

■ Installation Guide for PVC Sewer Pipe

March 2000 Edition

PW Pipe

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Note: In order to meet our customers' needs, PWPipe's product specifications and warranties are continually updated. So if the printed date on this literature is more than twelve (12) months old, please contact PWPipe for any changes that may have occurred.

Preface

This manual is intended for use by installers, supervisors, and inspectors responsible for the installation of PWPipe's PVC sewer pipe. It is not a design manual. Rather, it is intended as a guide for the proper handling, installation, and testing of PVC sanitary sewer and solid-wall stormdrain pipe. If used properly, the information in this booklet can maximize product performance and minimize the possibility of field problems.

This manual is not intended to assume the authority of the engineer. Because system requirements and actual field conditions may vary significantly, the sole responsibility for all design and installation decisions lies with the project engineer.

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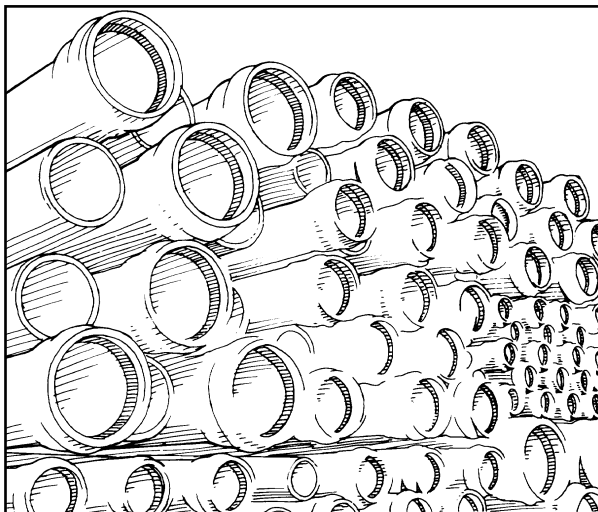
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Chapter I

■ General Information ■

Specifications

PWPipe produces PVC sewer pipe in conformance with ASTM D 3034 "Standard Specification for Type PSM Polyvinyl Chloride (PVC) Sewer Pipe and Fittings" for 4-inch through 15-inch sizes, and in conformance with ASTM F 679 "Standard Specification for Polyvinyl Chloride (PVC) Large Diameter Plastic Gravity Sewer Pipe and Fittings" for 18-inch and larger sizes. PWPipe recommends that the pipe be installed according to this guide and ASTM D 2321 "Standard Practice for Underground Installation of Flexible Thermoplastic Pipe for Sewers and other Gravity-Flow Applications."



Warranty

PWPipe warrants that its PVC pipe products were manufactured in accordance with applicable materials and product specifications and that the pipe is free from all defects in materials and workmanship using the applicable specifications as a standard.

Every claim under this warranty shall be deemed waived unless presented in writing and received by PWPipe within sixty (60) days of the date the defect was, or should have been, discovered or within two (2) years of the date of PWPipe's shipment of the product, whichever occurs sooner.

PWPipe makes no other warranty or representation of any kind, expressed or implied, in fact or in law, including without limitation the warrant of merchantability or fitness for a particular purpose, other than the limited warranty set forth above.

Limitation of Liability

It is expressly agreed that the limit of PWPipe's liability is the replacement of defective product with the same quantity of non-defective product, and that PWPipe shall have no such liability unless the claim results solely from breach of PWPipe's warranty.

In no event shall PWPipe be liable for any incidental or consequential damages of any kind, including without limitation, any expense or removal or reinstallation resulting from any defect.

Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you. This warranty gives you specific legal rights, and you may have other rights which vary from state to state.

Chapter II

- Receiving,
Unloading,
Storage, and
Handling

Receiving

When receiving the pipe shipment at the job site, the contractor or purchaser should exercise established precautions. Each pipe shipment should be inventoried and inspected with care upon arrival. The pipe was inspected and loaded with due care at the factory using methods acceptable to the carrier. It is the carrier's responsibility to deliver the shipment in good condition and it is the receiver's responsibility to ensure that there has been no loss or damage.



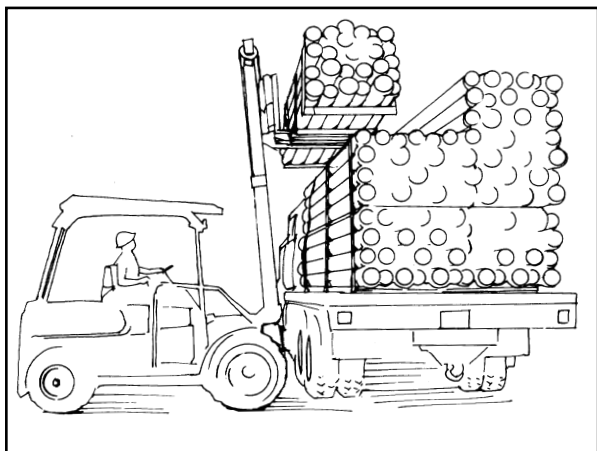
The following procedures are recommended for acceptance of delivery:

1. Make overall examination of the load. If the load is intact, ordinary inspection while unloading should be sufficient to ensure that the pipe has arrived in good condition.
2. If the load has shifted, has broken packaging, or shows rough treatment, carefully inspect each piece for damage.
3. Check total quantities of each item against shipping records.
4. Note any damaged or missing items on the delivery receipt.
5. Notify the carrier immediately and make a claim according to his instructions.
6. Do not dispose of any damaged material. The carrier will notify you of the procedure to follow.
7. Shortages and damaged materials are not re-shipped without request. If replacement materials are needed, reorder from PW Pipe or your distributor.

Unloading

The means by which the pipe is unloaded in the field is the decision and the responsibility of the receiver. These recommendations should be followed:

1. Remove restraints from the top unit loads. These may be either straps, ropes, or chains with padding.
2. Remove any boards on the top or sides of the load which are not part of the pipe packaging.
3. Using a fork lift with thin chisel forks (or a front-end loader equipped with forks), remove the top units one at a time from the truck.



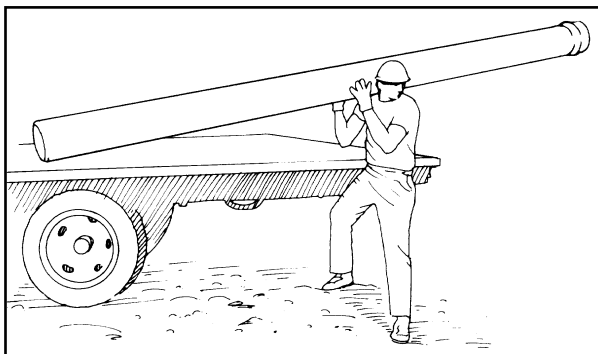
4. If a fork lift is not available, use a spreader bar with fabric straps capable of carrying the load. Space straps approximately eight feet apart. Loop straps under the load. Cables may be used only if they are cushioned to prevent damage to the pipe.
5. During the removal and handling, ensure that the units do not impact anything (especially in cold weather).
6. Place pipe package units on level ground.
7. Do not handle units with individual chains or single cables, even if padded.
8. Do not attach lifting cables to unit frames or bands.

