 2" wide.



Assume the load is uniformly distributed along the span length

Table 35 – Recommended Maximum Support Spacing in feet for Corzan CPVC *

Pipe Size (in.)	Schedule 80 CPVC						
	73°F (23°C)	100°F (38°C)	120°F (49°C)	140°F (60°C)	160°F (71°C)	180°F (82°C)	200ºF (92ºC)
1/2	3.1	3.0	2.9	2.8	2.7	2.7	2.5
3/4	3.5	3.4	3.3	3.2	3.1	3.0	2.8
1	4.1	3.9	3.8	3.7	3.6	3.5	3.3
1 1/4	4.6	4.5	4.4	4.2	4.1	4.0	3.7
1 1/2	5.0	4.8	4.7	4.6	4.4	4.3	4.0
2	5.6	5.5	5.3	5.2	5.0	4.9	4.5
2 1/2	6.5	6.3	6.1	5.9	5.7	5.6	5.2
3	7.2	7.0	6.8	6.6	6.4	6.2	5.8
4	8.3	8.1	7.8	7.6	7.4	7.1	6.7
6	10.4	10.1	9.8	9.5	9.2	9.0	8.4
8	12.1	11.7	11.4	11.0	10.7	10.4	9.7
10	13.8	13.4	13.0	12.6	12.3	11.9	11.1
12	15.4	15.0	14.5	14.1	13.7	13.3	12.4
14	16.4	15.9	15.4	15.0	14.5	14.1	13.2
16	17.8	17.3	16.8	16.3	15.4	14.9	14.3

Pipe Size (in.)	Schedule 40 CPVC						
	73°F (23°C)	100°F (38°C)	120°F (49°C)	140°F (60°C)	160°F (71°C)	180°F (82°C)	200ºF (92ºC)
1/2	3.0	2.9	2.8	2.7	2.7	2.6	2.4
3/4	3.4	3.3	3.2	3.1	3.0	2.9	2.7
1	3.9	3.8	3.7	3.5	3.4	3.3	3.1
1 1/4	4.4	4.3	4.1	4.0	3.9	3.8	3.5
1 1/2	4.7	4.6	4.4	4.3	4.2	4.0	3.8
2	5.3	5.1	5.0	4.8	4.7	4.5	4.2
2 1/2	6.1	5.9	5.7	5.6	5.4	5.2	4.9
3	6.7	6.5	6.3	6.1	6.0	5.8	5.4
4	7.7	7.4	7.2	7.0	6.8	6.6	6.2
6	9.4	9.1	8.8	8.6	8.3	8.1	7.5
8	10.8	10.5	10.2	9.9	9.6	9.3	8.7
10	12.2	11.8	11.5	11.1	10.8	10.5	9.8
12	13.4	13.0	12.7	12.3	11.9	11.5	10.6
14	14.2	13.8	13.4	13.0	12.6	12.2	11.3
16	15.5	15.1	14.6	14.2	13.8	13.4	12.1

*based on a sag limit of 0.2% of span length.
Note 1: Greater than 200ºF requires continuous support.
Note 2: Bearing Surface of supports should be at least 2" wide.

Table 36 – Support Spacing Correction Factors

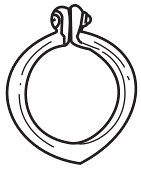
Specific Gravity	1.0	1.1	1.2	1.4	1.6	2.0	2.5
Correction Factor	1.00	0.98	0.96	0.93	0.90	0.85	0.80

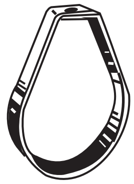
When the fluid has a specific gravity greater than water (1.0) the hanging distance must be decreased by multiplying the recommended support distance by the appropriate correction factor.

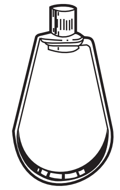
Figure 9 – Recommended Pipe Hangers for Thermoplastic Piping Systems

