Installation

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

Storage & Handling

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

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

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

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

Plastic Piping Tools

Tools used with Plastic Piping

The use of tools that have been specifically designed for use with thermoplastic pipe and fittings is strongly recommended to obtain optimum results when installing thermoplastic piping systems. A variety of tools that are designed for cutting, beveling, and assembling plastic pipe and fittings are readily available through local wholesale supply houses dealing in plastic pipe and fittings.

⚠ WARNING Improper use of tools normally used with metal piping systems, i.e., hacksaws, water pump pliers, pipe wrenches, etc., can cause damage to plastic pipe and fittings. Visible and non-visible fractures, scoring or gouging of material, and over tightening of plastic threaded connections are some of the major problems associated with the use of incorrect tools and/or procedures.

Pipe Cutters

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

Pipe Cutters for Large Diameter Pipe

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

Power Saws

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

Pipe Beveling Tools

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

Deburring Tools

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

Strap Wrenches

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

Chain Vises

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

Joining Devices

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

Fabrication

Cutting

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

Threading

GF Harvel PVC and CPVC pipe can be threaded using either standard hand pipe stocks or power-operated equipment. Since GF Harvel rigid PVC plastic pipe has the same outside diameter as standard steel pipe in comparable sizes, standard steel pipe taps and dies can be used. **A cut thread or deep scratch represents a stress concentration point and therefore only schedule 80 and schedule 120 pipe should be threaded.** The 50% pressure de-rating is provided to compensate for this. The thread grooves would be too deep for the relatively thin walls of schedule 40 pipe. For optimum results in threading, use new taps and dies; but in any case, they should be cleaned and sharpened in good condition. Power threading machines should be fitted with dies having a 5° negative front rake and ground especially for this type of pipe; tapered guide sleeves are not required. For hand stocks the dies should have a negative front rake of 5° to 10°. Dies which have been designed for use on brass or copper pipes may be used successfully. Carboloy dies give longer service. (Taps should be ground with a 0° to 10° negative rake, depending upon the size and pitch of the thread. Die chasers should have a 33° chamfer on the lead; a 10° front or negative rake; and a 5° rake on the back or relief edge.). Self-opening die heads and collapsible taps, power threading machines and a slight chamfer to lead the tap or dies will speed production; however, taps and dies should not be driven at high speeds or with heavy pressure.

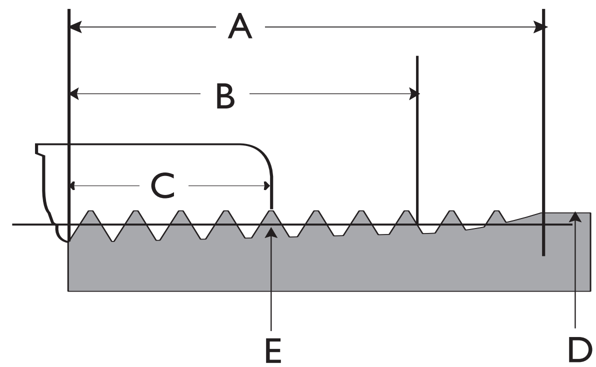
A tapered plug should be inserted into the pipe when threading, to hold the pipe round and to prevent the die from distorting and digging into the pipe wall. This insures uniform thread depth all the way around. Pipe for threading should be held in a suitable pipe vise, but saw-tooth jaws should not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

Installation

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

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

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



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

Hot Gas Welding

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

Heat Bending

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

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

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

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

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

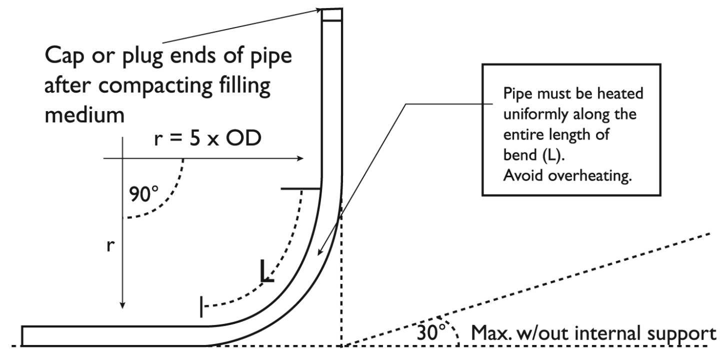
During this process, the pipe ends are capped or plugged and the filling medium is compacted as much as possible to remove any air pockets prior to heating. Once the bend is formed and cooled, the sand is emptied from the pipe and any remaining particles can be easily removed by rinsing with water.

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

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

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

HEAT BENDING OF RIGID PVC THERMOPLASTIC PIPING



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

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

Example:

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

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

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

L = 18.6"

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

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

Joining Techniques

Solvent Cementing

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

Safety Precautions

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

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

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

Virtually all solvent cements and primers for plastic pipe are flammable and should not be used or stored near heat, spark or open flames. Do not smoke during use. Eliminate all ignition sources. Primer and cement should be stored in closed containers in the shade at temperatures between 40˚F and 110˚F.

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

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

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

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

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

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

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

⚠ **WARNING Use Caution with Calcium Hypochlorite**
Do not use a dry granular calcium hypochlorite as a disinfecting material for water purification in potable water piping systems. The introduction of granules or pellets of calcium hypochlorite with solvent cements and primers (including their vapors) may result in violent chemical reactions if a water solution is not used. It is advisable to purify lines by pumping chlorinated water into the piping system—this solution will be nonvolatile.

