Installation Guide

For PVC Pipe And Fittings

Preface

This information is intended for Installers, Owners and Operators. We have tried to point out some of the basic principles involved when using PVC pipe and fittings. These pages should not be used as a design guide. If anything stated in this booklet raises questions, check with your Engineer or I.A. Certified Designer. NACO Industries, Inc. does not assume the responsibility of the Engineer. The final responsibility for all design and installation decisions rests with the project Engineer.

Common Abbreviations	
B	Bell - Solvent Weld
FIPT	Female Iron Pipe Thread
G	Gasket
IPS	Iron Pipe Size
MIPT	Male Iron Pipe Thread
PVC	Polyvinyl Chloride
SP	Spigot
SCH	Schedule
SW	Solvent Weld
SEW	Sewer
DWV	Drain Waste and Vent
SAD	Saddle
H	Hub - Solvent Weld Bell
PIP	Plastic Irrigation Pipe
S	Spigot

System Design

Before starting any installation, take some time to make sure your job has been designed properly.

There are many factors that come into play when designing a system. If one item is overlooked or miscalculated it can cause hundreds or even thousands of dollars in repair costs down the road.

Many times an item that works flawlessly by itself is installed into a system with many other parts and because of unforeseen variables creates a negative synergy.

It costs too much money to over build a system because of inadequate design or to not have the system work as planned because proper hydraulic principles were not taken into consideration in the design.

Make sure you have taken into consideration general design principles like friction loss, water velocity, adequate pump horsepower, air evacuation (pressure relief valves and air relief valves), elevation, grade changes and temperature changes. It saves so much time, money and resources to do the job right the first time.

Have an Engineer or an I.A. Certified Designer plan the job or check your design. Your local S.C.S. office can be an excellent resource for assistance in checking a system design.

Just like working with your family doctor, it doesn't hurt to get a second opinion. It will be well worth it in the long run.

Installation Overview

The following section of this manual is designed to be an overview of the installation process when working with PVC pipe and fittings. Most of the installation steps have a reference to a later section in this manual which gives more information on that particular step.

INSTALLATION STEPS

1. **TRENCH-** The trench bottom should be smooth and free from large rocks, chunks of frozen material or any other objects which may damage the pipe or fittings. Bell ends or gasket pockets should be recessed into the trench bottom so that the fittings and the pipe are uniformly supported.

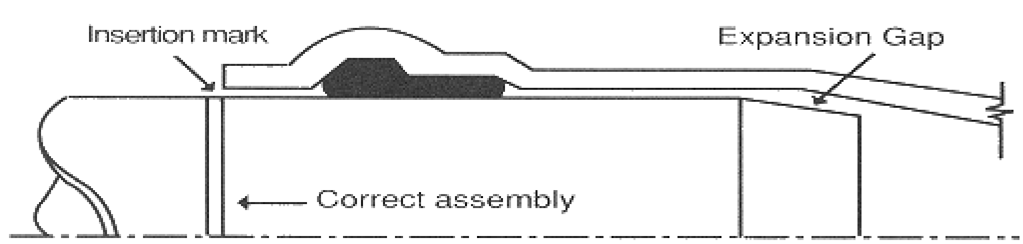
2. **CUT PIPE - SQUARELY**

3. **REMOVE BURRS** from the end of the pipe both inside and out.

4. **CLEAN THE PIPE AND THE FITTING** with a clean dry rag to remove dirt and moisture.

5. **ASSEMBLE THE JOINT**. This step is divided into two parts covering gasketed and solvent weld fittings.

   - **GASKETED JOINTS**
     - LUBRICATE the spigot end with approved gasket lubricant supplied by the pipe manufacturer.
     - ALIGN the fitting with the end of the pipe and push the two together. Insert the spigot only to the insertion mark! Do not use heavy equipment such as backhoes to assemble joints.
     - NEVER insert the spigot all the way to the end of the gasket pocket!



Make sure there is an appropriate expansion gap between the end of the spigot and the end of the gasket pocket.

- **SOLVENT WELD JOINTS**
  - CHECK THE DRY FIT of the joint by sliding the spigot into the bell.
  - APPLY PRIMER TO THE BELL END of the fitting or pipe.
  - APPLY PRIMER TO THE SPIGOT END of the fitting or pipe.
  - APPLY CEMENT INSIDE THE BELL END of the fitting or pipe.
  - APPLY CEMENT AROUND THE SPIGOT END of the fitting or pipe.
  - ASSEMBLE THE JOINT IMMEDIATELY
  - WIPE OFF EXCESS CEMENT
  - See the section on solvent weld joints for more information on cements, primers, applicators, usage and cure times.

6. **PVC SADDLES**

7. **INSTALL THRUST BLOCKS** in accordance with the system design. Thrust blocks are required with any change in direction, change in pipe size, as well as valves, hydrants, end caps or plugs.

8. **INSTALL THE INITIAL BACKFILL** in the trench leaving joints exposed until they have been tested.

9. **TEST SYSTEM FOR LEAKS**

10. **INSTALL FINAL BACKFILL**

WHEN RECEIVING SHIPMENTS

NACO products are manufactured to the highest quality control standards in the industry. Fittings are randomly pulled from production batches and run through several tests to assure consistent reliability. Each fitting is hand inspected by our quality control craftsmen before leaving the plant.

However, during the shipping and handling process, human errors can and do occur, resulting in shortages or damage to the fittings.

It is important that shortages or damage be noted on the shipping ticket before signing for the shipment.

In the case of concealed damage, notify the shipping company as soon as damages are found. Be prepared with shipping dates, invoice numbers, amounts, and pro numbers if possible.

It is the responsibility of those receiving the shipment to file a claim with the carrier for damages. Claims cannot be made by NACO Industries with the carrier.

Do not discard any damaged merchandise. Mark the damaged pieces and save them for inspection by the carrier or their representative.

WHEN HANDLING FITTINGS

In very cold weather PVC becomes stiff and loses much of its impact resistance. Just remember when the temperature falls handle the fittings gently. Don't drop fittings from warehouse shelves or truckbeds. Don't throw fittings from the back of trucks into or along side trenches. When using gasketed fittings, installation will be much easier if the fittings, with their gaskets, have been allowed to come up to a minimum temperature of 50 degrees Fahrenheit.

Never install outlets such as risers or nipples in fittings on the ground prior to installation. These can make great levers when straightening or positioning a fitting, unfortunately, they may also cause the fitting to fracture. Use a chain wrench or other suitable positioning device when installing and aligning the fittings in the line.

WHEN STORING FITTINGS

Take care that fittings are stored away from driveways, roads, or impact areas where they could be damaged.

When PVC pipe or fittings are allowed to be exposed for long periods of time to the direct rays of the sun, a discoloration or browning may occur on the top of the pipe or fitting. This discoloration merely shows that a harmless chemical transformation has occurred on the surface of the plastic. The impact strength may be reduced slightly, but not enough to be of any significance.

Trench Construction

EXCAVATING THE TRENCH

As a general rule, try not to open the trench too far ahead of the pipe installation. By keeping the open trench short, you reduce the possibility of flooding the trench, frozen ground, and trench caving.

TRENCH WIDTH

The trench width at the top will vary with local conditions. However, the width of the trench at the level of the pipe should be kept as narrow as possible and still allow you to work in the trench.

RULE OF THUMB: The maximum trench width at the top of the pipe should be the outside diameter of the pipe plus two feet. The minimum width should be the outside diameter of the pipe plus one foot.

If the trench width cannot be controlled and will be larger than the maximum, compacted backfill will be required. In this case, the compacted backfill must be installed at least 2 1/2 times the diameter of the pipe to each side of the pipe or to the trench wall whichever comes first for pipes and fittings up to 10 inches in diameter. For larger diameter pipes and fittings, install compacted backfill 1 pipe diameter or 2 feet (which ever is greater) to either side of the pipe.

TRENCH DEPTH

The recommended depth of the trench is at least six inches below the deepest recorded frost depth. In areas where frost is not a problem the depth should be from two to three feet to the top of the pipe depending on the surface loads that are anticipated after installation.

TRENCH BOTTOM

The trench bottom should be smooth. Rocks, dirt clods, and any frozen material should be removed. In rocky conditions the trench should be over excavated and a layer of sand or selected backfill placed at least four inches deep in the trench bottom. Any pipeline or fitting which rests directly on a rock is subject to breakage under the weight of the backfill load, surface load, earth movement or the movement of the pipe as the water flows through it. When the trench bottom is unstable due to quick sand, organic material etc., the trench bottom should be over excavated and brought back up to grade with approved material. Excavate under the bells for both the pipes and the fittings so the pipeline is uniformly supported along its length.

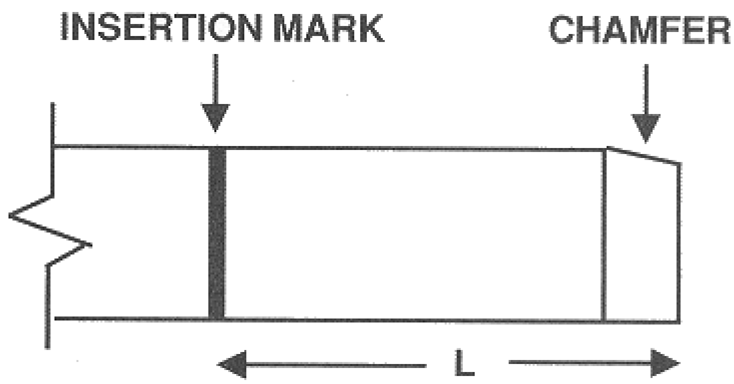
PLACING THE PIPE & FITTINGS

Lower the pipe and fittings separately into the trench. **Caution:** Impact can cause dents on the outside of the pipe. This may crack the inside of the pipe, resulting in a split when the line is pressurized.

