Lesson Three — Nonmetallic Piping

Preface

Piping has been a part of man's life and needs for thousands of years. Originally, piping was made from wood or clay. Water was transported over long distances by open stone channels which served as piping. Some of those channels built nearly two thousand years ago are still in use.

Although metal piping is in wide use today, nonmetallic piping is of equal importance for its applications, as you will learn from this lesson. In addition to materials which have been used for centuries, man now has new metals and nonmetallic piping materials to choose from. Older materials have been modified by new processes to make them useful for today's plant requirements.

In Lesson Three, you will learn what the common nonmetallic materials are, both old and new, and where they are most commonly used. You will also learn how sections of nonmetallic piping are joined, and how they are maintained.

Nonmetallic Piping Materials

3.01 The basic nonmetallic piping materials are as follows:

1. Clay.
2. Concrete.
3. Plastic.
4. Glass.
5. Wood.

Most of them are available in several forms and variations. Clay pipe, for example, is often glazed to provide corrosion resistance. Concrete is reinforced for greater strength. A number of plastics have been developed for use in piping. Cement, rubber, and plastics, as well as glass, are used for lining metal piping to provide corrosion resistance and to prevent contaminant damage and buildup.

3.02 Codes and specifications for nonmetallic piping have been established by engineering societies and standards groups. The properties and characteristics of all standard nonmetallic piping have been classified so that designers of piping systems will know what kinds of piping and material are best for a given application. You know that one of the reasons for devising codes is to help ensure the safety of personnel and to provide protection for equipment, including the system itself.

Clay Pipe

3.03 Clay pipe comes in two forms: VITRIFIED (glassy or glass-like) and UNGLAZED (not glassy, because it has not been subjected to the firing operation and pressure process used to make vitrified pipe). Both types are furnished in sizes from 4 to 36 inches in diameter, and both are available in more than one grade of strength. Clay

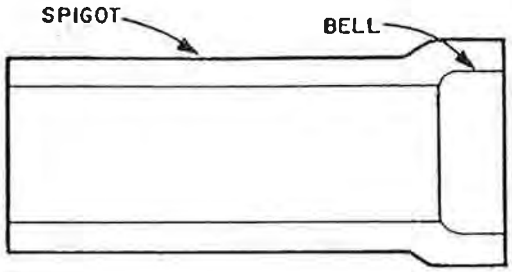


Fig. 3-1. Bell-and-spigot ends of clay pipe section.

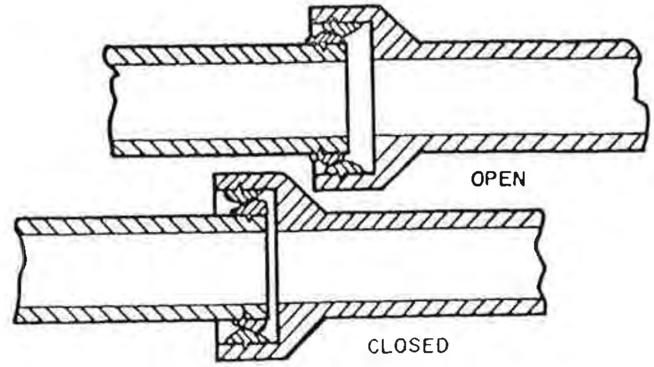


Fig. 3-2. Flexible joint for vitrified clay pipe.

piping is used to carry industrial wastes, sewage, and storm water.

3.04 Vitrified clay pipe is the most corrosion-proof product available for industrial and sewage wastes. In fact, it can carry every known chemical waste without being damaged, except one – hydrofluoric acid, which is seldom used by industry, and is rarely found in sanitary sewage. (The only safe way to hold hydrofluoric acid is in a wax or wax-lined container. It will eat through all other materials.)

3.05 Liquid flow in drain pipes depends on gravity and not on pressure provided by pumps. A pipe that carries fluid in this way, whether partly or completely filled, is called an OPEN CHANNEL pipe.

3.06 Clay pipe (both vitrified and unglazed) is made and joined with the same type of bell-and-spigot joint described in Lesson Two (see Fig. 3-1). In joining sections of clay pipe, you should first thoroughly clean both ends of the pipe. The spigot (small) end of the pipe should be centered properly, and then seated securely in the bell end. The bell is then packed with jute, which is thoroughly tamped down, until about one-third of the space is filled. Finally, the joint is filled with joint compound.