9. Do not stack package units more than eight feet high.
10. Protect units with packing materials the same way they were protected while on the truck.
11. To unload lower units, repeat the unloading process described above.
12. Do not unload by hand.
13. **WARNING: DO NOT STAND OR CLIMB ON CRATES OR CONTAINERS.**

Storage

The following procedures are recommended to prevent damage to the pipe:

1. Store the pipe, at the site, in unit packages.
2. Avoid compression, deformation or damage to bell ends of the pipe.
3. When unit packages are stacked, ensure that the weight of upper units does not cause deformation to pipe in lower units.
4. Support pipe unit packages on wood blocking to prevent damage to the bottom surfaces during storage. Space supports to prevent pipe bending.
5. Store solvent cement in tightly sealed containers away from excessive heat.
6. Do not store pipe where gaskets may be exposed to ozone, grease or oil.

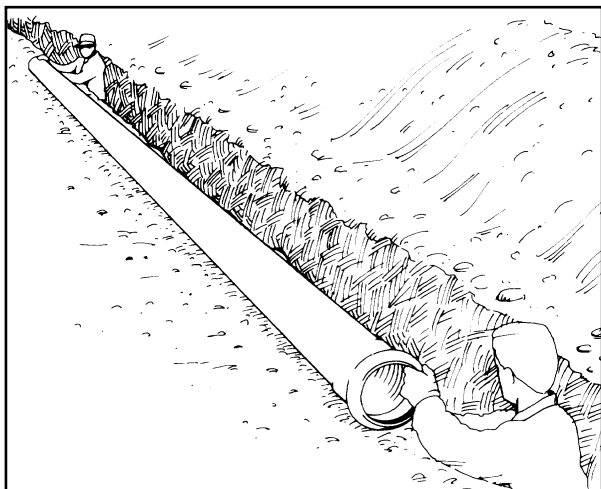


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7. Protect pipe interior and sealing surfaces from dirt and foreign matter.
 8. When unit packages are stacked, ensure that the stack remains stable.

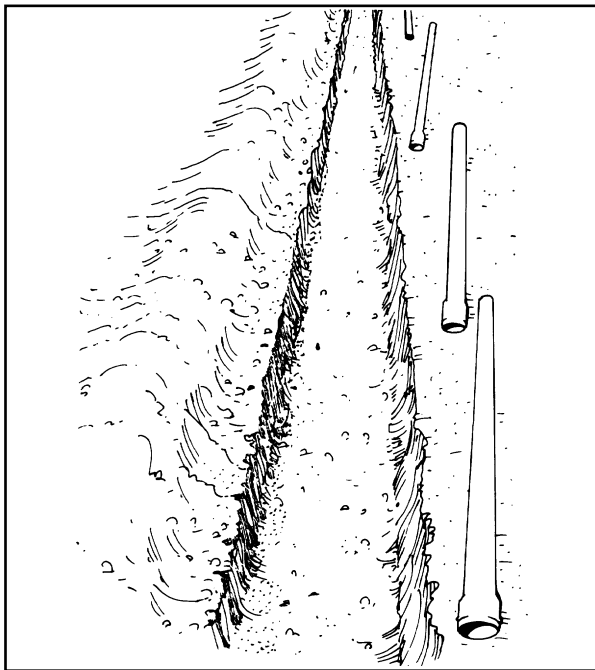
Handling

The following procedures are recommended:

1. When using mechanical equipment, exercise care to prevent damage to the pipe.
2. Lower pipe carefully from trucks and into trenches. Do not drop pipe.
3. In subfreezing temperatures, use caution to prevent impact damage. Handling methods considered acceptable for warm weather may be unacceptable during very cold weather.



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4. When distributing pipe along a trench (stringing), place pipe on the opposite side of the trench from the excavated earth. Place pipe with bell ends in the direction of the work progress.



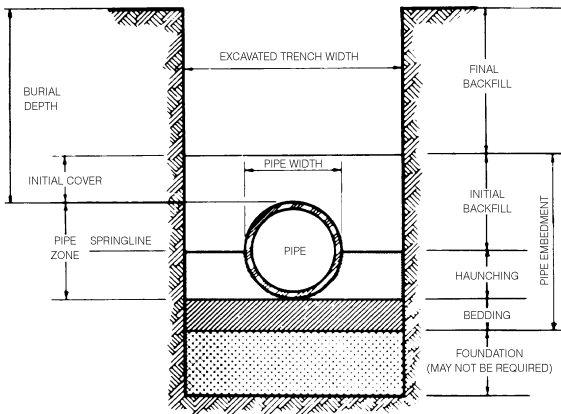
Chapter III

■ Trench Construction

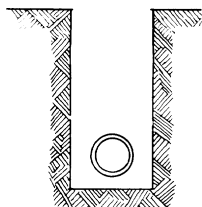
General

1. Trench excavation should comply with all applicable laws and regulations.
2. Excavated material such as debris and removed pavement is not suitable for trench backfill.
3. Where dewatering is necessary, water should be removed until the pipe has been installed and the backfill has been placed to a sufficient height to prevent flotation of the pipeline.
4. The maximum earth load on flexible pipe is the weight of the material directly over the pipe (prism load). Unlike rigid pipe, the width of the excavated trench does not affect pipe loading. Trench width is based solely on practical and economical construction.
5. See Figure 3.1 for trench terminology.

FIGURE 3.1
TRENCH CROSS-SECTION SHOWING
TERMINOLOGY



Narrow, Unsupported Vertical-Walled Trench

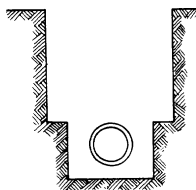


1. See Figure 3.1 for unsupported vertical-walled trench cross-section.
2. The width of narrow trenches is the minimum working room required for a worker to place haunching material. See Table 3.1.
3. In narrow trenches, pipe embedment should be compacted all the way to the trench wall.

TABLE 3.1

NARROW TRENCH WIDTH, MINIMUM		
NOMINAL PIPE SIZE	TRENCH WIDTH, MINIMUM	
Inches	No. of Pipe Diameters	Inches
4	4.3	18
6	2.9	18
8	2.9	24
10	2.5	26
12	2.4	30
15	2.0	30
18	1.8	32
21	1.6	34
24	1.5	36

Sub-Ditch Trench



The width of the subditch below the top of the pipe should meet the minimum dimensions of Table 3.1.