PRE ASSEMBLY

In the event that the pipe needs to be cut for length, it is essential to insure a proper assembly, that a square cut is achieved on the pipe end. It is best to make a mark around the entire circumference of the pipe before cutting.

Use the bevel from a factory made fitting or pipe end as a guide to determine the angle and length of taper when beveling a pipe end.



L = The length of the gasket pocket less 3/4 inch

The end may be beveled using a portable sander or grinder with an abrasive disk or by using a beveling tool, hand rasp or disk cutter.

After the pipe has been cut, re-mark the insertion mark on the end of the pipe before installation.

ASSEMBLY

1. **Clean the bell end of the fitting and gasket material** making sure there is no foreign material on either surface.

2. **Make sure the spigot end of the fitting or pipe is clean** by wiping it off with a clean, dry rag or cloth from the end of the spigot to a length at least one inch longer than the bell of the fitting it will be inserted into.

3. **Apply a thin coating of lubricant**, supplied by the pipe manufacturer, around the entire circumference of the spigot end. The coating should be the equivalent of a brush coating of enamel paint and can be applied by hand, cloth, pad, sponge, glove or paint brush. Do not allow the spigot end to touch the ground after the lubricant has been applied. Contamination can damage the gasket or cause the gasket to roll out of the gasket pocket.

4. **Brace the bell end** before inserting the spigot into the bell to prevent previously installed joints from closing up.

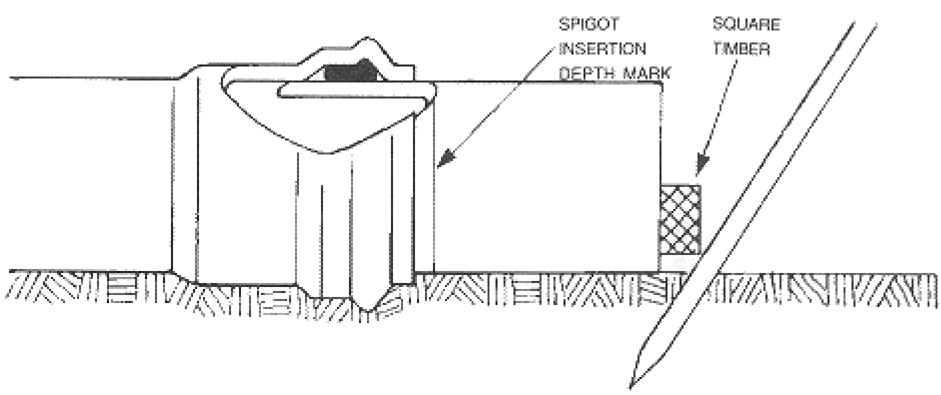
5. **Position the bevel of the spigot** so it is resting against the gasket inside the gasket pocket. Push the spigot into the gasket pocket until the insertion mark on the spigot end of the pipe lines up with the edge of the belled end of the pipe.

DO NOT OVER INSERT THE SPIGOT INTO THE GASKET POCKET!

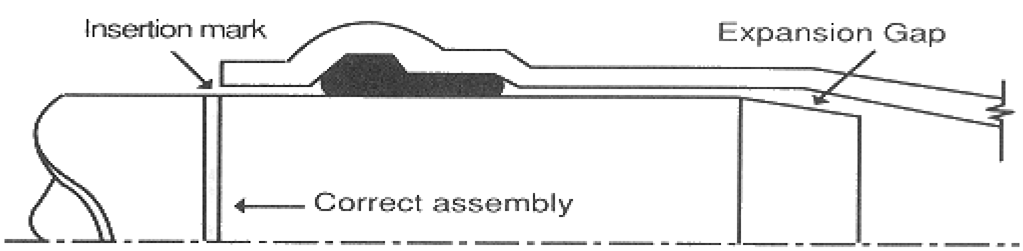
The assembly can be made by hand when using smaller diameters of pipe by twisting the spigot slightly as it enters the bell. Other assembly methods include using a bar and block, lever pullers or hydraulic jacks. **Backhoe buckets are not recommended for installing gasketed fittings**, even in large diameter sizes.

Generally, the backhoe operator cannot see the insertion mark on the spigot end and cannot feel when the spigot bottoms out in the gasket pocket. This is the cause of many broken pipes and fittings.

When using mechanical force to install joints, place a wooden block or plank over the end opposite the spigot to prevent damage to the fitting or the pipe end.



CAUTION! DO NOT OVER INSERT THE JOINT! When the spigot is inserted beyond the insertion mark, the chamfered end of the spigot acts like a wedge in wood, expanding out the bottom or tapered end of the gasket pocket and causing the pipe or fitting to split.

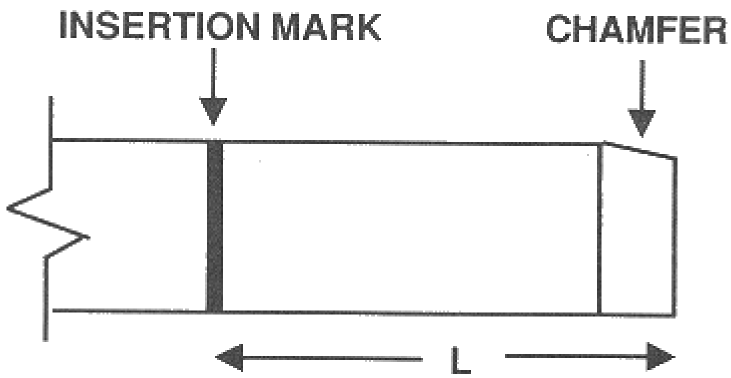


Over insertion of the spigot may not show up on the joint currently being assembled, but may cause splitting in a joint previously assembled.

It is necessary to have a gap between the end of the spigot and the end of the gasket pocket. This gap will allow for Thermal Expansion and Contraction of the pipe as it heats and cools during normal operation.

If there is no insertion mark on the pipe spigot or if the pipe has been cut and beveled an insertion mark *must* be placed on the spigot end.

To determine the correct position of the insertion mark, measure the length of the gasket pocket or bell end of the pipe or fitting. Subtract a minimum of 3/4 inch from this measurement, as explained in the Thermal Expansion section. Place a mark on the spigot to correlate with the adjusted measurement.



L = The length of the gasket pocket less 3/4 inch

CAUTION! Depths of gasket pockets or bell ends may vary with pipe manufacturers. Especially when using PIP pipe. The general rule for large diameter pipe is the length of the gasket pocket should be half of the diameter of the pipe. **ALWAYS double-check the insertion mark on the pipe to make sure it is the proper length for the fittings when starting a job.**

A quick way to check the insertion mark is to lay the fitting next to the spigot end of the pipe. When the end of the fitting lines up with the insertion mark on the pipe, the spigot end of the pipe should be approximately 3/4 inch back from the end of the gasket pocket on the fitting.

GASKET LUBRICANT

RECOMMENDED GASKET LUBRICANT JOINTS PER QUART					
SIZE	**JOINT**	**SIZE**	**JOINT**	**SIZE**	**JOINT**
3"	100	10"	35	21"	10
4"	85	12"	25	24"	9
6"	60	15"	15	27"	8
7"	45	18"	12	30"	7

Solvent Weld Pipe & Fittings

OBJECTIVE:

When using solvent weld pipe and fittings, the objective is to create an actual chemical weld between the two pieces of plastic. The joints are not just "glued", they actually become chemically welded. This is why we always refer to "Solvent Cement" rather than "Glue."

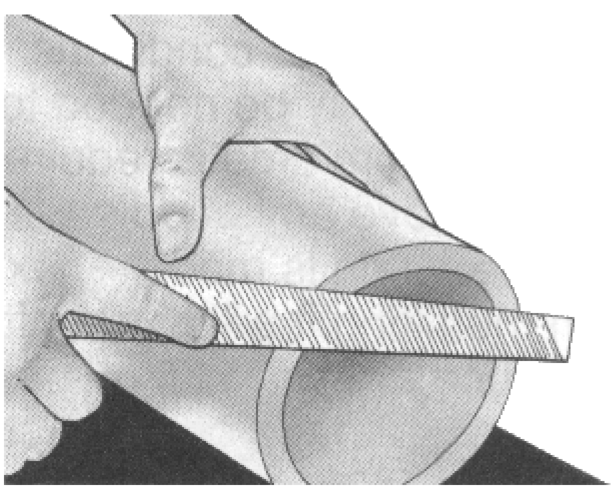
Most solvent weld joints are made with an "interference fit". This means there is a slight inward taper from the outside of the joint to the inside. In other words, the farther you slide the pipe into the fitting the tighter the joint gets.

Another characteristic of an interference fit is a small gap between the end of the bell and the spigot. This gap is filled with cement. The larger the diameter of the pipe, the larger this gap becomes. This is why large diameter fittings require different cement than small diameter fittings. Cements made for large diameter fittings have more filler material in them to adequately fill the gap. It is important to make sure you are using the right cement for the job. Check the manufacturers recommendations.