Furthermore, dry granular calcium hypochlorite should not be stored or used near solvent cements or primers.

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

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

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

Basic Principles of Solvent Cementing

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

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

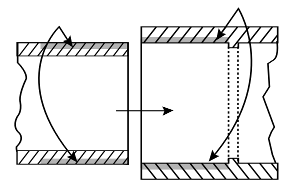
To consistently make good joints, the following should be carefully understood:

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

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

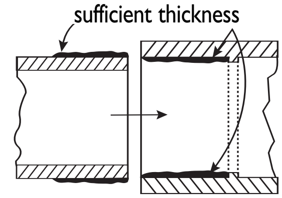
Softening and Penetration

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

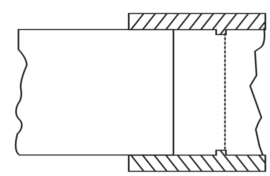


Sufficient Application of Cement

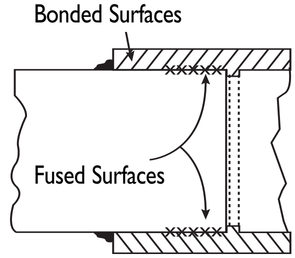
More than sufficient cement to fill the gap in the loose part of the joint must be applied. In addition to filling the gap, adequate cement layers will penetrate the joining surfaces and remain fluid until the joint is assembled.



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



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



Installation

Hot Weather
There are many occasions when solvent cementing GF Harvel piping products in 95˚F temperatures and over cannot be avoided. If a few special precautions are taken, problems can be avoided. Solvent cements contain high-strength solvents which evaporate faster at elevated temperatures. This is especially true when there is a hot wind blowing. If the pipe has been in direct sunlight for any length of time, surface temperatures may be 20˚F to 30˚F above air temperature. Solvents attack these hot surfaces faster and deeper, especially inside a joint. Thus, it is very important to avoid puddling inside sockets, and to wipe off excess cement outside.

Tips to Follow when Solvent Cementing in High Temperatures:

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

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

Tips to Follow when Solvent Cementing in Cold Temperatures:

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

Follow appropriate set and cure times prior to pressure testing.

Getting Started

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

Inspection Before Use

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

Check Material

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

Handling of Cement

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

Estimated Quantities of Solvent Cement

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

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

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

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

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

Socket Joints

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

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

Gasket Pipe (Lubricant)

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

Installation

Solvent Cement Assembly Instructions

General Instructions

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

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

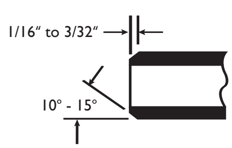
Component Preparation: Condition the pipe and fittings to the same temperature conditions prior to use. All pipe, fittings and tools used for joining must be clean and free of dirt, moisture, grease or other contamination prior to and during the joining process.

1. Cutting

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

2. Bevel/Debur

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



3. Joining Preparation

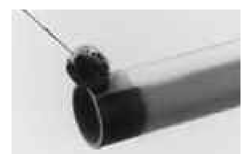
A. Inspect & Clean Components - Prior to assembly, all components shall be inspected for any damage or irregularities Mating components shall be checked to assure that tolerances and engagements are compatible. Do not use components that appear irregular or do not fit properly. Contact the appropriate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

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

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

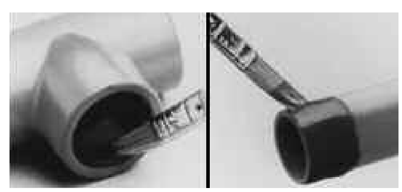
D. Position the pipe and fitting for alignment.

4. Primer Application



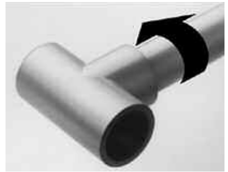
Primer must be used to prepare the bonding area for the addition of the solvent cement and subsequent assembly. It is important to use a proper applicator—a dauber, natural bristle brush, or roller approximately 1/2 the size of the pipe diameter is appropriate. A rag must NOT be used. Primer must be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

5. Solvent Cement Application



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

6. Assembly



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

7. Set and Cure Times

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

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

Set and Cure Times

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

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

Average Set Times

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

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

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

Installation

Hot Weather

There are many occasions when solvent cementing GF Harvel piping products in 95˚F temperatures and over cannot be avoided. If a few special precautions are taken, problems can be avoided. Solvent cements contain high-strength solvents that evaporate faster at elevated temperatures. This is especially true when there is a hot wind blowing. If the pipe has been in direct sunlight for any length of time, surface temperatures may be 20˚F to 30˚F above air temperature. Solvents attack these hot surfaces faster and deeper, especially inside a joint. Thus, it is very important to avoid puddling inside sockets, and to wipe off excess cement outside.

Tips to Follow when Solvent Cementing in High Temperatures:

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

Cold Weather

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

Tips to Follow when Solvent Cementing in Cold Temperatures:

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

Follow appropriate set and cure times prior to pressure testing.