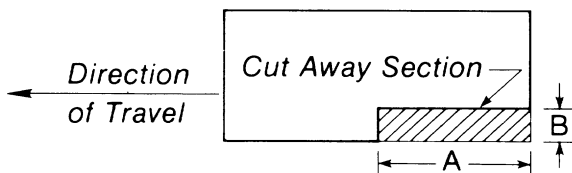
Supported Trench

1. This type of trench is used where unstable or flowing soil conditions are present in the trench walls.
2. Methods of support include sheeting, bracing, trench jacks, or trench box.
3. If conditions are extremely severe, it may be necessary to grout the soil adjacent to the trench to prevent migration between pipe embedment materials and trench wall soils.
4. Trench width must be sufficient to allow the same amount of clearance, as required in Table 3.1, between each side of the pipe and the inner face of the trench support.
5. Where timber sheeting is used below the top of the pipe, the sheeting should extend 2 feet (60 cm) below the bottom of the pipe and be left in place 1.5 feet (45 cm) above the top of the pipe.
6. Compact the foundation and embedment materials all the way to the trench wall or to the sheeting left in place.

Movable Trench Support

1. When trench supports are being moved, care should be exercised to prevent disturbing the pipe or its embedment.
2. Use of movable trench boxes should be limited to installations where:
 - a. Wide trench construction exists.
 - b. A shelf exists above the top of the pipe

FIGURE 3.2



3. To avoid these location restrictions, a modified box may be used which allows compaction of bedding at bottom cutouts. See Figure 3.2.
4. Any voids left in embedment material by support removal should be carefully filled and compacted.
5. Removal of bracing between sheeting should be done only where backfilling proceeds and bracing is removed in a manner that does not relax trench support.

Trench Bottom

1. The trench bottom should provide a uniform stable support for the pipe.
2. The soil surface at the bottom of the trench should be free of any irregularities that could cause pointloads on the pipe or bell.
3. Where an unstable trench bottom condition occurs, special foundations may be required. A layer of bedding material should be placed between foundation and pipe.
4. Where rock subgrade or stones larger than 1.5 inches are encountered, a minimum of 4 inches of bedding should be placed under the pipe above the rock.

Embedment Materials

1. See Table 3.2 for soil classifications.
2. The high void ratio of Class I material limits its use to areas where side support will not be lost due to migration of fines from the trench walls and bottom. Where such migration is possible, the minimum size range should be reduced and the gradation designed to limit void size.
3. Class II material should be well graded (not uniformly graded or gap graded) to prevent loss of side support as described in item 2.
4. For Class IV materials, caution should be exercised in the design and method of compaction due to difficulty in controlling moisture content in field conditions.
5. Class V materials are not recommended for bedding, haunching, or initial backfill.
6. See Table 3.3 for degree of compaction information for various compaction methods and embedment materials.



TABLE 3.2
Description of Embedment Material Classifications

SOIL CLASS	SOIL TYPE	DESCRIPTION OF MATERIAL CLASSIFICATION
CLASS I SOILS*		Manufactured angular, granular material, $\frac{1}{4}$ to $1\frac{1}{2}$ inches (6 to 40 mm) size, including materials having regional significance such as crushed stone or rock, broken coral, crushed slag, cinders, or crushed shells.
CLASS II SOILS**	GW	Well-graded gravels and gravel-sand mixtures, little or no fines. 50% or more of coarse fraction retained on No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
	GP	Poorly graded gravels and gravel-sand mixtures, little or no fines. 50% or more of coarse fraction retained on No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
	SW	Well-graded sands and gravelly sands, little or no fines. More than 50% of coarse fraction passes No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
	SP	Poorly graded sands and gravelly sands, little or no fines. More than 50% of coarse fraction passes No. 4 sieve. More than 95% retained on No. 200 sieve. Clean.
CLASS III SOILS***	GM	Silty gravels, gravel-sand-silt mixtures. 50% or more of coarse fraction retained on No. 4 sieve. More than 50% retained on No. 200 sieve.
	GC	Clayey gravels, gravel-sand-clay mixtures. 50% or more of coarse fraction retained on No. 4 sieve. More than 50% retained on No. 200 sieve.
	SM	Silty sands, sand-silt mixtures. More than 50% of coarse fraction passes No. 4 sieve. More than 50% retained on No. 200 sieve.
	SC	Clayey sands, sand-clay mixtures. More than 50% of coarse fraction passes No. 4 sieve. More than 50% retained on No. 200 sieve.

SOIL CLASS	SOIL TYPE	DESCRIPTION OF MATERIAL CLASSIFICATION
CLASS IV SOILS	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands. Liquid limit 50% or less. 50% or more passes No. 200 sieve.
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. Liquid limit 50% or less. 50% or more passes No. 200 sieve.
	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
	CH	Inorganic clays of high plasticity, fat clays. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
CLASS V SOILS	OL	Organic silts and organic silty clays of low plasticity. Liquid limit 50% or less. 50% or more passes No. 200 sieve.
	OH	Organic clays of medium to high plasticity. Liquid limit greater than 50%. 50% or more passes No. 200 sieve.
	PT	Peat, muck and other highly organic soils.

* Soils are as defined in ASTM D 2487, except for Class I material which is defined in ASTM D 2321.

** In accordance with ASTM D 2487, less than 5% pass No. 200 sieve.

*** In accordance with ASTM D 2487, soils with 5% to 12% passing No. 200 sieve fall in a borderline classification that is more characteristic of Class II than of Class III.

Compaction

1. Saturation — If saturation methods are used for compaction, the following recommendations should be followed:
 - a. Prevent flotation of the pipeline.
 - b. Do not use saturation during freezing temperatures.
 - c. Exercise care to prevent erosion at pipe sides and bottom caused by water jetting.
 - d. Apply only enough water to provide complete saturation.
 - e. Allow each layer to dewater and solidify until it will support the weight of workers.
2. Compaction equipment
 - a. Avoid contacting the pipe with compaction equipment.
 - b. Do not use compaction equipment directly over the pipe until sufficient backfill has been placed to prevent damaging or disturbing the pipe.