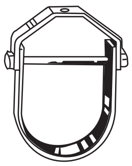
Pipe Rings

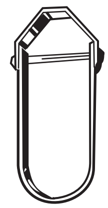

Adj. Swivel Ring
Split Ring type
3/4" to 8" pipe


Split Ring
3/8" - 8" pipe

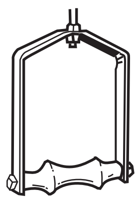

Adj. Ring
1/2" - 8" pipe

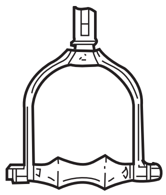

Adj. Swivel Ring
1/2" - 8" pipe

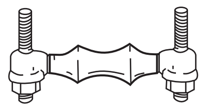

Adj. Clevis - Standard
1/2" - 30" pipe

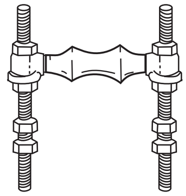

Adj. Clevis For Insulated Lines
3/4" - 12" pipe

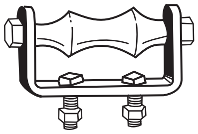
Pipe Rolls

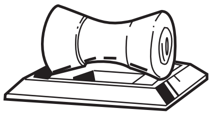

Adj. Steel Yoke Pipe Roll
2 1/2" - 20" pipe

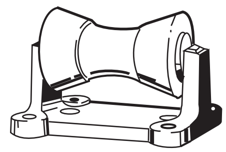

Adj. Swivel Pipe Roll
2 1/2" - 12" pipe


Single Pipe Roll
1" - 30" pipe

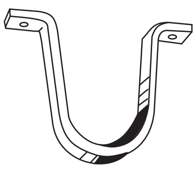

Adj. Pipe Roll Support
1" - 30" pipe

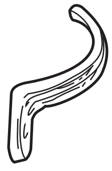

Roller Chair
2" - 12" pipe

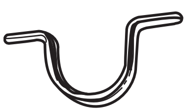

Pipe Roll and Plate
2" - 24" pipe


Pipe Roll Stand Complete
2" - 42" pipe

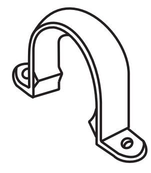
Pipe Straps and Hooks


Wrought Strap Short
1/2" - 4" pipe


One Hole Clamp
3/8" - 4" pipe


Tin Strap
1/2" - 2" pipe


IPEX Cobra Pipe Clip - Polyethylene 3/8" - 4" pipe

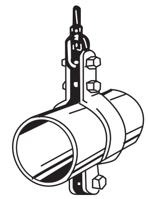

Saddle Clip - PVC or Polypropylene 3/8" - 4" pipe

Pipe Clips

All pipe clips should permit free axial pipe movement at all temperatures and should provide adequate bearing support to the pipe. Metal clips and supports should be free of sharp edges to prevent damaging the pipe.

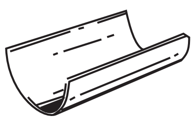
Pipe Clamps

Pipe Clamp Medium
½" - 24" pipe



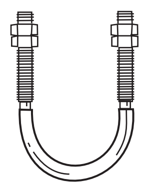
Double Bolt Pipe Clamp
¾" - 36" pipe

Pipe Covering



Insulation Protection Shield
½" - 24" pipe

Bolt



*Also available plastic coated.

U Bolt*
Standard: ½" - 30" pipe
Light Weight: ½" - 10" pipe

Note: Clamps used as anchors (such as U-bolts, etc.), if over-tightened, can produce a point-of-load stress on the pipe. This can result in cracking or premature burst failure. If U-bolts must be used, then a metal shield should be placed between the U-bolt and pipe surface. When anchoring plastic pipe, it is always desirable to spread the load over a wide area of contact.

INSTALLATION OF BURIED PIPES

Introduction

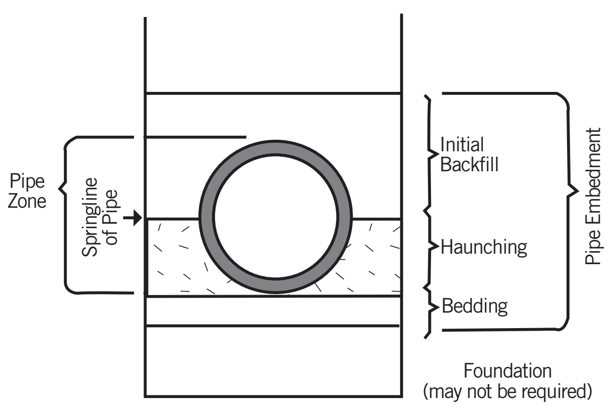
All buried piping systems are subjected to both internal and external loads. Internal loading is related to the requirements of the medium being carried and the material properties of the pipe as discussed previously in the Design section. For external loads, vinyl pipe is considered flexible (able to bend without breaking) and uses the pipe wall and the surrounding soil medium to support external loads. In other words, the soil and pipe form an integral structure. Depending on the loading characteristics, the pipe will either deflect or compress.

The external loads that need to be determined are earth, static and dynamic. Detail on determining external load characteristics is beyond the scope of this manual. For further information on determining load characteristics, the user is directed to other engineering textbooks such as the Uni–Bell Handbook of PVC Pipe.

Trench Preparation

Engineering documents for a project will specify the correct line and grade for the trench, however it is important to keep a few things in mind during the trenching operation.

Although the width at the top of the trench is generally dictated by local conditions, the width in the pipe zone should be as narrow as practical. The general rule is that the maximum width at the top of the pipe should not be more than the outside diameter of the pipe plus 24 inches. If trench width cannot be controlled and will exceed the maximum, then compacted backfill must be provided for a distance of 2½ pipe diameters on either side of the pipe to the trench wall for pipe sizes up to 10 inches. For larger size pipe (14" to 24"), the compacted haunching material should be placed one pipe diameter or 24 inches (whichever is greater) to either side of the pipe.



