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ABSTRACT

This manual for the classroom instructor provides the basic trade knowledge and product data required by the student and the graduate plumber. It is also useful as an on-the-job reference. First, an information page on metric conversion is provided. The contents are presented in what is considered to be the most logical instructional sequence. Topics covered in the 38 parts include tools and equipment used in the plumbing trade; rigging and hoisting materials, equipment, and methods; safety practices, flammable materials, and torches; pipe, fittings, and joints made of various materials; the victaulic grooved piping method; pipe hangers and supports; oxygen and acetylene welding; electric-power tools, equipment, and accessories; power-actuated tools; installation of bathroom and other fixtures; maintenance of plumbing systems; private sewage-disposal systems; public underground water-distribution systems; domestic-water pumps, softeners, and conditioners; corrosion of metal and its prevention; cross-connections and protection devices; connecting hospital equipment; compressed-air systems; design of water-distribution systems; insulations for piping, fittings, and equipment; proprietary plumbing systems; and symbols for architectural drawings. The manual is illustrated with numerous figures and tables. (YLB)

PLUMBING

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Province of British Columbia

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in cooperation with the Ministry of Labour

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Introduction

A **Manual of Instruction for the Plumbing Trade** is a revised edition of a manual of the same title published in 1977 by the Canadian Forces School of Military Engineering, Chilliwack, B.C. and the British Columbia Ministry of Labor.

The original manual was prepared by Mr. Leonard F. Stanbrook while he was employed as a vocational instructor by the Department of National Defence and the British Columbia Ministry of Education. It has gained widespread acceptance throughout Canada as an instructional model and an on-the-job reference. Mr. Stanbrook also served as technical consultant, other than on metric conversion, during the production of this revised edition.

The manual provides, in a composite format, the basic trade knowledge and product data required by the student and the graduate plumber, much of which otherwise would be obtainable only from individual source materials such as vocational-school handouts and industry print matter. This convenient format does not, however, obviate the need for familiarizing oneself with the specifics of manufacture and the recommended applications of a particular company's products. Therefore, trade catalogues should be kept at hand because they are not only promotional literature, but also valuable guideposts to craftsmanship.

No attempt has been made to include data from plumbing codes, Workers' Compensation Board and Fire Marshals' regulations, or detailed requirements of other regulatory agencies and standards associations, because such documents are periodically revised and therefore would soon outdate the permanence of a manual of this kind. Thus the student and the working plumber must keep abreast of current regulations.

The primary difference between this edition and the 1977 version is the conversion of imperial weights and measures to the SI metric system. It is important, however, that students and instructors give careful attention to the following page titled Metric Conversion before using the manual.

Since this manual has been designed as an instructional aid, the presentation of contents follows what is considered to be the most logical instructional sequence. However, because plumbing is a vast and complex subject with many interrelated aspects, instructors will doubtlessly find it necessary to draw connections between topics covered in widely separated locations. Certainly readers should keep in mind that this manual is not a self-contained explanatory guide to be read independently, but rather a complementary tool for the classroom instructor.

Most of the textual and pictorial content of this manual has been adapted from product literature supplied by the manufacture,s, and distributors listed in the Sources of Data appendix. The portrayal of tradename products should not, however, be construed as an endorsement by the Government of British Columbia of these particular lines to the disfavor of competitive products.

7

Metric Conversion

Weights and measures in this manual are generally expressed in SI metric terminology and symbolism in accordance with Canada's adoption of the International System of Units.

It should be recognized, however, that at this early stage of nation-wide conversion full uniformity in metric usage has yet to be attained. This is especially apparent in the plumbing trade, particularly concerning the standardization of metric usage in the sizing of certain pipes and fittings. Therefore, in the interests of ready clarification and the avoidance of misdirection, in certain instances metric symbols in this manual are given together with their imperial equivalents.

Students and instructors should also bear in mind the following observations when referring to manufacturers' catalogues:

1. At the time of publication of this manual, most Canadian plumbing catalogues still carried imperial weights and measures. Moreover, some companies had indicated that it would be a year or longer before it would be practicable for them to implement the metric system and revise their catalogues.

2. Companies that have converted their catalogues are not always typographically consistent in their use of SI metric style for the same types of products. (The conversions in this manual comply with official Canadian practice in so far as uniformity in style was determinable at the date of publication.)

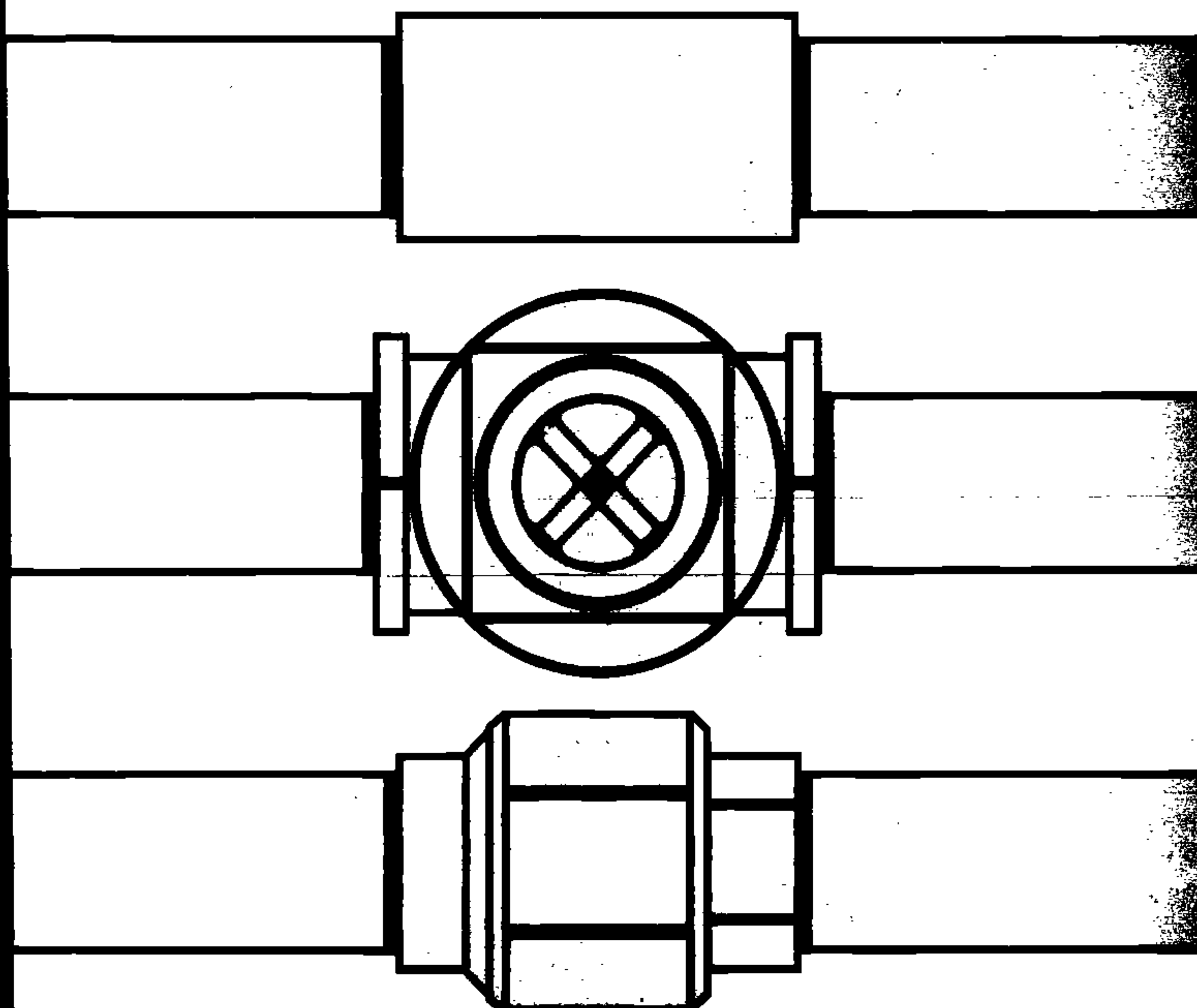
3. Most catalogues of American manufacturers of plumbing products carry imperial weights and measures, since the United States has not yet officially adopted the metric system.

The metrication of this manual therefore reflects the most up-to-date Canadian usage guidelines available to the B.C. Metric Conversion Office when the manual was being prepared. A glossary of metric symbols has not been included because training in SI metric language is now a part of the curriculum in Canadian schools and vocational institutes.

Information on the latest Canadian metric standards is obtainable from the Metric Conversion and Standards Information Office, Ministry of Education, Parliament Buildings, Victoria, B.C., V8W 2A1; or from Metric Commission Canada, Box 4000, Ottawa, Ont., K1S 5G8.

Contents

Tools and Equipment Used in the Plumbing Trade 1



PART 1
TOOLS AND EQUIPMENT USED IN THE PLUMBING TRADE

You must be able to correctly identify all pertinent plumbing tools and equipment. You must know the purpose of each tool or piece of equipment and be able to take care of it. Details on the proper use and care of plumbing tools and equipment appear in the appropriate parts of the manual.

TOOLS AND EQUIPMENT FOR STEEL PIPE AND FITTINGS

1. Pipe Wrenches

a) A typical pipe wrench is shown in Figure 1-1.

Figure 1-1. Typical Pipe Wrench

b) Pipe wrenches are adjustable and have two jaws that are not parallel. The outer jaw, which is adjustable, has a small amount of play to provide a tight grip on the pipe as the wrench handle is moved toward the movable jaw.

c) The jaws of a pipe wrench leave marks on the pipe and should never be used on anything but a round object (*but not on finishing material*) unless the corners of the object have been rounded so that it cannot be turned with any other type of wrench.

d) The wrench, and particularly its teeth, must be kept clean. Oil on the handle and worn teeth can cause minor injuries, such as skinned and bruised knuckles.

e) Pipe wrenches are made in a variety of styles and of at least two materials (malleable iron and aluminum alloy). They have steel jaws and an adjusting nut.

f) Some lengths of pipe wrenches and their respective pipe capacities are shown in Table 1-1. Pipe capacity is given to show how wide the jaws will open, not to indicate the length of wrench to use with that particular NPS (Nominal Pipe Size):

Table 1-1. Wrench Lengths and Pipe Capacities

Wrench Size	Pipe Capacity	
150 mm (6")	NPS ¾	OD 27 mm
200 mm (8")	NPS 1	OD 33 mm
250 mm (10")	NPS 1½	OD 48 mm
300 mm (12")	NPS 2	OD 60 mm
350 mm (14")	NPS 2	OD 60 mm
450 mm (18")	NPS 2½	OD 73 mm
600 mm (24")	NPS 3	OD 89 mm
900 mm (36")	NPS 5	OD 141 mm
1200 mm (48")	NPS 6	OD 168 mm
1500 mm (60")	NPS 8	OD 219 mm

g) Following are some styles of pipe wrenches.

Figure 1-2. Straight Pipe Wrench

The straight pipe wrench comes in the sizes shown in paragraph f) above, and is possibly the most widely used pipe wrench.

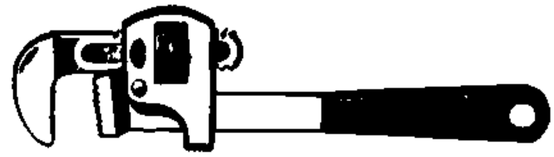


Figure 1-3. Stillson-Type Pipe Wrench

The Stillson-type pipe wrench is available in at least seven lengths from 200 to 1200 mm.

Figure 1-4. End Pipe Wrench

The end pipe wrench is available in eight lengths from 150 to 900 mm. It permits a longer handle swing on pipe work close to a wall, or in tight quarters, or on closely spaced parallel lines.

Figure 1-5. Offset Pipe Wrench

The offset pipe wrench is available in at least three lengths: 350, 450, and 600 mm. It is ideal for one-hand use overhead or in tight places.

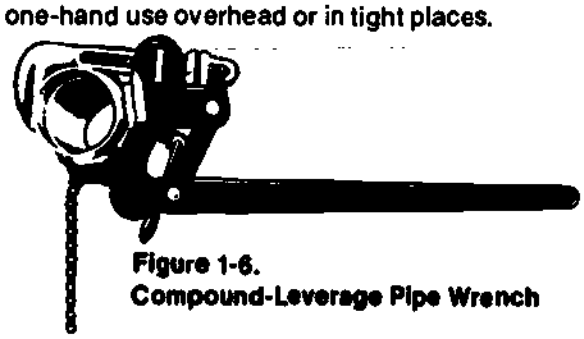


Figure 1-6. Compound-Leverage Pipe Wrench

The compound-leverage pipe wrench is available in four lengths with pipe capacities from NPS 2 to NPS 8. This type lets one person do the work of two. The turning force is multiplied by compound leverage.

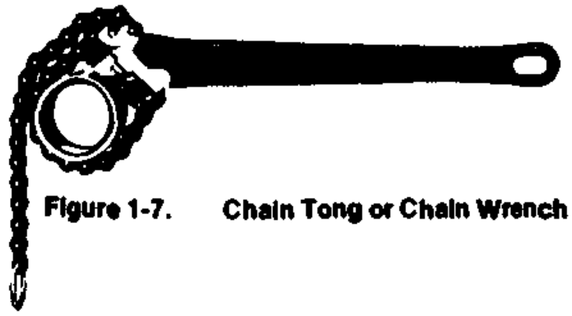


Figure 1-7. Chain Tong or Chain Wrench

h) A typical chain tong, or chain wrench, is shown in Figure 1-7. Chain tongs of this type come in different styles and lengths. Many users prefer this type for holding or turning pipes. It is used only on rough pipe and never on finishing material because, as already stated, the teeth in the jaws leave marks on the pipe.

2. Pipe Vises

a) A pipe vise is designed to hold round metal stock and pipes.

b) Six of the more common types of pipe vises are shown in Figures 1-8 to 1-10. Note that some have a hinge on one side and can be swung open; the pipe can then be positioned and the top part of the vise brought down and locked. The other type shown (Figure 1-9) has a chain that can be put over the top of the pipe and then tightened.

c) Note that some types of vises must be fixed to a bench, while others are portable. (Figures 1-8 to 1-10.)

Figure 1-8. Bench Vise

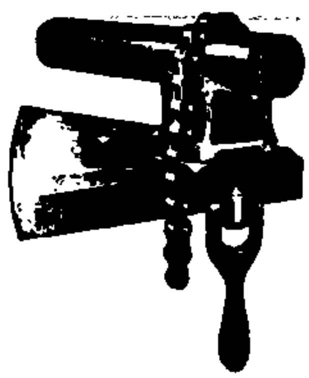


Figure 1-9. Chain Tong Bench Vise

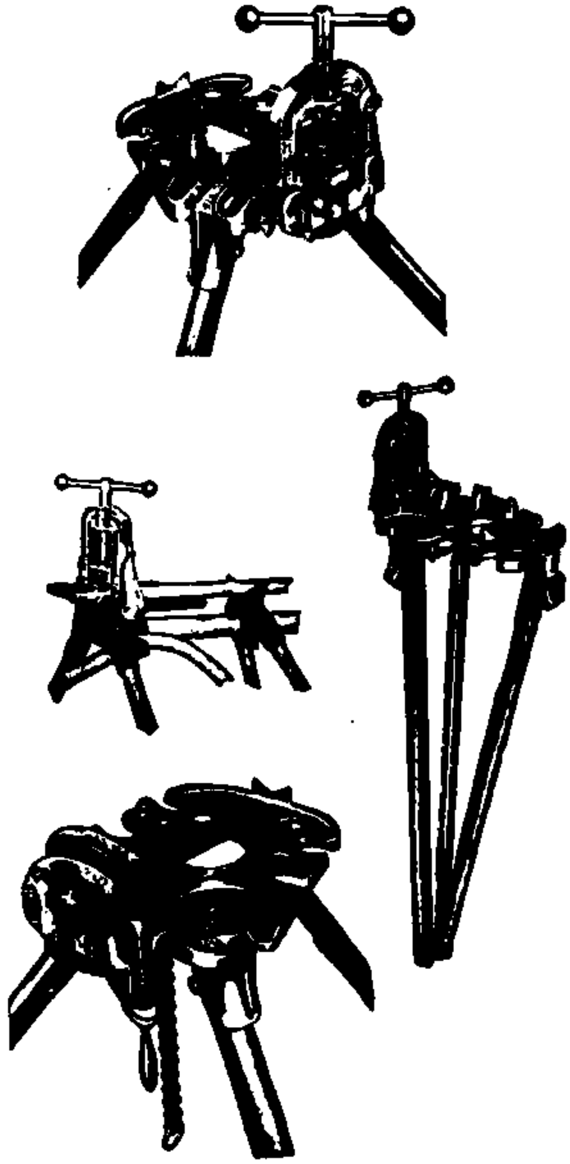


Figure 1-10. Portable Vises

3. Pipe Cutters (Wheel Type)

a) The following descriptions pertain to pipe cutters that may be used to cut mild steel, brass, and copper pipe. These should not be confused with other types of pipe and tubing cutters used to cut plastic pipe and tubing.

b) Modern pipe cutters generally have either two rollers and one cutting wheel or no rollers and four cutting wheels (Figures 1-11 to 1-15).

A cutter with two rollers and one cutting wheel (Figure 1-11) is available in several sizes for pipe up to NPS 2. One of the most popular cutters is for NPS ⅛ to NPS 2 pipe.

Figure 1-11. Cutter with Two Rollers and One Cutting Wheel

The cutter shown in Figure 1-12 is similar to the one shown in Figure 1-11 but heavier for cutting pipe up to NPS 6. In some cases, three sets of cutters of this type are needed to cut pipes from NPS 1 to NPS 6, each cutter being progressively larger than the other.

Figure 1-12. Two-Roller, Single Cutting Wheel—Heavy Duty

A cutter with four cutting wheels is designed for areas where a complete turn of the handle is impossible (Figure 1-12). At least one company manufactures it for cutting NPS ½ to NSP 2 pipe.

Figure 1-13. Cutter with Four Cutting Wheels

The cutter shown in Figure 1-14 is similar to that shown in Figure 1-13 except that it is heavier for cutting NPS 2½ to NPS 4 pipe.

Figure 1-14. Heavy-Duty Cutter with Four Cutting Wheels

c) The three-wheel cutter was popular in earlier years, and no doubt many are still in use.

d) Cutters require periodic wheel replacement, and in some cases the rollers have to be replaced. A descriptive example from a manufacturer's parts book is shown in Figure 1-15.

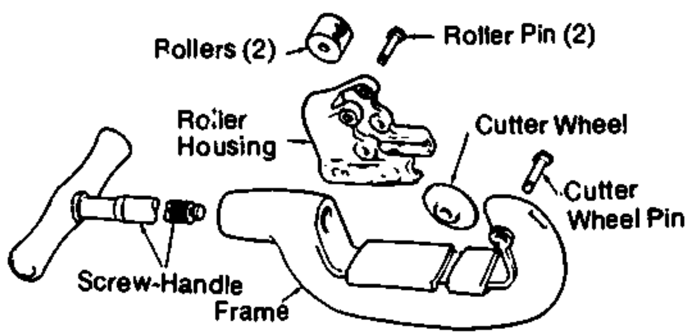


Figure 1-15. Parts of a Typical Pipe Cutter

e) Pipe cutters require little maintenance other than keeping them clean and periodically applying a few drops of oil to the rollers, the cutting wheel, and the thread on the handle.

f) Pipe cutters should not be left on the ground when not in use to avoid getting foreign matter on the moving parts, which could result in unnecessary wear of the components.

4. Pipe Reamers

a) As the pipe is cut, the cutting wheel presses down as it is turned around the pipe and this causes a bulge on the inside wall of the pipe. As the wheel cuts through this bulge it leaves a burr on the inside of the pipe that must be removed since it would restrict the water flow in the pipe and also cause blockage in a drain pipe. The reamer is designed solely to remove this burr.

b) The two basic hand reamers are shown in Figures 1-16 and 1-17.

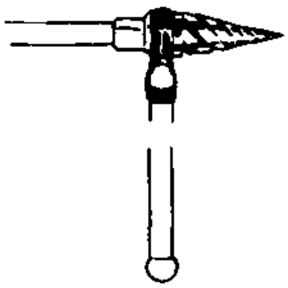


Figure 1-16. Spiral-Flute Reamer

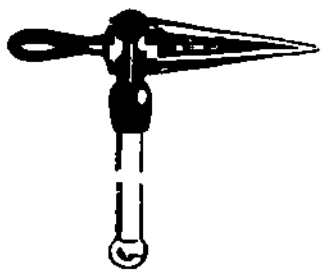


Figure 1-17. Straight-Flute Reamer

c) The hand reamer generally found in a plumber's tool box resembles one of the above and reams pipe from NPS ⅛ to NPS 2.

d) Both the spiral-flute and straight-flute reamers have ratchet handles, and require little maintenance except for keeping the reamers clean and periodically applying a few drops of oil to the ratchet.

5. Pipe Threaders (Stocks and Dies)

a) As a rule, steel pipe and fittings are joined by means of threads. Welding on galvanized pipe is prohibited by the plumbing code because when the necessary heat is applied to the pipe the galvanized (zinc) coating on the inside and outside surfaces is burned off.

b) There are many different makes and types of hand and power threaders for cutting threads on standard-size pipes.

c) A few of the modern types of hand pipe threaders (stocks and dies) are shown in Figures 1-18 to 1-20.

A drop-head threader (Figure 1-18) is used for cutting threads on NPS ⅛ to NPS 2 pipe, or similar threaders for NPS ⅛ to NPS 1 pipe. Die heads must be changed for different pipe sizes.

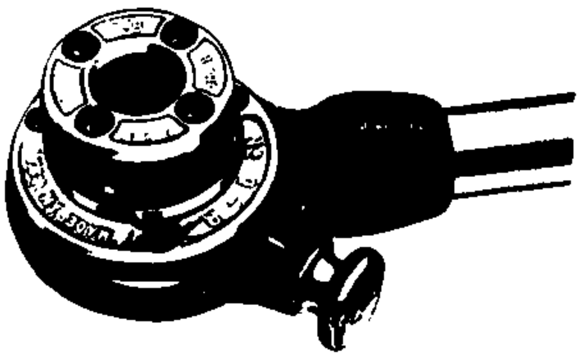


Figure 1-18. Drop-Head Threader

A jam-proof ratchet threader is used for cutting threads on NPS 1 to NPS 2 pipe. One set of dies threads all sizes of pipe.

Figure 1-19. Jam-Proof Ratchet Threader

The geared pipe threader (Figure 1-20) cuts threads on NPS 2½ to NPS 4 pipe, or larger models for NPS 4 to NPS 6 pipe. One set of dies threads four different-size pipes.

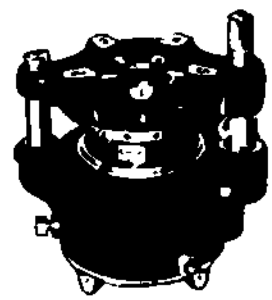


Figure 1-20. Geared Pipe Threader

NOTE: A universal drive shaft or drive bar, both of which are shown in Figures 1-21 and 1-22 respectively, may be used with a power threader or vise to operate the geared pipe threader.

Figure 1-21. Universal Drive Shaft

Figure 1-22. Drive Bar

6. Pipe Threads

a) The type of thread that plumbers cut on steel pipe is referred to as the National Pipe Thread, or NPT. It is also referred to on drawings as IPS (Iron Pipe Size), which means that it is a National Pipe Thread of a specified size.

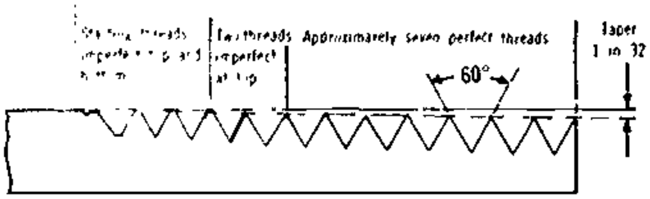


Figure 1-23. National Pipe Thread (NPT)

b) Figure 1-23 shows a typical NPT.

Starting Thread, Imperfect Top and Bottom

Two Threads, Imperfect at Top

Approximately Seven Perfect Threads

Taper 1 in 32

c) The National Pipe Thread is V-shaped with an angle of 60° and slightly rounded at the top. It has a taper of 1 in 32 of thread to provide a watertight joint.

d) A rule of thumb for checking a thread on the smaller-diameter pipes is that the pipe should turn three or four times by hand into a fitting and a further three or four times with a wrench.

e) Table 1-2 shows pipe size and number of threads per 25.4 mm for a National Pipe Thread for each size of pipe. Note that in some cases pipes of different sizes have the same number of threads per 25.4 mm. If there is an adjustment on the pipe threader that permits the dies to be opened wider and again closed, you can understand how, for instance, one set of dies would thread both NPS ¼ and NPS ⅜ pipe; one set of dies would thread both NPS ½ and NPS ¾ pipe; and one set of dies would thread NPS 1, 1¼, 1½, and 2 pipe; and one set of dies could thread all the pipes from NPS 2½ to NPS 12 pipe, although this would not be practical.

Table 1-2. Pipe Sizes and Number of Threads per 25.4 mm

NPS	Threads per 25.4 mm
⅛	27
¼, ⅜	18
½, ¾	14
1 to 2	11½
2½ to 12	8

7. Care of Pipe Threaders (Stocks and Dies)

a) When tools come in from a job, each one should be checked and tested to make sure it will function correctly on the next job.

b) Good stocks and dies produce good threads, but when the dies are worn and chipped they will produce bad threads.

c) Pipe threaders should be kept clean and free from pipe cuttings and foreign matter such as dirt, and a light coat of oil should be applied to the moving parts.

d) Cleaning a tool with a solvent will cause it to become dry; therefore, lubricate all moving parts after cleaning.

8. Hand-Operated Oilers

a) Figures 1-24 to 1-27 show four types of hand-operated oilers.

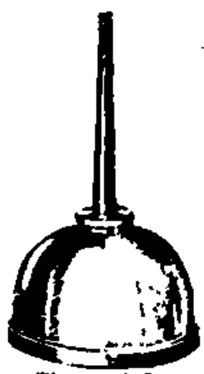


Figure 1-24. Low-Cost Oil Can

Figure 1-25. Pump-Type Oil Can

Figure 1-26. Hand-Operated Continuous Oiler Pump

Figure 1-27. Hand-Operated Continuous Oiler Pump

b) Hand-operated oilers need very little maintenance, but the type of oil used in them is very important when cutting threads on different materials.

c) A good thread-cutting oil must cool and speed removal of the metal, produce a smooth finish, and prevent chips from welding to the dies. Since no oil in its pure state will perform these functions, oils for thread cutting are a formulated blend and often contain sulphur and lard oil, and in some cases an anti-foam agent. *Thread-cutting oils should not be used as a lubricant for other parts of tools.*

9. Steel Tapes

a) Always carry a steel tape in your pocket. Two such tapes are shown in Figures 1-28 and 1-29.

b) Steel tapes should be kept clean and given a very light coat of oil.

Figure 1-28. Clip-on Tape Measure

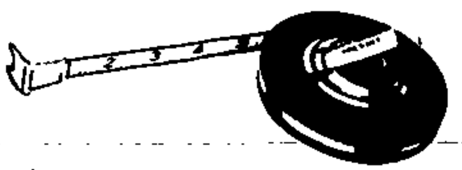


Figure 1-29. Long Tape Measure

10. Paint Brush

Use a small paint brush to apply pipe-joint compound to the thread before inserting it into the fitting. Keep the brush clean.

OTHER TOOLS COMMON TO THE TRADE

11. Special Wrenches and Hacksaws

The spud wrench (Figure 1-30) is similar to the former monkey wrench for use on flat surfaces, such as packing nuts on valves.

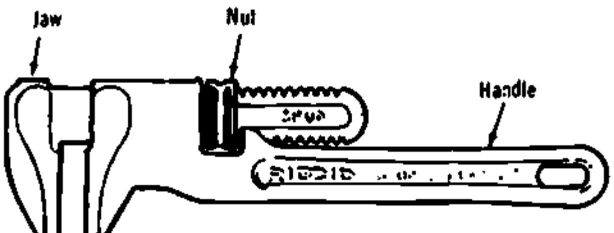


Figure 1-30. Spud Wrench

A straight hex wrench is available in at least nine lengths and fits nuts from NPS $\frac{3}{8}$ to 2 (Figure 1-31).

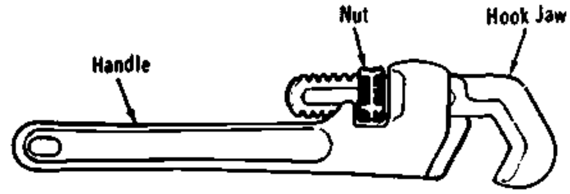


Figure 1-31. Straight Hex Wrench

An end hex wrench is available in the same lengths as those of the straight hex wrench (Figure 1-32).

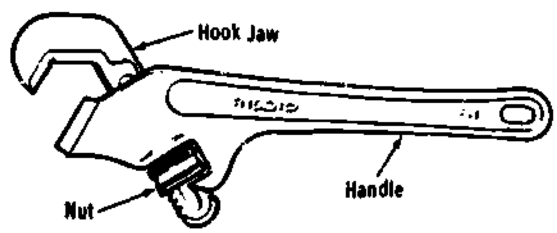


Figure 1-32. End Hex Wrench

The offset hex wrench has a capacity for up to NPS 1½ drain nuts (Figure 1-33).

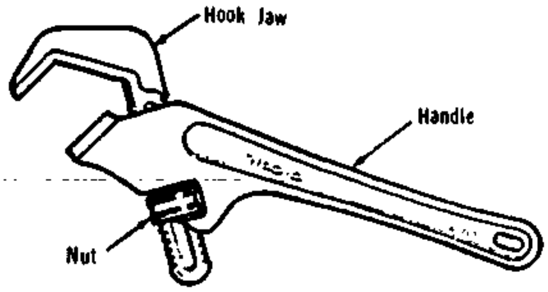


Figure 1-33. Offset Hex Wrench

The open-end adjustable wrench shown in Figure 1-34 is available in lengths from 100 mm to 600 mm.

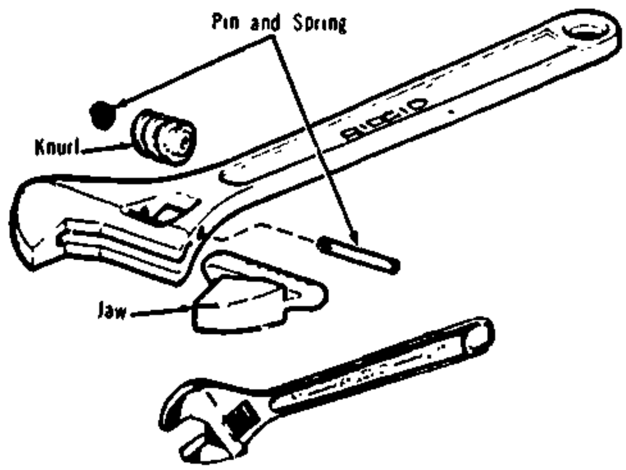


Figure 1-34. Open-End Adjustable Wrench

The hacksaw is used for cutting most ferrous and non-ferrous metals and plastic (Figure 1-35).

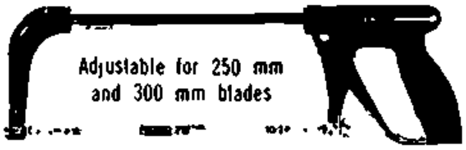


Figure 1-35. Hacksaw

12. Pliers

A few of the many different types of pliers are shown in Figures 1-36 to 1-49. Select the correct pair for the job. They should be kept clean and replaced when worn or damaged:

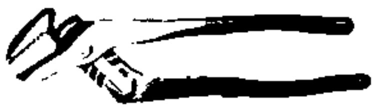


Figure 1-36. Tongue-and-Groove Pliers

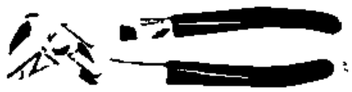


Figure 1-37. Water-Pump Pliers

Figure 1-38. Lineman's Side-Cutting Pliers

Figure 1-39. High-Leverage Lineman's Pliers

Figure 1-40. Long-Chain Nose Pliers with Cutter

Figure 1-41. Long-Reach Duckbill Pliers

Figure 1-42. Long Needle-Nose Pliers

Figure 1-43. End-Cutting Nippers

Figure 1-44. Round-Nose Looping Pliers

Figure 1-45. Diagonal-Cutting Pliers

Figure 1-46. High-Leverage Diagonal-Cutting Pliers

Figure 1-47. Slip-Joint Utility Pliers

Figure 1-48. Vise-Grip

Figure 1-49. Vise-Grip with Wire Cutters

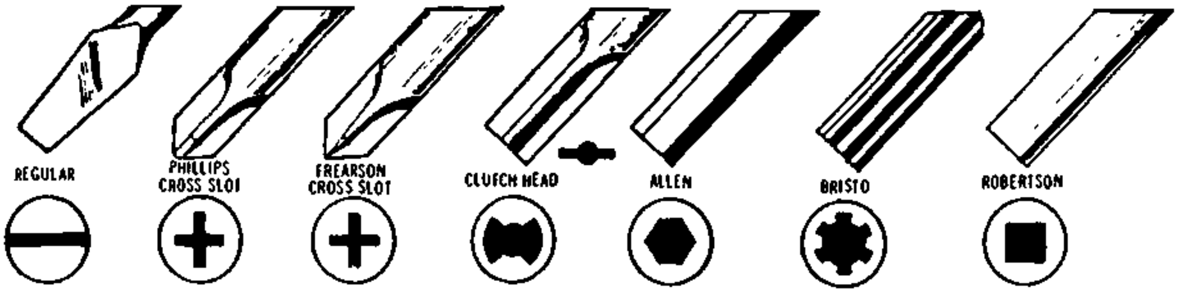


Figure 1-50. Ends on Screwdrivers

13. Screwdrivers, Including Allen Wrenches

a) Screwdrivers are available in many lengths, widths and types of blades, and handle materials.

b) Figure 1-50 shows some of the types of ends on screwdrivers and Allen wrenches. Those most used by plumbers are the regular and the Phillips and Robertson screwdrivers, and the Allen wrenches.

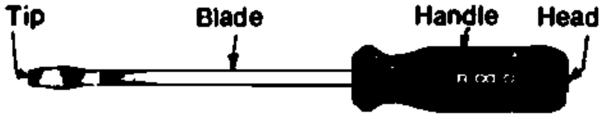


Figure 1-51. Screwdriver Components

c) Figure 1-51 defines the components of a screwdriver:

d) The blade may be round, square, slim, or heavy. It may range from a very short "stubby" (or pocket) screwdriver to one of about 450 mm. The widths of the tips in common use range from 3 mm to 13 mm.

e) The Robertson screwdriver comes in three different sizes; and, starting with the smaller one, the handles are green, red, and black.

f) Two types of offset screwdrivers are shown in Figures 1-52 and 1-53.

Figure 1-52. Phillips Offset Screwdriver

Figure 1-53. Regular Offset Screwdriver

g) Figure 1-54 shows a typical set of Allen, or hexagon, wrenches.

Figure 1-54. Set of Allen Wrenches

Power Threading Machines and Power Vises

a) Power threading machines not only cut, ream, and thread all sizes of pipes but also, with the proper dies, thread bolts and cut bolt threads on large and small round iron stock.

b) These machines come in various sizes and are portable and non-portable. One type is shown in Figure 1-55.

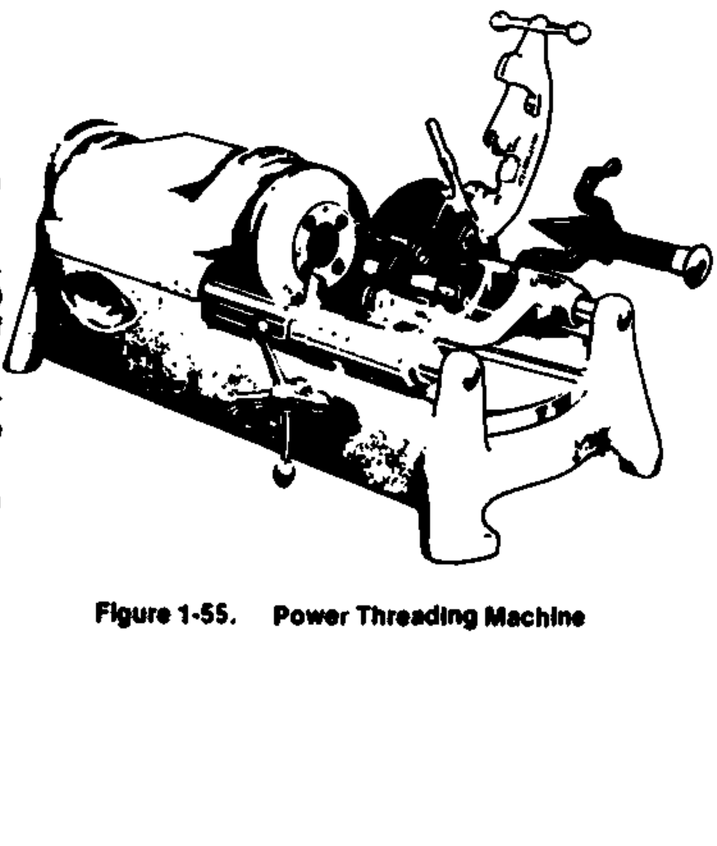


Figure 1-55. Power Threading Machine

c) A few of the power vises or drives are shown in Figures 1-56 and 1-57.

d) There is only one way to correctly operate and maintain power threading machines and power vises and drives, and that is *according to the manufacturer's instruc'ions.*

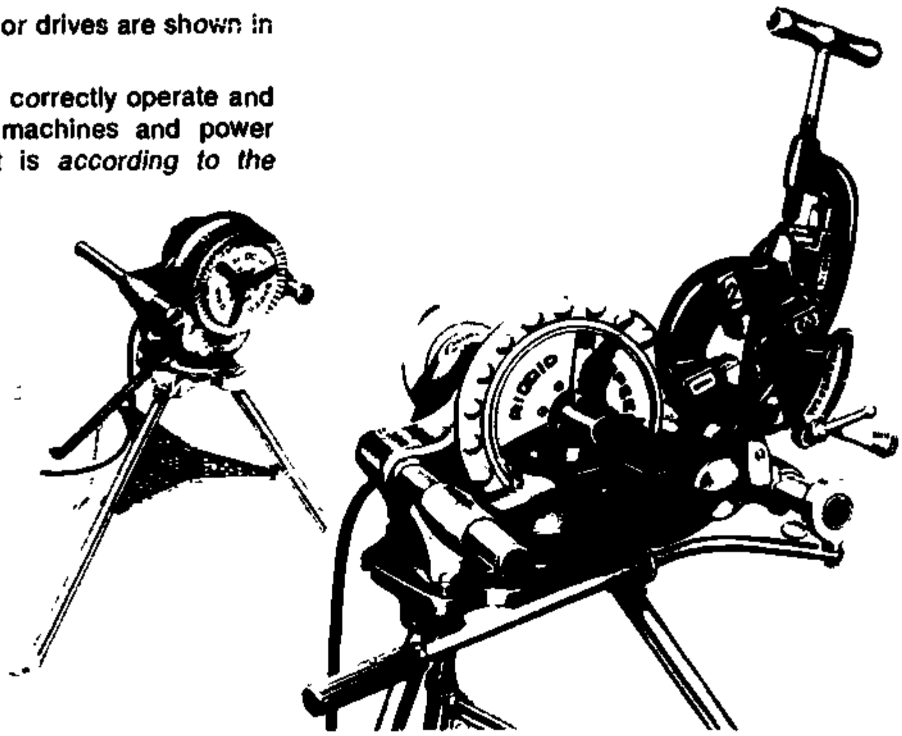


Figure 1-56. Portable Power Vises

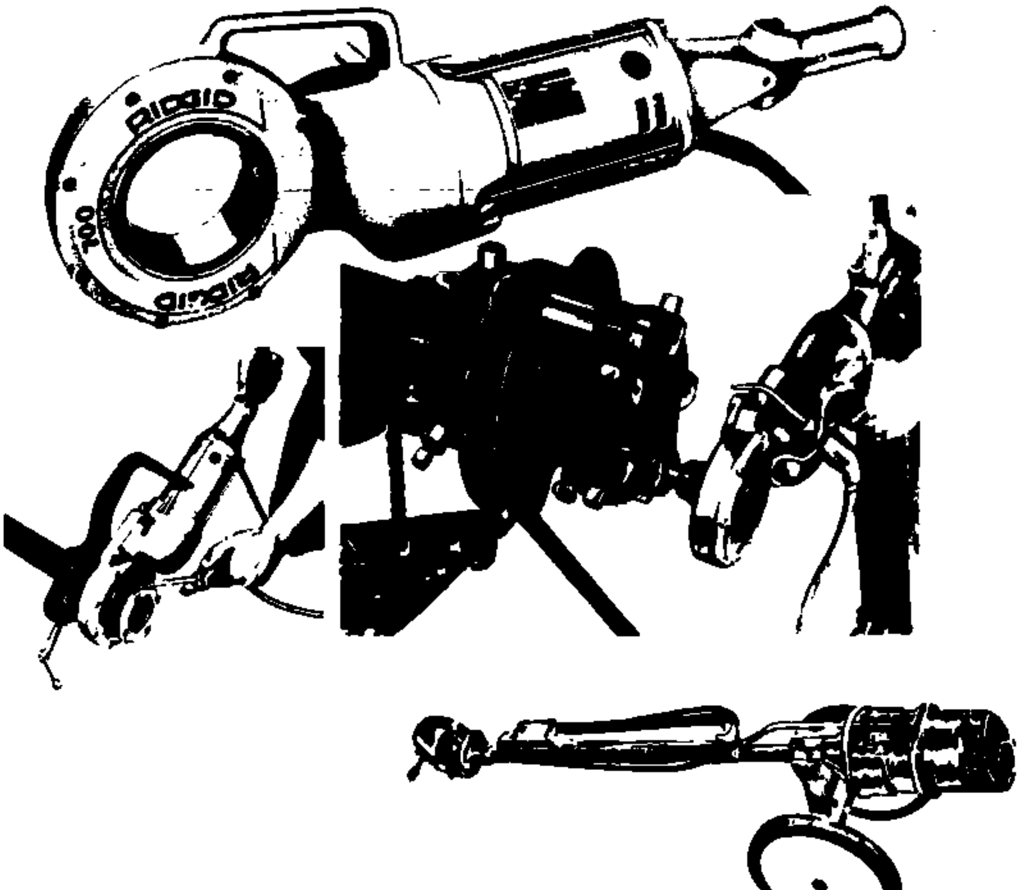
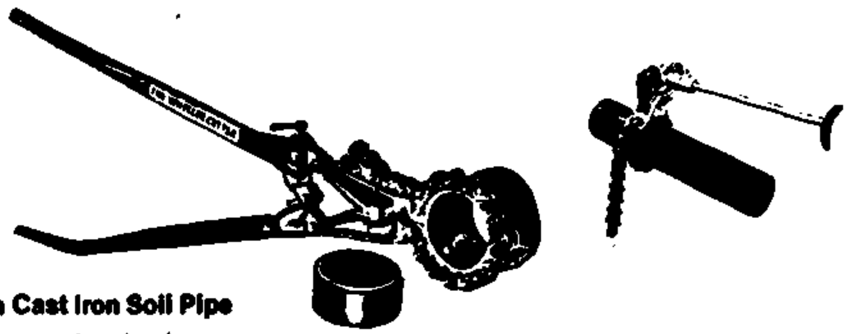


Figure 1-57. Portable Power Vises or Drives



Tools and Equipment Used with Cast Iron Soil Pipe

In addition to some of the tools previously shown, others are described and shown in Figures 1-58 and 1-60 for working with cast iron soil pipe.

14. Pipe Cutters (Snap Type)

a) In the past, cast iron soil pipe was generally cut with a cold chisel and a hammer, but owing to a change in the method of manufacturing the pipe, this means can no longer be used.

b) Snap-type cutters similar to those shown in Figure 1-58 are used to cut cast iron soil pipe, vitrified clay pipe, concrete pipe, and asbestos cement pipe.

c) A problem with snap-type cutters is that they are often left on the ground and collect sand or other foreign matter that is not often removed. This results in wear on the parts. The only maintenance needed is to keep the cutter clean and periodically apply a few drops of oil to the moving parts.

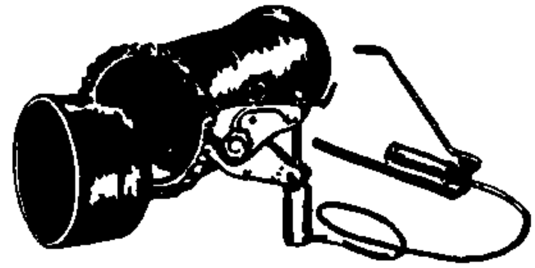


Figure 1-58. Three Types of Snap Cutters

15. Torque Wrenches for Clamps on M.J. (Hubless) Pipe

Two different types of torque wrenches are shown in Figures 1-59 and 1-60. One is for tightening bolts on stainless steel clamps; the other is for tightening bolts on certain types of cast iron clamps. The only maintenance needed is that they be kept clean and a few drops of oil applied periodically to the ratchets.

The torque wrench for stainless steel couplings applies about 6 N.m torque (Figure 1-59).

A torque wrench for cast iron couplings applies about 20 N.m torque (Figure 1-60).

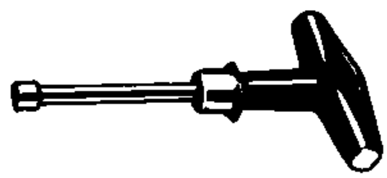


Figure 1-59. Torque Wrench for Stainless Steel Couplings

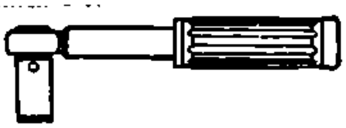


Figure 1-60. Torque Wrench for Cast Iron Couplings

16. Assembly Tool for Compression-Joint Cast Iron Soil Pipe

A tool similar to the one shown in Figure 1-61 is required when assembling or dismantling cast iron soil pipe and fittings with compression joints. Maintenance must be according to the manufacturer's instructions.

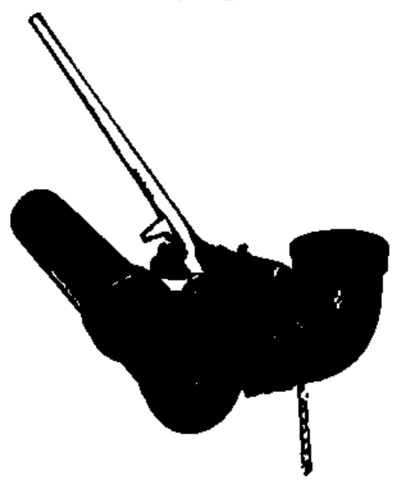


Figure 1-61. Assembly Tool for Compression-Joint Pipe

17. Lead Caulk Joint

This type of joint is rarely used today except on maintenance and repair work on earlier installations of cast iron soil pipe.

TOOLS AND EQUIPMENT USED WITH COPPER TUBING

18. Tubing Cutters

a) There are many makes of copper tubing cutters, but they are similar in design and operation.

b) Three sets of copper tubing cutters are needed to cut pipe from NPS ¼ (OD 10.3 mm) to NPS 4 (OD 114 mm) — that is, one set for NPS ¼ (OD 10.3 mm) to NPS 1 (OD 33 mm); one set for NPS 1 (OD 33 mm) to NPS 2 (OD 60 mm); and one set for NPS 2½ (OD 73 mm) to NPS 4 (OD 114 mm).

c) Reamers are combined with many types of tubing cutters and many of these cutters have a slide-action adjustment that saves time because the cutter wheel can be pushed against the tubing rather than being tightened solely by turning the handle.

d) Four types of tubing cutters are shown in Figure 1-62.

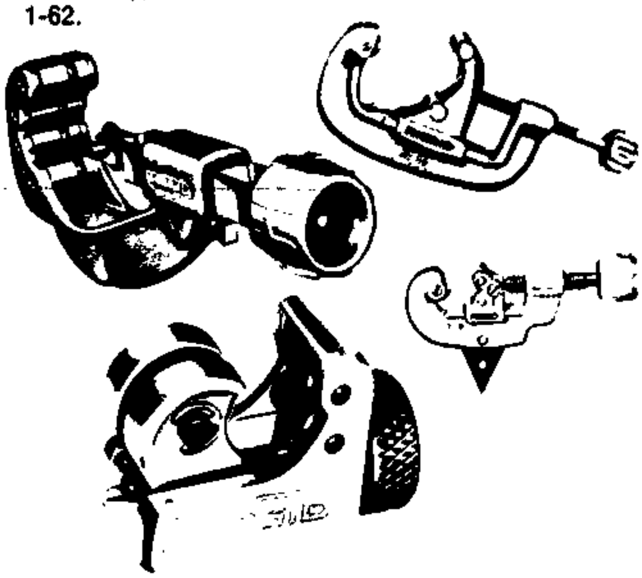


Figure 1-62. Tubing Cutters

e) Tubing cutters need very little maintenance if kept clean and a few drops of oil are periodically applied to the moving parts. These cutters should be used only for the purpose for which they are made.

f) The cutting wheels will last a long time if properly used, and can readily be replaced when needed.

g) Some manufacturers make various types of cutting wheels for use on different materials. For example, different cutting wheels are available for copper tubing, aluminum tubing, and certain types of rigid and flexible plastic pipes. The proper cutting wheel should always be installed before cutting any of these materials.

19. Tubing Benders

a) There are several makes and types of tubing benders, but most of them operate in a similar manner.

b) Three of the more common types are shown in Figures 1-63 to 1-65: the lever, geared-ratchet, and outside-spring types.

These are often used to bend tubing up to NPS ¾.

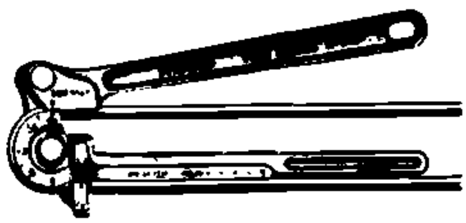


Figure 1-63. Lever Type of Tubing Bender

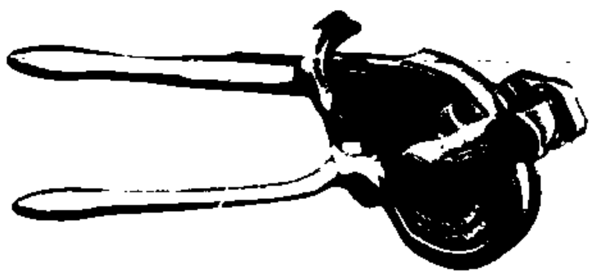


Figure 1-64. Geared-Ratchet Type of Tubing Bender

Figure 1-65. Outside-Spring Type of Tubing Bender

c) The manufacturer's instructions should be followed in both the use and care of a tubing bender.

20. Flaring Tool

a) This tool puts a flare on the end of a piece of tubing so that a tight joint will result when a flare nut tightens the flare against the face of an external flare fitting.

b) Two typical models are shown in Figures 1-66.

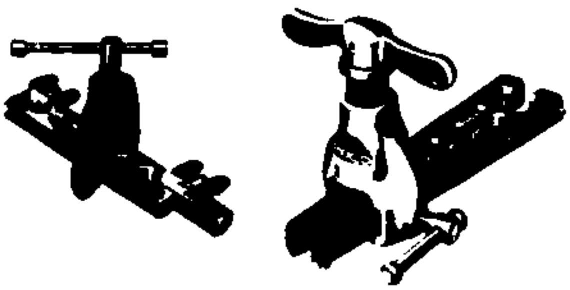


Figure 1-66. Two Types of Flaring Tools

c) Another type in general use is the hammer-type flaring tool shown in Figure 1-67. It puts flares on copper tubing up to NPS 2.

Figure 1-67. Hammer-Type Flaring Tool

d) Flaring tools need little care, but they should be kept clean and given a few drops of oil on the moving parts. They should not be left around where they could be damaged.

21. Sizing Tool

a) The sizing tool (Figure 1-68) can be used to resize copper tubing ends that have become deformed. It is used on NPS ½ to NPS 1 tubing.

Figure 1-68. Sizing Tool

22. Tools and Equipment for Cleaning Copper Tubing

a) When making solder joints, the copper must be very clean. Use sand cloth, steel wool, a wire brush, or any product made for this purpose.

b) Figures 1-69 to 1-71 show some of the tools and equipment for cleaning copper tubing and fittings.

Figure 1-69 shows a hand cleaner for NPS ½ and NPS ¾ copper tubing. It is made of washable rubber impregnated with abrasive material.

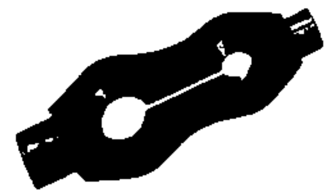


Figure 1-69. Copper Tubing Cleaning Tool

The machine shown in Figure 1-70 brushes, reams, faces, and de-burrs tubing and fittings from NPS ½ to NPS 6. This type is normally used on large jobs or prefabrication setups.

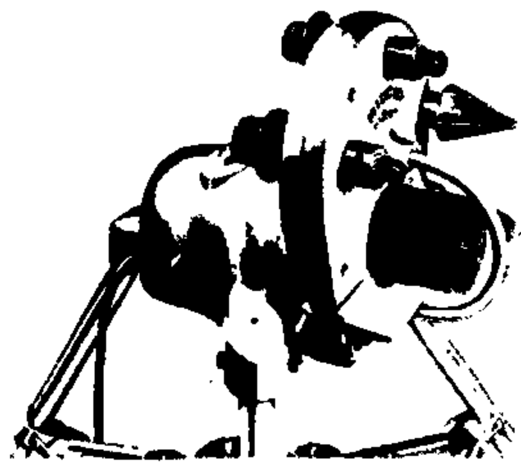


Figure 1-70. Portable Electric Cleaning Machine

c) Use a small wire brush to clean the inside of the smaller-size copper solder joint fittings. Wire brushes of the type shown in Figure 1-71 are available for cleaning fittings up to at least NPS 1. Various types of handles are attached to the end of the wire to simplify turning.

d) Files are also used to remove burrs from the end of tubing. (See file details later in this part of the manual.)

Figure 1-71. Wire Bristle Brush

23. Torches

Types of torches for making solder joints on copper tubing are described in Part 3.

TOOLS AND EQUIPMENT FOR MAKING JOINTS ON PLASTIC ABS AND PVC SOLVENT-WELD TYPES OF PIPE AND FITTINGS

24. Pipe Cutters

a) Cutters similar to those for copper tubing may be used to cut ABS and PVC (DWV) pipe provided that the correct cutting wheel is inserted.

b) Handsaws and hacksaws are also used to cut this type of pipe, but they should be used with a mitre box to ensure that the pipe is cut squarely.

25. Paint Brushes

a) For ABS pipe joints, use a non-synthetic bristle brush.

b) For PVC pipe joints, the brush may be of natural or nylon bristle.

c) Brushes should be cleaned with thinners when not immediately required.

d) The recommended sizes of brushes are 13 mm for pipes of NPS ½ or less; 25 mm for pipes to NPS 2; and at least half the pipe size for pipes larger than NPS 2; but the brush widths need not be larger than 50 mm.

26. Additional Tools

A pocket knife or file can be used to remove burrs from pipe ends.

TOOLS AND EQUIPMENT FOR MAKING JOINTS ON ASBESTOS CEMENT PIPE AND FITTINGS

27. Pipe Cutters

a) Snap-type cutters such as those used to cut cast iron soil pipe may be used to cut asbestos cement pipe.

b) Figures 1-72 and 1-73 show two types of cutters made for this purpose. These have carbide-tipped cutting blades and do not leave rough or snapped ends.

NOTE: Other sizes in similar pipe cutters are available.

c) Asbestos cement pipe may also be cut with a crosscut handsaw and a mitre box, but use this method only when the correct pipe cutters are unavailable.

d) Cutters should be kept clean and the moving parts lightly oiled.

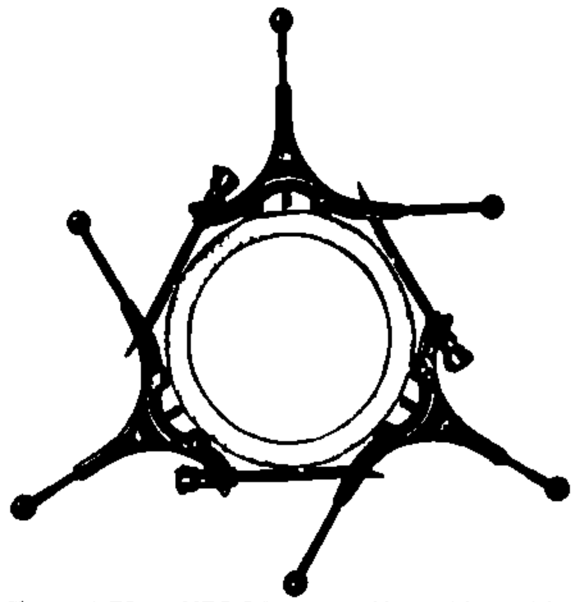


Figure 1-72. NPS 250 mm to NPS 400 mm Pipe Cutter

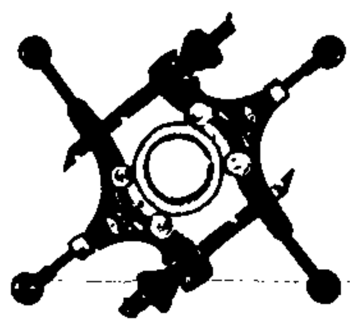


Figure 1-73. NPS 50 mm to NPS 150 mm Pipe Cutter

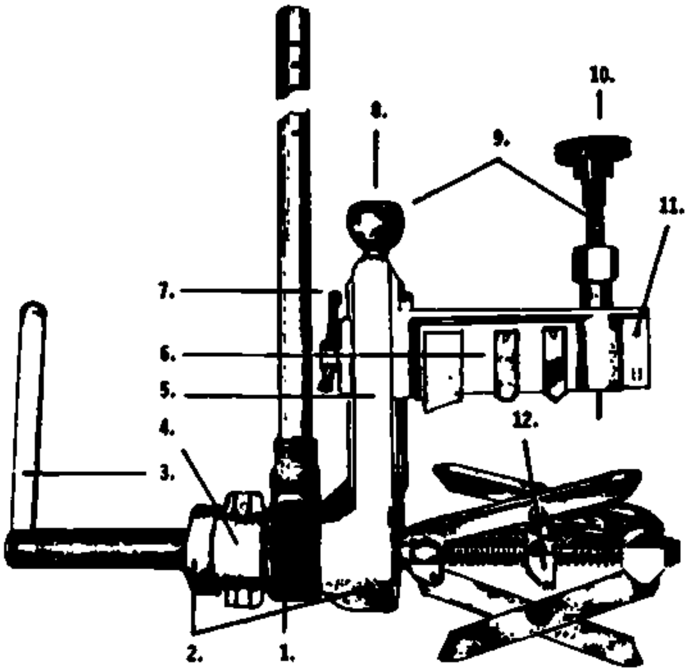


Figure 1-74. Field Lathe

28. Field Lathes

a) There are several different styles of field lathes for trimming and machining pipe ends.

b) The field lathe shown in Figure 1-74 trims and machines the ends of pipe from NPS 3 to NPS 8.

1. Ratchet
2. Sealed ball bearings
3. Integral arbor handle
4. Quick-action lead screw nut
5. Scale
6. Single-arm-holding cutting tools
7. Spring-loaded tool-holder clamp
8. Micromatic adjusting screw
9. Rigid frame permits complete machining in a single pass
10. Retractable trim tool
11. Advance tool can be moved to this position
12. Cam-action arbor

c) A power drive used with the above lathe is a practical investment for major installations or when the shop is doing a large volume of work with asbestos cement pipe.

d) Figure 1-75 shows a larger type of field lathe that will machine ends of asbestos cement pipe from 100 mm to 350 mm. It is also available with an electric power drive.

e) Field lathes should be kept clean and accessible moving parts lightly oiled. Damaged or worn parts should be replaced.

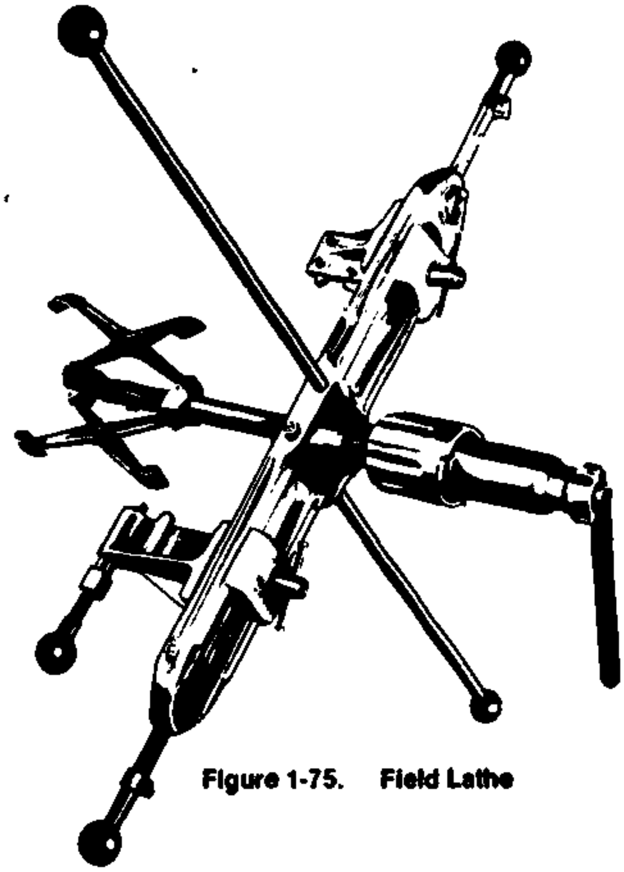


Figure 1-75. Field Lathe

29. Assembly Equipment

a) The lever puller shown in Figure 1-76 is used to pull pipes together. It is chained to installed pipe A, the puller chain is wrapped around length B being installed, and the handle is then pulled forward to pull the pipe into the coupling.

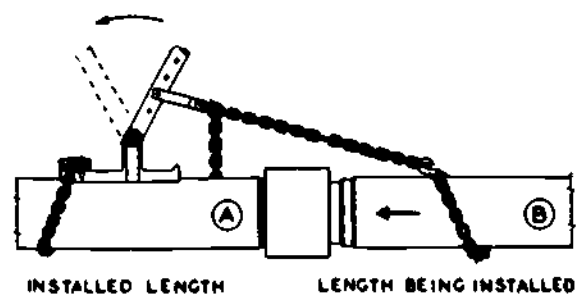


Figure 1-76. Lever Puller

b) The frame puller (Figure 1-77) comprises two frames that clamp the pipe on each side of the coupling. They are joined by two handles on each side that connect to levers. When pressure is applied to the levers, the frame tightens on the pipe, giving a positive pull between the two pipes.

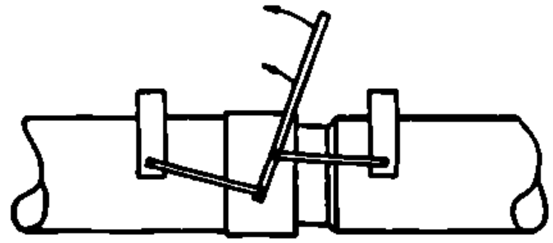


Figure 1-77. Frame Puller

The frames are adjusted to fit the required diameter of the pipe. This puller also may be used to pull fittings or couplings onto a pipe.

c) In pipe sizes under NPS 8, or 200 mm, and when a mechanical puller is not available, the pipe and fittings can be assembled with a bar and block of wood as illustrated in Figure 1-78.

d) On the smaller-size pipes, asse .bly is sometimes done with a block of wood and a hammer.

e) Mechanical pullers should be kept clean and not left around where they can be damaged.

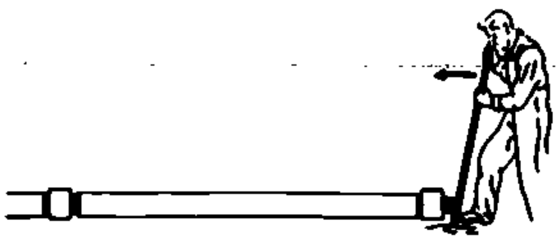


Figure 1-78. Method for Hand Levering

TOOLS AND EQUIPMENT FOR MAKING JOINTS ON VICTAULIC PIPE

30. Victaulic Pipe Groovers

a) Victaulic pipe groovers are available in both manually operated and power-operated types. The lighter models are portable; the heavier ones are more suitable for shop production. Groovers are available for cutting grooves in pipes from NPS ¾ to NPS 24. Shown in Figure 1-79 is one type of Victaulic groover, known as the Individual Vic Groover, which is available for pipes from NPS ¾ to NPS 8 with an adjustable model for NPS 4 to NPS 6 steel pipe.