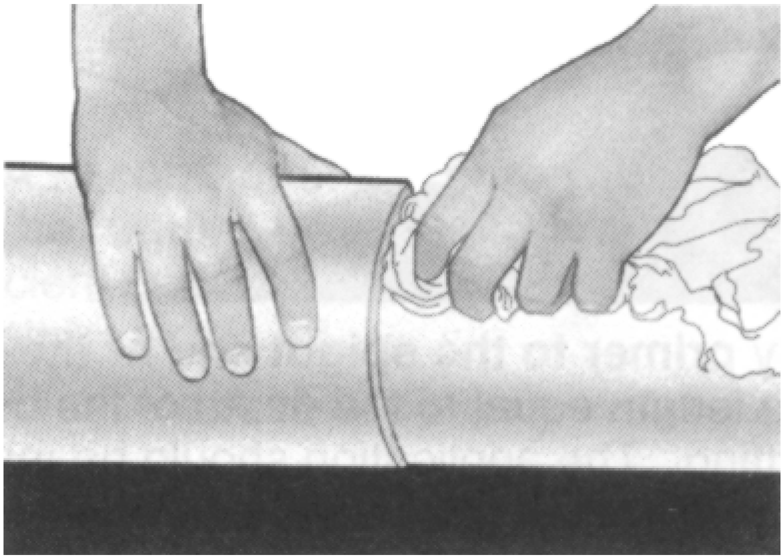
PRE ASSEMBLY:

1. **Cut the pipe** as square as possible to ensure a proper fit. It is a good idea to mark the pipe all the way around before cutting.

2. **Remove the burrs and the sharp edges** from the cut end of the pipe with a knife, file, reamer or de-burring tool. It is best on large diameter pipe to round the outside edge of the pipe giving it a slight chamfer. Burrs or sharp edges left on the cut end of the pipe can create grooves or cause hang-ups in softened plastic.



3. **Wipe both surfaces to be cemented with a clean rag** removing all dirt and moisture. Dirt and other foreign material can prevent adhesion and cause an inadequate chemical weld.



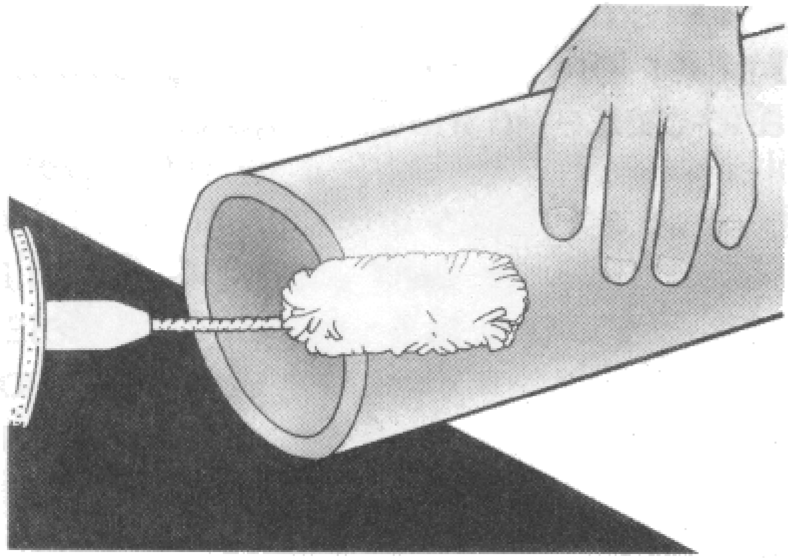
4. **Place the fitting on the Pipe without any cement or primer and check the dry fit.** The pipe should be able to slide part way into the fitting and should not be loose or sloppy.

ASSEMBLY:

PRIMING

1. **Apply a liberal coat of primer to the bell end of the fitting.** Make sure the primer has evenly coated the surface of the fitting both top and bottom. Keep the surface of the fitting wet with primer until it starts to soften. Softening times will vary with weather conditions. Additional coats of primer may be needed to achieve softening. More time is required in cold weather. Remove any puddles of primer when proper penetration is made. If extra primer is left in the fitting it will over soften the material and reduce the strength of the plastic.

   It is recommended that a *colored* primer be used such as Valor V700, or equal, purple primer.

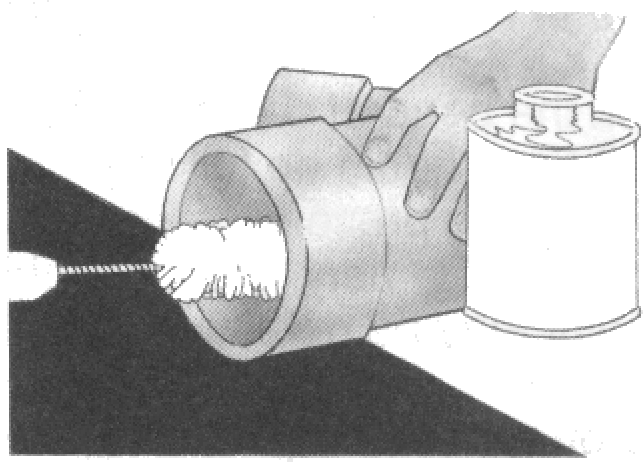


2. **Apply primer to the spigot end of the pipe** to a length equal to the depth of the bell on the fitting. The application should be made in the same manner as the bell end of the fitting in step 1.

3. **Double check the bell end of the fitting and the spigot end of the pipe for proper softening.** In some cases a second coat of primer is required.

CEMENTING

1. As soon as the plastic has been softened with the primer and while the surface is still wet, **apply a medium layer of cement inside the bell end of the fitting**. Remove any puddles of cement. Do not apply cement any deeper than the end of the bell. Do not allow the cement to run down the pipe or fitting.

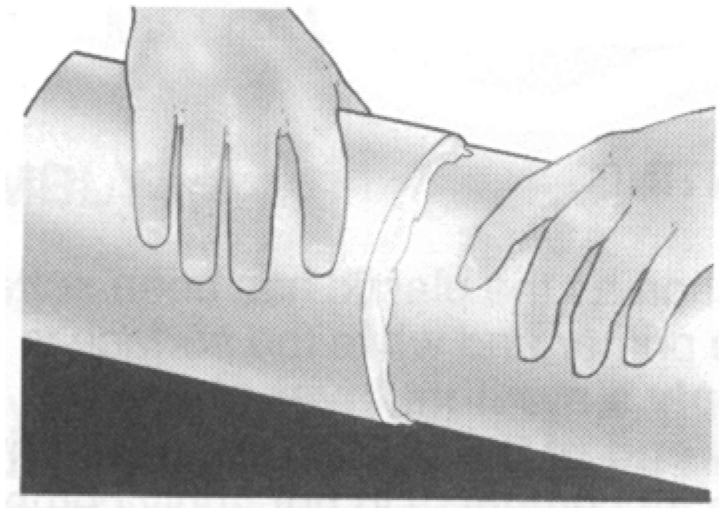


2. **Quickly apply a full even layer of cement to the spigot end of the pipe** which has been softened with the primer. Take care not to brush out the cement like paint. Flow the cement around the pipe with the appropriate size applicator. Spread the cement around the

pipe up to a length equal to the bell of the fitting.

3. **A second coat of cement on the pipe may be required** when using large diameters. Sufficient cement is required to fill any gap in the joint.

4. **Immediately assemble the pipe and the fitting.** If possible twist the pipe 1/8 to 1/4 turn as you insert it.



5. **Hold the joint together for a short time** (usually around 30 seconds) until the pipe quits trying to push away from the fitting joint.

6. Check the bead of cement around the fitting. The bead should be full with no voids or gaps. If gaps are present in the cement there was not enough cement applied to the joint and the joint may be defective.

7. Wipe off excess cement with a rag. If excess cement is left on the pipe it can cause over softening of the pipe. After the joint has been properly made and it starts to set up, the active agent in the cement dissipates out of the joint leaving behing two plastic surfaces which have been chemically bonded.

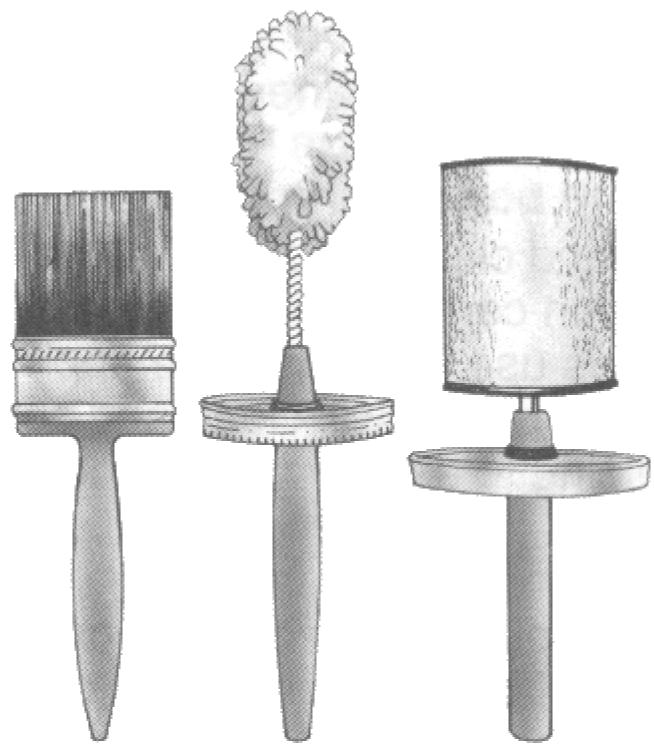
TIPS ON SOLVENT WELD JOINTS

THE RIGHT SIZED APPLICATOR

When applying primer or cement it is important to use the right applicator for the size of the fitting. Cement must be wet when joints are assembled.

When too small an applicator is used and and too much time is taken, the cement drys out, or "skins over". When this happens a chemical weld may not occur and you have a "dry joint" or a joint that is held together with only the friction of the interference fit.