Trench Depth

As mentioned in the Design section of this manual, thermoplastic pipe will tend to deflect rather than crack under loading. The amount of deflection can be derived from the depth of burial, pipe stiffness and the amount of loading (e.g. soil, traffic) on the pipe. Although the maximum allowable deflection is 7.5% at a 4:1 safety factor, critical buckling occurs at 30%. For a given situation, the actual deflection and burial depth can be calculated.

For more detail regarding burial depth and estimating deflection under different conditions, consult your IPEX representative.

<u>Minimum Cover</u>

Although the project may have specifications for the required depth of burial, the following guidelines for minimum cover may prove helpful:

- Pipe should be placed 6 inches below the frost line
- For expected truck traffic (live loading - Highway H20), use a minimum cover of 12 inches (or 1 pipe diameter, whichever is greater) providing a minimum soil stiffness of E' = 1000.
- For expected heavy truck or train traffic, (live loading - Railway E80) use a minimum cover of 36 inches (or 1 pipe diameter, whichever is greater) providing a minimum soil stiffness of E' = 1000.

<u>Maximum Cover</u>

Pipe that is buried too deeply is also not advisable for reasons of cost and loading. For the maximum recommended cover, refer to Table 37.

Table 37 – Maximum Recommended Cover

Soil* Class	Standard Proctor Density Range (%)	E' Modulus of Soil Reaction (psi)	Maximum Height of Cover (ft)
I	-	3000	50
II	85-95	2000	50
	75-85	1000	50
	65-75	200	17
III	85-95	1000	50
	75-85	400	28
	65-75	100	12
IV	85-95	400	28
	75-85	200	17
	65-75	50	9

* as per ASTM D2321
Source: Uni–Bell Plastic Pipe Association

INSTALLATION

Trench Bottom

To properly support the pipe, the trench bottom should be continuous, relatively smooth, and free of rocks. Where hardpan or boulders are encountered, the trench bottom should be padded using a minimum of 4" of crushed rock or sand beneath the pipe. Frozen material should not be used to either support or bed the pipe.

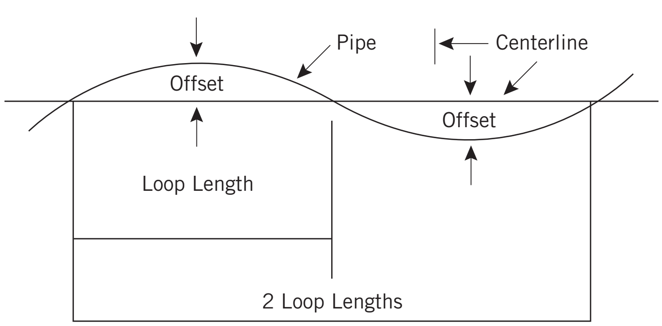
Where the soil medium is unstable, (e.g. organic material), the trench bottom should be over excavated and brought back to grade with suitable material.

Placing the Pipe

The pipe and fittings should be placed into the trench using ropes and skids, slings on a backhoe bucket or by hand. Do not throw or drop the pipe or fittings into the trench, as damage may result. Particular care should be taken when handling pipe in cold weather, as the material is less impact resistant at reduced temperatures. Before assembly ensure that all materials are in good condition.

Snaking of Pipe

After the PVC and CPVC pipe has been solvent welded, it is advisable to snake the pipe beside the trench according to the following recommendation. BE ESPECIALLY CAREFUL NOT TO APPLY ANY STRESS THAT WILL DISTURB THE UNDRIED JOINT. This snaking is necessary in order to allow for any anticipated thermal contraction that will take place in the newly joined pipeline.



Pipe Snaking

Loop Offset in Inches for Contraction

Maximum Temperature Variation, ºF Between Time of Solvent and Final Use			
Degrees	Loop Length		
	20'	50'	100'
10	3"	7"	13"
20	4"	9"	18"
30	5"	11"	22"
40	5"	13"	26"
50	6"	14"	29"
60	6"	16"	32"
70	7"	17"	35"
80	7"	18"	37"
90	8"	19"	40"
100	8"	20"	42"

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

Assembly

Assemble joints in accordance with instructions found in the Installation section under Joining methods.

Resisting Thrust

For buried pressure pipe applications, thrust forces can occur at any point in a piping system where the directional or cross-sectional area of the waterway changes. These forces must be reduced by means of concrete thrust blocks or concrete encasement. This can be accomplished by pouring concrete into appropriately sized forms at each point in the line where thrust forces will develop. The concrete block must be placed between the fitting and the undisturbed native soil at the side of the trench.