Average Cure Times

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

! NOTE In damp or humid weather allow 50%, more cure time. The cure schedules shown are provided as a courtesy and are suggested as guides only. They are based on laboratory test data, and should not be taken to be the recommendations of all cement manufacturers. Individual solvent cement manufacturer's recommendations for the particular cement being used should be followed. The above cure schedules are based on laboratory test data obtained on Net Fit Joints (NET FIT = in a dry fit, the pipe bottoms snugly in the fitting socket without meeting interference). Contact the appropriate solvent cement manufacturer for additional information. Installers should verify for themselves that they can make satisfactory joints under varying conditions and should receive training in installation and safety procedures.

Applicators

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

Primers

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

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

Solvent Cements

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

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

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

1. **Light/Regular Bodied –** Cements for smaller diameters (i.e. < 4") and thin-wall classes and Schedule 40 piping with interference fits. They typically are called Schedule 40, quick-dry, regular body cement, or light-body cement. These cements are not designed to fill as much of a gap, tend to dry faster, do not bite into the pipe and fitting as much, and cure somewhat faster.
2. **Medium Bodied –** Cements for smaller diameters (i.e. < 4") for all classes, Schedule 40 and Schedule 80 pipe with interference fits. These cements have slightly better gap filler properties than regular bodied cement but are still considered fast setting cements.
3. **Heavy Bodied & Extra Heavy Bodied –** Cements for large diameters, and heavier-wall Schedule 80 and 120 products where the pipe is not as roundable. These cements are called heavy-weight, heavy-body, or Schedule 80 cements, and are designed to fill larger gaps, dry slower, bite into the pipe and fitting more, and have longer cure times.
4. **Specialty Cements -** Specialty cements have been formulated, developed, and tested for use with specific products and applications. Examples include Low VOC cements, transition cements, product specific, and one-step cements. One-step cements do not require the use of primer prior to the application of the cement, however their use is somewhat limited. Examples include one-step cements for use with CPVC fire sprinkler piping, CPVC hot and cold water plumbing pipe, and clean PVC cements for use in high purity applications (i.e. GF Harvel LXT®). Another example is specialty cements developed with improved chemical resistance to caustics. Specialty cements must be used in strict accordance with the manufacturers instructions for the intended application and should not be used to join conventional PVC/CPVC piping without investigating their suitability for use.

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

Installation

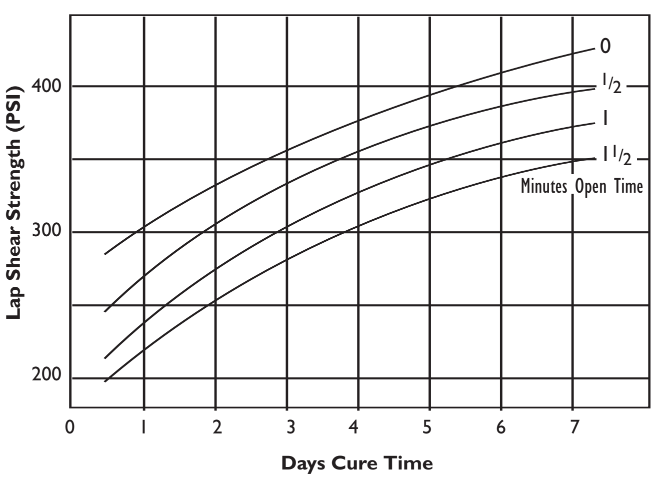
Joint Strength

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

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

Days Cure Time vs. Shear Strength & Open Time

Tests Conducted with 20 mil (.020") Gap



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

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

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

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

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

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

Minimum cement shear strength = 300 PSI

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

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

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

Safety factor 9543/3603 = 2.65

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

Tolerances and Fits

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

In the case of a fitting with the maximum diameter and the pipe with the minimum diameter, a loose fit could result. Applying two coats of solvent cement under these conditions will help assure a good joint.

Conversely, if the pipe diameter is on the maximum side and the fitting on the minimum side, the interference may be too great, and sanding of the pipe O.D. to permit entrance may be necessary.

For these specific reasons, it is important to check dry fits prior to making a solvent welded joint. The Schedule 40 and lighter wall SDR pipe have a tendency to round themselves within the Schedule 40 fittings, thus permitting a greater degree of interference. However, in the case of Schedule 80 fittings, the heavy wall on the pipe will cause the pipe to be "non roundable". Interference can be less on large diameter Schedule 80 fittings (particularly fabricated fittings), which in many cases will allow the pipe to "bottom dry" with very little interference. It is under these conditions that it may be necessary to use a extra heavy bodied solvent cement and to apply more than one coat of solvent cement to the pipe and fitting if the "dry fit" seems loose. Prior to assembly, all piping system components should be inspected for damage or irregularities. Mating components should be checked to assure that tolerances and engagements are compatible. Do not use any components that appear irregular or do not fit properly. Contact the appropriate manufacturer of the product in question to determine usability.