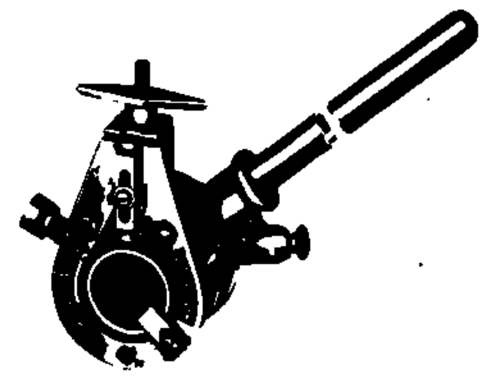


Figure 1-79. Victaulic Pipe Groover

b) Instructions for re-sharpening the grooving knives, and a knife template, are furnished with each Vic Groover tool.

c) The Vic Groover can be used for cutting steel pipe by removing the depth stop.

d) The Vic Groover should be used in accordance with the manufacturer's instructions. (See Part 13 for details of the Victaulic grooved piping method.)

e) A speeder, or ratchet, with socket is the recommended wrench for use on bolts on Victaulic couplings (Figure 1-80).

Figure 1-80. Speeder and Socket with a Victaulic Coupling

MISCELLANEOUS TOOLS AND EQUIPMENT

31. Files

a) Files are used for cutting, smoothing, or removing small amounts of metal. They are made in various lengths, shapes, cuts, and spacings of teeth, as shown in Figure 1-81.

b) A file has five parts: the point; the edges; the face, or cutting teeth; the heel, or shoulder; and the tang. (See Figure 1-82.)

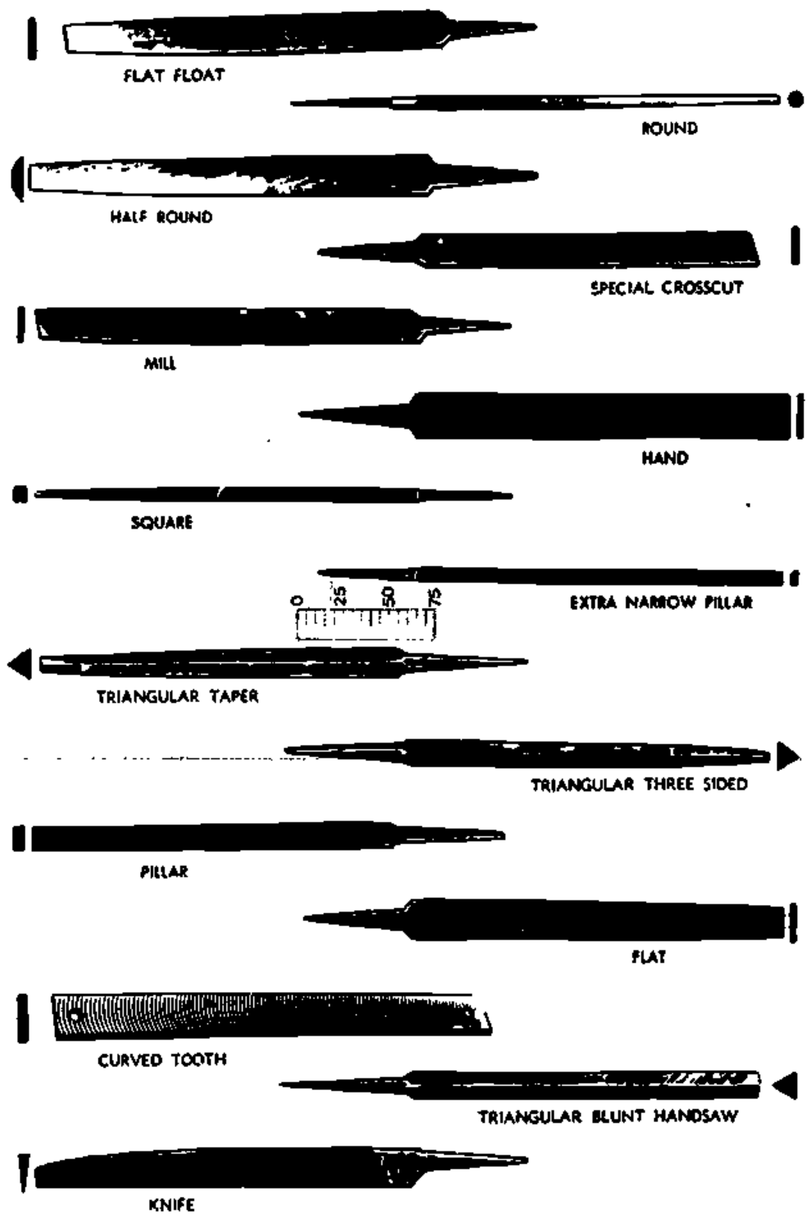


Figure 1-81. Types of Steel Files

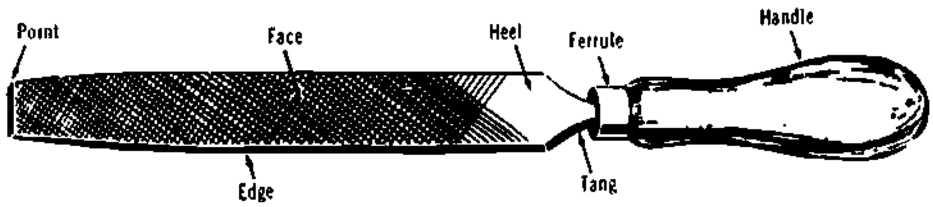


Figure 1-82. Components of a File

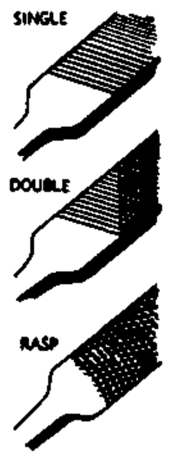


Figure 1-83. Single-Cut, Double-Cut, Rasp-Cut Files

c) A single-cut file has a single set of diagonal rows of teeth. The teeth are parallel throughout the file. (See Figure 1-83.)

d) A double-cut file has two sets of diagonal rows of teeth. The first set is called the over-cut. On top of it a second set crosses the first. The second set is called the upcut and is not as coarse or as deep as the over-cut. (See Figure 1-83.)

e) A rasp-cut file is made by a single-pointed tool, or punch, that forms each tooth separately. The teeth are formed consecutively, side by side, in a row. (See Figure 1-83.)

f) The number of teeth to the centimetre or spacing varies slightly with the make of file. The spacing also changes with the length of the file, increasing proportionately as the length is increased. A file may have rough, coarse, bastard (medium coarse), second-cut, smooth-cut, or dead-smooth grade of teeth. For fast removal of metal on rough work, the rough, coarse, and bastard files are used. For finishing, the second-cut file (small teeth), the smooth-cut file (very small teeth), and the dead-smooth file (very fine teeth) are used. (See Figure 1-84.)

g) After using a new file, the teeth will be clogged with metal filings. Using a clogged file will scratch the work: this condition is called "pinning." One way to prevent it is to rub chalk between the teeth before filing. However, the best way to keep the file clean is to use a file scorer and a file cleaner brush as shown in Figure 1-85.

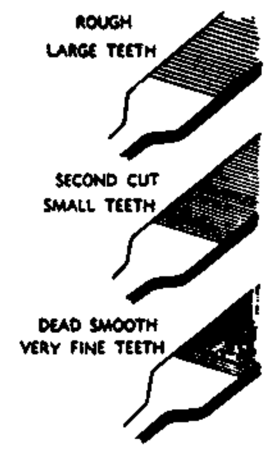
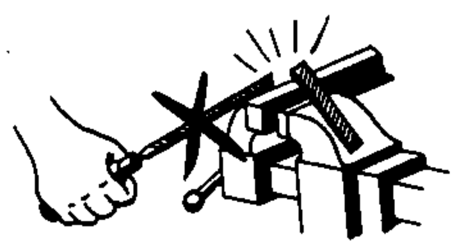


Figure 1-84. Finishing Files

Use of File Cleaner Brush

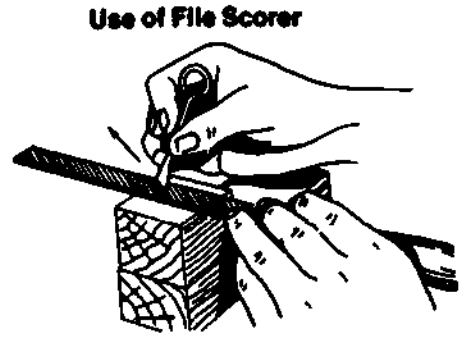
Figure 1-85. Use of File Cleaner Brush



The Wrong Way

Figure 1-86. Improper Method for Cleaning File

Use of File Scorer



The Right Way

Figure 1-87. Use of File Scorer

32. Wood Chisels

a) Wood chisels are made in a variety of sizes from 3 mm to 50 mm blade width. The blade lengths are generally from 50 mm to 150 mm. Wood chisels have a bevelled cutting edge, and are either the tang or the socket type, as shown in Figures 1-88 and 1-89. The shank has a point that fits into the handle. The point is called a tang. If the shank of the chisel is shaped like a tapered cup for the handle to fit into, it is called a socket chisel.

b) A tang chisel is designed for *hand manipulation only.*

c) A socket chisel is designed for striking with a wooden mallet, *never with a steel hammer.*

d) The handles may be made from wood, plastic, or another material.

e) Chisels must be kept properly ground and sharpened to obtain good workmanship.

f) Grinding a chisel is necessary when the cutting edge has been badly nicked and the nicks cannot be removed by whetting on a coarse oilstone, or when the bevel has become too short or rounded from frequent or careless whetting.

Figure 1-88. Tang Chisel

Figure 1-89. Socket Chisel

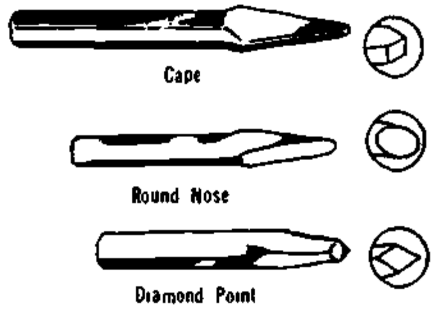


Figure 1-90. Types of Steel Chisels

33. Steel Chisels

a) The round-nose, cape, and diamond-point all-steel chisels are shown in Figure 1-90.

b) The round-nose chisel has its cutting edge ground at an angle of 60 degrees with the axis of the chisel. The round-nose chisel, with one edge ground flat and the other making a round cutting edge, is used for cutting metals.

c) The cape chisel has a smaller point than that of the diamond-point chisel. It is used to cut keyways or slots in metal, also for dividing work so that a cold chisel can be used to finish the job.

d) The diamond-point chisel has a solid point and is used to cut V-grooves, drawing holes, and cutting holes in flat stock.

e) The "mushroom" head on chisels, as seen in Figure 1-91, is very dangerous. When struck with a hammer, chips may break off and injure the user or others.

f) The ragged edges of a chisel head must be removed by grinding. A well-shaped head is seen in Figure 1-92.

Figure 1-91. Worn Chisel Head

Figure 1-92. Properly Ground Chisel Head

34. Punches

a) Punches are used to make holes in metal, leather, paper, and other materials; to mark metal and drive pins or rivets; to free frozen pins from their holes and align holes in different sections of metal.

b) The most common punches are the solid types, which have various-shaped points. Hollow punches have a circular cutting edge and are sized according to their cutting diameter.

c) Solid punches are made to mark materials, to drive out straight or tapered pins, to mark metal for starting holes to be drilled, to align holes in different sections of metal, and to punch holes by hand in metal that is 0.8 mm to 3 mm thick.

d) Centre, drive-pin, drift, and aligning punches are shown in Figures 1-93 to 1-96.

e) The centre punch has a narrow cone-shaped point terminating in a sharp 90-degree conical tip. It ranges from a 3 mm to 16 mm diameter stock and in length from 75 mm to 150 mm. It is normally used for starting holes to be drilled.

f) Drive-pin punches are used for driving out straight or tapered pins. The standard drive-pin punch tapers to a point ranging in diameter from 0.8 mm to 13 mm. Some drive-pin punches are straight without taper. The shanks may be knurled, or hexagon-shaped, for better gripping. Some drive-pin punches have long tapers.

g) Drift and aligning punches are normally tapered to a 3 mm, 5 mm, 5.5 mm, 6 mm, 8 mm, 9.5 mm, or 13 mm point, and range in length from 180 mm to 380 mm. Drift and aligning punches are used to line up holes in metal work.

h) After using a punch, wipe it clean and apply a thin film of oil to prevent rusting.

35. Twist Drills

a) Making a hole in a piece of metal is generally a simple operation, but an important and precise job.

b) The most common tool for making holes in metal is the twist drill. It consists of a cylindrical piece of steel with spiral grooves. One end of the cylinder is pointed while the other is shaped to fit a drill. A tang is found only on a tapered-shank drill, which is designed to fit into a slot in the socket or spindle of a drilling machine.

c) A twist drill is shown in Figure 1-97 with names of the principal parts.

d) Drills should be kept clean, free of rust, and in a container designed for them.

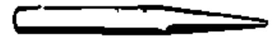


Figure 1-93. Centre Punch

Figure 1-94. Drive-Pin Punch

Figure 1-95. Drift Punch

Figure 1-96. Aligning Punch

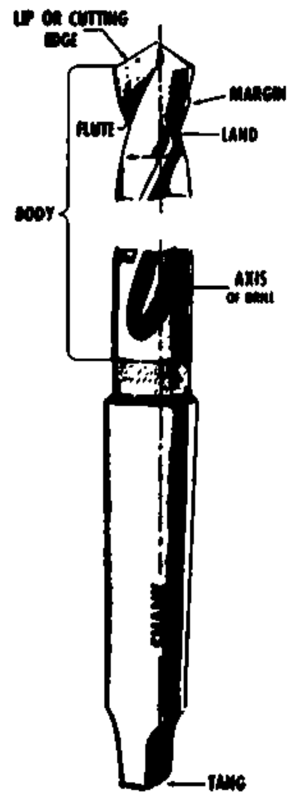


Figure 1-97. Twist Drill

36. Auger Bits

a) Construction trade terminology for wood drilling is "wood boring" and "drilling" is the term for making holes in all other materials.

b) An auger bit is a screw-shaped tool comprising six basic parts: cutter, screw, spur, twist, shank, and tang, as shown in Figure 1-98. Sizes of auger bits are indicated in sixteenths of an inch and are stamped on the tang. A number 10 stamped on the tang means ${}^{10}/_{16}$" or $5/8$" (16 mm).

c) The expansive auger bit has adjustable cutters for boring holes of different diameters. It is generally made in two different sizes. The larger has three cutters and bores holes up to 100 mm diameter; the smaller has two cutters and bores holes up to 75 mm diameter.

d) Figure 1-99 shows a typical expansive auger bit.

e) Figure 1-100 shows the method of inserting the auger bit into a wood brace.

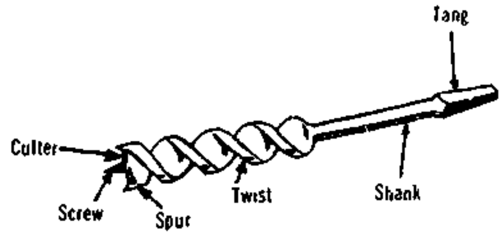


Figure 1-98. Parts of an Auger Bit

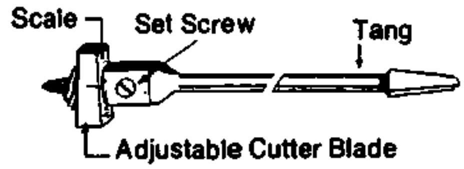


Figure 1-99. Parts of an Expansive Auger Bit

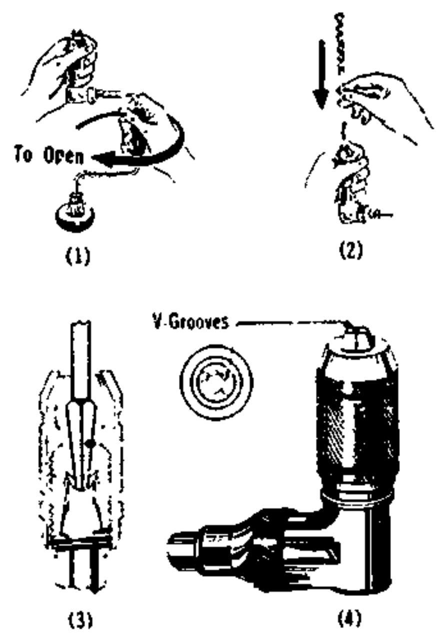


Figure 1-100. Inserting the Auger Bit

37. Breast Drill and Ratchet Bit Brace

a) The breast drill and ratchet bit brace are used to hold various kinds of bits and twist drills used for drilling, boring, and reaming holes and to drive screws, etc.

b) Figure 1-101 shows a typical breast drill and ratchet brace.

NOTE: Power drilling and boring equipment is detailed in Part 19 of the manual.

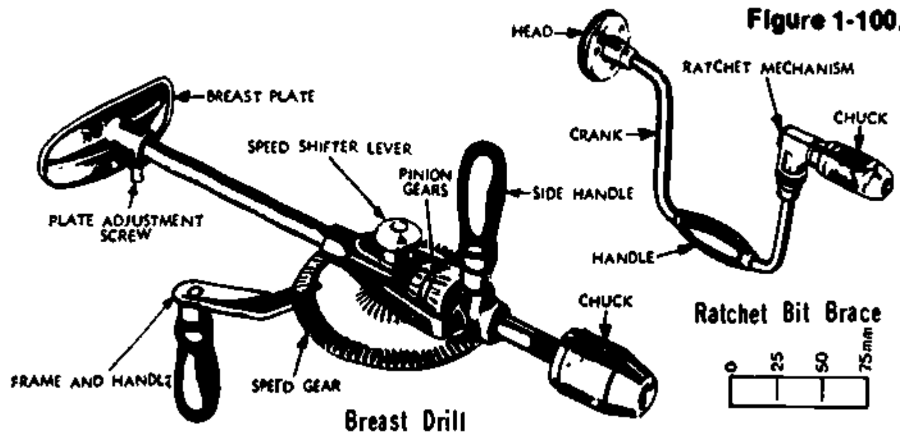


Figure 1-101. Parts of Breast Drill and Ratchet Bit Brace

38. Handsaws

a) The most common plumber's handsaws consist of a steel blade with a wooden handle. The narrower end of the blade is called the point, or toe. The end of the blade under the handle is called the heel. The teeth cut two parallel grooves close together and are bent alternately to both sides.

b) Shown in Figures 1-102 and 1-103 are a typical handsaw (which could be either a crosscut or a ripsaw) and a compass saw respectively. A keyhole saw is similar to the compass saw but is much smaller.

c) The main difference between a ripsaw and a crosscut saw is in the shape of the teeth. A tooth with a square-faced, chisel-type cutting edge like the ripsaw tooth seen in Figure 1-104 does a good job of cutting with the grain of the wood (called ripping), but a poor job of cutting across the grain.

d) A tooth with a bevelled, knife-type cutting edge like the crosscut saw tooth shown in Figure 105 does a good job of cutting across the grain, but a poor job of cutting with the grain.

e) An unused saw should be hung up or stored in a proper container. Storing a saw in a toolbox may cause the teeth to become dulled or bent by contacting other tools.

f) A saw should be kept clean and sharp, and when in storage it should have a film of oil on the blade.

39. Taps and Bolt Dies

a) The taps are for cutting internal threads and the dies are for cutting external threads.

b) There are several types of taps, but the most commonly used are the taper, plug, bottoming, and pipe taps shown in Figures 1-106 to 1-110.

c) The taper tap has a chamfer length of from eight to ten threads. It is used when starting the tapping operation and when tapping coarse threads in through-holes, especially in harder metals.

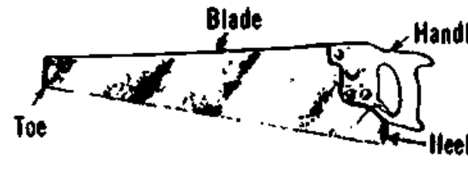


Figure 1-102. Typical Handsaw

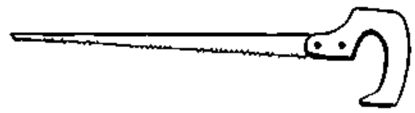


Figure 1-103. Compass Saw

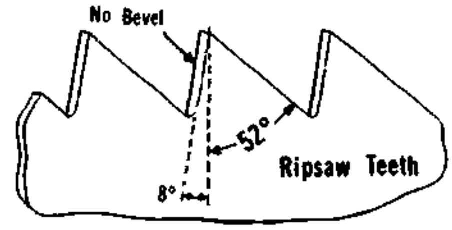


Figure 1-104. Tooth Specifications for Ripsaw Blade

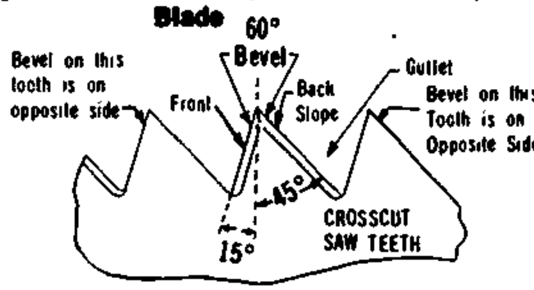


Figure 1-105. Tooth Specifications for Crosscut Blade

Figure 1-106. Taper Tap

Figure 1-107. Plug Tap (Metric)

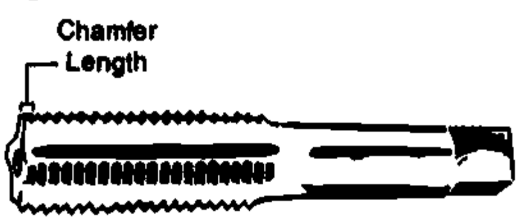


Figure 1-108. Bottoming Tap

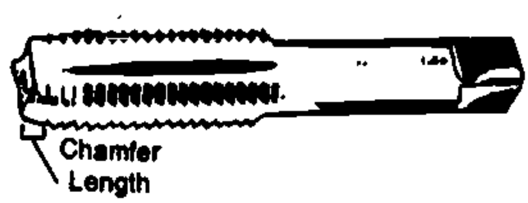


Figure 1-109. Plug Tap (National Coarse). National Fine Taps Are Also Available

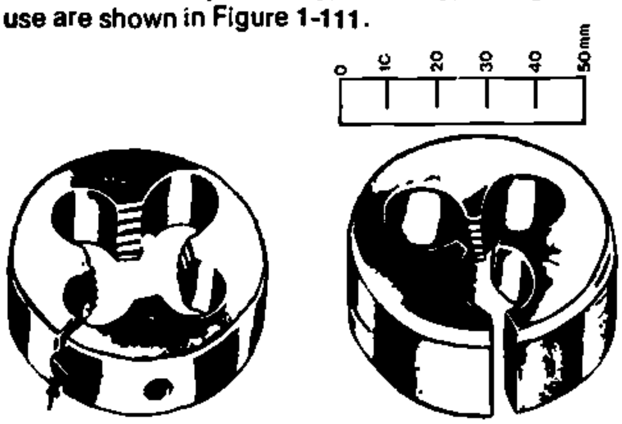
Figure 1-110. Pipe-Thread Tap

d) Plug taps are for use after the taper tap, and in through-holes when tapping softer metals or fine-pitch threads. They have a chamfer length of from three to five threads and are very popular.

e) Bottoming taps are used for threading the bottom of a blind hole. They have a very short chamfer length, only 1 to 1½ threads. This tap is always used after using the plug tap, and is for hard metals. Both the taper and the plug tap should be used before the bottoming tap.

f) A taper pipe tap is used for pipe fittings and other places where extremely tight fits are necessary. The tap diameter, from end to end of the threaded portion, increases at the rate of 1 mm in 16 mm. All threads are cutting threads, compared to those of the straight taps where only the non-chamfered portion does the cutting.

g) Bolt dies come in many different shapes and are of the solid or adjustable type. Two types in general use are shown in Figure 1-111.



Screw-Adjusting Type

Open-Adjusting Type

Figure 1-111. Bolt Dies

h) Figure 1-112 shows a few of the many types of tap wrenches and diestocks available.

i) Do not attempt to sharpen taps or dies. Sharpening entails several high-precision cutting processes in which the thread characteristics, chamfer angle, and spiral point are involved. These cutting procedures must be done by experts to maintain the accuracy and cutting effectiveness of taps and dies.

j) Keep taps and dies clean and well oiled when not in use. Store them so that they do not contact each other or other tools.

40. Hammers

a) Two or three hammers are generally included in a plumber's kit.

b) Hammers are designated according to weight without the handle, and according to style and shape.

c) Ball-peen hammers come in different weights — usually 0.11 kg, 0.17 kg, 0.23 kg, and 0.34 kg, and 0.5 kg, 0.75 kg, and 1 kg.

d) A typical ball-peen hammer is illustrated in Figure 1-113.

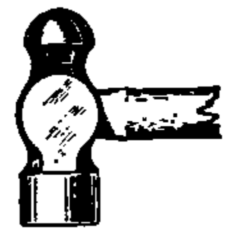
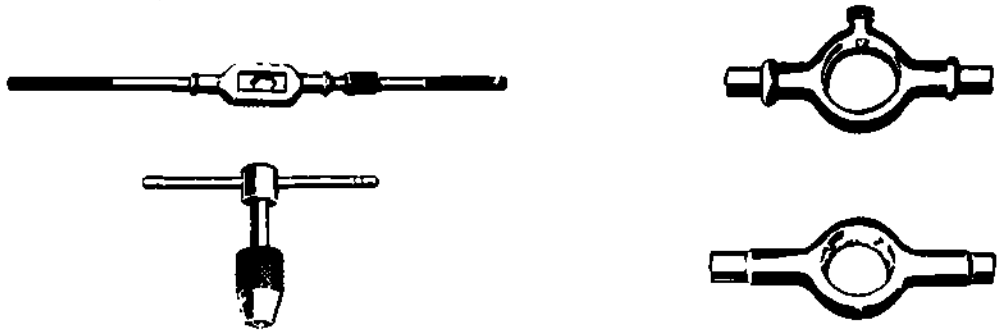


Figure 1-113. Ball-Peen Hammer



Tap Wrenches

Diestocks

Figure 1-112. Tap Wrenches and Diestocks

e) A soft-face hammer should be used when there is a danger of damaging the surface of the work. Many have heads that can be replaced as needed.

f) Three types of soft-face hammers are shown in Figure 1-114.

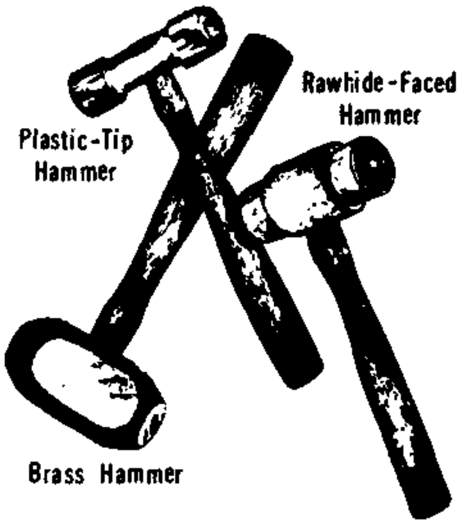


Figure 1-114. Soft-Face Hammers

g) The carpenter's, or claw, hammer is made of steel and may have a wooden handle or steel handle. A typical claw hammer with wooden handle is shown in Figure 1-115. It is essential for a plumber engaged in repair work.

h) The main use for a claw hammer is driving or pulling nails.

Figure 1-115. Claw Hammer

i) The mallet is a short-handled tool for driving wooden-handled chisels, etc. The mallet head may be made of wood, rubber, or another material (Figure 1-116).

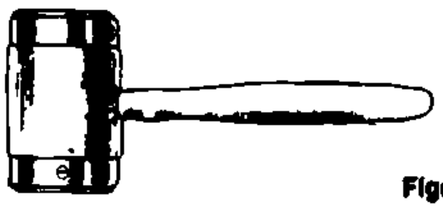


Figure 1-116. Mallet

j) The sledge is a steel-headed, heavy-duty driving tool that has many uses.

k) Short-handled sledges are used to drive bolts, drift pins, and large nails, and to strike cold chisels and small hand rock drills.

l) Long-handled sledges are used to break rock and concrete, to drive spikes, bolts, or stakes, and to strike rock drills and chisels.

m) A typical sledge hammer head, shown in Figure 1-117, weighs from 2 kg to 7.5 kg, with handles from 400 mm to 900 mm.

Figure 1-117. Sledge Hammer Head

n) When a hammer, mallet, or sledge is not in use it should be kept clean and in good repair. Metal portions should be given a light coat of oil and correctly stored.

o) The face of a hammer head should be regularly dressed to remove battered edges. The head should be securely attached to the handle of the proper type. Make sure the steel or hardwood wedges are in tight. Never use screws or nails in place of wedges because they may come out or split the handle. Replace a defective handle.

p) Figures 1-118 to 1-121 show typical wedges and how to use them.

Figure 1-118. Wooden Wedge

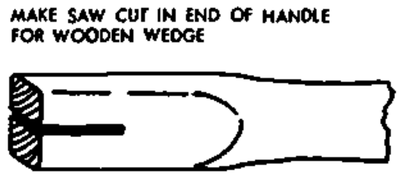


Figure 1-119. Preparation of Wooden Handle

Figure 1-120. Metal Wedge

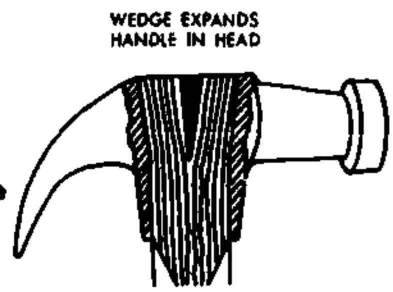


Figure 1-121. Cutaway of Handle and Head with Wedge

41. Soldering Irons

a) Soldering is the joining of two pieces of metal by adhesion. The soldering iron is the source of heat for melting solder and for heating to the proper temperature the parts to be joined.

b) Typical non-electric and electric soldering irons (Figure 1-122) and a soldering gun (Figure 1-123) are shown.

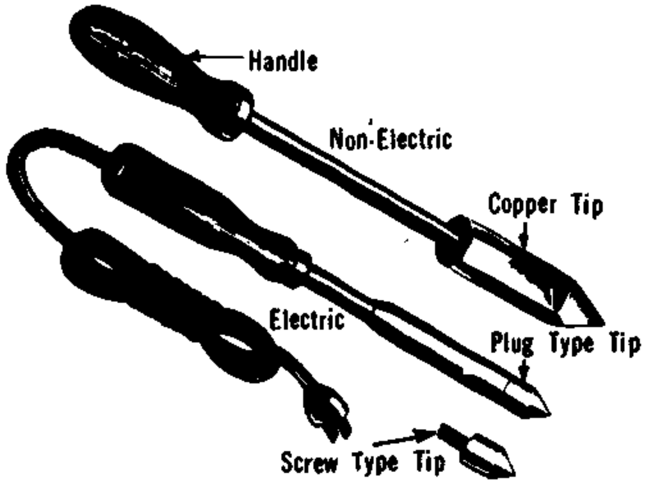


Figure 1-122. Soldering Irons

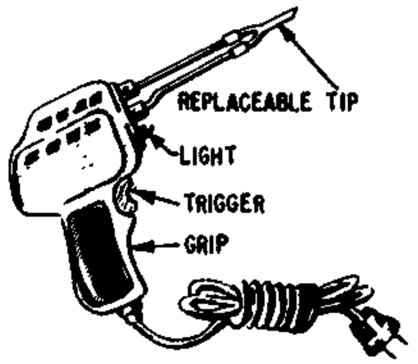


Figure 1-123. Electric Soldering Gun

NOTE: Soldering irons for use with propane-air and acetylene-air torches are described in Part 3.

c) Before using a soldering iron, the faces of the tip must be filed smooth and "tinned" (coated with solder). For ordinary work, the tip of the soldering iron is tinned on all four sides.

d) For work where the iron is held under the object to be soldered, only one face is tinned, as shown in Figure 1-124.

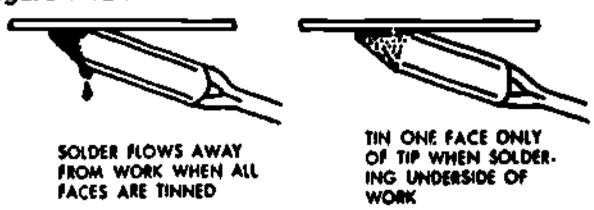


Figure 1-124. Technique for Soldering

e) Steps for tinning an electric soldering iron:

Clamp tne iron in a vise and file the tip faces bright while the iron is cold, as illustrated in Figure 1-125.

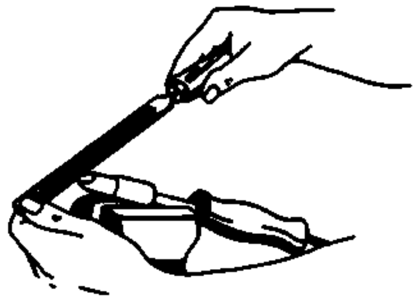


Figure 1-125. Tinning an Electric Soldering Iron

Remove the iron from the vise. Plug in the electrical cord and, as the iron heats up, rub the flux and solder over the tip faces every 15 to 20 seconds. At first the iron will not be hot enough to melt the solder, but as soon as the temperature has risen enough the solder will spread smoothly and evenly over the faces. This procedure does the tinning as soon as the copper is hot enough to melt the solder and before it has had a chance to oxidize.

When the tinning is completed, wipe the tip with a rag while the solder is hot and molten. This will expose an even, mirror-like layer of molten solder on the faces of the tip.

f) Following are two common procedures for tinning a non-electric soldering iron:

Procedure 1

Heat the iron as for soldering.

Use a fine file to smooth off the rough edges.

Re-heat the soldering iron to the required temperature.

Rub the tip of the iron on a block of sal ammoniac with a few drops of solder until the iron is tinned.

Procedure 2

Heat the iron to required temperature.

File the surfaces quickly.

Put pieces of rosin or a little soldering paste on a non-combustible surface and, with a little solder, rub the hot iron on the non-combustible surface until the iron is tinned.

Some plumbers prefer to tin one or two surfaces at a time, then re-heat and tin the remainder.

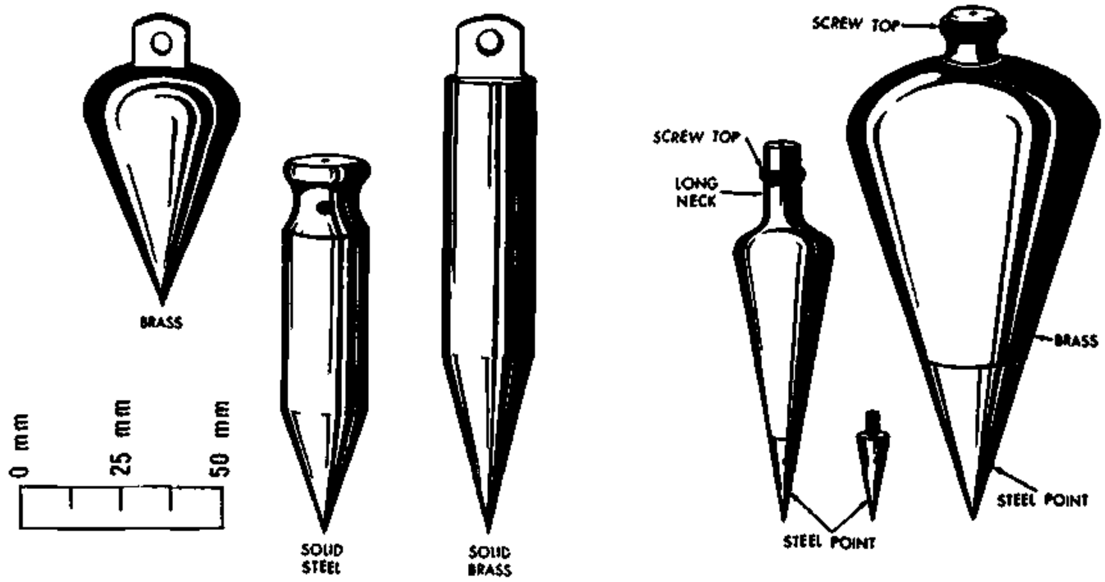


Figure 1-126. Various Plumb Bobs

42. Plumb Bobs

a) The common plumb bob is connected to a strong cord and is used to determine a true vertical position. It ensures that one pipe opening is directly over a lower one, and that a pipe is plumb.

b) Shown in Figure 1-126 are different types of plumb bobs.

c) To locate a point exactly below a particular point in space, secure the plumb bob cord to the upper point (see A in Figure 1-127). When the plumb bob stops swinging, the point as indicated at A will be exactly above B.

d) To plumb a structural member, or a pipe, in the plumbing system, secure the plumb line A, as in Figure 1-128, so that you can see both the line and the piece behind it. Then, by sighting, line up the member or pipe with the plumb line. If this cannot be done, you may have to secure the plumb line at some point such as B and then measure the offset from line to pipe at two different places. For instance, lengths C and D should be the same; if not, the pipe is not plumb.

e) Handle plumb bobs with care. Do not drop them or use them for other than their intended purposes, and wipe them clean before use.

f) Any metal removed from the plumb bob will result in an incorrect plumb, or reading, since its balance will be affected. The true vertical of the lower point will be canted.

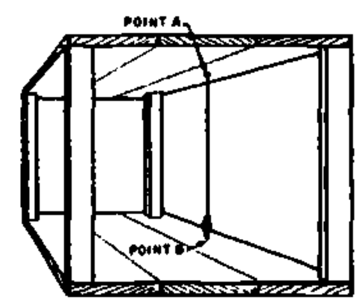


Figure 1-127. Locating a Point Exactly Below a Reference Point

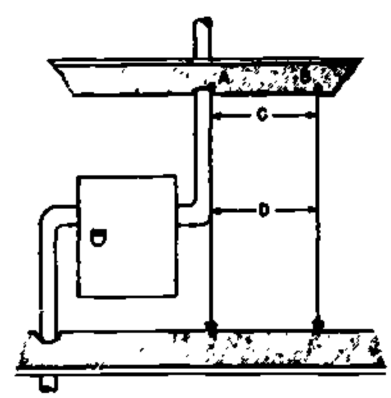


Figure 1-128. Use of Plumb Bob

g) Keep a level at hand to ensure that pipes are plumb, level, or have the proper grade. Two types are shown in Figure 1-129 but there are many others ranging in size from a few centimetres to several metres. They are generally made of die-cast aluminum, but may also be available in other materials.

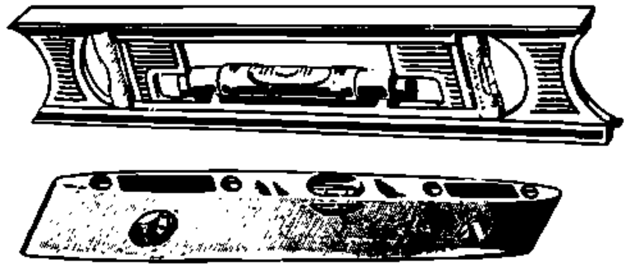


Figure 1-129. Levels

43. Snips

Keep at least one pair of snips in your tool box to cut sheet lead and hanger iron, etc. Never use snips to cut wire because this will often cause nicks in the blades. Three snips in general use are shown in Figures 1-130 and 1-131.

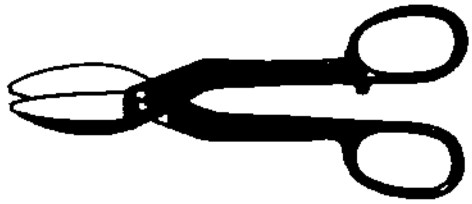


Figure 1-130. General-Purpose Snips

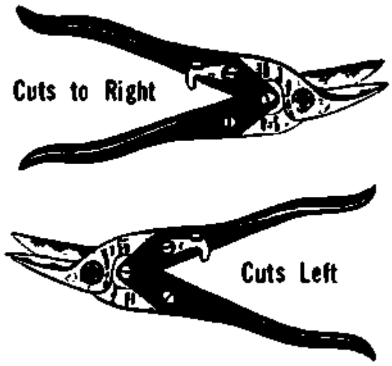


Figure 1-131. Compound-Action Snips (Aviation Snips)

44. Open-End Wrenches

Various open-end wrenches are shown in Figure 1-132. They are mostly double-ended. The size of the opening between the jaws determines the size of the open-end wrench. The size of each opening is usually stamped on the side.

45. Box Wrenches

a) Box wrenches are so named because they surround, or box, the bolt head or nut. The opening in the box head usually has six or twelve notches (called "points") arranged in a circle. The box wrench is a safer tool than the open-end wrench, since it will not slip off. As little as $^1/_{12}$ of a turn can be taken at one stroke if necessary in close quarters. A few types are shown in Figure 1-133.

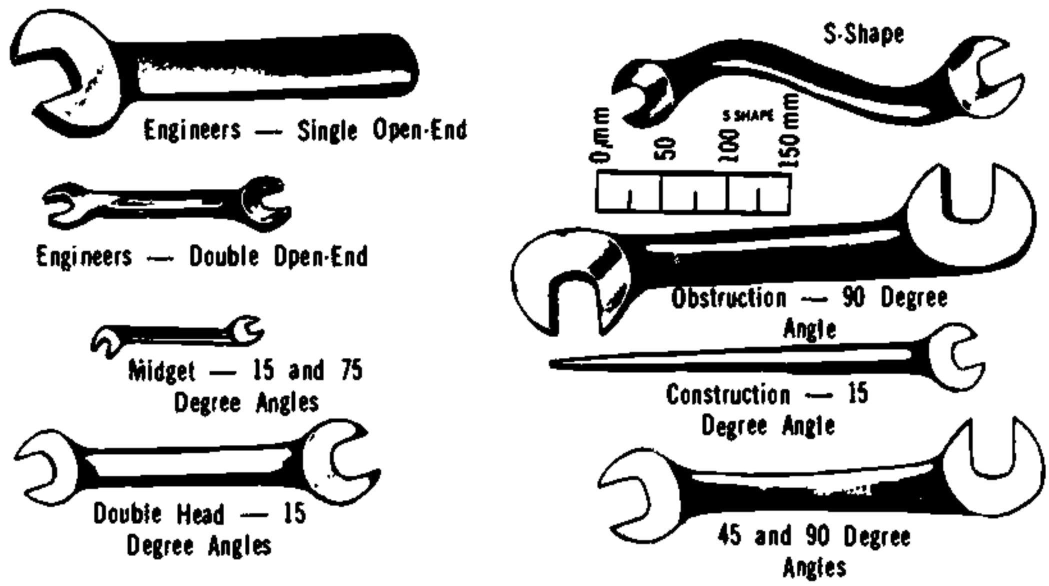


Figure 1-132. Styles of Open-End Wrenches

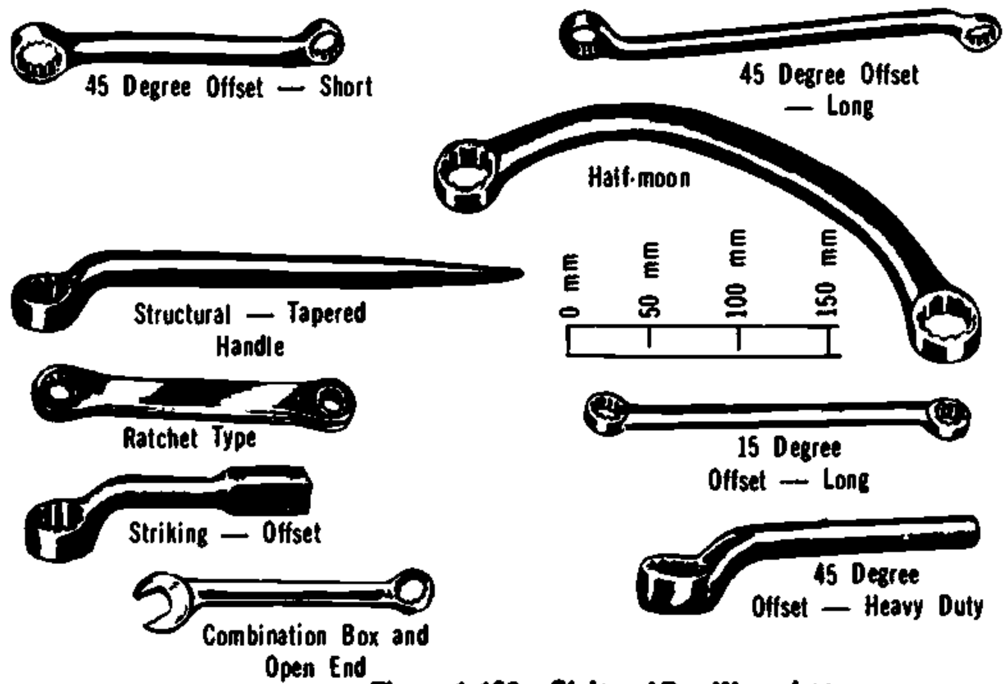


Figure 1-133. Styles of Box Wrenches

46. Combination Open and Box Wrenches

Combination open and box wrenches have one open end and one box wrench at the other end. These wrenches may be made with any combination of sizes, offsets, and angles.

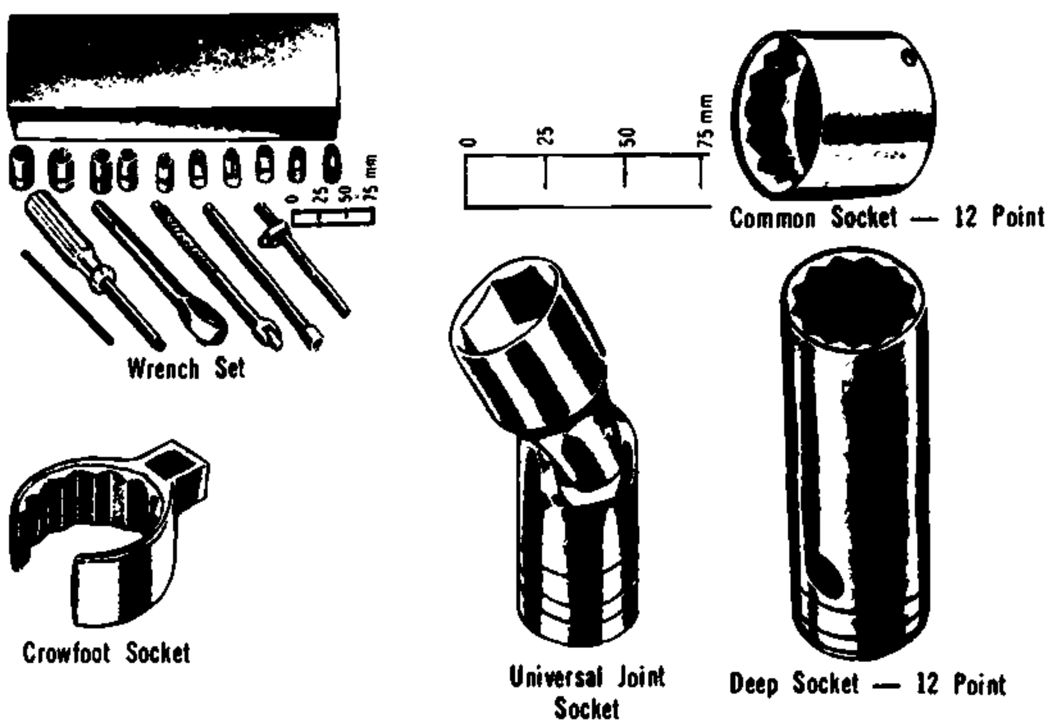


Figure 1-134. Socket Drives

47. Socket Wrenches

The common socket wrench is boxlike and made as a detachable socket for various types of handles. A set usually consists of various-size sockets, a ratchet, a sliding bar tee, a speeder, a speed tee, a ratchet adapter, and a nut spinner; and will be 6.3 mm, 10 mm, 12.5 mm, or 20 mm drive. Typical socket wrench sets are shown in Figures 1-134 and 1-135.

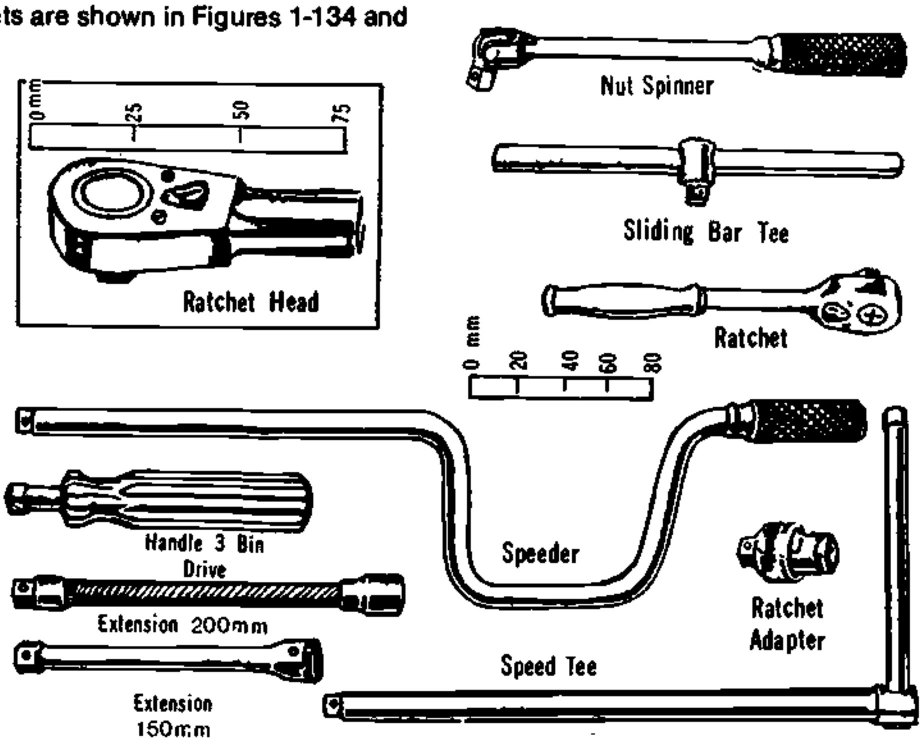


Figure 1-135. Socket Wrench Set

48. Other Tools for Finishing Work

a) The strap wrench shown in Figure 1-136, when correctly used, will not normally mar the chrome finish on a pipe when tightening it in place.

b) The handy basin wrench shown in Figure 1-137 fits where no other standard wrench will, such as in water-closet tanks, under basins, or in tight corners.

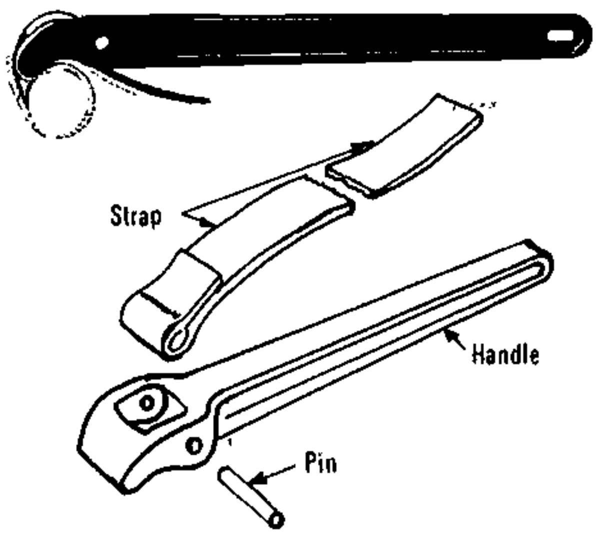


Figure 1-136. Strap Wrench

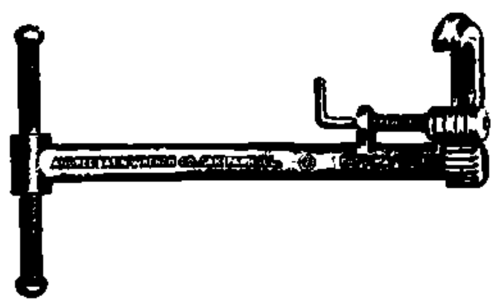


Figure 1-137. Basin Wrench

c) The spud wrench shown in Figure 1-138 is handy for internally gripping closet spuds, flush valves, trap bushings, push nipples, sink strainers, PO plugs, and wastes and overflows.

d) The internal wrench (or nipple extractor) shown in Figure 1-139 is used to tighten or loosen nipples and pipes that an ordinary pipe wrench cannot grip. It is available in pipe sizes from NPS ¾ to NPS 2.

e) The combination internal wrench shown in Figure 1-140 is used with PO plugs and closet spuds, and with bath-waste outlets.

f) A practical and inexpensive NPS 2 closet spud holder is shown in Figure 1-141.

g) The type of spud wrench shown in Figure 1-142 has been used by plumbers for more than 50 years. There are various sizes, but the one in general use fits the lock nut on NPS 2 water-closet spuds and the NPS 2 coupling on flush elbows.

h) The bath wrench (Figure 1-143) is for holding and tightening the strainer in some types of bath wastes and overflows.

i) The lock-nut wrench (Figure 1-144) is used for tightening or loosening lock nuts on sink strainers.

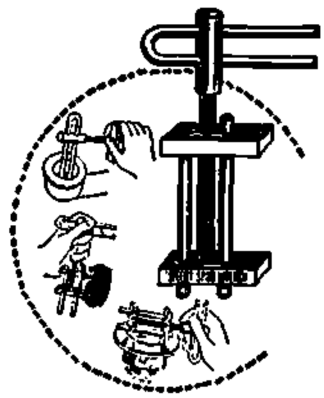


Figure 1-138. Spud Wrench

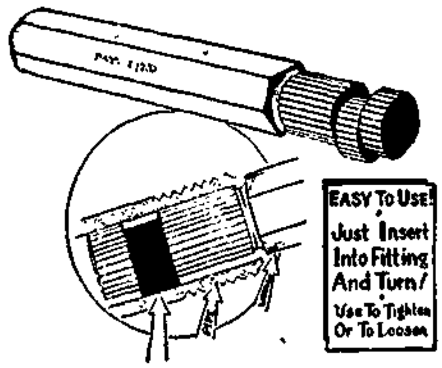


Figure 1-139. Internal Wrench (Nipple Extractor)

Figure 1-140. Combination Internal Wrench

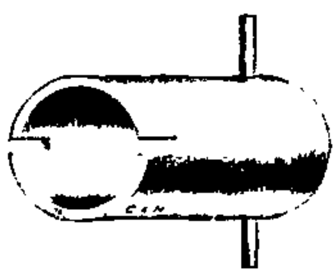


Figure 1-141. Closet Spud Holder

Figure 1-142. Spud Wrench

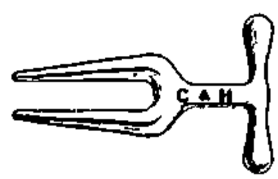
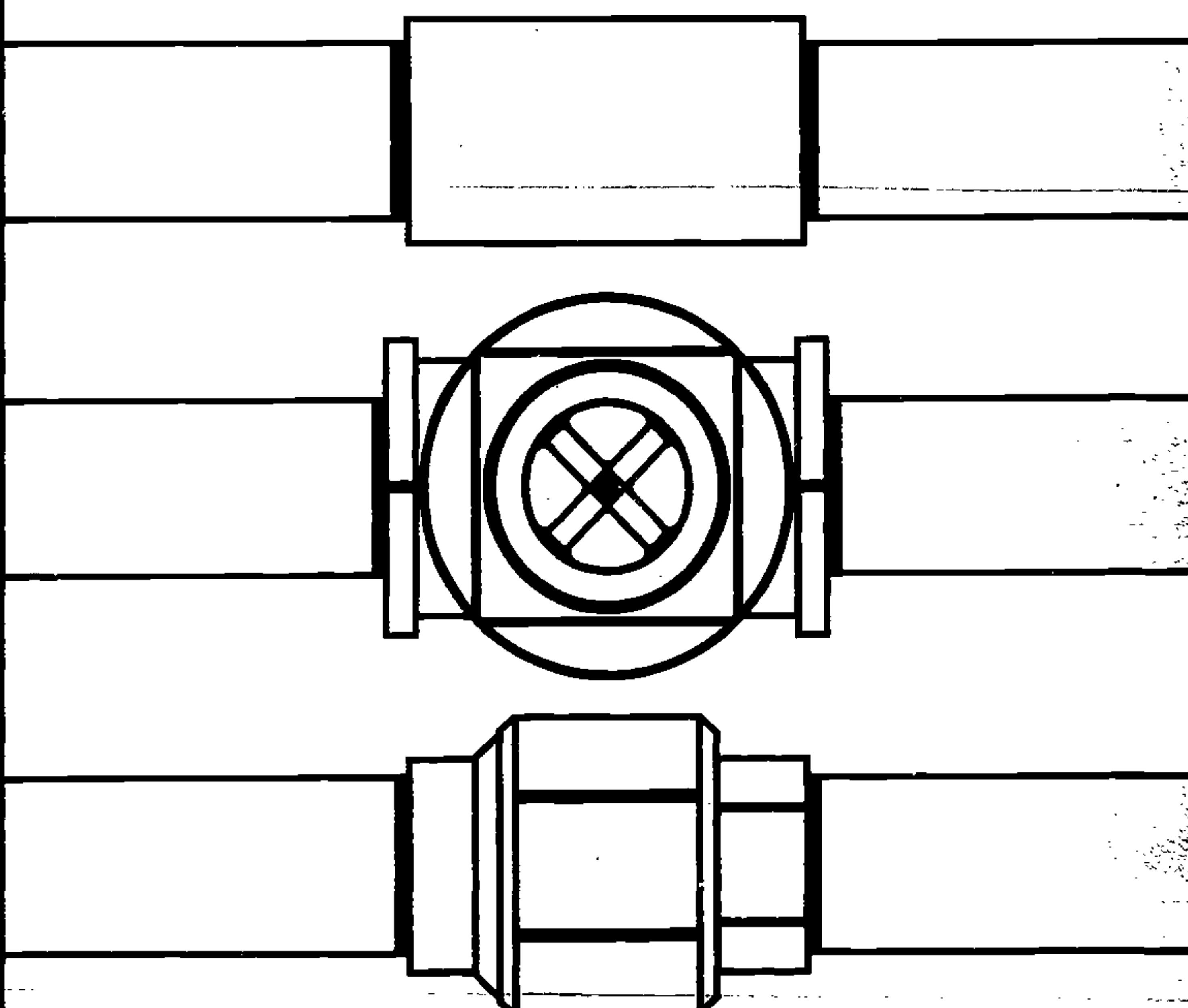


Figure 1-143. Bath Wrench

Figure 1-144. Lock-Nut Wrench

Rigging and Hoisting 2
Materials, Equipment, and Methods



PART 2
RIGGING AND HOISTING MATERIALS, EQUIPMENT, AND METHODS

1. Rigging and Hoisting — General Information

a) The installation and maintenance of plumbing systems sometimes involves the moving of heavy parts or complete equipment. This requires knowledge of four basic factors: the item to be moved; where it is to be moved to; the available moving equipment; the safety considerations.

b) The weight of the item to be moved will determine the size and choice of the hoisting equipment to be used. A light load may be hoisted with rope blocks, but heavier loads require chain blocks or "come-alongs." (See section 3 hereunder covering hoisting equipment.)

c) The type of construction of the object to be moved also determines the ease of handling and the degree of care required. For instance, a large boiler or casting requires less care in handling and slinging than does a complex item with protruding parts that must be protected. Over-all dimensions of the load should be carefully considered, since what appears to be the shortest and easiest route to a new location is often too narrow or too low.

2. Skids

a) A heavy load can be moved along the floor by securing it on a pair of skids and dragging or rolling it as close as possible to the new location. Short lengths of pipe (the larger the better) make good rollers, but all rollers should be the same size and extend beyond the sides of the skid.

b) Illustrated in Figure 2-1 is a typical skid design.

c) The skid should be made to suit the base dimensions of the load, and be wide and long enough to keep the load from being top-heavy, as illustrated in Figure 2-2.

d) Material for the skid should be strong enough to support the load without bending. Its exact dimensions will be determined by the material at hand. A flat, flexible skid should be avoided. Figure 2-3 shows what could happen if the skid material is flexible.

e) If the load is to be moved a considerable distance and a winch is available, use it because the winch and a snatch block will make the moving easier and quicker, as illustrated in Figure 2-4.

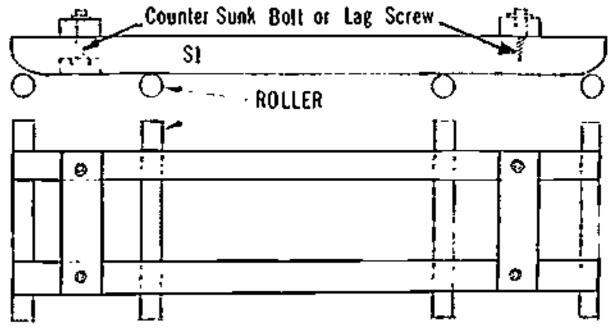


Figure 2-1. Typical Skid Design

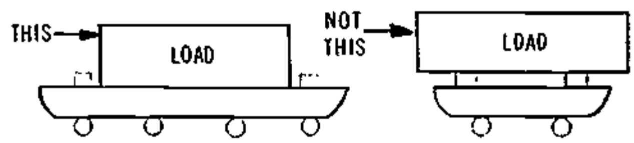


Figure 2-2. Proper Base Dimensions for Load

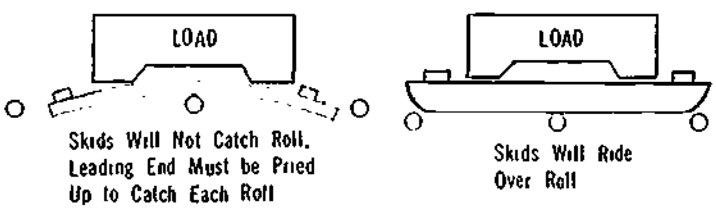


Figure 2-3. Rigid Base Supports Load

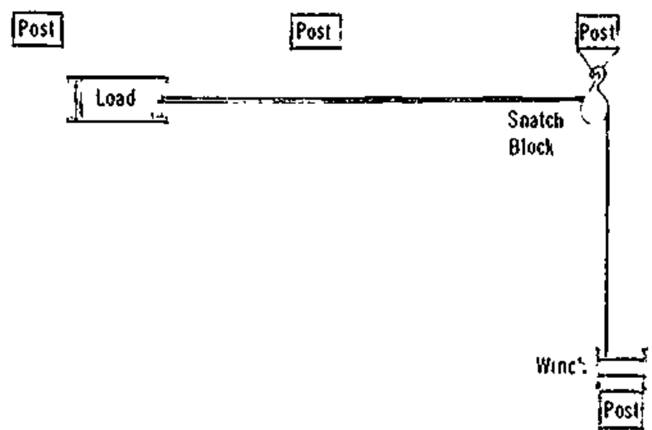


Figure 2-4. Use of Winch and Snatch Block

f) If the winch line runs along or across a walkway, it should be marked or guarded with rags or similar material to make it plainly visible and thus prevent accidents. Frequently, a guard railing or barrier is needed for safety, especially where vehicles may be passing.

3. Hoisting

a) When power cranes and winches are unavailable, chain blocks and come-alongs are often used where a load must be lifted and held suspended, or where a slight vertical movement is needed. (Rope blocks are covered later in this section.)

b) Figure 2-5 shows three types of chain blocks and a come-along.

NOTE: "Come-along" is a trade term. There are similar types of pullers, some with chains and others with steel cable.

c) Chain blocks are generally used for vertical lifting because a deviation from the vertical makes the pull chain more difficult to handle. The come-along can be used in any position from vertical to horizontal, and it works equally well in the inverted position.

d) Chain blocks are designed with the lower hook weaker than the top one so that overloading will first show by distortion of the bottom hook. A hook strained by overloading should not be forged back to shape but replaced.

e) When using a chain block, be sure the load is less than the rated capacity of the block.

f) Do not choke a load with a lift chain, rope, or cable. Use the correct sling or chain arrangement as shown in Figure 2-6.

g) Do not use the lift hook to hold two sling eyes unless they are both in a vertical lift. If the sling legs are spread, shackle them and place the shackle on the lift hook. For maximum safety, two or more eyes should always be held in a shackle, even if they are in a vertical lift.

h) When loading a hook with two sling eyes, make sure that one eye does not lie on top of or above the other, and that both are at the bottom of the hook, as shown in Figure 2-7.

i) Hand signals must be standard and be understood by every member of the crew. When hoisting or skidding, one man should be responsible for all signals, although it may be necessary to have others relay them. Signals must always be visible to the person operating the hoisting or pulling equipment.