For more detail regarding estimating and compensating for thrust forces, refer to the IPEX Installation Guide and engineering textbooks such as the *Uni–Bell Handbook of PVC Pipe.*

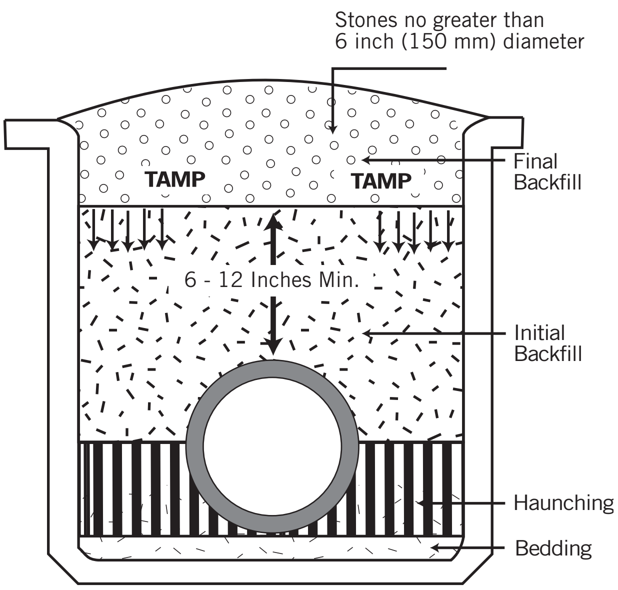
Initial Backfilling

Initial backfilling is done by covering the pipe to a depth of 6" to 12" with proper backfill material that is free from rocks, sharp objects, debris or particles larger than 3". Add layers in 6" increments ensuring that the proper compaction levels are reached for each and backfill until there is 6" to 12" of cover over the crest of the pipe.

Ensure that all joints remain exposed for visual inspection. Leave the piping to settle and normalize dimensionally then check all joints for tightness. If the piping is satisfactory then tamp the initial backfill layer.

Note 1: While tamping, ensure that the pipe alignment, both vertical and horizontal, is not disturbed.

Note 2: During hot weather it is recommended that backfilling be done in the cooler morning hours when the piping is fully contracted to avoid improper compaction due to pipe expansion.



System Testing

After the system has been assembled and initially backfilled, the system must be tested for leaks. Note that the pipe must be sufficiently backfilled to prevent movement during testing.

Conduct a pressure test as per the testing procedure in this manual in the Installation section under Testing. If the test is passed, the system can be covered. If not, make the necessary repairs and test again until the system is sound.

Compacting the Final Backfill

Final backfilling is the material that is placed over the initial backfill to the top of the trench.

Compact the haunching, initial backfill and final backfill using manual equipment in accordance with the job drawings. Observe the following precautions.

1) When a “self-compacting” material is used, such as crushed stone, ensure that the material does not arch or bridge beneath the haunch of the pipe. Remove such voids with the tip of a spade.
2) When compacting the material underneath and at either side of the pipe do not allow the tool or the machine to strike the pipe.
3) When compaction in excess of 85% standard proctor density is required in the haunching area ensure that the compacting effort does not dislodge the pipe from the correct grade. If the compacting effort dislodges the pipe, re-lay the pipe to the correct grade.
4) It is not necessary to compact the initial backfill directly over the top of the pipe for the sake of the pipe’s structural strength. However, it may be necessary for the sake of roadway integrity.
5) When laying long runs of piping in elevated air temperatures, it is advisable to begin working from a fixed point – such as the entry or exit from a building, and work away from that point, testing and backfilling in accordance with preceding paragraphs. This procedure should then allow the piping to assume soil temperature progressively as work proceeds.

CAUTION: Do not use or test the products in this manual with compressed air or other gases including air-over-water boosters.

TESTING

Site Pressure Testing

The purpose of an onsite pressure test is to establish that the installed section of line, and in particular all joints and fittings, will withstand the design working pressure, plus a safety margin, without loss of pressure or fluid.

Generally a test pressure of 1½ times the safe working pressure for the pipe installed is adequate. Whenever possible, it is recommended that hydrostatic testing be carried out. It is suggested that the following hydrostatic test procedure be followed after the solvent-welded joints have been allowed to cure for a minimum period of 24 hours at 73ºF (23ºC) (timed from the cure of last joint). For more detail, refer to the joint cure schedules in Table 22 in the Installation section.

Hydrostatic Test Procedure

1) Fully inspect the installed piping for evidence of mechanical abuse and/or dry suspect joints.
2) Split the system into convenient test sections not exceeding 1,000 ft.
3) Slowly fill the pipe section with water, preferably at a velocity of 1.0 fps or less. Any entrapped air should be evacuated by venting from the high points. Do not pressurize at this stage.
4) Leave the section for at least 1 hour to allow equilibrium temperature to be achieved.
5) Check the system for leaks. If clear, check for and remove any remaining air and increase pressure up to 50 psi. Do not pressurize further at this stage.
6) Leave the section pressurized for 10 minutes. If the pressure decays, inspect for leaks. If the pressure remains constant, slowly increase the hydrostatic pressure to 1½ times the nominal working pressure.
7) Leave the section pressurized for a period not exceeding 1 hour. During this time, the pressure should not change.

If there is a significant drop in static pressure or extended times are required to achieve pressure, either joint leakage has occurred or air remains in the line. Inspect for leakage and if none is apparent, reduce the pressure and check for trapped air. This must be removed before further testing.