TABLE 3.3
**Approximate Guide for Estimated Range of Degree
of Compaction versus Embedment Class and Method of Placement
as Percent of Standard Proctor Density**

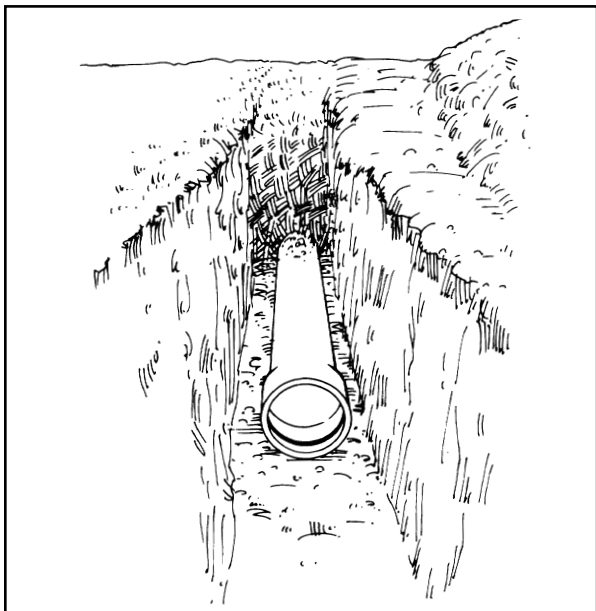
CLASS OF EMBEDMENT	I	II	III	IV
MATERIAL DESCRIPTION	Manufactured Granular Materials	Sand & Gravel Soils — Clean	Mixed-Grain Soils	Fine-Grain Soils
Optimum moisture content range limit % of dry weight	—	9-12	9-18	6-30
Soil Consolidation Method	% of Proctor Density Range			
Compact by power tamper or rammer	95-100	95-100	95-100	90-100

Densify by portable vibrators	80-95	80-95	80-95	75-90
Consolidate by saturation	80-95	80-95	—	—
Place by hand	60-80	—	—	—
Tamp by hand	—	60-80	60-80	60-75
Dump	60-80	60-80	60-80	60-75

NOTE: This table serves as an approximate guide defining average Proctor densities attained through various methods of soil consolidation in different classes of soil. The table is intended to provide guidance and is not recommended for design use. Actual design values should be developed by the engineer for specific soils at specific moisture contents.

Bedding

1. Bedding is required to bring the trench bottom up to grade and to provide longitudinal support under the pipe. Blocking must not be used to bring the pipe to grade.
2. Bell holes are necessary at each joint to maintain continuous support for the pipe.
3. Bedding thickness of 4 to 6 inches of compacted material is usually adequate.
4. Use of well-graded material is recommended where trench native soil is fine-grained.



Haunching

1. Haunching provides side support to the pipe. This area is the most important for controlling pipe deflection.
2. Haunching material should be worked under the sides of the pipe to ensure side support.
3. Where coarse materials have been used for bedding, the same materials should be used for haunching.
4. Haunching should extend to the springline of the pipe.

Initial Backfill

1. Initial backfill is placed to protect the pipe from impact damage during final backfill.
2. Since initial backfill provides little additional structural support, special compaction is not required.

Final Backfill

1. The material used for final backfill need not be as carefully selected as material in the embedment zone, but should not contain boulders, frozen clumps or rubble which could damage the pipe.
2. Under open fields, natural compaction should be adequate. Under improved surfaces, special compaction (as specified by the design engineer) is required.

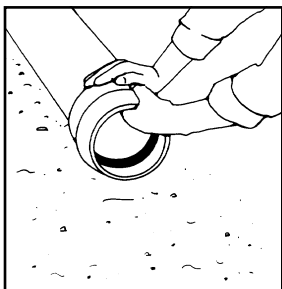
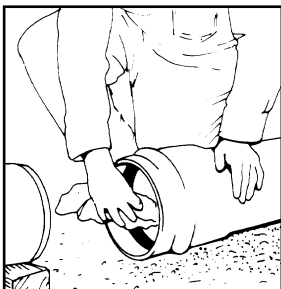
Chapter IV

■ Pipe Assembly

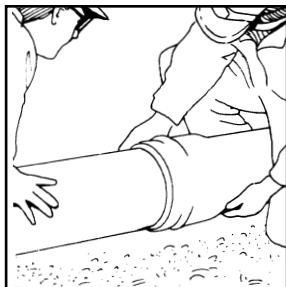
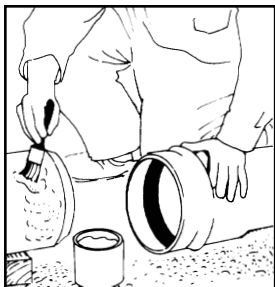
Gasketed Pipe

PWPipe gasketed pipe is an integrally belled product. All gaskets are installed at the factory.

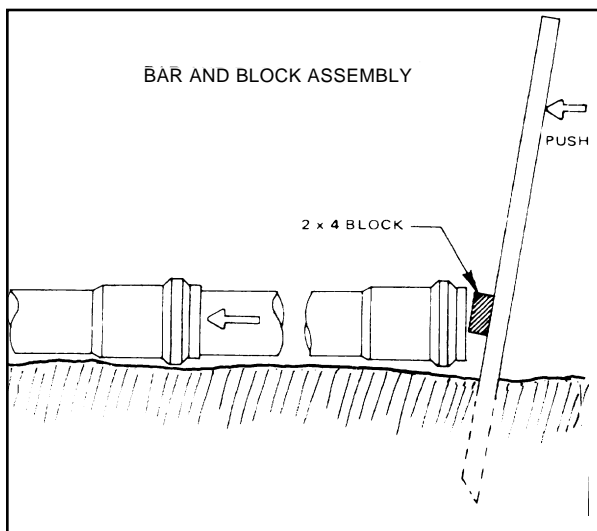
The joint is engineered to provide problem-free service for the life of the pipe, but proper procedures must be followed to ensure its effectiveness:



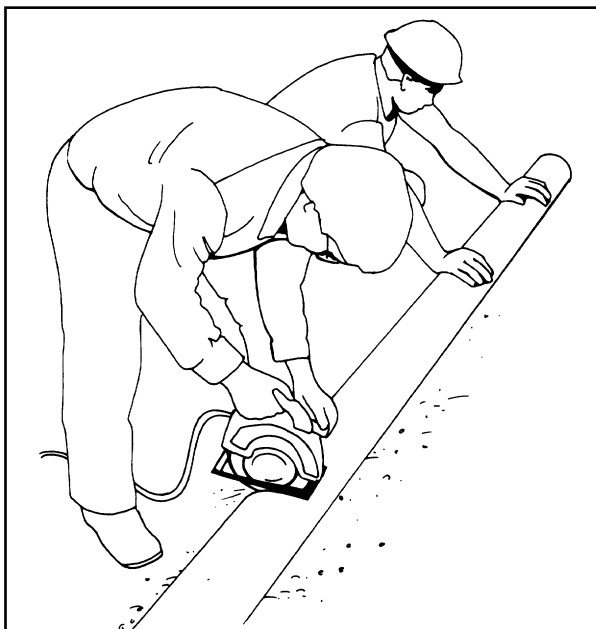
1. Clean the gasket area. Remove sand, dirt, grease, and debris. Do not remove gaskets from bells — removal could cause improper reinstallation.
2. Check the gasket. Make sure it is seated uniformly in the groove by running your finger around the inner edge of the gasket.
3. Clean the spigot. Use a rag to wipe the spigot clean.
4. Lower the pipe into the trench. Lower carefully to avoid getting dirt into the bell or spigot.
5. Lubricate. Apply lubricant only to the bevel of the spigot end and approximately mid-way back to the stop line. **WARNING:** Use only those lubricants supplied by PWPipe — the use of other lubricants may cause deterioration of pipe or gasket.