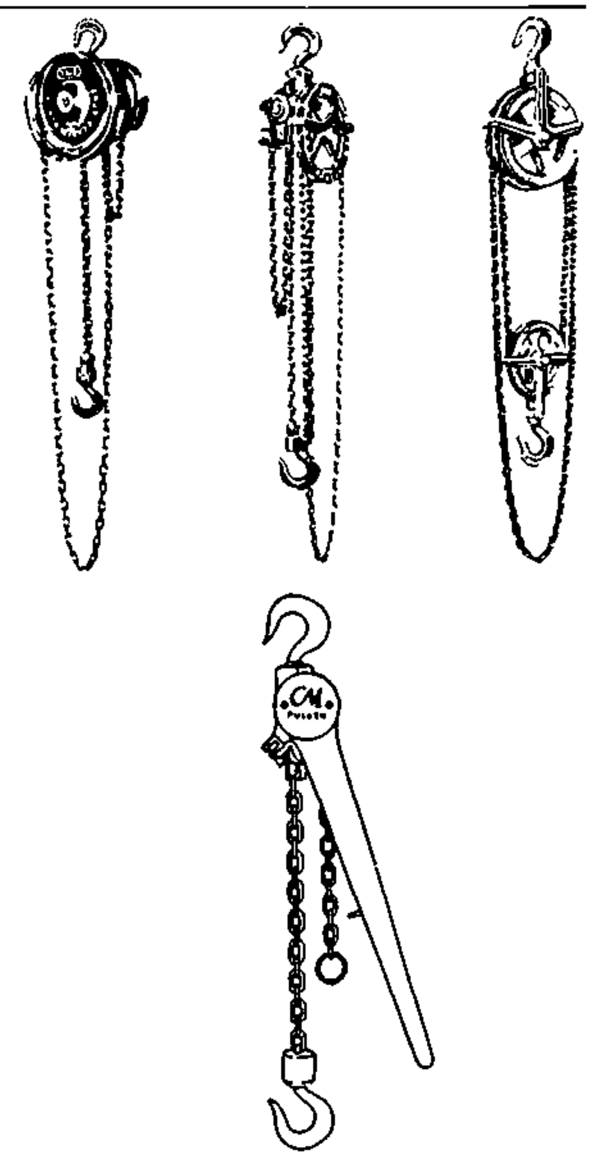


Figure 2-5. Hoisting Mechanisms

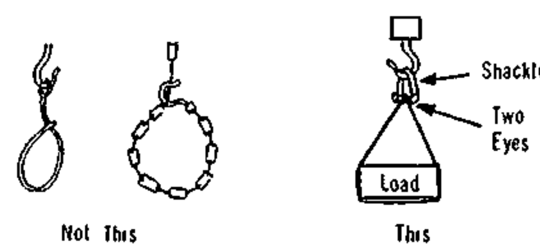


Figure 2-6. Proper Sling or Chain Arrangement

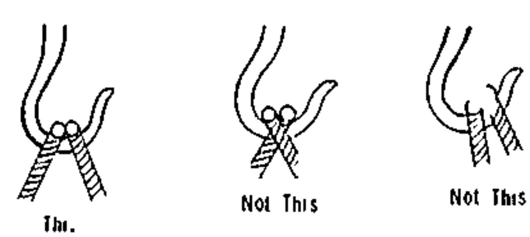


Figure 2-7. Correct Loading of Hook

4. Slings

a) An evenly shaped load can often be safely lifted with one sling, but if the load is uneven in dimensions or weight it will require at least two. A long load that may be damaged by bending will require two chain blocks or come-alongs, as illustrated in Figure 2-8.

b) Slings should be spliced only by a qualified person; if made of wire rope, they should be protected against kinking or coiling, and scrapped when showing signs of wire breaks or sharp kinks.

c) Fibre rope is made from several different fibres—mainly hemp, sisal, jute, and cotton—in decreasing order of strength. Rope is measured either by diameter or by circumference. The circumference is generally considered to be three times the diameter. (See Figure 2-9.)

d) When a rope is spliced to a hook, ring, or pulley block, place a thimble in the eye to reduce wear and stress that would develop when the rope is bent around a small diameter, as shown in Figure 2-10.

e) Rope ends must be fastened to prevent fraying or untwisting. This is generally done by whipping or seizing, but several wrappings of friction or plastic tape will do instead although they will tend to pull off after the rope becomes wet.

5. Synthetic Ropes

a) Synthetic ropes are made of nylon, dacron, saran, and polyethylene.

b) Nylon rope is very strong and elastic and is used where shock-loading is common, or when a rope smaller than hemp but of equal strength is required. It resists mineral oils and greases but is affected by paint, linseed oil, and acid. Nylon rope becomes slippery when wet and loses some of its strength, but it will not rot or mildew.

c) Dacron rope has less elasticity than that of nylon but better resistance to acids and water, and greater tensile strength. Dacron maintains its strength wet or dry and is resistant to abrasion, rot, and mildew.

d) Saran rope has a working strength of about three times that of manila rope. It is highly resistant to acids, alkalies, and organic solvents, and is practically non-water absorbent. It has good strength, high resistance to abrasion, and does not deteriorate when exposed to weather. Saran rope cannot be used at temperatures above 49°C because of its low melting point.

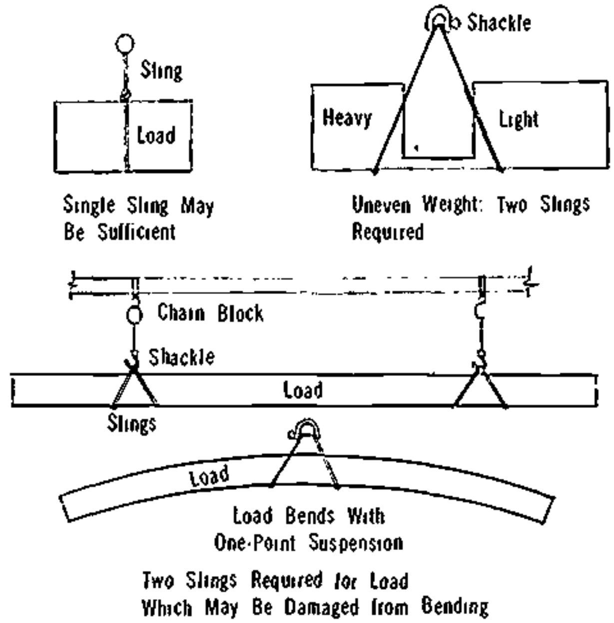


Figure 2-8. Correct Use of Slings

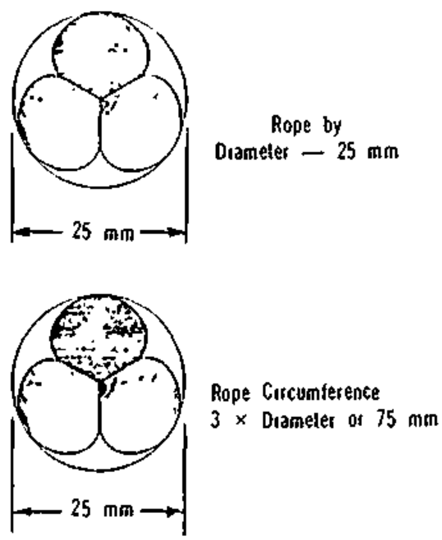


Figure 2-9. Example of Rope Circumference

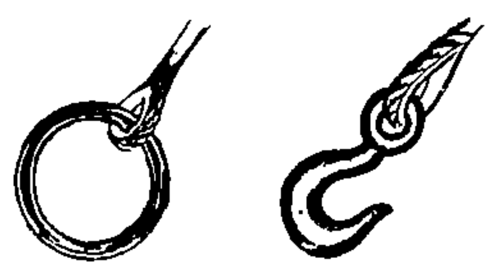


Figure 2-10. Use of a Thimble Reduces Wear

e) Polyethylene rope is electrically non-conducting, highly resistant to acids, alkalies, and common solvents, and is not affected by mildew rot or fungi. It has high elasticity but poor resistance to abrasion. It remains buoyant since it absorbs practically no water and is a good rope for use in water.

f) Generally, synthetic ropes have greater strength, elasticity, and resistance to wear, weather, and contamination, but the limitations of each synthetic must be known before using the rope.

g) The nine steps below explain how to extend the life of synthetic rope:

Select the correct synthetic rope for a particular use.

Know its breaking strength.

Make sure the working equipment is smooth. Rough edges can cut the toughest rope.

Avoid sharp bends—they can break the fibres.

Even out the wear on the line by periodically reversing the ends.

Synthetic ropes are pre-lubricated at the factory for their life, and the application of other lubricants will only shorten it.

Keep the line clean.

Do not pull the rope through a reel that is lying on its side.

Correctly coil and store the rope when not in use.

6. Knots and Hitches for Fibre Rope

a) Many jobs require a hand line for lifting tools, planks, and pieces of equipment, or as a snub line or sway line; therefore, you should be familiar with the following easily tied and untied, yet secure, knots and hitches:

b) When making knots and hitches, the rope is described as having three parts, as depicted in Figure 2-11.

c) The timber hitch forms a secure knot that stays tight under a load yet is easily undone when the line is slack (Figure 2-12).

d) The half hitch is used for casual work if the load is light and the pull steady. Its effectiveness depends on binding action at only one point.

CAUTION: Keep away from under the load.

e) When a plank or an object is lifted in a near-vertical position, a half hitch is added above the timber hitch as an extra choke to keep the line from slipping (Figure 2-14).

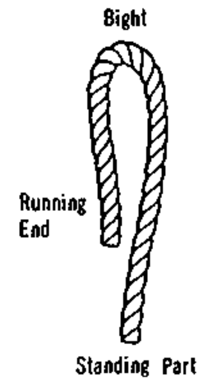


Figure 2-11. Three Parts of Rope

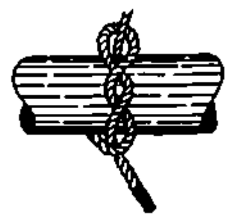


Figure 2-12. The Timber Hitch

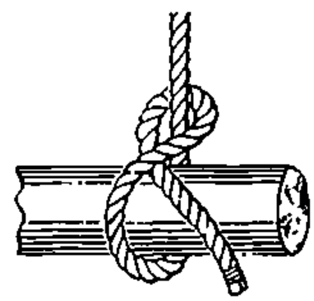


Figure 2-13. The Half Hitch

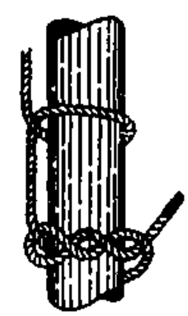


Figure 2-14. The Timber Hitch with Half Hitch

f) The timber hitch is a half hitch with the running end wrapped at least two full turns to increase the area of friction contact with both load and the rope itself.

g) The double half hitch attaches the rope to an object. It stays tied whether the line is tight or slack and is easily untied.

h) The clove hitch attaches a rope for a right-angle pull. It holds position with a tight or slack line. The clove hitch may be made in the line and passed over one end of the load as shown in Figure 2-15, or it may be made in position on the load (Figure 2-16).

i) The blackwall hitch attaches a single rope to a hook for hoisting. The standing part must be on top of the running part and tension must be constant (Figure 2-17). Use this hitch with caution.

j) The overhand knot is the simplest one to make, but should be used only with small cord or twine on parcels. On a larger rope, such as is used in hand lines and rope blocks, this knot jams when pulled tight and damages the fibres of the rope (Figure 2-18).

k) The figure 8 knot is used for tying on the end of a rope. It does not injure the rope fibres and is better than an overhand knot (Figure 2-19).

l) The square, or reef, knot is used to tie two ropes of the same size, or to tie the ends of a short rope to make a temporary sling. Properly tied, a square knot will not slip when the rope is dry and the knot has 50 per cent of the rope strength. When tying a square knot, the standing part and the running end of each rope must pass through the bight of the other rope in the same direction. Figure 2-20 shows the two methods of tying the square knot.

m) The granny knot and the thief knot look like a square knot but are unsafe as they could slip and jam under a load (Figure 2-21).

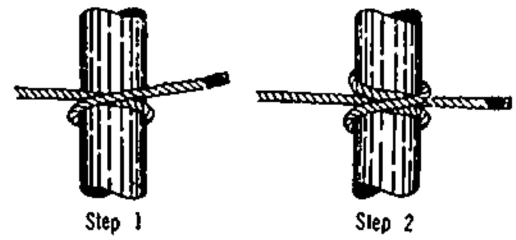


Figure 2-15. The Clove Hitch (First Method)

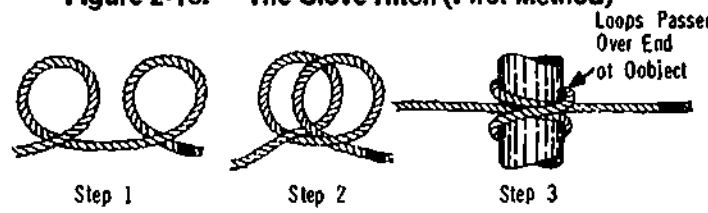


Figure 2-16. The Clove Hitch (Second Method)

Figure 2-17. The Blackwall Hitch

Figure 2-18. The Overhand Knot

Figure 2-19. The Figure 8 Knot

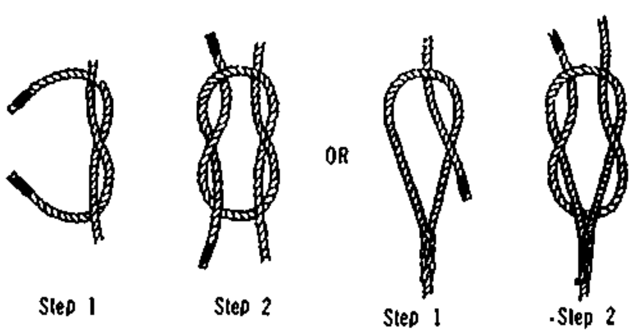


Figure 2-20. Two Methods for Tying the Square or Reef Knot

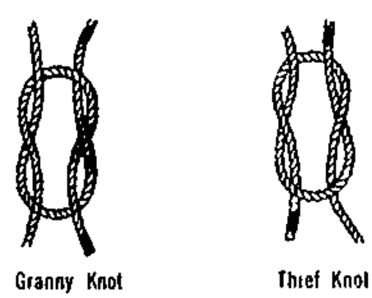


Figure 2-21. Unsafe Knots

n) The bowline knot makes a non-slip loop on the end of a rope. It can easily be untied when the rope is slack. There are two methods of tying a bowline as shown in Figure 2-22.

o) The bowline on a bight is used to make a loop at any point in a rope. It is easily untied and does not slip with a load. The three steps in tying this knot are shown in Figure 2-23.

p) Snubbing refers to taking two or more turns of rope around a fixed object to hold or lower it slowly. To lower the load connected to the upper line, slacken the rope gradually until it starts to slip around the anchor. When slackening the snubbed rope, use both hands in hand-over-hand fashion. The number of wraps around an anchor needed to hold a load cannot be given exactly, but if in doubt add one extra wrap. Figure 2-24 shows the wrong and right ways to snub a rope.

Keep hands away from the pinch-point of the line (where the rope touches the anchor).

The load can be held in any position by properly snubbing the hitch as shown in Figure 2-25.

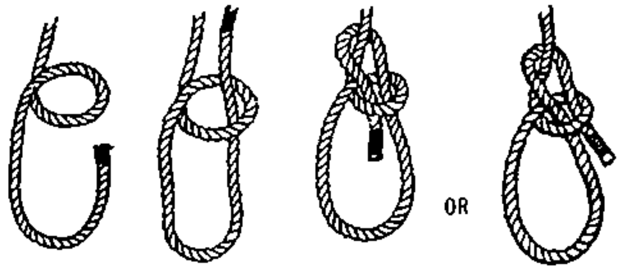


Figure 2-22. Two Methods for Tying the Bowline Knot

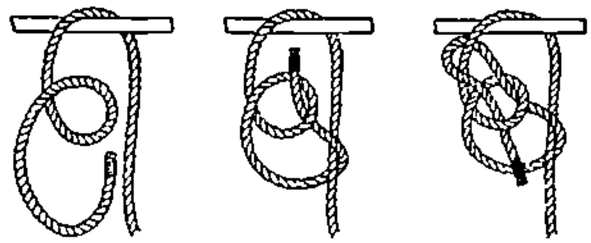


Figure 2-23. Assembling the Bowline on a Bight

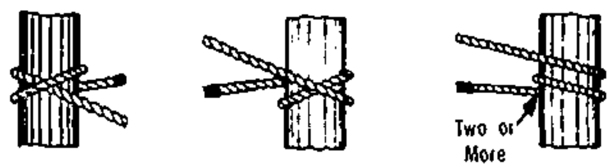


Figure 2-24. Correct Method for Snubbing

7. Fibre Rope Slings

a) A rope sling is a length of rope spliced to form an endless loop, or a length of rope with an eye spliced in each end.

b) Rope slings are very flexible and have good frictional holding ability when choked around a smooth object such as a pipe.

c) Rope slings should not be used to lift objects with sharp edges, or where the object will hit a sharp corner or plate edge.

8. Relative Strengths of Line, Splice, and Knots

Straight rope	100%	Clove hitch	60%
Eye splice	80-90%	Square knot	50%
Timber hitch	65%	Overhand knot	45%
Bowline	60%		

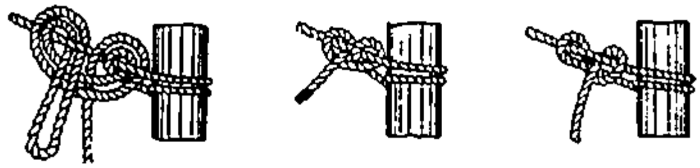


Figure 2-25. Use of Snubbing Hitch

9. Rope Blocks — Fibre Rope

a) Rope blocks are generally used only for light lifting (45 kg to 136 kg).

b) They are light, easily carried, easily put up and taken down, and can be used to lift on a long vertical distance.

c) The mechanical advantage is estimated as being equivalent to the number of ropes supporting the bottom block, disregarding friction. The force applied to the fall line, multiplied by the number of ropes supporting the bottom block, should give the load that can be lifted.

d) Friction loss is not considered, but in actual application it will amount to roughly 10 per cent or more, depending on the construction and mechanical condition of the sheaves. The 10-per-cent loss is for each sheave in a set of blocks.

e) Examples of rope blocks are shown in Figure 2-26.

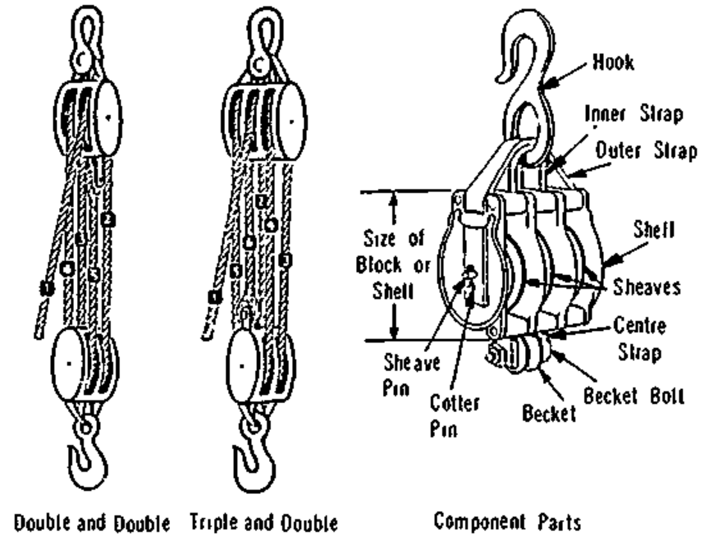


Figure 2-26. Two Types of Rope Blocks and Their Components

10. Ladders and Scaffolding

Ladders

a) All ladders must conform to the Workers' Compensation Board regulations.

b) Figure 2-27 shows some types of ladders that plumbers may need.

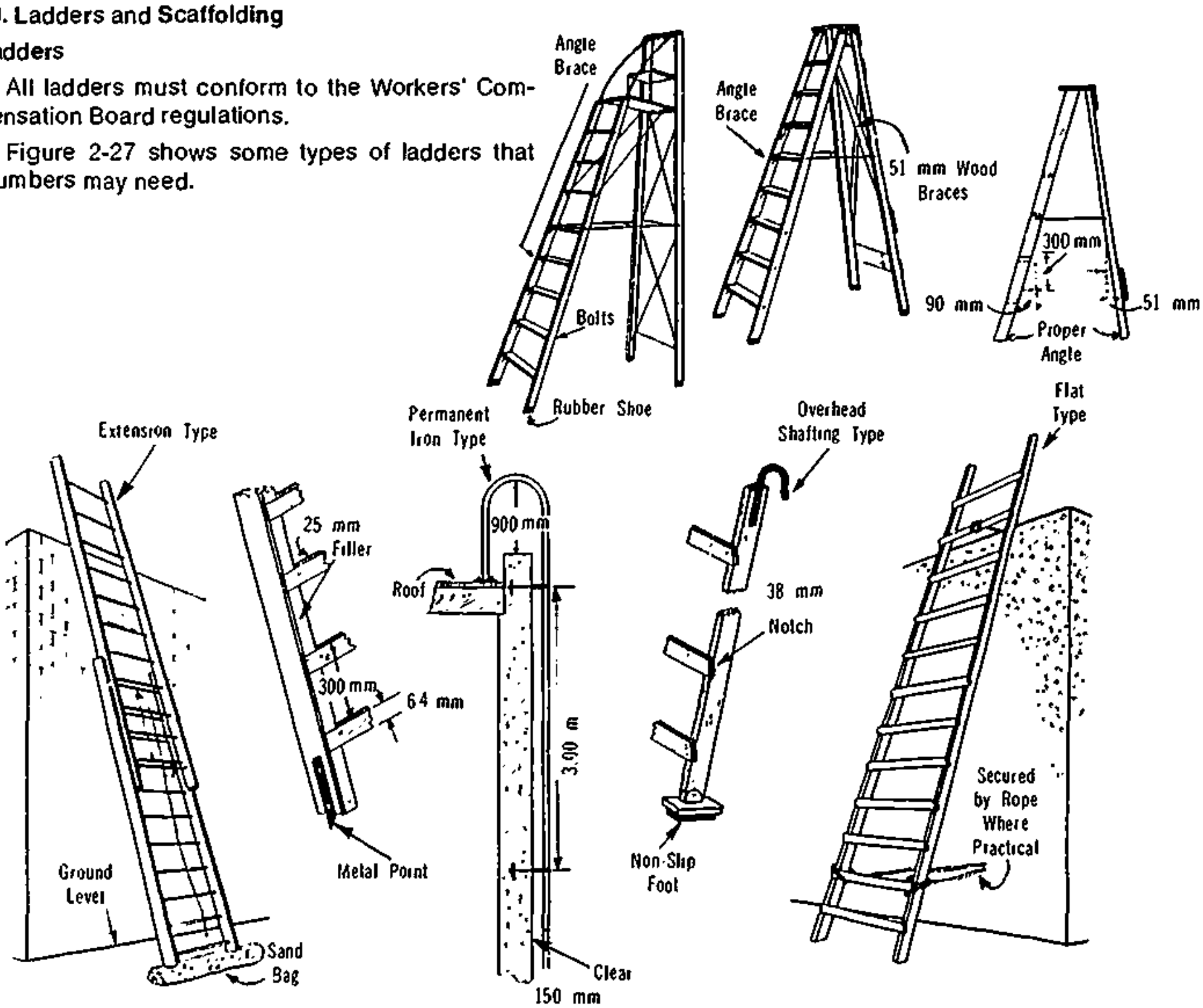


Figure 2-27. Types of Ladders

c) Before climbing a ladder, check the following points to ensure your safety:

The ladder must be of an approved type.

The side rails and rungs must be free of cracks and broken or missing parts.

The ladder must have safety feet in good condition, or be braced against a weight or an immovable object, as illustrated in Figure 2-28.

The top of the ladder should rest firmly against an object so that both rails are touching it. The top should also be fastened in case you need to reach sideways. The ladder should not be set up with too steep or too flat a pitch, but should conform to the sketch details in Figure 2-29. The legs of a step ladder should be fully extended.

d) Portable ladders should be carefuly handled, and when not in use they should be correctly stored. Wooden ladders should be stored in a dry location, but not close to extreme heat such as that of steam pipes or radiators.

e) Ladders should be carefully checked at intervals and defects repaired or the ladder replaced.

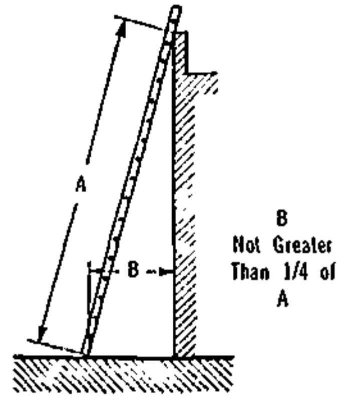


Figure 2-29. Correct Positioning of Ladder

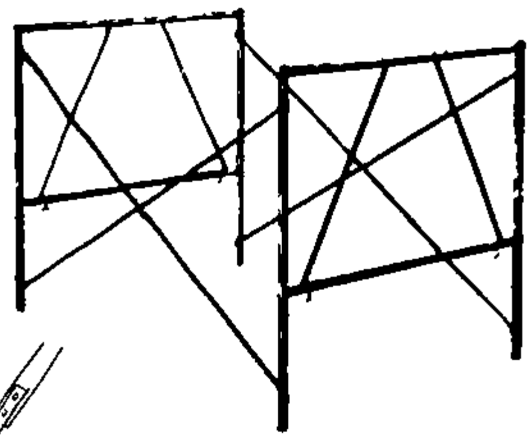


Figure 2-30. Typical Metal Scaffold

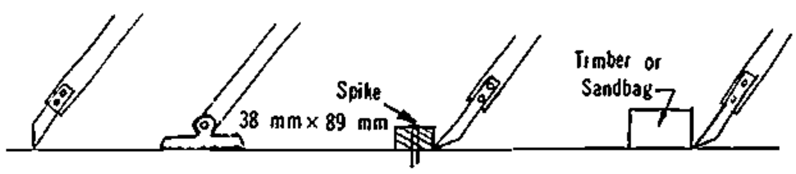


Figure 2-28. Correct Bracing for Ladders

Scaffolding

a) Scaffolds of all types must conform to requirements of the Workers' Compensation Board regulations.

b) Approved sectional metal scaffolds are light, portable, and easily assembled, and they can be taken down with a minimum amount of time and tools; but their erection must be plumb and level according to the manufacturer's instructions. A typical metal scaffold is shown in Figure 2-30.

Sectional metal scaffolds are also made so that a section may be placed upon another to give the required height. Additional bracing is sometimes required.

c) Plumbers are not normally involved in the erection of high wooden scaffolds, but often might have to erect simple scaffolding as shown in Figure 2-31. The scaffold must conform to Workers' Compensation Board regulations in all respects, including the sizes of lumber used for legs, braces, and planks; as well as conforming to requirements governing fastening devices and safety features.

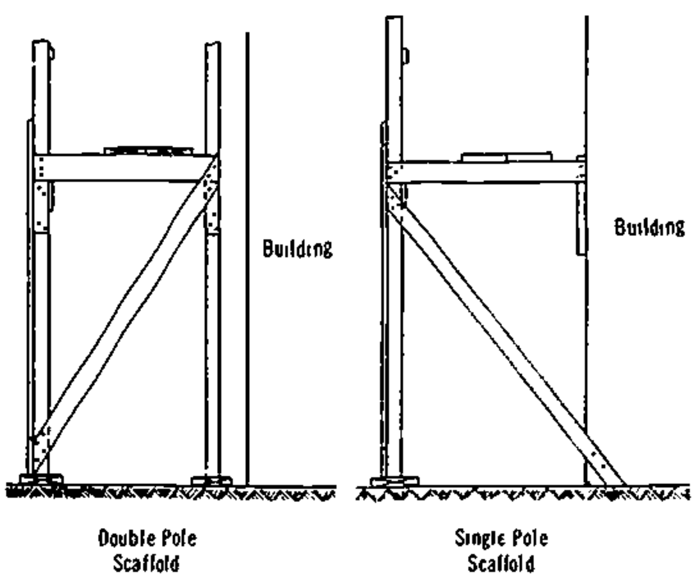


Figure 2-31. Two Scaffold Configurations

Figures 2-31 to 2-33 show examples of scaffold construction that must conform to Workers' Compensation Board regulations.

d) The minimum size, maximum span, and minimum overlap for scaffolding planks must conform to the Workers' Compensation Board regulations. The Figure 2-33 sketches describe the overlap of scaffold planks.

Scaffolding planks should be tested frequently with four times the intended load.

e) The trestle scaffold is a type of movable scaffolding and is very useful when it is required to move the scaffold below pipelines, or for servicing suspended equipment. A typical trestle scaffold is shown but all trestle scaffolds must conform to requirements of the Workers' Compensation Board regulations.

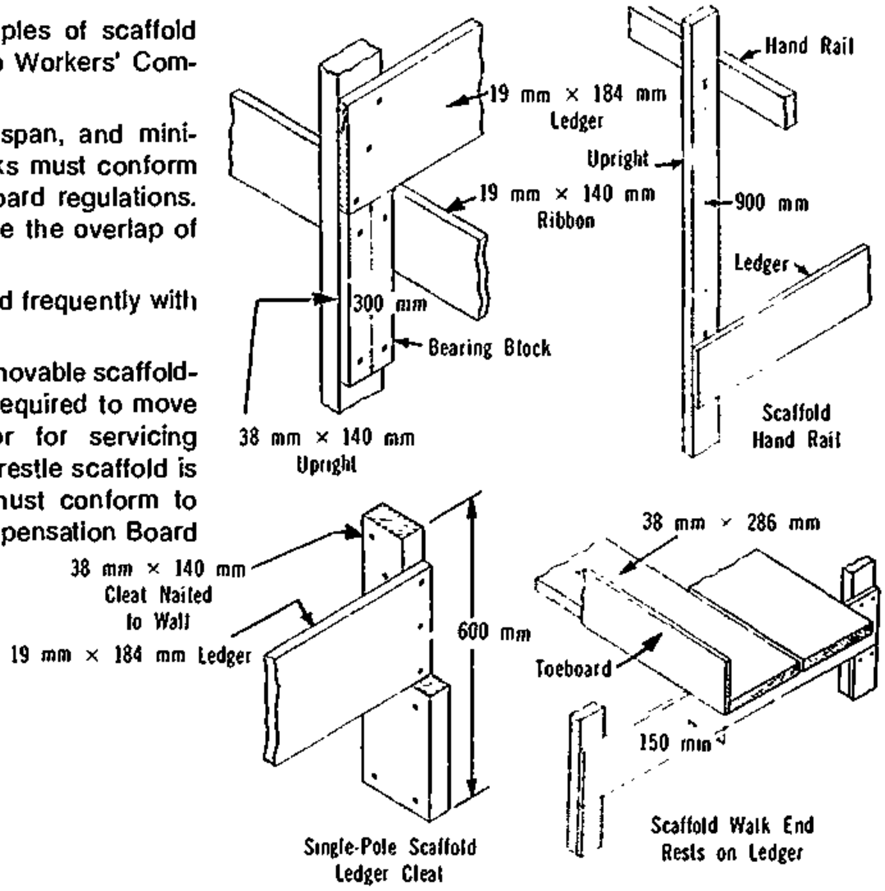


Figure 2-32. Examples of Scaffold Specifications

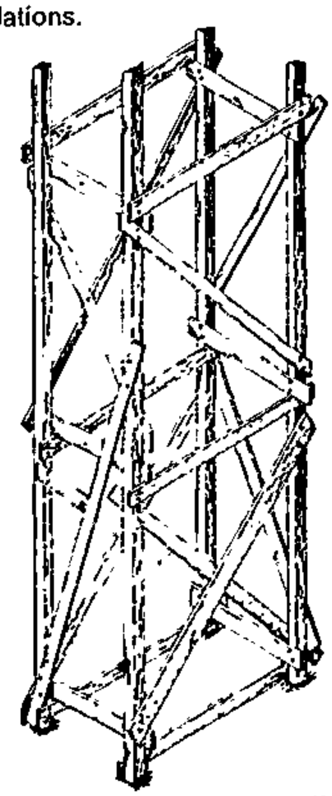
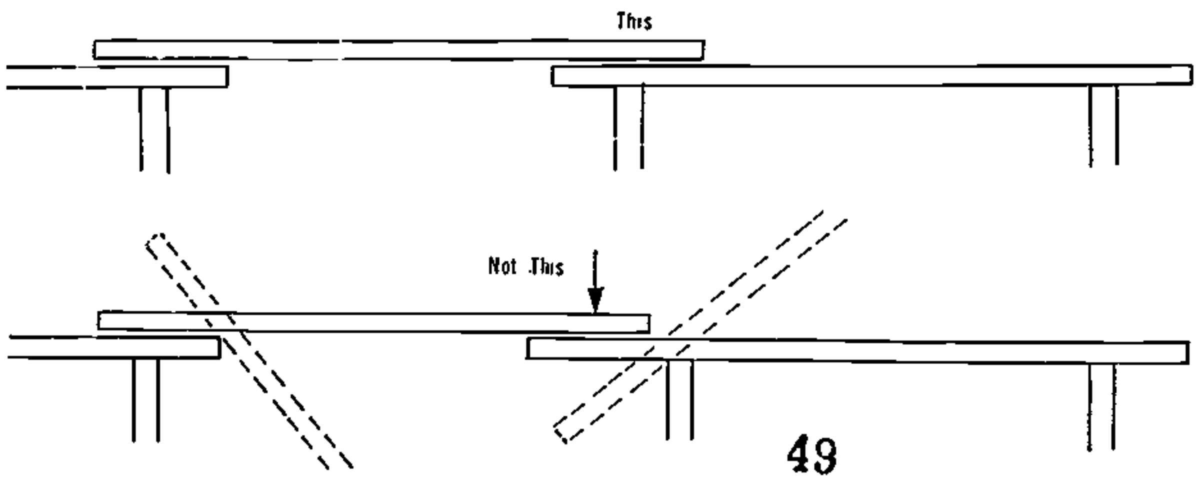


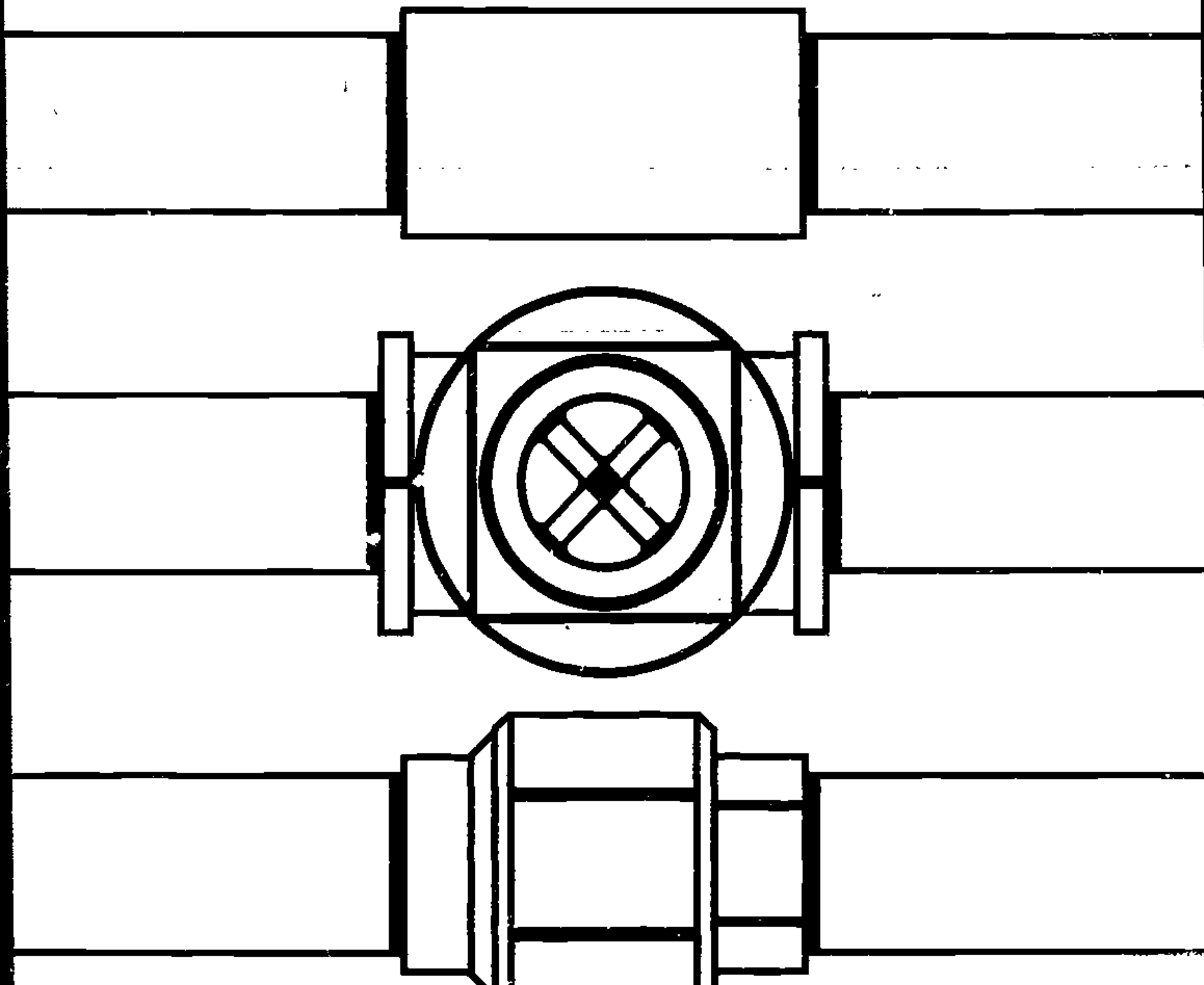
Figure 2-34. Trestle Scaffold

Figure 2-33. Plank Overlapping



Safety Practices, Flammable Materials, and Torches

3



Fire and explosions are among the greatest boons to mankind, but they remain assets only so long as they are controlled.

An accident on the job could wipe out all benefits of your trade education. This part of the manual therefore deals with general safety in the plumbing and allied trades, but does not alter or supplant regulations of local, provincial, and federal authorities.

Safety rules and tips applicable to a specialized area of skill are included in that particular part of the manual.

1. Dust, Explosion, Plastic Fumes, Paint-Spray Mist

a) Although liquids, vapors, and gases are usually associated with explosions, another equally powerful danger is dust or fine-powdered particles of working materials.

Dust is injurious to the lungs, and appropriate masks should be worn on dust-making or dust-collecting work. Dust also enters bearings and moving parts of machinery and has a wearing, or abrasive, action.

b) No direct-fired furnaces or heaters, but only explosion-proof electric motors, should be used in dust-laden or misty areas. Once again, adequate natural or induced-draft ventilation must be maintained.

c) The operation of combustion-type engines or motors in confined spaces exposes you to carbon monoxide poisoning. All exhausts therefore must be carried into the open air.

d) Many obnoxious and injurious gases, such as those from the ignition of synthetics and plastics, sink to differing levels and induce immediate paralysis. Constant vigilance is essential.

2. Noise and Personal Protection

a) The plumber working on commercial and industrial jobs is subject to noise assault from tools, equipment, or manufacturing processes. Ear muffs or plugs must be worn under these conditions.

b) Hardhats are mandatory on all new construction work and wherever others are working above you.

c) Steel-toed boots are essential when moving materials or tools.

d) Leather jackets are essential for welding wherever sparks are generated, as well as gloves adequate for the material weight and the type of work.

3. Storage, Handling, and Use of Flammable Materials

Definitions

a) Flammable liquid is any liquid that has a flash point below 60°C. Flammable liquids are divided into two classes:

Class 1 liquids include those having a flash point below 38°C.

Class 2 liquids include those having a flash point at or above 38°C but below 60°C.

b) *An approved safety can* is a metal container having a pouring spout with a tight-fitting, spring-closed cap that also provides an emergency vent when the can is exposed to fire or other heat sources. The can must bear the listing label of the Underwriters boratories or the Factory Mutual Laboratories.

c) *An approved portable container* is a metal container designed for the storage of flammable liquids, with tight-fitting screw caps and gaskets that will not deteriorate from contact with gasoline and related products. Included in this definition is an approved safety can.

Special Precautions

Additional precautions are needed for the safe storage, handling, and use of liquids having one or more of the following properties:

a) Unusual burning characteristics.
b) Subject to self-ignition when exposed to air.
c) Highly reactive with other substances.
d) Subject to explosive decomposition.
e) Other special properties that call for appropriate safeguards.

Storage

a) Flammable-liquid containers and storage cabinets should not be located near exits, stairways, or other areas used by people. Storage facilities generally require approval of the local assistant fire marshal.

b) Where required for ready use, quantities of flammable liquids not exceeding 23 L may be stored in buildings but must be in approved safety cans.

c) Containers must be painted red, with the name of the contents stencilled or painted on the side in a contrasting color.

Handling

a) Dangers associated with the dispensing and handling of flammable liquids with a low flash point must be brought to the attention of all concerned. Flammable liquids must not be handled, drawn, or dispensed where flammable vapors may contact a source of ignition.

b) Owing to the volatility of flammable liquids with a low flash point, extreme caution must be taken when transferring them from one container to another or when fuelling blow torches, firepots, etc. Fuelling should not be done inside buildings. One litre of gasoline will produce about 156 L of pure vapor under normal conditions, and when diffused into the air this quantity of vapor could produce about 12.5 m^3 of explosive mixture.

Cleaning Solvents or Agents

a) Class 1 flammable liquids must never be used as a cleaning solvent or agent.

b) Suitable non-flammable solvents should be used whenever practical. Where circumstances do not permit their use, a class 2 flammable liquid such as Varsol may be substituted. The dangers of these so-called "safety solvents" must be clearly understood so that ordinary precautions are observed when handling them. When heated to their flash point, they produce vapors as flammable as those of gasoline and often with a greater explosive range

c) Solvents and solvent vapors are toxic in varying degrees. Adequate ventilation is therefore necessary to keep the vapor concentrations within safe limits.

Portable Plastic Containers

Portable plastic containers up to 23 L capacity that comply with the appropriate Canadian standard have been listed by the Underwriters' Laboratories of Canada. They are not, however, intended as a substitute for an approved safety can as defined in paragraph c) under "Definitions" above. These plastic containers are listed for outdoor use only and therefore should not be used indoors for the storage or handling of flammable liquids.

Housekeeping

a) Rubbish and waste are frequently classed as fire causes, although (except in cases of spontaneous ignition) they do not actually cause the fire but merely furnish tinder for ignition by small sources of heat and provide fuel for the spread of incipient fires. The maintenance of a high standard of cleanliness and order is therefore a basic element of fire prevention.

b) The lack of cleanliness in lockers and their use for storing waste are definite fire hazards, particularly when stored waste includes paint-smeared oily rags or cloths that cause spontaneous combustion.

c) Oily waste and clothing, wiping rags, sawdust, and lint are highly dangerous, particularly if soaked with oils subject to spontaneous ignition. A standard waste can bearing the label of the Underwriters' Laboratories or the Factory Mutual Laboratories should be used. Cans containing oily waste should be emptied daily, and wiping rags kept in covered containers should be laundered promptly.

4. Types and Uses of Fire Extinguishers

a) Place the fire extinguisher where it is easily accessible and centrally located.

b) Identify each fire unit for the type of fire for which it is designed.

c) Extinguishers should be located neither too high nor too low, but approximately 1.5 m from the top of the extinguisher to the floor.

d) *Stored-Pressure Water Extinguishers.* Uses: paper, wood, and rubbish fires. Since these extinguishers contain water they should be protected against freezing temperatures.

e) *Cartridge-Operated Water Extinguishers.* Uses. paper, wood, and rubbish fires, etc. The operation of this extinguisher is simple — gently bump the top against the floor and a 12 m stream of water starts immediately. This extinguisher also must be kept in a heated area because it contains water and will freeze.

f) *Stored-Pressure Anti-Freeze Extinguishers and Cartridge Anti-Freeze Extinguishers.* Uses paper, wood, and rubbish fires, etc. These extinguishers are stored pressure with instantaneous action for all class A fires. To operate, pull the pin and squeeze the lever. A 14 m stream is immediately projected. These extinguishers can be used in outside areas because they will not freeze The cartridge anti-freeze extinguisher is also used by gently bumping the top on the floor, which causes the extinguisher to throw a 14 m stream.

g) *Clear-Water/Anti-Freeze Pump Tanks.* Uses: paper, wood, and rubbish fires, etc These tanks can be loaded with either clear water or a freeze-proof charge that is protected for a temperature as low as −40°C. To operate, place one foot on the support at the base, take the hose in one hand and pump with the other. A stream of 12 m to 15 m is discharged immediately.

h) *Soda-Acid Extinguisher.* Uses: paper, wood, and rubbish fires, etc This extinguisher is recharged with a soda-acid kit. To operate, take the hose in one hand, point it at the top of the extinguisher and hold the top ring handle in the same hand. Invert the extinguisher by holding the handle across the bottom in the other hand. Gas is internally generated when the extinguisher is inverted, metering acid into the soda-acid water solution. This expels a stream of fire-killing solution 12 m to 15 m.

i) *Cartridge-Operated, Stored-Pressure Chemical Extinguisher* Uses. flammable liquids and electrical fires To operate this cartridge-type extinguisher, simply invert and bump the cartridge, piercing the mechanism, then control the stream of powder with the release-squeezing valve on the hose.

j) *Vapor, Hand-Pump Extinguisher.* Uses: flammable liquids and electrical fires. This extinguisher can be used either indoors or outdoors. However, its use is not always advisable because of the accumulation of fumes after use. Common sense must be exercised when positioning this type of extinguisher. Because it will not freeze, it makes a good all-round extinguisher and can be easily adapted to field equipment. Simply turn the handle and pump, and an 8 m to 9 m stream will be expelled at any angle.

k) Chemical-Foam Extinguisher. Uses: wood, paper, and rubbish fires, etc. A chemical-foam extinguisher provides protection against flammable liquid such as oil, paint, and varnish, as well as against wood, paper, and rubbish fires. When inverted, the extinguisher generates pressure that expels a 9 m stream. It is very easy to operate: simply turn it upside down and you get a full stream.

l) *Carbon Dioxide Hand-Portable Extinguisher.* Uses. flammable liquids and electrical fires. These extinguishers are excellent in field crews or industrial plants because they are very easy to operate and the carbon dioxide will not damage or injure machinery or equipment. Carbon dioxide is a clean, dry, odorless gas that smothers a fire instantly. To operate, just pull the pin and direct the stream.

NOTE: The fire extinguishers described above are cited for the express purpose of familiarizing present and future supervisors with the type of fire equipment on their particular job sites.

5. Propane and Acetylene Torches

Blow torches and firepots have not been included in this manual because they are no longer in general use in the plumbing trade. Plumbers who still use this equipment should, of course, follow the particular manufacturer's instructions on safety and use. There are, however, several makes of propane and acetylene torches, space permits the description of only the following representative types.

6. TurboTorches

a) TurboTorch, manufactured by Wingaersheek Inc., is one of the most commonly used torches in the plumbing trade. The following instructional information was adapted from the manufacturer's catalogue. The term Total LP is a trademark of the company.

b) Until 1967, all torches were of the secondary-combustion type, which means the combustion took place beyond the end of the tip in the ambient air. The efficiency of this type of flame is poor because of the low rate of combustion and loss of heat through inability to direct the available heat on target.

c) In 1967, after much research utilizing knowledge gained from development of the gas-turbine engine, Wingaersheek introduced its TurboTorch (Figure 3-1), the first swirl-combustion torch and the first propane torch to use primary swirl combustion.

d) Metered pressured gas is mixed with the combustion air, which is drawn by the venturi through the air-intake holes at the base of the tip. The gas mixture, after passing through the venturi and the mixing chamber, is then swirled into the flametube by a stationary helical-blade rotor similar to the blades in a gas turbine. Combustion takes place inside the flametube (Figure 3-2). The expansion of the gases in combustion creates a high-velocity swirl flame with very rapid heat transfer to the target.

e) This revolutionary propane swirl torch surpassed the target heats of even the air-acetylene torches then available, and opened up many new uses for the single gas torch. The TurboTorch manufacturer then applied this new swirl principle to air-acetylene and doubled the effective heat of the old style air-acetylene torches that had dominated the industry for many years.

f) In keeping with development of the new gases being developed and introduced in the LP field, the company perfected the Total LP torch that functions on all LP gases. This one torch eliminates the need for a series of torches, each designed for a different gas.

The adjustable regulator can be set for each LP gas at the correct pressure needed. The torch kit operates with any tank equipped with a standard POL fitting.

g) The new Total LP is ideal for soft soldering and silver soldering, as well as for general heating of copper tubing and steel pipe. By utilizing propane as a fuel, it produces a target heat of about 980°C, a very satisfactory heat range for plumbing rough-in and soft soldering of copper tubing.

h) Total LP TurboTorches have the capability of using the hotter high-energy gases for maximum heat, and the capability of using oropane for economy where high heat is not necessary.

i) The Total LP Torch Kits work in conjunction with the lightweight TurboTanks, eliminating the need for the heavy and non-portable acetylene and oxygen tanks.

j) In comparison with acetylene, in using the Total LP torch one 3.4 kg tank of LP gas will last as long as 3½ "B" tanks of acetylene.

The lightness of the LP tanks (6.6 kg), compared with a B tank of acetylene at 14.5 kg, makes it easier to handle. The LP gases are also more stable and safer than acetylene.

k) The Total LP TurboTorch, with the high-energy LP gases such as Mapp*, can produce target heats in excess of 1260°C, which will easily allow bronze brazing, silver soldering, and repair work where a higher heat is necessary.

*Mapp is a registered trade name, as are Abachi, HP, and Flamex gases.

l) "Target heat" is the effective heat in a torch flame that can be applied directly to the target (Figure 3-3). By comparison, the total heat (flame temperature) of a propane-air flame is 1900°C. If all this heat could be applied to a target, it would be sufficient to melt steel, whereas an air-propane flame directed from a torch cannot melt steel. The TurboTorch system has a target heat of 950°C, about 370°C hotter than the target heats of secondary-combustion propane torches. Likewise, TurboTorch acetylene target heat is 1500°C or about 650°C hotter than the old secondary combustion acetylene torches.

The Acetylene TurboTorch

a) The acetylene TurboTorch is designed for soldering and brazing. TurboTorch acetylene employs a small concentrated hot flame that is twice as hot as secondary air-acetylene torches.

b) TurboTorch acetylene is particularly designed for the person who needs an intensely hot concentrated flame for jobs such as air conditioning and repair work. It is also very effective on standard plumbing jobs where speed is important. In most cases it matches the speed of oxy-acetylene torches while actually producing a better brazed joint at one-half the cost and with one-third the equipment.

c) TurboTorch air-acetylene eliminates the need for an extra oxygen bottle, and not only cuts costs but also makes for a much more portable unit for field installations and repairs.

d) TurboTorch acetylene has proven capabilities of soldering copper tubing with water in the line, and of bronze brazing cast iron pipe fittings in the field. Figure 3-1 shows soldering, or unsoldering, with water in the line.

e) TurboTorch offers assembled kits ready to use and to fit varied needs. Accessories to extend the uses of the torches are also available.

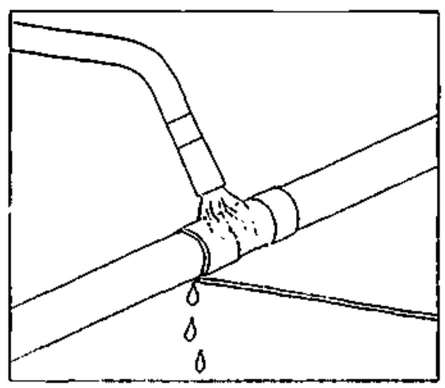


Figure 3-1. TurboTorch in Use

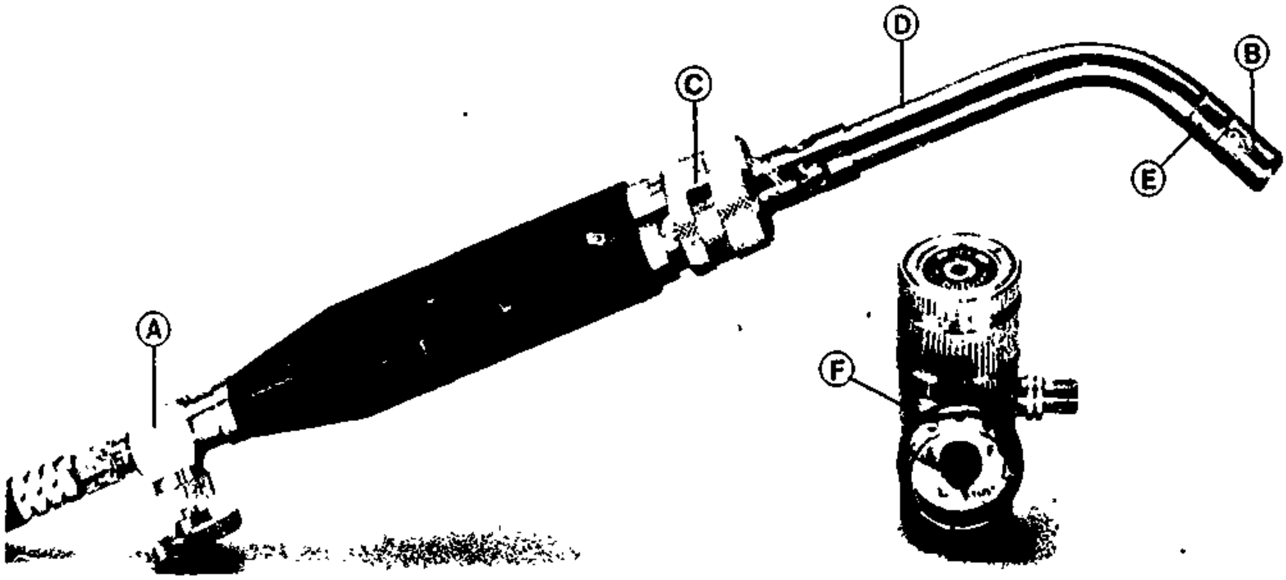


Figure 3-2. Components of the TurboTorch

8. TurboTorch Features

(A) Handle Valve
Instant light-up with positive, quick on-off valve. No adjustment is necessary for a perfect flame.

(B) Swirl Combustion
The swirl combustion introduces a stable blowout-proof flame designed for maximum heat transfer and fuel economy.

(C) Quick Disconnect
The handle has a quick disconnect to speed up changing tips for the exact flame for your target needs. It takes all sizes of tips.

(D) Full Line of Tips
A complete line of tips is available, each designed for a wide range of work. They have removable, cleanable orifices with a cleaning port in the handle for reverse blowout.

(E) Helical Rotor
The carefully machined metal helical rotor provides a better, smoother swirl flame.

(F) Durable Metal Regulators
Regulators with metal cap to prevent breakage and permit field repair. New patented non-diaphragm design.

Figure 3-3. View of Turbo Swirl Looking Into Flametube

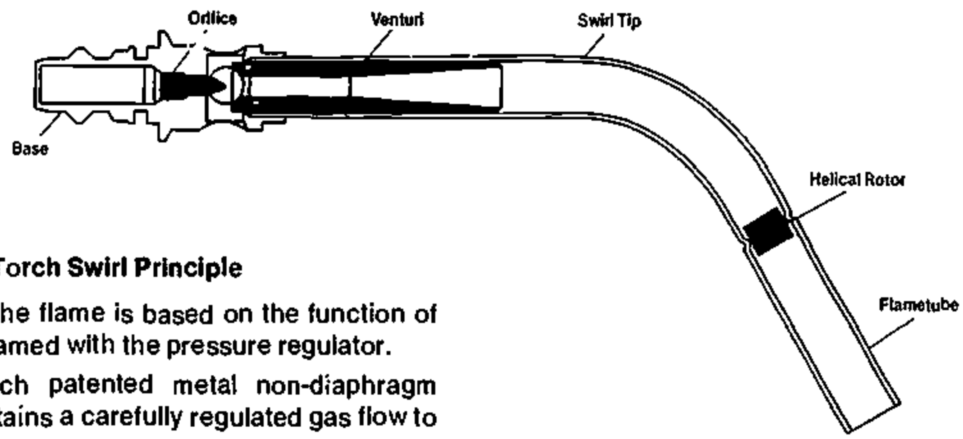


Figure 3-4. **Cross-Sectional View of TurboTorch**

9. The TurboTorch Swirl Principle

The secret of the flame is based on the function of the swirl tip, teamed with the pressure regulator.

The TurboTorch patented metal non-diaphragm regulator maintains a carefully regulated gas flow to the tip.

The removable, cleanable orifice meters the precise amount of pressurized gas to the venturi.

The venturi acts as a jet pump and pulls in the exact amount of air through the air intakes to form a perfect mixture of gas and air in the mixing chamber.

This pressurized gas-air mixture is then forced through the helical rotor, which swirls the gas-air mixture as it ignites into the flametube. At the same time, the non-combustible gases are centrifuged to the outside of the flame, insulating it from any cooling effect by the flametube itself.

This combination of combustion within the flametube and velocity created by expansion effects a heat transfer to the target. The manufacturer claims that this combustion makes TurboTorch the most effective heating and brazing torch ever developed.

Turbo combustion produces an exceptionally stable flame that cannot blow out even in hurricane-force winds. The flame has a wrap-around effect with no feather, resulting in heat concentration on the target with none on the surrounding areas.

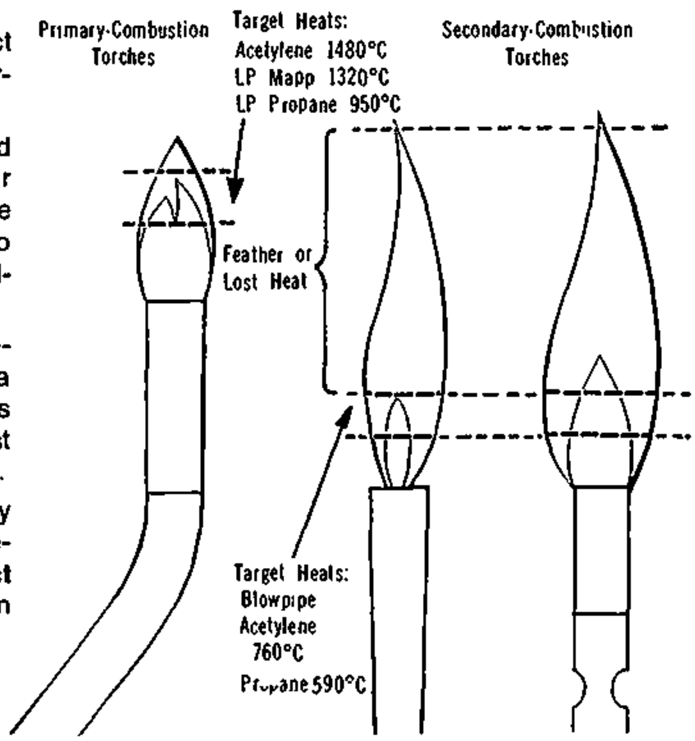


Figure 3-5. **Primary and Secondary Combustion Torches**

10. Table 3-1. "Total LP" Torch Tips

Tip No.	Tip Size (mm)	Gas Flow 165 kPa (kg/hr)	Gas Flow 247kPa (kg/hr)	Copper Tubing Size Capacities: Propane 165 kPa Soft Soldering (NPS)	Propane 165 kPa Silver Soldering (NPS)	Mapp Gas 247 kPa Soft Soldering (NPS)	Mapp Gas 247 kPa Silver Soldering (NPS)
T-2	7.9	0.06	0.08	⅛ to ⅜	1/16 to ¼	1⅛ to 1½	.. to ⅜
T-3	9.5	0.09	0.11	¼ to 1	⅛ to ¾	⅜ to 1½	¼ to ⅝
T-4	12.7	0.18	0.22	⅜ to 1½	¼ to ⅝	⅜ to 2½	¼ to 1⅜
T-5	19.0	0.50	0.59	1 to 2½	⅝ to 1⅜	1 to 4	⅜ to 2⅛
T-6	25.4	0.95	1.13	1½ to 4	⅞ to 2⅛	1½ to 6	⅞ to 4
T-8	41.4	2.86	3.40	To 6	2⅜ to 6	To 8	2⅜ to 8

Note. To find kJ—Propane Gas: Gas flow (kg/hr) x 50.7 = kJ
—Mapp Gas: Gas flow (kg/hr) x 48.8 = kJ

11. Table 3-2. Acetylene Torch Tips

Tip No.	Flame Size (mm)	Gas Flow 100 kPa (m^3/hr)	Copper Tubing Size Capacities: Soft Soldering (mm)	Silver Soldering (mm)
A2	4.6	0.06	3 to 16	3 to 13
A3	6.4	0.10	6 to 25	3 to 9
A5	7.9	0.16	19 to 38	9.5 to 22
A8	9.5	0.24	25 to 50	16 to 29
A11	11.1	0.31	38 to 75	22 to 41
A14	12.7	0.41	50 to 90	29 to 54
A22*	15.9	0.63	50 to 75	41 to 79
A32*	19.0	0.94	100 and over	41 to 105

Note: To find MJ—Gas Flow (m^3/hr) x 54.8 = MJ

*Use with large tank only

12. TurboTanks

Part No.	Description
T-6P-MT—Empty	Refillable steel LPG tanks.
T-6P-F—Full *Note:* T-6FP shipped filled with propane.	For use with propane, Apachi, HPG, or Flamex. Standard POL tank fittings, DoT-stamped 2.7 kg capacity. Do not refill with Mapp gas.
T-6M-MT—Empty T-6M—Full	Same as above but DoT-stamped for use with Mapp gas. Do not refill with propane.
PT-1	Propane replacement tank for use with TurboTorch Gold Medal Edition HandTorches. Contains 0.4 kg of propane.
MT-1	Mapp replacement tank for use with TurboTorch Gold Medal Edition HandTorches. Contains 0.45 kg of Mapp gas.
SB-1	Propane replacement tank for use with TurboTorch SPY.5 refrigerant leak detector. Contains 0.17 kg of purity propane. Will not operate with HandTorches.

Figure 3-6. Various Types of Gas Tanks and Gases

13. Presto-lite Gas Tanks and Soldering Equipment

a) Tanks

Presto-lite tanks come in two sizes: the one commonly referred to as the "B Tank" holds 1130 L of Presto-lite gas. The smaller tank known as style "MC" holds 280 L. (See Figure 3-7.)

Presto-lite gas is pure acetylene containing 92.3 per cent carbon. When burned in appropriate equipment, this gas produces the hottest gas flame known to science. In burning, the Presto-lite requires no oxygen cylinder, since all the oxygen needed to support combustion is drawn from the air. This air is mixed with the acetylene in the torch in the same manner as air is mixed with the gas in a kitchen range. When the air-acetylene mixture is ignited at the torch tip it produces a flame with a temperature of about 2200°C, which is ample heat for almost all silver-soldering jobs, brazing jobs, and for all the soft-solder work in the plumbing field.

The air-acetylene flame produced by Presto-lite is concentrated and easy to control and intensely hot, much hotter than the manufactured gases such as butane or propane, natural gas, or gasoline. There are no objectionable fumes whether the torch is used indoors or outdoors.

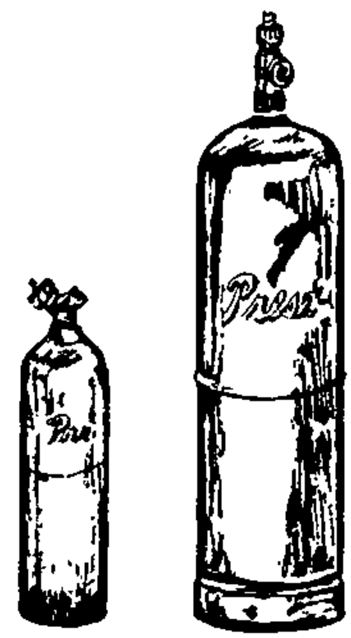


Figure 3-7. Presto-lite "B" and "MC" Tanks

The torch is much superior to a blowtorch, etc., as it lights instantly and can be shut off instantly, and there is no pumping or priming as in other torches.

Because Presto-lite fuel will not freeze, it can be used in any kind of weather. The Presto-lite tank is packed with a porous material saturated with a chemical (acetone) that has the peculiar quality of dissolving many times its own volume of acetylene, so there is no free gas in the tank. It is gas dissolved in a liquid, but when pressure is released by the opening of the tank valve, gas comes out of solution and pure acetylene ready for use is delivered.

The pressure inside a fully charged Presto-lite tank at a temperature of about 20°C is about 1.7 MPa At higher temperatures the pressure will be higher and at lower temperatures lower, but these pressure variations have no effect on the quantity of gas in the tank. The amount of pressure change caused by a change in temperature varies according to the amount of acetylene in the tank.

The relationship between temperature and pressure under different conditions is shown in Table 3-3.

Table 3-3. Pressure and Effects of Temperature

Tank Contents	Change in Pressure for a Change of 1°C
Full	31 kPa
¾ Full	25 kPa
½ Full	17 kPa
¼ Full	11 kPa

b) Presto-lite Tips

Presto-lite tips (see Figure 3-8) come in a variety of sizes. The smaller tips are used for small pipes and the larger ones for larger pipes. They can also be used for heating pipe for bending, and for thawing frozen lines. There is a multi-flame tip of a wrap-around type for heating large pipes up to NPS 2. A soldering iron is also available for small soldering copper jobs. Presto-lite handles can be purchased with or without shut-offs. The shut-off is very convenient as it saves the time and effort required to reach the shut-off at the tank.

c) Hose

The Presto-lite hose (see Figure 3-9) is available in 1.8 m, 3.8 m, and 7.6 m lengths. It is one-ply, 4.8 mm diameter and is made by vulcanizing the rubber under pressure into the fabric carcass.

d) Pressure Regulator

Presto-lites should always be equipped with a pressure regulator. The Presto-lites operate at a pressure of 69 kPa; thus, the pressure in the container being 1.724 MPa, the need for a regulator can be clearly seen. It also provides an added measure of protection by safeguarding the hose and connections against full tank pressure.