Any joint leaks should be repaired and allowed to cure fully before re-pressurizing for a minimum of 24 hours.

WARNING

- **NEVER** use compressed air or gas in PVC/CPVC/PP/PVDF pipe and fittings.
- **NEVER** test PVC/CPVC/PP/PVDF pipe and fittings with compressed air or gas, or air-over-water boosters.
- **ONLY** use PVC/CPVC/PP/PVDF pipe for water and approved chemicals.

Use of compressed air or gas in PVC/CPVC/PP/PVDF pipe and fittings can result in explosive failures and cause severe injury or death.

REPAIRS

Repairs Below Ground

Defective joints or damaged sections in pipes below ground may be repaired quickly and easily using gasketed repair couplings as follows:

1) Cut out the damaged section (minimum 18 inches long).
2) File the ends square and chamfer by 45° to assist entry of pipe into the fitting.
3) Measure gap and cut new section of pipe to the measured length minus ¼ inches.
4) Prepare ends of this new pipe to a 45° chamfer.
5) Clean the existing and new pipe. Do not abrade.
6) Push o-ring repair couplings onto the exposed ends of the existing pipe.
7) Insert new pipe into the gap.
8) Draw repair couplings on the new pipe so that the joint between pipes is at the center of the coupling.

Note 1: Do not use solvent cement, or primer MEK cleaner with gasketed repair couplings.

Note 2: The pipe route should be examined to ensure that axial movement of the pipes will not take place upon pressurizing the system. If this seems likely, suitable anchors must be provided to resist the thrusts that occur under pressure.

Joint Repairs

Taking into consideration the cost of materials, time involved and labor costs, in most cases the installer is better off cutting out the defective joint, replacing it with new materials and taking greater care in the joining process.

However, fillet welding of a minor leak in a joint is possible.

Repairing Thermoplastic Pipe Joints

Scope

The most common method for repairing faulty and leaking joints is hot gas welding at the fillet formed by the fitting socket entrance and the pipe. Fillet welding of thermoplastics is quite similar to the acetylene welding or brazing process used with metals. The fundamental differences are that the plastic rod must always be the same basic material as the pieces to be joined and heated gas, rather than burning gas, is used to melt the rod and adjacent surfaces.

Welding with plastics involves only surface melting because plastics, unlike metals, must never be "puddled". Therefore the resulting weld is not as strong as the parent pipe and fitting material. This being the case, fillet welding as a repair technique is recommended for minor leaks only. It is not recommended as a primary joining technique for pressure rated systems.

Welding Tools and Materials

- Plastic welding gun with pressure regulator, gauge and hose
- Filler rod
- Emery cloth
- Cotton rags
- Cutting pliers
- Hand grinder (optional)
- Compressed air supply or bottled nitrogen (see Caution)
- Source of compressed air

Weld Area Preparation

Wipe all dirt, oil and moisture from the joint area. A very mild solvent may be necessary to remove oil.

CAUTION: Make sure that all liquid has been removed from the portion of the piping system where the weld is to be made.

Welding Faulty Joints

1. Remove residual solvent cement from the weld area using emery cloth. When welding threaded joints, a file can be used to remove threads in the weld area.

2. Wipe the weld area clean of dust, dirt and moisture.

3. Determine the mount of the correct filler rod (see Table) necessary to make one complete pass around the joint by wrapping the rod around the pipe to be welded. Increase this length enough to allow for handling the rod at the end of pass.

4. Make about a 60º angular cut on the lead end of the filler rod. This will make it easier to initiate melting and will insure fusion of the rod and base material at the beginning of the weld.

5. Welding temperatures vary for different thermoplastic materials (500ºF – 550ºF (260ºC - 288ºC) for PVC and CPVC). Welding temperatures can be adjusted for the various thermoplastic materials as well as any desired welding rate by adjusting the pressure regulator (which controls the gas flow rate) between 3 and 8 psi.

CAUTION: For welding guns which require compressed gas, nitrogen is preferred when the compressed plant air system does not contain adequate drying and filtrations.

Because of its economy, compressed air is normally the gas of choice for most plastic welding. A welding gun which generates its own air supply is frequently desirable for field-made pipe joints where ultimate weld strength is not required. For welding guns which require compressed gas, nitrogen is preferable when the compressed plant air system does not contain adequate drying and filtration. (Presence of moisture in the gas stream causes premature failure in the heater element of the welding gun. Impurities in the gas stream, particularly those in oil, may oxidize the plastic polymer, resulting in loss of strength. Polypropylene is known to be affected in this manner.)

6. With air or inert gas flowing through the welding gun, insert the electrical plug for the heating element into an appropriate electrical socket to facilitate heating of the gas and wait approximately 7 minutes for the welding gas to reach the proper temperature.

CAUTION: The metal barrel of the welding gun houses the heating element so it can attain extremely high temperatures. Avoid contact with the barrel and do not allow it to contact any combustible materials.