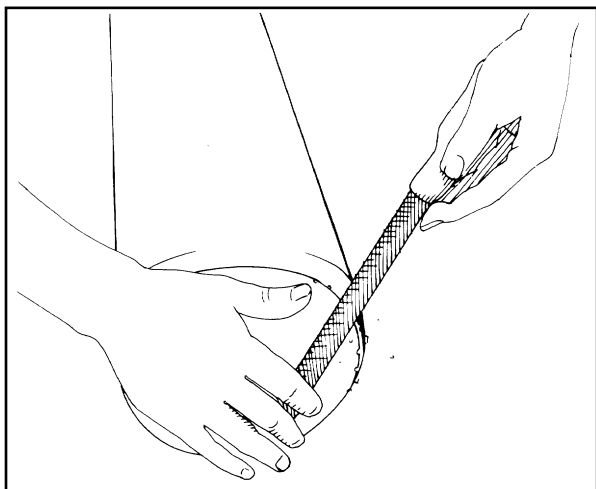
6. Keep lubricated areas clean. If dirt or sand adhere to lubricated areas, clean and re-lubricate.
7. Assemble pipe. Insert the spigot end into the bell until it contacts the gasket uniformly. **Straight alignment is essential for ease of assembly.** Apply steady pressure by hand or by mechanical means until the spigot slips through the gasket. Insert pipe until the stop line is flush with the bell end. Bar and block assembly is recommended where possible because a worker is able to feel the amount of force being used and whether the joint goes together smoothly. Special jointing methods, such as ratchets, jacks, or backhoes



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- can also be used if care is taken to insure that the spigot is not over-inserted and that previously assembled pipe joints are not disturbed.
8. If undue resistance to pipe insertion is encountered or if the pipe cannot be inserted to the reference mark, disassemble the joint and check the position of the gasket.
 - a. If the gasket has been dislodged from the race, inspect the pipe and gasket for damage, replace damaged items, clean the components, and repeat the assembly steps, assuring **straight** alignment.
 - b. If the gasket is still properly positioned, verify proper positioning of the reference mark. Relocate the mark if it is not correctly positioned. In general, fittings allow less pipe insertion than do pipe bells. If the pipe still cannot be inserted properly, call PWPipe for assistance.



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9. If the pipe must be field-cut, mark the entire circumference of the pipe to ensure a square cut. The pipe can be cut with a hacksaw, handsaw, or portable power saw with a steel blade or abrasive disc. Bevel the cut end using a pipe beveling tool, a portable sander, or abrasive disc. Round off any sharp edges on the leading



edge of the bevel with a pocket knife or a file. Mark cut end with an insertion line similar to uncut pipe.

Bevel requirements vary with different joint types:

Joint	Bevel
a. PVC pipe bell	Same as factory bevel
b. PVC push-on fitting	Same as factory bevel
c. Other pipe bell/push-on fitting	Shorter bevel length

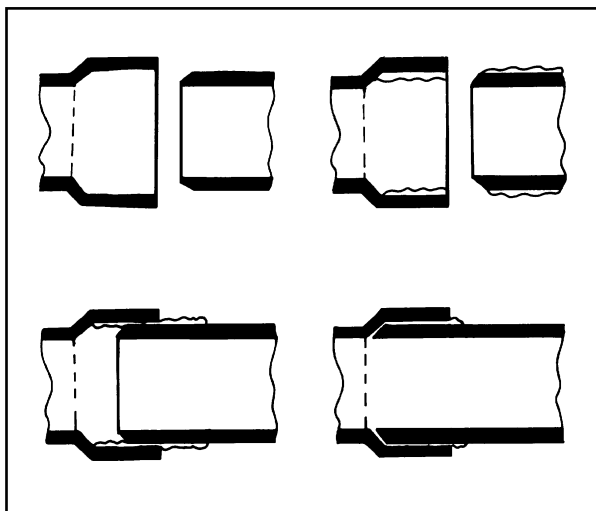
Solvent-Cemented Pipe

1. Specifications:

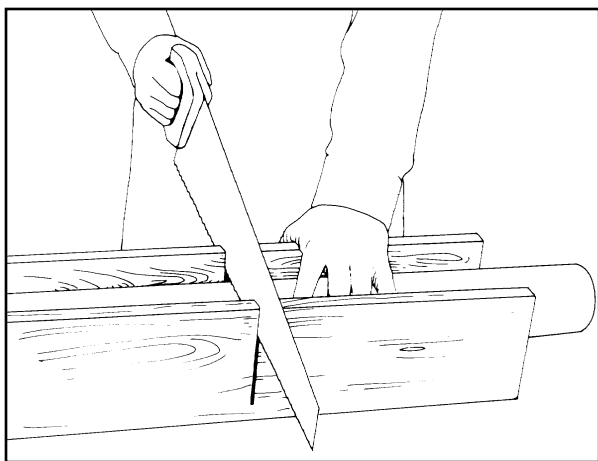
Solvent-cemented joints should be made in accordance with ASTM D 2855 "Standard Recommended Practice for Making Solvent-Cemented Joints with Polyvinyl Chloride (PVC) Pipe and Fittings." The solvent cement should conform to ASTM D 2564 "Standard Specification for Solvent Cements for Polyvinyl Chloride (PVC) Plastic Pipe and Fittings," and the primer should conform to ASTM F 656 "Specification for Primers for use in Solvent Cement Joints of PVC Plastic Pipe and Fittings." The handling of solvent cements should be in accordance with ASTM F 402 "Standard Recommended Practice for Safe Handling of Solvent Cements Used for Joining Thermoplastic Pipe and Fittings."

2. Basic principles of solvent-cemented joints:

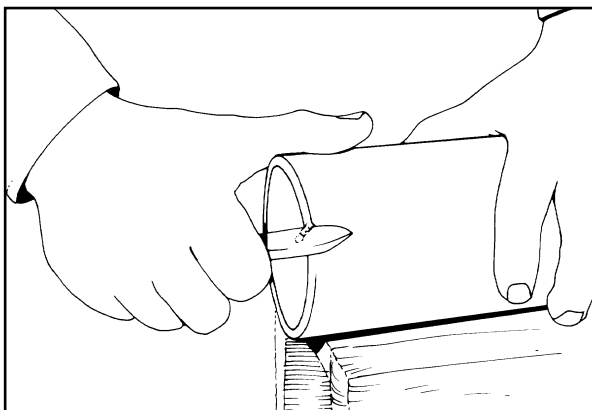
- a. The joining surfaces must be clean and dry.
- b. The joining surfaces must be softened and made semi-fluid.
- c. Sufficient cement must be applied to fill the gap between male and female ends.