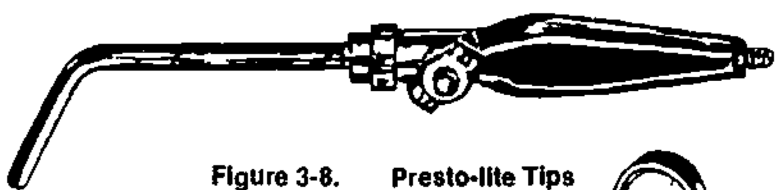


Figure 3-8. Presto-lite Tips

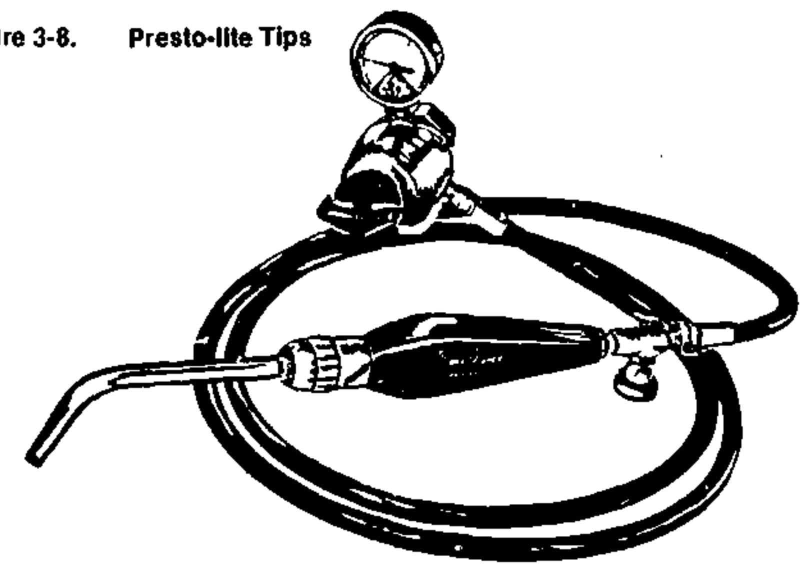


Figure 3-9. Complete Presto-lite Assembly

The pressure regulator is equipped with a pressure-regulating screw for exact adjustment of any delivery pressure from 7 kPa to 90 kPa.

It is also equipped with a fabric-reinforced rubber diaphragm that is very sensitive to pressure changes The gauge shows the gas content at all times (see Figure 3-10).

e) **Pressure Gauge**

A delivery pressure gauge to show working pressure in kilopascals can be added at any time to the pressure regulator if the operator feels the lettered graduation on the shank of the pressure-adjusting screw is not adequate for the need (see Figure 3-10).

f) **Soldering with the Presto-lite**

Make sure the correct size of tip is selected — a number 3 or 4 tip for NPS ½ to NPS 1½ copper pipe.

Make sure the pressure regulator connecting the nut is secure, as well as all hose coupling nuts; then test to make sure there are no leaks. Turn the control all the way on at the pressure regulator.

Open the needle valve on the torch handle slightly and light with a flint lighter.

Adjust the flame to the required amount.

If the flame should blow out, adjust the regulator, but make sure the pressure is right.

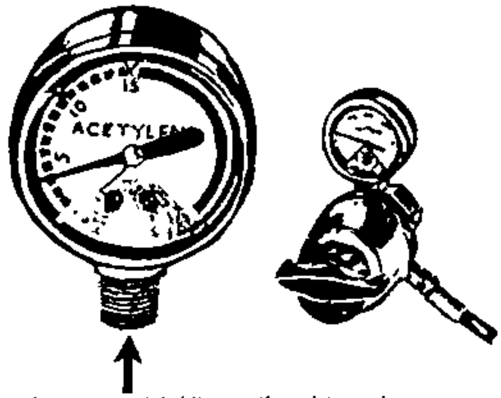
The Presto-lite equipment is now ready for heating the project.

During a temporary work interruption the control should be flicked to the "gas miser" pilot control on the torch valve, or to a low flame on torch handles not equipped with the gas miser. This is done to conserve gas.

When not using the torch for a period, it should be shut off at the regulator to safeguard the hose and connections against full tank pressure.

Do no exert force on the connecting nuts.

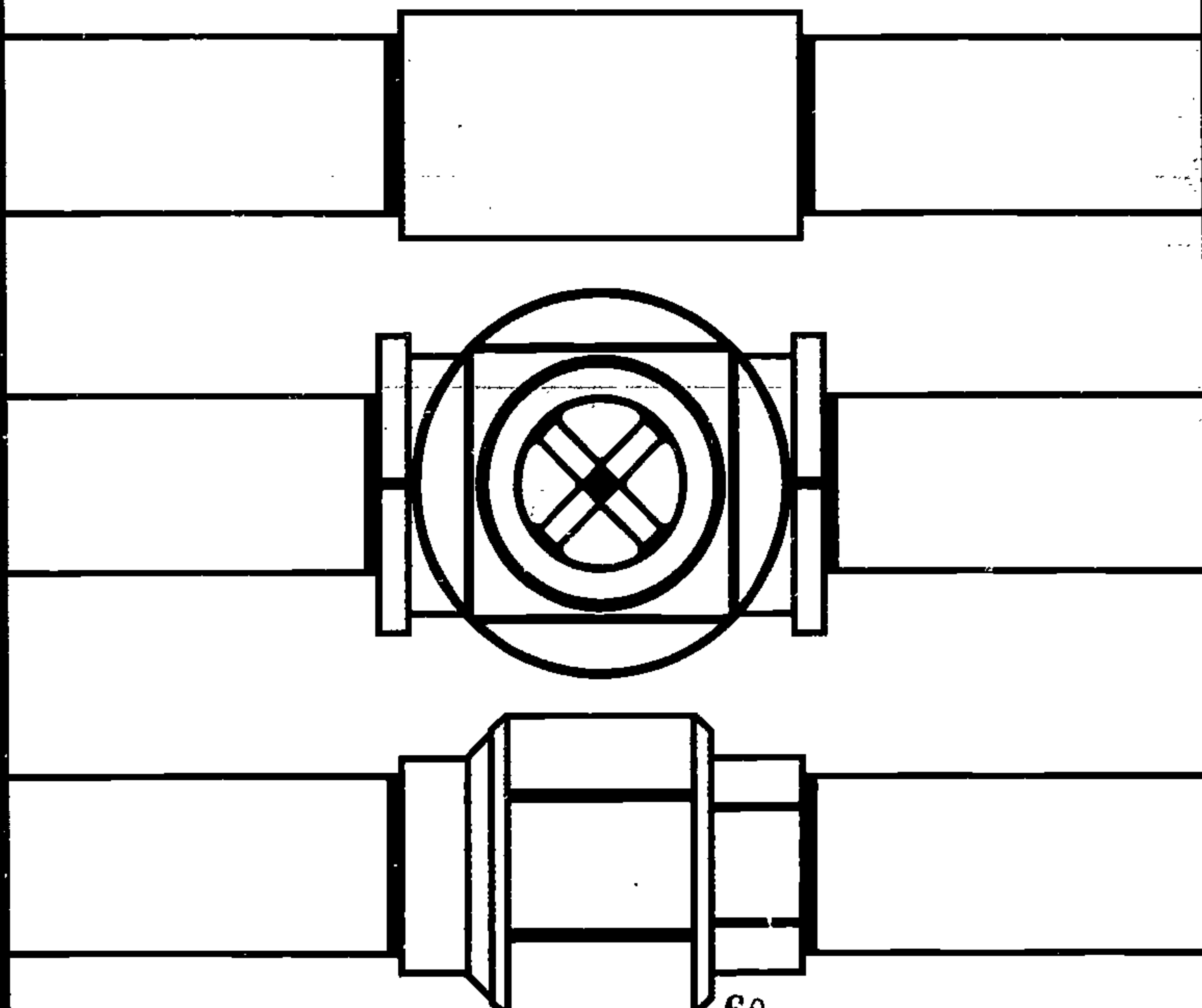
Care must be taken not to bump the pressure regulator nor to allow the hose to come in contact with flame, sharp objects, oil, or grease.



A porous metal filter in the inlet nipple prevents dirt or foreign particles from entering the regulator

Figure 3-10. Pressure Gauge

Cast Iron Soil Pipe, Fittings, and Joints 4



PART 4
CAST IRON SOIL PIPE, FITTINGS, AND JOINTS

1. Cast Iron Soil Pipe

1. Cast iron soil pipe and fittings must conform to the standard specified in the appropriate plumbing code.

2. The former "medium" and "extra-heavy" class designations were discontinued in 1970.

3. Cast iron soil pipe may be used in such places in the drainage and venting systems as are approved by the plumbing code.

4. Cast iron soil pipe and fittings are joined by three different methods:

   a) Mechanical joints.
   b) Compression joint.
   c) Lead caulk joint.

2. Mechanical-Joint Cast Iron Soil Pipe and Fittings (No Hub)

1. Mechanical-joint cast iron soil pipe is made in nominal pipe sizes 50, 75, 100, 125, 150, 200, 250, 300, and 375 mm.

2. This type of cast iron soil pipe is available in 3.0 m lengths.

3. The joints consist of a specially designed butyl rubber sleeve or a neoprene sleeve that fits over the end of the pipe of fitting and is clamped to it with separate stainless-steel screw clamps, or cast iron clamps with stainless-steel bolts and nuts.

4. A few of the different fittings made for this type of pipe are shown in Figures 4-1 and 4-2.

5. The following fittings are not all shown in the figures, but the student must learn to identify them:

   a) Various types of sanitary tees, with and without side inlets.
   b) Combination Y and ⅛ bends.
   c) Y's and double Y's with various types of side inlets.
   d) Tapped Y's and sanitary tees.
   e) Adapters.
   f) Traps, standard and deep seal.
   g) Increasers and reducers.
   h) Cleanouts.
   i) Water-closet flanges.
   j) Back-water valves.

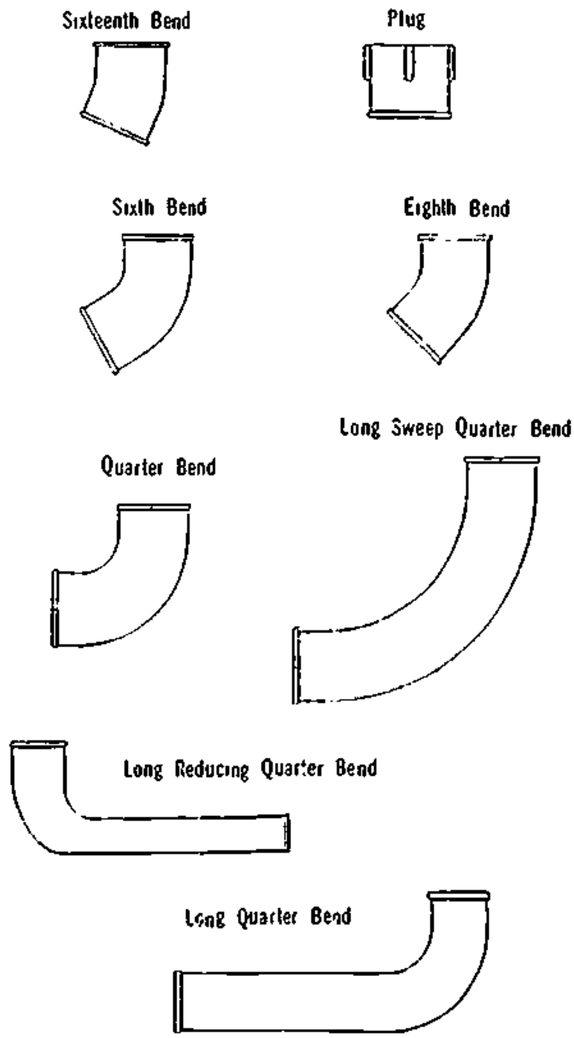


Figure 4-1. Various Pipe Fittings

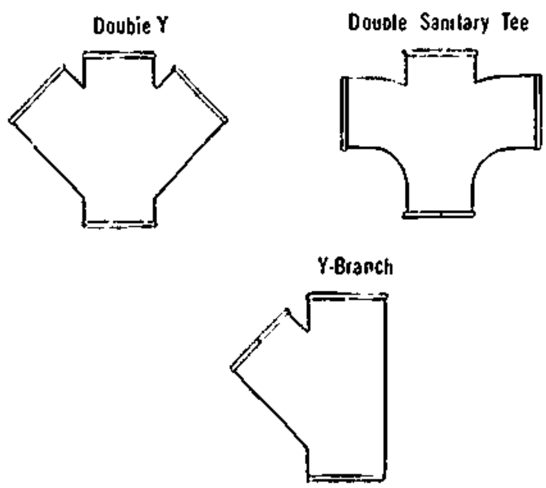


Figure 4-2. Various Pipe Fittings

6. Two of the various types of clamps or couplings used for joining pipes and fittings are shown in Figures 4-3 to 4-6.

7. One other type of sleeve is used to join this type of pipe and fittings. It is a butyl rubber sleeve or a neoprene sleeve that is specially designed in shape and strength to fulfil all requirements of its purpose without the extra sheath.

3. Assembly Instructions for Mechanical Joints

Method 1 for most installations, types 1 and 2:

a) Spread the clamps a few notches if necessary (Figure 4-7).

b) Fit the butyl rubber or neoprene sleeve over the end of the pipe or fitting so that the centre rib butts against the end of the pipe or fitting (Figure 4-8).

c) Fit the pipe or fitting into the sleeve. A partial turn while entering will assist assembly.

d) Tighten the screws to 6 to 7 N.m torque.

Method 2 for confined spaces using type 2:

a) Spread the clamp a few notches (Figure 4-7).

b) Fit the butyl rubber or neoprene sleeve over the end of the pipe or fitting so that the centre rib butts against the end of the pipe or fitting (Figure 4-8).

c) Tighten the clamp slightly over the first pipe.

d) Place the second pipe or fitting into the sleeve. A partial turn will assist assembly.

e) Tighten the screws alternately to 7 N.m torque (Figure 4-9).

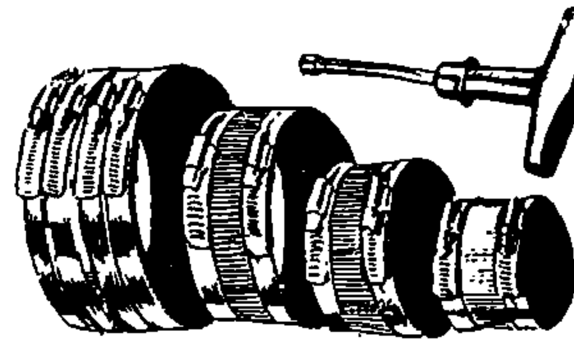


Figure 4-4. Various Clamps with Torque Wrench

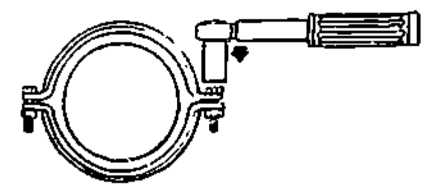


Figure 4-5. Jo-Line 3008 Torque Wrench for Cast Iron Couplings

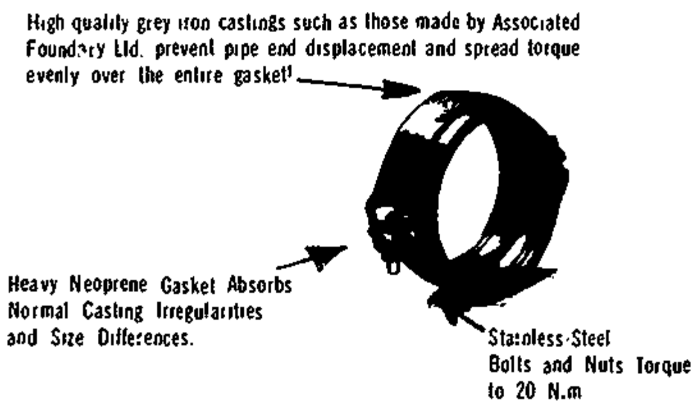


Figure 4-6. Grey-Iron Cast Coupling

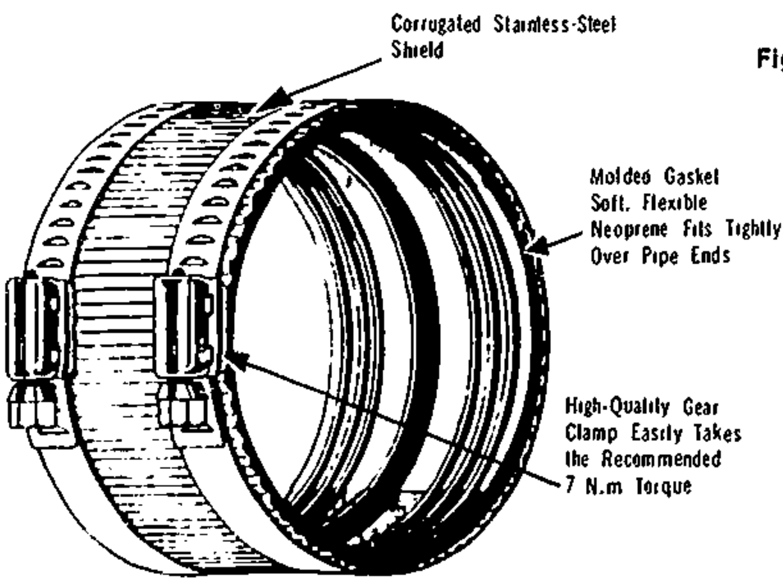


Figure 4-3. Components of Gear-Clamp Coupling

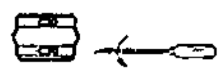


Figure 4-7. Spreading Clamps if Necessary

Figure 4-8. Fitting Elastomer Sleeve

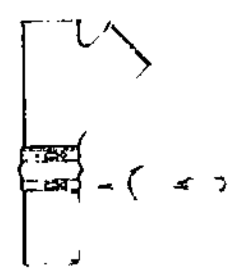


Figure 4-9. Tightening Screws Alternately

Method 3 for confined spaces or for cutting into an existing line using type 1:

a) Separate the stainless-steel sub-assembly (the corrugated sheath and clamps) from the sleeve (Figure 4-10).

b) Place the stainless-steel sub-assembly over the pipe or fitting in readiness for later assemb (Figure 4-11).

c) Fit the sleeve over the end of the pipe or fitting so that the centre rib butts against the end of the pipe or fitting.

d) Roll the protruding end of the sleeve over itself until the centre rib is exposed (Figure 4-11).

e) Position the second pipe or fitting against the centre rib and unroll the sleeve over this pipe or fitting (Figure 4-11).

f) Slide the stainless-steel sub-assembly into a centred position over the sleeve and tighten the clamps alternately to 6 to 7 N.m torque.

4. Cutting Cast Iron Soil Pipe

1. The best way to cut this pipe is with a snap-type cutter, which has sharp, hardened cutting wheels. It is fast and accurate, but it is important that it be maintained in good condition. One type of snap cutter is shown in Figure 4-12.

5. Installation of Hangers and Supports

1. The plumbing code governs the minimum requirements for hangers and supports.

2. Where mechanical joints are used, a double hanger is preferred and sway bracing is recommended. (See Figures 4-13 and 4-14)

3. Vertical pipes should be supported with a substantial clamp as in Figure 4-15. The proper location of the clamps will be specified in the plumbing code.

Figure 4-10. Separating Sub-Assembly

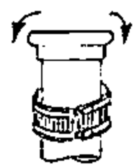


Figure 4-11. Fitting Elastomer Sleeve to Pipe

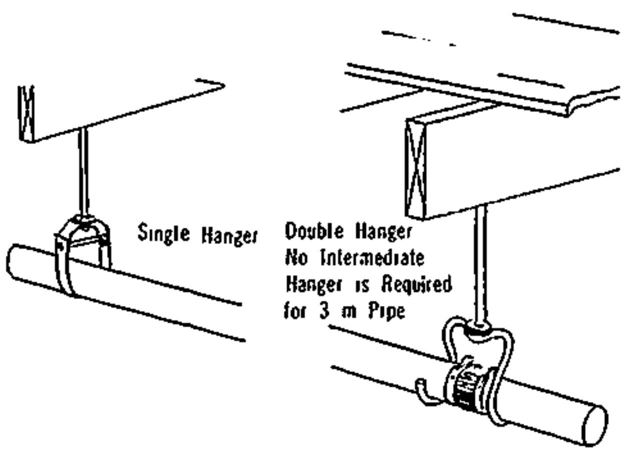


Figure 4-13. Single and Double Hangers

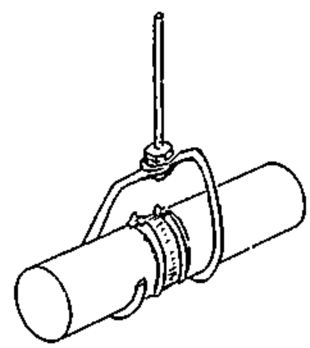


Figure 4-14. Double Hanger for Horizontal Piping

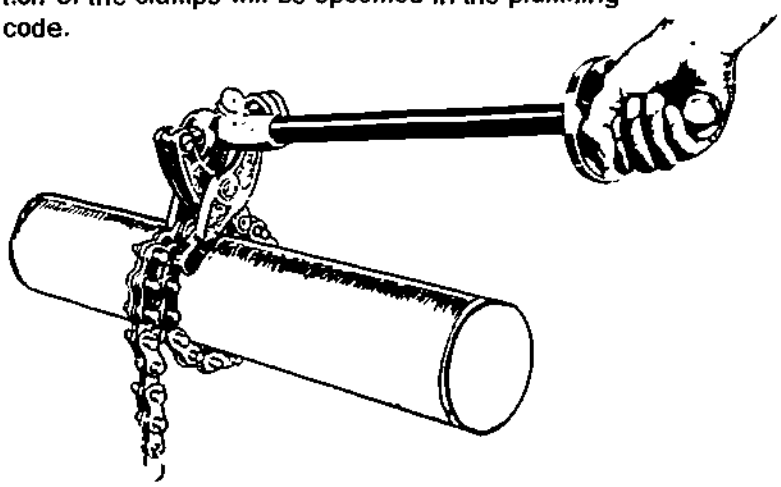


Figure 4-12. Cast Iron Soil Pipe Cutter

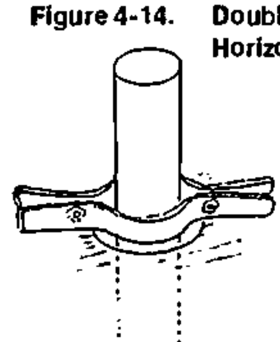


Figure 4-15. Riser Clamp for Vertical Piping

4. Hangers and supports should be designed with enough strength to support the pipes when full of water.

5. When anchors are used, consideration must be given to thermal expansion of the piping and building components so that the piping is not restricted.

6. The cast-on hanger eye on some closet bends (Figure 4-16) lessens installation time and helps to protect against costly blow-outs during tests. Closet flanges are also available with the tie-down assembly bolts (Figure 4-17).

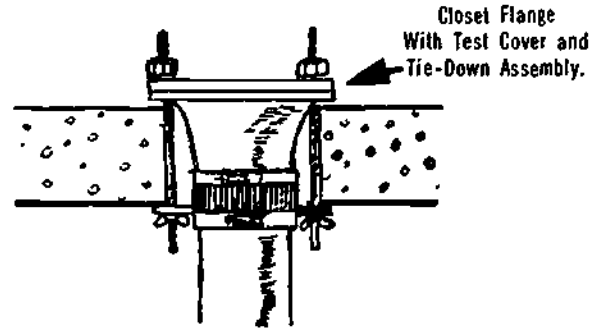


Figure 4-17. Closet Flange Assembly

FOR CONCRETE FLOOR AND SLAB INSTALLATIONS

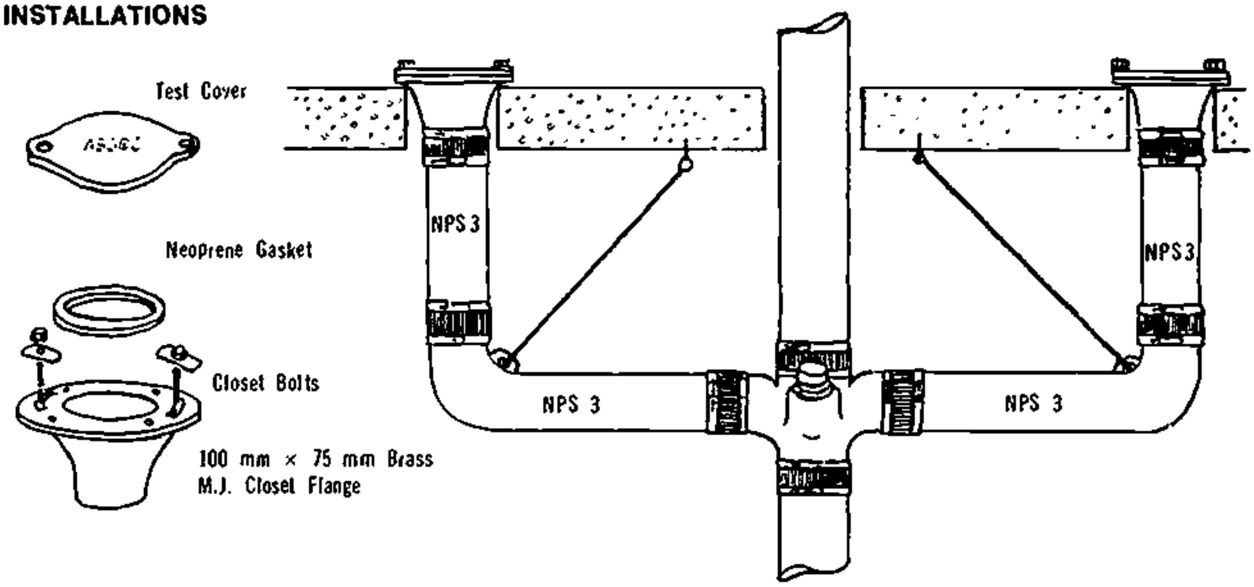


Figure 4-16. Piping Installation Through Flooring

6. Bedding and Backfilling

1. Shoring and working conditions in trenches are governed by regulations of the Workers' Compensation Board.

2. The method of installing and supporting pipes is governed by the plumbing code. Figures 4-18 and 4-19 are only examples.

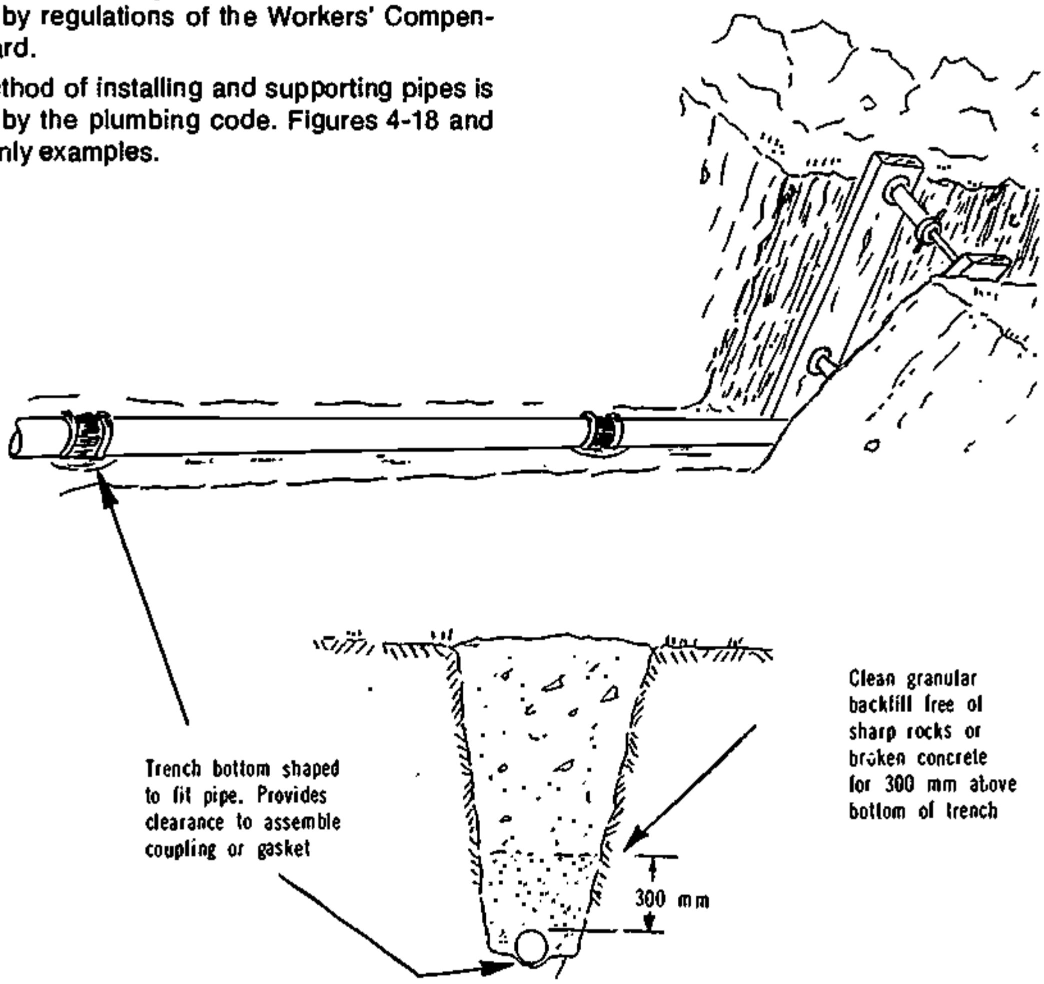


Figure 4-18. Examples of Installing and Supporting Pipes

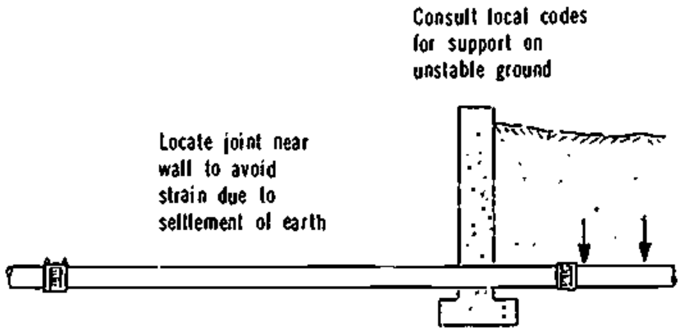


Figure 4-19. Example of Installing and Supporting Pipes

7. Compression-Joint Cast Iron Soil Pipe and Fittings

1. The joint, shown in Figure 4-20, consists of a specially designed, patented gasket pressed into the space between the hub and the barrel.

2. The dimensions of the hub and the pipe are important to the effectiveness of the compression gasket, and the manufacturer guarantees its performance only when the pipe conforms to Canadian standards.

3. A significant feature of both the compression and no-hub, or mechanical joint is that a quiet plumbing drainage system is ensured. The problem of noise is particularly acute in multiple-dwelling units; and although soundproofing has become a major factor in construction design, certain plumbing products not only carry noise but also, in some cases, amplify it. The use of rubber or neoprene gaskets and cast iron soil pipe reduces noise and vibration. Because of the weight and wall thickness of the pipe, sound is muffled rather than transmitted or amplified, and the rubber gaskets separate the lengths of pipe and the units of fittings so that they cushion any contact-related sound.

4. This type of pipe is manufactured in the same nominal pipe sizes as mechanical joint (no hub) cast iron soil pipe.

5. As a rule, pipe is manufactured with only one hub on a length. Lengths are available in at least 1 m, 1.5 m, 1.8 m, and 3 m.

These are the laying lengths as shown in Figure 4-21.

6. Fittings also have hubs and plain spigot ends without a bead.

7. Types of fittings available are similar to those used with mechanical joint (no hub) cast iron soil pipe and include bends of varying degrees, tees, sanitary tees, Y's, combination Y and ⅛ bends, various types of cleanouts, traps, slide inlet fittings, and back-water valves.

8. Cutting Compression-Joint Cast Iron Steel Pipe

1. This pipe is cut in the same manner as a mechanical-joint (no hub) cast iron soil pipe, as illustrated in Figure 4-12 on page 61.

9. Assembly Procedure for Compression Joints

1. A locking chain and pipe coupler, shown in Figure 4-22, are the only tools required to complete the assembly of a compression joint.

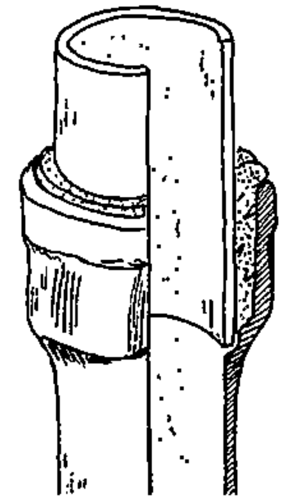


Figure 4-20. Gasket Pressed Between Hub and Barrel

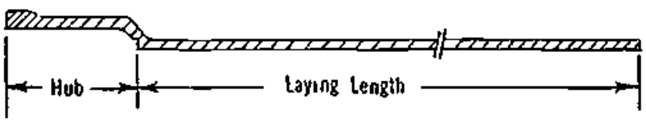


Figure 4-21. Laying Length of Pipe

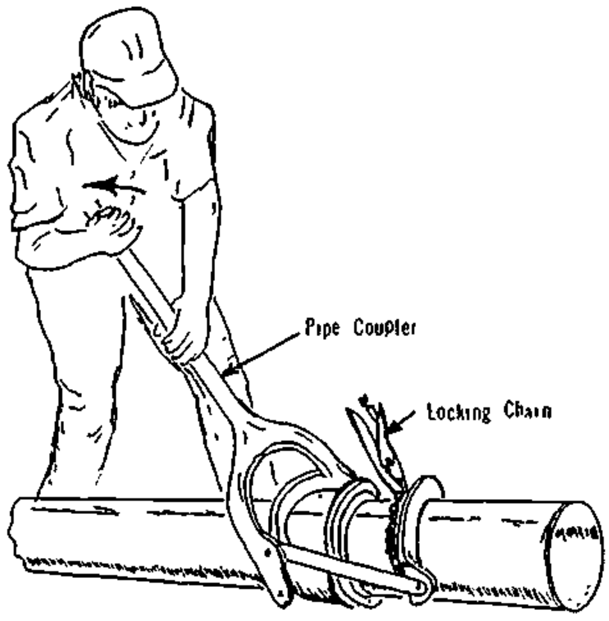


Figure 4-22. Assembly of Compression Joint

2. Steps in assembling pipe and fittings:

a) Inspect and clean the hub.

b) Knock the gasket into the hub by hand, or use a hammer or a wood block.

c) When using cut pipe, the spigot must be filed to remove burrs. Full-length pipe spigot ends require no preparation except the removal of foreign matter.

d) Apply the manufacturer's pipe lubricant to the inside part of the gasket and to about 75 mm of the spigot end of the pipe.

e) Fasten the locking chain around the spigot to provide an anchor for the pipe coupler as illustrated in Figure 4-22.

f) Mate the pipe spigot or fitting spigot to the hub and attach the pipe coupler as shown in Figure 4-22.

g) Force the spigot into the hub with a downward stroke of the pipe-coupler handle.

10. Disassembling Joints

1. Steps in taking apart pipe and fittings:

a) Attach the locking chain further from the hub than is indicated in Figure 4-22.

b) Butt the yokes of the pipe coupler against the upstream side of the hub and locking chain.

c) Pull up on the coupler handle to separate the pipes.

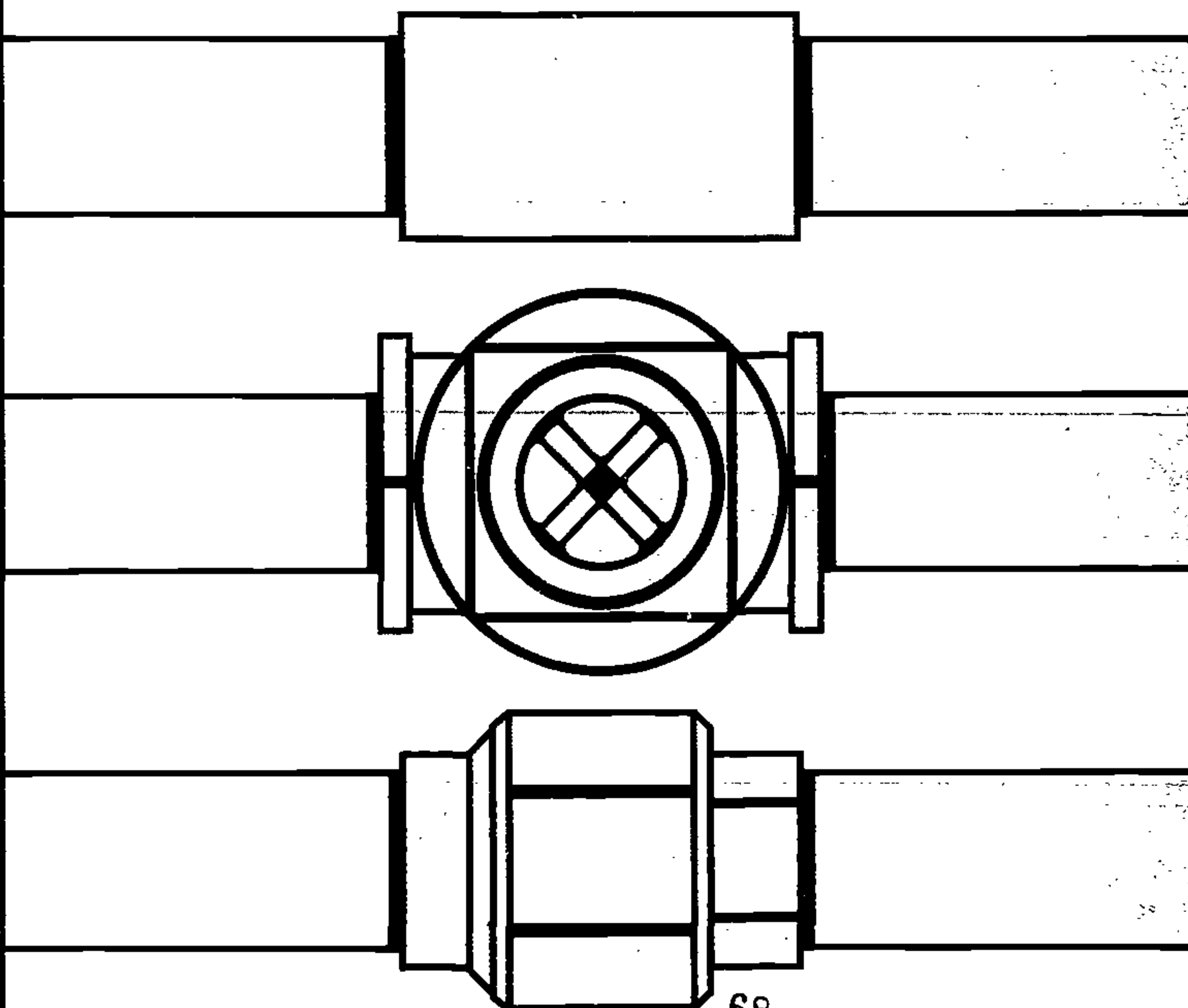
11. Sheet Lead and Lead Wool

1. Sheet lead is made in much the same manner as that of other metallic sheets. First, molten lead is cast into large slabs many millimetres thick. The slabs are then cold-rolled back and forth between steel rollers, the distance between the rollers being reduced after each pass until the desired thickness is reached.

2. Sheet lead is designated in terms of pounds per square foot or, in metric equivalence, kilograms per square metre. For example, 3 pounds per square foot has mass of 14.65 kg per m^2; and one square metre of lead 0.4 mm thick has mass of about 4.54 kg.

3. Lead wool is made by passing molten lead through a steel die having a number of fine holes. The lead solidifies after passing through and the fine strands of lead are then compressed into rope form.

Asbestos Cement Pipe, Fittings, and Joints 5



PART 5
ASBESTOS CEMENT PIPE, FITTINGS, AND JOINTS

1. Types of Pipe

The following four types of asbestos cement pipe manufactured in Canada are covered by the Canadian General Standards Board (formerly the Canadian Government Specifications Board). Data on relevant CGSB standards are obtainable from Canadian General Standards Board (Sales), Department of Supply and Services, Place du Portage, Phase 111, 2B3, 11 Laurier St., Hull, Que. K1A 0S5:

Asbestos cement pressure pipe. CGSB Standard 34-GP-1M. This pipe is suitable for conveying fluids under pressure.

Asbestos cement sewer pipe. CGSB Standard 34-GP-9M. This refers to non-pressure, large-diameter pipes 200 mm and up, suitable for conveying sanitary sewage in gravity-flow systems.

Asbestos cement drain pipe. CGSB Standard 34-GP-22M. This pipe is also referred to as asbestos cement soil pipe. It is suitable for drainage, waste, and vent systems.

Asbestos cement house-connection sewer pipe. CGSB Standard 34-GP-23M. This is a non-pressure, small-diameter pipe that is suitable as a building sewer pipe.

NOTE: The plumbing code stipulates where each type of asbestos cement pipe may be used.

2. Pipe Classifications

The various types of asbestos cement pipes are made in a number of classes, as follows:

Asbestos cement pressure pipe is made in three classes: Class 100, 150, and 200. This pipe must withstand an internal hydrostatic pressure according to its class, but not less than that shown in Table 5-1.

Table 5-1. Hydrostatic Resistance, Pressure Pipe

Class	Applied Pressure MPa (Min.)
100	2.4
150	3.6
200	4.8

Asbestos cement sewer pipe is made in seven classes: Class 1500, 2400, 3300, 4000, 5000, 6000, 7000. A 300 mm length of pipe without bevelled ends has a crushing strength of not less than that shown in Table 5-

Table 5-2. Crushing Strength, Sewer Pipe

Pipe Class	Crushing Strength kNm
1500	22
2400	35
3300	48
4000	58
5000	73
6000	88
7000	102

Asbestos cement drain pipe is made in two classes. Type 1 (3000) class, and Type 2 (4000) class. Standard and random lengths of pipe of all sizes must not show any sign of leaking, weeping, or cracking when tested under an internal water pressure of 345 kPa.

Asbestos cement house-connection sewer pipe is made in three classes: Class 1500, 2400, 3300. A 300 mm length of pipe without bevelled ends has a crushing strength of not less than that shown in Table 5-3.

Table 5-3. Crushing Strength, House-Connection Sewer Pipe

Pipe Class	Crushing Strength kNm
1500	22
2400	35
3300	48

3. Pipe Sizes

Asbestos cement pressure pipe is made in the nominal inside pipe sizes shown in Table 5-4.

Table 5-4 Nominal Inside Pipe Sizes, Pressure Pipe

100 mm	300 mm	500 mm
150 mm	350 mm	600 mm
200 mm	400 mm	
250 mm	450 mm	

Asbestos cement sewer pipe is made in nominal inside pipe sizes shown in Table 5-5 for the various classes of pipe.

Table 5-5. Nominal Inside Pipe Sizes, Sewer Pipe

Pipe Class	Nominal Inside Size (mm)
1500	200, 250, 300, 350, 400
2400	200, 250, 300, 350, 400, 450, 500, 600
3300	200, 250, 300, 350, 400, 450, 500, 600, 750
4000	250, 300, 350, 400, 450, 500, 600, 750, 900, 975, 1055
5000	250, 300, 350, 400, 450, 500, 600, 750, 900, 975, 1055
6000	900, 975, 1055
7000	900, 975, 1055

Asbestos cement drain pipe is made in the nominal inside pipe sizes shown in Table 5 6 for the various classes of pipe.

Table 5-6. Nominal Inside Pipe Sizes, Drain Pipe

Type 1 Pipe Class 3000	Type 2 Pipe Class 4000
200 mm	75 mm
200 mm	100 mm
300 mm	125 mm
350 mm	150 mm
400 mm	200 mm
450 mm	250 mm
500 mm	300 mm
600 mm	350 mm
	400 mm
	450 mm
	500 mm
	600 mm

Asbestos cement house-connection sewer pipe is made in nominal inside pipe sizes 100, 125, and 150 mm

4. Pipe Lengths

a) The standard lengths for *asbestos cement pressure pipe* are 4.0 m for all sizes of pipe except the 100 mm and 150 mm diameter pipe, and 3.0 m or 4.0 m for the 100 mm and 150 mm diameter pipe.

A maximum of 10 per cent of the pipe in any one order may be in random lengths of not less than 2.0 m.

Short lengths of pipe, either one-half the standard length (2.0 m) or one-quarter the standard length (1.0 m), are available for making connections to fittings.

b) The standard length for *asbestos cement sewer pipe* is 4 0 m.

A maximum of 15 per cent of a purchase order may be in random lengths of not less than 2.0 m.

Short lengths specifically required for making rigid connections to manholes or other structures must not exceed 2.0 m.

c) The standard lengths for *asbestos cement drain pipe* are 2 0, 3.0, and 4.0 m.

A maximum of 15 per cent of an order may be in random lengths of not less than 1.5 m when the standard length is 2.0 m, and not less than 2.0 m when the standard length is 3.0 or 4.0 m.

d) The standard lengths for *asbestos cement house-connection sewer pipe* are 1.5, 2.0, and 3.0 m, or 4 0 m at the option of the supplier.

A maximum of 15 per cent of an order may be in random lengths of not less than 1.2 m when the standard length is 1.5 or 2.0 m, and not less than 2.0 m when the standard length is 3.0 or 4.0 m.

5. **Identification of Pipes and Fittings**

a) Each standard and random length of pipe must be indelibly marked in contrasting color with the letters AC/DWV, the manufacturer's name or trademark, the nominal pipe size and type, and the year of manufacture.

b) Each asbestos cement fitting must be marked to show the class and size of pipe with which it is to be used.

c) Cast iron, ABS, and PVC fittings must conform to the applicable national or provincial standard.

6. **Fittings**

a) Fittings used with asbestos cement pipe are made from asbestos cement, cast iron, ABS, and PVC.

b) The ferrous components are coated with corrosion-resistant material.

c) A few of the available types of fittings are shown in Figure 5-1.

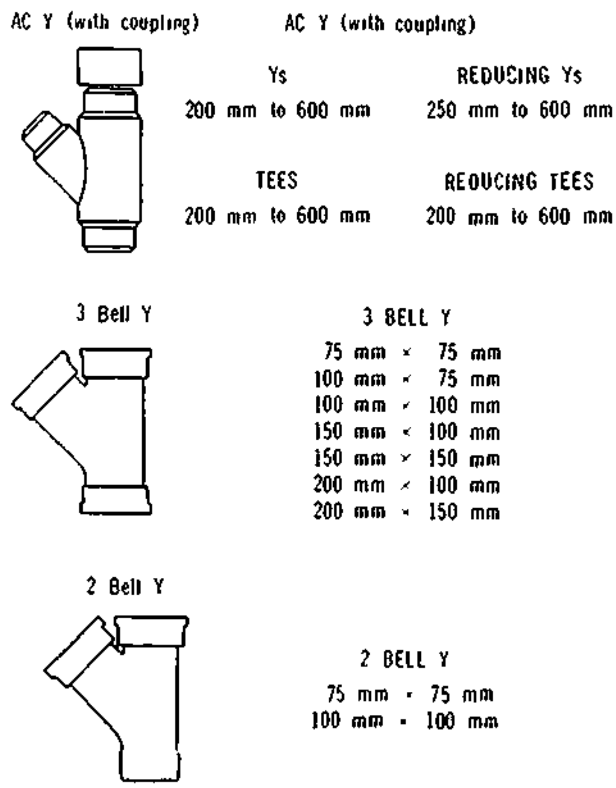


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Figure 5-1. Available Types of Fittings

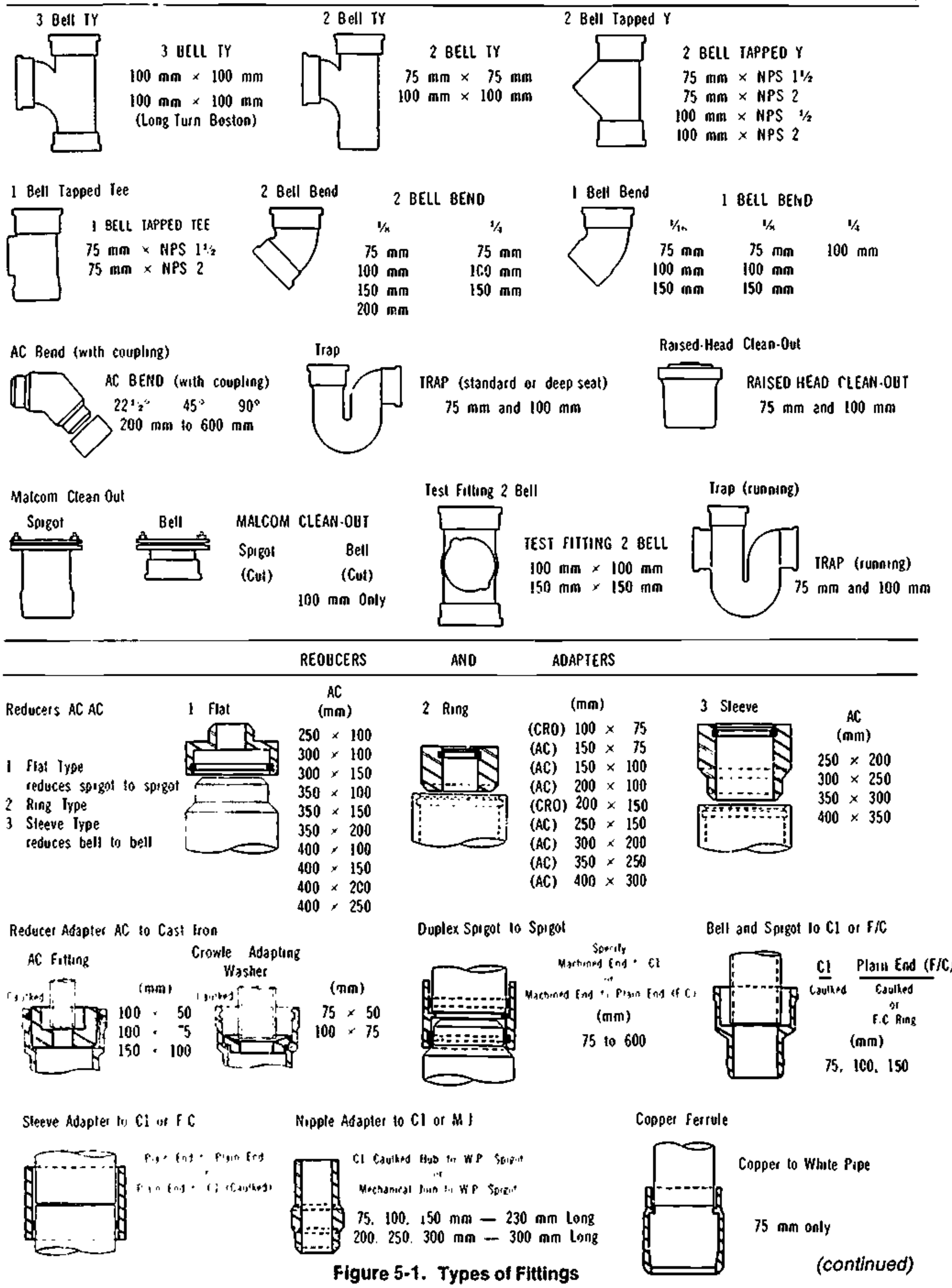


Figure 5-1. Types of Fittings *(continued)*

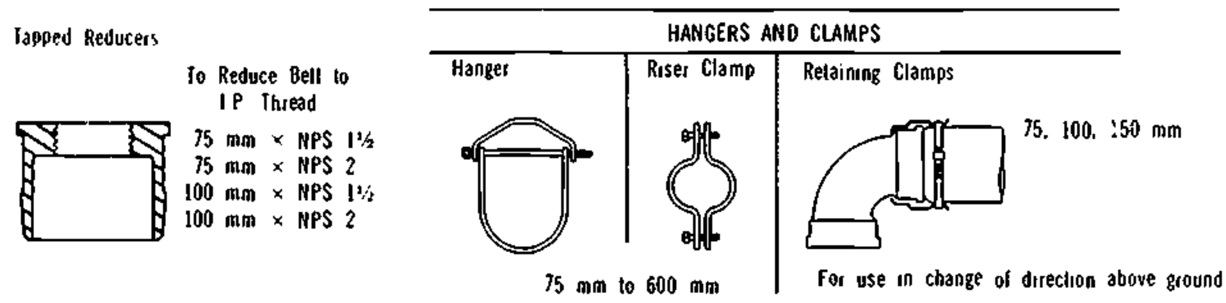


Figure 5-1. Types of Fittings

7. Joints

a) The joint between pipe and fitting is made watertight by the use of rubber or neoprene rings. The number of rings depends on the type of pipe and fitting, and on the manufacturer.

b) Each ring must have the manufacturer's name, or trademark, and the pipe size permanently marked.

c) Figure 5-2 shows typical cutaway sections of joints between asbestos cement pipe and fittings.

d) The joint assembly is a sliding assembly in which the pipe ends (generally machined to a correct bevel), or the spigot end of a fitting, slide through the rubber ring and into place in the fitting hub.

e) The groove must be clean because dirt under the ring will not permit it to seat completely and this could cause trouble when the water test is applied.

f) The end of the pipe and the spigot end of fittings also must be wiped clean before assembling.

g) A lubricant recommended by the pipe manufacturer should be applied to the entire outer circumference surface of the pipe end up to the shoulder. It should be applied to the thickness of a brush coat, and can be applied by hand or with a cloth pad, sponge, or glove.

h) Mechanical aid is needed when assembling the larger-size pipes, but the smaller ones usually can be pushed together by hand.

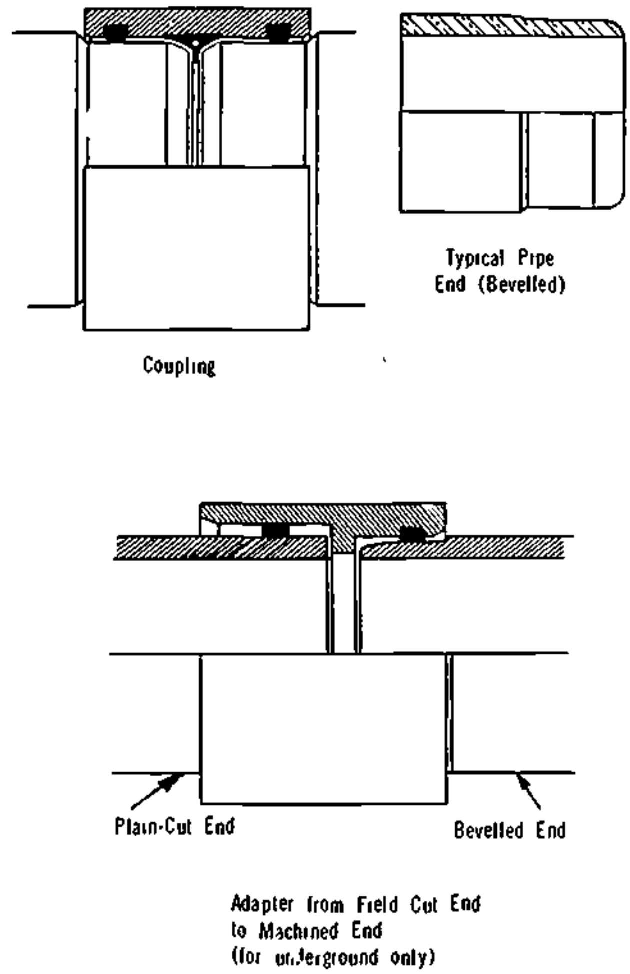


Figure 5-2. Cutaway Sections of Joints

i) The bar-and-wood method of assembly is depicted in Figure 5-3. (See Figure 5-3.)

With the pipe being properly supported, line up the bevelled end so that it just snugs all around into the rubber ring in the fitting hub or bell. Drive the bar into the ground; then, using a wood block between the bar and pipe, push the pipe into the hub until properly seated.

j) The lever-puller method, as illustrated in Figure 5-4, is also used to assemble pipe and fittings. The lever puller is chained to the installed pipe as shown in A, and the pulling chain is then wrapped around length B that is being installed. Then, by pushing the handle forward, the pulling chain is connected to the handle assembly. By pulling back on the handle, pipe B is drawn into the coupling on pipe A.

k) Another type of puller that may be used to assemble asbestos cement pipe and fittings is a "frame puller." It consists of two frames that clamp the pipe on each side of the coupling. The frames are joined by two handle assemblies that form two levers between the clamps. When pressure is applied to the levers, the frames tighten on the pipe, giving a positive pull between the two pipes. A frame puller is shown in Figure 5-5.

The frames are adjusted to the required diameter to fit the barrel of the pipe. They are set down on the pipe at a distance between each that will permit the handles sufficient travel. This type of puller may also be used to pull fittings or couplings onto the pipe.

NOTE: These are not the only available pullers, but the operating principle of each is similar to that of others.

l) Tools and equipment used to cut asbestos cement pipe and to machine the ends of the pipe are identified in Part 1 of the manual.

m) Field-machining tools and equipment (like all others) should be used in accordance with the manufacturer's instructions.

The following general suggestions apply to all machining tools:

Use a factory-machined end as a guide for setting blades.

Turn the handle clockwise, never backward, when the blade is in contact with the pipe as the blade could break from the carrier.

Check the dimensions of the field-machined end (see Table 5-7) below to ensure that the machining tool has not loosened during operation.

Figure 5-3. Bar-and-Wood Lever for Pipe Assembly

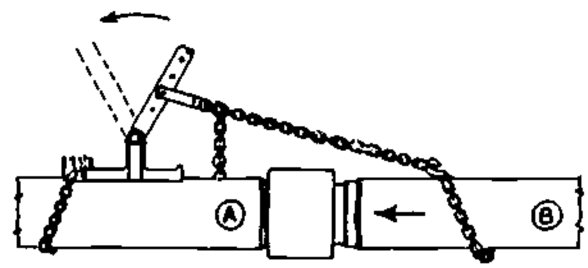


Figure 5-4. Lever Puller

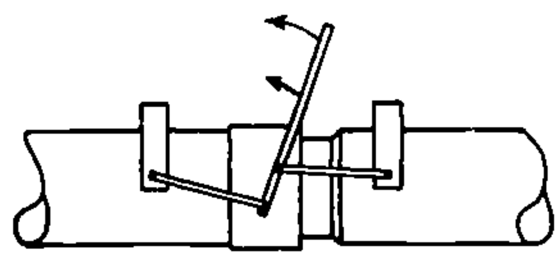
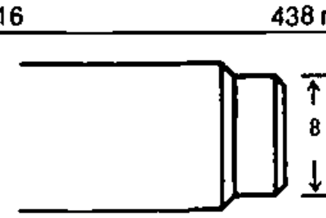


Figure 5-5. Frame Puller

Round the pipe nose with a coarse wood rasp to allow the rings to start easier.

Table 5-7. Dimensions of Field-Machined Ends

Nominal Pipe Size	Actual Diameter (B)
3	91 mm
4	116 mm
6	169 mm
8	226 mm
10	279 mm
12	323 mm
14	385 mm
16	438 mm



Use a feeler gauge to check the assembly. Insert the gauge as shown in Figure 5-6, ensuring that it touches the rubber ring all around the joint. If the pipe is pulled in tight and the ring can be touched with the gauge, the joint is properly assembled.

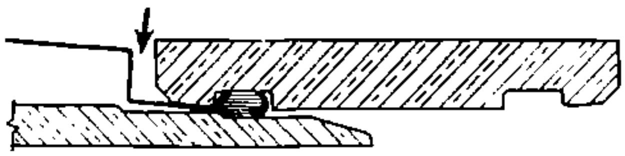


Figure 5-6. Feeler Gauge to Check Assembly

8. Repair, Tie-in, and Closure

a) There are several procedures for replacing a section of pipe or adding a branch connection.

b) The adapter shown in Figure 5-7 may be used for the repair of or tie-in to a line by sliding it over the pipe and caulking to join the unmachined ends.

This adapter is large enough to slide over the rough barrel of the pipe. It may also be used to join a cast iron soil pipe spigot to asbestos cement pipe.

c) A duplex to field-cut adapter, shown in Figure 5-8, may also be used for repair, tie-in, and closure.

The large field-cut ring is applied over the end of the non-machined pipe, without using lubricant, and rolled into place in the hub. The pipe could also be caulked into the adapter.

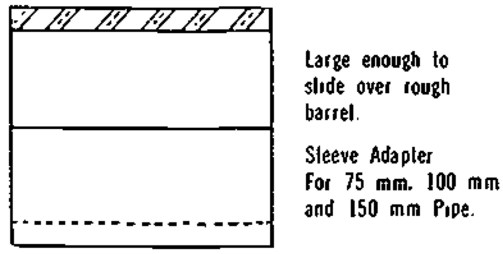


Figure 5-7. Sleeve Adapter

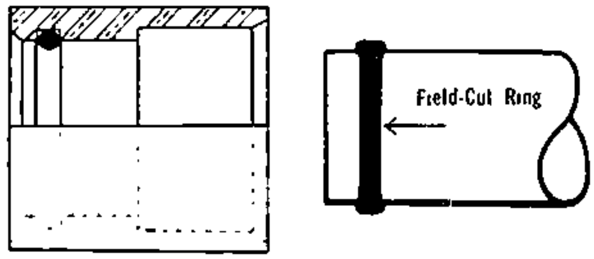


Figure 5-8. Duplex to Field-Cut Adapter

9. Hangers and Supports

a) Hangers and supports must also be installed in accordance with the plumbing code.

b) As a rule, the pipe should not be supported by a hanger attached to a fitting or by a support under a fitting. The hanger or support should be on or under the pipe close to the fitting. This is because the weight of the pipe should not be supported by the rubber ring in the fitting hub or bell.

c) The above requirement applies not only to asbestos cement pipe installations, but also to many similar types of joints on other materials. (Refer to pipe hangers and supports in Part 17.)

d) Sway bracing and anchors must be a consideration when installing pipe of any type that depends on what might be referred to as a "slip joint," if a slip joint were defined as a joint containing a gasket or packing that can be pulled or blown apart without rupturing the fitting or the pipe. Some of these joints are classified by manufacturers and standards manuals as compression joints, mechanical joints, etc., but whatever the name, it does not eliminate the need for anchors and sway bracing on certain installations.

10. Couplings

NOTE: Students should bear in mind that the following comments supersede, *where applicable,* statements appearing in the preceding pages of this part of the manual. For more specific references, consult your instructor.

a) A coupling similar to the stainless-steel band with neoprene gasket, as approved for use with mechanical-joint cast iron soil pipe, is now available for asbestos cement *drain pipe*, also referred to as *soil pipe.* This coupling is approved for use on 75 mm, 100 mm, 150 mm, and 200 mm asbestos cement drain pipe, and between such pipe and mechanical-joint (no hub) cast iron soil pipe and fittings.

c) The various types of this new coupling are as follows:

For rough-barrel A/C pipe connection to rough-barrel A/C pipe.

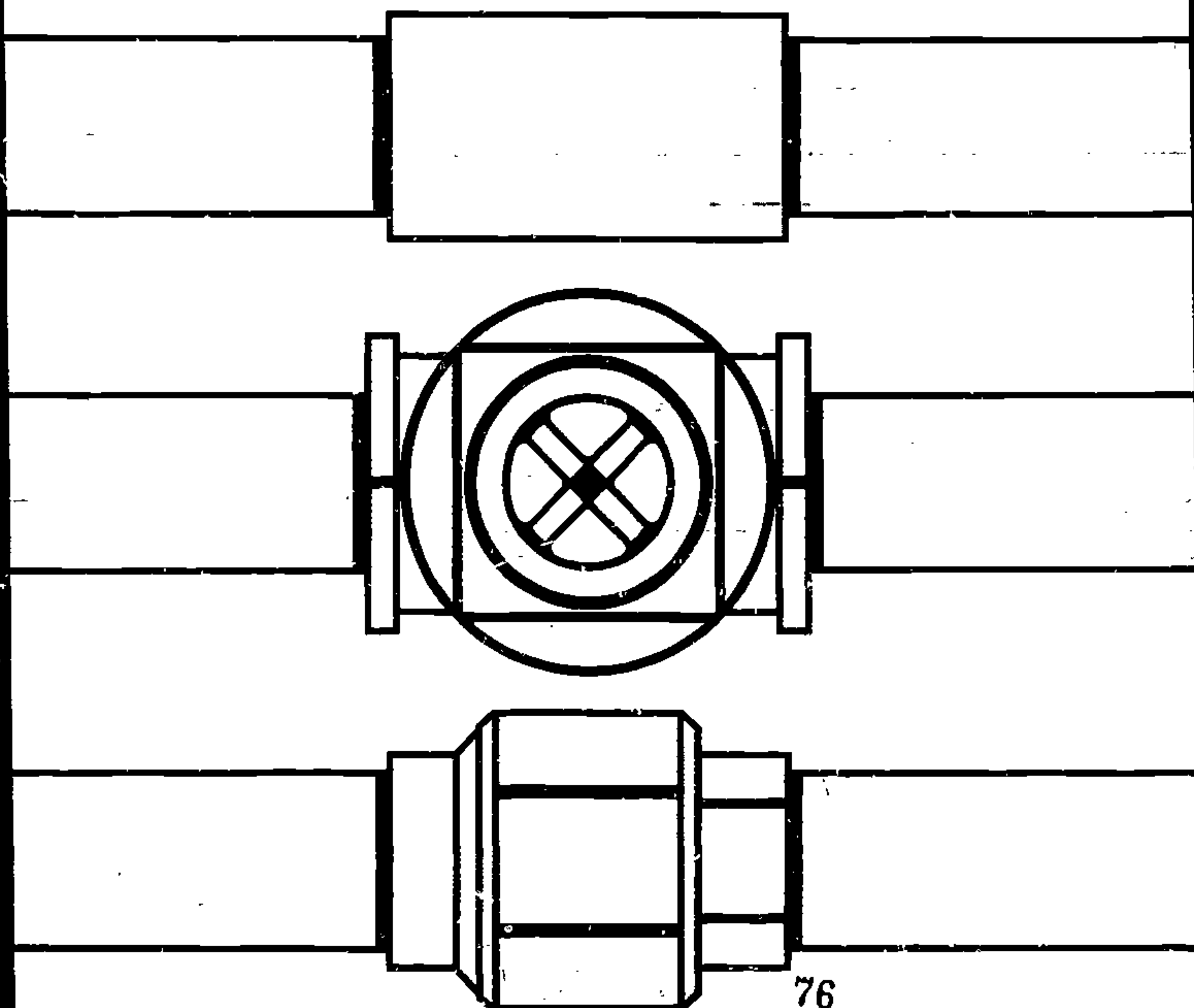
For rough-barrel A/C pipe connection to machined-end A/C pipe.