Remember: **A major cause of "Dry Joints" is the use an applicator too small for the size of the pipe and fitting.**



Too thin a layer, too slowly applied = "Dry Joint"

As a general rule, for smaller diameter fittings try to use an applicator that is 1/2 the size of the pipe diameter. Recommended applicators for large diameter fittings include paint brushes, large cotton swabs and rollers (cotton swabs and rollers should be of the type made specifically for applying primers and cements).

PRIMERS & CLEANERS

Primers contain an active ingredient which is an etching and softening agent. It is designed to break down the glossy outer layer of the pipe and soften the plastic, preparing it for chemical penetration by the cement.

The chemicals in cleaners break down the glossy outer layer of the plastic and clean the surface but do not soften the plastic in preparation for the cement.

Do not confuse **cleaners and primers** as being the same thing.

Primer and cleaner both have their purposes. When cementing PVC pipe and fittings, always use primer before applying the cement. The primer will clean and soften the plastic helping to assure good penetration of the cement.

Test the softening time of the primer on a scrap piece of pipe. Apply a coat of primer to the pipe and see how long it takes to soften the plastic to the point that by scraping the pipe with a knife or scraper you can peel up a few thousandths of an inch of plastic.

CEMENTING

If the joint has been left open long enough that the cement has started to skin (a rubbery, dull film on the outside of the cement), try applying a wet coat of primer over the cement, taking care not to brush away the cement. The primer will re-soften the cement.

Keep dirt and other contaminants away from the cement. Any contaminants, (particularly moisture), may prevent a successful chemical weld.

When cementing large diameter fittings it is recommended that two installers apply primer and cement decreasing the open time of the joint.

Mechanical devices such as "come alongs" or blocks and bars may be needed to pull the joint together and hold it until it is stable. Make sure everything is laid out and ready to use before applying primer and cement. Once the joint is started there is no time for error.

CEMENT USAGE

RECOMMENDED CEMENT USE - JOINTS PER QUART 917, 919, OR EQUAL CEMENTS					
SIZE	4"	6"	8"	10"	12"
JOINTS	30	20	10	6	4
SIZE	15"	18"	21"	24"	27"
JOINTS	3	1 1/2	1	3/4	1/2
Figures are estimates based on laboratory tests. Due to many variables in the field, these figures should be used as a general guide only.					

CEMENT CURING TIME

RECOMMENDED CEMENT CURE TIME FOR 917,919, OR EQUAL CEMENTS					
TEMP RANGE	1 1/2" - 3"		3 1/5" - 8"		10"-15"
	UP TO 180#	180 TO 315#	UP TO 180#	180 TO 315#	UP TO 100#
60-100	2 hrs	12 hrs	6 hrs	24 hrs	24 hrs
40-60	4 hrs	24 hrs	12 hrs	48 hrs	48 hrs
0-40	16 hrs	96 hrs	48 hrs	8 days	8 days
Figures based on relative humidity of 60% or less. Damp / humid weather allow 50% more cure time.					

COLD WEATHER

When cold weather joints become unavoidable, good joints can still be made by using a few precautions.

In cold weather, solvents penetrate and soften the PVC surfaces slower than in warm weather. Also, the plastic becomes more resistant to the penetration process of the primer and cement. Therefore it becomes more important to pre-soften the plastic surfaces with a good quality primer. Also, because of slower evaporation during cold weather, the cure time will slow down dramatically.

Tips for cold weather cementing:

1. Prefabricate as much of the system as possible in a heated work area.
2. Store your cements and primers in a warm area when you are not using them and make sure they remain fluid.
3. Remove all moisture including ice and snow. Do not allow moisture to enter your cement or primer cans. This will contaminate the mixture and may cause the joints to fail.
4. Use a qood quality primer such as Valor V-700 or equal to soften the plastic. More than one application may be needed.
5. Allow a longer cure time before the system is used and remove excess cement.

A good quality cement and primer will make successful joints in temperatures as low as -15°

Fahrenheit without any additives and with proper attention during installation.

HOT WEATHER

When making solvent weld joints, you must remember that the softening agents in the primer and the cement dissipate out as the joint cures. In hot temperatures this dissipation occurs more rapidly, possibly before you have the joint assembled properly.

Heat also speeds up the softening process. If puddles are allowed to sit, they can over soften the plastic and go right through the pipe, or fittings.

Tips for hot weather cementing:

1. Store cements and primers in a cool or shaded area.
2. Use heavier, higher viscosity cement, as it will provide more open time after application and before insertion.
3. If possible, store the fitting and the end of the pipe to be cemented in the shade until the joint is assembled.

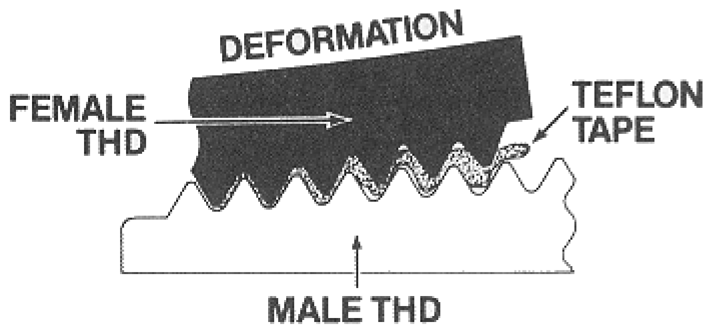
4. Cool the surfaces to be joined by wiping with a cool damp rag. Make sure the plastic is dry before applying the primer and cement.

5. Try to make your solvent weld joints in the cooler morning hours.

6. Make sure the cement on both pieces being joined is still wet and has not formed a "skin" over the top. If skinning has occurred you can try applying a thin coat of primer over the cement to reactivate it. With large diameter pipe and fittings, more help may be required to get the joints together before skinning occurs.

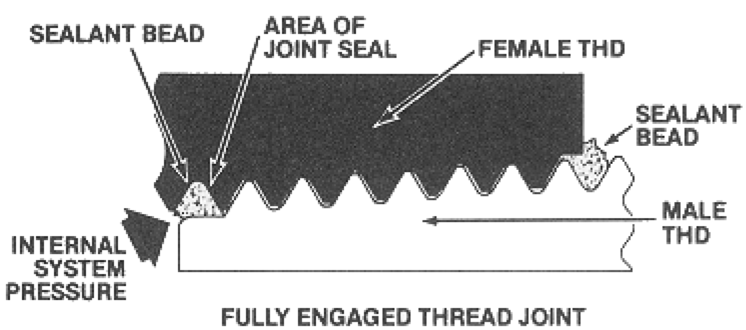
Threaded Fittings

Teflon tape, when compressed between male and female threads in plastic fittings and joints, can cause deformation, leading to leakage and, possibly, to cracked fittings.



Sealant, when compressed between threads, flows outward to achieve an effective seal against leakage.

We recommend the use of a teflon paste made for plastic fittings such as **Lasco** "Blue Pipe Thread Sealant" or **IPS Weld On** "Seal-On 500" teflon paste for plastic fittings. **The use of a teflon paste not specifically made for plastic could cause deterioration and destroy the fitting.**



INSTALLING SADDLES ON PVC PIPE

The successful installation of saddles on PVC pipe can be achieved quickly and easily in the field with the proper equipment and materials.There are three basic necessities: USE ADEQUATE SOLVENT CEMENT, USE STEEL BANDS, AND WORK QUICKLY!

MATERIALS

The following list of materials should be assembled for the field.

1. Heavy-duty power drill with hole saw attachment and generator.
2. Two pre-cut steel bands per saddle; 5" to 10" longer than the circumference of the pipe.
3. Two steel strapping tensioners and one crimper.
4. Valor V700, or equal, colored primer and Valor PVC-919, or equal, solvent cement and applicators.

PROCEDURES

1. Once the lateral is assembled and cemented, mark the placements where the saddles are to be installed with a felt marker. Be sure to note the temperature when these are marked. The effects of temperature change can lengthen and shorten a PVC line by as much as 2 inches per 100 feet.
2. Place two steel strapping bands, one on each side of the drilled hole, and take up most of the slack with the tensioning tools. The straps should be loose enough to easily slip over the saddle. We strongly recommend the use of steel strapping and the proper tools. Even though the initial tool costs are higher, the time they save will easily recover the investment in a couple of jobs, or in one repair job that you don't have to perform. If the steel tools are out of the question, we then recommend stainless steel "ideal clamps". Although they are not as fast, they do an adequate job. We do not recommend the use of plastic banding. Plastic cannot be tightened down satisfactorily without breaking.
3. Clean both the saddle and the pipe surface with a dry cloth; then prime with primer and a large cotton swab or roller.

4. Apply a thick layer of Valor 919 or IPS Weld On 719 cement to both surfaces. If you can see white pipe through the glue layer, it is too thin. We suggest using a large cotton swab or a roller for this application. Use plenty of cement; it is less expensive than a repair.

5. While one man holds the saddle in place, the second man slides the steel strapping over the two ends of the saddle and quickly cinches them down. The bands should be positioned halfway between the edge of the saddle and the riser to prevent buckling of the fitting. Note that the second man is using two tensioners, one on each band. He tightens them both, one at a time, using one hand. Excessive pressure with both hands can strip the mechanism and cause unnecessary wear on the tools. He then crimps the bands. Elapsed time from priming to installed and tightened should be about 50 to 60 seconds.

6. You should now be ready to move onto the next saddle installation.

NOTE:

See the solvent weld joints section for more information on the proper use of primers and cements. The same rules that apply to primers and cements in solvent weld joints apply to installing saddles. Wipe off any excessive primer or cement that has dripped down the side of the pipe. These drips can puddle at the bottom of the pipe and continue to soften the plastic creating a weak spot or hole in the pipe.