3.07 Figure 3-2 shows a newer type of joint, which is flexible, and commonly used for joining vitrified clay pipe. The sealing elements are made from natural or synthetic rubber or from a plastic that successfully resists the corrosive effects of the fluids carried by the pipe.

3.08 Drainage and sewage lines designed for gravity flow are laid downgrade at an angle, with the bell ends of the pipe pointing upgrade. Installations vary, but all must provide the pipe with strong support in the trench. Unglazed clay pipe must be protected against the effects of ground moisture and soil contaminants (a precaution unnecessary for vitrified pipe). Both types must be positioned to prevent undue stresses. The pipe is laid so that it is supported along its small dimension and not on the bell end.

3.09 Waste pipelines normally are designed with a pipe size large enough to handle a load 40 percent higher than usual, because the amount of waste and waste water from a plant may vary during different seasons of the year. This is especially true for cooling equipment or processes. It also depends on the level of plant production.

3-1. The five basic nonmetallic piping materials are:

________ ________
________ ________
____

3-2. Nonmetallic piping codes help ensure the ________ of personnel and equipment.

3-3. The two basic types of clay pipe are ________ and ________.

3-4. The most corrosion-proof pipe available for carrying industrial and sewage wastes is ________ ________ pipe.

3-5. Liquid flow in drain pipes normally depends on ________.

3-6. A pipe that carries liquid by gravity is called ________ ________ pipe.

3-7. Before sections of clay pipe are joined, the ends should first be ________.

3-8. Drainage and sewage lines designed for gravity flow are laid ________ at an angle.

Concrete Pipe

3.10 Concrete is a common pipe material, and is furnished in several forms:

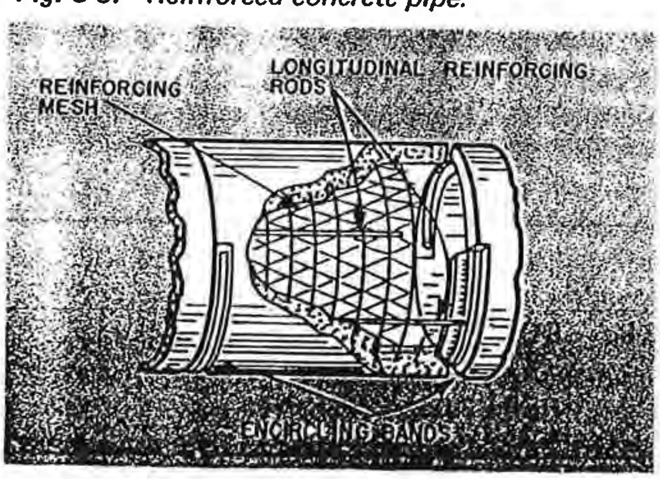
1. Nonreinforced concrete
2. Reinforced concrete.
3. Reinforced and prestressed concrete pressure pipe.

Although nearly all concrete piping is used for carrying industrial wastes, sewage, and storm water, some is also used in service lines. Except for the reinforced-and-prestressed pressure pipe, most concrete pipe is limited to low-pressure use. It is not recommended where there is likely to be underground acid seepage, which would damage or destroy the pipe. Concrete is also somewhat brittle, a condition which can be overcome by reinforcing it with metal rods or mesh.

3.11 Concrete pipe, like other piping, is covered by codes and specifications concerning type of pipe, wall thickness, diameter and pressures. The external pressure from the weight of fill above the concrete pipe is also considered.

3.12 Nonreinforced, or ordinary concrete pipe, is furnished in diameters from 4 to 24 inches. It is made with bell-and-spigot ends, as is the vitrified clay pipe already described, and is used for similar purposes: small sewer lines and culverts. Details of its installation are similar to those that apply to clay piping.

Fig. 3-3. Reinforced concrete pipe.



Reinforced Concrete Pipe

3.13 Reinforced concrete pipe is used for carrying sewage, storm water, and industrial wastes. It is also used in culverts. This type of pipe is so named because it has been strengthened by steel rods buried lengthwise in the pipe wall. Diameters of reinforced concrete pipe range from 12 to 144 inches.

3.14 Sections of reinforced concrete pipe are joined by the bell-and-spigot joint, or by tongue-and-groove joints.

Reinforced and Prestressed Concrete Pressure Pipe

3.15 When concrete piping is to be subjected to a heavy load or pressure, it is strengthened by reinforcement, prestressing, or both. As its name suggests, concrete pressure pipe can carry fluids with pressures of up to 600 psi. Although such piping can be used in gravity-flow situations, pumps are commonly used in such systems. Sizes range from 12 to 180 inches in diameter.