For rough-barrel A/C pipe connection to MJ cast iron pipe and fittings.

For machined-end A/C pipe connection to MJ cast iron pipe and fittings.

ABS and PVC Plastic DWV Pipe, Fittings, and Joints

6



PART 6
ABS AND PVC PLASTIC DWV PIPE, FITTINGS, AND JOINTS

ABS AND PVC PLASTIC DWV PIPE FITTINGS, AND JOINTS

1. Abbreviations

ABS: Acrylentrile, Butadiene, Styrene.
PVC: Poly (Vinyl Chloride).
DWV: Drainage, Waste, and Vent.

2. DWV Pipe

a) ABS and PVC pipe must conform to the standard specified in the appropriate plumbing code.

b) Some plumbing codes require all ABS pipes and fittings to be black, and all PVC pipes and fittings to be grey, so that the material can be quickly identified.

c) ABS piping will support combustion; but although PVC piping will burn, it will extinguish itself if a supporting flame is removed.

d) Both ABS and PVC pipes are well suited for DWV installations as permitted by the plumbing code.

3. DWV Fittings

a) ABS and PVC fittings are made from the same material as that of the piping, and are similar to those used with cast iron soil pipe.

b) Expansion joints are classified as type 1 and type 2. Type 1 means a joint providing for at least 75 mm of travel. Type 2 means a joint providing for at least 200 mm of travel.

c) Where an expansion joint is unsuitable for use in both vertical and horizontal lines, this restriction must be shown on the expansion joint.

4. Joints

a) ABS and PVC pipes and fittings are joined by a solvent cement.

b) Some plumbing codes stipulate that the solvent cement used for PVC DWV pipe not be used with ABS, or vice versa.

c) Only solvent cements recommended by the pipe manufacturers are to be used on ABS and PVC pipes and fittings. The appropriate standard specifies that the container must identify the manufacturer and the type of material, as well as stating the recommended procedure for its use and the safety procedures normally required with solutions containing solvents of this type.

d) Some plumbing codes stipulate that the solvent cement used with ABS plastic pipes and fittings be either black or yellow, and that the one used with PVC be grey or clear.

e) The piping may be cut with a hacksaw or other fine-toothed mechanical saw, or a handsaw. Piping or tubing cutters fitted with special plastic cutting wheels may be used. The following other tools are required:

A mitre box or guide to ensure a square cut when a saw is used.

A paint brush as described in Part 1 of the manual, depending on whether the material is ABS or PVC.

A knife or coarse file for removing burrs or rough edges.

A clean lint-free cloth.

A workbench or supports for the pipe and fitting assembly, when applicable.

f) Following is the procedure for making a solvent cement joint on ABS or PVC DWV pipe and fittings:

Cut the pipe to the wanted length, using the tools listed in paragraph 4 e) above.

When using a wheel cutter, be sure to remove burrs on the inside and outside of the pipe.

Remove dirt or moisture with a rag.

The pipe should penetrate at least one-third of the way into the socket without being forced.

If the fit is too tight, file or sand the pipe to the proper fit within the socket area, taking care not to make flats or gouges on the pipe.

Brush the cement on the pipe with a full brush, then a thin coat in the fitting and on the pipe again, keeping the brush in the cement between applications. Do not add thinners to solvent cement. If it becomes thick or lumpy, but throw it away. Keep the can closed when not in use.

Do not put too much solvent cement in the fitting socket.

Work quickly, assemble immediately, and rotate and bottom the pipe in the socket while both surfaces are still wet, then hold it for a minute.

Wipe off excess cement while not disturbing fresh joints, and carefully install the pipe into position.

Because solvent-cement joints set up in seconds, the pipe and fittings should be marked so that they will be correctly positioned when assembled.

Hangers, clamps, and anchors for these types of piping are as outlined in Part 17, and must be installed in accordance with the plumbing code.

g) The set period for a new solvent-cement joint depends on four factors — type of cement, size of pipe, air temperature, and dry tightness of the joint.

5. Advantages of ABS and PVC Pipe and Fittings

a) They are light and easy to handle.

b) No special tools are needed to install them.

c) No special skill is needed to make good joints.

d) They will not rust or corrode.

e) They have good impact resistance.

6. Disadvantages of ABS and PVC Pipe and Fittings

a) They are difficult to thaw when pipes are frozen.

b) Thermal expansion is greater than with most other types of piping used in DWV systems.

c) Care must be taken when winterizing a building to use the correct anti-freeze in the traps, etc.

d) Linseed oil-base putty is prohibited by some codes when setting water-closet bowls on plastic closet flanges.

e) It is said that ABS and PVC pipes and fittings are noisier than cast iron soil pipe when installed in an above-ground drainage system.

7. Hazards of Primers and Solvent Cements

a) Since most solvents are flammable, precautions must be taken to prevent fires and explosions.

b) Always have fire-fighting equipment near when using primers and solvent cements.

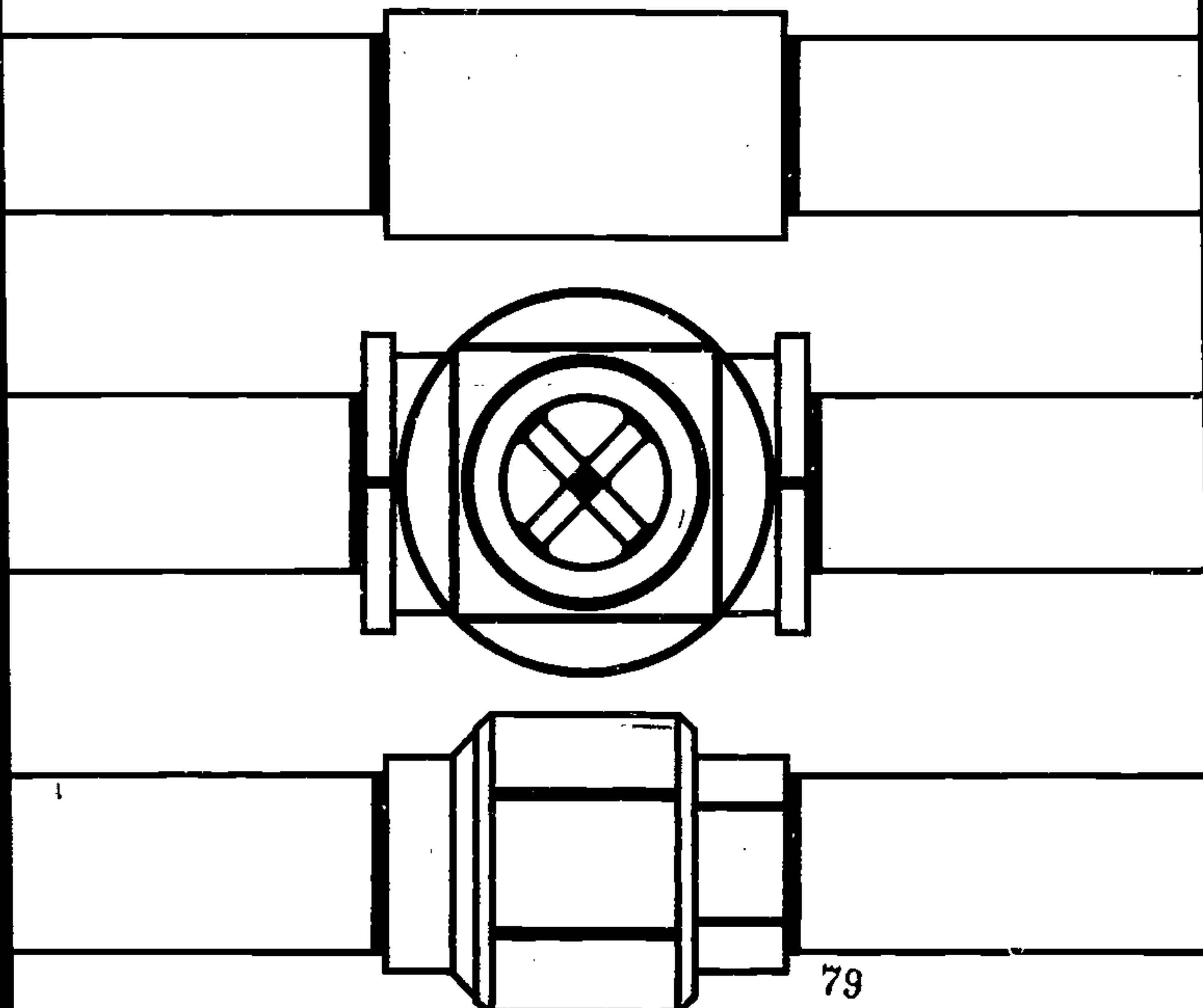
c) Ventilation is essential when using primers and solvent cements because breathing the vapors could endanger your health.

d) Do not let solvent cement get into your eyes. If it should, flush your eyes with water and see a doctor immediately.

e) Do not apply solvent cement by hand, but only with a brush. Should the solvent contact your skin, wash immediately with soap and water.

f) Never eat food without first washing your hands after using solvent cement.

Galvanized Pipe, Fittings, and Joints 7



PART 7
GALVANIZED PIPE, FITTINGS, AND JOINTS

Welded and Seamless Steel Pipe

1 Steel pipe is manufactured in nominal pipe sizes (NPS) of ⅛, ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 3½, 4, 5, 6, 8, 10, 12, and larger.

2. Sizes from NPS ⅛ to NPS 12 are known by their nominal size, which differs somewhat from the actual inside diameter.

3 In the early days, manufacturers made the walls in the smaller-size pipes much too thick; in correcting this error in design, they took the excess from the inside of the pipe to avoid changing the sizes of the companion fittings. To distinguish pipe sizes from the actual measured diameters, the term "nominal pipe size" (NPS), or "iron pipe size" (IPS), is generally used.

4. Examples of how the actual inside diameter and the nominal size differ in the smaller steel pipes are given below for standard-weight steel pipe:

Actual Inside Diameter	Nominal Pipe Size
6.8 mm	⅛
9.2 mm	¼
12.5 mm	⅜
15.8 mm	½
20.9 mm	¾
26.6 mm	1

5. Pipe referred to as *galvanized steel pipe* is steel pipe that has been coated with zinc inside and out.

6 Steel pipe is made in several different weights, which are referred to as "weight class" or "schedule number." Examples:

Weight Class	Schedule Number
Standard pipe	40
Extra-strong pipe	80
Double-extra-strong pipe	—

There are other schedule numbers but they are not in general use by plumbers.

7. Methods of manufacture change periodically, but galvanized steel pipe can generally be classified as one of the three types as shown in Figure 7-1.

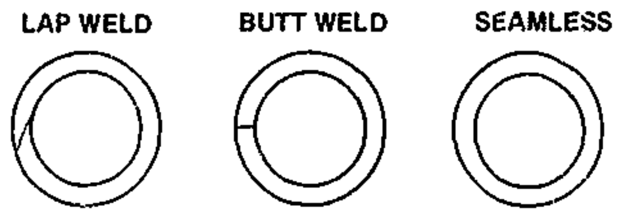


Figure 7-1. Types of Galvanized Steel Pipe

8. Standard galvanized steel pipe comes in random lengths, which may vary from 5 m to 6.7 m.

9. Extra-strong and double-extra-strong galvanized steel pipe comes in random lengths, which may vary from 4 m to 6.7 m.

10. As a rule, galvanized steel pipe comes in about 6.1 m lengths.

11. Galvanized steel pipe may be ordered with plain ends or with threaded ends complete with a galvanized steel coupling.

12. The locations in the plumbing system where galvanized steel pipe may be used are governed by the plumbing code.

13. Galvanized steel pipe, where permitted by the plumbing code, may be used with:

a) Galvanized malleable iron fittings.
b) Galvanized or black cast iron recess drainage fittings.
c) Specific galvanized cast iron fittings.
d) Valves made for use with this type of pipe.
e) Adapters made for use with this type of pipe.

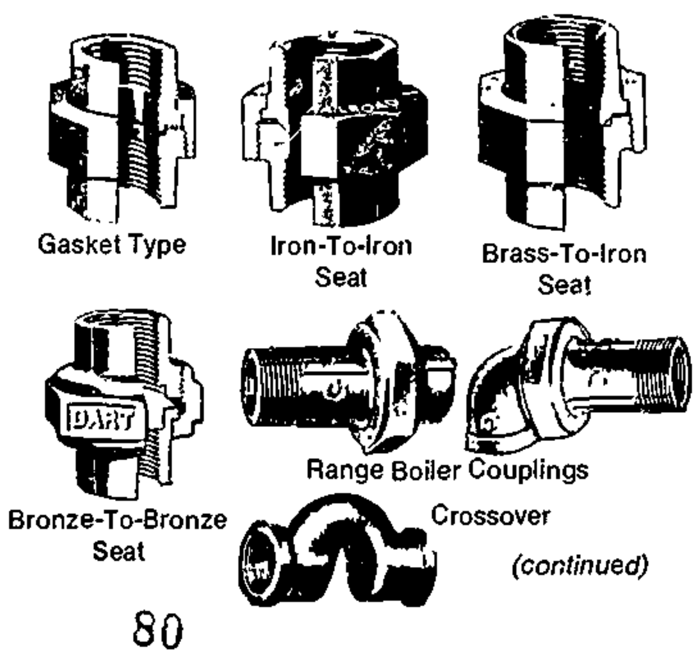
14. Galvanized steel pipe and fittings are, as a rule, joined with threads on the outside of the pipe and on the inside of the fitting.

Galvanized Malleable Iron Fittings

1. Plumbing codes generally approve the use of these fittings in specified locations in a plumbing system.

2. Plumbers quickly learn to identify each fitting by sight. Some of those in general use are shown in Figure 7-2.

Figure 7-2. Some Galvanized Malleable Iron Fittings



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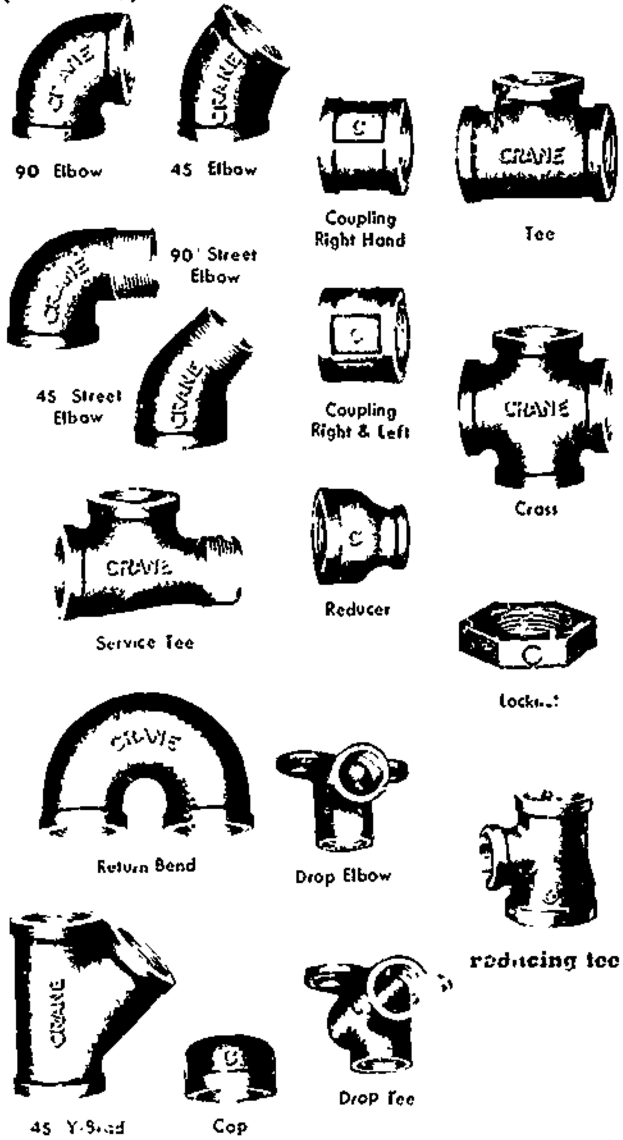


Figure 7-2. Some Galvanized Malleable Iron Fittings

Galvanized Cast Iron Fittings

Plumbing codes, as a general rule, permit the use of galvanized cast iron fittings in specified locations in a plumbing system. Figures 7-3 and 7-4 show a few of those in general use.

Figure 7-3. Plugs

Figure 7-4. Bushings

Cast Iron Recess Drainage Fittings

1. These fittings are not now in general use, but many are installed in older plumbing systems.

2. Plumbing codes generally still permit the use of cast iron recess fittings in specified locations in drainage and venting systems.

3. Between the lead-pipe and copper-tube eras, these fittings were used extensively in NPS 1¼, 1½, and 2 drainage and venting systems.

4. The inlet of the fittings is tapped so that when a pipe is installed it has a slope of 1 in 50.

5. They are made of cast iron and are painted black or are galvanized.

6. They have a shoulder of the same diameter as the pipe, thus making a continuous passage when the pipe is screwed to the shoulder.

7. A few types of recess drainage fittings are illustrated in Figure 7-5.

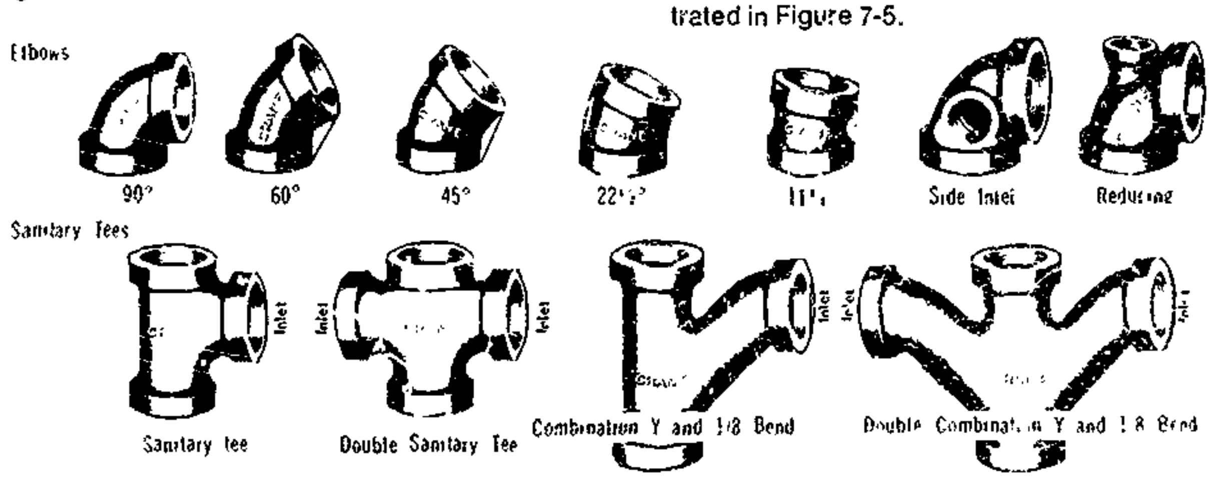


Figure 7-5. Elbows and Sanitary Tees

Galvanized Steel Nipples

1. Nipples are short pieces of piping with a thread on each end.

2. If the thread on each end touches in the centre, this fitting is called a "close nipple." (See Figure 7-6.)

3. If there is a small section of pipe between the two threads, this fitting is often referred to as a "shoulder nipple."

4. If the nipples are longer than those mentioned, they are referred to simply as "nipples" or as "long nipples." (See Figure 7-7.)

5. They are available in a range of section lengths (increasing in multiples of 13 mm from the close nipple up to 150 mm, and in multiples of 25 mm from 150 mm to 300 mm). It is unlikely that all wholesalers will stock nipples with pipe lengths over 150 mm.

6. They are available in the same weight class or schedule number as the piping used in the plumbing system.

7. They can be made in the shop or on the job with hand or power tools, but generally it costs more to make one than to buy it.

8. If working with galvanized steel piping and the fittings used with it, you should have an assortment of nipples on hand.

Valves (General Information)

1. Valves are used to close off the water suppy to a part or parts of the water-distribution system. They are also used to throttle the water supply, to reduce the pressure in a pipe, or to prevent water from backing up into a pipeline. Sometimes they are used to drain systems. A faucet on a fixture and the stop on the water supply to a fixture are also forms of valves.

Gate Valves

1. The gate valves shown in Figure 7-8 are two of the most common types found in a water-distribution system. They get their name from the gate-like disc that raises and lowers across the path of the water flow. There is very little friction loss in a valve of this type because the opening is about the same size as the inside diameter of the pipe to which it is connected.

2. Gate valves are used a great deal on pump lines and for main supply lines. They should be kept in the fully open or closed position. They should not be used as a throttling valve because they will eventually fail to close tight.

4. They are made in many designs and of many different materials.

Figure 7-6. Close Nipple

Figure 7-7. Long Nipple

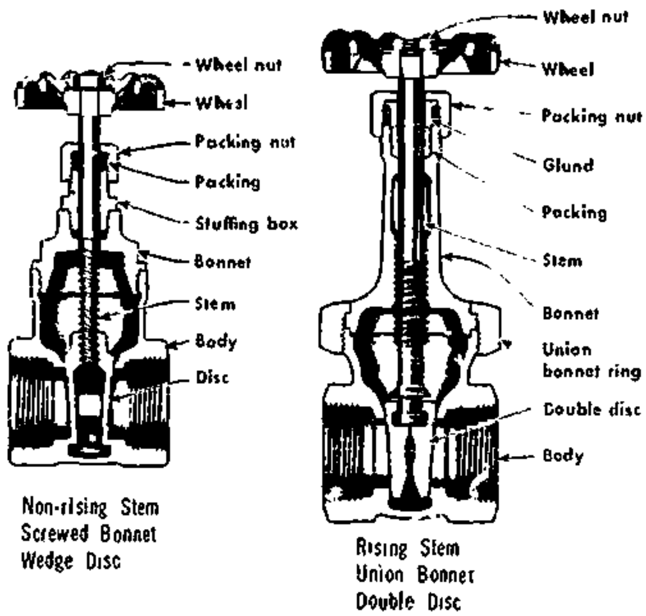


Figure 7-8. Gate Valves

3. They may be purchased with a rising stem or a non-rising stem.

Globe Valves

1. This type of valve is an excellent throttling valve because it resists the wear generally associated with a partially open valve. It affords greater resistance to flow, compared to a gate valve, owing to the change in direction of the flow within the valve.

2. The disc and seat in many globe valves can be reground or replaced, which in many cases would reduce maintenance cost.

3. There are three general types of globe valves, as shown in Figure 7-9. The plug-type disc valve has a long tapered disc and matching seat. Its wide bearing surface gives it good resistance to the cutting action of scale, dirt, and other matter commonly found in pipes. It satisfies the requirements for the most demanding flow-control service.

4. Perhaps the best known of the three types is the conventional disc valve. Its chief advantage is that it permits a pressure-tight bearing to be obtained between the disc and the seat. It is made in several seating styles of varying degrees of taper.

5. The third type is one with a composition disc. It comprises a metal holder, the composition disc, and a retainer nut. Various types of discs may be used, thus enabling this valve to be used for many different purposes: gasoline, steam, hot and cold water, etc. This adaptability, along with the fact that the composition disc can be turned over or replaced without removing the valve, accounts for its popularity.

Angle Valves

1. The operation of angle valves is similar to that of globe valves.

2. They come in a range of disc and seat designs similar to those of globe valves.

3. They are used when making a 90° turn in a pipeline. When thus used, fewer fittings are needed.

4. Angle valves, like globe and gate valves, are made from a variety of materials, including bronze, steel, and cast iron.

5. A typical angle valve is shown in Figure 7-10.

Check Valves

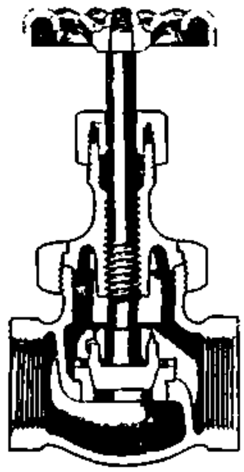
1. Check valves prevent the reversal of flow in pipes and must be correctly installed.

2. They are of two basic designs, the swing check valve and the lift check valve. (See Figure 7-11.)

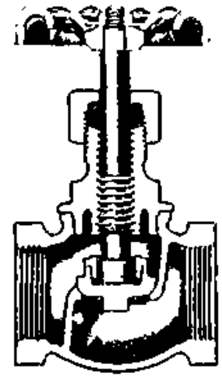
3. Swing check valves are generally installed on a horizontal pipeline, but lift check valves are used on both horizontal and vertical pipelines.

4. The plumbing code and good trade practice dictate where check valves are to be used.

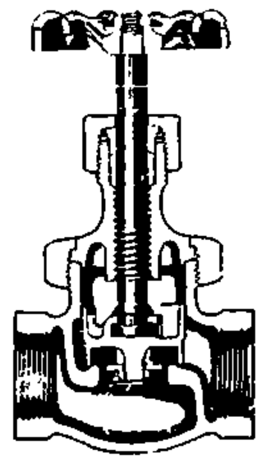
5. They are made of a variety of different materials, including bronze and cast iron.



Plug Type



Conventional
Disc Type



Composition
Disc Type

Figure 7-9. Globe Valves

Figure 7-10. Angle Valve

6. Three types of check valves are illustrated in Figure 7-11.

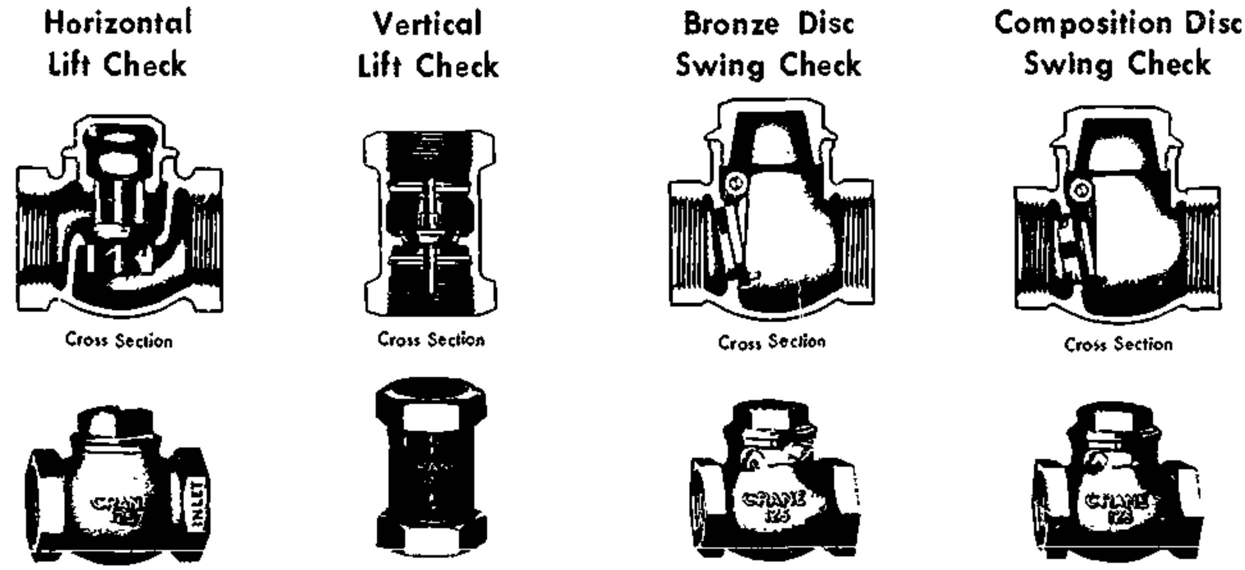


Figure 7-11. Check Valves

Compression Stop

1. The design of the compression stop is similar to that of the globe valve but much lighter. It is generally made in sizes from NPS ⅜ to NPS 1.

2. It is perhaps the lowest-priced valve in its field.

3. It may be a straight stop or an angle stop, as in Figure 7-12, and may be threaded, solder end, or slip-joint compression end.

4. It is made only in the smaller sizes, and is used as a shut-off valve in such places as the water supply to hot water tanks and to an individual fixture or a group of fixtures.

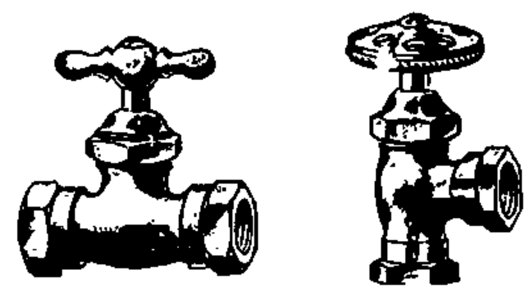


Figure 7-12. Compression Stop

Compression Stop and Drain

1. This valve, shown in threaded pattern in Figure 7-13, is also referred to as a compression stop and waste.

2. Its design is the same as that of the compression stop, except that a drain has been added to the side.

3. It is generally available only in the smaller sizes up to NPS 1.

4 Plumbing codes generally state where this valve may be used, but it is also used on small water pipelines to shut off the water and then to drain a section — for example, on the downstream end of a water-service pipe, a supply pipe to risers, or where a pipe passes through an exterior wall to supply water to the exterior of the building (when a frost-proof hydrant is not used).

5. It may be either threaded or solder joint.

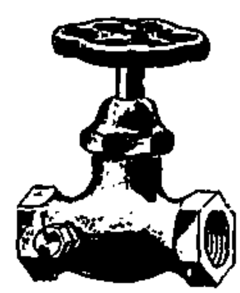


Figure 7-13. Compression Stop and Drain

Corporation Stop

1. This valve (Figure 7-14) is used when tapping into a water main that is under pressure.

2. A special machine is used to drill, tap, and insert it into the water main.

3. It also serves as a primary shut-off valve for the water-service pipe for a building. (See definition of water-service pipe in the plumbing code.)

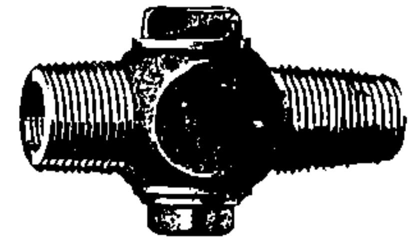


Figure 7-14. Corporation Stop

Curb Stop

1. A curb stop (Figure 7-15) is generally installed on the water-service pipe at the property line. In many cases, the stop is accessible through a cast iron curb-stop box that extends from the valve to the surface of the ground. Shown also is a long-handled key wrench that turns the valve on or off.

2. The curb stop is generally made of brass and is of the stop-and-drain type. The drain opening is on the side, and when the valve is turned off it automatically drains the pipe.

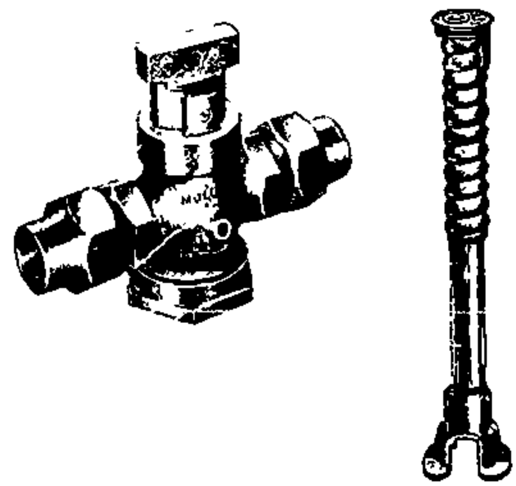


Figure 7-15. Curb Stop

Sediment Faucet

The sediment faucet (Figure 7-16) is a low-cost valve or faucet that is often installed at the bottom of a hot water tank so that the tank can be drained. It is also used as a lawn faucet and for similar installations where a faucet with a hose bibb is required. It is also made with copper solder joint inlet.

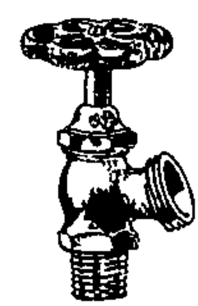


Figure 7-16. Sediment Faucet

Other Types of Valves

1. There are many other types and designs of valves, some of which are shown in Figures 7-17 to 7-22.

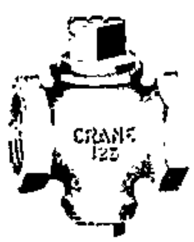


Figure 7-17. Plug Cock

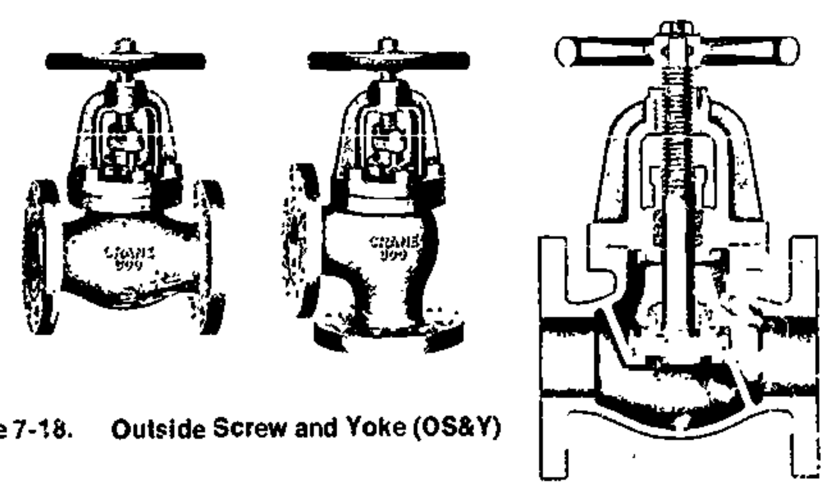


Figure 7-18. Outside Screw and Yoke (OS&Y)

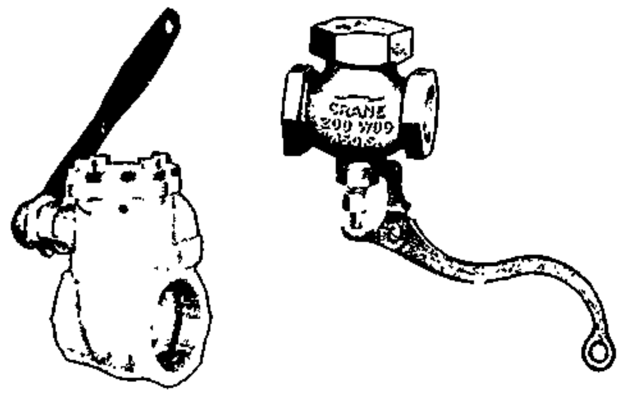


Figure 7-19. **Quick-Opening Valves**

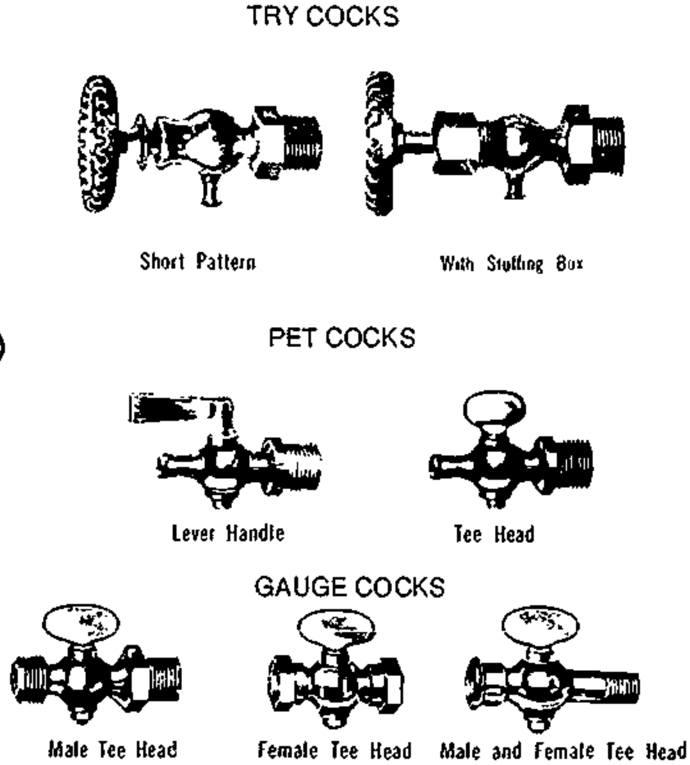


Figure 7-20. Other Types of Valves

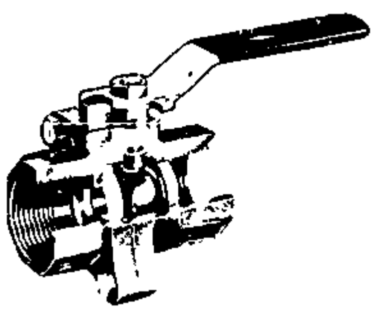


Figure 7-21. Ball Valve

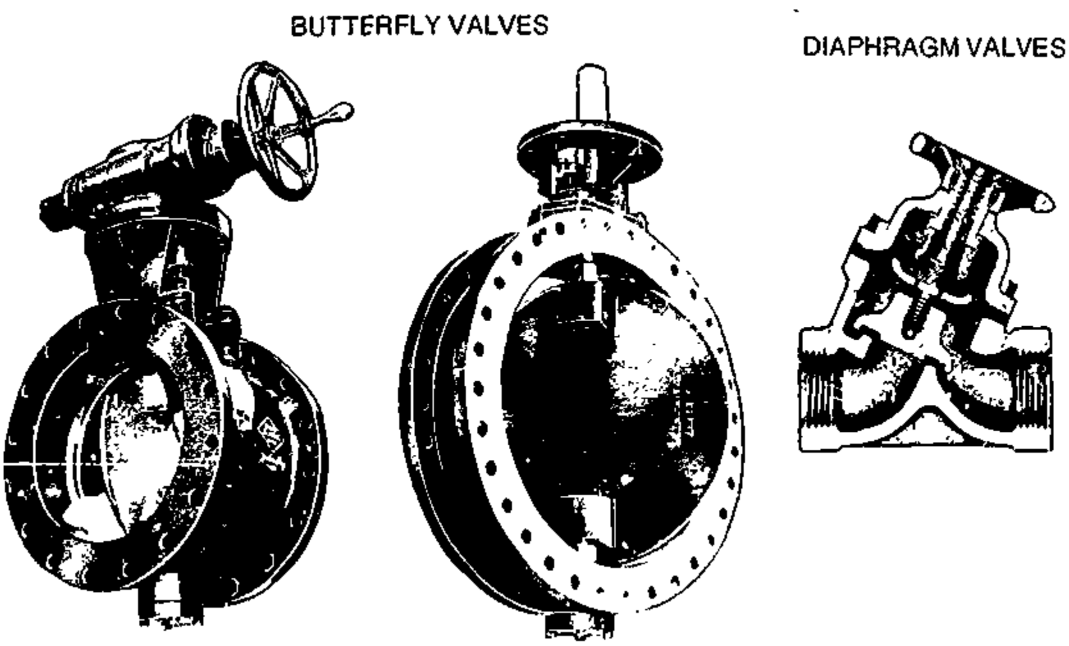


Figure 7-22. Butterfly and Diaphragm Valves

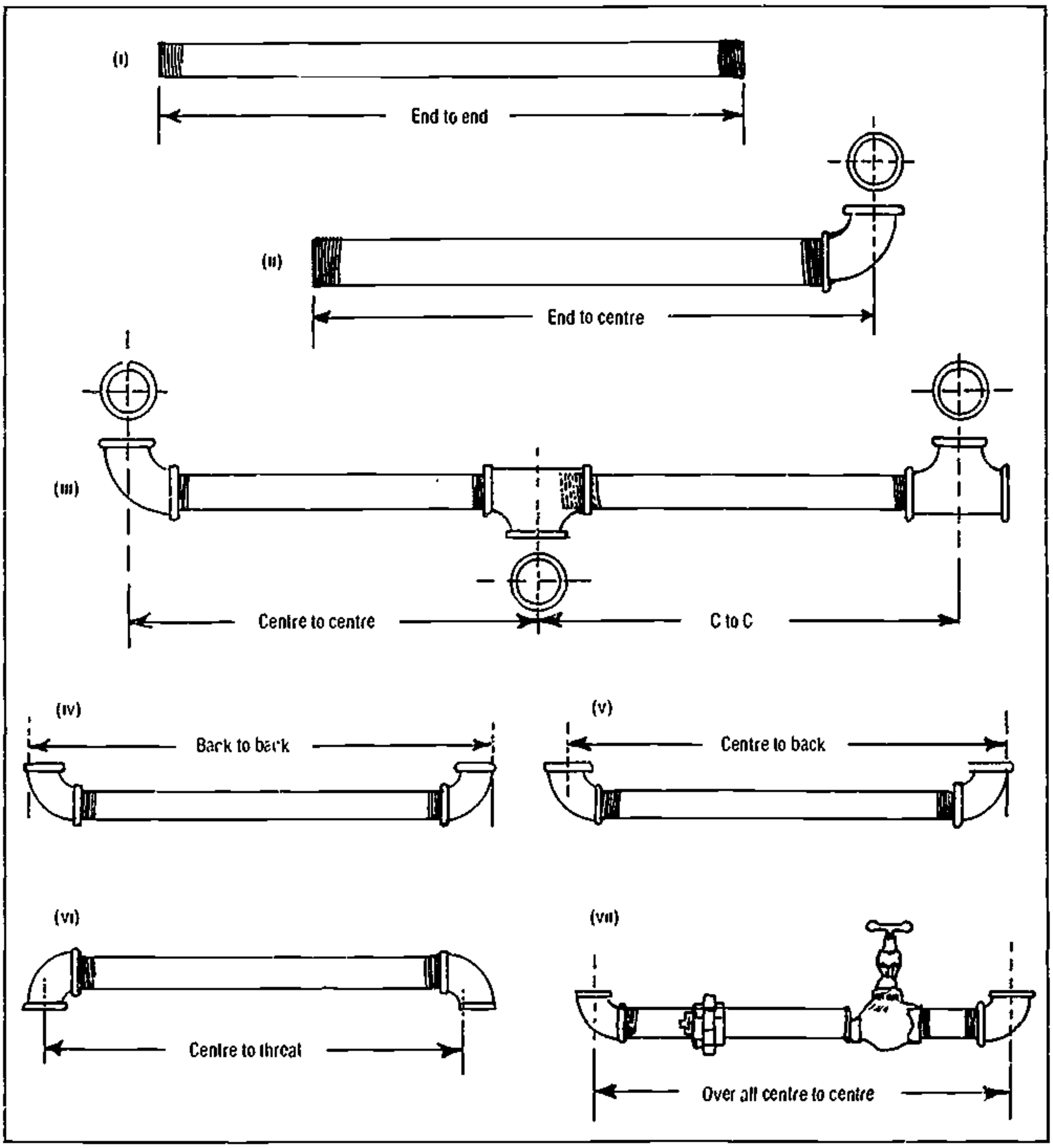


Figure 7-23. Methods of Taking Measurements for Piping Installation

Measuring, Cutting, Rea..ning, Threading Pipe, and Tightening Fittings

1. Measurer nts

a) Before cutting a piece of pipe, make certain you determine the correct length.

b) Following are some of the different methods of taking measurements for a piping installation (see also Figure 7-23):

c) End-to-end measurement includes the threaded portions of the pipe.

d) End-to-centre and centre-to-end measurements mean the same thing. This is perhaps the most common measurement taken in the plumbing trade. The fitting is generally tightened on the pipe first, then the tape is placed so that the desired measurement is in the centre of the fitting and a mark is made at the end of the tape. When the pipe is cut on the mark, the result will be a piece of pipe with an elbow or a tee on it and cut to a specified centre-to-end measurement.

e) Centre-to-centre measurement is used when both ends of the pipe have elbows or tees on them. One fitting can be tightened onto the pipe as in the preceding paragraph; but before the pipe is cut, allowance for the other fitting must be deducted from the measurement. The pipe can then be cut to the correct length.

f) The remaining measurement sketches in Figure 7-23 should be fully understood before proceeding.

2. Cutting Steel Pipe

a) Use a pipe cutter only when there are no nicks or burrs on the cutting wheel.

b) Determine the length of pipe needed and clearly mark the cutting spot.

c) Place the pipe in the vise and lock it securely with the cutting mark about 20 cm from the front of the vise.

d) Open the jaws of the cutter by turning the handle counter-clockwise.

e) Figure 7-24 shows the pipe cutter being positioned on the cutting mark.

f) The best cuts are made when the cutter is only lightly tightened onto the pipe for the first turn. This results in a light track being cut around the pipe and far less chance of a spiralling effect or "barber-poling." Too often the pressure is immediately applied full strength on the cutting wheel with no attempt to cut the initial guide or track.

g) Some plumbers work the cutter back and forth while cutting the pipe, but others make complete turns in the one direction with only a short back-and-forth movement of the cutter when tightening the handle. Either method is effective so long as only reasonable force is used.

h) A spot of oil on each cutter makes the work easier.

i) When the pipe is cut, there will be a burr on the inside that not only reduces the size of the pipe, but also becomes an obstruction. When certain types of pipe cutters are used, a raised portion will result on either side of the cut on the exterior of the pipe.

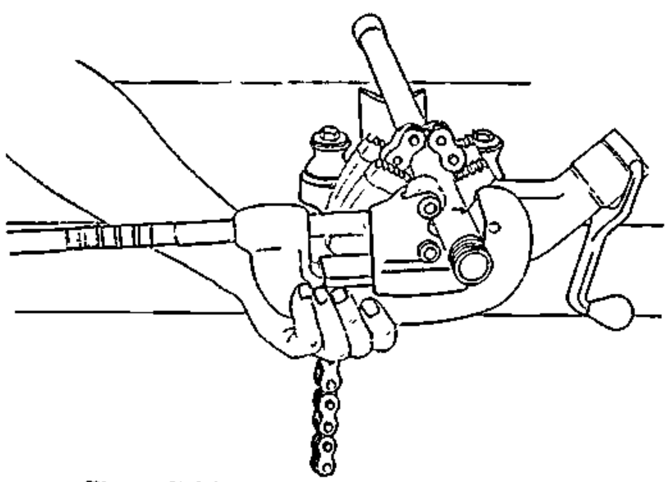


Figure 7-24. Positioning the Pipe Cutter

These burrs must be removed before threading.

j) A hacksaw will also cut steel pipe, but the best results are obtained with a pipe cutter as it is difficult to make a good right-angle cut with a hacksaw. More often, the cut-off will be made at an angle, and if the pipe is then to be threaded but is not squarely cut, it could result in unsatisfactory threads and possible broken dies.

3. Reaming a Pipe End

a) As mentioned above, when a pipe has been cut with a pipe cutter the burr on the inside must be removed.

b) The reamer is pushed into the pipe end and is turned clockwise with short, even strokes. When using a spiral-flute reamer, very little pressure is needed when pushing it into the pipe end. The spiral-flute reamer will bind very quickly if too much force is applied, and it should never be used with a power vise.

c) When using a straight-flute reamer, considerable force is needed to push the reamer into the pipe end so that the blades will cut the metal burr.

d) Figure 7-25 shows a reamer in use.

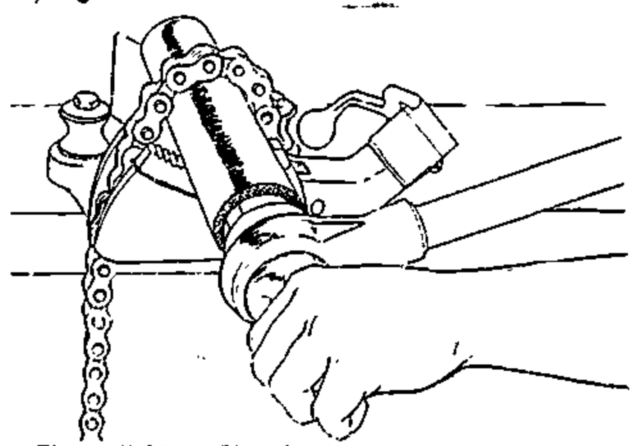


Figure 7-25. Showing a Reamer in Use

e) The reamer must remove all the burr from the inside of the pipe before threading is started.

f) If the cutter has produced a burr or a raised part on the outside of the pipe it must be filed off before starting to cut a thread.

4. Threading

a) Follow the manufacturer's instructions on the use and care of threaders.

b) The following explanations of how to thread pipe are general and should not be interpreted as superseding the manufacturer's instructions:

c) Some threaders, as in Figure 7-26, require that considerable force be applied to the face to get the dies started on the pipe:

d) Threaders such as shown in Figure 7-27 do not require force, but are drawn onto the pipe as it is rotated. The locking device at the rear must be tightened to the pipe

e) When cutting threads, a good grade of lard or sulphur thread-cutting oil must be used unless the manufacturer recommends a specific type of oil.

f) Oil the cutting surface as soon as the dies have started to cut and oil again frequently as they move along the pipe.

g) After removing the threader, wipe off any excess oil and chips on the threads.

h) For the correct lengths of threads, see Part 1, Section 6 e .

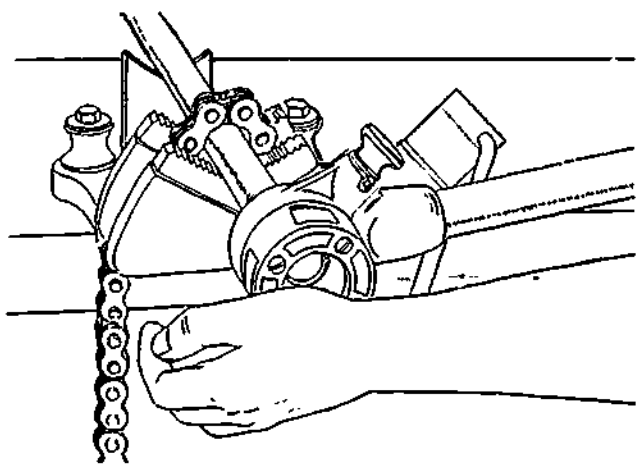


Figure 7-26. Pipe Threader Requiring Applied Force

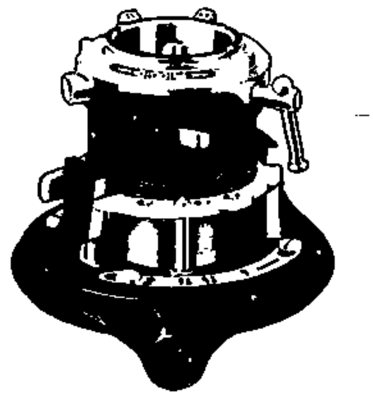


Figure 7-27. Pipe Threader Not Requiring Force

5. Tightening Fittings onto Pipe

a) Pipe-joint compounds come in many different forms such as stick, paste, tape, and powder that must be mixed into a paste. All are good if used for their stated purpose.

b) Pipe-joint compound must be applied to the *exterior thread* of all pipes and fittings before they are assembled. It should never be applied to the inside thread of a fitting to be used in a water service, or to any other system where the compound might travel inside the pipe and block or damage controls, etc.

c) After tightening the fitting by hand onto a pipe, tighten it further with a wrench or another appropriate tool.

d) Never use a pipe wrench to bend, raise, or lift a pipe. Putting such an additional strain on a wrench can result in a broken housing. Since a pipe wrench is designed only to turn pipe, use it solely for this purpose.

e) Use a wrench with an offset-style handle when working in close quarters. It is designed so that when gripping a pipe close to a wall or ceiling the handle can still be turned freely. This type of wrench is not restricted to this use, but it does tend to keep your knuckles free from obstructions in a confined area.

f) It is most important when using a pipe wrench of any size to maintain enough gap between the back of the hook jaw and the pipe itself. The pressure of two points only — the heel jaw and the teeth of the hook jaw — produces the gripping action of the wrench. If a third point, such as the back of the hook jaw, is put in contact with the pipe, it will reduce the gripping action. Keeping that gap between the back of the hook jaw and the pipe ensures maximum gripping action and rotating force of the wrench.

g) A "cheater" is a makeshift device for adding leverage when using a pipe wrench, but do not use one to loosen frozen pipes and fittings. If you do, you risk bending or breaking the wrench handle. If a wrench were designed to withstand the added strain of using a 1.8 m length of pipe as a cheater, it would have been made with a 1.8 m ` ^ndle. *A compound-leverage wrench, specifically o. 'ned to provide the necessary added leverage, solv. the problem of separating frozen pipes and fittings.*

h) Fittings should be tightened onto pipes as explained in Part 1.

i) Always position an adjustable open-end wrench so that the force used to turn it is applied to the stationary-jaw side as depicted in Figure 7-28.

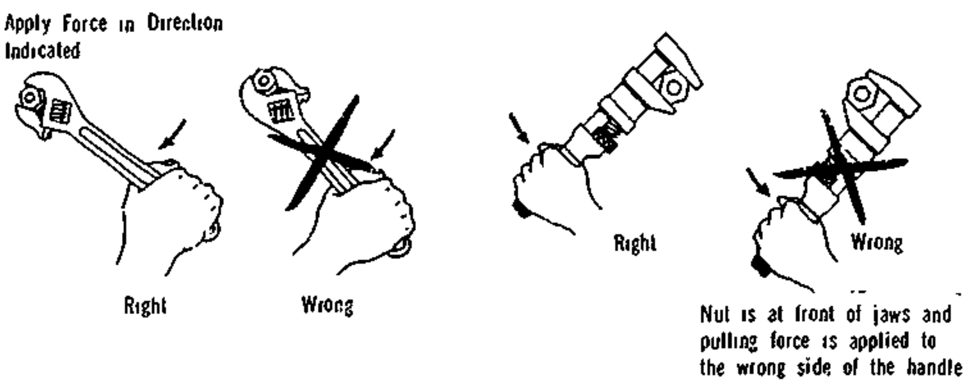
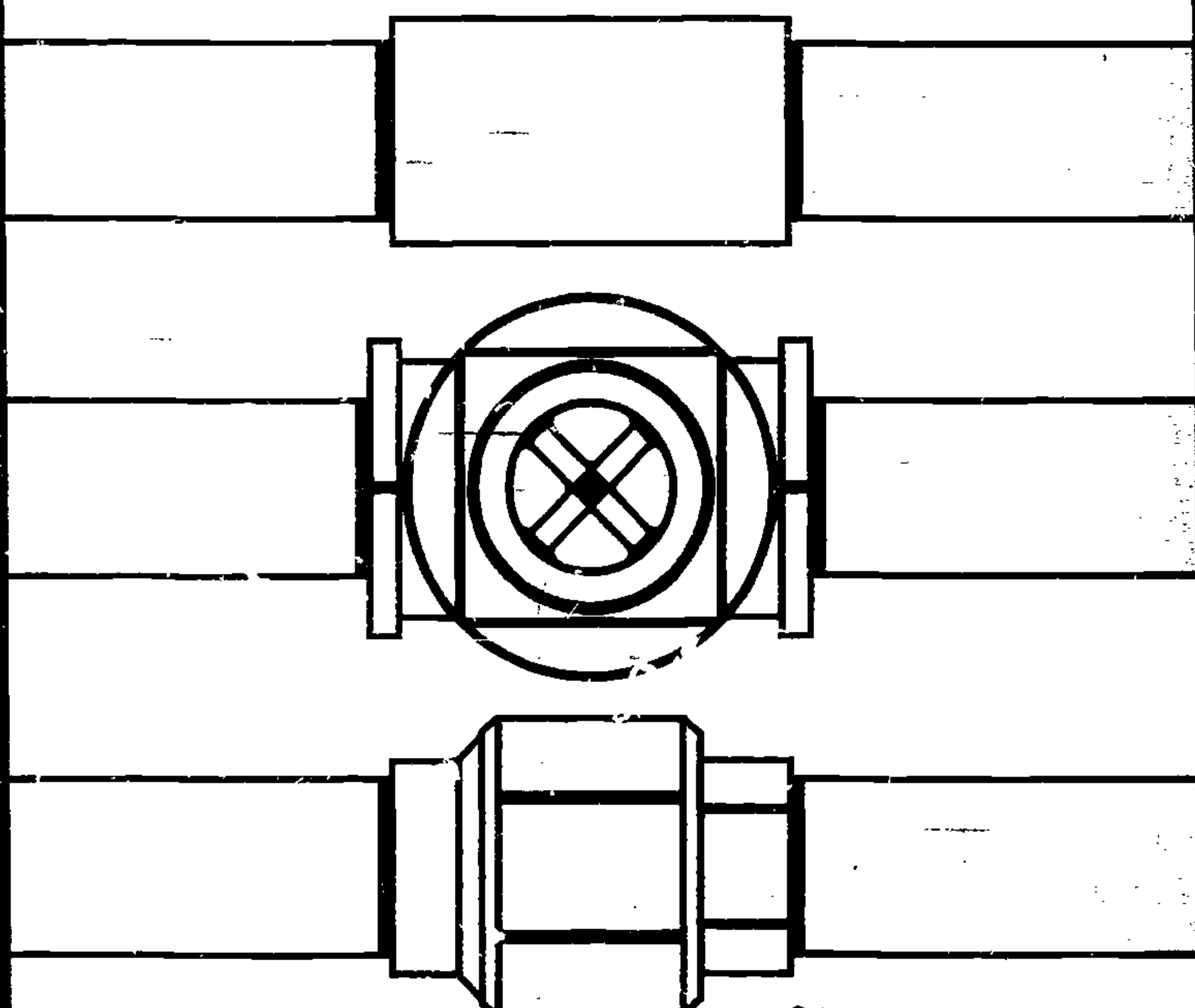


Figure 7-28. Use of Open-Ended Wrenches

Copper Tubing, Fittings, and Joints 8



PART 8
COPPER TUBING, FITTINGS, AND JOINTS

SEAMLESS COPPER TUBING

1. Types

a) In the plumbing trade, the terms copper pipe and copper tubing have two different meanings.

b) The distinction between the pipe and tubing is explained in the standard specified in the plumbing code, but a quick method for learning purposes is that for something to be referred to as copper pipe, it must have an outside diameter and wall thickness such that a National Pipe Thread of standard size can be cut on the end. Copper tubing has a smaller outside diameter than copper pipe of the same nominal size.

c) Various types (or weights) of copper tubing are available in three different tempers: hard temper (hard-drawn), semi-hard temper (light-drawn); soft temper (annealed).

d) Types (or weights) of copper tubing permitted in the various parts of a plumbing system are governed by the plumbing code.

e) Types (or weights) of copper tubing made for plumbing purposes are K, L, M, and DWV.

2. Sizes

a) Copper tubing for plumbing comes in the following "standard sizes," meaning "nominal sizes":

Types K and L
NPS ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 4, 5, 6.

Type M
As in types K and L except that NPS ¼ is unavailable.

Type DWV
NPS 1¼, 1½, 2, 3, 4, 5, 6. Other sizes are not generally available.

b) The standard size by which copper tubing is designated is its nominal outside diameter. Example:

The outside diameter of NPS 1 standard size copper tubing is 25.4 mm + 3.2 mm = 28.6 mm The actual inside diameter will vary with the wall thickness of the particular type of tubing.

3. Lengths of Copper Tubing

a) Hard-temper and semi-hard-temper copper tubing is supplied in 3.66 m and 6.10 m lengths. Depending on the location, wholesalers may carry only one of these lengths but will generally order the others if required.

b) The smaller sizes of soft-temper type K and L copper tubing come in the following standard-length coils: type K, 20.12 m; type L, 18.29 m.

c) The larger-size, soft-temper copper tubing is normally furnished only in 3.66 m and 6.10 m lengths.

4. Identification

All copper plumbing tubing and pipe is produced in Canada and the United States to the appropriate ASTM standards.

COPPER SOLDER JOINT FITTINGS

1. Types

a) Copper solder joint fittings may be of wrought copper or cast bronze, and also forged or machined from bar stock.

b) They may be pressure-type or drainage (DWV) fittings.

c) The plumbing code stipulates where each type may and may not be used, and the standard with which it must comply.

d) Pressure-type fittings include:

Elbows of all types, with or without threads.

Tees of all types, with or without threads.

Couplings.

Bushings and reducers.

Unions.

Adapters to change from copper to all other types of piping.

Caps, plugs, etc.

e) When a fitting is described as CXC it means that each opening in the fitting has been cast or expanded to form a socket into which the end of the copper tubing will fit.

f) If a fitting is described as Fit.XC it means that the fitting end has the same outside diameter as the tubing and will fit into the socket of another fitting.

g) Adapters for copper to NPT may be described as Fit.XIPT (inside pipe thread); Fit to OPT (outside pipe thread); CXIPT or CXOPT. Inside pipe threads are also referred to as FPT (female pipe thread), and outside pipe threads as MPT (male pipe thread).

h) DWV fittings have thinner wall thicknesses than those used for pressure installations. The inside diameter of the fitting is such that when DWV tubing is inserted into the fitting socket no obstruction is created whereby waste material might build up and later cause blockages.

i) Drainage, or DWV, fittings come in a complete range of elbows, tees, couplings, adapters, ferrules, double and single Y's and sanitary tees, traps, closet-floor flanges, expansion joints, etc. There is a correct fitting for each part of every job.

SOLDERING AND BRAZING COPPER JOINTS

1. Selection of Materials

a) Before soldering copper tubing joints, consideration must be given to the materials to be used. The selection of the solder depends on the service for which the tubing is intended and, in some cases, on the requirements of the plumbing code.

b) In ordinary circumstances, regardless of what good-quality solder is used, a properly made soft-solder joint will be stronger than the tubing itself for stresses of short duration. However, this is not true for stresses of long duration at elevated temperatures where the solder, being somewhat plastic, may give when the stress is less than that which would produce a break with short-time loads. This condition is known as "creep" and the creep strength of various types of solder varies widely.

c) Solders must be of the types approved by the plumbing code. Where permitted, a good grade of 50-50 tin-lead solder may be used for pressures and temperatures shown in Table 8-1.

d) A good assurance of quality solder is if the spool is plainly marked with the composition, name, and trademark of the producer.

e) For all temperatures up to 120°C where high strengths are required, a 95-5 tin-antimony solder should be used. Some plumbers prefer this solder when the temperature is in the 93°C to 32°C range. Generally, 95-5 solder melts at a higher temperature than does 50-50, has less of a pasty range, and is therefore somewhat more difficult to handle, particularly for a vertical joint to be filled upward.

f) Where high strength is required in temperatures between 120°C and 180°C, the necessary strength can be obtained with brazing filler metals of the silver or copper-phosphorus types. This is covered in greater detail later in this part of the manual.

g) The essential difference between brazing and soldering is the temperature at which the filler metal will melt. Various solders melt at 182°C to 316°C. Brazing filler metals will melt at temperatures above 427°C but below the melting points of the base metals being joined. Because of the high brazing temperatures, a much hotter flame is required, and this will discolor the tubing and anneal or partially anneal it in the heat-affected area.

h) While brazing is the most satisfactory method of joining tubing by capillary connections for service temperatures over 120°C, it does not offer any significant advantages if the service temperature will remain below that figure.

i) Brazing is the preferred joining method at subzero temperatures.

2. Fluxes

a) Fluxes best suited to the 50-50 and the 95-5 solders for use with copper are in paste form, and consist of a petrolatum base containing zinc and ammonium chlorides. It should not be the function of the flux to clean the copper; but, assuming that the copper has been cleaned, the flux may be reasonably expected to remove residues of oxide; in addition, it serves to protect the surfaces from oxidation during the heating process, floats out the remaining oxides ahead of the molten solder, and promotes wetting action of the solder. Unlike liquid fluxes, paste fluxes stand a moderate amount of over-heating without losing their effectiveness.

Table 8-1. Rated Internal Working Pressures of Joints with Copper Tubing and Solder-Joint Fittings

Solder Used in Joints	Service Temperature Degrees (Celsius)	Copper Water Tubing K, L, and M — Nominal Pipe Sizes					
		Water					Saturated Steam
		¼ to 1	1¼ to 2	2½ to 4	5 to 8	10 to 12	All Sizes
50-50 Tin-Lead	38	1379 kPa	1207 kPa	1084 kPa	896 kPa	689 kPa	—
	66	1034 kPa	861 kPa	689 kPa	620 kPa	483 kPa	—
	93	689 kPa	621 kPa	517 kPa	483 kPa	345 kPa	—
	121	586 kPa	517 kPa	345 kPa	345 kPa	276 kPa	10 kPa
95-5 Tin-Antimony	38	3447 kPa	2758 kPa	206[illegible] kPa	1034 kPa	1034 kPa	—
	66	2758 kPa	2413 kPa	189 kPa	1034 kPa	1034 kPa	—
	93	2068 kPa	1724 kPa	1379 kPa	1034 kPa	965 kPa	—
	121	1379 kPa	1207 kPa	1034 kPa	965 kPa	758 kPa	10 kPa

b) Liquid fluxes may serve the purpose of removing oxides, but generally they serve none of the other purposes of a flux In an effort to produce a flux that will also clean the copper without manual cleaning, ammonia compounds might be used in dangerous amounts For these reasons, some of the liquid fluxes available are not recommended.

c) There are paste-type fluxes for which it is claimed cleaning before use is not required. Some of them may work reasonably well except where the tubing or fitting is very dirty or greasy. Before using such a flux, however, satisfy yourself that the flux can do what is claimed for it when used on the job under the existing conditions. It is stressed that if a flux permits a joint to be soldered without cleaning — that is, if the solder covers up the scale or surface dirt — a weak joint may result.

d) For brazing, the type of flux selected depends on the filler metal, and for best results use the flux recommended by the manufacturer of the filler metal Filler metals in the copper-phosphorus group are generally self-fluxing on copper-to-copper, but fluxes are required when joining copper to brass. However, manual cleaning before brazing is required in all operations.