Thrust Blocking

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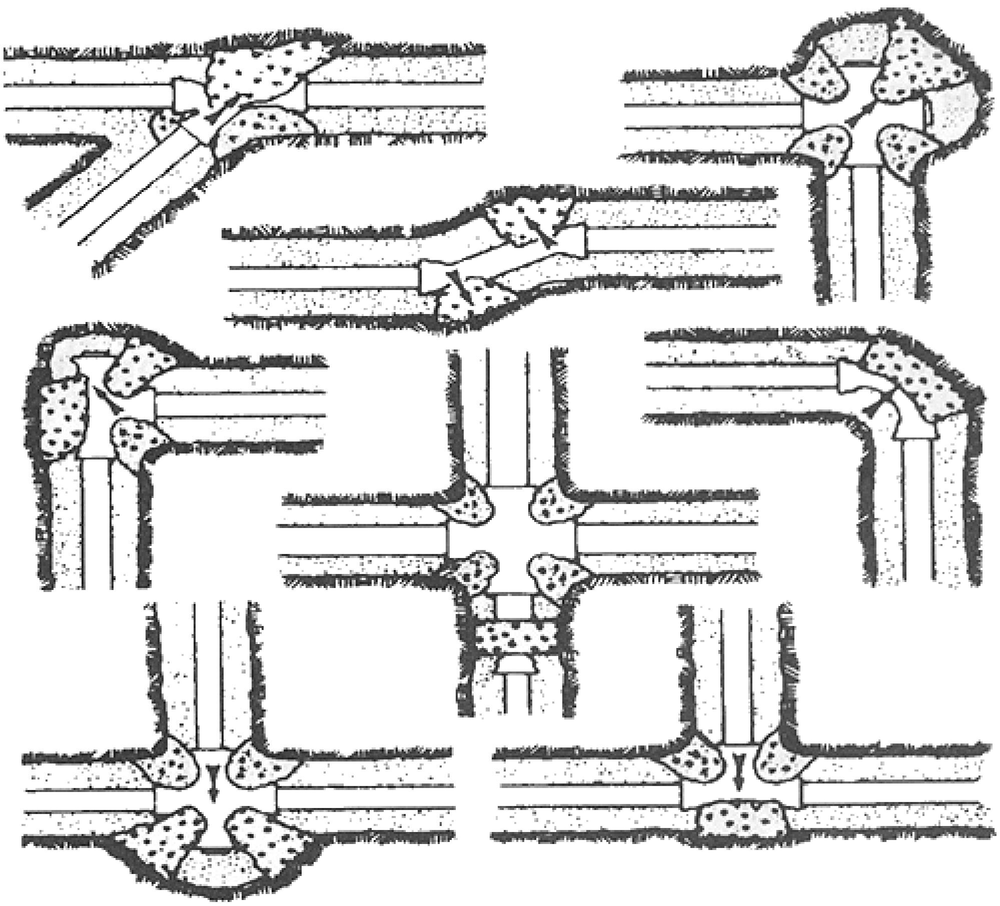
Imagine a freight train speeding along a railroad track pulling fifty rail cars loaded with freight. Now imagine trying to make that train follow a sharp 90° bend you have placed in the track just ahead.

Water flowing through a pipe under pressure, like the train, develops a tremendous amount of force. In very large diameter pipe it can exceed 100,000 pounds force at 100 PSI.

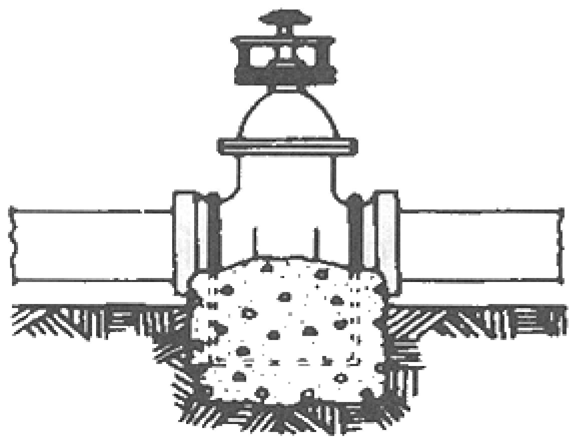
AREAS TO PLACE THRUST BLOCKS

1. **CHANGES IN DIRECTION** such as elbows and tees. The amount of force developed increases with the angle of deflection. The amount of the internal pressure, plus the force created by the direction change, must be restrained.



2. **CHANGES IN SIZE** when reducers are placed in line. The larger the reduction the more force developed.

3. **VALVES.** All valves regardless of the type, size, or frequency of use should be anchored.



MAKING A THRUST BLOCK

At each of the above points where thrust force will develop, a thrust block poured from concrete needs to be installed. Run the concrete on the opposite side of the water flow. The concrete should go from the fitting back to the natural, undisturbed trench wall. It is best to hand dig the area for the thrust block to provide maximum holding power. A form for the thrust block can be made using cardboard boxes or a wooden frame. Pour a mix of one part cement, two parts washed sand, and five parts washed gravel. The pipe and the fitting should be wrapped with builders felt where it will contact the concrete to prevent wear caused from vibration.

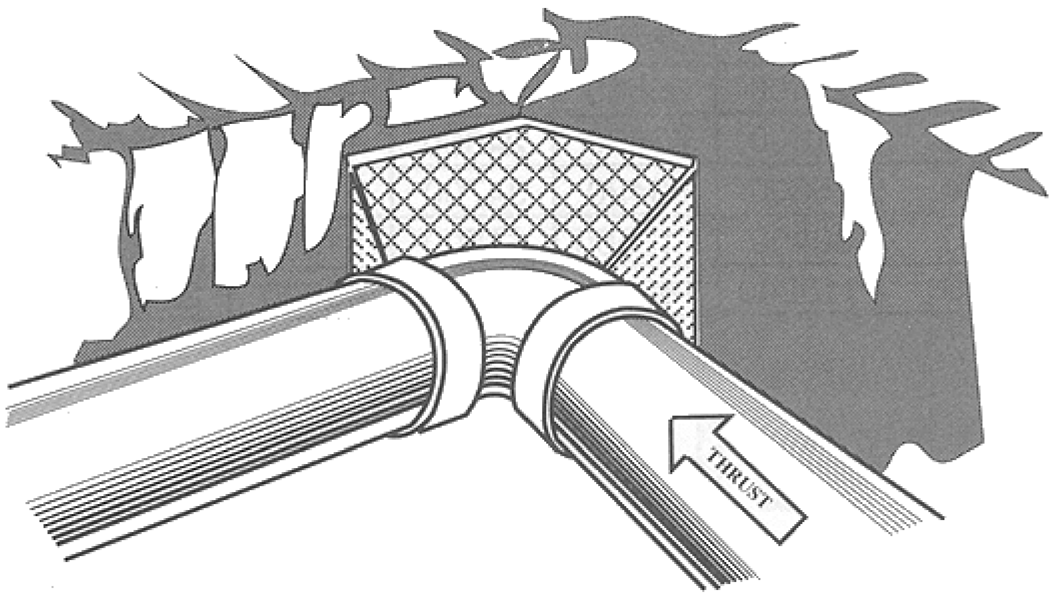
THE SIZE OF THE THRUST BLOCK

The size of the thrust block is determined by the thrust force in pounds divided by the bearing strength of the soil.

BEARING STRENGTH OF SOILS

Soft Clay	1,000 lbs/sq. ft.
Sand	2,000 lbs/ sq. ft.
Sand & Gravel	3,000 lbs/ sq. ft.
Sand, Gravel & Clay	4,000 lbs/ sq. ft.
Hard Shale	10,000 lbs/ sq. ft

For greater accuracy we recommend soil bearing tests be conducted by an engineer as wet soil greatly reduces the bearing strength.



THE SIZE OF THE THRUST BLOCK

The area of trench wall to be covered with the thrust block is computed as follows:

Area (A)=Thrust Force divided by Bearing Strength of Soil.

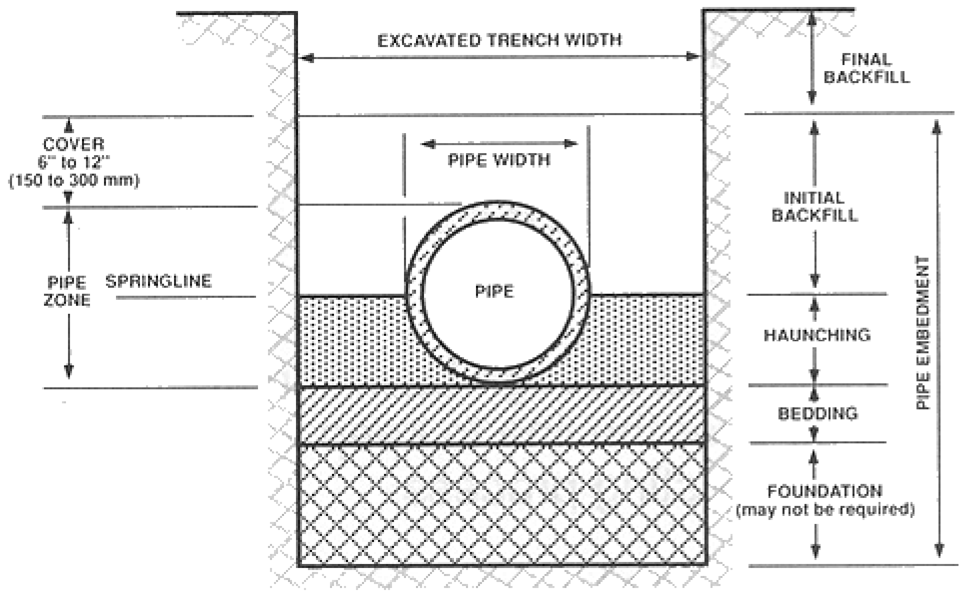
The following table shows the amount of thrust force in pounds per 100 PSI.