Large Diameter Pipe

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

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

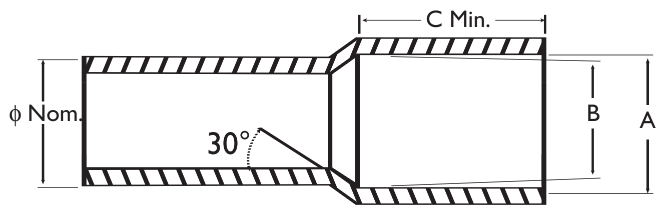
IPS Weld On 719 is a gray, extra heavy bodied, thixotropic (paste like), high strength PVC Solvent Cement. It provides thicker layers and has a higher gap filling property than regular heavyweight cement. It also allows slightly more open time before assembly. It is formulated for joining large size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

Installation

Belled End Pipe

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

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



GF Harvel Belled-End Pipe Dimensions

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

Techniques to Assure Strong Joints

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

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

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

Joint Evaluation

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

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

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

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

Joining Techniques

Threaded Connections

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

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

Assembly

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

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

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

Plastic To Metal Threaded Joints

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

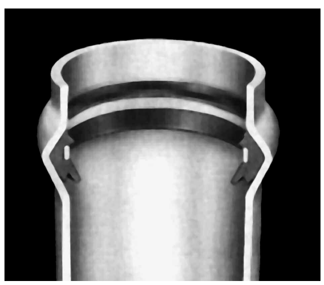
Joining Techniques

PVC Gasketed Pipe

Standards and Specifications

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

Rieber style gasket
2" through 8"



Retained Ring style gasket
10" through 24"

Gasket Design

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

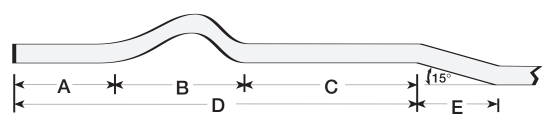
GF Harvel gasketed pipe offers low assembly force; flexibility to allow for variations in line pressure and changing working conditions; compensation for movement due to thermal expansion and contraction; a certain amount of allowable joint deflection; and positive, leak-free seals for both high- and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

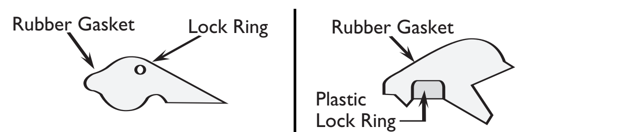
Installation – Gasketed Pipe

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

Dimensions

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





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

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

Deflection

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

Thrust Blocking

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

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

The most common method of thrust blocking involves the pouring of concrete (to the size of block required) between the pipe fitting and the bearing wall of the trench. Mechanical thrust restraint devices are also used, but must be of design for use with PVC pipe.

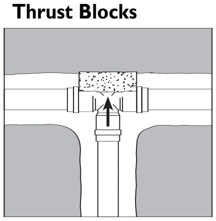
Thrust in lb. @ 100 psi Operating Pressure

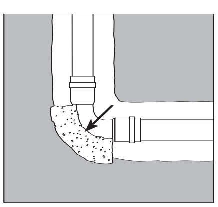
Pipe Size (in.)	90° Bend	45° Bend	22.5° Bend	Tee, Cap Plug, 60°Bend
2	645	350	180	455
2-1/2	935	510	260	660
3	1,395	755	385	985
4	2,295	1,245	635	1,620
6	4,950	2.680	1,370	3,500
8	8,375	4,540	2,320	5,930
10	13,040	7,060	3,600	9,230
12	18,340	10,000	5,240	13,000
14	21,780	11,770	6,010	15,400
16	28,440	15,370	7,850	20,110
18	35,990	19,450	9,930	25,450
20	44,430	24,010	12,260	31,420
24	63,970	34,570	17,650	45,240

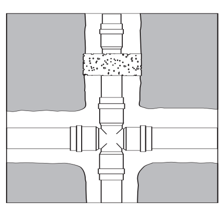
Safe Bearing Capacity

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

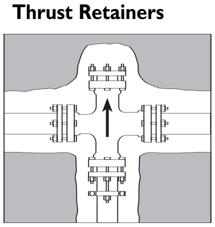
Thrust Blocks

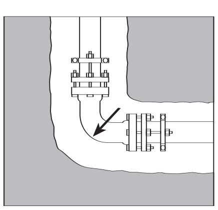

Thru line connection, tee

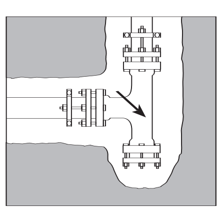

Direction change, elbow


Change line size, reducer

Thrust Retainers


Thru line connection, cross used as tee


Direction change, elbow


Direction change, tee used as elbow

Assembly Instructions

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

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

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

Pounds of Force Required to Assemble GF Harvel Gasket Pipe

Rieber

Pipe Size (in.)	ft.-lb.
2	113
2-1/2	124
3	137
4	157
6	284
8	352

Retaining Ring

Pipe Size (in.)	ft.-lb.
10	250
12	300
14	385
16	360
18	450
20	520
24	600

Trenching–Initial Backfill

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

The trench bottom should be continuous, relatively smooth, and free of rocks and debris. Adequate backfill should be in place immediately after installation, prior to filling or testing the line, to help distribute the effects of expansion/contraction evenly over each pipe length. The initial backfill material should consist of particles of 1/2" in size or less, and properly tamped. Generally a minimum of 6"–12" of backfill is desirable for the initial phase. Where hardpan, ledge rock, or large boulders are encountered, the trench bottom should be padded with sand or compacted fine-grain soils to provide adequate protection. Joints should be left exposed for visual inspection during testing.

Testing should be done before final backfill.