3.16 All concrete pressure pipe is reinforced by steel rods or bars embedded lengthwise in the pipe wall. In some cases, wire cages are included, as well. In addition, reinforcing rings circle the rods at intervals. The rods and rings form a kind of cage, Fig. 3-3. The reinforcement strengthens the pipe wall against both internal pressure from the fluid, and external pressure from the weight of the fill used to cover the pipe in a deep trench.

3.17 A second and much stronger type of reinforced concrete pipe is a CYLINDER pipe. It has the same reinforcing rods and rings, but, in addition, a welded steel shell is embedded in the concrete. This shell is tested to ensure that it is watertight and is then further strengthened by banding it with reinforcing rings. Finally, it is given an internal coating of regular concrete, and an outside layer of reinforced concrete. Fluids in the pipe are not in contact with the steel shell itself, but with the concrete lining. It is the combination of the steel shell and the reinforced concrete outer layer which gives the pipe its strength. This is heavy-duty pipe that will handle pressures up to 260 psi.

3.18 Still further strength can be obtained by prestressing the concrete. Concrete is by nature a brittle material. A concrete rod would snap easily. On the other hand, concrete has high compression strength or resistance to being compressed. That is, if the same rod were placed in an upright position, it could support a far greater weight. Prestressed concrete pipes are placed under a compression force permanently when manufactured.

3.19 The first step in making a prestressed concrete pipe is to line a welded steel cylinder with concrete. When the lining has set, the cylinder is tightly wrapped with high-strength wire. The steel cylinder in turn squeezes the concrete lining, placing it under compression. The outside of the pipe is concrete coated. The pipe has greater strength because the concrete has been compressed. It is the prestressed type which can carry the 600 psi.

3.20 Either a lead-and-steel or a rubber-and-steel joint is used to join such pipes. This is a more advanced form of the bell-and-spigot joint. In the rubber-and-steel joint, the rubber gasket is first lubricated with vegetable soap. The gasket fits on the spigot (small) end of the pipe, which is pushed into the bell end of the next section of pipe. The outer area of the joint is then filled with concrete. The joint is wrapped with reinforced paper or cloth to prevent the concrete filling from running out of the joint. After the two pipes have been securely joined, any remaining space is filled with mortar.

3.21 Cement is also used to line cast iron pipe to improve corrosion resistance. The lining is coated later with a sealant material. The outside walls of this type of pipe are given a white waterproof coating to reflect heat and help prevent the iron pipe and lining from separating because of heat expansion.

Asbestos-Cement Pipe

3.22 Strong and corrosion-resistant, asbestos-cement pipe is being used increasingly for carrying water and sewage. The material itself is a mixture of asbestos fibers, portland cement, and silica flour. Standard sizes are from 3 to 36 inches. This type of pipe is classified in two ways: as pressure pipe (200 psi maximum working pressure) and as sewer pipe. Each is available in several grades of strength.

3.23 The particular advantages of asbestos-cement piping include its high resistance to corrosion, and the fact that it is not subject to tuberculation. It should not be used, however, for carrying highly acid solutions or unusually soft water, unless its inner and outer walls are given a special surface treatment. An outstanding advantage of asbestos-cement piping is its light weight, which means greater ease of handling.

3.24 Joining asbestos-cement pipe is done by using asbestos-cement sleeves having a larger I.D. than the pipe's O.D. The ends of the closely and squarely machined pipe fit in the sleeves and are sealed with natural or synthetic rubber seals or gaskets. The gaskets act as expansion joints.

Plastic Piping

3.25 The use of plastic for piping is becoming increasingly common. In many applications, in fact, plastic piping is replacing both metallic and nonmetallic piping because of its particular advantages, which include:

1. High corrosion resistance, both internal and external.
2. Self-insulating properties (plastic piping is rarely insulated).
3. Freedom from rust and rot.
4. Light weight (from 1/6 to 1/2 the weight of other piping materials).
5. Ease of joining.

Additional advantages are that most types of plastic piping will not burn, and they do not need to be painted. Another consideration is that plastic is lower in cost than many other piping materials. Plastic piping is easily maintained and, properly applied, has a long service life. Both rigid and flexible types are made.