3. Cleaning

a) Both the inside of the socket of the fitting and the outer surface of the tubing where it is to enter the fitting should be cleaned bright before fluxing. There are several ways of doing this. No.00 emery cloth or steel wool may be used. Also, there are specially produced sand cloths that do a good job. If steel wool is used, take care to keep particles of steel out of the area to be soldered and out of the tubing.

b) Wire brushes are available for cleaning both tubing and fittings. The proper-size brush must be used for each size of tubing or fitting.

c) There are other types of patented cleaners, including power-operated ones. All are good if the result conforms to paragraph a).

4. Comments by CCBDA

a) The six-step procedure outlined in Section 5. Preparation, has long been used with excellent results. Naturally, there will always be an effort to improve the process; but, as already stated, efforts to eliminate manual cleaning by the use of self-cleaning fluxes have not been very successful. Sometimes they may be considered satisfactory, but more often their results are uncertain and the repair of a few leaks can cost more than is saved by eliminating the cleaning process.

b) A similar situation applies with the paste-type solders or solder paints. These consist of a finely granulated solder, generally 50-50, in suspension in a paste flux. Most of these are in fluxes for which it is claimed that cleaning of the copper is not required. Since in melting the solder the flux will run out of the joint, it is necessary to go back over all but the smallest jobs to fill the joint with wire-type solder. With this paste-type solder, it is almost impossible to make a neat and satisfactory vertical joint, because the solder and flux will run down the tubing.

Paste-type solders may do a satisfactory job provided that the work is manually cleaned before soldering and the joints are filled with regular solder; otherwise, this product is not recommended.

c) Pre-tinning (heating and coating the faces with solder and wiping off) is not necessary and generally not recommended. Some plumbers prefer this method on piping of NPS 2½ and up.

d) If the metal is properly cleaned and fluxed, capillary action should draw in all the solder needed for the joint. Pre-tinning may interfere to some extent with the capillary action.

e) Over-size fittings will result in a loose fit. The capillary action is dependent on a fairly tight fit. A certain amount of looseness can be tolerated but is more apt to cause difficulties in the larger sizes. This is particularly true with horizontal joints where an over-size fitting may allow the tubing to rest directly on the socket, resulting in a double-width space at the top. Whenever possible, such joints should be made up in the vertical position before assembly However, best results are obtained by using fittings that conform to accepted standards.

5. Preparation

a) The following six preliminary steps must be adhered to if a satisfactory joint is to be obtained by either the soldering or brazing operation:

The accuracy of measurement of the tubing is not really part of the soldering job but it may affect the quality of the joints. If a piece of tubing is cut too long it can be shortened by another cut, but if too short it will not enter all the way into the socket of the fitting and an imperfect joint will result.

Tubing should be cut to exact length with a square cut Tubing cutters are generally used for sizes up to NPS 1, but larger-size cutters are available The alternative method is to cut with a hacksaw Some vises are equipped with guides for the hacksaw blade, thus assuring a square cut.

The cutter will leave a small burr on the tubing and this should be removed by the reamer attached to the cutter, or by a file. If a hacksaw has been used, there may be both burrs and slivers, which also must be removed.

The surfaces to be joined must be clean and free of oil, grease, and heavy oxides. The end of the tubing should be cleaned for a distance only slightly more than the distance that it is to enter the socket of the fitting. Fine sand cloth, emery cloth, steel wool, or special brushes or equipment may be used. Rub hard enough to remove the surface soil, taking care not to remove the copper. If the cleaning is done on work in place, be sure that particles of steel wool or other material do not fall into and lodge in either the tubing or the fitting. The socket of the fitting should be cleaned by the same method used to clean the tubing end, and the same precautions should be taken. Even if the socket looks clean, clean it anyway.

Immediately after cleaning, the surfaces of the tubing and the fitting to be joined should be covered with a thin film of flux. Use flux brushes to apply it for even distribution. For soft soldering, the preferred flux is one that is mildly corrosive, containing zinc and ammonium chlorides in a petrolatum base. The paste should be thoroughly stirred when a new can is opened because the chemicals tend to settle after long-standing. For brazing, fluxing should be done according to recommendations of the manufacturer of the brazing material. Excess flux, particularly on areas not cleaned, does not help the braze but may serve to avoid oxidation on adjoining areas. Especially avoid getting excess flux on the inside of the tubing where it could become a problem, such as causing blockage in cold water lines, plugging and sticking orifices in hot water lines, and hindering valve action on oxygen, nitrogen, and air lines.

Assemble the joint by inserting the tubing into the fitting, making sure that the tubing is hard against the stop of the socket. A small twist will help spread the flux over the two surfaces. The joint is now ready for soldering. A common practice is to clean, flux, and assemble a large number of joints before soldering. However, the assembly should not get more than two or three hours ahead of soldering, and certainly the fluxed assembly should never be left overnight before soldering.

b) The approximate quantity of solder needed to make 100 joints is shown in Table 8-2. The quantity of flux required is about 0.125 kg per kg of solder.

Table 8-2. Quantity of Solder per 100 Joints

Copper Plumbing Tubing Size (NPS)	Pressure Fittings	Drainage Fittings
⅜	0.227 kg	—
½	0.340 kg	—
¾	0.454 kg	—
1	0.680 kg	—
1¼	0.794 kg	0.590 kg
1½	0.907 kg	0.680 kg
2	1.114 kg	0.907 kg
2½	1.542 kg	—
3	1.905 kg	1.451 kg
3½	2.177 kg	—
4	2.722 kg	2.041 kg
5	3.856 kg	—
6	7.257 kg	—

6. Soldering

a) The six steps given in the "Preparation" section 5 must first be followed carefully since their correct application is the basis for well-soldered joints. Then proceed as follows:

b) Heat is usually applied by a gas-air type of torch. The flame should be played on the fitting, pointing toward the tubing, and should be kept in motion to heat as large an area as possible. When the metal is hot enough, the flame should be removed and the solder should melt on contact with the tubing; if it does not, remove the solder and add more heat, then try again. Avoid over-heating because it may burn the flux and destroy its effectiveness. If the flux has been burned, the solder will not enter the joint, and it must then be re-opened, re-cleaned, and re-fluxed.

c) When the joint is at the correct temperature the end of the wire of solder is touched to the joint. Never apply the flame directly to the solder, which should melt on contact with the metal and then be drawn into the joint by the natural force of capillary attraction, regardless of whether the solder is being fed in upward, downward, or sideways. If the joint has been properly made, almost instantly a ring of solder will be seen all around the joint Opinions differ as to whether a "fillet" is desirable — a fillet being a bead of solder across the end face of the fitting and on the pipe at an angle of about 45 degrees.

d) While the joint is still hot, remove any surplus solder and flux with a rag or a brush. This will improve the appearance of the assembly and prevent any chance of continued corrosive action by the surplus flux.

e) Let the newly soldered joint cool naturally before applying water.

f) When the assembly has been completed, test it for leaks. If the joints have been made as described there should be no leaks. However, if leaks must be repaired it is best to disassemble and re-clear. the joint, then flux and re-solder. If it is not possible to disassemble the parts, the tub. g must be thoroughly drained because even a few drops of water could prevent re-heating of the joint to the solder-melting temperature.

g) With tubing and fittings larger than NPS 2 the method just described may be used, with consideration being given to the size of the torch and flame being used. The torch or flame should be of sufficient size to bring the fitting and tubing to soldering temperature without spot-heating. The flame should be kept moving to permit an even temperature rise of the joint. For large fittings, two torches may be used simultaneously but the operators must be careful to avoid burning each other. Preferably, use a single torch with two nozzles. There is a circular type of torch with nozzles all around the circumference that permit heating the entire joint quickly and efficiently in one operation.

h) If the tubing is out of round, as it may be when coils have been straightened, it can be brought to true dimensions and roundness with a sizing tool, which consists of a plug and a sizing ring

i) The quantities of solder required for copper tubing joints vary widely depending on the skill of the operator as well as on the type of heating and the position of the joint. It is recommended that estimates be based on personal recorded data. As a guide, the figures listed in Table 8-2 on the quantity of solder per 100 joints may be used.

7. Brazing

a) Some types of air-acetylene or air-propane torches are used for making braze joints on smaller copper tubing and fittings. These torches are described in Part 3.

b) Strong leak-tight brazed connections for copper tubing may be made with brazing alloys at temperatures in the approximate range of between 590°C and 820°C. These are often referred to as "hard solders," but are properly described as "silver brazing."

c) Care must be taken when referring to "silver brazing" as "silver soldering." Some silver solders must be classified as soft solders because they will melt and flow at 200°C, and when used to join copper the joint has a tensile strength of about 100 MPa at 72°C, much higher than that of tin-lead solders.

d) The temperature at which a brazing material starts to melt is known as the "solidus temperature." At the "liquidus temperature" the brazing material is completely melted, and this is the minimum temperature at which brazing takes place. The difference between solidus and liquidus is known as the melting range, and it may be of importance in the selection of the brazing material, especially as an indication of the rapidity with which the alloy will "freeze" after brazing.

e) Brazing materials suitable for joining copper tubing may be divided into two classes — the alloys containing silver and the copper-phosphorus alloys. The two classes have a fairly wide difference in melting and flowing characteristics, and you should consider these as well as the time required to make a joint when selecting the brazing material. For join .g copper tubing with copper capillary fittings, any of these brazing alloys will provide the necessary strength.

Never heat the pipe or fittings to a temperature beyond that needed to make an efficient joint. Brazing or hard soldering is not favored for cast bronze fittings.

f) The strength of a brazed copper tubing joint does not vary too much with the different brazing materials but depends largely on maintenance of the proper clearance between the outside of the tubing and the fitting. Because copper water tubing and solder-type fittings are accurately made for each other, the tolerances permitted for each ensure that the capillary space (see Figure 8-1) will be kept within the limits necessary for a joint of satisfactory strength.

g) The rated internal working pressure of lines at service temperatures up to 177°C is 1862 kPa for sizes up to NPS 1; 1310 kPa for sizes NPS 1¼ to NPS 2. These pressures are based on a safety factor of five, and should be used only when the fitting is designed with the close tolerances that will accurately maintain the correct capillary space. The resulting joint will be liquid-tight, gas-tight, and vacuum-tight and can be safely used for temperatures of up to 218°C.

h) Many of the steps for making a braze joint are the same as those for soldering with an ordinary tin-lead solder.

i) The preparation of the joint is also the same. (Refer to "Preparation" section 5.)

j) Brazing is started by applying heat to the parts being joined. The preferred method is by oxy-acetylene flame, but good results may also be obtained on smaller pipes with some types of air-gas torches.

k) A slightly reducing flame should be used, with a slight feather on the inner blue cone. The outer portion of the flame is a pale green.

l) Heat the tubing first, beginning about 25 mm from the edge of the fitting. Sweep the flame around the tubing in short strokes up and down at right-angle to the run of the tubing. It is very important that the flame be in continuous motion and not be allowed to remain on any one point, to avoid over-heating the tubing. Generally, the flux may be used as a guide as to how long to heat the tubing, continuing the heating after the flux starts to bubble or work and until it becomes quiet and transparent like clear water.

Now switch the flame to the fitting at the base of the cup. Heat uniformly, sweeping the flame from the fitting to the tubing until the flux on the fitting becomes quiet. Avoid excessive heating of the fitting.

m) With tubing NPS 1 and larger it is difficult to bring the whole joint up to heat at one time. It frequently will be necessary to use a double-tip torch to maintain the proper temperature over the larger area. A mild pre-heating of the whole fitting is recommended for the larger sizes. Where difficulty is encountered in getting the whole joint up to heat at one time, when the joint portion is nearly up to

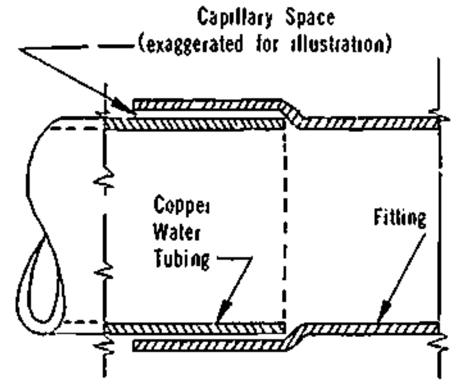


Figure 8-1. Cross Sectional View of Copper Tubing Joint

the desired temperature the flame can be concentrated in a limited area. At the brazing temperature the alloy is fed into that area, and the torch is then moved to an adjacent area and the operation is continued all around the joint.

n) When the flux appears liquid and transparent on both the tubing and the fitting, sweep the flame back and forth along the axis of the joint to maintain heat on the parts to be joined, especially toward the base of the fitting cup. The flame must be kept moving to avoid over-heating the tubing or the fitting.

o) Apply the brazing wire or rod at a point where the tubing enters the socket of the fitting. With the temperature of the joint being hot enough to melt the brazing alloy, keep the flame from the rod or wire as it is fed into the joint. Keep both the fitting and the tubing heated by moving the flame back and forth from one to the other as the alloy is drawn into the joint. When the proper temperature is reached, the alloy will readily flow into the space between the outer wall of the tubing and the fitting socket, being drawn in by the natural force of capillary attraction. When the joint is filled, a continuous fillet of brazing alloy will be visible around the joint. Stop feeding as soon as the joint is filled, using Table 8-3 as a guide.

p) When making horizontal joints, it is preferable to start by applying the brazing alloy at the top, then the two sides, and finally the bottom, making sure the operations overlap.

Table 8-3. Approximate Consumption of Brazing Alloy in Linear Millimetres

Copper Water Tubing Size NPS	1.6 mm Wire*	2.4 mm Wire*	2.0 mm Wire*
¼	19	—	—
⅜	25	—	—
½	38	19	22
¾	51	25	29
1	76	38	41
1¼	102	51	54
1½	—	64	67
2	—	95	102
2½	—	152	178
3	—	254	279
3½	—	305	330
4	—	356	394
5	—	419	457
6	—	533	584
Linear metres of alloy per kg	60 m	26.6 m	29.3m

*Other sizes are available.

q) On vertical down-joints, it is immaterial where you start. But on vertical up-joints, take care to avoid over-heating the tubing as this may cause the alloy to run down it. If this does happen, remove the heat and let the alloy set. Then re-heat the band of the fitting to draw up the alloy.

r) After the brazing alloy has set, clean off the remaining flux with a wet brush or swab. Wrought fittings may be chilled quickly; however, it is advisable to allow cast fittings to cool naturally before swabbing. All flux must be removed before inspection and pressure testing.

s) If the alloy fails to flow or tends to ball up, this indicates oxidation on the metal surfaces or insufficient heat on the parts to be joined. If oxidation occurs during heating, this indicates too little flux or a flux of too thin a consistency. If the brazing alloy refuses to enter the joint and tends to flow over the outside of either member of the joint, this indicates that this member is over-heated, or the other is under-heated, or both.

t) The equipment best suited for the job may be selected from Table 8-4.

8. Flare Joints

a) There are two methods in general use for making a flare joint using soft-temper copper tubing.

b) After the tubing has been cut to length and the burrs removed, the coupling nut is then slipped over the end of the tubing.

Table 8-4. Recommended Equipment for Jobs

Copper Water Tubing Size NPS	Torch Tip Drill Size Number	Acetylene Consumption (m^3/hr.)	For Estimating Purposes Oxygen Pressure Approx. (kPa)	Acetylene Pressure Approx. (kPa)
¼	54	0.450	27.6	27.6
⅜	54	0.450	27.6	27.6
½	51	0.702	34.5	34.5
¾	51	0.702	34.5	34.5
1	48	0.895	41.4	41.4
1¼	48	0.895	41.4	41.4
1½	44	1.096	48.3	43.3
2	40	1.699	48.3	48.3
2½	40	1.699	48.3	48.3
3	35	1 982	51.7	51.7
3½	35	1.982	51.7	51.7
4	30	2.506	62.1	62.1
5	30	2.506	62.1	62.1
6	30	2.506	62.1	62.1

c) In impact flaring, the flaring tool is inserted into the end of the tubing. Then a few light hammer blows on the flaring tool will expand the tubing to the proper flare for the style of fitting to be used. (See Figures 8-2 and 8-3.)

Figure 8-2. Inserting Flaring Tool

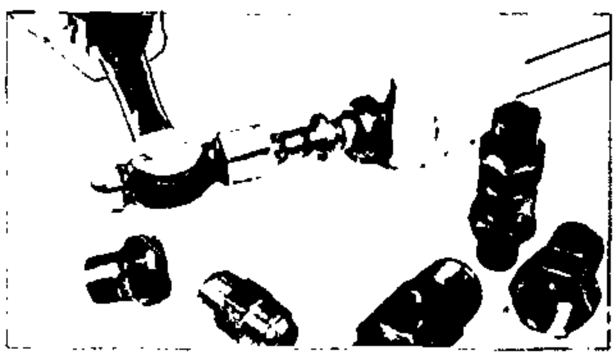


Figure 8-3. Flare Made by Hammering

d) The tubing is now flared and ready for assembly of the fitting, which is tightened by using two wrenches, one on the nut and the other on the body of the fitting, as illustrated in Figure 8-4.

e) In screw-type flaring, the first three steps are the same as those for impact flaring, namely: the tubing is cut to length, the burrs are removed, then the coupling nut is slipped over the end of the tubing.

f) The tubing is clamped in the flaring bar so that the end of the tubing is slightly above the face of the bar, as illustrated in Figure 8-5.

g) The yoke of the flaring tool is placed on the bar so that the bevelled end of the compressor cone is over the end of the tubing. The compressor screw is then tightened down, forming the flare between the chamfer of the flaring bar and the bevelled compressor cone as shown in Figure 8-6. The flaring tool is then removed and the joint is assembled (see Figure 8-7) in the same manner as that described under impact flaring.

Figure 8-4. Assembly of the Fitting

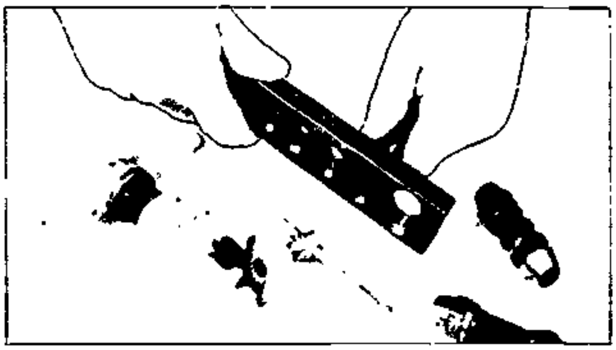


Figure 8-5. Tubing Clamped into Flaring Bar

9. Tubing Benders

a) There are many different types of tubing benders, but only the outside spring type and the open-side mandrel type are covered here.

b) In all cases, the manufacturer's instructions should be followed when using tubing benders. The following information is only a guide:

c) Spring-type tubing benders are available for bending copper and aluminum tubing ranging from 6 mm to 22 mm OD. When using this type of bender, first select the size that will just slip over the size of the tubing to be bent. Then slip the bender over the tubing so that it centres at the middle of the proposed bend. Grasp the bender with both hands and make the bend. The restraining action of the bender will prevent the tubing from collapsing at the bend and will produce a smooth curve. To remove the bender, grasp the belled end and pull it off the tubing. (Figure 8-8.)

Figure 8-6. Compressor Screw Used to Form Flare

Figure 8-7. Assembly of the Fitting

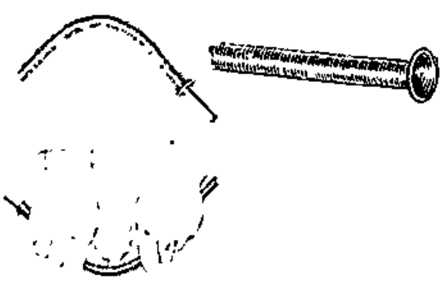


Figure 8-8. Spring-Type Tubing Bender

d) Shown in Figure 8-9 is one type of open-side mandrel tubing bender. "Open-side" means that one side is open so that the bender can be placed on the tubing at any point along its length.

e) The mandrel is the circular portion of the bender around which the tubing is formed or bent. Place the bender on the tubing at the point where the bend is required. The zero line on the bender indicates the start of the bend. Now close the bender as illustrated in Figure 8-9 and, by bringing your hands toward each other, bend the tubing around the mandrel until the index line on the arm indicates the angle of the bend that you want. Then open the bender and remove it from the tubing. For larger tubing, similar mandrel-type benders are used. These are often geared for greater mechanical advantage but their operation is basically the same.

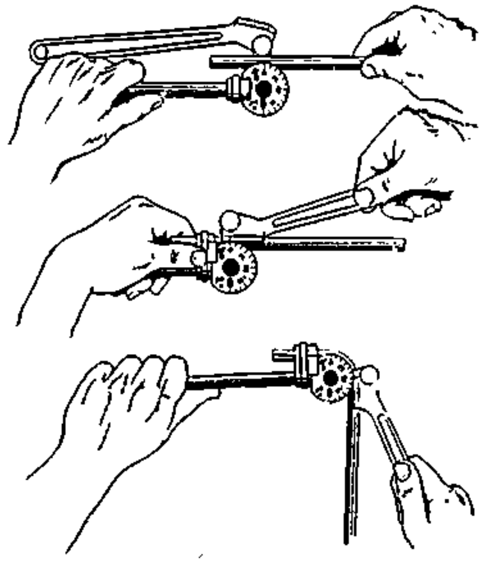


Figure 8-9. Open-Side Mandrel Tubing Bender

10. Compression Fittings

a) There are perhaps as many different compression fittings as there are flare fittings, but they are not in as common use by plumbers as are flare fittings.

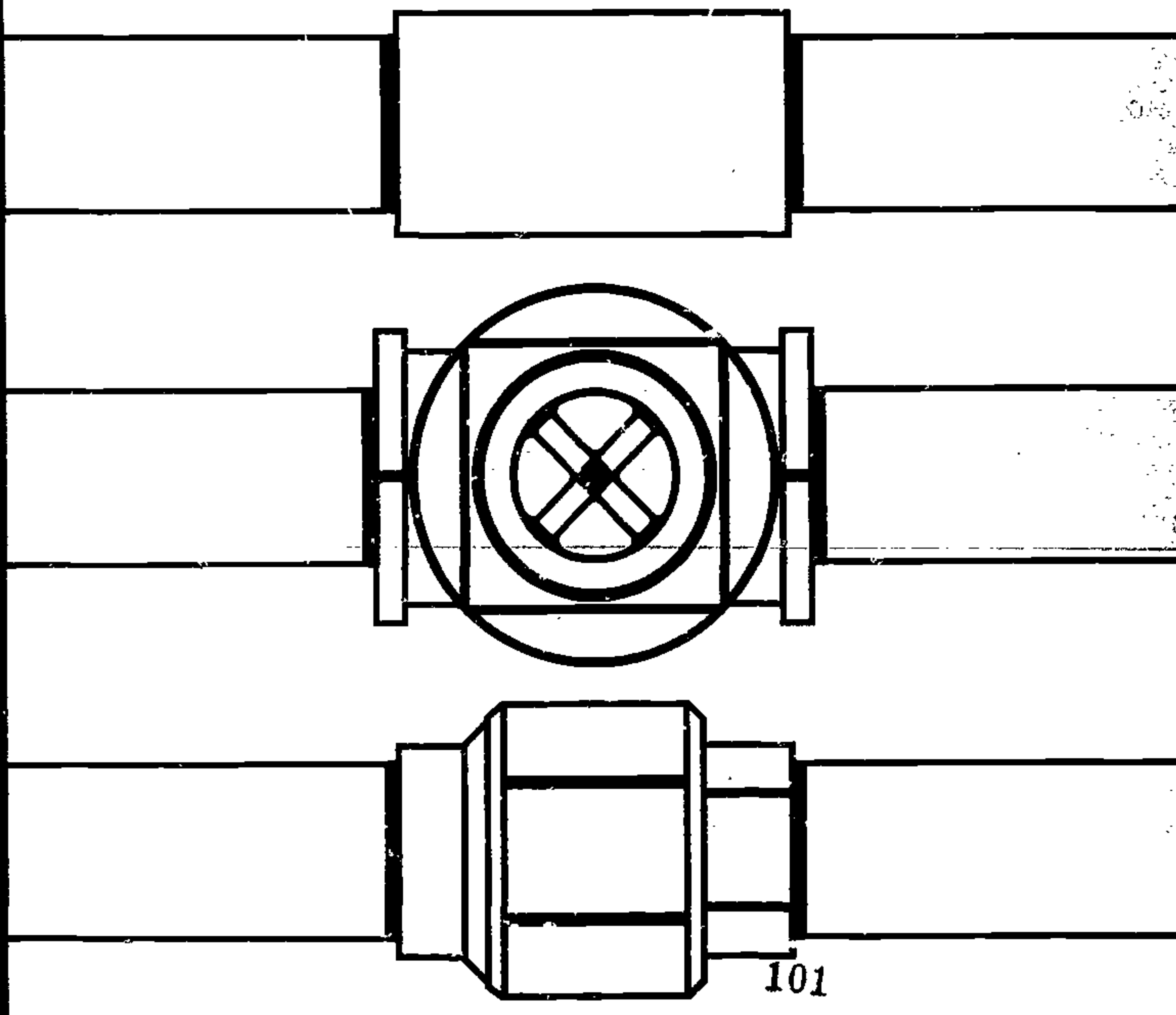
b) Following is the procedure for making a compression joint:

Cut the tubing to the desired length and remove the burr.

Place the nut over the end of the tubing and then put the ferrule sleeve over it, permitting the end of the tubing to extend a little past the end of the ferrule.

Place the end of the tubing in the fitting, screw the nut on tightly by hand, and further tighten it by using two wrenches, one on the nut and the other on the fitting.

Seamless Copper Pipe and Red Brass Pipe 9



PART 9

SEAMLESS COPPER PIPE AND RED BRASS PIPE

1. General

a) It is often difficult for the student to accept the fact that there is a difference between copper tubing and copper pipe in the plumbing trade. They are manufactured to different standards, hence the information elsewhere in this manual on the standards for copper tubing does not apply to copper pipe, and vice versa.

b) A pipe is best described as having a sufficiently heavy wall thickness and the correct outside diameter to enable a National Pipe Thread to be cut on the end. Tubing manufactured for plumbing purposes does not meet this requirement.

c) Copper pipe and red brass pipe have the same outside diameter as galvanized steel pipe, and can be joined with National Pipe Threads.

d) Copper pipe has nearly the same resistance to corrosive waters as has red brass pipe. The material in the copper pipe is at least 99.9 per cent copper, the remainder being phosphorus.

e) Red brass pipe contains 84 to 86 per cent copper and 14 to 16 per cent zinc with maximums of 0.06 per cent lead and 0.05 per cent iron.

f) The standard length of these pipes is 3.7 m.

g) Copper pipe and red brass pipe are available in regular and extra-strong classes (known as schedules 40 and 80).

h) They are available in nominal pipe sizes from NPS ⅛ to 12.

2. Copper Pipe

Copper pipe is normally supplied in drawn temper, but when required for bending it can be ordered to a temper agreed on by the manufacturer and the purchaser.

3. Red Brass Pipe

Red brass pipe is normally supplied in annealed condition, but may be in drawn temper if agreed on by the manufacturer and the purchaser.

4. Threading

a) Special dies are available for use in threaders when cutting National Pipe Threads on copper pipe or red brass pipe.

b) Regular steel pipe dies are often used when only a few threads are needed.

5. Fittings

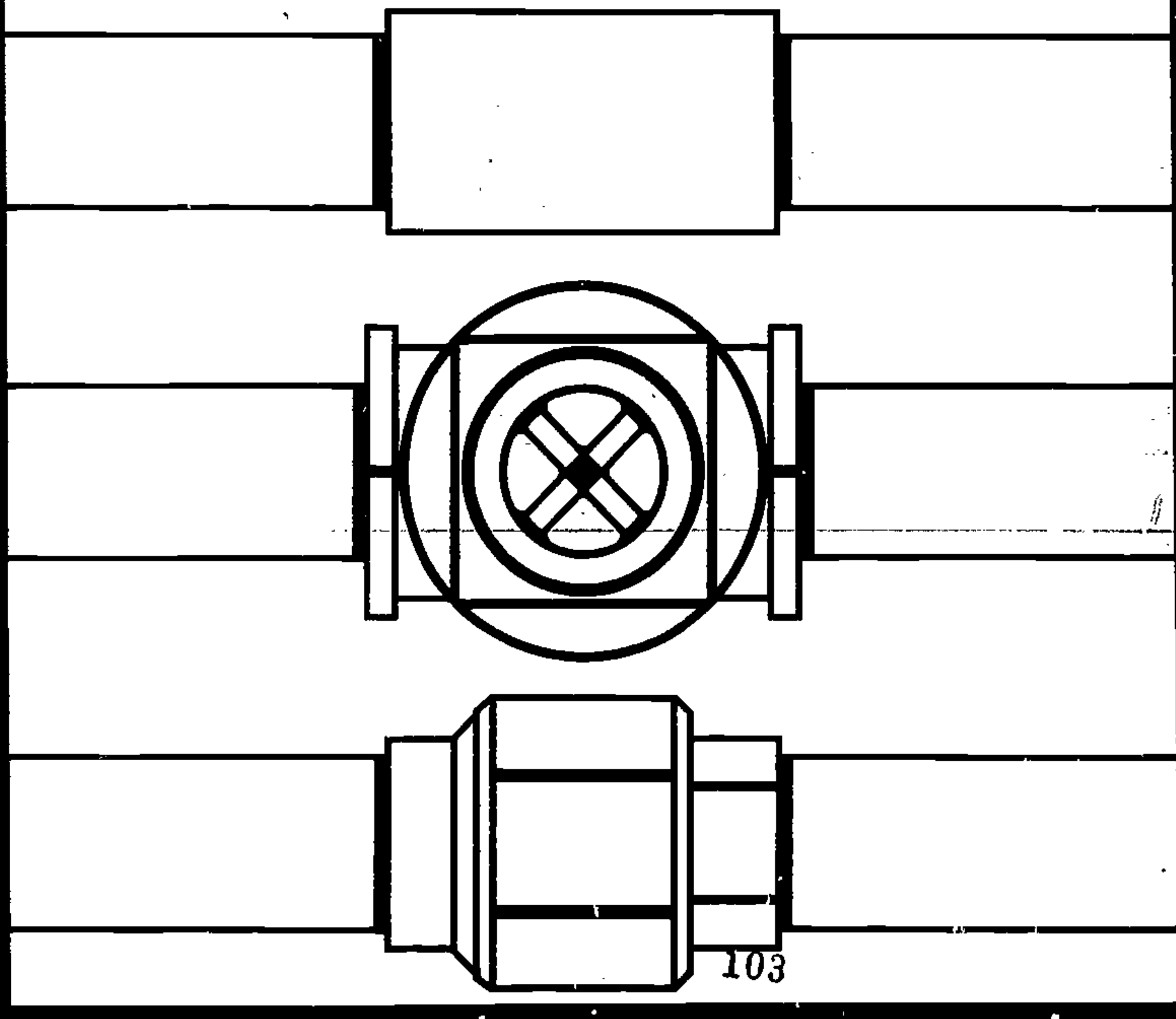
A full line of water-pipe fittings and nipples is available for copper pipe and red brass pipe.

6. Installation

a) Care must be taken not to stretch the shoulder of the fitting by over-tightening it on the pipe. This generally causes leakage.

b) Fine hemp (sometimes referred to as angel's hair) is often used with pipe-joint compound on the joints.

Polyethylene Pipe, Fittings, and Joints 10



PART 10
POLYETHYLENE PIPE, FITTINGS, AND JOINTS

POLYETHYLENE PIPE, FITTINGS, AND JOINTS

1. Polyethylene Pipe

a) The locations where polyethylene pipe may be used are governed by the plumbing code, as is the case with all plumbing material; but generally it is used in water-service pipes to homes, suction lines in domestic wells, lawn-irrigation systems, and in supplying cold water to buildings around a farm.

b) Polyethylene pipe is made in three types: low density (LD), medium density (MD), and high density (HD). Only the LD and MD types are described in these pages. The HD pipe is a much more rigid type than the LD or MD, and the manufacturers recommend it as suitable for DWV installations.

c) The pipe is made in two different types of pipe sizes. One is for nominal inside-diameter (ID) pipe, which is used with insert fittings, and the other is classified as OD (outside diameter) pipe.

d) Polyethylene pipe is made in five different weight or pressure classes, which are referred to as "series" and denote the maximum *working* pressure. These series numbers are 50, 75, 100, 125, and 160 indicating pounds per square inch or, in metric equivalence, 345 kPa, 520 kPa, 690 kPa, 860 kPa. and 1100 kPa. The corresponding *bursting* pressures for these working pressures are 1380 kPa, 2070 kPa, 2760 kPa, 3450 kPa, and 4410 kPa.

e) Polyethylene pipe is made in the following sizes. NPS ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 4, and 6.

f) The pipe and fittings must conform to the standard specified in the appropriate plumbing code.

g) Polyethylene pipes can be produced in any length agreed on by the manufacturer and the purchaser The smaller sizes are generally available in at least 30 m and 150 m coils. The lengths of the larger sizes would be restricted by the mode of transportation.

h) The general characteristics of polyethylene pipe are:

- Light weight and low specific gravity.
- Almost unbreakable.
- Resistant to abrasion.
- Non-wetting.
- Flexible.
- Chemically inert.
- Very smooth bore.
- High coefficient of linear expansion.
- Low tensile strength.
- Low temperature resistance.
- Low pressure capabilities.
- Non-conductor of electricity.
- Low thermal conductivity.
- Softens when heated.

2. Fittings

a) Plastic and metallic insert fittings and threaded inse adapters are available in a wide range for general applications.

b) Figure 10-1 shows types of insert fittings and clamps used with polyethylene pipe.

c) Standard waterworks brass flare fittings and compression-type fittings are available for polyethylene pipe.

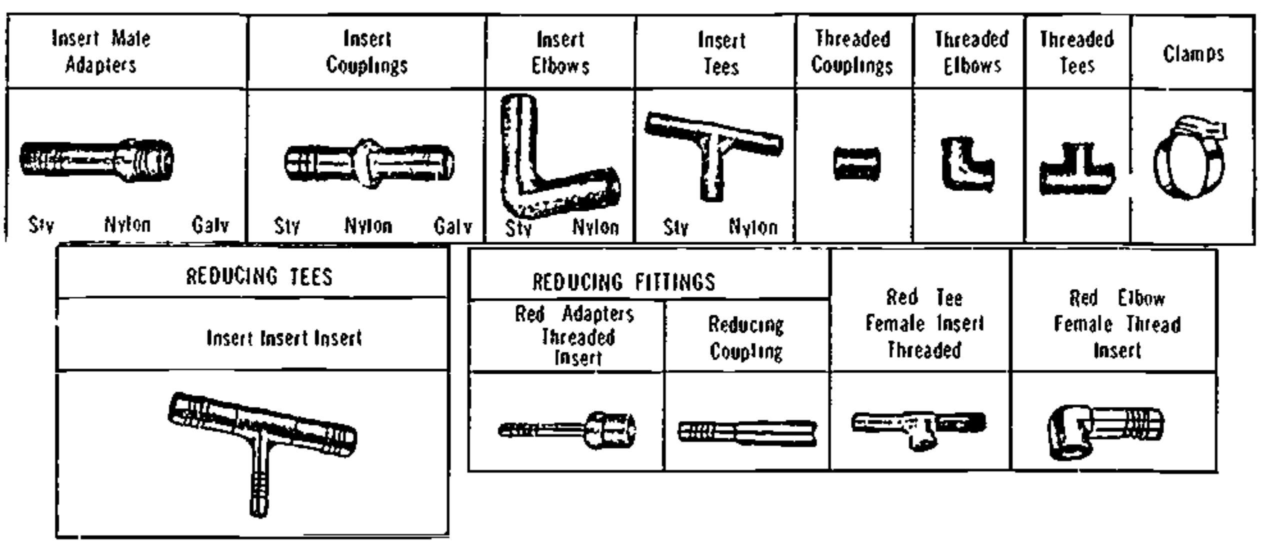


Figure 10-1. Insert Fittings and Clamps

3. Joints

a) Polyethylene pipe and fittings are commonly joined with insert fittings and clamps. The following directions apply to making joints using insert fittings and clamps:

Use galvanized insert fittings where higher pressures or large-diameter pipes are involved.

Plastic insert fittings are adequate and more economical for low-pressure service and general use.

When using galvanized insert fittings where there is a danger of external corrosion, apply pressure-sensitive polyethylene tape to protect the joints.

Stainless steel gear clamps are recommended for use on buried pipelines.

Use cadmium-plated carbon-steel screws with gear clamps on other applications.

Use two gear clamps for joints on high-pressure pipelines Polyethylene pipe may be cut to the correct length with a saw or a sharp knife. The burr should then be removed from the inside with a knife.

Place the gear clamp or clamps over the end of the pipe to be joined to a fitting.

In cool weather, warm the end of the pipe before inserting the fitting by dipping it in boiling water until it becomes flexible. This softens the pipe end and results in better joints. A torch may be used to heat the pipe end, but the flame should not be permitted to touch the pipe.

Push the insert fitting into the pipe until the pipe butts against the fitting shoulder.

Position the gear clamp over the flat portion of the fitting (past the serrations on the fitting) and tighten it securely with a screwdriver, making sure the clamp is squarely on the pipe.

f) When making a joint with a compression fitting, the compression nut is slipped over the end of the pipe and the stainless steel or brass sleeve is inserted into the end of the pipe. The compression ring is placed over the pipe end, the pipe end is inserted into the fitting, and the compression nut is tightened

c) When using a flare fitting, the coupling nut is put over the end of the pipe, the pipe end is warmed and the flaring tool is inserted into it with enough force to form a good flare. Remove the flaring tool after about 45 seconds and assemble the flare joint. In cold weather, warm the flaring tool. If "cold flaring" is to be used, follow the manufacturer's instructions.

d) The joining technique when using socket fusion employs a heating tool with male and female ends to heat both the pipe end and the interior of the socket to melting point When the polyethylene is soft, the pipe and socket are removed from the tool and quickly forced together. Usually, a compression band is used to hold the mating surfaces closely together during cooling. Once cool, a strong monolithic joint is formed.

4. Pipes In Trenches

a) Polyethylene pipes in the smaller sizes tolerate considerable ground unevenness. The larger the pipe size the more evenly the trench bottom should be prepared.

b) Preferably, trench bottoms should be free from rocks and sharp projections. If the natural trench bottom is unsuitable, cover it with sand or earth to a depth of from approximately 100 mm to 150 mm.

c) Trenches may be as narrow as is practical because the joints can be generally made above the trench and then pushed into place.

d) The pipes should be snaked into the trench to allow for expansion and contraction.

e) Tamping of the fill under and around the pipe may be required depending on soil conditions. Do not drop large stones onto the pipe. When backfilling, avoid using earth containing large rocks or frozen lumps that may be driven down onto the pipe.

f) Polyethylene pipe is a non-conductor of electricity. Bury a suitable tracer wire with the pipe if detection will be necessary. Do not use the pipe as an electrical ground

5. Support of Pipe

a) The pipe should be continuously supported if it is to carry hot water.

b) Plastic hangers may be used for pipes carrying water at ground temperature. Do not use supports with sharp edges. Take care not to over-tighten hanger clamps so that they can cut into the pipe.

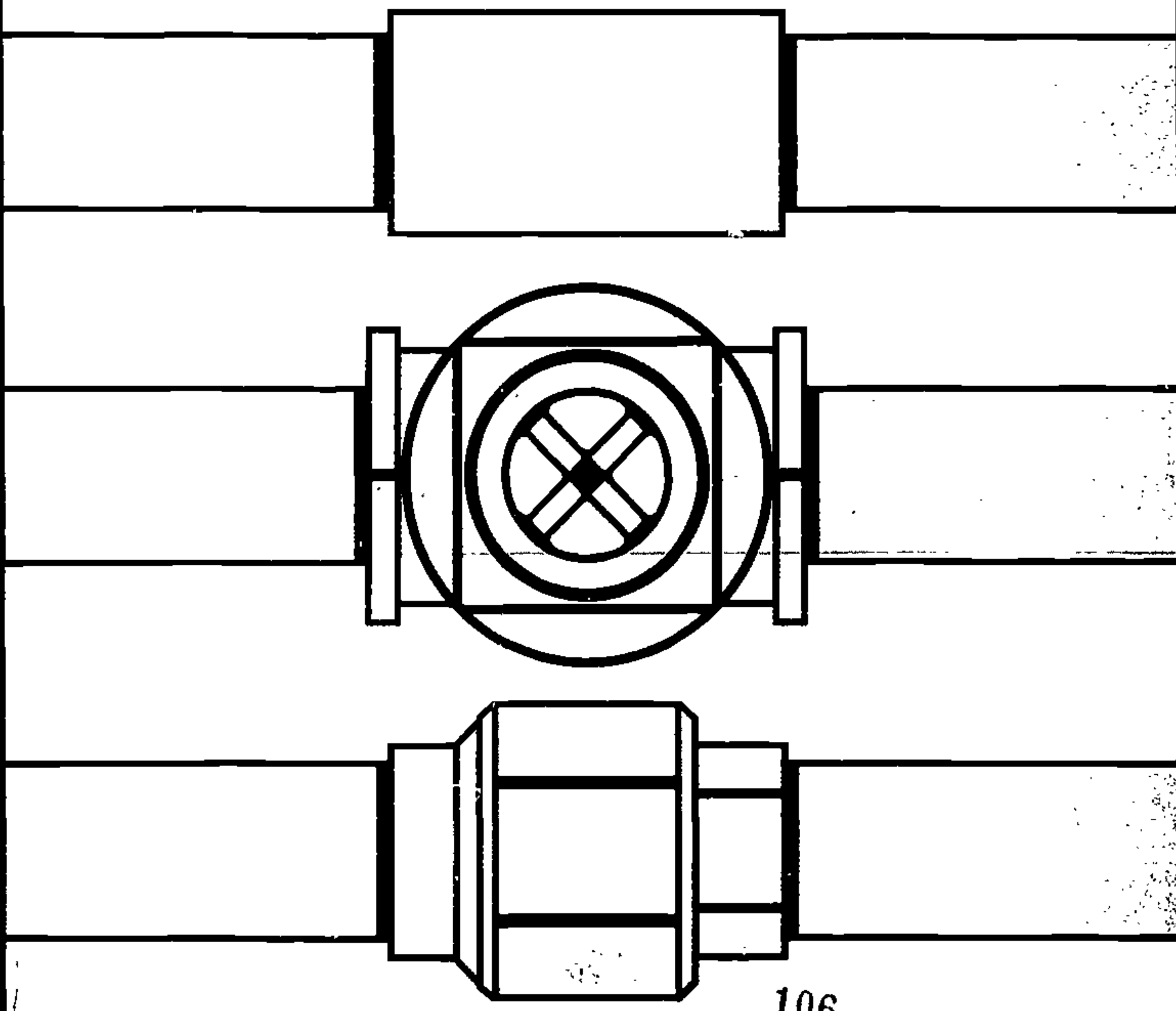
c) Anchor the valves and controls securely to prevent their turning movements from being transmitted to the pipe.

d) Do not install polyethylene pipes so that they can come in contact with a hot surface.

e) Enough hangers should be installed to prevent sagging of the pipe.

f) Where there are insufficient changes in direction of the pipe to accommodate expansion and contraction, the pipe should be looped.

11 Chlorinated Polyvinyl Chloride (CPVC) Tubing, Fittings, and Joints



PART 11

CHLORINATED POLYVINYL CHLORIDE (CPVC) TUBING, FITTINGS, AND JOINTS

1. CPVC Tubing Characteristics

a) Highly resistant to chemicals and non-corrosive.

b) Light weight and low specific gravity.

c) High impact strength and resistance to abrasion.

d) High temperature resistance and easily withstands temperatures in hot and cold water systems.

e) Very smooth, non-wetting, non-fouling bore.

f) Semi-rigid.

g) High tensile strength among thermoplastics, but low compared with that of metals.

h) Low coefficient of expansion among thermoplastics, but high compared with that of metals.

i) Good insulation value.

j) Self-extinguishing, in that it will not support combustion.

k) Non-conductor of electricity.

l) Low sound transmission.

m) Solvent-weld joints.

2. CPVC Tubing Particulars

a) Manufactured in 3.05 m lengths and packed in cartons for convenient handling, shipping, and storage.

b) The tubing and fittings must conform to the standard specified in the appropriate plumbing code and be used only in locations approved by it.

c) Care must be taken in handling to prevent the gouging or scratching of the tubing and fittings.

d) Avoid dropping the tubing lengths on hard surfaces.

e) Store loose tubing in a horizontal position and supported along its entire length on surfaces free from nails and other sharp protrusions.

f) Do not walk on the tubing nor store other materials on it.

3. CPVC Fittings

a) A full range of moulded CPVC fittings and adapters is available for solvent-weld joining purposes and for transitions from threaded and unthreaded metallic systems to CPVC tubing.

b) Brass and other compression-type transition fittings, manufactured especially for CPVC systems, are also available.

4. Joints

a) CPVC tubing can be cut with a tubing cutter or a fine-toothed handsaw.

b) Examine tubing ends for damage such as hairline cracks, deep scratches, and abrasions caused during transport and handling. If necessary, cut back the tubing and discard the damaged ends, but make sure the tubing is cut square.

c) With a file, sharp knife, or sandpaper, smooth the tubing end to remove the raised ridge made by the tubing cutter or the burrs made by the handsaw.

d) A good fit is indicated if the tubing fits snugly one-third to two-thirds into the fitting socket when inserted dry; when the welding compound is applied, the tubing will slide easily into place.

e) Do not join tubing and fittings that fit so loosely that the fittings can fall off, but choose other components.

f) Use only a solvent welding compound designed for use with CPVC tubing. Regular PVC solvent welding compounds must not be used with CPVC tubing.

g) Keep the container of solvent welding compound tightly closed for storage and away from extremes of heat or cold. Open the container only when required for assembly. Keep it closed when not in use to prevent evaporation of the solvents and the entry of dirt.

h) Discard a compound that has become thick, gelled, or discolored. The compound must not be thinned by the addition of solvents.

i) Solvents in the cleaning and welding compounds are flammable. Do not use them near an open flame or sparks.

j) Apply pipe cleaner and welding compound only in a well-ventilated area. Avoid prolonged breathing of the fumes and contact with the skin. Use goggles, or a face shield, and gloves that are impervious to and otherwise unaffected by the solvents.

k) Avoid spilling cleaning and welding compounds on finished floors that can be damaged by the solvents.

l) Use only a natural-bristle brush 10 mm to 15 mm in width to apply welding compounds.

m) Remove any grease or dirt and the glossy surface from both the inside of the fitting socket and the outside of the tubing end, using a clean rag moistened with CPVC pipe cleaner.

n) Using the natural-bristle brush, cover all mating surfaces thoroughly with the solvent welding compound by flowing a light coating into the fitting socket and a heavy coating onto the outside of the tubing end. Take care when flowing the compound not to allow it to run or clog the bore. Do this within 60 seconds and make only one joint at a time because the welding compound dries quickly.

NOTE: Good joints depend on the use of sufficient solvent welding compound. Do not use painting techniques, but apply the compound direct from the can to the tubing or fitting without first wiping excess cement off the brush on the rim of the can.

o) Immediately after applying the compound, push the tubing into the fitting socket with a slight twisting motion to spread the compound and simultaneously align the direction of the fitting. Hold the joint in place for about 15 seconds or until any tendency of the fitting to back off the tube has been overcome. Do not attempt to adjust the joint after the compound has begun to set.

p) A properly made joint will normally have a bead of solvent welding compound around its perimeter. Gaps in the bead may indicate a defective assembly job owing to insufficient compound. Wipe off the bead and any other excess compound with a clean rag.

q) The system should be pressure-tested after 16 hours following the making of the last joint. Under normal job conditions, it is advisable to test each day's work at the start of the next working day.

5. Adapters

a) Compression fittings are designed for adapting CPVC tubing to copper tubing and iron pipe thread fittings. The use of plastic or metal ferrules or epoxy compounds is not recommended as such joints are prone to failure.

b) The flaring of CPVC tubing is not recommended as it creates areas of stress and weakens the tubing.

c) Do not thread CPVC tubing direct as the tubing walls are too thin to accept threads, but use solvent-weld adapter fittings.

d) Do not over-tighten CPVC threaded joints. Firm-hand tightness is adequate when screwing CPVC male-threaded adapters into metal fittings, followed by not more than one full turn with a wrench.

e) Standard-thread sealing compounds or tape may be used as interfacing lubricants.

6. Hangers and Supports

a) Use plastic pipe clips at every other joist or on 800 mm centres. Burrs and rough edges on metal pipe clips can cause damage to the tubing.

b) Do not tighten supports and hangers so that the tubing becomes compressed, distorted, or bent.

c) Support all valves, stops, etc., to ensure that the turning moments resulting from their operation are not transmitted to the tubing.

d) Fasten vertical runs of tubing to the wall or partition with plastic pipe clips at 1.20 m intervals and support the runs at each floor level.

7. Allowances for Thermal Expansion and Contraction

a) Make sure the tubing can move longitudinally in supports and hangers.

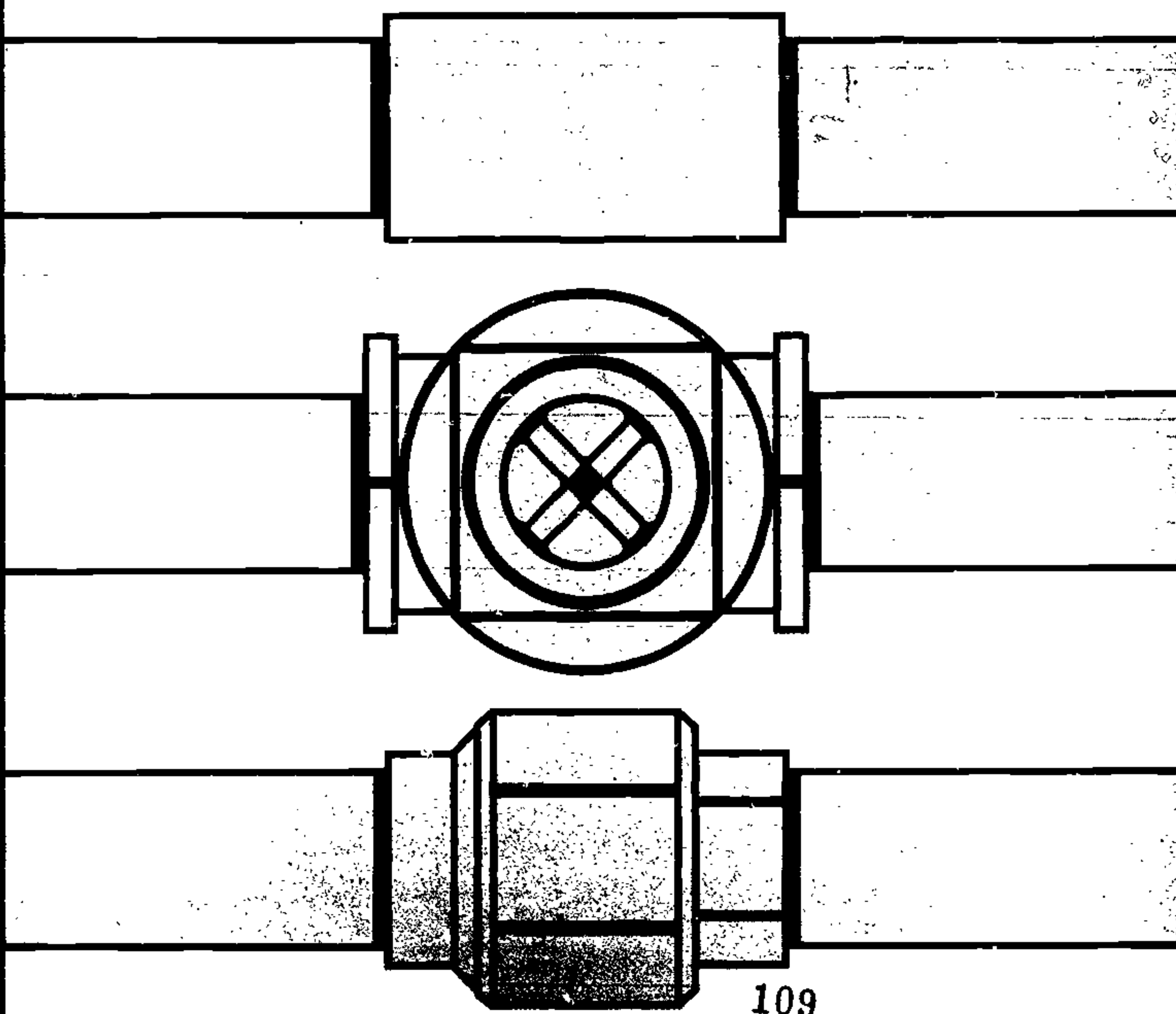
b) Do not install elbows and fittings close to a wall or joists in such a manner that they would restrict the linear expansion or contraction of the tubing.

c) In short runs of tubing, where there are frequent changes of direction, the degree of expansion or contraction is small and may be absorbed without harming the tubing and fittings.

d) Where the tubing must be installed so that it is restrained from linear movement, provision must be made to absorb the movement. This can often be accomplished by the installation of offsets.

e) A 1 m length of tubing will expand 0.76 mm for each 10°C temperature difference.

Plastic Sewer Pipe, Fittings, and Joints 12



PART 12
PLASTIC SEWER PIPE, FITTINGS, AND JOINTS

1. Plastic Sewer Pipe

a) Plastic sewer pipe should be used only under ground for gravity-type drainage of sewage and other liquid wastes.

b) The plumbing code governs the locations where this pipe may be used in a plumbing system.

c) Chemicals commonly found in industrial waste lines may be too highly concentrated for satisfactory performance of plastic sewer pipe over an extended period.

d) The pipe and fittings must conform to the standard specified in the appropriate plumbing code.

e) This pipe is available in 3 m lengths that do not include a bell end or coupling.

f) The pipe may be solid or perforated. The latter type is suitable for use in septic-tank disposal fields, foundation drains, and sub-soil drains.

g) The solid pipe is available in NPS 2, 3, 4, 5, and 6.

h) The perforated pipe is available only in NPS 3 and NPS 4, the NPS 4 being the most popular size in some areas.

i) The pipe material may be a composition of polyvinyl chloride or rubber-modified styrene, and may contain stabilizers, lubricants, fillers, modifiers, and pigments.

2. Fittings

a) The fittings used with plastic sewer pipe are bends, sanitary tees, Ys, couplings, cleanouts, adapters, bushings, and caps.

b) The fittings generally have hubs into which the pipe is inserted.

3. Joints

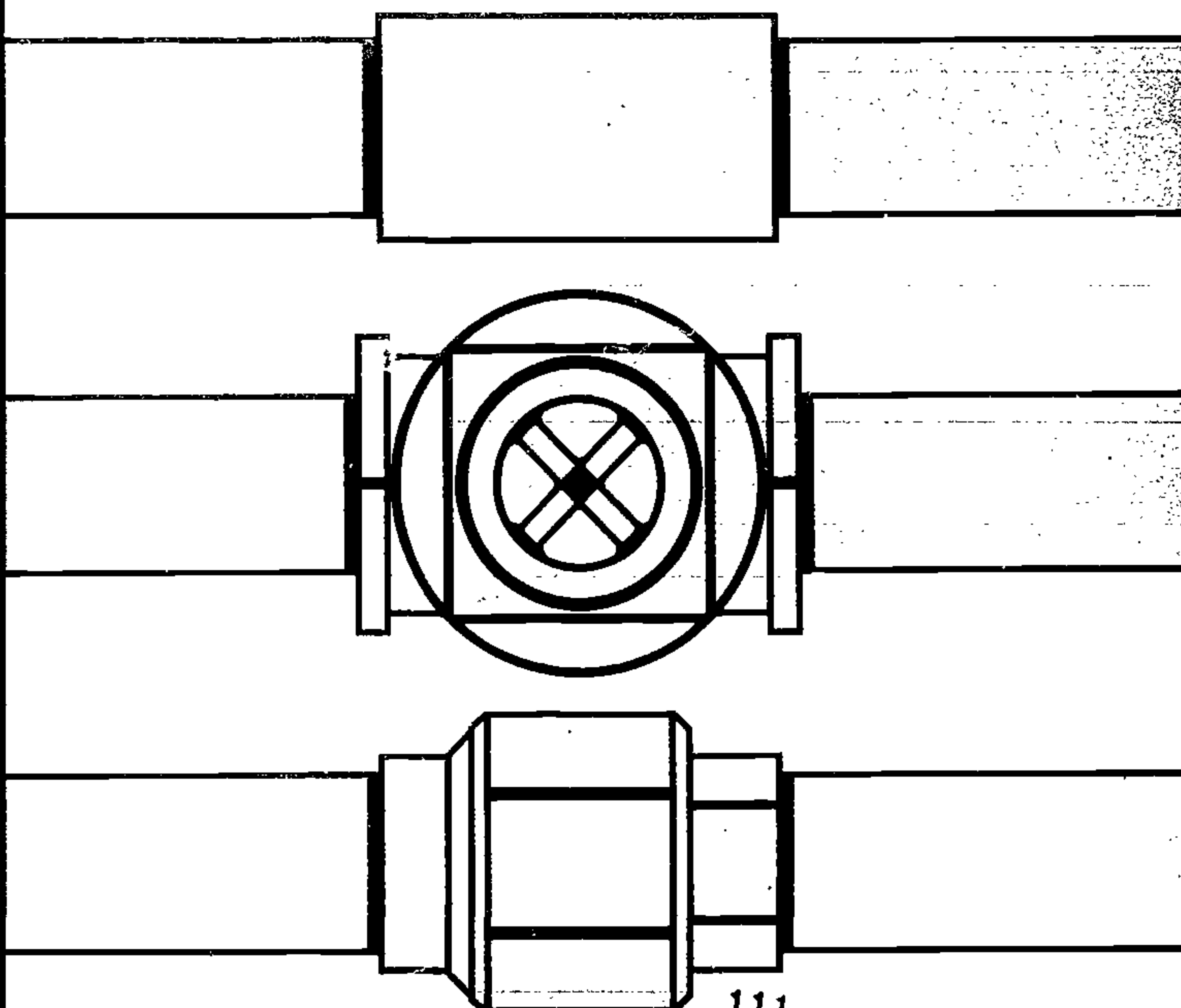
a) Joints on a plastic sewer pipe are made watertight with a solvent cement compound.

b) The solvent cement and thinners should be of the types recommended by the manufacturer of the pipe and fittings.

c) The labels on the containers of solvent cement compound and thinners should specify the manufacturer's name, the type of material they can be used on, the recommended procedure for their use, and the safety precautions to be observed.

d) A plastic sewer pipe is cut and the joints made in the same manner as that for other plastic pipes utilizing solvent cement compound joints.

The Victaulic Grooved Piping Method 13



PART 13

THE VICTAULIC GROOVED PIPING METHOD

1. General Information

a) Victaulic grooved piping is a method of joining pipe for a wide variety of piping services. It offers the advantages of easy handling and assembly. The Victaulic method provides expansion, flexibility, and vibration reduction with a union at each joint. It can be applied to black or galvanized steel, stainless, aluminum, wrought iron, plastic — almost any pipe of NPS dimensions (See Figure 13-1.)

b) Based on a groove machined into the pipe end, the system is joined by ductile or malleable-iron housings that engage into the grooves enclosing a synthetic rubber gasket to create the seal.

c) The housing segments are precisely cast of ductile or malleable iron. The housing key engages into the pipe grooves around the entire circumference, joining the pipes in a positive connection.

d) The gasket is designed to seal under pressure or vacuum. Moulded of various synthetic elastomers, the gasket is designed to provide long life for the intended service.

e) The oval-neck steel track bolts seat into the bolt recesses, permitting assembly with a single wrench.

f) The groove permits joining of the pipes without clamping. This provides the controlled flexibility and permits rapid assembly. Pipe is available from mills or distributors already grooved for Victaulic couplings. A complete line of portable tools adds versatility for easy on-site grooving.

g) Victaulic pipe groovers are covered in Part 1 and should be used according to the manufacturer's instructions.

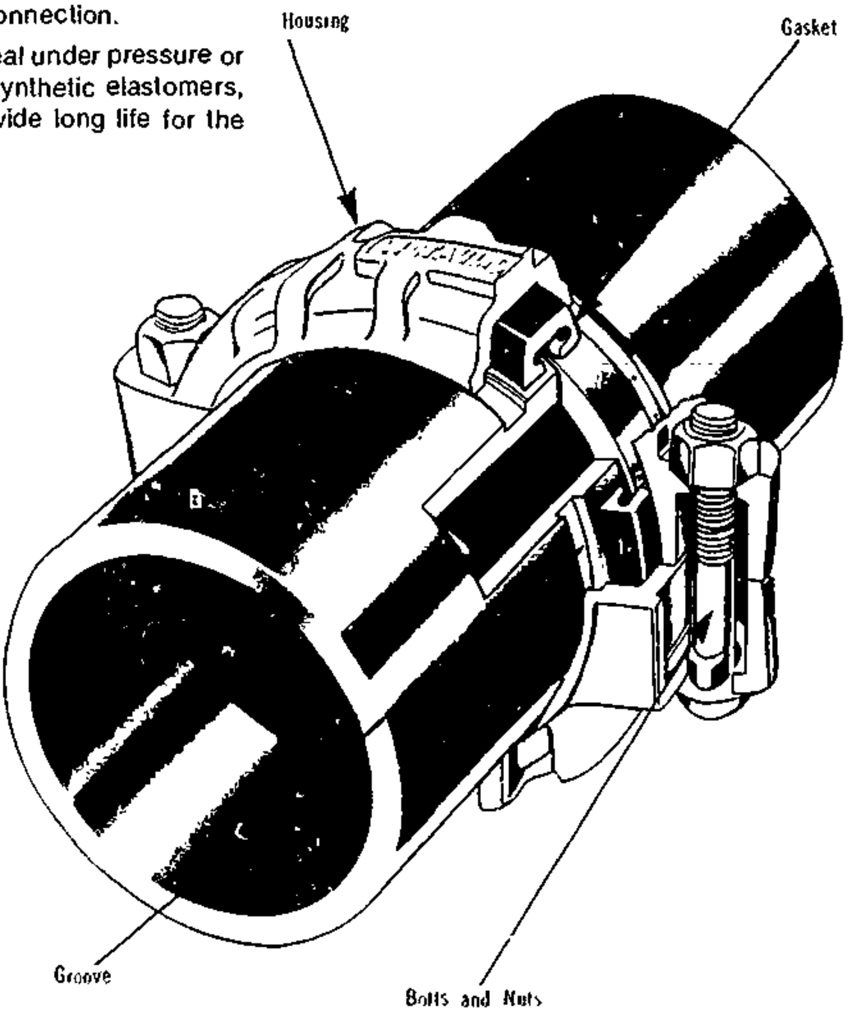
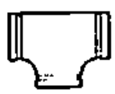


Figure 13-1. Cutaway View of Victaulic Grooved Piping Method

2. Product Selection

As shown in Table 13-1, Victaulic couplings, fittings, and valves are identified by a style number, and in some cases by a special product trade name as indicated by an asterisk. Various styles are designed for steel-pipe dimensions, others for AWWA cast-pipe sizes, still others for special pipe sizes. For complete product data, refer to the Victaulic general catalogue or the Victaulic piping-design manual.

Table 13-1. Identification of Victaulic Couplings, Fittings, and Valves

STYLE NUMBER	NPS RANGE	DIMENS. CHARAC.	STYLE NUMBER	NPS RANGE	DIMENS. CHARAC.	STYLE NUMBER	NPS RANGE	DIMENS. CHARAC.	STYLE NUMBER	NPS RANGE	DIMENS. CHARAC
Style 77 Style 71 	¾-24	NPS	Style 72 Outlet 	2x¾ to 6x2	NPS	Style 31 Standard Cast 	4-24	AWWA CAST	Style HP-70 ES Endseal* 	2-12	NPS (lined)
Style 75 	2-8	NPS	Style HP-70 Rigid 	2-12	NPS	Style 341 Style 342 Vic-Flange* 	4-24	AWWA cast	Style 77-A Aluminum 	2-12	NPS aluminum
Style 78 Snap Joint* 	1-8	NPS	Style 920/921 Mechanical T* 	2x¾ to 8x4	NPS	Fittings Cast Iron 	3-24	AWWA cast	Style 78-A 	10	NPS aluminum
Style 750 Reducing 	2x1½ to 8x6	NPS	Fittings Standard 	¾-24	NPS	Style 22 Vic-Ring* 	17-60	Vic-Ring*	Style 77-S Stainless 	2-12	NPS stainless
Style 741 Vic-Flange* 	2-12	NPS	Style 742 Vic-Flange* 	14-24	NPS	Style 41 Vic-Ring* 	30-66	Vic-Ring*	Fittings Aluminum Stainless 	2-12	NPS
Butterfly Valves 	1½-12	NPS	Check Valves Series 710 	2½-10	NPS	Style 44 Vic-Ring* 	4-60	Vic-Ring*	Style 775 Plastic 	2-12	NPS plastic

* Victaulic tradename

3. Preparation of the Pipe

a) The pipe may be grooved by cutting material out of the pipe wall, either with a square or radiused, bottom corner, or by cold-rolling the groove into the pipe wall.

b) The selection of the general pipe-grooving method is shown in Table 13-2.