Installation

Testing

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

⚠ WARNING Air must be completely vented from the line prior to pressure testing; entrapped air can generate excessive surge pressures that are potentially damaging and can cause bodily injury or death. Air relief valves should be provided. The use of compressed air or gases for testing is not recommended.

GF Harvel suggests testing sections of pipe as it is installed to verify proper installation and joint assembly.

Make certain the section of piping to be tested is backfilled sufficiently to prevent movement under test pressure. If concrete thrust blocks are utilized, allow sufficient time for concrete to set up prior to testing. Test ends must be capped and braced properly to withstand thrusts developed during testing.

Final Backfill

Backfilling should be conducted in layers; each layer must be compacted sufficiently so that lateral soil forces are developed uniformly. Under certain conditions it may be desirable to pressurize line during the backfill operation. Vibratory methods are recommended when compacting sand or gravel. Sand and gravel containing a significant proportion of fine-grained materials (silt, clay, etc.) should be compacted by mechanical tampers. When water flooding is used, sufficient cover must be provided by the initial backfill to ensure complete coverage of the pipe; precautions must be taken to prevent "floating" the pipe in the trench. Additional layers of backfill should not be applied until the water-flooded backfill is firm enough to walk on.

In all cases, the backfill should be placed and spread in uniform layers to eliminate voids. Large rocks, frozen dirt clods, and other debris larger than 3" should be removed to prevent damage to the pipe. Rolling equipment or heavy tampers should only be used to consolidate the final backfill. Additional information pertaining to underground installation is contained in ASTM D2774 (Underground Installation of Thermoplastic Pressure Pipe), and ASTM D2321 (Underground Installation of Flexible Thermoplastic Sewer Pipe).

Water Volume Gallons Per 100 Feet

Pipe Size (in.)	Sch. 40	Sch. 80	Sch. 120	SDR. 21	SDR. 26	SDR. 41
2	17	15	14	19	20	–
2-1/2	25	22	21	28	29	–
3	38	34	32	41	43	–
4	66	60	54	68	70	–
6	150	135	123	146	152	–
8	260	237	–	248	258	–
10	409	373	–	–	401	–
12	582	528	–	–	565	–
14	703	637	–	–	681	–
16	917	836	–	–	889	–
18	–	1060	–	–	1125	1195
20	–	–	–	–	1390	1475
24	–	–	–	–	2000	2125

Joining Techniques
Flanged Connections

When to Use Flange Connections

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

Flange Installation Instructions

Flange Gasket

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

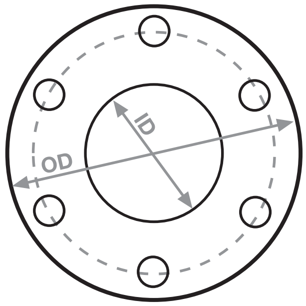
Contact GF Harvel for torque recommendations if other gasket hardness is required.

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

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

Flange Dimensions

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



Fastener Specifications

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

The following fastener combinations are acceptable:

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

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

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

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

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

Flange Bolt Specifications

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

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

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

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

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

5: Unified Coarse Threads

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

Installation

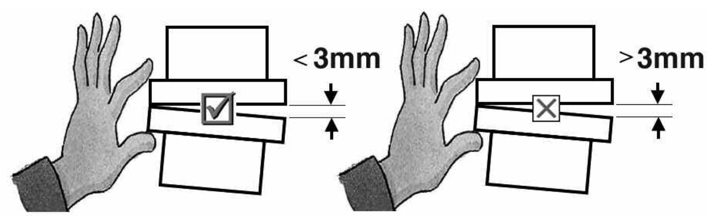
Checking System Alignment

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

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

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

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



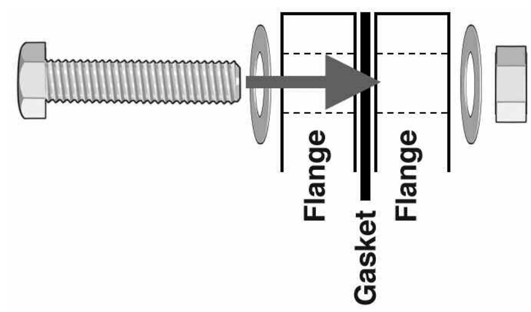
If the gap between the components cannot be closed by pinching them with one hand, or if the angle between them is too large, refit the system with proper alignment before bolting.

Assembly of the Flange

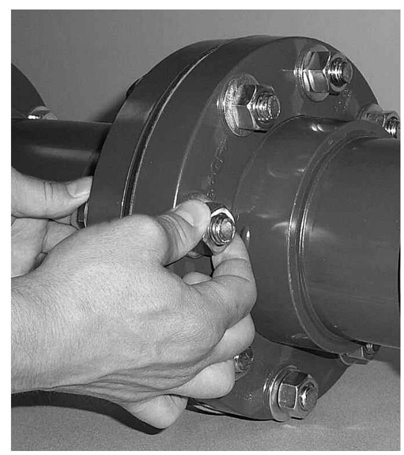
Center the gasket between the flange faces, with the bolt holes aligned with corresponding holes in the gasket. A full-face gasket cut to the specified dimensions (see table “Flange Dimensions”) should come just to the inner edge of the flange face near the flow path, or overlap the edge slightly.