3.26 The term "plastic" refers to a group of materials, not just one material. Generally speaking, plastic piping is made from either of two major classes of plastic: THERMOPLASTIC and THERMOSETTING. A thermoplastic material can be softened by heating and will then reharden when cooled. A thermosetting plastic, on the other hand, remains hardened once it has been formed, and cannot be softened and rehardened as a thermoplastic can be. Most of the piping you will work with is likely to be of the thermoplastic types.

3.27 Generally, plastic pipe is furnished in iron-pipe sizes (IPS), although other types are available. Thermoplastic pipe ranges in diameter from 1/8 inch to 14 inches. Thermosetting pipe is made in standard sizes from 2 inches to 60 inches, and has been made as large as 144 inches in diameter.

Thermoplastic Piping

3.28 Although there are variations, most standard thermoplastic piping is made from one of the following four materials:

1. PVC (Polyvinyl Chloride).
2. PE (Polyethylene).
3. ABS (Acrylonitrile-butadiene-styrene).
4. CAB (Cellulose-acetate-butyrate).

You can see why they are usually referred to by their initials rather than by their chemical names. Each of the four types is furnished in more than one grade. Selection is determined by the requirements of the application itself, as is selection of the type of piping to use.

3.29 PVC piping is rigid, tough, and resistant to attack by chemicals which would destroy many other kinds of piping. Typical materials carried by PVC piping include: most acids; salt solutions; alcohols; caustic solutions; and many chemicals. Other applications include carrying cold water, since PVC is nontoxic, and will not affect the taste or cause odor. Because PVC won't produce sparks if struck, it is safe to use around explosives and explosive vapors. (That is also true of the other plastics.) Another advantage of PVC piping is that it does not allow water contaminants to build up on its walls.

3.30 PE piping has many of the same advantages as PVC. More flexible than PVC, it is widely used for water lines, and for carrying salt water, chemical wastes, and in gas-collecting systems. It is also used for conduit to carry telephone and power cables.

3.31 ABS piping is tough and has good resistance to chemical attack. It is used for carrying many acids, some alcohols, and gases such as chlorine and ammonia. Other applications include its use for sewage piping, and carrying gases, salt water, and crude oil.

3.32 CAB piping is semirigid. It is stiff enough to be carried and shipped in straight lengths, yet flexible enough to follow the shape of the ground. It is used for sewage lines and for carrying other fluids, as well as low-pressure gas. In oil refineries, CAB piping carries sour crude oil, salt water, and gases produced as part of the refining process.

Thermosetting Plastics

3.33 Basically, there are two common thermosetting plastics used for piping: epoxies and polyesters. Both are rigid types, and are reinforced with glass or asbestos fibers.

3.34 Commercial epoxy piping is usually furnished in diameters from 2 through 12 inches in standard pipe sizes. Its applications include carrying sewage, waste process water, many acids, and other solutions. It is also used in some processes in the food and beverage industries.

3.35 Commercial polyester pipe is normally available in diameters up to 60 inches, and can be used for carrying materials up to 121°C (250°F). Polyester piping has resistance to most acids, and to alcohols, bleaches, and solvents.

3-9. Name three types of concrete pipe.

____

____

____

3-10. Concrete pressure pipe can carry fluids at pressures up to __________ psi.

3-11. Cast iron pipe can be lined with cement to increase its resistance to __________ .

3-12. Asbestos-cement pipe is joined by asbestos-cement __________.

3-13. The two major classes of plastic used for piping are _______________ and _______________ .

3-14. Using their initials, name the four commor thermoplastic piping materials.

__________ __________

__________ __________

3-15. Plastic piping is safe to use around explosives because it will not produc __________ if struck.

3-16. Piping made from thermosetting plastics i: __________.
(flexible/rigid)