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- d. The assembly must be made while the surfaces are still wet and fluid.
 - e. Joint strength develops as the cement dries. In the tight part of the joint, the surfaces will fuse together. In the loose part, the cement will bond with both surfaces.
 - f. Completed joints should not be disturbed until they have cured sufficiently to withstand handling.
3. Storage:
PVC solvent cements should be stored in a cool place except when actually in use at the job site. Consult the cement manufacturer for specific storage recommendations on storage conditions and shelf life.
 4. Procedure:
 - a. Cutting the Pipe — Cut pipe square with the axis, using a fine-tooth saw with a miter box or guide.

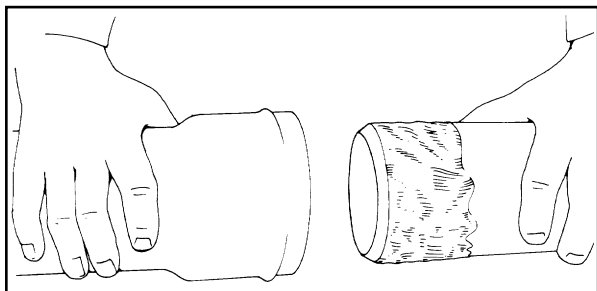


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- b. Joint Preparation — Remove all burrs and break the sharp lead edges.
 - c. Cleaning — Surfaces to be joined must be cleaned and free of dirt, moisture, oil, and other foreign material.



- d. Handling Cement — Keep cement can closed and shaded when not actually in use. Discard the cement when a noticeable change in viscosity occurs, when the cement does not flow freely from the brush, or when the cement appears lumpy and stringy. Keep the brush immersed in cement between applications.
- e. Application of Primer and Cement — The time necessary for the primer to etch the pipe surface is dependent on ambient temperature. PVC solvent cement is fast drying and should be applied as quickly as possible, consistent with good workmanship. Follow the manufacturer's recommendations for application of primer and cement.
- f. Assembly of Joint — While both the inside socket surface and the outside surface of the male end of the pipe are SOFT and WET with solvent cement, forcefully bottom the male end in the socket. Turn the pipe or fitting $\frac{1}{4}$ turn during assembly (but not

after the pipe is bottomed) to distribute the cement evenly. Assembly should be completed within 20 seconds after the last application of cement.



After assembly, wipe excess cement from the pipe at the end of the socket. Any gaps in the cement bead around the pipe perimeter may indicate a defective assembly.

- g. Set Time — Handle the newly assembled joints carefully until after the set period as follows:

Temperature Range		Minimum Set Time
°F	°C	
60 to 100	15 to 40	30 minutes
40 to 60	5 to 15	1 hour
20 to 40	5 to 15	2 hours
0 to 20	-20 to -5	4 hours

5. Installation:

After the set period, the pipe may be carefully placed in a prepared ditch.

6. Safe Handling of Solvent Cement:

- Keep solvent cements and primers away from all sources of ignition.
- Provide adequate ventilation to reduce fire hazard and to minimize breathing of vapors.
- Avoid contact with skin and eyes.
- Refer to ASTM F 402 for more information.

Chapter V

■ Testing

General

This chapter gives PWPipe's recommendations for project testing, but the final authority on testing requirements is the project engineer.

Sewer pipe installations are tested for alignment, leakage, and deflection. Sections of the system that fail to pass testing should be located, repaired, and re-tested until tests are passed.

Prior to the start of testing, all sewer lines should be cleaned. The use of a sewer cleaning ball or high velocity jet may be necessary.

Visual Testing

Sewer lines may be visually inspected:

1. Purpose — To verify accuracy of alignment and freedom from major defects, debris, and obstructions.
2. Methods — Usual methods are photography, closed circuit television, or lamping with mirrors and lights.

Leakage Testing

Methods of testing are air exfiltration, water infiltration, or water exfiltration. PWPipe recommends the use of low pressure air exfiltration. Only those lines tested after backfilling to final grade should be accepted.

1. Air Exfiltration Testing
 - a. Safety — All plugs and caps should be secured to prevent blowouts. All pressurizing equipment should include a relief valve set no higher than 9 psig to avoid over-pressurizing.
 - b. Line Preparation — During construction, all laterals, stubs, and fittings should be plugged or capped to prevent air loss that could affect air test results.
 - c. Isolation of Test Section — Pneumatic or mechanical testing plugs should be installed at each end of the pipe sections to be tested.

-
- d. Line Pressurization — Low pressure air should be slowly introduced into the test section until the air pressure reaches 4.0 psig greater than the average external pressure of any groundwater above the pipe. Maintain this internal pressure for at least two minutes to allow pressure stabilization, and then shut off the air supply.
 - e. Timing of Pressure Loss — At any convenient observed pressure reading between 3.5 and 4.0 psig greater than the average external pressure of any groundwater above the pipe, begin timing the pressure loss. If the time shown in Table 5.1 for the designated pipe size and length elapses before the air pressure drops 0.5 psig, the section is considered to have passed the test. The test may be discontinued once the prescribed time has elapsed, even though the 0.5 psig loss has not occurred.
 - f. Technical data
 - 1. Allowable air loss rate (Q) — The value for Q is 0.0015 cubic feet per minute per square foot of internal surface.
 - 2. Test time table — If the specified pressure drop is 1.0 psig, the time values in Table 5.1 should be doubled.
 - 3. Testing main sewers with lateral sewers — If lateral sewers are included in the test, their lengths may be ignored for computing test times. (Ignoring the laterals results in a slightly more severe test.)

TABLE 5.1
Specification Time Required for a 0.5 PSIG Pressure Drop
for Size and Length of Pipe Indicated for Q = 0.0015

1 Pipe Diam. (in.)	2 Min. Time (min: sec)	3 Length for Min. Time (ft)	4 Time for Longer Length (sec)	Specification Time for Length (L) Shown (min: sec)							
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
4	1:53	597	.190 L	1:53	1:53	1:53	1:53	1:53	1:53	1:53	1:53
6	2:50	398	.427 L	2:50	2:50	2:50	2:50	2:50	2:50	2:51	3:12
8	3:47	298	.760 L	3:47	3:47	3:47	3:47	3:48	4:26	5:04	5:42
10	4:43	239	1.187 L	4:43	4:43	4:43	4:57	5:56	6:55	7:54	8:54
12	5:40	199	1.709 L	5:40	5:40	5:42	7:08	8:33	9:58	11:24	12:50
15	7:05	159	2.671 L	7:05	7:05	8:54	11:08	13:21	15:35	17:48	20:02
18	8:30	133	3.846 L	8:30	9:37	12:49	16:01	19:14	22:26	25:38	28:51
21	9:55	114	5.235 L	9:55	13:05	17:27	21:49	26:11	30:32	34:54	39:16
24	11:20	99	6.837 L	11:24	17:57	22:48	28:30	34:11	39:53	45:35	51:17

2. Water Infiltration Testing

- a. Ground water requirements — This method of testing is acceptable only when the ground water level is above the top of the pipe throughout the length being tested.
- b. Allowable infiltration — as measured by a weir or current meter, infiltration should not exceed 50 gallons per inch of internal pipe diameter per mile per day (4.6 liters/mm/km/day).