Table 13-2. Selection of Grooving Method

TYPE OF PIPE	STANDARD SQUARE-CUT GROOVE	STANDARD ROLL GROOVE	STANDARD RADIUS-CUT GROOVE
Standard Steel	X		
Lightwall Steel		X	
Heavywall Steel	X		
Stainless Steel	X	X	
Aluminum	X	X	
Cast/ Ductile			X
Plastic PVC Sched. 80			X
Plastic PVC Sched. 40		X	
Lined	X	X	

c) Grooving dimensions are very important. The groove provides for coupling engagement to lock the joint, yet there also must be enough wall thickness under the groove for pressure service. This is easily done by ensuring that all grooves are in accordance with dimension standards published in Victaulic catalogues and grooving-tool instruction brochures (see Figure 13-2).

Dimension A, or distance from pipe end to groove, provides the gasket seating area. This distance also controls the allowable amount of pipe movement and end gap.

Dimension B, or groove width, controls expansion and angular deflection by the distance it is located from the pipe end and its width in relation to the housing "key" width.

Dimension C is the proper diameter at the base of the groove. This must be within diameter tolerance and concentric with the OD for proper fit of the coupling.

Dimension D is the nominal depth of the groove and is only a reference dimension. This dimension is affected by variations in the OD of the pipe. This dimension must be altered if necessary to keep dimension C within the stated tolerance. The groove must conform to the C dimension.

Dimension T, minimum wall, is the lightest grade or thickness of pipe suitable for cut grooving, or for roll grooving. Pipe of less than minimum wall for cut grooving may be roll-grooved or adapted for Victaulic couplings with applied Vic-Rings. Vic-Rings can also be used on pipe of less than minimum wall, on pipe too large to groove, or for abrasive services. Contact the company for details.

Dimension R is the radius necessary at the bottom of the groove to eliminate a point of stress concentration for cast pipe (grey and ductile) and PVC plastic pipe.

d) Standard Steel Pipe

The pipe ends must be square cut. The nominal outside diameter of pipe to be grooved must not vary more than: NPS ¾ through NPS 2½—plus 1 per cent or minus 1 per cent; NPS 3 through NPS 5—plus 1 per cent or minus 0.8 mm; NPS 6 and up—plus 1.6 mm or minus 0.8 mm.

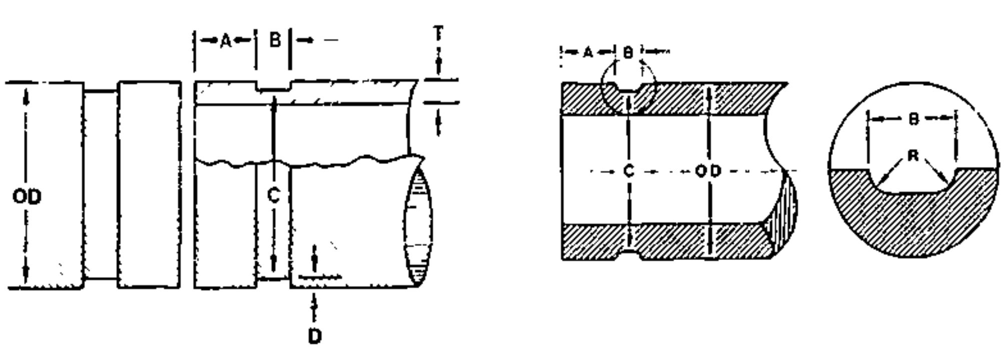


Figure 13-2. **Dimension Standards**

Any internal or external weld bead or seams in the groove area must be ground smooth and flush. The internal end of the pipe must be cleaned of coarse scale, dirt, or other material that might interfere with or damage the internal roll of the grooving tool.

e) Cast Pipe (Grey and Ductile)
The outside surface of the pipe between the groove and the pipe end must be smooth and free from deep pits or swells to provide a leak-tight seat for the Victaulic gasket. All rust, loose scale, oil, grease, and dirt must be removed. Peened surfaces may require corrective action to provide a leak-tight gasket seal.

4. **Installation and Assembly of the Victaulic Joint**

a) Maximum service life is dependent upon proper gasket selection and installation. Be sure to check the grade and style of the supplied gasket to make certain it is suited to the intended service.

b) Table 13-3 provides general service recommendations for standard Victaulic gaskets. Gaskets are color-coded for easy identification. For more detailed information, consult the Victaulic Gasket Selection Guide or contact the company.

Table 13-3. General Service Recommendations

Grade	Temp. Range	Compound	Color Code	General Service Recommendations
E*	-34°C to 110°C	EPDM	Green Stripe	Recommended for hot water service within the specified temperature range plus a variety of dilute acids, air without hydrocarbons, and many chemical services. *Not recommended for hydrocarbon services.*
T	-29°C to 82°C	Buna-N	Orange Stripe	Recommended for petroleum products, air with oil vapors, vegetable and mineral oils within the specified temperature range — except hot dry air over +60°C and water over +66°C. *Not recommended for hot water services.*

*Grade H chlorinated butyl (white code) may be supplied and is interchangeable for most grade E services, except hot water above 93 C. Hot water applications must be noted on all orders.

c) Refer to the latest Victaulic Gasket Selection Guide for specific recommendations and other available gaskets.

d) Always use ample lubrication for proper coupling assembly.

e) Thorough lubrication of the gasket exterior, including the lips and pipe ends and housing interiors, is essential to prevent pinching of the gasket. Lubrication assists proper gasket seating and alignment while easing installation.

f) Use Victaulic lubricant for installation. Other compatible materials such as silicone may be used, but petroleum-based lubricants must not be used on grades E and H gaskets.

g) Assembly of couplings — styles 22, 31, 41, 44, 71, 75, 77 — is shown step-by-step in Figures 13-3 to 13-8.

Step 1: The pipe must be free from indentations, projections, or roll marks on the exterior from the end to the groove (Figure 13-3) to ensure a leak-tight seat for the gasket.

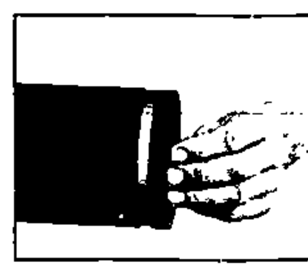


Figure 13-3. Checking Pipe Ends

Figure 13-4. Checking Gasket and Lubricating

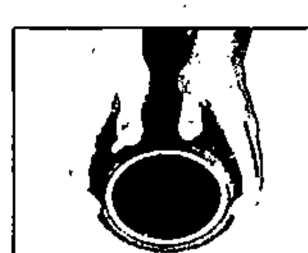


Figure 13-5. Installing Gasket

Figure 13-6. **Aligning Pipe Ends**

Figure 13-7. **Placing Housings Over the Gasket**

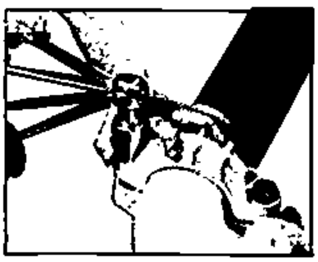


Figure 13-8. **Tightening Nuts**

Step 2. Check the supplied gasket to be certain it is suited to the intended service. The color code identifies the gasket grade. Apply a thin coat of Victaulic lubricant, or silicone lubricant, to the lips and the outside of the gasket (Figure 13-4).

Step 3: Place the gasket over the pipe end, being sure the gasket lip does not overhang the end (Figure 13-5).

Step 4: Align and bring the two pipe ends together and slide the gasket into position centred between the grooves on each pipe. No portion of the gasket should extend into the groove on either pipe (Figure 13-6).

Step 5: Place housings over the gasket, making sure the housing keys engage into the grooves. Insert the bolts and apply the nuts finger-tight (Figure 13-7).

Step 6: Tighten the nuts alternately and equally until the housing bolt pads are firmly together — metal to metal (Figure 13-8). Excessive nut-tightening is not necessary. **CAUTION:** Uneven tightening may cause the gasket to pinch.

h) Assembly of style HP-70 Rigid coupling and style HP-70ES coupling is shown in Figures 13-9 to 13-14.

Step 1: The pipe must be free from indentations, projections, or roll marks on the exterior from the end to the groove to ensure a leak-tight seat for the gasket (Figure 13-9).

Step 2: Check the gasket supplied to be certain it is suited for the intended service. The color code identifies the gasket grade. Apply a thin coat of Victaulic lubricant, or silicone lubricant, to the gasket lips and outside of the gasket (Figure 13-10).

Step 3: Place the gasket over the pipe end (Figure 13-11), being sure the gasket lip does not overhang the pipe end. (For "ES" gasket see sub-section "i").

Step 4: Align and bring the two pipe ends together and slide the gasket into position centred between the grooves on each pipe (Figure 13-12). No portion of the gasket should extend into the groove on either pipe.

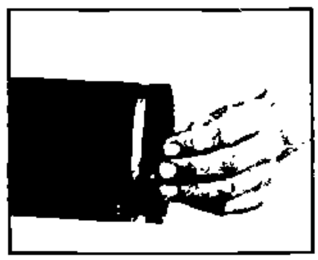


Figure 13-9. **Checking Pipe Ends**

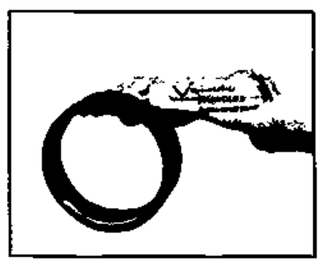


Figure 13-10. **Checking Gasket and Lubricating**

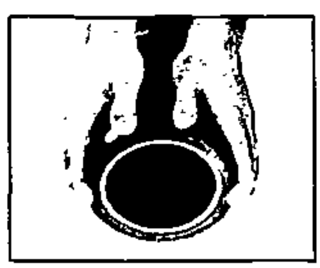


Figure 13-11. **Installing Gasket**

Figure 13-12. Aligning Pipe Ends

Step 5: Place housings over gasket, being sure the housing keys engage into the grooves. Insert bolts and apply the nuts finger-tight. Tighten nuts alternately and equally until fully tight (Figure 13-13). **Caution:** Uneven tightening may cause the gasket to pinch.

Step 6: Note: HP-70 and HP-70ES housings have a tongue and recess feature and must be properly mated, tongue to recess (Figure 13-14). Failure to properly mate the tongue and recess can cause joint failure.

i) HP-70ES with ES gasket:

The HP-70ES gasket is moulded with a central leg that fits between the pipe ends for plastic or cement lining protection (Figure 13-15). Check to be certain the proper gasket has been supplied.

Note: For proper application of Endseal gaskets and HP-70ES couplings, the pipe must be prepared to Victaulic "ES" groove specifications.

With Endseal gaskets, slide the gasket over one pipe end only up to the central gasket leg.

Slide the adjoining pipe end into the gasket until the pipe end touches the central gasket leg.

Note. HP-70ES bolts must be torqued to 80 N.m to 110 N.m.

j) To achieve maximum expansion contraction allowance, the joints must be installed with the proper pipe-end spacing. This can be done in several ways, the most popular being as follows:

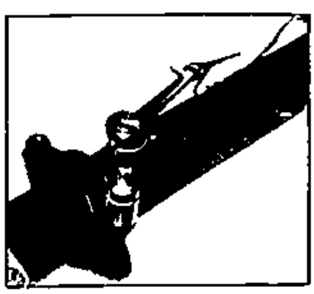


Figure 13-13. Applying Housing and Tightening Nuts

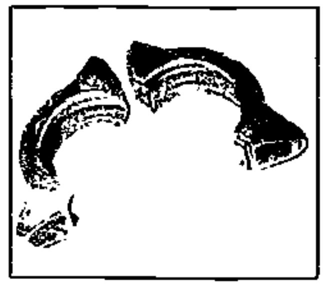


Figure 13-14. Tongue and Recess Housing

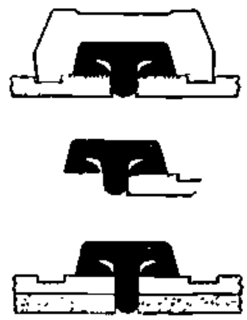


Figure 13-15. Endseal (ES) Gasket

For Maximum Expansion:

Method 1: Vertical systems can be assembled as the pipe is lowered, coupling the joints into position using the weight of the pipe to pull the pipe ends open. Use a gap gauge of the appropriate size to check end gaps (see the following section entitled Groove/Coupling Gapping).

Method 2: Anchor the system at one end, then install the joints and proper guides. Cap the system, pressurize it to fully open the pipe ends, then anchor the other end with the joints fully opened.

Method 3. Install the joints using a "come-along" to pull the pipe for full end separation, then secure the pipe to maintain the opening (Figure 13-16).
13-16.

For Maximum Contraction:

Method 1: In vertical systems, stack the pipe using the weight of the pipe to butt the pipe ends, then anchor the pipe to retain the butted position.

Method 2: In horizontal systems, install the joints with the pipe ends butted by using a "come-along" to draw the pipe ends together, if necessary; then secure the pipe in position (Figure 13-17).

For Expansion and Contraction:

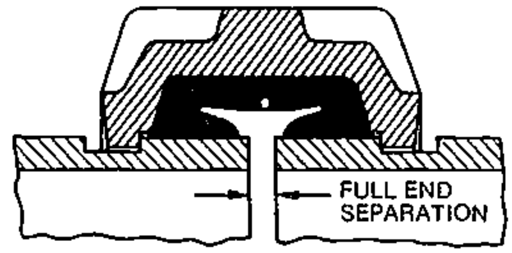
Alternate the above procedures in proportion to the need for expansion or contraction

Groove/Coupling Gapping:

The pipe-end separation and related maximum allowable pipe-end movement bear a relationship with the visible gaps on either side of the coupling housing between the housing and rear edge of the groove. These visible gaps can be used as a check for ensuring proper installation of most couplings for maximum movement (Figure 13-18).

Where pipe expansion is required, the pipe ends are assembled in the full-open gap position (G), which leaves one-half the gap allowance (G/2) visible at each side of the coupling. For pipe contraction, no gap should be visible at the outside of the coupling.

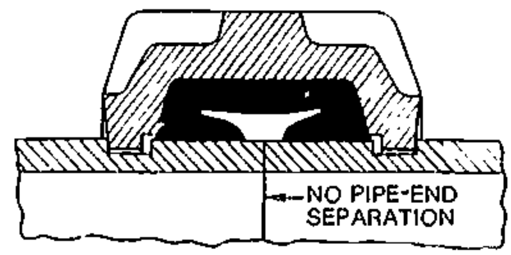
FOR MAXIMUM EXPANSION



JOINTS MUST BE ASSEMBLED WITH FULL PIPE-END SEPARATION

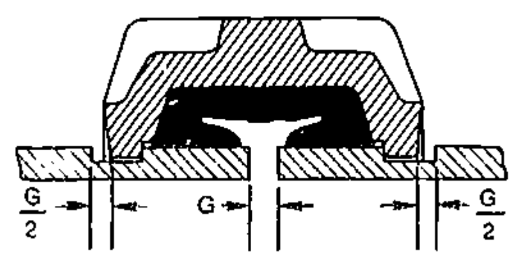
Figure 13-16. Pipe-End Spacing for Maximum Expansion

FOR MAXIMUM CONTRACTION



JOINTS MUST BE ASSEMBLED WITH PIPE – ENDS BUTTED

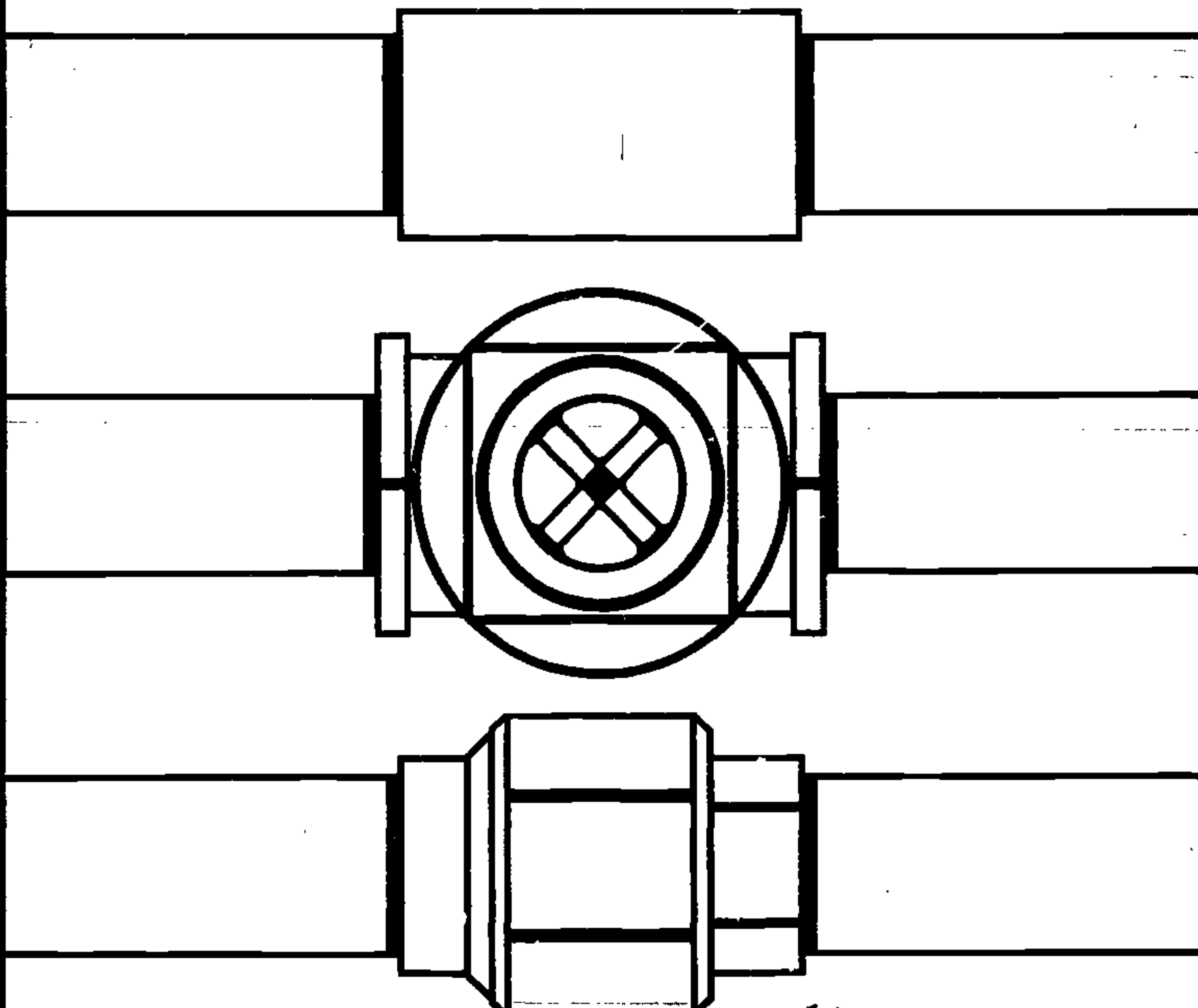
Figure 13-17. Pipe-End Spacing for Maximum Contraction



$\frac{G}{2} + \frac{G}{2}$ Maximum Allowable Pipe-End Movement

Figure 13-18. Groove/Coupling Gapping

Ductile Iron Pipe Fittings, and Joints 14



PART 14
DUCTILE IRON PIPE, FITTINGS, AND JOINTS

DUCTILE IRON PIPE, FITTINGS, AND JOINTS

1. Ductile Iron Pipe

a) Ductile iron pipe, first introduced and manufactured in Canada in 1961, is made of cast iron with the addition of a magnesium alloy. It is noted for these four major characteristics:

Ductility: The ability to stretch or deform when stressed beyond its yield point.

Strength: Superior tensile strength to withstand severe external loads and high internal pressures.

Toughness: Excellent resistance to shock or impact from improper handling, water hammer, and unstable soil conditions.

Corrosion Resistance: Equal or superior to grey cast iron.

b) Ductile iron pipe is made in NPS 4, 6, 8, 10, 12, 14, 16, 18, 20, and 24.

c) It is made in six different classes, namely 50 to 56. The higher the class the greater the pipe weight per linear metre.

d) In Canada it is supplied in 5.5 m lengths.

e) It once was available with mechanical joints but this line has been discontinued.

f) The pipe and fittings mostly in use are assembled with a compression joint, which the pipe manufacturer calls Tyton Joint, as illustrated in Figure 14-1.

2. Fittings

a) Cast iron fittings available for use with ductile iron pipe:

Various types of bends from 11¼° to 90°.

Tees and crosses.

Ys.

Reducers and plugs, etc.

NOTE: Consult the manufacturers' catalogues for further information on pipe and fittings.

3. Compression Joints

a) The recommended procedure for making a compression joint (Tyton Joint) between ductile pipe and fittings is as follows:

Make sure the spigot end of the pipe and the inside of the fitting or pipe hub are clean and free from foreign matter that could cause a leak.

Insert the gasket with the gasket groove over the bead on the inside of the hub as illustrated in Figure 14-2.

Wipe a film of the lubricant recommended by the manufacturer over the inside of the gasket (Figure 14-3).

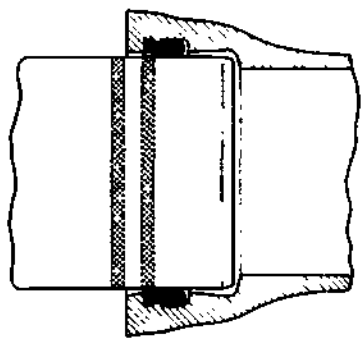


Figure 14-1. Cross-Sectional View of Tyton Joint

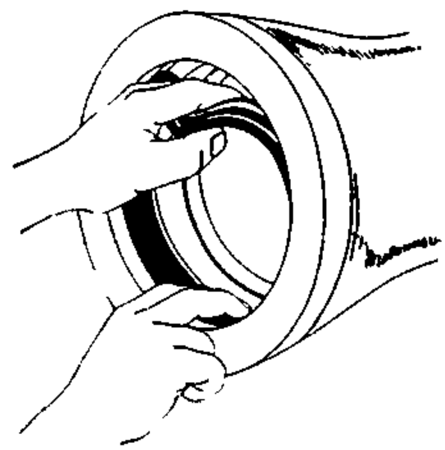


Figure 14-2. Installation of Gasket

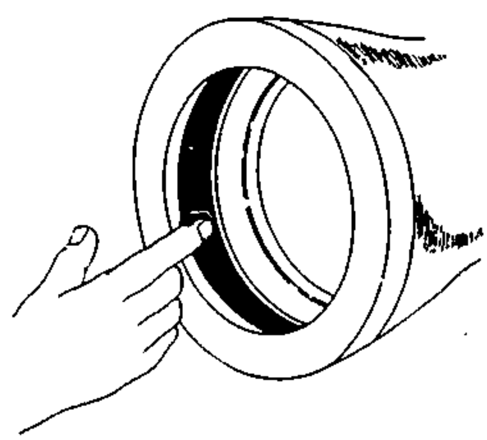


Figure 14-3. Application of Lubricant

Insert the spigot end of the pipe until it touches the gasket as shown here. Note the two painted stripes on the pipe end (Figure 14-4).

Push the entering pipe until the first painted stripe disappears and the second stripe is about flush with the face of the hub. (See Figure 14-1 in this part of the manual.) The joint is now ready for testing.

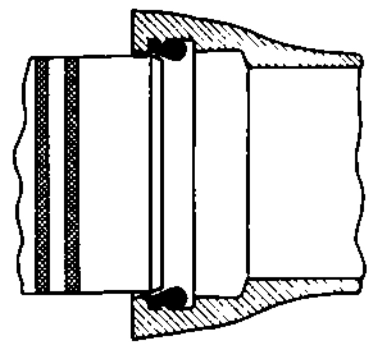


Figure 14-4. Joining the Pipes

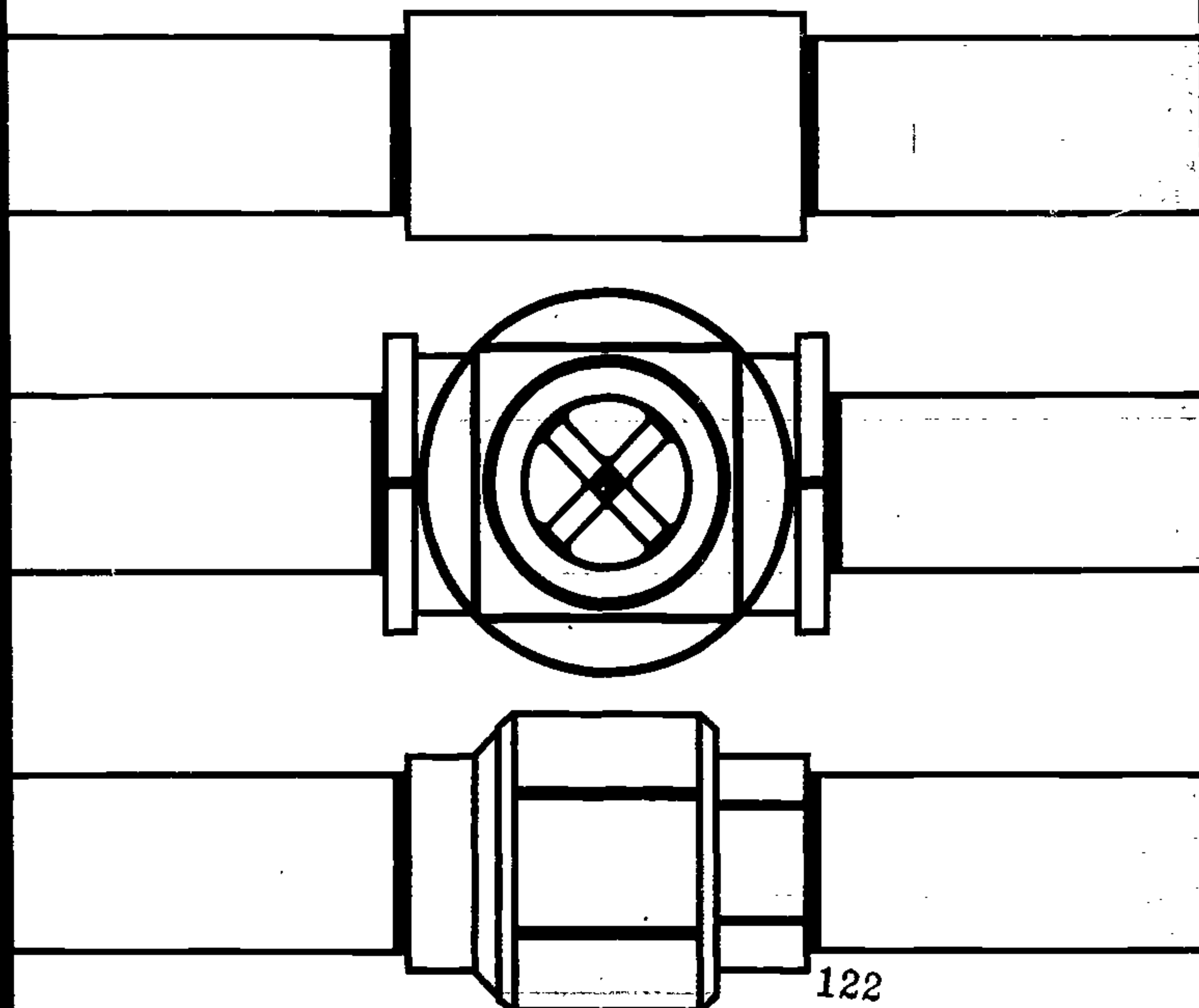
4. Cutting Pipe

Ductile iron pipe should be cut by abrasive wheel saws or milling wheel saws. The cut ends and rough edges should be ground smooth and the cut ends bevelled slightly.

5. Thrust Blocks

Thrust blocks at fittings should be located where the resultant force of the thrust is directed. Thrust blocks are generally made of good-quality concrete; however, hardwood and stone are occasionally used. *Consult your local inspec' 1 authority for details.*

15 Vitrified Clay Pipe, Fittings, and Joints



PART 15
VITRIFIED CLAY PIPE, FITTINGS, AND JOINTS

1. Vitrified Clay Pipe

a) "Vitrification" is defined as a method of changing clay into a glass-like substance.

b) Clay is a fine-grained earth that is found in several colors and is plastic when wet. It is used in the manufacture of vitrified clay pipe.

c) Vitrified clay sewer pipe is manufactured from several different types of clay, and sometimes from a combination of several types. It is moistened and moulded into the desired shape and then exposed to a high termperature.

d) Vitrified clay sewer pipe manufactured or sold in Canada must conform to the requirements specified in the plumbing code.

e) The applicable standard covers the manufacture of vitrified clay pipe in NPS 100, 125, 150, 200, 225, 250, 350, 375, 400, 450, 500, 525, 600, 675, 750, 825, and 900 mm, although not all of these sizes may be readily available.

f) The lengths of pipe available must be at least 900 mm but in many cases they are much longer.

g) Take care in handling vitrified clay pipe and fittings because, although the material is very hard, it is also very brittle and will shatter if dropped on a hard surface, knocked against another pipe or fitting, or struck with a metal tool.

h) The pipe may be of the bell-and-spigot type or the plain-end type It may be glazed or unglazed.

i) Glazing may be done by the salt-glazed process or the ceramic-glazed process.

j) The manufacturer must legibly mark each length of pipe with the company's name and location of the plant for identification purposes.

k) Vitrified clay pipe is made in two strengths: standard strength and extra strength.

l) The pipe may be cut with a snap-type cutter or with a cold chisel and hammer, using very light blows.

m) Years ago the joint between the end of the pipe or fitting and the bell was made by packing it with a few strands of oakum and filling the balance of the joint with a cement mortar composed of equal parts of clean, sharp sand and portland cement.

n) There are now three basic types of flexible joints used, or permitted for use, in assembling vitrified clay pipe and fittings, as follows:

A factory-made coupling for plain-end pipe consisting of a butyl rubber or neoprene sleeve incorporating corrosion-resistant bands and tightening mechanisms for mechanically joining the ends of the pipe.

A joint for plain-end pipe consisting of a suitable resilient-type plastic material factory-applied to both ends of the pipe and a separate rigid external sleeve coupling for joining the pipe together. The pre-formed spigot components and the internal contour of the sleeve coupling must be designed to form a compressed mating surface when the pipes and couplings are telescopically assembled.

A factory-applied joint for bell and spigot pipe made from resilient-type plastic material attached to both the bell and spigot ends of the pipe. Different types of plastic material may be used in the bell and spigot ends, and the resilient material of one joint surface may be harder than that in the other one.

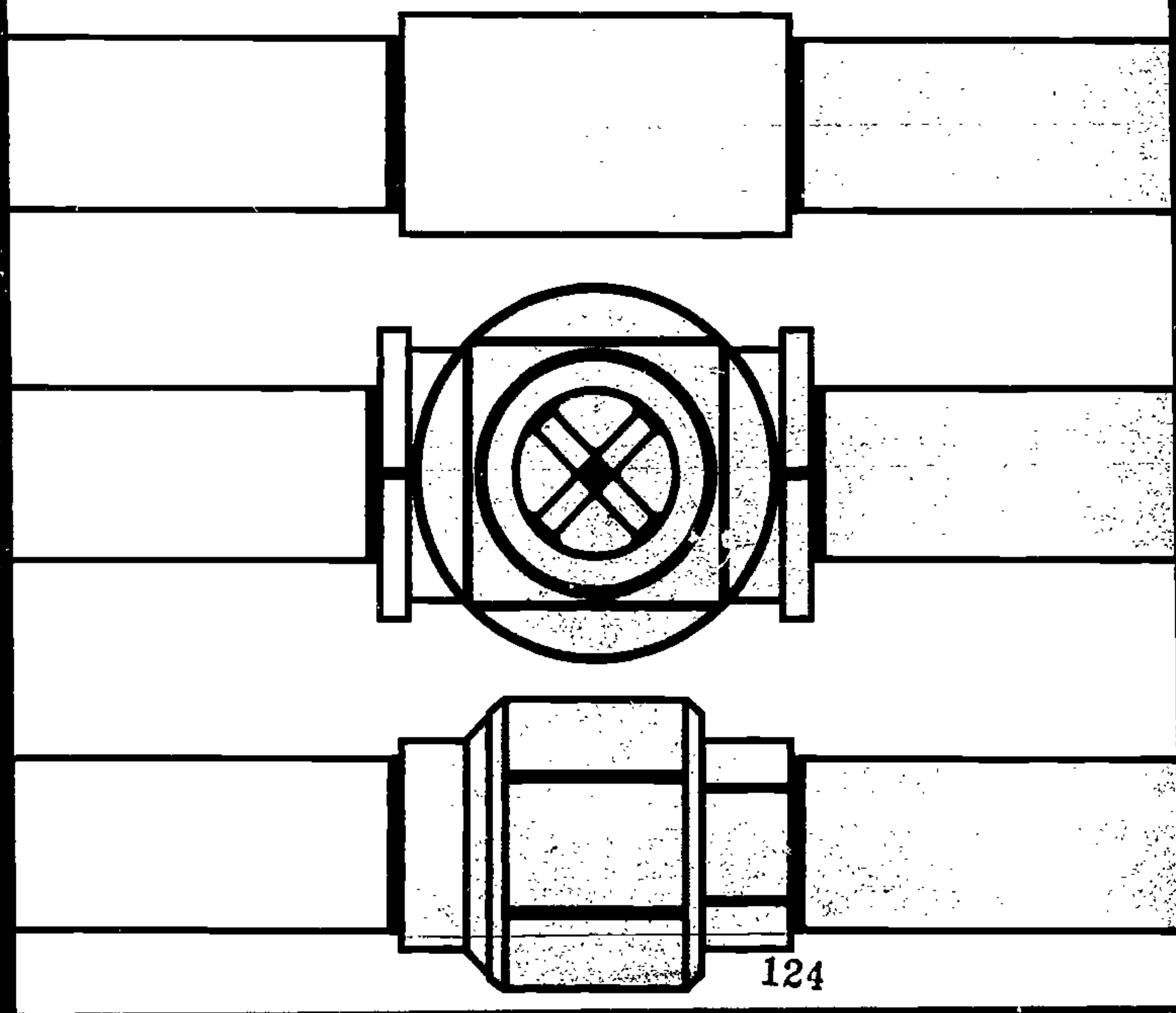
o) Care must be taken when installing vitrified clay pipe. The bed on which the pipe is laid should be free of rocks—preferably a few inches of sand backfilled with rock-free soil and tamped to a depth of 300 mm above the pipe.

2. Fittings

a) Bends of various degrees, sanitary tees, double sanitary tees, Ys, double Ys, increasers, and traps are available.

b) Channel or split pipe, bends, and branches are also available for use in such places as manholes.

PVC Pipe for Pressure Applications 16



PART 16
PVC PIPE FOR PRESSURE APPLICATIONS

1 PVC pressure pipe is made for such applications as water mains, water-service piping, and process piping.

2. The plumbing code governs where it may be used in a plumbing system.

3 It is classified by schedules and series numbers as follows:

PVC Schedule 40	PVC Series 125
PVC Schedule 80	PVC Series 160
PVC Series 80	PVC Series 200
PVC Series 100	

The series number on a PVC pressure pipe, which denotes the psi rating, when multiplied by seven equals the approximate working pressure in kilopascals for that particular pipe when used with cold water.

4. PVC pipe for pressure applications must conform to the standard specified in the appropriate plumbing code.

5. PVC pressure pipe is made in NPS ⅛, ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 3½, 4, 5, 6, 8, 10, 12. The availability of sizes depends mainly on the demand for them.

6. The pipe is available in 6.0 m length with plain ends unless otherwise specified by the purchaser.

7. Moulded Schedule 80 PVC fittings and adapters for solvent welding are generally available in all sizes up to NPS 8 and with flanges up to NPS 12.

8. Fabricated fittings can be obtained with Victaulic grooved ends.

9. Adapters are generally available to connect PVC pressure pipe to other types of pipe. Compression couplings, such as Dresser couplings, may also be used.

10. Depending on the application, telescoping-type PVC expansion joints and fabricated expansion loops are available.

11. PVC valves for up to and including NPS 4 pipe are generally available.

12. Joints are generally made with a solvent welding compound made for the specific purpose, and in the same manner as that described in this manual for ABS and PVC pipe.

13. Threaded PVC pipe is not recommended as a general rule. Where threaded joints are preferred, only Schedule 80 pipe should be used. Threading is done by standard metal-cutting threaders with clean, sharp dies. Hand threaders are preferred and thread-cutting lubricants are not required. Do not make the thread longer than standard because this will make it impossible to screw fittings on far enough to make a tight seal.

14. Do not mate male-threaded components to PVC sockets because this may cause joint failure owing to the different expansion factors of the materials.

15. Extra design and installation considerations should be given for systems that are to operate with a water temperature above 24°C or below freezing.

16. This type of pipe should be isolated from sources of severe vibration.

17. Following are some advantages of PVC pressure pipe:

It is strong and resists high pressures and mechanical abuse.

It is highly resistant to many chemicals and immune from attack by electrolytic corrosion.

Low head loss is maintained throughout its service life, there is no pitting of pipe walls, and it resists scaling and fouling of the bore.

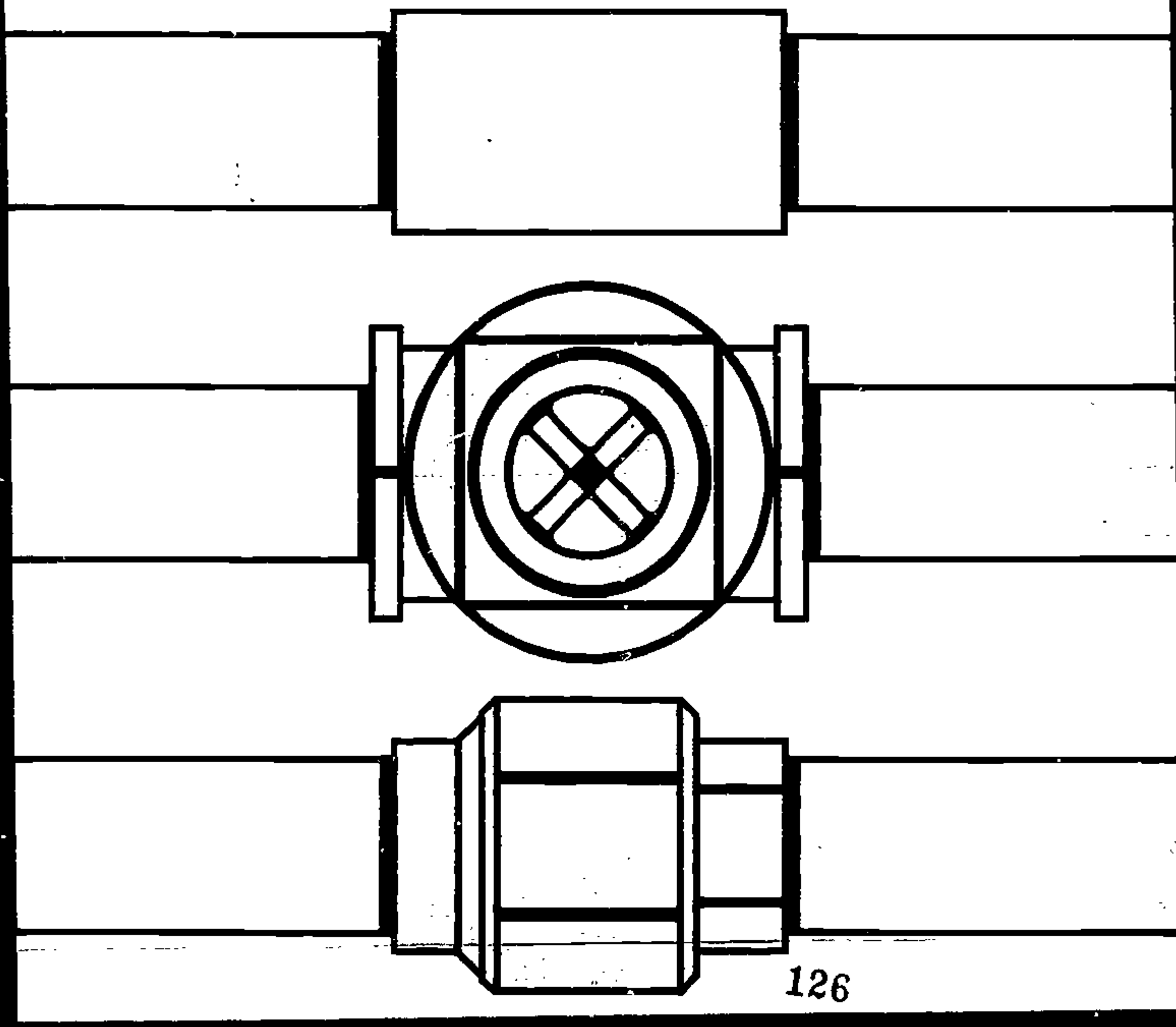
It does not support fungi, algae, or bacterial growth.

It allows high velocities and is highly resistant to abrasion.

Its flexibility reduces stresses caused by water-hammer factors and absorbs normal vibration and shock.

It has low thermal conductivity, which reduces the risk of sweating.

Pipe Hangers and Supports 17



PART 17
PIPE HANGERS AND SUPPORTS

1. Hangers and Supports

a) There are innumerable types and makes of pipe hangers, but only the more popular types are covered here.

b) The location of hangers is mainly governed by the plumbing code and the plumber's knowledge of the materials to be supported.

c) The pipe strap shown in Figure 17-1 is widely used by plumbers. It is generally available in galvanized steel and copper, cast malleable, and plastic. It is used on vertical and horizontal pipe installations, and is available in NPS ½ to NPS 4.

d) The adjustable clevis hanger shown in Figure 17-2 is also popular for plumbing installations. It comes in black, galvanized, and copper plated, the black being the one most used. The hanger load nut above the clevis must be tightened securely to ensure proper performance. When an over-size clevis is used, a nipple or short piece of pipe should be placed over the clevis bolt as a spacer to ensure that the lower U-strap will not move in on the bolt and create a sag in the pipeline. The adjustable clevis hanger comes in a wide range of pipe sizes from NPS ½ to NPS 30.

e) The steel ring with bolt shown in Figure 17-3 was a popular hanger years ago and is still available. It is recommended for use on pipelines where expansion and contraction are not considerations. Its finish is black, and it comes in pipe sizes from NPS ½ to NPS 12.

f) The solid-ring hanger is also popular. It may be either the long or the short type, as illustrated in Figure 17-4, and is available with a black or a galvanized finish, and with a pipe range from NPS ½ to NPS 2. It is recommended for the suspension of non-insulated stationary pipelines where no adjustment is necessary.

g) The adjustable swivel ring (Figure 17-5) has a solid ring as opposed to the split-ring type shown in Figure 17-6. It comes in pipe sizes from at least NPS ¾ to NPS 8. When properly installed, it supports loads of up to 4.4 kN depending on the ring size. An NPS ¾ hanger in some cases has a recommended maximum load of 1.8 kN.

h) The adjustable swivel with split ring (Figure 17-6) is similar to the solid-ring type except that it can be opened and placed around the pipe. This enables the hanger to be installed before installation of the pipe. The off-centre hinge permits seating of the pipe during installation.

Figure 17-1. Pipe Strap

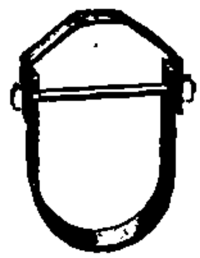


Figure 17-2. Adjustable Clevis Hanger

Figure 17-3. Steel Ring-and-Bolt Hanger

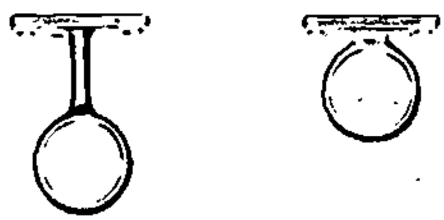


Figure 17-4. Long and Short Solid-Ring Hangers

Figure 17-5. Adjustable Solid-Ring Swivel Hanger

Figure 17-6. Adjustable Split-Ring Swivel Hanger

i) An extension bar. shown in Figure 17-7, is used with a ring and bolt-type hanger. It is often formed into a ring-type hanger by bending it around the pipe. It is available in copper, black, and galvanized steel. It is correctly referred to as hanger iron, strap iron, grabble iron, or perforated band iron. Depending on the width and thickness, it comes in straight lengths and coils.

j) Steel rods play a vital part in the installation of many types of wire pipe hangers. They vary in diameter from ¼" to ¾" with NC (National Coarse) thread, or from 6 mm to 20 mm with ISO thread. The threads are generally NC standard bolt threads. When ordering the rod illustrated in Figure 17-8 the dimensions of A, B, and T must be specified.

k) The U-hanger shown in Figure 17-9 comes in two designs.

l) The all-threaded rod (Figure 17-10) has a continuous thread and it may be cut to any length. When ordering it, dimensions A and B must be specified.

m) The coupling shown in Figure 17-11 may be used with threaded rods.

n) The welded-eye rod (Figure 17-12) is often used where the upper end of the rod is to be bolted to an object. (Eye rods on which the eye is bent but not welded are also available, but they do not have the strength of the welded-eye bolt.) When ordering them, dimensions A, C, D, and T must be specified.

o) Turnbuckle tie rods with one or more turnbuckles (Figure 17-13) are obtainable in at least ¼" to 2" diameter with NC thread, or 6 mm to 50 mm diameter with ISO thread. Any length of rod may be developed. One end of the rod has a right-hand thread, and the other a left-hand thread.

p) The welded linked-eye rod shown in Figure 17-14 is recommended for heavy-duty service where pivoted connections are required. When ordering this type of rod, the dimensions of A, C, D, L, and T must be specified.

q) The coach-screw and machine-thread rod shown in Figure 17-15 is available in many diameters and lengths. The machine thread is generally a National Coarse thread. This type of rod is generally used where the end of the coach-screw can be screwed into a wood member of a building and a hanger attached to the other end.

Figure 17-7. Extension Bar

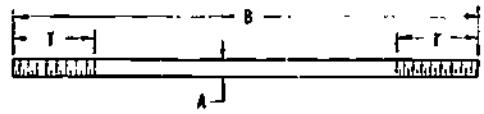


Figure 17-8. Steel Rod with Threaded Ends

Figure 17-9. U-Hanger

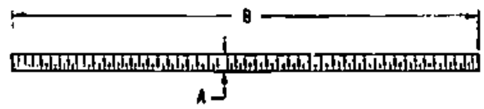


Figure 17-10. All-Threaded Rod

Figure 17-11. Rod Coupling

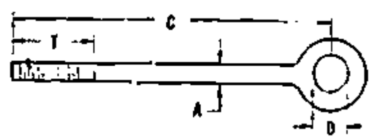


Figure 17-12. Welded-Eye Rod

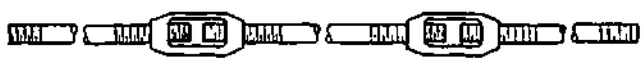


Figure 17-13. Turnbuckle Tie Rods

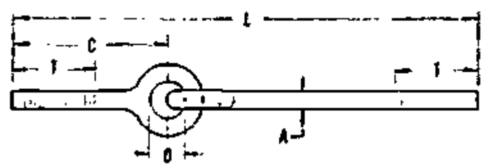


Figure 17-14. Welded Linked-Eye Rod

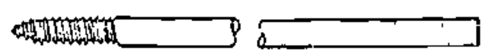


Figure 17-15. Coach-Screw and Machine-Threaded Rod

r) The pipe-hanger flange (Figure 17-16) is also popular for attaching a pipe hanger to the ceiling or elsewhere.

s) Four of the many different types of beam clamps for use with hanger rods are illustrated in Figure 17-17.

t) A riser clamp is essentially a vertical pipe hanger. The standard riser clamp (Figure 17-18) is suitable for use on vertical steel pipe or cast iron soil pipe and, when properly insulated, on copper tubing. The clamp grips the pipe and forms a solid support. It may be tack-welded to steel pipe if desired.

u) Space does not permit listing all the different hangers and supports, but several other types of hangers are shown in Figure 17-19.

Figure 17-16. Pipe-Hanger Flange

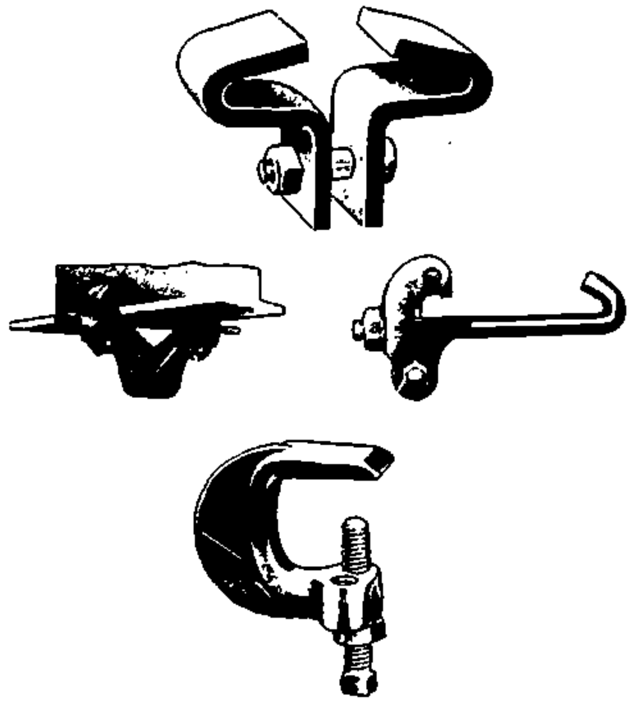
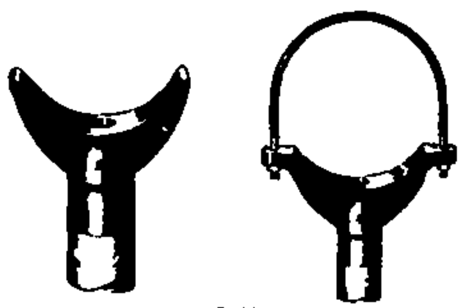
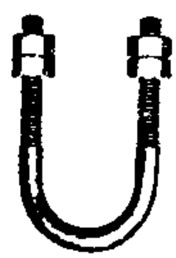


Figure 17-17. Various Styles of Beam Clamps

Figure 17-18. Standard Riser Clamp



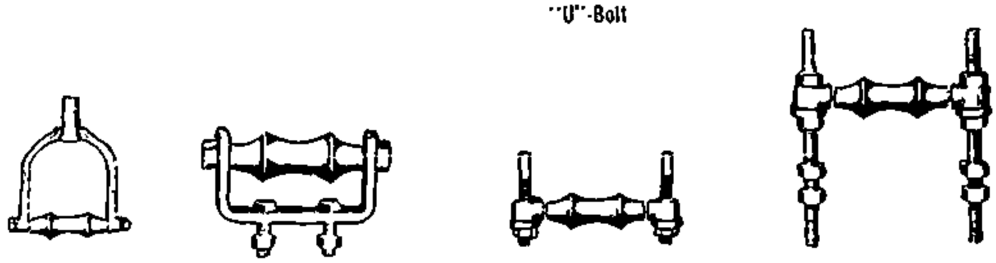
Saddles



"U"-Bolt

Ceiling Bracket

Coach-Screw With Flattened End and Bolt



Pipe Rollers

Figure 17-19. Other Types of Hangers and Supports

2. Nuts and Bolts (General Information)

a) No attempt is made to list all the nuts and bolts available, nor the many different materials from which they are made. Only those believed to be in general use are covered in this section.

b) Nuts and bolts are a system of fastening objects into a set position by the leverage of the thread. They fasten pipes, fixtures, equipment, etc., into position and allow for their removal. The general materials of nuts and bolts used in the plumbing trade are black steel, galvanized steel, stainless steel, and brass. Both square-headed and hexagon-headed nuts and bolts are in general use.

c) National Coarse threads (NC) are the most commonly used for nuts and bolts where easy assembly is required and are in general use by plumbers.

d) Unified National Coarse threads and Unified National Fine threads (UNC and UNF) are interchangeable with NC and NF and will no doubt eventually replace them.

e) Threads are normally right-hand unless specified otherwise.

f) The fit between two mating parts is the relationship between them with respect to the degree of clearance or interference present when they are assembled.

g) "Class 1 fit" (loose) designates screw threads in which the threads must assemble easily, and where an allowance is required to permit ready assembly, even when the threads are slightly bruised or dirty

h) "Class 2 fit" designates a high-quality commercial screw-thread product and is recommended for the major portion of interchangeable screw-thread work, for finished and semi-finished nuts and bolts, and for machine screws, etc., where no allowance is required.

i) "Class 3 fit" is the same as "Class 2 fit" except that its tolerances are smaller. It is intended to apply to interchangeable screw-thread work requiring the smallest practical tolerances. Tapped holes with Class 3 tolerances are difficult and expensive to produce commercially.

j) All nuts and bolts for general-purpose use are a "Class 2 fit."

k) Nuts and bolts are available in the following finishes:

Unfinished: Not machined on any surface except the threads.

Semi-finished: Machined or otherwise formed or treated on the bearing surface to provide a washer face for bolt heads and nuts.

Finished: As in semi-finished, except that surfaces other than the bearing surface have been treated to provide a special appearance.

l) The length of a bolt is measured from under the head to the end, except with counter-sunk head bolts that are measured over-all.

m) Carriage bolts (Figure 17-20) have an NC thread and a square nut unless ordered otherwise.

n) The machine bolt (Figure 17-21) has a square head and a square nut. The thread is an NC thread. Machine bolts with hexagon heads and nuts are available.

o) A flat-head, slotted stove bolt with square nut is shown in Figure 17-22. It has an NC thread and may be made of steel or brass, etc. It is available in a variety of sizes and lengths.

p) A round-head, slotted stove bolt with square nut is shown in Figure 17-23. It also has an NC thread and may be made of steel, brass, etc. It is available in a variety of sizes and lengths.

Figure 17-20. Standard Carriage Bolts

Figure 17-21. Machine Bolt

Figure 17-22. Flat-Head, Slotted Stove Bolt

Figure 17-23. Round-Head, Slotted Stove Bolt

q) Illustrated in Figure 27-24 are two types of hexagon nuts and a wing nut.

r) To minimize friction and ensure that the bolt and nut remain tight under vibration, flat washers and serrated or spring washers are inserted between the material and the bolt heads or nuts.

3. Screws

a) Only a few of the many different types of screws can be illustrated in this section.

b) It is sometimes difficult to tell the difference between bolts and some types of screws. The six screws shown in Figure 17-25 could be mistaken for bolts.

c) There are many types of metal screws in varying sizes and lengths. Shown in Figure 17-26 are three different types of heads found on self-tapping metal screws.

d) Wood screws also come in a large variety of sizes, lengths, and heads. Four types are shown in Figure 17-27.

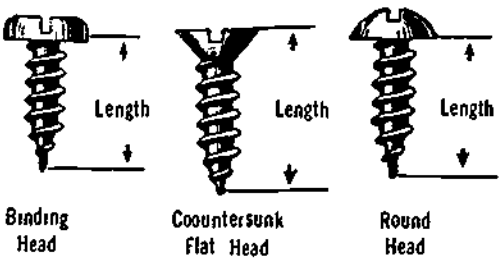


Figure 17-26. Self-Tapping Metal Screws

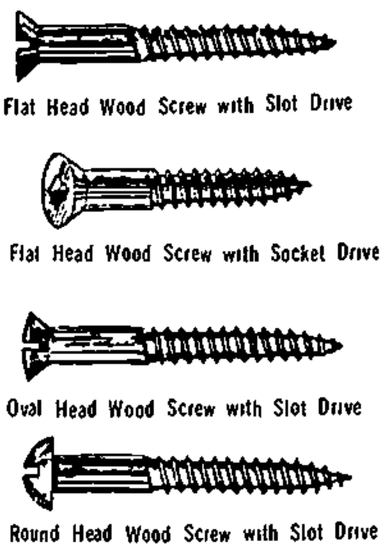


Figure 17-27. Various Types of Wood Screws

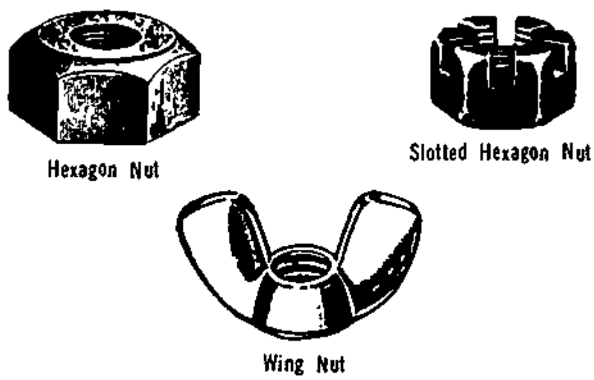


Figure 17-24. Hexagon and Wing Nuts

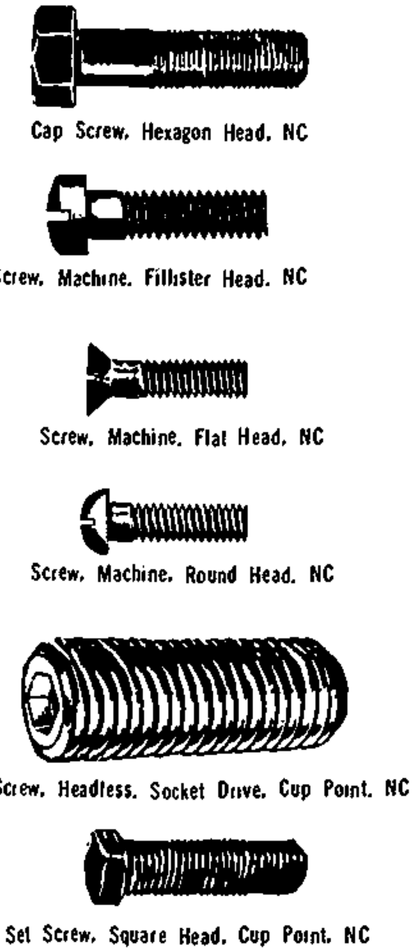


Figure 17-25. Various Types of Screws

e) Screw lengths are determined from the data in Table 17-1.

Table 17-1. Determination of Screw Lengths

Type of Screw	Length Under Head	Length Over-all
Cap Screw	x	
Drive Screw	x	
Lag Screw	x	
Machine Screw, Fillister Head	x	
Machine Screw, Flat Head		x
Machine Screw, Round Head	x	
Set Screw, Headless		x
Set Screw, Square Head	x	
Sheet Metal Screw, Round Head	x	
Wood Screw: See Figure 17-28		

f) Wood-screw diameters are expressed in size numbers. Table 17-2 shows some of the size numbers available and the decimal equivalents in millimetres.

Table 17-2. Metric Equivalents for Screw Sizes

Size Number:	0	1	2	3	4	5
Millimetres:	1.52	1.85	2.18	2.51	2.84	3.18
Size Number:	6	7	8	9	10	11
Millimetres:	3.51	3.84	4.17	4.50	4.83	5.16
Size Number:	12	14	16	18	20	24
Millimetres:	5.49	6.15	6.81	7.47	8.13	9.45

4. Expansion Shields and Anchors

a) There are many types of shields and anchors available for fastening hangers and supports to concrete walls and ceilings. They are made of iron, lead, and plastic.

b) The toggle bolt shown in Figure 17-29 is one of many makes and is an old-time favorite for walls with hollow spaces such as concrete block walls.

c) There are also many types of metal insert anchors for use with machine bolts and lag screws. Two are shown in Figure 17-30.

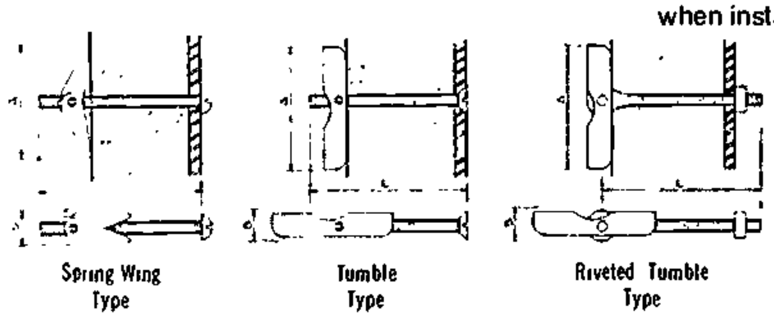


Figure 17-29. Toggle Bolt

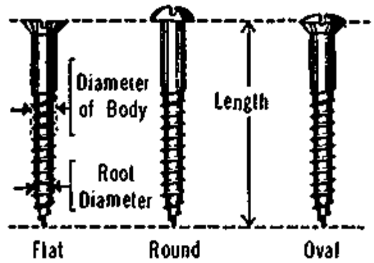


Figure 17-28. Lengths of Wood Screws

These types of shields require that a correct size of hole be drilled into the concrete or similar material, the shield inserted, then the bolt or screw inserted through the hanger and tightened into the shield.

d) Lead shields are still available and are adequate for holding screws supporting glass holders and similar-type bathroom accessories. Figure 17-31 shows a lead shield and wood screw. This shield also requires a pre-drilled hole.

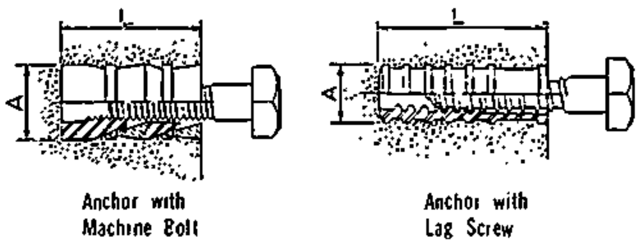


Figure 17-30. Metal Insert Anchors

Figure 17-31. Lead Shield with Wood Screw

e) Self-drilling anchors are possibly the most popular anchors used today (not including powder-actuated guns, which are dealt with in Part 20 of the manual). They come in a variety of sizes and can be installed with a hammer and a holder-driver or an impact hammer in conjunction with a chuck head. The manufacturer's instructions should be followed when installing these anchors.

5. Cutting Machine Threads on Rods

a) To cut threads on a piece of round stock, first grind a chamfer on the end of the rod as shown in Figure 17-32. This aids in starting the die and also inserting the finish thread into its final location.

b) To thread the rod, place it in a vise and start the die squarely with the work. Hold one handle with each hand and apply pressure while turning it clockwise until you feel the dies cutting into the rod. Use a generous amount of good-grade thread-cutting oil while cutting the thread. When the die has started to cut, rotate the die stock one-half turn and back it off one-quarter turn, as illustrated in Figure 17-33. This breaks the metal chips. When the thread is cut to the desired length, remove the die and try the thread in the intended location.

c) Adjusting a threading die to produce a thread of the proper fit is a trial-and-error procedure. If the fit is too loose and the dies are adjustable, cut off the portion of the rod that was threaded and expand the die with the adjusting screw so that the die will cut shallower threads on the rod and produce a tighter fit.

d) If the fit is too tight, contract the die with the adjusting screw; this will cause the die to remove more metal to allow a looser fit.

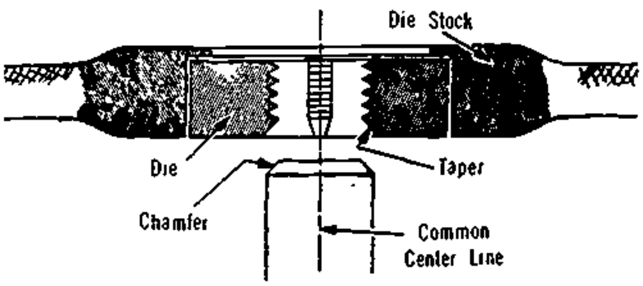


Figure 17-32. Chamfer Ground on End Before Starting Die

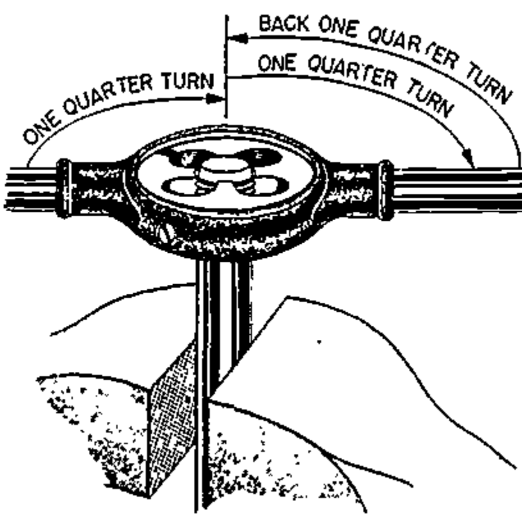


Figure 17-33. Procedure for Threading Rod

6. Cutting Machine Threads with Taps

a) To determine the exact size of metal drill to use when drilling a hole that is to be tapped, refer to an American National Form threads chart, similar to Table 17-3, or to an ISO thread chart in the case of metric threads.