Cabot Piping Systems

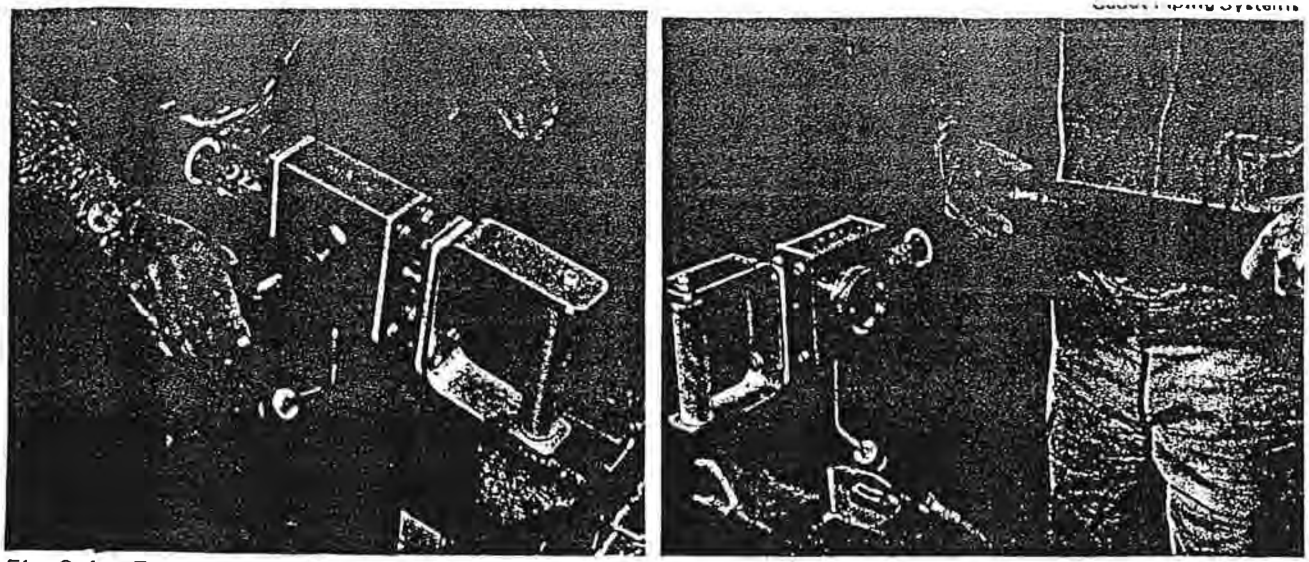


Fig. 3-4. Fusion welding.

Limitations of Plastic Piping

3.36 While plastic piping has definite advantages, it also has certain disadvantages, which include: (1) limited temperature range (approximately 66°C or 150°F maximum for most thermoplastic piping, and 121°C or 250°F for epoxy and polyester piping); (2) low-pressure operation (although certain types can withstand 250 psi; pressures are usually 75 or 100 psi); (3) most types must be supported at closer intervals than iron or steel pipe; and (4) plastic piping cannot be used for carrying certain solvents which would dissolve them.

3.37 The strength of plastic piping decreases as the temperature of the materials it carries increases. For example, a 2-inch PE pipe can handle a pressure of 75 psi at 24°C (75°F), but only 25 psi when the temperature increases to 71°C (160°F). The possible softening of the pipe is one of the chief reasons for the closer spacing required for supports.

Joining Plastic Pipe

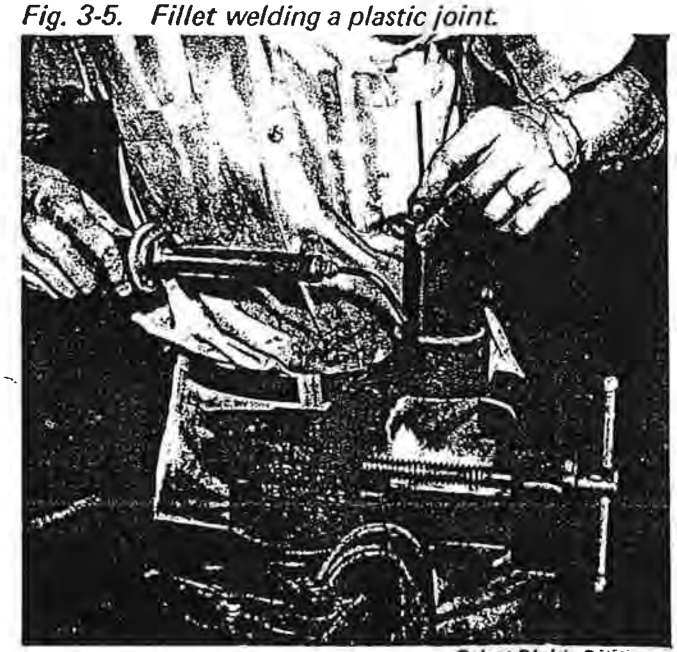
3.38 Thermoplastic piping can be joined in any of several ways, as can metallic piping. The basic methods are forms of welding, threaded joints, and flanges. (Flanges will be covered in a later lesson.)

3.39 The welding processes are: (1) solvent welding; (2) fusion welding; and (3) fillet welding. All three are done at far lower temperatures than would be used for welding metal piping. All that is required is enough heat to soften the plastic to the point where it will flow, the heat being provided by chemical action or hot air rather than open flame.