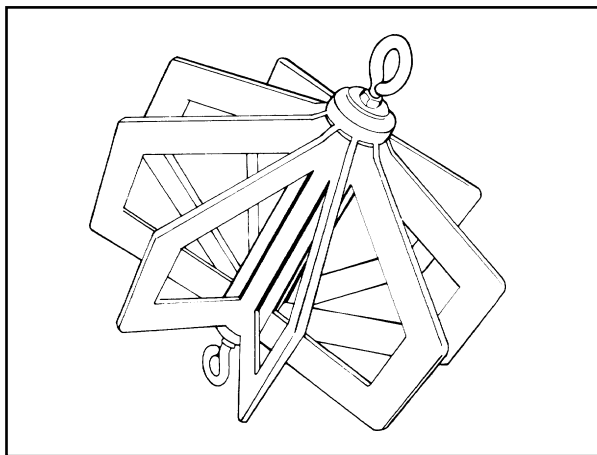
3. Water Exfiltration Testing

- a. Ground water requirements — Ground water must be low enough that external pressures generated by the ground water above the pipe do not interfere with the test.
- b. Test head — The maximum internal water head should not exceed 25 feet (7.6m) at the lowest end, and the water level in the manhole should be 2 feet (0.6m) higher than the top of the pipe or 2 feet (0.6m) higher than the ground water level, whichever is greater.
- c. Allowable exfiltration — Water exfiltration should not exceed 50 gallons per inch of internal pipe diameter per mile per day (4.6 liters/mm/km/day).

Deflection Testing

The engineer chooses locations and methods for deflection tests.

1. Purpose — To verify proper installation of the pipe in areas where difficult construction conditions were encountered .



2. Method — The recommended method is a mandrel sized for the allowable deflection.
3. Allowable deflection — The maximum allowable reduction in inside diameter should be $7\frac{1}{2}\%$. Inside diameter and $7\frac{1}{2}\%$ mandrel dimensions are as follows:

TABLE 5.2

ASTM BASE INSIDE DIAMETERS - SDR 35 AND 7½% DEFLECTION MANDREL DIMENSIONS		
Nominal Size, In.	Base Inside Diameter, In.	7½% Deflection Mandrel, In.
6	5.742	5.31
8	7.665	7.09
10	9.563	8.84
12	11.361	10.51
15	13.898	12.86
18	16.976	15.70
21	20.004	18.50
24	22.480	20.80

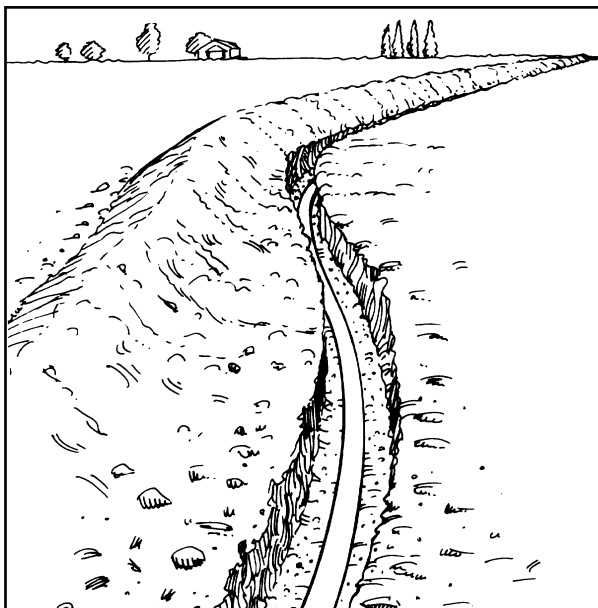
NOTE: Base I.D. is a pipe I.D. derived by subtracting a statistical tolerance package from the pipe's average I.D. The tolerance package is defined as the square root of the sum of squared standard manufacturing tolerances.

Chapter VI

■ Special Considerations

Longitudinal Bending

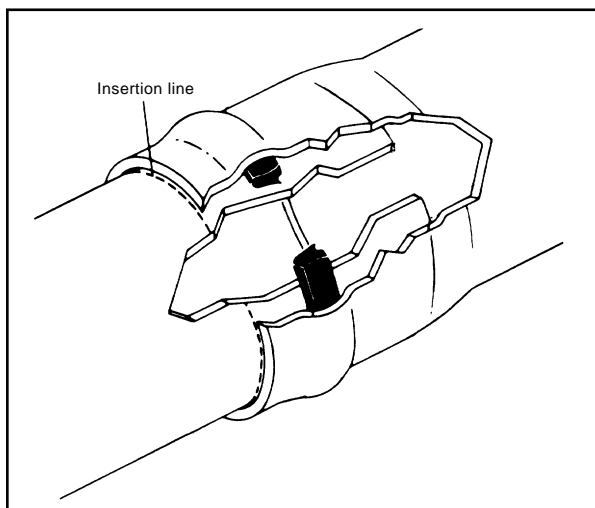
1. The ability of PVC pipe to bend is a significant advantage over rigid pipes.
2. Longitudinal bending may be done deliberately during construction or may be the result of changes that occur in the pipe-soil system after construction.



3. Longitudinal bending is accomplished by axial flexure of the pipe combined with deflection of the gasketed joints:
 - a. Axial flexure — The minimum bending radius is recommended to be 160 times the pipe OD.
 - b. Joint deflection — For design purposes, joint deflection should be zero; in the field the maximum allowable joint deflection is one degree.
4. Where bending is required, it should be done manually. The use of mechanical equipment may cause damage to the pipe or joining system.

Thermal Expansion and Contraction

1. All materials expand and contract with changes in temperature. Linear expansion of pipe in the longitudinal direction is dependent on:
 - a. Variation in temperature
 - b. Coefficient of thermal expansion of the material. It is important to note that the rate of thermal expansion and contraction is not dependent on pipe size or wall thickness.
2. The coefficient of thermal expansion for PVC is 3.0×10^{-5} in/in/°F (5.4×10^{-5} mm/mm/°C).
3. Allowance for thermal movement:
 - a. 0.36 inch of length variation for every 100 feet of pipe for each 10° F change in temperature.
 - b. 5.4 mm of length variation for every 10 meters of pipe for each 10° C change in temperature.