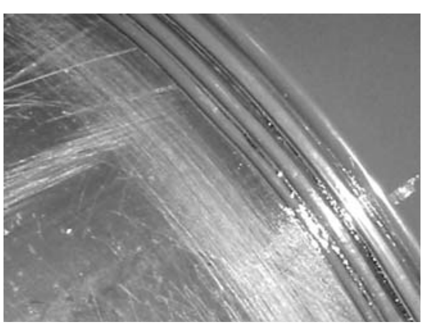
Filler rod size and number of weld passes required to make a good plastic weld are dependent upon the size of the pipe to be welded as presented below:

Pipe Sizes (in)	Rod Sizes (in)	Number of Passes
1/2 - 3/4	3/32	3
1 - 2	1/8	3
2-1/2 - 4	3/16	3
6 - 8	3/16	5
10 - 12	3/16	5

7. Place the leading end of the filler rod through the speed tip opening and into the fillet formed by the junction of the pipe and fitting socket entrance. Holding the weld tip at a 45º angle to the fitting, slowly move the weld tip across the area to be welded while applying a slight pressure by pushing the rod from the inlet side. The weld tip should be approximately 1/4" to 1/2" away from the material.

8. End each pass by mating the rod end to the starting point. Do not overlap on top or to the side of the start point. Each weld end should match perfectly with the starting point.

9. When welding large diameter pipe, more than three weld passes may be required. The first bead should be deposited at the bottom of the fillet and subsequent beads should be deposited on each side of the first bead. When making multiple pass welds, the starting points for each bead should be staggered and ample time must be allowed for each weld to cool before proceeding with additional welds.



10. Properly applied plastic welds can be recognized by the presence of small flow lines or waves on both sides of the deposited bead. This indicates that sufficient heat was applied to the surfaces of the rod and base materials to effect adequate melting and that sufficient pressure was applied to the rod to force the rod melt to fuse with base material melt. If insufficient heat is used when welding PVC or CPVC the filler rod will appear in its original form and can easily be pulled away from the base material. Excessive heat will result in a brown or black discoloration of the weld.

Welding Principles

The procedures for making good thermoplastic welds can be summarized into four basic essentials:

- Correct Heating
  Excessive heating will char or overmelt. Insufficient heating will result in incomplete melting.
- Correct Pressure
  Excessive pressure can result in stress cracking when the weld cools. Insufficient pressure will result in incomplete fusion of the rod material with the base material.
- Correct Angle
  Incorrect rod angle during welding will stretch the rod and the rod material with the base material.
- Correct Speed
  Excessive welding speed will stretch the weld bead and the finished weld will crack upon cooling.

INSTALLATION CONSIDERATIONS

Entrapped Air

Air entrapment in pressure pipelines is a much studied and discussed topic. Most designers are concerned about it but may not understand the full implications of the problem or the processes used to reduce the dangers associated with entrapped air. The problem with entrapped air is that it is a complex issue. The behavior of air in a piping system is not easy to analyze, but the effects can be devastating.

Sources of Air in Pipelines

There are many potential sources for air in pipelines and the sources are usually multiple in any given system. The most likely source occurs during filling, either initially or when refilled after drainage. In some systems, air re-enters each time the pumps are shut off as the pipelines drain through low lying sprinklers or open valves.

Air is often introduced at the point where water enters the system. This is an especially common problem with gravity fed pipelines, but may occur with pumped systems as well. Even water pumped from deep wells may be subject to air entering from cascading water in the well.

A less obvious source of air comes from the release of dissolved air in the water, due to changes in temperature and/or pressure. The quantities may be small in this case, but accumulations over time can create problems.

It is also common for air to enter through mechanical air release valves or vacuum breakers when the pressure drops below atmospheric pressure. This can occur during pump shutdown or during negative surges.

Why is Entrapped Air a Problem?

Air in a piping system tends to accumulate at high points during low flow or static conditions. As the flowrate increases, the air can be forced along the pipeline by the moving water and may become lodged at the more extreme high points where it reduces the area available for flow. Thus, these pockets of air cause flow restrictions that reduce the efficiency and performance of the system.

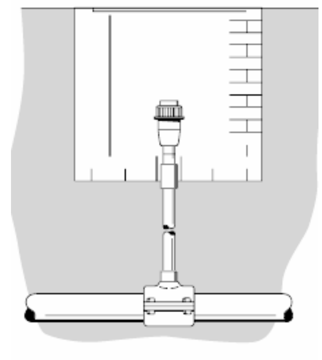
As an air pocket grows, the velocity past that point increases until eventually the air is swept on toward an outlet. While line restrictions are problems, a more serious situation can occur when air is rapidly vented from the system under pressure. Water is about five times more dense than air at 100 psi, so when a pocket of compressed air reaches an outlet, such as a sprinkler head or air release valve, it escapes very rapidly. As it escapes, water rushes in to replace the void.