3.40 At this point, a safety precaution should be mentioned. When working with solvent cements, and joining plastic piping, be certain that the working area is well ventilated and that no open flame is permitted. Most plastic solvents are highly toxic, and many of them are flammable.

3.41 Solvent welding is a chemical process used for joining sections of PVC, ABS, and CAB plastics. A solvent-cement is applied to the ends of the sections to be joined, which are then pressed into appropriate fittings or couplings. It is essential that the correct type of cement be used, however,

Fig. 3-5. Fillet welding a plastic joint.



Cabot Piping Systems

for the type of plastic being joined. This process provides tighter and stronger joints than threading.

3.42 PE and similar plastics are joined by fusion welding, a process which uses a heating device like the one shown in Fig. 3-4. The mating surfaces are heated at the same time, softening to the same point. The sections are then joined, the result being a tight, leakproof joint that is stronger than the pipe itself.

3.43 Figure 3-5 shows the fillet welding process, limited in use to particular plastics. The torch shown is furnishing hot air to the plastic rod which provides the material to fill the joint. This method is also used for repairing leaks in thermoplastic piping.

3.44 Threaded connections are used in a number of cases, usually when the line may have to be dismantled or moved later. Basically the same tools and techniques are used as for threading metal pipes. A disadvantage of threading, however, is that it weakens the wall strength of the pipe, and, therefore, reduces the pressure-carrying capacity of the pipe. Threading is only used for pipe which is Schedule 80 or heavier.

3.45 Thermosetting (reinforced) plastic piping sections can be joined by standard screwed and sleeve- or socket-type fittings and couplings. For better sealing and to provide greater strength to the joint, some fittings have tapered socket joints.

3.46 Another common method is the butt-and-strap joint, used for joining pipe sections in the field. One reason for its popularity is that it's the most economical method. The butt-and-strap type makes the joint as strong as the pipe itself.

3.47 To make the joint, the surfaces of the pipe ends are first roughened for a few inches on each side of the seam. This can be done with a power sander, a hand file, or with coarse sandpaper. After being coated with a clear dope, or resin, the ends are firmly and accurately butted together. It is best to do this with the pipe sections already mounted in their permanent supports. Two or more reinforced plastic patches maintain alignment while the joint is completed.

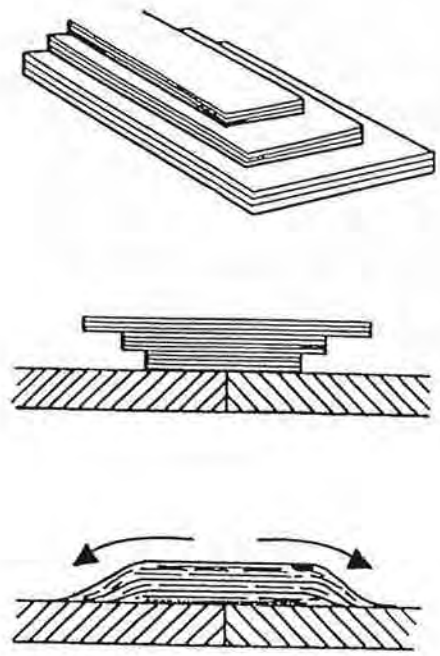


Fig. 3-6. How layers are arranged for butt-and-strap joints.

3.48 The seam is wrapped with nine or ten strips of fiberglass mat or woven roving (a strong cloth, spun with continuous glass threads).

3.49 The narrowest strip is put on first, directly around the seam. Successive strips are added, increasing in width as the joint is built up with the widest strip on the outside of the completed joint. See Fig. 3-6. The strips are cut long enough to reach once around the pipe with at least a one-inch overlap. Before being applied, the strips are soaked with a resin, preferably the same type used in making the pipe itself. After the joint is made, it is rolled with a paint roller to eliminate air pockets.

3.50 The most common methods of butt-and strap joining are SINGLE-LAYER APPLICATION and MULTIPLE-LAYER APPLICATION. In single-layer applications, straps are applied one at a time until the required joint thickness has been reached. However, the single-layer method takes longer. In the multiple-layer method the layers are built up away from the pipe, then applied to the pipe at one time. This method ensures an even overlap of the wider straps over the narrower ones, and shortens the time required.