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

Insert bolts through washers and bolts holes as shown:

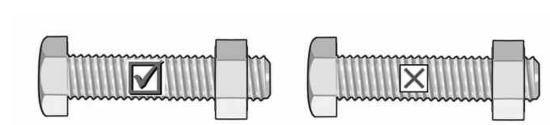


Tightening the Bolts



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

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



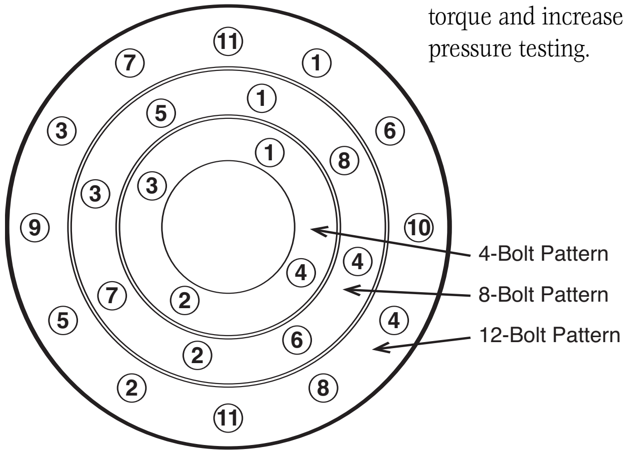
To ensure even distribution of stresses in the fully-installed flange, tighten the bolts in a star pattern then repeat the star pattern while tightening to the next torque value, and so on up to the maximum torque value.

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

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

Flange Bolt Torque

Size (in.)	Torque Sequence (ft-lb, lubed*)
1/2	10-15
3/4	10-15
1	10-15
1-1/4	10-15
1-1/2	20-30
2	20-30
2-1/2	20-30
3	20-30
4	20-30
6	30-50
8	30-50
10	50-80
12	80-100



Flange Connection to other Components

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

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

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

Joining Techniques

Groove Style Connections

In many installations where transition to metal pipe, or where disassembly is a prime factor, metallic grooved style couplings can be used to join PVC and CPVC pipe to alternate IPS size piping materials. In addition to the ease of disassembly, this type of connection also allows for a certain degree of angular adjustment and expansion/contraction. In order to prepare the plastic pipe for adapting the grooved style couplings, it is necessary to roll or cut a groove onto the end of the pipe without jeopardizing the wall thickness. Where shock loads from intermittent operation are probable, particularly with large diameter pipe, angular displacement should be avoided and the pipe aligned longitudinally to minimize high stress levels on the grooves. Grooved end pipe is available from GF Harvel.

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

Groove Style (roll or cut)

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

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

Installation

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

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

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

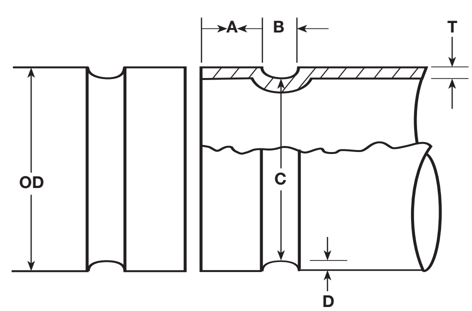
Roll Groove Specifications (IPS)

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

Roll Groove Specifications (IPS)

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

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



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

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

Joining Techniques

Specialty Adapters

Specialty reinforced molded female adapters are available in PVC and CPVC for use as transition fittings to alternate materials. Unlike conventional plastic female adapters, these fittings incorporate the use of a stainless steel restraining collar located on the exterior of the FIPT threads of the adapter. This design allows direct connection to male metal threads without the need for pressure de-rating normally associated with conventional FIPT adapters, as the radial stress generated by thread engagement is contained. In addition, this style of fitting also helps to compensate for stresses that may be generated as the result of differences in dissimilar material thermal expansion/contraction rates and related stresses.

Underground Installation

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

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

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

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

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

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

Trench depth is determined by intended service and local conditions. Pipe for conveying liquids susceptible to freezing should be buried no less than 12" below the maximum frost level. Permanent lines subjected to heavy traffic should have a minimum cover of 24". For light traffic 12" to 18" is normally sufficient for small diameter pipe (typically < 3" diameter). With larger sizes, bearing stresses should be calculated to determine cover required. Reliability and safety should always be considered, as well as local, state, and national codes.

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

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

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

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

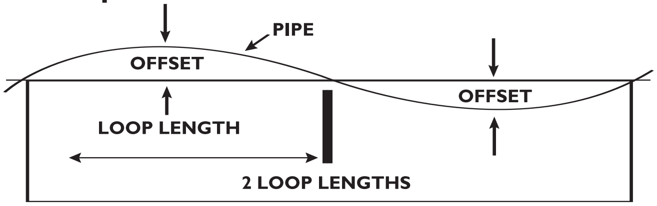
Snaking of Pipe: For small diameter piping systems (typically < 3" diameter), snaking of pipe is particularly important to compensate for thermal expansion and contraction of the piping when installing pipe in hot weather. This may also apply to larger diameter piping under specific applications and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

Installation

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

For Pipe Diameters < 3" diameter

Loop Offset in Inches for Contraction:



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

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

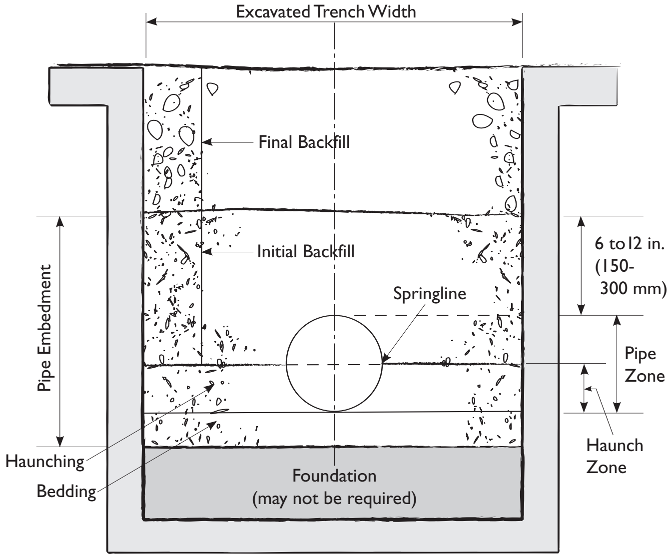
NOTE Expansion and contraction could become excessive in systems operating at near or at the maximum allowable temperature ranges with intermittent flow and buried lines. In these cases the lines should not be snaked. The use of properly installed expansion joints installed within suitable concrete pit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

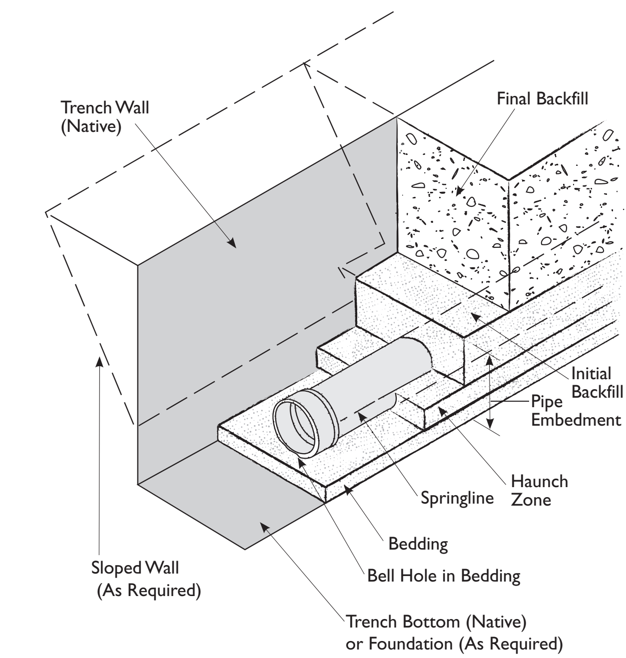
Bedding and Haunching: The pipe must be uniformly and continuously supported over its entire length on firm, stable material. Proper bedding and haunching materials are dependent on local soil conditions and type. Follow classes of embedment and backfill materials called-out in Table 1 "Pipe Stiffness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

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

Sufficient cover must be maintained to keep external stress levels below acceptable design stress. Reliability and safety of service is of major importance in determining minimum cover. Rolling equipment or heavy tampers should only be used to consolidate the final backfill. Attention should be given to local pipe laying experience that may indicate particular pipe bedding problems. Local, state and national codes may also govern.

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





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

Additional information on underground installations is contained in ASTM D2774 "Underground Installation of Thermoplastic Pressure Piping", ASTM F645, Standard Guide For "Selection Design and Installation of Thermoplastic Water Pressure Piping Systems", and ASTM D2321 "Underground Installation of Flexible Thermoplastic Sewer Pipe."

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

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

Calculating Burial Depth Limitations

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

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

Modified Iowa Equation

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

Where:

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

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

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

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

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

Installation

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

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

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

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

Example 1:

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

Using the Modified Iowa Equation:

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

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

$$\% \text{ Deflection} = 0.78 \pm 1\%$$

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

Example 2:

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

Using the Modified Iowa Equation:

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

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

$$\% \text{ Deflection} = 1.45 \pm 1\%$$

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

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

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

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

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

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

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

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

ASTM Designation D 2487, USBR Designation E-3.

LL = Liquid limit.

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

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

Above Ground Installation

Thermal Expansion & Contraction

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

Outdoor Applications

PVC and CPVC piping products have been used successfully in outdoor applications when proper recommendations are followed. As with any other piping, the system must be protected from freezing in applications subject to colder temperatures. Many standard cold weather piping design and installation practices can be used to protect the system from freezing such as use of pipe insulation, anti-freeze solutions, and heat trace tapes. The manufacturers of these products should be consulted for suitability and compatibility of their products for use with PVC and CPVC products prior to use.