When water reaches the opening, the velocity suddenly decreases, since air escapes about five times faster than water at 100 psi. The result is similar to instantaneous valve closure, except that the velocity change can far exceed the normal flow velocity in the pipeline. During tests at Colorado State University, pressure surges up to 15 times the operating pressure have been recorded when entrapped air was rapidly vented under pressure. Such pressure surges can easily exceed the strength of the system components and even at lower magnitudes, repeated surges will weaken the system over time.

Dealing with Entrapped Air

Obviously, the best way to reduce problems caused by entrapped air would be to prevent it from entering the system. Precautions should be taken to eliminate air entrance. When systems are filled, either initially or after draining for winterization or repair, they should be filled slowly, at a velocity of 1.0 fps or less, and the air should be vented from the high points before the system is pressurized. Even with these precautions, some air can remain in the system.

To deal with this remaining air or newly admitted air generated by the process itself, one or more continuous-acting air relief valves should be incorporated in the line. One solution would be to use manual vent valves such as ball valves. This solution is not ideal as strategically positioned manual vent valves can deal with entrapped air at startup, but will not deal automatically or effectively with recurring air entrapment problems. In addition, manually operated vents will inevitably lead to spills potentially resulting in site contamination or operator injury (depending on the carried media).



To ensure an effective means of dealing with entrapped air, continuous acting valves should be the preferred choice. Continuous-acting valves contain a float mechanism which allows the air to vent through a small orifice, even when the line is pressurized.

Also available on the market are combination air-release/vacuum braking valves. These products have dual functions. For example, when a tank is being filled, the entrapped air is allowed to escape and the liquid is allowed to rush in unopposed by air pockets. When the process is reversed, during the draining of a tank, the valve shutting mechanism opens the valve allowing air to rush in and replace the volume previously held by the liquid, thus preventing the formation of a potentially damaging vacuum.

IPEX offers the VA Air Release valve, a piston style air-release/vacuum breaker valve in 3/4", 1 1/4" and 2" sizes. It is important to note that the open and close functions of this 'smart' valve are controlled by media and not pressure as in other air-release valves. This feature provides several advantages. No minimum pressure or vacuum is required to either open or close the valve, thus guaranteeing responsiveness in any and all conditions while eliminating the potential for spillage.

CAUTION: Do not use or test the products in this manual with compressed air or other gases including air-over-water boosters.

Ultraviolet Light

UV sterilizers for killing bacteria in de-ionized water are common. Over time, the intense light generated by these sterilizers will stress crack PVC and CPVC pipe directly connected to the sterilizer. To minimize this problem, a transition trap between the sterilizer and the vinyl pipe is recommended.

Ozone

Ozone (O_3) is a form of oxygen. In its pure form, it is an unstable blue gas with a pungent odor. Ozone is used as a bactericide in de-ionized water systems in low concentrations of 0.04 to 5 ppm. It presents no problem to thermoplastic piping in aqueous form.

Note: Ozone in gaseous form should not be used with PVC or CPVC pipe.

Commercial mixtures are ordinarily 2% ozone and are produced by the electronic irradiation of air. It is usually manufactured on the spot, as it is too costly to ship.

Butyl rubber and ethylene propylene rubber (EPDM) have good resistance to ozone, as does fluorine rubber (Viton) and chlorosulfonated polyethylene (Hypalon). NEOPRENE AND BUNA-N OR NITRILE ARE SEVERELY ATTACKED.

Chemical Resistance

Pipe, Valves and Fittings

Thermoplastics have outstanding resistance to a wide range of chemical reagents. Such resistance is a function of both temperature and concentration, and there are many reagents which can be handled for limited temperature ranges and concentrations. In borderline cases, there may be limited attack, generally resulting in some swelling due to absorption. There are also many cases where some attack will occur under specific conditions. For such applications, the use of plastic is justified on economic grounds when considered against alternative materials. Chemical resistance is often affected (and frequently reduced) when handling a number of chemicals or compounds containing impurities. When specific applications are being considered, it is often worthwhile to conduct tests using the actual fluid that will be used in service.

In general, PVC is suitable with most strong acids, alkalis, aqueous solutions, aliphatic hydrocarbons, fluorides, photographic and plating solutions, brine and mineral oils. It should not be used with aldehydes and ketones, ethers, esters or aromatic and chlorinated hydrocarbons.

CPVC has a chemical resistance similar to or marginally better than PVC.

Gaskets and Seals

EPDM has excellent resistance to oxidation products but will show a certain swelling when in contact with mineral and petroleum oils, diester base lubricants and organic solvents.

Nitrile is a general purpose oil resistant polymer known as nitrile rubber. Nitrile is a copolymer of butadiene and acrylonitrile. Nitrile has good solvent, oil, water and hydraulic fluid resistance. It displays good compression set, abrasion resistance and tensile strength. Nitirle should not be used with highly polar solvents such as acetone and methyl ethyl ketone, nor should it be used with chlorinated hydrocarbons, ozone or nitro hydrocarbons. Temperature ranges from -65°F (-54°C) to 275°F (135°C).