	THRUST FORCE (POUNDS) PER 100 PSI PRESSURE				
Pipe Diameter (In.)	Valves Tees Caps	90° Elbows	45° Elbows	22 ½° Elbows	11 ¼° Elbows
4	1600	2240	1226	635	320
6	3450	4830	2650	1370	690
8	5850	8200	4480	2320	1170
10	9100	12750	6980	3610	1820
12	12790	17900	9790	5080	2550
14	15400	21500	11800	6100	3080
16	20100	28150	15400	7960	4020
18	25400	35560	19460	10060	5080
20	31400	43960	24060	12440	6280
24	45300	63420	34700	17940	9060
30	80400	113500	61500	31500	15800
36	115200	162900	88100	45000	22600

Backfill

Initial Backfill

The material from the bottom of the trench to a height of 6 to 12 inches above the top of the pipe is considered the initial backfill. This material should be soil or sand that is free from rocks or stones larger than 1 inch in diameter. The initial backfill material may be the native material as long as rocks, stones, clods and frozen chunks have been removed. When backfilling riser tees, hold the riser and backfill with a hand shovel.



Final Backfill

Unless otherwise specified by the system designer or engineer, the final backfill material may be made up of native material and should be free of large rocks, frozen clods, and other debris greater than 3 to 4 inches in diameter. The material should be placed and spread in uniform layers so that there will be no unfilled spaces.

Testing

The most critical period in the lifetime of a pipeline is the initial filling and testing. Because of the higher than normal pressures used during testing and the increased tendency to entrap air, extreme caution must be taken when filling and testing the line.

Generally, the system designer or engineer will specify testing procedures including test pressures, duration of test, and leakage allowances.

The following are some basic guidelines when filling and testing the system.

1. Make sure that enough time has been allowed for concrete thrust blocks to cure before pressurizing the system.

2. Make sure that enough backfill material has been placed over the line to keep it from moving during the testing process.

3. Pipelines should have been laid to grade with a minimum number of high points based on the terrain.

4. All air vents, flap valves, and pressure relief valves need to be in place to allow escape of entrapped air.

5. The pipeline should be allowed to sit a minimum of 24 hours from the time it is filled to allow the pipe walls to absorb water.

6. All air should be purged from the system before performing pressure or acceptance tests on the system.

7. If a large amount of water is needed to increase the pressure during testing, entrapped air, leakage at joints, or a broken line may be suspected. Discontinue testing until the problem is found and corrected.

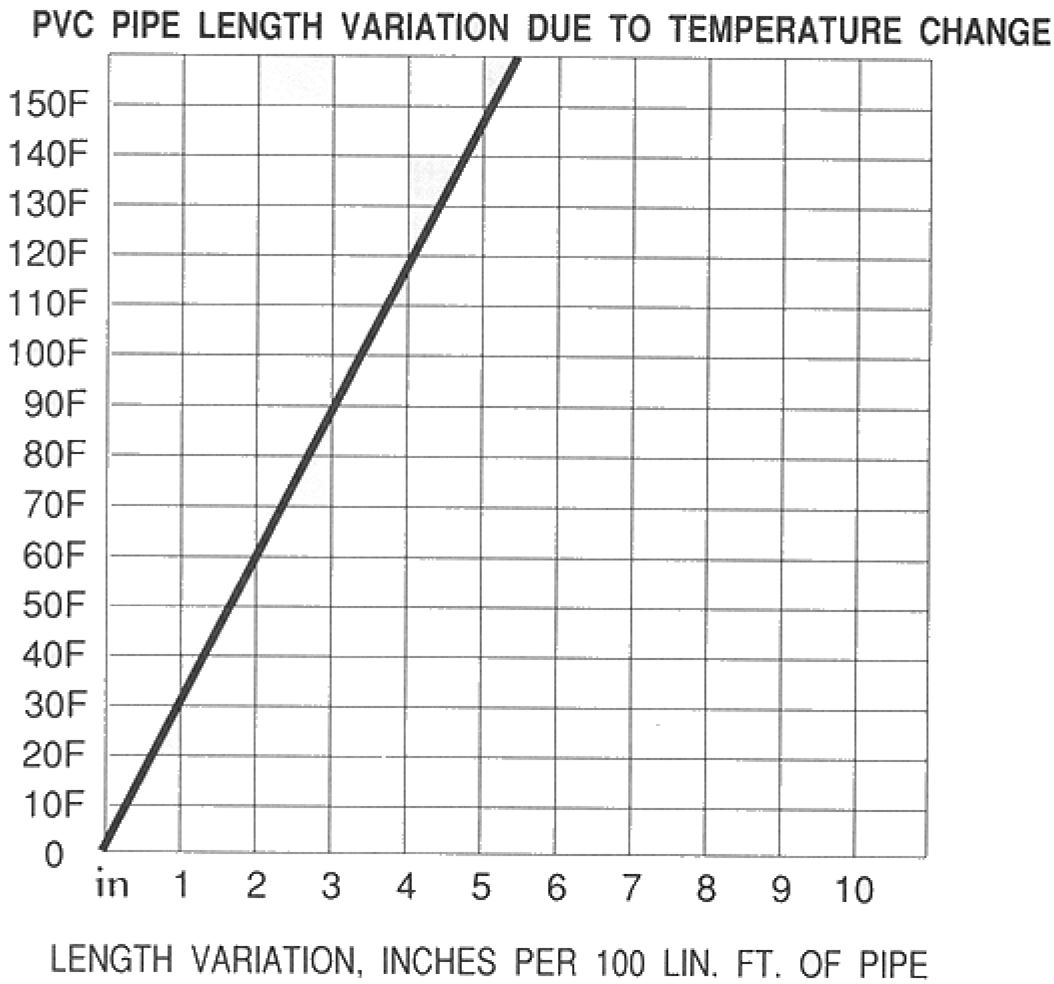
8. The average water velocity when filling a pipeline should be less than 1 fps and should not exceed 2 fps.

Thermal Expansion

Plastic, with its ability to be flexible, resist corrosion and rusting, and the ability to be solvent cemented in the field make it an ideal material for the construction of pipe.

Another characteristic of plastic is its ability to expand and contract with temperature change. When the temperature rises, PVC pipe will expand or increase in length. Likewise, when the temperature goes down, PVC pipe will shrink or shorten in length. This is what we refer to as thermal expansion and contraction.

The following table shows the amount of expansion and contraction of PVC pipe with temperature change.



Each block on the graph represents the change in length in the pipe per 100 feet with 10 degrees change in temperature. Keep in mind that temperature change may come from changes in ground or atmospheric temperatures or from the difference in the temperature of the pipe and the water moving through it.

RULE OF THUMB As you can see, the general rule of thumb for thermal expansion is 3/8 inch for every 100 feet of pipe for every 10 degrees temperature change.

What does that mean for your installation? Let's take a look at an example and see.

Let's say you were to install a line of gasketed pipe late in the season with ground and air temperature approximately 33 degrees fahrenheit. Next summer starts off warm and the ground temperature at the pipe level is now 73 degrees fahrenheit. You have a temperature difference of 40 degrees. With this much variance you will have about 1 ½" expansion in every 100 feet of pipe.

If you have installed your fittings correctly as described in this manual, the gap left between the end of the spigot and the end of the gasket pocket will absorb this additional length in your pipe. If the spigot was inserted all the way to the end of the gasket pocket or "bottomed out", there is no space for the additional length to go. This may result in the spigot splitting the bell or gasket pocket.

Problems caused by thermal expansion are tricky because they don't show up when the line is installed. They are like time bombs planted under the ground waiting to go off.

The solution to thermal expansion is to make sure you have allowed expansion gaps in your joints by inserting the spigot only to the insertion mark as outlined in the section on installing gasketed fittings.

When installing solvent weld fittings, the complications of thermal expansion are not as controllable by the installer.

Engineers usually take thermal expansion into consideration when working with solvent weld pipe and fittings and will often times require an expansion joint at given intervals to absorb the length changes.

TEMPERATURE CHANGES

As operating temperatures decrease, PVC pipe's stiffness and tensile strength increase, thereby increasing the pipe's pressure capacity and its ability to resist earth-loading deflection. Conversely, with the drop in temperature, PVC pipe decreases in impact strength and becomes less flexible.

As the operating temperatures increase, PVC pipe decreases in tensile strength and stiffness. With this rise in temperature the pressure capacity of the pipe also decreases.

The following table shows the effects on pressure ratings with increase in temperature.

SDR	**PSI**	73°F	80°F	90°F	100°F	110°F	120°F	130°F
21	**200**	200	180	152	128	102	80	62
26	**160**	160	144	121	102	81	64	49
32.5	**125**	125	112	95	80	63	50	38
41	**100**	100	90	76	64	51	40	31
64	**63**	63	56	47	40	32	25	19

Air Entrapment

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Air trapped in the line reduces the capacity of the pipe to carry water. An air pocket trapped in a high point of the line is the equivalent of installing a reducer in the line. As this restriction becomes larger the pump needs to work harder to maintain the desired volume in the line.

Water is almost incompressible compared to air. Compressed air in lines can reach pressures far in excess of the static pressure of the line. As the pump is increased to compensate for the loss in volume caused by the restriction from the trapped air pocket, the air is compressed even more becoming a greater threat to the system.