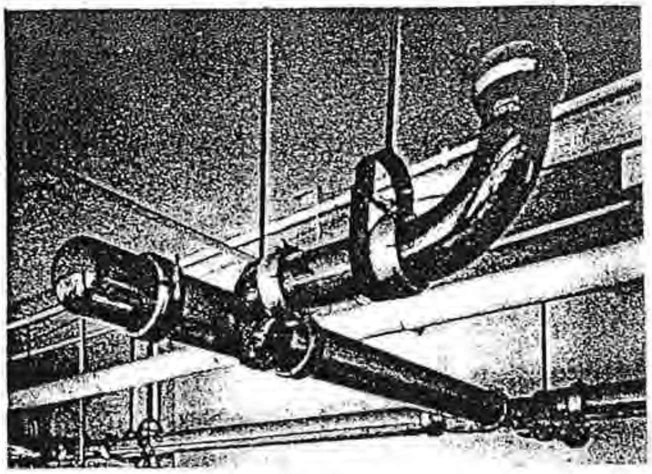


Fig. 3-7. Glass piping, showing couplings and supports.

3.51 To provide maximum strength, the resin used in these joints takes time to cure, or set chemically. Time required for curing depends on air temperature, humidity, and the heat developed during the curing cycle. Best results are obtained when the work is done at an air temperature of from 18°C (65°F) to 29°C (85°F).

Plastic Pipe Maintenance

3.52 Plastic pipes are relatively easy to maintain. Since their surfaces resist corrosion, they do not need to be painted, or cleaned out. Periodic inspection for leaks, sagging, and out-of-roundness is necessary.

3.53 Leaks are repaired with the type of solvent-cement designed for the particular type of pipe material. The pipe must be first drained and allowed to dry thoroughly. After the repair is made, a drying period of at least 10 hours is essential before the pipe is brought back up to its normal pressure and temperature. As a general precaution, remember that plastic pipes are easily damaged if hit with a hard object, such as a carelessly driven fork-lift truck. Always use a strap wrench instead of pipe or monkey wrenches to protect the plastic.

Glass Piping

3.54 Glass is a hard, brittle material which has a number of advantages making it highly suitable for many applications. Those advantages include its great resistance to corrosion, contamination, and heat. Glass is transparent, which permits visual observation of the pipe's internal condition and contents at any time. See Fig. 3-7. Diameters range from 1 to 18 inches.

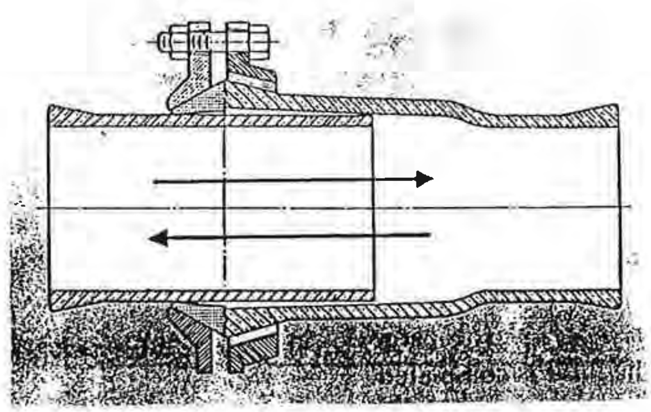
3.55 The limitations of glass are the brittleness already mentioned, and the fact that it can be used only for relatively low pressures (75 psi is a practical maximum). Types of glass can, however, be sheathed in a shell or layers of fiberglass or polyester plastic to allow them to handle up to 150 psi. As is true for plastics, improvements and new developments can increase the strength and pressure resistance of glass, and, therefore, its range of applications.

3.56 Because of its corrosion and heat resistance, glass piping is used extensively in paper mills, and in food, beverage, and chemical industries. Its resistance to contaminant buildup makes it valuable in the dairy products industries, as well as in drug or pharmaceutical plants. Glass piping is also commonly used in laboratory applications, because it is easy to clean, and is resistant to most acids and caustic solutions.

3.57 Another advantage of glass is its resistance to thermal shock. This means that a glass pipeline can be steam cleaned, and immediately afterward be used for carrying a cold liquid, such as milk, without cracking or shattering. This would not be possible in a plastic pipeline.

3.58 Sections of glass pipe are connected by joints made of a stainless steel shell, a rubber gasket or sleeve, and a plastic liner. No caulking is needed. Compared to many materials, glass has a low rate of temperature expansion, but it does expand and contract with changes in temperature, which makes the use of expansion joints advisable.