FPM (Viton) has excellent resistance to chemical agents. It is virtually inert to oil and most solvents and it also exhibits good chemical capability with many aromatic and aliphatic hydrocarbons.

Please refer to the IPEX Chemical Resistance Guide for specific applications.

Heat Tracing

Although thermoplastic pipes are poor conductors of heat, heat tracing may be necessary to maintain a constant elevated temperature for a viscous liquid, to prevent liquid from freezing, or to prevent a liquid such as 50% sodium hydroxide, from crystallizing in a pipeline. Electric heat tracing with self-regulating temperature-sensing tape will maintain a 90°F (32ºC). temperature to prevent sodium hydroxide from freezing. The tape should be S-pattern-wrapped on the pipe, allowing for pipe repairs and avoiding deflection caused by heating one side of the pipe.

Heat tracing should be applied directly on the pipe within the insulation, and must not exceed the temperature, pressure or chemical resistance design of the system.

In some cases, it may be necessary to install 2 or more cables with reduced output to ensure a more even heat distribution and penetration without exceeding the maximum operating temperature of the pipe.

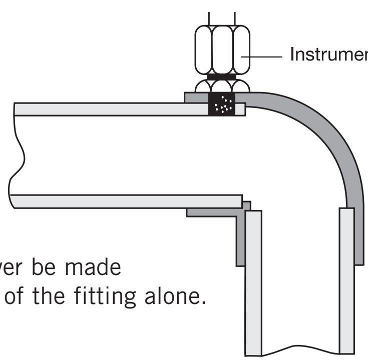
Tapping for Instrumentation Connections

For applications that require tapping PVC systems for instrumentation connections, the following guidelines should be followed:

a. Hole drilling and tapping should be performed while the system is non-pressurized.
b. IPEX recommends using schedule 80 pipe and fittings to maximize wall thickness.
c. Tapping should be done by drilling through the area where the pipe and fitting socket overlap. This area will have maximum wall thickness to allow for sufficient threads.
d. Teflon® (PTFE) tape or an IPEX approved thread sealant should be used for sealing threads.

Listed below are the pipe sizes and maximum connection sizes that may be used:

Pipe Size	Size of Connection
1/4" to 2"	Use tees, reducer bushings, and threaded fittings
2-1/2" to 4"	Max tapping 1/2" NPT
6" and greater	Max tapping 1" NPT



A tap should never be made through the wall of the fitting alone.

Direct Tapping

For applications that require direct tapping of existing PVC lines, the following guidelines should be followed:

a. Hole drilling and tapping should be performed while the line is non-pressurized.
b. Direct tapping should only be performed on Schedule 80 pipe:
   i. IPEX does not recommend direct tapping 1/4" to 2" pipe sizes.
   ii. Hole sizes should be no greater than 1/2" NPT for 2-1/2" to 4" pipe sizes.
   iii. Hole sizes should be no greater than 1" NPT for 6" and greater pipe sizes.
c. Taps should be made at least 3 feet from the end of the pipe (unless tapping through a fitting socket into pipe)
d. Teflon® (PTFE) tape or an IPEX approved thread sealant should be used for sealing threads.
e. Where saddle connections are required, hole sizing should be no larger than one half of the nominal pipe size:
   i. When assembling Saddles to PVC pipe, IPEX recommends Industrial Polychemical Service (IPS) #719 cement, or equivalent.
   ii. Although good connections may be accomplished without Saddle Straps, IPEX recommends the use of a clamp or strap device during the assembly step to ensure good compression between the pipe and fitting surfaces as the solvent cures.

For further details, please contact your IPEX representative.

These recommendations should always be referenced against local plumbing and mechanical codes as well as the local authority having jurisdiction.

Static Electricity

The non-conductive properties of thermoplastic piping materials, such as PVC and CPVC, are generally considered advantageous, particularly in electrical or electronic applications. In certain other applications these properties are considered a disadvantage, as the flowing media can allow electrostatic charges to be generated and accumulated. The potential exists for charges to accumulate to the point of becoming sources of ignition that can create sparks.

Static electricity (electrostatic charge) is generated by the separation and insulation of like bodies. In general this occurs during the transport of dry bulk solids, powders and slurries. In the case of powders, electrical charge can accumulate on several items in the piping process, including but not limited to the material itself, containers the material is poured into, metal equipment involved in or proximate to the pouring operation, as well as on the operators themselves.

In order to prevent charge from accumulating, all equipment and personnel should be grounded and measures should be taken to directly dissipate any charges by increasing the conductivity of the pipeline. This can be done by several methods, including:

- Coating the pipe surfaces with a solvent-free conductive metallic powder coating then grounding the pipe.
- Wrapping conductive wire around the pipe for the entire length of pipe and then running it to ground.
- Increasing the relative atmospheric humidity. A thin film of moisture on the pipe will improve conductivity. Although this is a somewhat temporary measure, the film can be made more intact by treating the pipeline surface with a **compatible** hygroscopic (water loving) soap.