As compressed air exits the system, the water flowing behind the air closes the air relief valve. If the air is evacuated too fast, the water can create water hammer surges great enough to rupture the pipe as it runs into the air relief valve and comes to a sudden stop.

SOURCES OF AIR ENTRAPMENT

The most common source of air entrapment is the initial filling of the line after installation or the refilling of the line after it has been drained. Another point of entry for air is at the pump station or in a gravity flow system at the water inlet. Air can also be released from the water itself due to changes in temperature, pressure, or from the turbulent action of the pump.

In some situations, such as when a valve closes or when the system is drained, a negative pressure can occur creating a vacuum in the line. When a vacuum occurs, air needs to be allowed to enter the system to replace the water that is flowing out.

RESTRICTING AIR ENTRAPMENT The best way to control air in the line, after the initial fill, is to restrict air from entering the system in the first place. Proper design of the system is the key. A well engineered pump station or gravity inlet, laying the pipe to grade, adequate air and vacuum relief valves, and proper filling and testing procedures will control most of the problems associated with air entrapment.

CONTROLLING AIR, VACUUM AND PRESSURE

1. Vacuum relief valves should be placed on the discharge side of the pump and after each in-line valve to prevent a negative pressure situation and collapse of the pipe.

2. Continuous acting air relief valves need to be placed on the discharge side of the pump, at changes in elevation or high spots in the line, and at the line termination.

3. Air relief valves should be placed along the line in sufficient number to evacuate air upon filling the line. The ratio of air release valve diameter to the pipe diameter for valves intended to release air when filling the pipe should not be less than 1/10.

AIR RELEASE VALVES

There are basically four types of valves to relieve air pressure and or vacuum.

1. **Air Relief Valves** are continuous acting valves that have a small venting orifice, generally ranging between 1/16 and 3/8 inches. This valve releases pockets of air from the pipeline once the line is filled and under working pressure.

2. **Air/Vacuum Relief Valves** refer to valves which have a large venting orifice and exhaust large quantities of air from the pipeline during filling. This also allows air to re-enter the line and prevents a vacuum from forming during the emptying of the line. This type of valve is sometimes called an air-vacuum-release valve. It is not continuous acting because it does not allow further escape of air once the line has pressurized and the valve has closed.

3. **A Combination Air Valve** is sometimes called a combination air-release and air-vacuum valve or combination air-and-vacuum-relief valve. It is continuous acting and combines the functions of both the air-release valve and the air-and-vacuum valve. Both types of valves are housed in one valve body.

4. **Manual Air Relief Valves** can be any type of manually operated valve. It is positioned along the line and used as an air purging device. These valves are usually installed on the top of a standpipe which is used to collect the air.

There is no room for uncertainty in the placement of air and pressure relief valves in the system. It will save repairs and allow the system to function properly. It is like insurance on your system.

If not enough relief is allowed, air pockets will accumulate and cause restrictions which will result in a loss of water flow or damage to the pipeline.

Make sure the system design has been checked and approved by a competent system certified designer or engineer.

Pressure Relief Valves

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Pressure relief valves are just as important to your water system as brakes are to your car.

The working pressure of the system should not exceed 72% of the maximum rated pressure of the pipe or fittings. This gives you a built in safety margin to compensate for pressure surges or water hammer.

Ideally, the pressure relief valve should be set at no more than 5 pounds higher than this 72% rate or at 5 pounds higher than the maximum anticipated pressure if it is lower than 72% of the rated pipe pressure.

The pressure relief valve should be sized no smaller than 1/4 inch nominal size for every 1 inch of pipe diameter.

PLACEMENT OF PRESSURE RELIEF

Pressure relief valves need to be installed in at least the following areas:

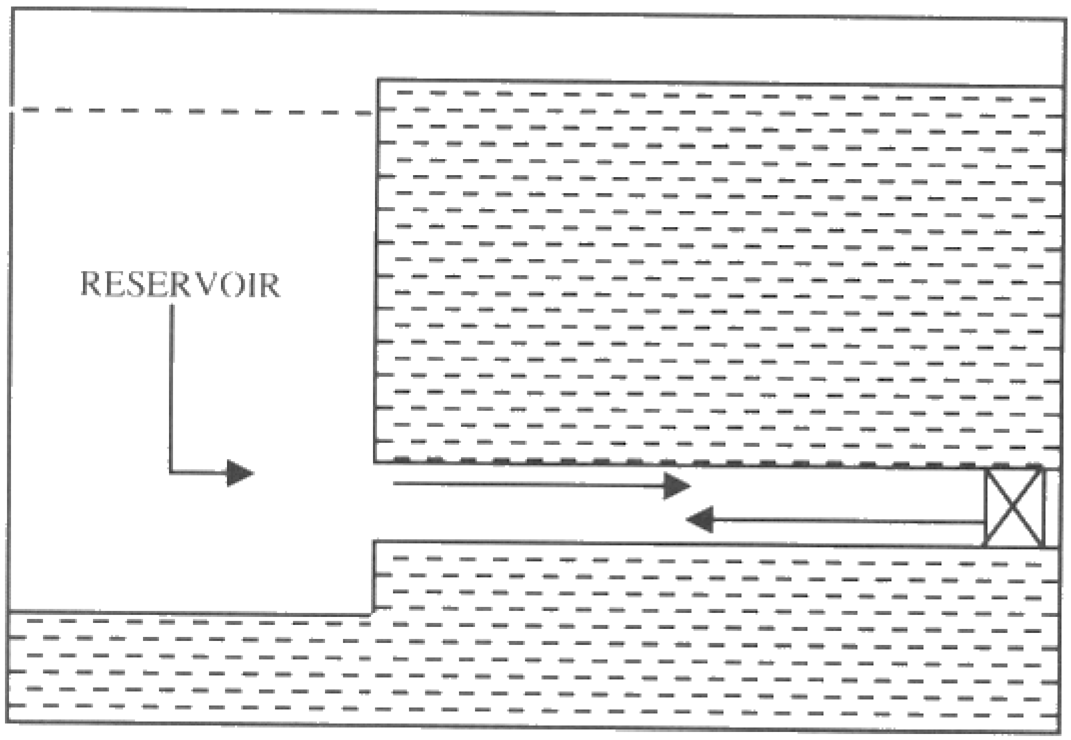
1. Between the pump discharge and pipeline (on the discharge side of the check valve).

2. Up-line from all in-line valves. This helps control water surges and increased pressures when valves are closed.

3. The end of every line or lateral.

Water Hammer

To achieve a basic understanding of water hammer let's take a look at a typical example, illustrated below.



In our example, we have a reservoir of water. Toward the bottom of the reservoir there is a PVC pipe taking water out to our irrigation lines. Several feet down the line there is a shutoff valve.

When the valve is open, the elevation head (weight of the water in the reservoir) forces water through the outlet pipe and out of the reservoir. We now have a constant velocity of water running through the pipe. Generally, systems using PVC pipe should be designed with a maximum of 5.5 second feet of water flow.

When the valve is suddenly closed, the water flowing through the pipe slams into the valve. This is like trying to stop a freight train on a dime. The forward momentum of the water is re-directed outward forcing the pipe to expand under increased pressure. As soon as the first layer of water is re-directed, the process is continued with the next layer. The water upstream, flowing down from the reservoir, continues to flow at the same speed until the re-directed layers of water work themselves back to the reservoir.

The high pressure (water hammer) moves upstream like a wave of the sea. The water in front of it is still flowing down towards the valve as before.The water behind it has been brought to rest but is still exerting outward pressure on the pipe.

Eventually, the high pressure wave reaches the reservoir and has stopped all movement of water down the pipeline towards the valve. When the energy is released from the re-directed water in the pipe, the water moves toward the reservoir and away from the valve. Since the valve is still shut, a vacuum is created in the pipeline. This, together with the elevation head in the reservoir, causes another wave of water to flow down the pipe and slam into the valve.

This process continues at predictable intervals until due to water friction and the elasticity of the pipe the waves are finally slowed to a complete stop.

CAUSES OF WATER HAMMER:

When a pipe contains a column of liquid, there is considerable kinetic energy stored in the liquid by virtue of its mass and velocity. If the velocity is suddenly destroyed (by the quick closing of a valve or a cock) this energy cannot be absorbed, since the liquid is nearly incompressible and, therefore, appears as an instantaneous shock which may represent excessively high pressures. This effect is greater as the pipe line is longer, the velocities higher, and the time closing the valve shorter. Fairly long lines may contain enough mass of liquid to produce a water hammer of sufficient intensity to break pipe and fittings. Quick closing valves, therefore, should be used only on short lines.

This nomograph may be used to predict the pressure surge that will result from given service conditions. The chart may be used for any liquid. Since the values given by the chart indicate only the pressure rise in the system, the value of the static pressure head must be added to the pressure rise to give the maximum pressures experienced in the system under the conditions involved.

HOW TO USE THE CHART:

1. Locate the desired water flow rate through the pipe on the velocity line.
2. Locate the length of pipe on the pipe length line.
3. Line up these points with a straight edge.
4. At the point of intersection on the pivot line, pivot the straight edge to the valve closure time line.
5. Read the pressure rise at the intersection of the pressure line.

EXAMPLE (see chart #1)

200 ft. pipe line: water flow at 3.5 ft. per sec., valve closure in 0.1 secs.; static pressure of 20 psi.

1) Line up 3.5 ft. per sec. with 200 ft.

2) Pivot about the pivot line to 0.1 sec.

3) Read 490 psi from the pressure line.

4) Add 20 psi to 490 to get 510 psi as the instantaneous pressure under the selected service conditions.