Fig. 3-8. Sleeve-type expansion joint for glass piping.



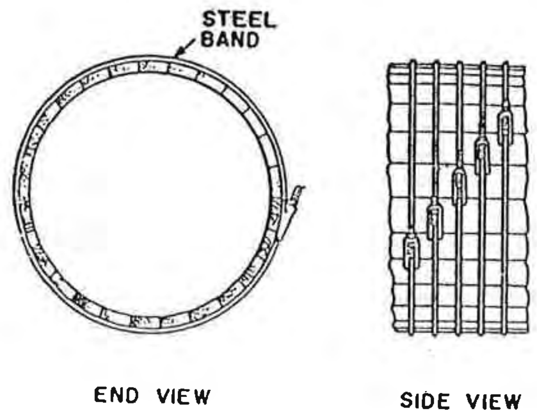


Fig. 3-9. Wood-stave piping.

Figure 3-8 illustrates a sleeve-type expansion joint. One piece of pipe extends several inches inside the joint. The space between the two sections of pipe is covered by a self-centering rubber gasket, held firmly by the bolted clamp. Construction is such that one piece of pipe can slide either way with respect to the other, as both sections expand or contract.

3.59 Maintenance of glass piping is the same as maintenance for any other type. Particular attention is required, though, to properly support glass, because of its brittleness. Standard hangers and supports are used, with the addition of protective padding.

Other Piping Materials

3.60 Chemical porcelain pipe is made of a high quality ceramic covered with a special glaze. Porcelain piping materials withstand quite high temperatures, in the range of 204°C (400°F) to 260°C (500°F). They will not, however, withstand a sudden change over 90°. Above that point, the temperature rise should be gradual, so the pipe will expand evenly. When the rise is too sudden, one surface will expand before the rest of the material does, and cracking results. Porcelain is highly corrosion resistant, but relatively fragile.

3.61 Chemical stoneware, another glass-like material, is corrosion-proof against all materials except hydrofluoric acid and strong, hot caustic. It is not as good as chemical porcelain, however, for carrying high-temperature fluids. Made in bell-and-spigot form, stoneware piping is used for drain lines and for carrying fluids that won't affect the cement used for caulking the joints. Stoneware can be used at higher temperatures and pressures by placing it inside a split metal shell. The space between the stoneware pipe and the outer shell is filled with a thin mortar (GROUT) of portland cement.

3.62 In the western part of the United States continuous strip wooden pipe, in diameters up to 20 feet, is used for carrying water and waste chemicals. Pressure-creosoted Douglas fir staves protect against fungus, slime, scale, and insects. The staves or strips are carefully fitted to form a round pipe, and are securely bound by steel bands set 10 inches apart or less. See Fig. 3-9. Steel pipe is sometimes lined with wood, to provide a strong, corrosion-resistant pipe which can be used under pressure.

3.63 Cast iron and steel piping is available with rubber or plastic linings for carrying corrosive materials or where contaminant protection is needed. Such liners have resistance to abrasion, and so can be used to carry solids. In gravity-flow circumstances, such solids are moved dry. When they must be pumped, the solids are carried by liquids. Some fertilizers are examples of such solids.

Maintenance Requirements

3.64 Maintenance for nonmetallic piping is much the same as maintenance for metal pipes. It must be protected against corrosion, leakage, and against the effects of temperature variations. In addition, nonmetallic piping is affected by the mechanical factors of vibration, stresses, and strains, as well as water hammer. That is particularly true for certain materials, as has been mentioned.

3.65 Although nonmetallic piping sections can be readily joined to one another, it is also possible to connect them to metal piping, as well. This is accomplished by flanging, which will be covered in a later lesson.

3.66 It is important to remember that each type of piping used, whether metallic or nonmetallic, has been selected on the basis of the application's requirements.

3-17.	The strength of plastic piping ________ *(decreases/increases)* as temperature increases.
3-18.	Name three basic methods for joining thermoplastic piping. ________ ________ ________
3-19.	When joining plastic piping, no ________ ________ should be permitted.
3-20.	In a temporary line, sections of plastic pipe are usually connected by ________ joints.
3-21.	Threading of plastic pipe should be limited to Schedule ________ and heavier pipe.
3-22.	Glass is a hard, but ________ pipe material.
3-23.	A great advantage of glass pipe is its resistance to ________ shock.
3-24.	Maintenance of nonmetallic piping is basically the ________ as for metal piping.