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

Hangers and Supports

Hanger Support Spacing

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

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

Hanger Selection

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

Placement

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

Precautions

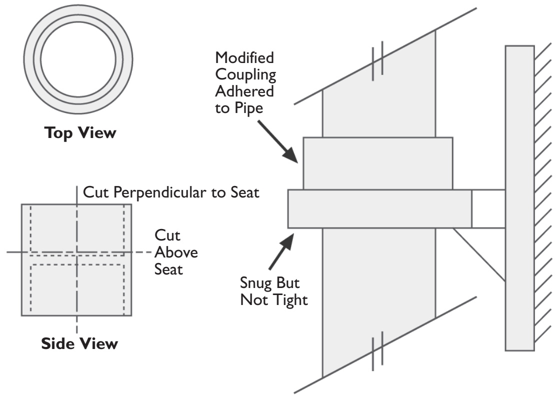
The use of protective sleeves or pads between the pipe and the hanger may be desirable in certain applications, as their use will distribute stress loads over a greater surface area, particularly when using U-bolt or roller type hangers. Piping should not be permitted to contact abrasive surfaces that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

Vertical Support

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

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

Installation



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

For vertical risers requiring support where horizontal take-offs may not be present; one common approach is to install clamps just below a modified coupling so that the shoulder of the coupling rests on the clamp. Fittings can be modified in the field to achieve this by cutting a coupling in two, just above the stop at the socket bottom, and then cutting this piece in half lengthwise to provide two halves which do not contain the stop. The two halves are then solvent cemented to the pipe at the proper location, so that the shoulder of the modified coupling rests on the clamp once the joint is allowed to cure properly. Note: A modified coupling must only be used to provide support to the riser, and must not be used to join two pieces of pipe. The load bearing strength of a modified coupling used for riser support is directly related to the surface area of the coupling and the integrity of the solvent weld (Lap Shear strength).

Anchors and Guides

Anchors are utilized to direct movement of the piping by providing restraint at key points in the system. Their use may be required to control the effects of movement caused by expansion and contraction, forces generated by pressure surges, vibration, and other transient conditions. Anchors and guides are typically installed on long straight runs, at changes in direction of the system, and where expansion joints and other methods of thermal compensation are utilized. Guides are necessary to help direct this movement between anchors by allowing longitudinal movement while restricting lateral movement. Since guides act as supports, they should have the same load bearing surface and other requirements of hangers designed for the system. Guides must be rigidly attached to the structure to prevent lateral movement, but should not restrict longitudinal movement of the pipe through the guide. Anchors and guides must be engineered and installed in such a manor to perform adequately without point loading the system. Reference should be made to the section concerning Thermal expansion and contraction for additional information.

Hanger Support Recommendations

Horizontal pipe system support spacing is greatly influenced by operating temperature. The charts show the recommended support spacing according to size, schedule, and operating temperatures. Do not clamp supports tightly — this restricts axial movement of the pipe. If short spacing is necessary, continuous supports may be more economical. Charts are based on liquids up to 1.00 specific gravity, but do not include concentrated loads, nor do they include allowance for aggressive reagents.

The following hanger support spacing recommendations are considered conservative in nature and are based on straight runs of un-insulated lines with fluids being conveyed that have a specific gravity of 1.00 or less. These values do not consider concentrated weight loads or aggressive reagents.

PVC PIPE SUPPORT SPACING (ft.)

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

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

CPVC PIPE SUPPORT SPACING (ft.)

PIPE SIZE (in.)	SCHEDULE 40						SCHEDULE 80					
	73°F	100°F	120°F	140°F	160°F	180°F	73°F	100°F	120°F	140°F	160°F	180°F
1/2	5	4-1/2	4-1/2	4	2-1/2	2-1/2	5-1/2	5	4-1/2	4-1/2	3	2-1/2
3/4	5	5	4-1/2	4	2-1/2	2-1/2	5-1/2	5-1/2	5	4-1/2	3	2-1/2
1	5-1/2	5-1/2	5	4-1/2	3	2-1/2	6	6	5-1/2	5	31/2	3
1-1/4	5-1/2	5-1/2	5-1/2	5	3	3	6-1/2	6	6	5-1/2	31/2	3
1-1/2	6	6	5-1/2	5	3-1/2	3	7	6-1/2	6	5-1/2	31/2	3-1/2
2	6	6	5-1/2	5	3-1/2	3	7	7	6-1/2	6	4	3-1/2
2-1/2	7	7	6-1/2	6	4	3-1/2	8	7-1/2	7-1/2	6-1/2	41/2	4
3	7	7	7	6	4	3-1/2	8	8	7-1/2	7	41/2	4
3-1/2	7-1/2	7-1/2	7	6-1/2	4	4	8-1/2	8-1/2	8	7-1/2	5	4-1/2
4	7-1/2	7-1/2	7	6-1/2	4-1/2	4	9	8-1/2	8-1/2	7-1/2	5	4-1/2
6	8-1/2	8	7-1/2	7	5	4-1/2	10	9-1/2	9	8	51/2	5
8	9-1/2	9	8-1/2	7-1/2	5-1/2	5	11	10-1/2	10	9	6	5-1/2
10	10-1/2	10	9-1/2	8	6	5-1/2	11-1/2	11	10-1/2	9-1/2	61/2	6
12	11-1/2	10-1/2	10	8-1/2	6-1/2	6	12-1/2	12	11-1/2	10-1/2	71/2	6-1/2
14	12	11	10	9	8	6	15	13-1/2	12-1/2	11	91/2	8
16	13	12	11	9-1/2	8-1/2	7	16	15	13-1/2	12	10	8-1/2
18	13	12-1/2	11	10	9	7-1/2	16	15-1/2	14	12-1/2	10-1/2	9
20	14	13	11-1/2	10-1/2	9	7-1/2	17	16	14-1/2	13	11	9-1/2
24	15	14	12-1/2	11	9-12	8	17-1/2	16-1/2	15	13-1/2	11-1/2	10

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