This chart is based on the Formula:

$$P = \frac{.070 * VL}{T}$$

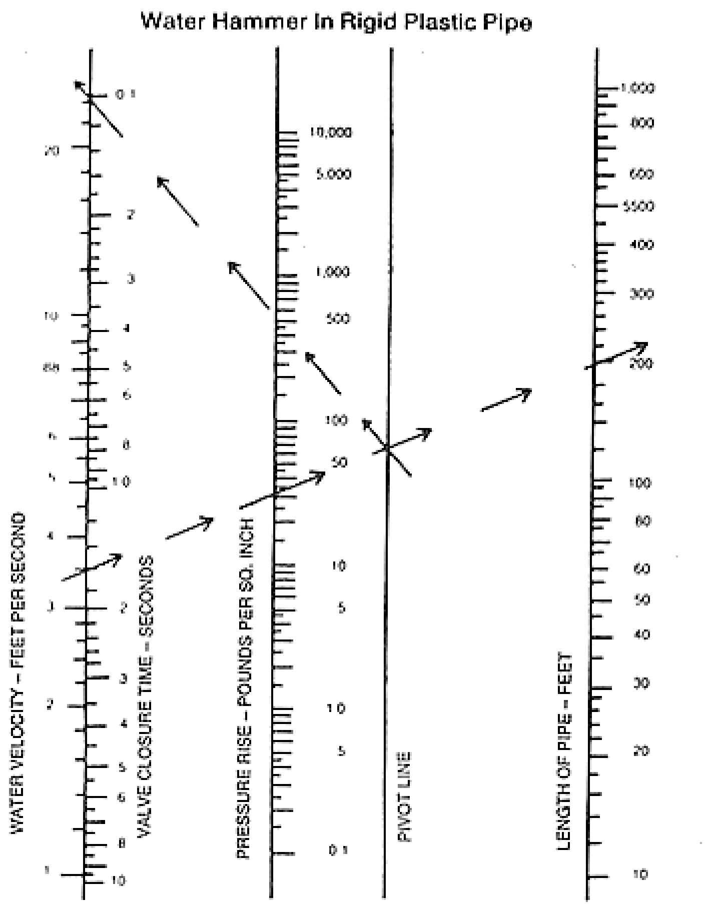
P = Pressure rise (psi) above the static pressure.

V = Liquid velocity in the pipe (ft. per sec.)

L = Length of pipe ahead of the valve causing the hammer (ft.)

T = Time required to close the valve (sec.)

Chart #1



Water Hammer In Rigid Plastic Pipe
WATER VELOCITY – FEET PER SECOND
VALVE CLOSURE TIME – SECONDS
PRESSURE RISE – POUNDS PER SQ. INCH
PIVOT LINE
LENGTH OF PIPE – FEET

Friction Loss & Flow Chart

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HOW TO USE THIS NOMOGRAPH:

1. Select the desired pipe size (Inside Diameter).
2. Determine the amount of water to flow through the pipe.
3. Place a straight-edge on these two points.
4. The points at which the straight-edge intersects the head-loss line and the velocity line give these two values under the given conditions.

EXAMPLES:

2 PV- 160 (I. D. 2.193)
40 Gal. per Min Service

1) Line up these points with a straight-edge.
2) Read .95 (or 2.2 ft.) from the Head-Loss Line.
3) Read 3.49 Ft. Per Sec. from the Velocity Line.

THE VALUES ON THIS GRAPH ARE BASED ON THE WILLIAMS AND HAZEN FORMULA:

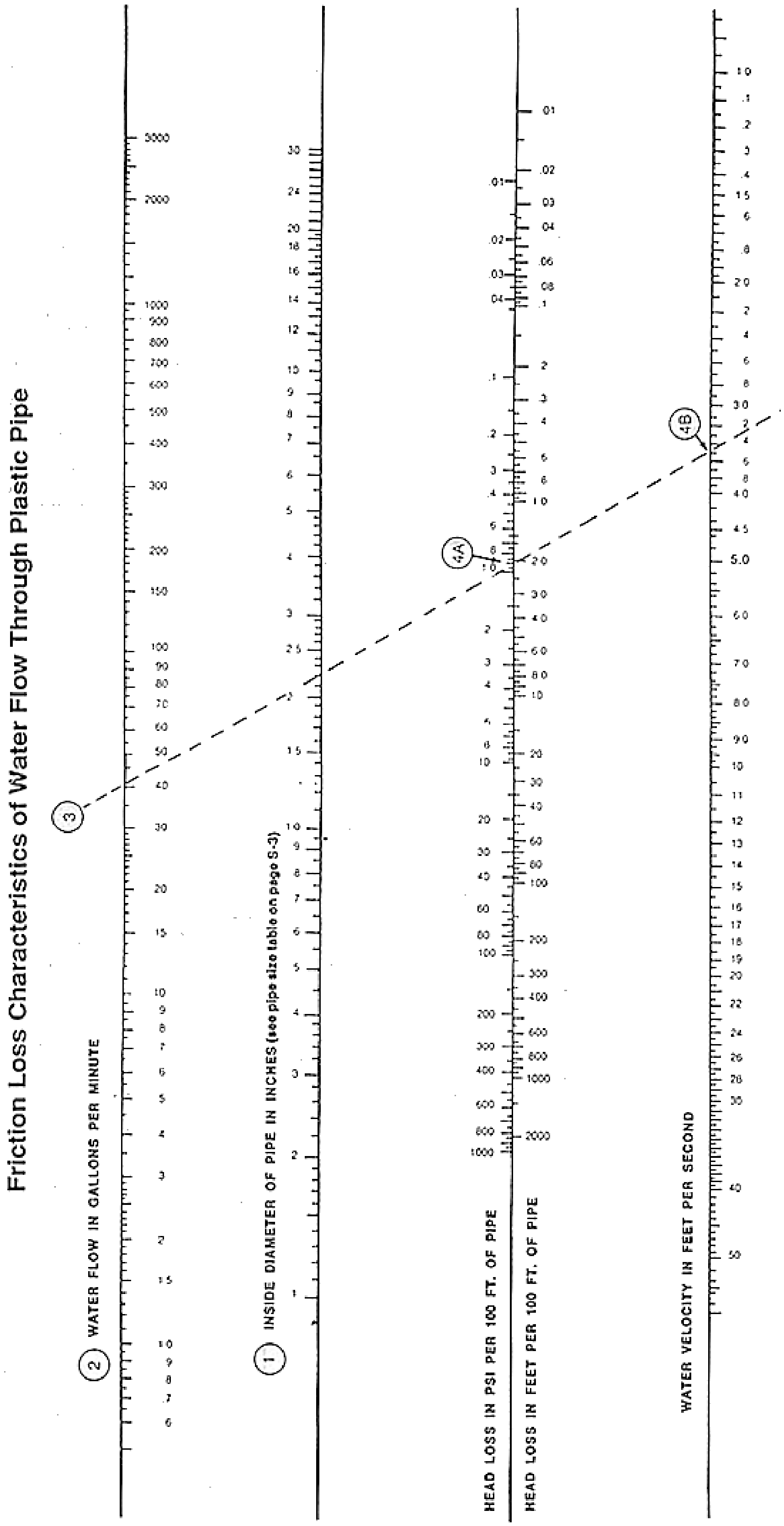
$$f = .2083 * \left[\frac{100}{c}\right]^{1.85} * \frac{q}{d} * \frac{1.85}{4.8655}$$

or

$$f = .0985 * \frac{q\ 1.85}{d\ 4.866}$$

f = Friction head in feet of water per 100 feet of pipe.
d = Inside diameter of pipe in inches.
q = Flow in gallons per minute.
c = Constant for inside roughness of the pipe. (150)

NOMOGRAPH FOR FRICTION LOSS & WATER FLOW



PVC Pipe Specifications

PIP

Nominal Pipe Size	Outside Diameter	Minimum Wall Thickness			
		SDR 81 50 psi	SDR 51 80 psi	SDR 41 100 psi	SDR 32.5 125 psi
4	4.130	---	---	0.101	0.127
6	6.140	0.076	0.120	0.150	0.189
8	8.160	0.101	0.160	0.199	0.251
10	10.200	0.126	0.200	0.249	0.314
12	12.240	0.151	0.240	0.299	0.377
15	15.300	0.189	0.300	0.373	0.471
18.7	18.701	---	0.366	0.456	0.575
21	22.047	---	0.432	0.538	0.678
24	24.803	---	0.486	0.605	0.763
27	27.953	---	0.548	0.682	0.860

IPS

Nominal Pipe Size	Outside Diameter	Minimum Wall Thickness ASTM D - 2241			
		SDR 41 Class 100	SDR 32.5 Class 125	SDR 26 Class 160	SDR 21 Class 200
1	1.315	---	0.050	0.060	0.063
1.25	1.660	---	0.060	0.064	0.079
1.5	1.900	---	0.060	0.073	0.090
2	2.375	---	0.073	0.091	0.113
2.5	2.875	---	0.088	0.110	0.137
3	3.500	0.085	0.108	0.135	0.167
4	4.5	0.110	0.138	0.173	0.214
5	5.563	0.136	0.171	0.214	0.265
6	6.625	0.162	0.204	0.255	0.316
8	8.625	0.210	0.265	0.332	0.410
10	10.750	0.262	0.331	0.413	0.511
12	12.750	0.311	0.392	0.490	0.606
14	14.000	0.341	0.430	0.538	---
16	16.000	0.390	0.492	0.615	---
18	18.000	0.439	0.554	0.692	---
20	20.000	0.489	0.615	0.769	---
24	24.000	0.585	0.738	0.923	---