-
4. Gasketed joints — When gasketed joints are used, thermal movement is not a significant design factor as long as:
 - a. Pipe temperatures are kept within accepted limits for PVC pipe.
 - b. Joints are properly installed with the pipe spigots inserted into the bells to the insertion line.

WARNING: IF PIPE SPIGOTS ARE INSERTED PAST THE INSERTION LINE, THERMAL EXPANSION MAY CAUSE SIGNIFICANT STRESSES IN THE PIPE BELLS.

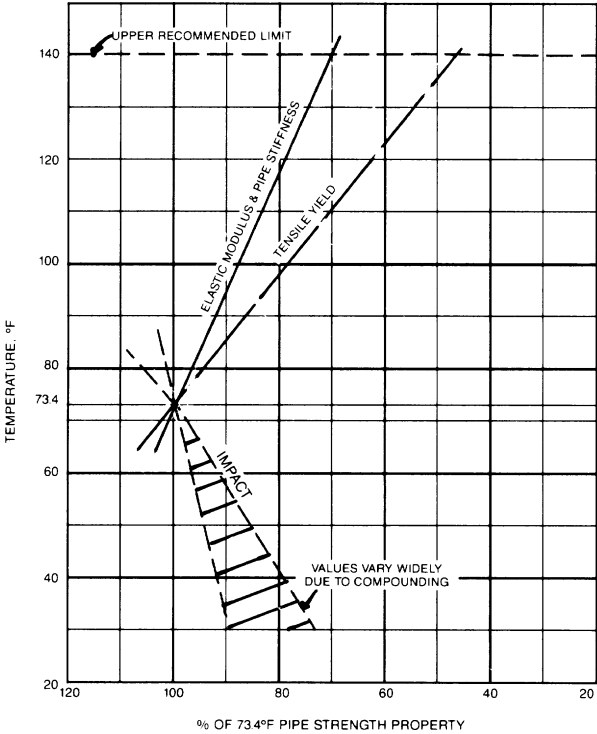
5. Solvent cemented joints — When solvent cemented joints are used, thermal movement cannot be accommodated in the pipe joints. After the joints are properly cured, pipe should be installed in straight alignment. Before backfill to the extent that restricts longitudinal movement, the product temperature should be adjusted to within 15° F (8° C) of operating temperature.
6. Where the operating temperature cannot be closely controlled, the stresses resulting from extreme temperature variations must be considered in the design. The design engineer should be consulted for guidance.

Thermal Effects on PVC Properties

The physical properties of PVC vary with changes in temperature. The rated values for PVC properties are established at 73.4° F (23° C).

1. As temperature decreases below 73.4° F, pipe stiffness and tensile strength increase while impact strength decreases. This decrease in impact strength requires that more care be taken during installation in cold temperatures.
2. Conversely, as temperatures increase, pipe stiffness and tensile strength decrease while impact strength increases. Decreases in pipe stiffness require that more care be taken during installation in hot weather.

APPROXIMATE RELATIONSHIP FOR 12454 PVC FOR FLEXIBLE
PIPE STRENGTH PROPERTIES VS. TEMPERATURE



Ultraviolet (UV) Radiation

Like most plastics, PVC can experience degradation when exposed to UV radiation. This degradation occurs only on surfaces exposed to the sun and penetrates only about .001 inch into the pipe wall. The affected areas often turn a yellow color. When the pipe is no longer exposed to the sun, further degradation does not occur.

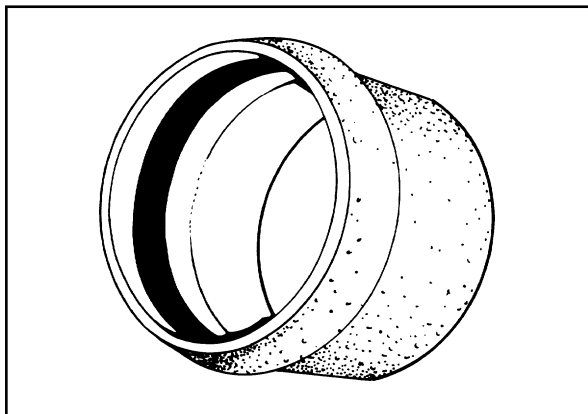
Ultraviolet exposure does not significantly affect pipe stiffness or tensile modulus properties. However, there is a measurable reduction in values for impact strength.

PVC pipe's high initial impact strength means that reductions in impact properties due to UV radiation are of little concern. If good construction practice is followed in unloading, handling, and installation, pipe breakage due to impact loads will not be a problem.

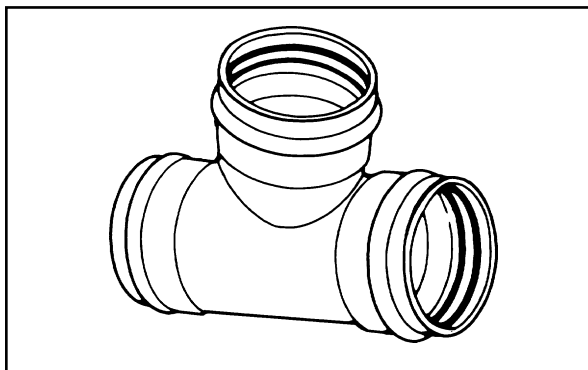
Appurtenances

1. Manholes
 - a. Purpose — Manholes provide access to the sewer line for inspection and maintenance, and provide control of hydraulic flow at flow discontinuities.
 - b. Spacing — The interval between sanitary sewer manholes is usually 300 to 500 feet.
 - c. Foundations — A stable foundation is essential to prevent settlement which could damage the pipe/manhole connection.

-
- d. Connections — An elastomeric waterstop gasket should be used to prevent leakage and allow longitudinal movement of the pipe. A non-shrink or expansive grout should be used for connections to manhole walls.



2. Fittings — Fittings are required at all house connections, cleanout accesses, and changes in line direction or size not occurring at manholes. Fittings may be molded or fabricated.



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3. Saddles — Taps into existing lines should use a gasketed PVC saddle wye or tee. Saddles should be installed per the manufacturer's recommendations.
 4. Service lines — Lines from the property line to the collection sewer should be at a minimum depth of 3 feet (1 m) at the property line.
 5. Risers — Vertical risers (chimneys) may cause significant loads on pipe or fittings. Where pipe geometry or soil conditions tend to produce riser settlement, the project engineer should design proper riser support.

Applications Precautions

1. Sewers on steep slopes — Sewers on slopes of 20% or greater should be anchored securely with concrete collars cast immediately downhill from bells to prevent downhill movement of the pipe.
2. Minimum cover — Tests performed by the federal government have shown that SDR 35 PVC sewer pipe minimum cover requirements are 12 inches for H20 highway loading and 24 inches for light and medium aircraft loads.
3. Safety — All applicable federal, state, and local safety regulations should be followed.

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