Table 17-3. Thread and Tap Drill Sizes

Nominal Size	Thread Series	Major Diameter (Inch)	Root Diameter (Inch)	Tap Drill to Produce Approximately 75% Full Thread	Decimal Equivalent of Tap Drill (Inch)
0-80	NF	0.0600	0.0438	3/64	0.0469
1-64	NC	0.0730	0.0527	53	0.0595
72	NF	0.0730	0.0550	53	0.0595
2-56	NC	0.0860	0.0628	50	0.0700
64	NF	0.0860	0.0657	50	0.0700
3-18	NC	0.0990	0.0719	47	0.0785
56	NF	0.0990	0.0758	45	0.0820
4-10	NC	0.1120	0.0795	43	0.0890
48	NF	0.1120	0.0849	42	0.0935
5-40	NC	0.1250	0.0925	38	0.1015
44	NF	0.1250	0.0955	37	0.1040
6-32	NC	0.1380	0.0974	36	0.1065
40	NF	0.1380	0.1055	33	0.1130
8-32	NC	0.1640	0.1234	29	0.1360
36	NF	0.1640	0.1279	29	0.1360
10-24	NC	0.1900	0.1359	25	0.1495
32	NF	0.1900	0.1494	21	0.1590
12-24	NC	0.2160	0.1619	16	0.1770
28	NF	0.2160	0.1696	14	0.1820
1/4-20	NC	0.2500	0.1850	7	0.2010
28	NF	0.2500	0.2036	3	0.2130
5/16-18	NC	0.3125	0.2403	F	0.2570
24	NF	0.3125	0.2584	I	0.2720
3/8-16	NC	0.3750	0.2938	5/16	0.3125
24	NF	0.3750	0.3209	Q	0.3320
7/16-14	NC	0.4375	0.3447	U	0.3680
20	NF	0.4375	0.3726	25/64	0.3906
1/2-13	NC	0.5000	0.4001	27/64	0.4219
20	NF	0.5000	0.4351	29/64	0.4531
9/16-12	NC	0.5625	0.4562	31/64	0.4844
18	NF	0.5625	0.4903	33/64	0.5156
5/8-11	NC	0.6250	0.5069	17/32	0.5312
18	NF	0.6250	0.5528	37/64	0.5781
3/4-10	NC	0.7500	0.6201	21/32	0.6562
16	NF	0.7500	0.6688	11/16	0.6875
7/8-9	NC	0.8750	0.7307	49/64	0.7656
14	NF	0.8750	0.7822	13/16	0.8125
1-8	NC	1.0000	0.8376	7/8	0.8750
14	NF	1.0000	0.9072	15/16	0.9375

b) If the tap drill selected is over-sized the tap hole will also be over-sized and the tap can only cut shallow threads. (See Figure 17-34.)

c) If the tap drill is under-sized the tap hole will also be under-sized and there will be no clearance; the tap will be hard to turn, will tear the threads, and will probably break. (See Figure 17-35.)

d) As required in threading all metals, a thread-cutting oil must be used when cutting threads with a tap.

e) The tap should be square with the work as shown in Figure 17-36.

f) Start the tap carefully with its axis on the centre line of the hole, and continue tapping by turning the tap forward a half-turn and back a quarter-turn to break the chips, then forward again to take up the slack. Continue this sequence until the required threads are cut.

g) After the first two or three turns, the downward pressure on the tap wrench is no longer required.

h) To tap a blind hole, start with the taper tap. For a blind hole the taper, plug, and bottoming taps are required. Be sure they are the correct size and thread and that the tap hole is also the correct size. Figure 17-37 shows how the taper tap is used first.

A shows the taper tap starting to cut.

B shows it extending further into the hole.

C shows that it has bottomed in the hole after having cut a few full threads near the top.

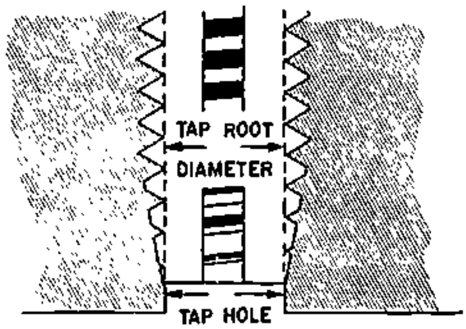


Figure 17-35. Under-Sized Drilled Hole for Tapping

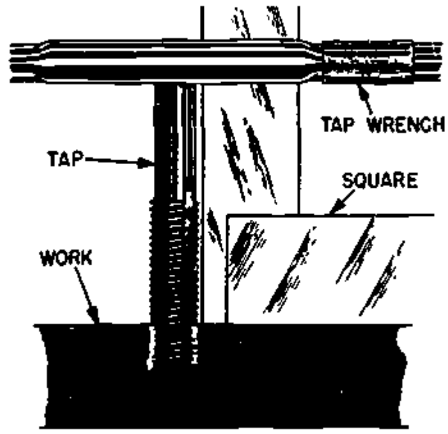


Figure 17-36. Tapping Procedure

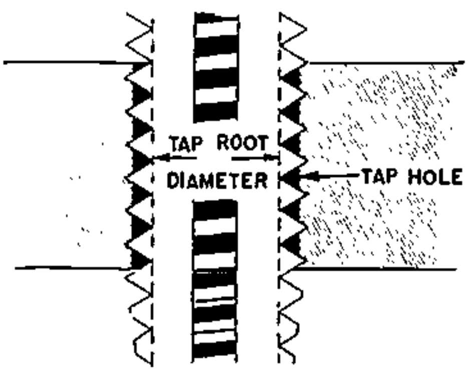


Figure 17-34. Over-Sized Drilled Hole for Tapping

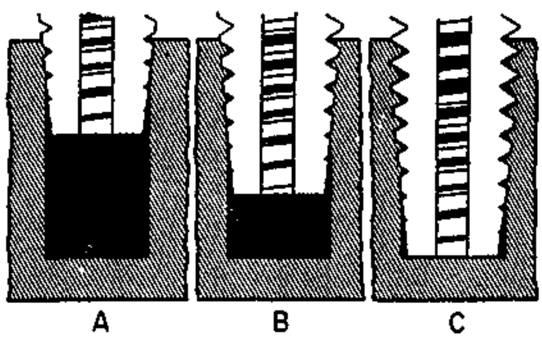


Figure 17-37. Use of Taper Tap for Blind Hole

i) The procedure for the taper tap also applies to the plug tap, as shown in Figure 17-38.

j) The third step is to use the bottoming tap. Figure 17-39 shows how it will cut full threads to the bottom of the hole. The blind hole has now been completely tapped.

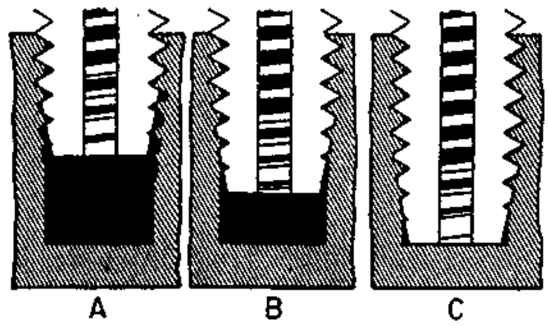


Figure 17-38. Use of Plug Tap After Taper Tap

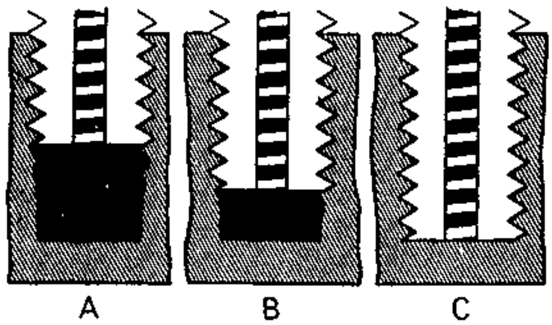
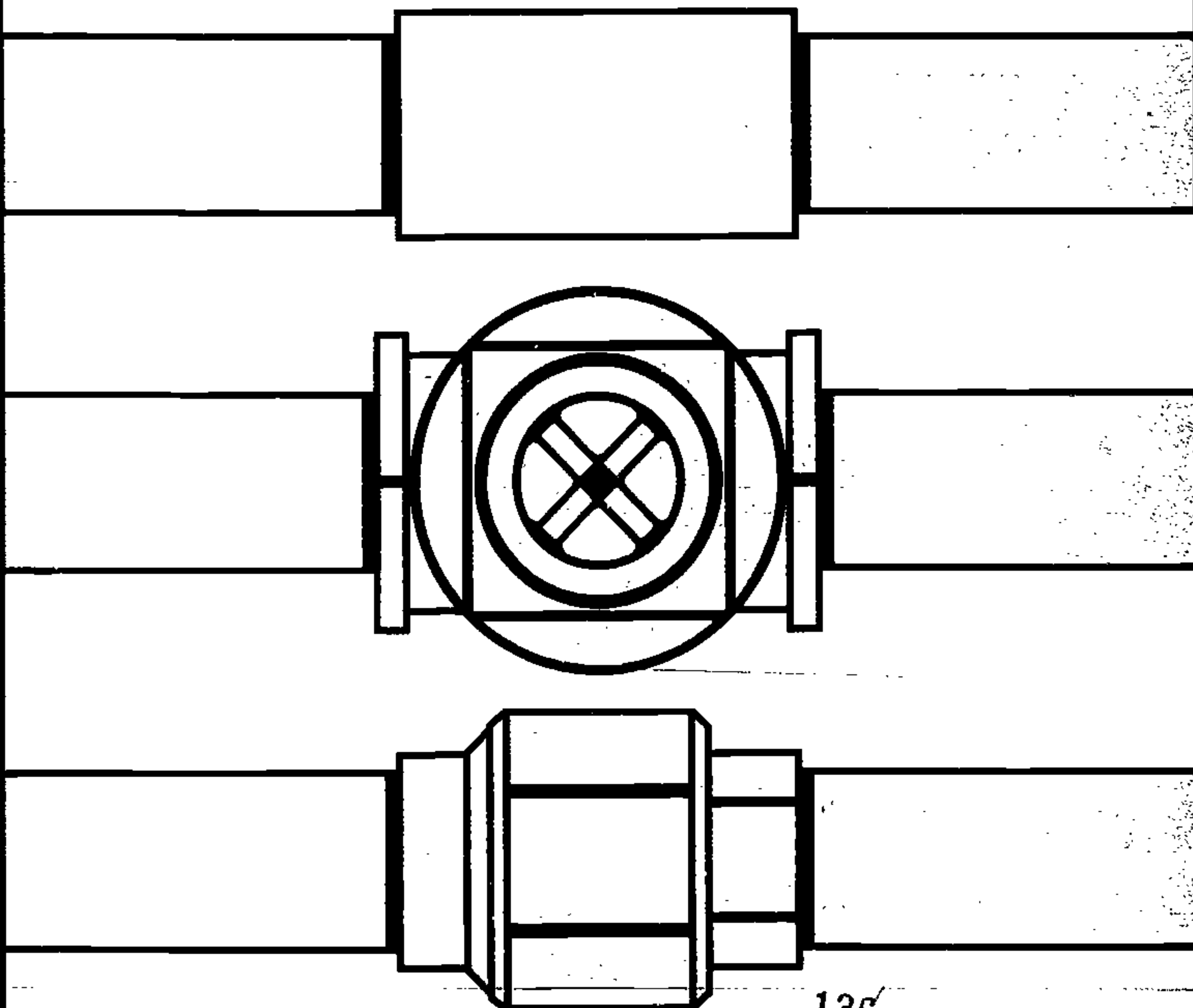


Figure 17-39. Bottoming Tap Completes Blind Hole

Oxygen and Acetylene Welding 18



PART 18

OXYGEN AND ACETYLENE WELDING

1. General Information

a) Plumbers generally are called upon to do basic flat welding and brazing, as in the case of fabricating hangers, etc., and repairing broken components of certain types of equipment.

b) Until they qualify as welders and possess a pressure-welding certificate, plumbers should not be employed to weld pipelines.

c) They may also be called upon to use oxygen and acetylene equipment to cut materials for the fabrication of hangers, etc.

2. Cylinders — Handling, Storage, and Safety

a) The storage and handling of oxygen and acetylene cylinders are governed by the Fire Marshal's regulations, which also specify the safety precautions that must be taken when welding and cutting. These regulations supersede the following general precautions for the handling and storage of cylinders:

b) Be sure the cylinders contain the proper gas and are stored with like gases and *never mixed with other types of gas cylinders.*

c) Protect the cylinders against the weather when stored outdoors, particularly against ice, snow, and direct rays of the sun.

d) Store empty cylinders separately from full cylinders, and mark the empty ones so that they can be so recognized.

e) Do not store cylinders close to hot surfaces such as radiators and stoves.

f) Be sure cylinder storage rooms are well ventilated.

g) Chain or fasten cylinders to a carrier, or to a fixed object, when in use.

h) Protection caps should be in place on the top of the cylinders when they are in storage, and when they are being moved to and from the shop or storage area.

i) Always close the cylinder valves when the equipment is not in use.

j) Do not refer to oxygen as "air" nor to acetylene as "gas." Refer to them as "oxygen" and "acetylene."

k) Handle cylinders carefully and never drop them. Use a cradle or a holder when lifting them with a crane. Never use a magnet for lifting cylinders.

l) Be sure the cylinders are fastened so that they cannot move when being transported. Lift, rather than slide, a cylinder from the vehicle and keep the cap in place.

m) Never roll cylinders nor use them as rollers.

n) Keep oil and grease from the cylinder valves.

o) Store cylinders securely so that they cannot fall or be struck by mechanical or other objects, and where they cannot contact salt or corrosive chemicals or fumes.

p) Cylinders should be kept in an upright position when in use and in storage.

q) Cylinders should be used in the order that they are received from the supplier.

r) Cylinders should not be placed in locations where sparks or flame from welding or cutting can contact them.

s) Extreme care must be taken to ensure that the arc from an electric welder never touches a cylinder.

t) Cylinders should never come into contact with bare electric wires.

u) To prevent serious explosive reaction, oily and greasy substances must be kept from oxygen cylinders, valves, hose, and appurtenances.

v) Do not attempt to repair cylinder valves.

w) Make sure the valve is tightly closed when handling the cylinder. Do not remove the key from the valve while the cylinder is in use.

x) Remove a leaking cylinder into the open air at a safe distance from any type of flame.

y) Do not tamper with the fusible safety plug on acetylene cylinders.

z) Keep the top of acetylene cylinders away from tools and other objects.

3. Hose and Connections

a) Use only first-grade quality hose.

b) Hose should be protected at all times against damage and misuse.

c) Hose should be placed so that it will not create a tripping or stumbling hazard.

d) Oxygen hose should be green and acetylene hose red.

e) Connections should be either the ferrule or the clamp type, capable of withstanding, without leakage, a pressure equal to twice the maximum delivery pressure of the pressure regulators provided.

f) Standard oxygen equipment has right-hand threads, and acetylene equipment left-hand threads. The connections must never be forced.

g) Hose should be frequently examined for leaks and defects.

h) Never use oil or grease to make connections.

i) Never use tape to repair a hose.

4. Oxygen and Acetylene Welding Set-Up

Figure 18-1 depicts a typical oxyacetylene welding set-up:

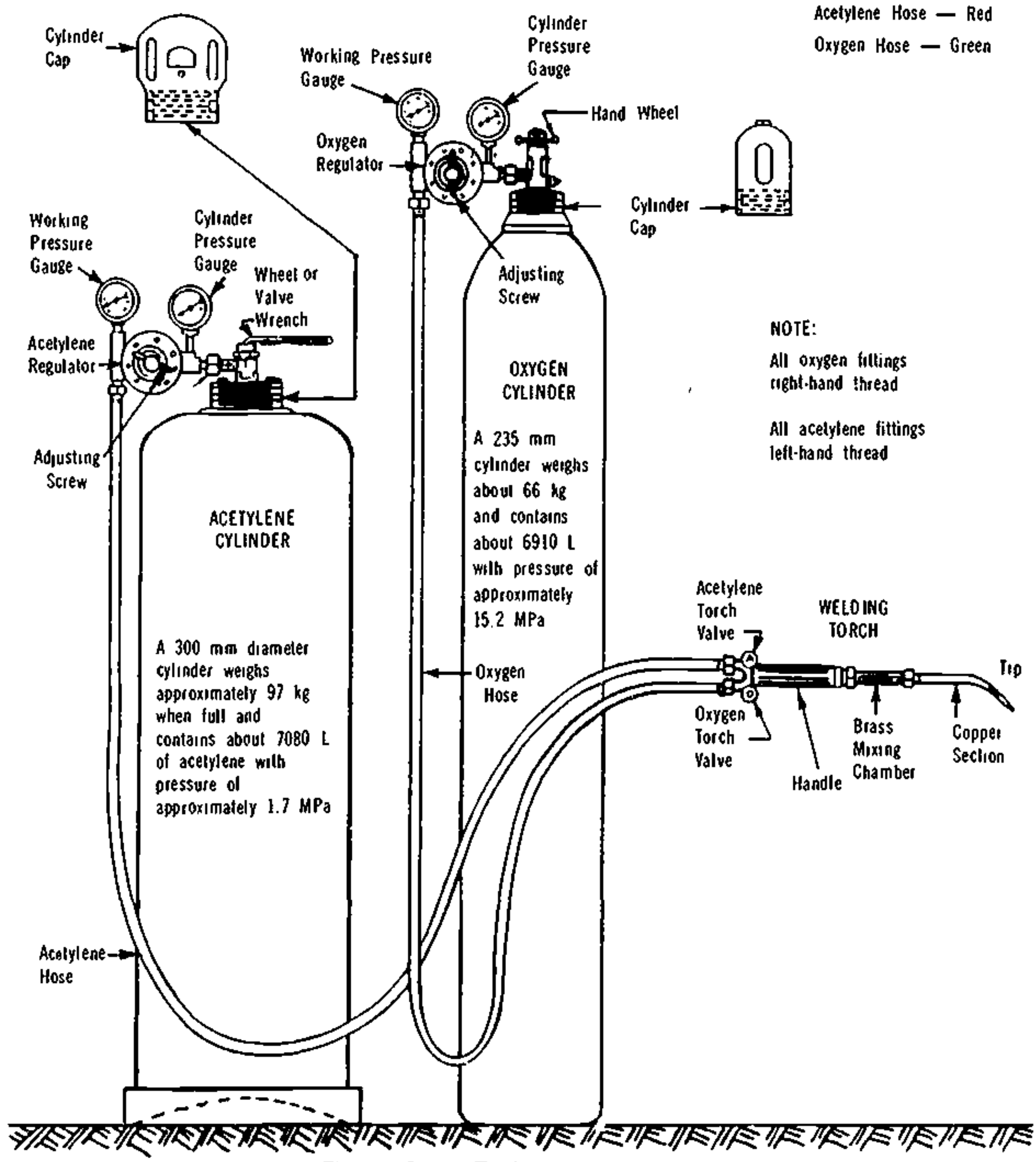


Figure 18-1. Typical Oxyacetylene Outfit

5. Components of a Welding Set-Up

Note the following components of a welding set-up in Figure 18-1:

Acetylene and oxygen cylinders.

Cylinder caps.

Pressure and working gauges connected to the acetylene and oxygen tank regulators.

Note that the acetylene cylinder valve may have a wheel handle or a wrench for opening and closing the valve.

Acetylene and oxygen hoses and their connections.

Welding torch with the two control valves, mixing chamber, and tip.

6. Cylinders—General Information

a) Cylinders are shipping containers for compressed gases and are therefore subject to the rules and requirements of the Board of Transport Commissioners and other regulatory bodies.

b) Cylinders are not generally sold but are rented subject to demurrage charges.

c) Cylinders come in a number of different sizes. The smaller ones are suitable for shops not involved in large cutting and welding jobs.

d) The cylinder valve shown in Figure 18-2 is designed to operate at high pressures. The double-seat construction prevents leakage of oxygen around the stem when the valve is fully open. The safety device in the valve consists of a pressure or rupture disc that will burst and release the oxygen before the cylinder can be ruptured by excessive heat.

e) The two types of acetylene cylinders shown in Figure 18-3 are filled with a porous material such as asbestos, charcoal, or balsa wood.

f) The porous filler is saturated with acetone, a liquid that is flammable, quite volatile, and has a strong odor, but has the ability to absorb acetylene gas and is used in cylinders to make them safe at high pressure. As free acetylene is dangerous when stored at pressures above 100 kPa, this porous material and the acetone prevents formation of large open areas and therefore enables the manufacturer to charge the acetylene cylinders to a pressure of about 1.7 MPa and up to 10 m^3 capacity.

g) Acetylene cylinders must be used in an upright position, otherwise the acetone will flow into and plug the regulator, hose, and torch.

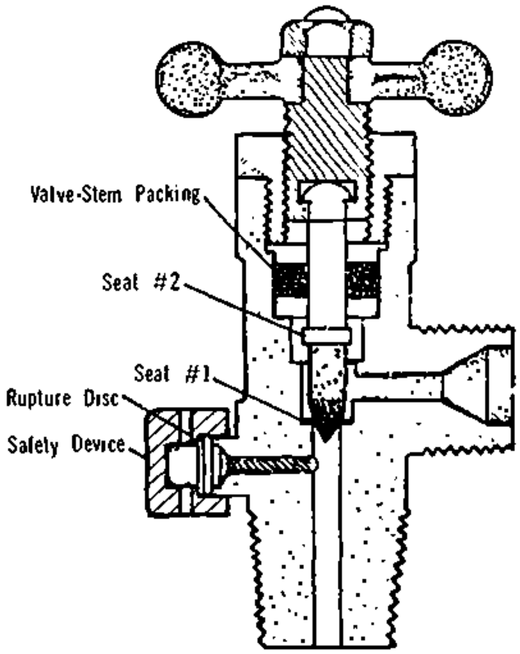


Figure 18-2. Cylinder Valve

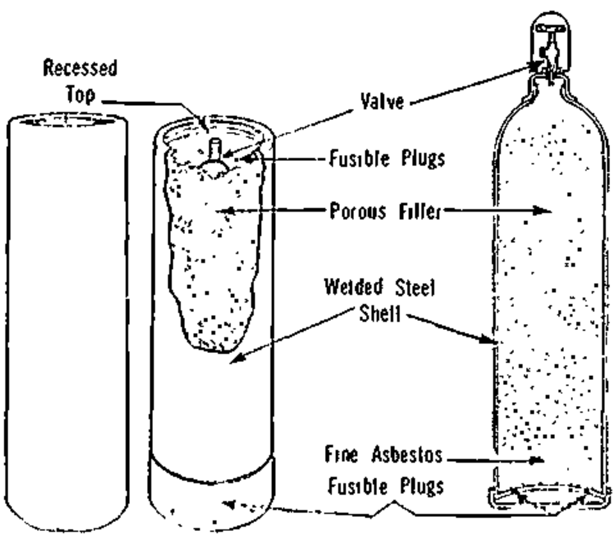


Figure 18-3. Cross-Sectional View of Acetylene Cylinders

7. Oxygen

a) Oxygen is a colorless, odorless, and tasteless gas at ordinary temperatures and is slightly heavier than air.

b) Oxygen forms approximately 20 per cent of the air we breathe, the remainder being composed of about 78 per cent nitrogen and the rest other gases.

c) Combustible items burn much more rapidly in pure oxygen than in air.

d) Steel is not considered a combustible material, but when heated red-hot and oxygen is applied it will burn quite rapidly, reducing the reacted metal to iron oxides.

e) Oxyacetylene flame-cutting is a controlled burning process and it is possible, for example, to cut 6 mm steel plate at speeds up to 660 mm per minute, or an 80 mm thick steel plate at speeds up to 200 mm per minute.

f) Oxygen is always a potential danger because it tends to speed up the combustion of known flammable materials, and combines readily and often violently with materials not generally considered combustible.

g) The gas in the oxygen cylinder is pure oxygen gas and the chemical symbol is O.

8. Acetylene

a) The chemical symbol for acetylene is C_2H_2, which means that it is composed of two atoms of carbon and two atoms of hydrogen.

b) Acetylene gas is colorless, but has a strong pungent ordor Thus as little as 1 per cent acetylene in the air is noticeable to the sense of smell. It acts as an anesthetic, and in its pure form has been used for this purpose.

c) The upper flammable limit of acetylene gas is about 87 per cent gas and 13 per cent air. With less air, the gas will not burn. This range is extended when the air is replaced with pure oxygen.

d) The lower flammable limit of acetylene gas is about 3 per cent acetylene and 97 per cent air. With less acetylene, the gas will not burn.

e) Regardless of paragraphs c) and d), all mixtures of air or oxygen and acetylene should be treated as explosive Acetylene can be smelled, take no chances—extinguish open flames and ventilate the room.

f) Acetylene is an unstable compound, that is, the material is likely to break down or undergo a chemical change without much provocation. When this occurs, it is said to have reached its critical point.

g) The critical point of acetylene is 193 kPa pressure at 21°C. At this point, acetylene breaks down into its components (carbon and hydrogen), releasing its endothermic heat and usually igniting spontaneously. In other words, it "explodes." The critical pressure is affected by the temperature of the gas. If the temperature is higher than 21°C, the pressure at which the acetylene becomes critical will be lower than 193 kPa. Thus it is understandable why the pressure in the acetylene hose and torch is always kept below 100 kPa.

h) Fittings on acetylene lines must be made of yellow brass, iron, or steel. Never use copper or red brass fittings or tubing because the acetylene gas will react with the copper and form acetylene, a residue that may cause an explosion at the slightest shock.

i) Weighing is the only accurate method of determining the amount of acetylene that has been used on a job or is left in a cylinder. One kilogram of acetylene gas equals 905 L at 21°C. Thus, if you multiply the weight of gas by 905, you have the litre content of acetylene in the tank. The weight of the cylinder including the acetone content is stamped on the cylinder.

j) Acetylene is sold by weight.

9. The Welding Torch

a) There are many manufacturers of welding equipment, and each manufacturer's instructions should be observed. Following are the basic items on most welding torches in this field:

b) A typical welding torch of the type discussed here is seen in Figure 18-1, where the basic components are shown as the acetylene torch valve, the oxygen torch valve, the handle, the brass mixing chamber, and the tip.

c) Note also that the red hose (acetylene) is connected to the acetylene valve on the welding torch and that the green hose (oxygen) is connected to the oxygen valve on the torch. It is difficult to confus these hoses and valves because all components of the acetylene system have left-hand threads, while those on the oxygen system have right-hand threads.

d) The tips of welding torches must be clean and in good condition, that is, the face square to the axis of the tip, etc. To do this, tip cleaners or drills are used, and these are identified by numerals.

e) How to clean a torch tip with a tip cleaner.

Select a cleaner needle one size smaller than the orifice in the tip (do not force a larger cleaner needle into the orifice).

The up-and-down motion with the cleaner needle has to be straight to prevent flaring of the orifice.

After withdrawing the cleaning needle, open the oxygen valve slightly to blow out any dirt.

f) When using a drill for cleaning a tip:

Select the correct size (do not use a drill that is larger than the orifice).

Drills are very brittle and care must be taken not to apply too much pressure nor to bend them sideways because they will break in the orifice and create other problems.

g) Table 18-1 is only a guide to the selection of tip sizes, oxygen and acetylene pressure, and tip-cleaner size. For more specific information, consult the torch manufacturer's instructions.

Table 18-1. Recommendations for Welding

Thickness of Metal	Tip Number	Oxygen and Acetylene Pressure	Tip-Cleaner Size
0.4 mm	00	7.0 kPa	7
0.8 mm	0	7.0 kPa	8
1.6 mm	1	7.0 kPa	10
2.5 mm	2	14.0 kPa	14
3.5 mm	3	21.0 kPa	18
5.0 mm	4	28.0 kPa	22
7.0 mm	5	35.0 kPa	26
8.0 mm	6	41.0 kPa	30
10.0 mm	7	48.0 kPa	34
12.0 mm	8	55.0 kPa	37
16.0 mm	9	62.0 kPa	42
20.0 mm	10	69.0 kPa	45

Note the relationship between the tip size and the recommended pressure.

h) Torches should be lit by a friction lighter, and never by a match.

i) When torches are changed or welding is stopped for longer than about five minutes, all cylinder valves should be closed.

j) A clear, unobstructed space should be maintained between the working point and the cylinders so the pressure regulators can be reached quickly.

k) Torches should not be re-lit from hot metal, especially when operating in a small confined space; if gases do not light instantly, ignition may be violent.

10. Setting Up Oxygen-Acetylene Welding Equipment

a) Crack the cylinder valves to blow out any dust (Figure 18-4).

Figure 18-4. Cracking Cylinder Valves

b) Attach the regulators. Set the nuts up snugly with a wrench, not with pliers (Figure 18-5). Beware of grease.

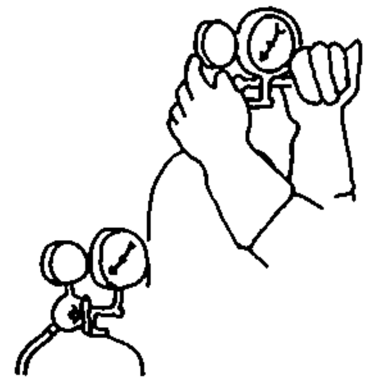


Figure 18-5. Attaching Regulators

c) Attach the hose to the regulators. Be sure that all connections are clean and gas-tight (Figure 18-6).

Figure 18-6. Attaching Hose

d) Release the regulator-adjusting screws and open the cylinder valves (Figure 18-7).

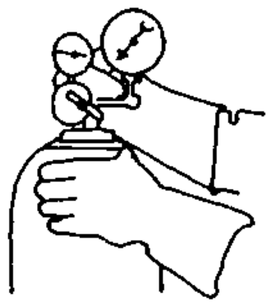


Figure 18-7. Releasing Regulator Adjusting Screws

e) Open the cylinder valves slightly to blow out the hose (Figure 18-8).

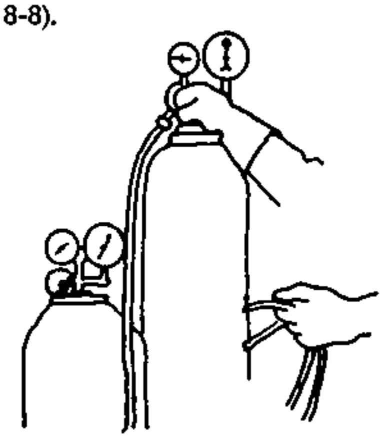


Figure 18-8. Opening Cylinder Valves Slightly

f) Open the needle valves of the torch. Connect the oxygen hose and crack the cylinder valves to blow out the interior of the torch, then close (Figure 18-9).

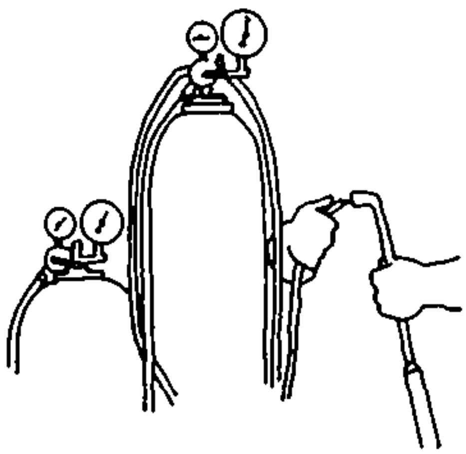


Figure 18-9. Connecting Hose

g) Connect the acetylene hose to the torch. Make connections clean and gas-tight (Figure 18-10).

h) Insert the tip in the torch head and tighten it. Be sure the tip is clean. Use just enough pressure when tightening the tip to ensure that it is tight. Consult the manufacturer's chart when selecting the tip.

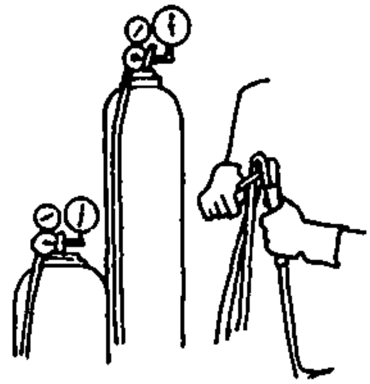


Figure 18-10. Inserting Tip

i) Open the acetylene needle valve and turn the regulator-adjusting screw until the desired acetylene pressure is obtained (Figure 18-11).

Figure 18-11. Opening Acetylene Needle Valve

j) Open the needle valve of the torch and turn the oxygen regulator-adjusting screw until the desired working pressure is indicated, then close the needle valve (Figure 18-12).

Figure 18-12. Opening Torch Needle Valve and Regulating Oxygen

k) Open the acetylene needle valve slightly and light it with a lighter, not with a match (Figure 18-13).

Figure 18-13. Lighting Acetylene

l) Open the oxygen needle valve and adjust the flame (Figure 18-14).

NOTE: While setting up the equipment, be sure the correct pressure is maintained and there are no gas leaks Observe the manufacturer's instructions.

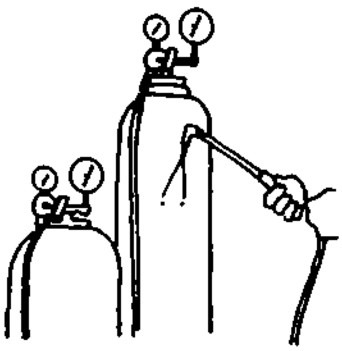


Figure 18-14. Opening Oxygen Needle Valve and Adjusting Flame

11. Flashback

a) A flashback is a burning-back of the pre-heat flames inside the equipment. The flames simply disappear, sometimes with a pop as in the case of a backfire, but you can recognize a flashback by one or more of the following signals:

A squealing or hissing noise from inside the blowpipe. Sparks coming out of the nozzle.

Heavy black smoke coming out of the nozzle.

The blowpipe handle becoming hot, or fire bursting through the acetylene hose.

b) A flashback can seriously damage the blowpipe, hose, and regulators; when one occurs, act quickly. A flashback rarely occurs when equipment is in good working order and is operated correctly.

c) In a flashback, the flames burn back into the mixing chamber or beyond (Figure 18-15).

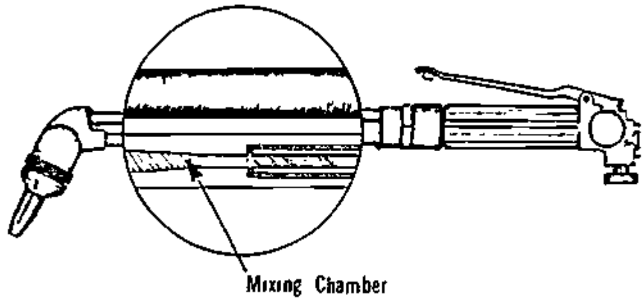


Figure 18-15. View of Mixing Chamber

d) The following action must be taken quickly if a flashback occurs and the flame disappears, followed by a squealing noise and nozzle sparks:

Close the oxygen needle valve on the torch.

Close the acetylene needle valve on the torch.

Close the oxygen regulator.

Close the acetylene regulator.

e) If heavy smoke comes from the nozzle and the blowpipe handle becomes hot, the flashback has likely travelled back beyond the mixing chamber of the torch and into the hose. Quickly shut off both gases at the cylinders. While closing the cylinder valves, stand behind and away from the equipment (regulators). Before re-lighting the torch, examine the various components for damage caused by the flashback.

f) Some causes of flashbacks:

Grossly unequal pressures that cause the higher-pressure gas to back up into the lower-pressure line and explode if the pressure and mixture are right.

Mildly unequal pressure plus an obstruction. Should tip blockage occur, close both needle valves on the torch immediately, then clean the tip.

Failure to purge each line before lighting the torch.

A torch that has been idle may well have an explosive mixture in the line. This could be brought on by the torch's being bumped or dropped, causing needle valves to open slightly. Any obstruction of the tip would further increase the danger.

Faulty manipulation of valves, such as lighting a torch with both needle valves open or otherwise failing to operate equipment in the recommended manner.

g) Figure 18-16 shows the areas that are susceptible to backfires, burnbacks, and flashbacks.

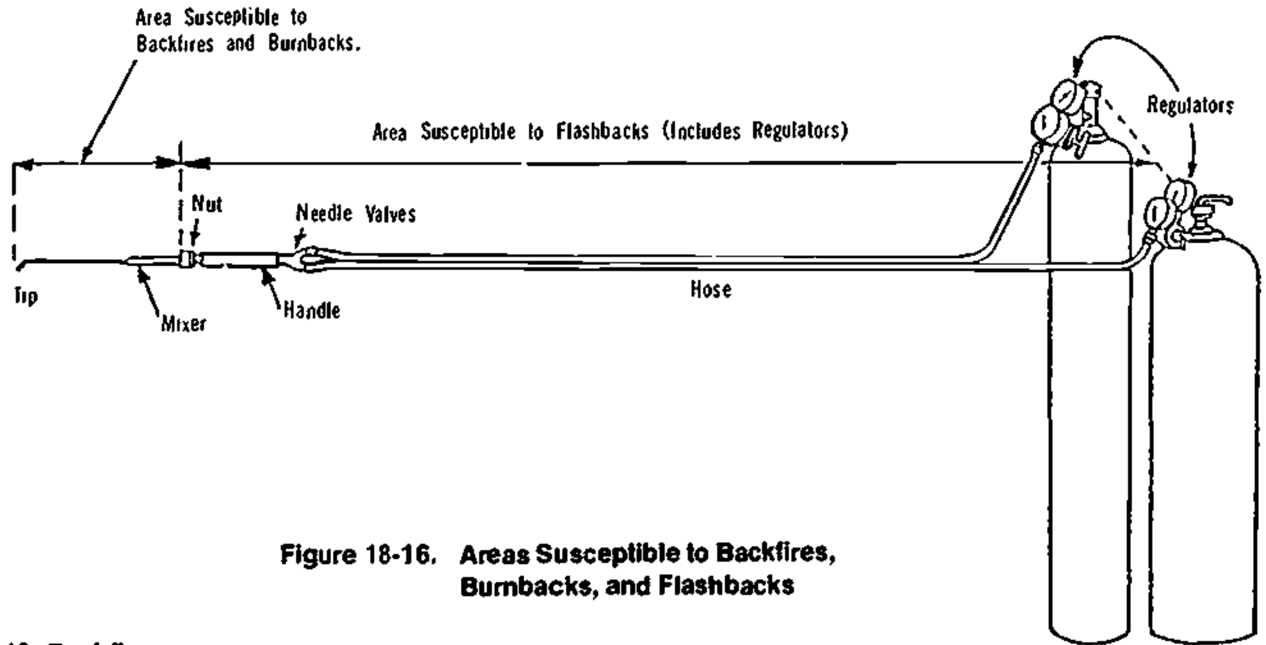


Figure 18-16. Areas Susceptible to Backfires, Burnbacks, and Flashbacks

12. Backfires

a) Some causes of backfires:

Too little gas speed. This may result from low pressure or failure to open the needle valves enough to avoid the smoke range.

Obstruction of gas flow. This may result from holding the torch too close to the work, dipping the tip in the puddle, or passing the rod end too close to the tip.

Loose or faulty seat connections between the tip and torch, which will cause popping.

A dirty tip. This may be caused by a series of backfires, or working in deep grooves or blind holes. The heat in the tip pre-heats gases, causing a rise in the speed of flame propagation with a consequent rapid series of backfires. Close the needle valves, open the oxy-needle valve slightly, and quench the torch in water. Blow out the water with oxygen, then re-light.

13. Oxygen-Acetylene Flames

a) Three different types of flames can be produced by adjusting the needle valve on the torch that controls the amount of acetylene and oxygen being burned.

b) The neutral flame (Figure 18-17) is the ideal flame for welding mild steel, copper, and cast iron. The ratio between acetylene and oxygen supplied to the torch is about 1-to-1. The temperature of this flame is about 3260°C.

c) The reducing flame (Figure 18-8)—also referred to as a carburizing flame—has more acetylene than oxygen supplied to the torch than the 1-to-1 ratio, producing an inner cone with a feather. The length of the feather indicates the amount of acetylene and is expressed in relation to the inner cone: e.g., "3 X reducing" means that the white feather is three times the length of the inner cone. When steel is melted, the puddle is boiling and not clear when this flame is used. This is the best flame to use for aluminum welding, aluminum brazing, fusion welding of stainless steel, silver b-azing, and hard-surfacing. The temperature of this flame ranges from 2980°C to 3200°C.

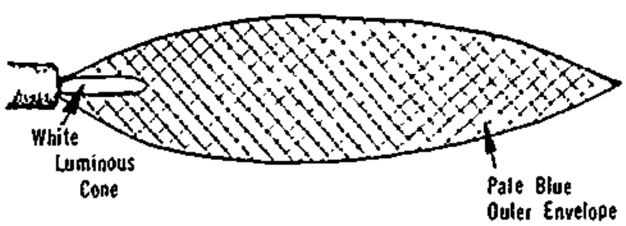


Figure 18-17. Neutral Flame

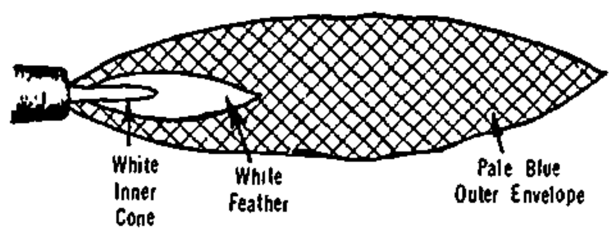


Figure 18-18. Reducing Flame

d) The oxidizing flame (Figure 18-19) has excess oxygen. There is more oxygen than acetylene fed to the torch for this type of flame than the 1-to-1 ratio of the neutral flame, producing a shorter, more bluish cone and a somewhat shorter outer envelope. Melting steel with this flame produces excessive foaming and sparking of the metal. Its main use is in braze welding and fusion welding of manganese.

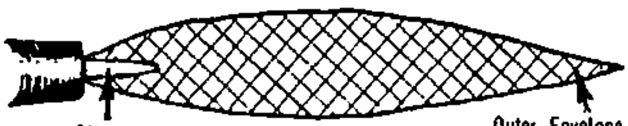


Figure 18-19. Oxidizing Flame

14. Welding

a) When two pieces of metal are brought together and the edges are melted with oxygen-acetylene flame, the molten metal will flow together until both edges are fused. After the metal has cooled, there is a single continuous piece with no seam.

b) Welds made in the manner just described are known as fusion welds, because the base metal of the two pieces is actually melted and fused. Metal from the welding rod is fused in as well. In fusion welding, the base metal and the welding rod generally have essentially the same composition.

c) In all oxygen-acetylene welding, it is essential that the weld penetrate through the metal. Where the thickness of the metal is such that it would be difficult to secure full penetration if edges were simply butted together, it is customary to bevel the edges before welding. Placing the two bevelled pieces together forms a vee nearly through to the underside of the two pieces. The weld can now penetrate to the bottom of the joint.

d) With fairly light metal, a distance equal to the thickness of the metal may be left between the pieces to be welded. This rule may also be used in welding standard pipe up to but not over NPS 1½ diameter. A larger pipe must be bevelled.

e) To build the weld up to the original surface, more metal must be added to fill up the vee. The metal used for this purpose comes from the welding rod, which varies in diameter from 4.2 mm to 9.5 mm.

15. Welding Techniques (Steel)

a) The manner in which the torch is manipulated affects the size and shape of the finished weld, and is determined by the thickness of the metal to be welded, the joint preparation, and the fit-up.

b) The factors to be considered are the torch movement, the angle of torch to joint, and the direction and speed of travel.

c) The torch movement may be full-circular or semi-circular.

d) In some cases where a wide weld bead is required the torch may be moved from side to side, alternating with the rod, across the joint.

e) The angle of the torch to the joint is determined by the thickness of the metal on each side of the joint. In welding plates of equal thickness, the torch should be held at right-angle to the joint. When one side is heavier, the angle should be such as to bring both sides of the joint up to the melting temperature at the same time.

f) The rod should always be held in line with the joint and protected against oxidation by the envelope of the flame.

g) The size of the rod should be in proportion to the thickness of the metal being welded and the size of the tip.

h) The following rule must be observed when fusion-welding mild steel: *Never add rod except to a molten puddle.*

16. Brazing

a) Brazing is a method of joining metals without melting the base metal. The base metal is brought only to a dull red heat.

b) With the base metal at the proper temperature, and with the aid of a suitable flux, metal from a filler rod (bronze, silver alloy, etc.) will form a strong molecular union with the base metal. The base metal has to be perfectly clean before the operation can be started.

c) The following metals may be bronze-welded or brazed, this including the joining of dissimilar metals: copper, brass, nickel, tool steels, malleable iron, stainless steel, cast iron, and mild steel.

17. Brazing Techniques

a) Thoroughly clean the parts to be brazed. Remove oil, grease, paint, rust, and scale by grinding or with emery cloth or steel wool.

b) Any type of joint is satisfactory. Butt joints with metal thickness over 3 mm should be bevelled to have a total angle of 90°. Remove all sharp edges.

c) Flat position is preferred; other positions are more difficult.

d) Clamp the materials or have them in a jig to hold broken pieces in alignment.

e) Pre-heating is not generally required although up to 204°C may be advantageous.

f) Use a good bronze rod, naval brass, manganese bronze, or high-zinc brass.

g) A suitable flux must be used for braze welding. The flux is a compound that chemically cleans the surface of the metal by dissolving and lowering the melting point of oxides. It also prevents formation of oxides during the welding process. Some rods are flux-coated while others must be dipped in powdered flux, which adheres to the surface of a slightly heated rod.

h) The flame should be neutral to slightly oxidizing.

i) Do not melt the base metal; heat it to only a faint red. Keep the rod in the envelope of the flame, and as it melts apply it to the joint to "tin." The base metal will not tin properly if it is unclean. Unless the tinning is satisfactory, it will be impossible to make a sound braze weld. Do not overheat the base metal, as this will cause some of the zinc in the filler rod to boil out, weakening the weld and leaving a white deposit on the surface of the base metal. If applied too cold, the filler metal will ball up and not "tin."

j) Remove slag by chipping and brushing.

k) Many different metals can be braze-welded, e.g., cast iron, malleable iron, carbon and alloy steels, copper, bronze, brass, nickel, etc. Dissimilar metals can also be joined by this process. Other advantages are that braze welds are corrosion-resistant, easy to machine, and done faster than fusion welds.

18. Silver Brazing

a) Because of their low melting points, and their free-flowing and fast-working qualities, brazing with silver alloys is a simple operation.

b) Following are six simple but fundamental steps that, if carefully followed, will ensure sound, strong joints:

Joint edges must be smooth and properly fitted Clearances of 0.038 mm to 0.127 mm between mating surfaces will allow room for just the right amount of alloy to provide maximum joining strength.

Clean the metal of all oxide, scale, oil, and dirt — either chemically or mechanically.

Proper fluxing is very important. Always use the flux recommended by the manufacturer for use with each type of brazing alloy. Flux should be brushed on as a thin paste; both surfaces to be joined, as well as the brazing alloy, should be fluxed.

Use light, simple jigs to prevent sag and movement of parts, and maintain tolerances during the heating operation.

Using a soft flame on a large tip, slowly heat the joint and surrounding metal. When both parts being joined reach the melting point of the silver brazing alloy, apply it to the work. Let the heat of the parts being joined flow the alloy.

Clean joint. Many fluxes are soluble in hot water.

19. Flame-Cutting

a) Flame-cutting is accomplished by rapid oxidation of combustion of heated steel when a jet of pure oxygen from a cutting torch is directed against it. The steel is cut by first heating a small area to the kindling temperature by the pre-heating flames, then directing a jet of oxygen against the preheated area, as illustrated in Figure 18-20.

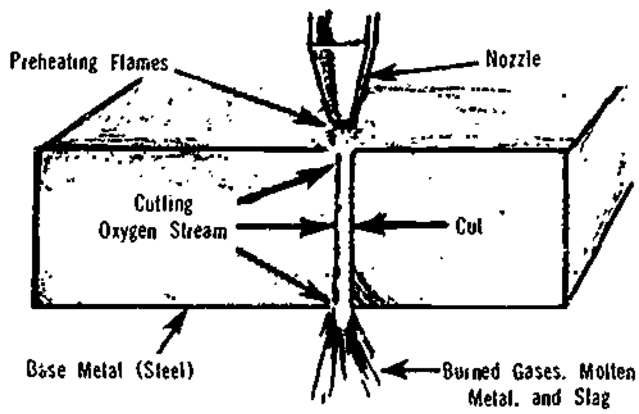


Figure 18-20. Flame-Cutting

b) To prepare the welding torch for flame-cutting, remove the tip and the tip nut and replace them with the cutting torch assembly, as shown in Figure 18-21.

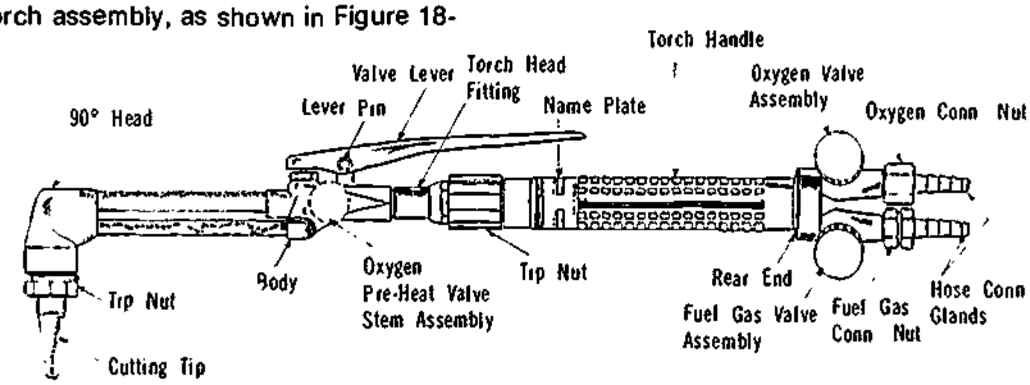


Figure 18-21. Components of Cutting-Torch Handle

c) Table 18-2 provides only a guide to the recommended tip sizes and pressure settings as given in one manufacturer's catalogue. Consult your particular manufacturer's instructions for details pertaining to other torches, etc.

Table 18-2. Recommended Tip Sizes and Pressure Settings

Thickness of Metal	Tip Number	Oxygen Pressure	Acetylene Pressure
7.0 mm	0	210 kPa	21 kPa
10.0 mm	1	210 kPa	21 kPa
12.0 mm	1	280 kPa	21 kPa
20.0 mm	2	280 kPa	21 kPa
25.0 mm	2	350 kPa	21 kPa
40.0 mm	3	350 kPa	21 kPa

NOTE: Gas pressures should be increased slightly for hoses longer than 7.5 m.

20. Goggles, Gloves, Aprons

a) This topic is not treated at length here because it is fully covered in the Workers' Compensation Board regulations.

b) Goggles must be worn at all times when welding or cutting.

c) There are many different types of goggles. Some have darker glass than others, and some are designed for use by workers who normally wear glasses.

d) Leather gloves and aprons are recognized and essential parts of welding accessories to protect the welder from flying sparks and hot materials.

21. Fire Prevention

a) The welder should inspect the immediate working area, as well as the opposite sides of any partitions, floor, etc., to make certain there is no danger of falling or penetrating sparks causing a fire. Sparks may bounce up to 30 m and still be hot enough to ignite flammable materials.

b) Before starting work, determine the location of fire extinguishers and the method of their operation.

c) A fire extinguisher should be readily available in the immediate work area.

d) Welding or cutting must not be performed in or near a room containing flammable vapors, dust, or liquid. Move the operation to a safe distance.

e) Partitions, screens, and booths should be of non-flammable materials.

f) Where there is a possibility that a smoldering fire may have been started, a watcher should be assigned to inspect the area for half an hour after work has been completed, or as long as is necessary to ensure that there is no outbreak of fire.

g) Safety supervisors must be consulted if welding or cutting is to be performed in areas with potential fire hazards (wooden walls, floors, etc.), or in areas suspected of having a flammable or explosive atmosphere.

22. Confined Working Areas

Working in confined areas requires extra precautions when welding or cutting. A confined space may be called an area of limited size with a limited oxygen supply and, in most cases, with restricted exits.

Tanks, boilers, pressure vessels, compartments, or holds of ships and vaults, are among the more common confined places.

Special Precautions:

a) Adequate ventilation *(Never use oxygen).*

b) No cylinders inside.

c) Helper outside — if necessary, with a lifeline.

d) Special attention to leaks.

e) Welding or cutting torches should be lighted outside and nanded in where possible.

f) Never take welding or cutting torches inside until pressures have been regulated.

g) Do not leave torches inside.

h) Be aware of harmful concentrations of ozone (inert-gas welding).

i) Be aware of explosive vapors that are present or may be formed by the operation.

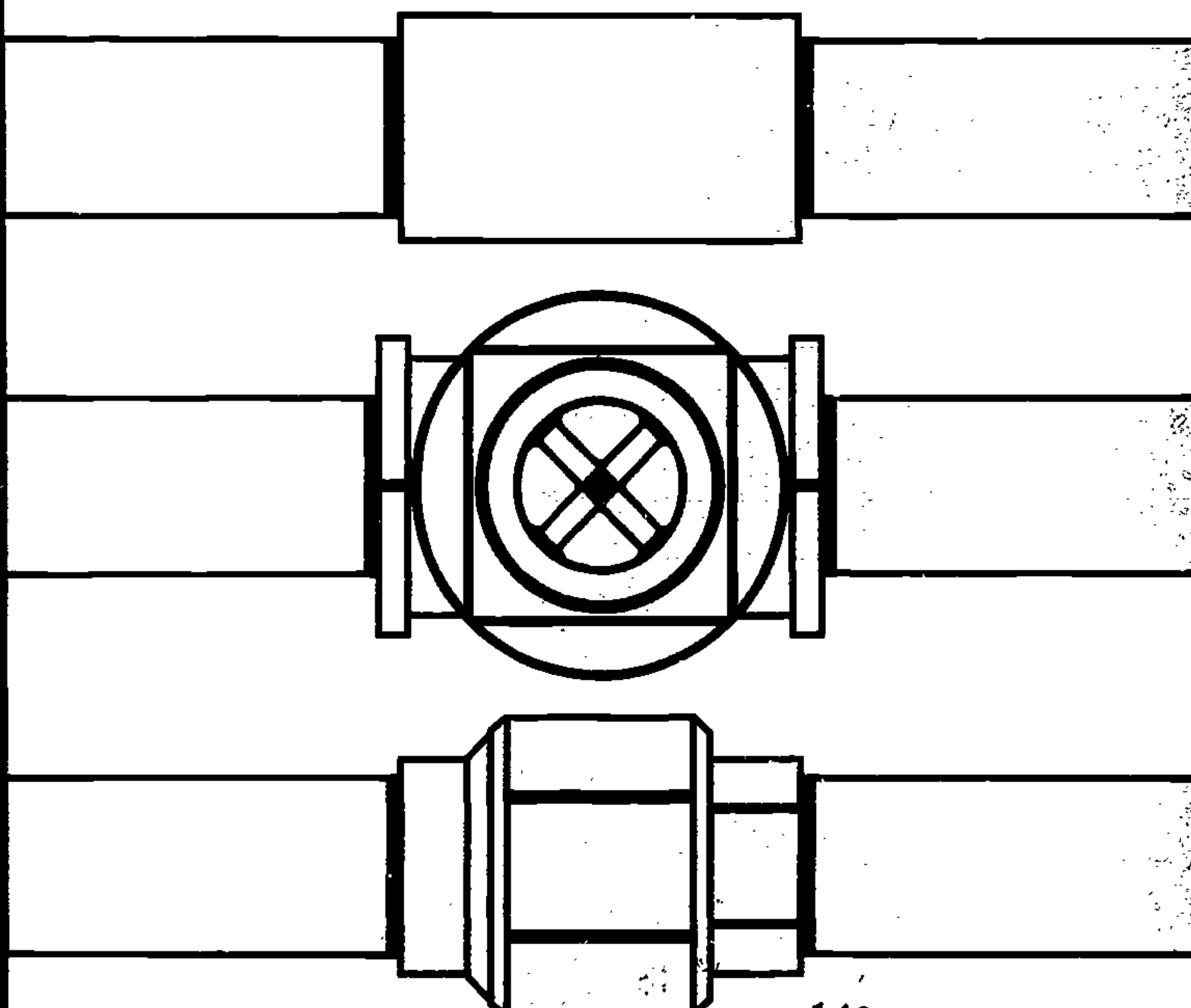
23. Hazards of CO_2 (Carbon Dioxide)

a) CO_2 is composed of one part carbon and two parts oxygen. This is not an inert gas, but is used for shielding purposes in some welding processes not discussed extensively in this manual. In welding, CO_2 tends to break down in the arc. About 7.7 per cent to 12 per cent of the gas turns to carbon monoxide, which is classified as a toxic gas. The carbon monoxide can exist only in the high temperature zones and it rapidly re-combines into carbon dioxide under good ventilation conditions.

b) Carbon monoxide is a colorless, odorless gas that cannot be detected by the sense of smell, Becau ɘ CO_2 is heavier than air, it tends to settle in the lower sections of rooms, tanks, etc; therefore adequate ventilation is essential.

c) Never operate a gasoline-powered welder where you cannot get rid of the engine fumes. Carbon monoxide can cause serious injury or death.

19 Electric-Power Tools, Equipment, and Accessories



ELECTRIC-POWER TOOLS, EQUIPMENT, AND ACCESSORIES 173

1. General Information

a) Only a very basic knowledge of this large subject can be included here.

b) Again it is emphasized that you must follow the manufacturer's instructions when using any type of tool or equipment.

2. Safety

a) Electric 110 V and 240 V tools should be equipped with a three-pronged grounding plug for safety. When the plug (Figure 19-1) is inserted in a properly grounded receptacle it will protect you against shock if the insulation fails or if a short circuit occurs.

b) Do not stand on wet surfaces nor touch water or other piping while operating electric tools.

c) When extension cords are used for extra length, the coupling prong and socket should be tied or the cord looped and tied.

d) Many motors on portable equipment are ruined by over-loading and voltage drop on temporary extension lines.

e) Avoid crimping the cord, because continual flexing may cause breaks in the wire.

f) Do not operate electric tools in a gaseous or explosive atmosphere.

g) Use an air hose occasionally to keep the motor and vents free from foreign matter.

h) Wear safety goggles where required.

3. Electric Drills

a) There are many different types of electric drills, but those shown in Figures 19-2 to 19-6 are some of the types that a plumber could need in day-to-day work.

b) Electric drills may operate on 110 V or 115 V a.c. or, in some cases, on 12 V d.c.

The type of electric drill shown in Figure 19-2 is generally used for light work. Its chuck capacity is usually 6 mm or 9.5 mm drill size. Some models have a reversing switch and speed control.

A typical heavy-duty electric drill is shown in Figure 19-3. Maximum chuck capacities may range from 12.5 mm to 19 mm. It is usually equipped with a reversing switch and a heavy-duty chuck.

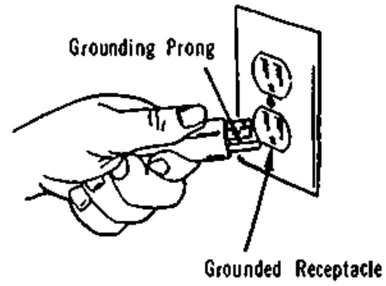


Figure 19-1. Grounding Prong

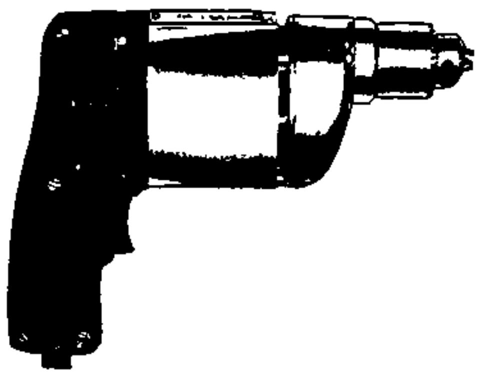


Figure 19-2. Standard Utility Drill

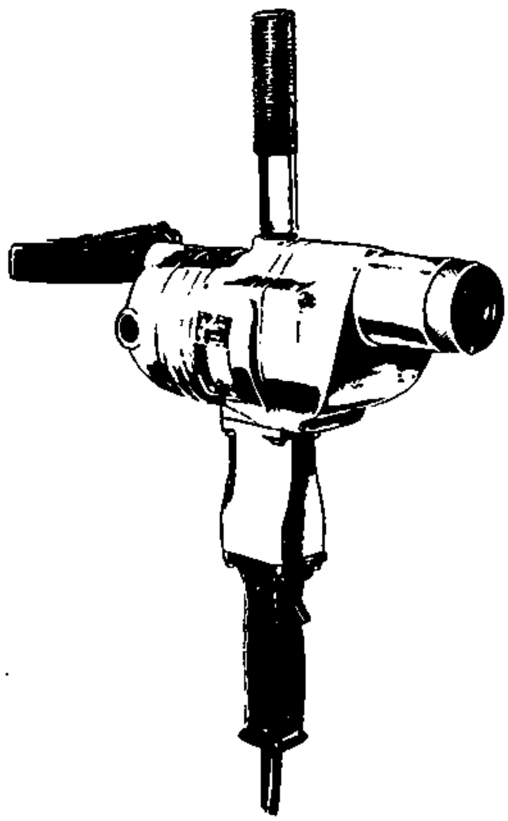


Figure 19-3. Typical Heavy-Duty Electric Drill

Figure 19-4 shows a right-angle-drive electric drill for drilling between joists, studding, and in tight corners. Some models have a speed control and a reversing switch.

The style of electric drill shown in Figure 19-5 is designed for drilling between studs and joists. It has the power and torque to handle up to 120 mm self-feed bits in wood and 12.5 mm in steel. It is generally equipped with a speed control and a reversing switch.

A rotary hammer drill for fast drilling in concrete is shown in Figure 19-6. The manufacturer claims it is capable of drilling 140 mm a minute with a 13 mm bit in construction-grade concrete. Types similar to this can be used as a standard drill with or without the hammer action. Carbide-tip bits are generally used for concrete.

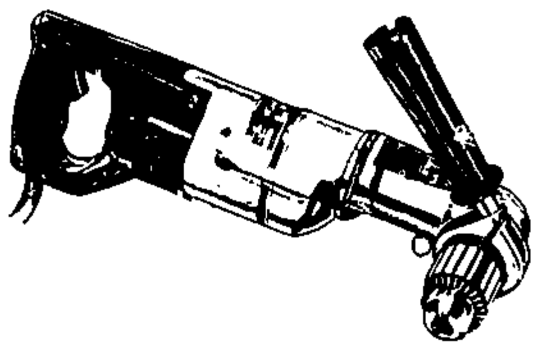


Figure 19-4. Right-Angle-Drive Electric Drill

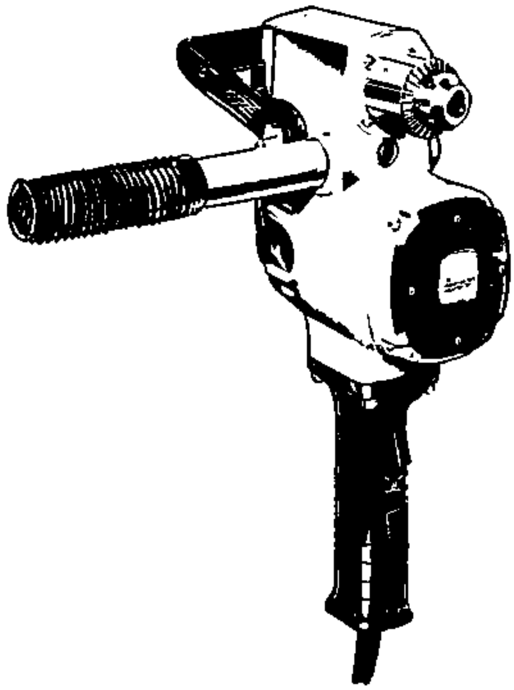


Figure 19-5. Compact Heavy-Duty Electric Drill

4. Accessories for Drills

a) A few of the many different types of drill accessories are described and shown in Figures 19-7 to 19-11.

The type of bit referred to as a self-feed bit (Figure 19-7) is popular for cutting holes in wood construction for pipe sizes ranging from NPS ½ to 4. Some self-feed bits have replaceable feed-screw pilots.

Auger bits (Figure 19-8) for electric drills are available in sizes for NPS ⅜ to 1 pipe.

Flat boring bits (Figure 19-9) are available in 6 mm to 40 mm diameters. They are generally used with a small pistol-grip electric drill.

Figure 19-6. Heavy-Duty Electric Rotary Hammer

Figure 19-8. Auger Bit

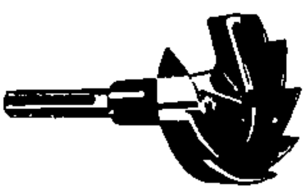


Figure 19-7. Self-Feed Bit

Figure 19-9. Flat Boring Bit

The high-speed hole cutter (Figure 19-10) is available in many types for several purposes. Some models have carbide tips and cut to depths of at least 45 mm. It is used for cutting holes in wood, steel, aluminum, copper, brass, sheet metal, stainless steel, and plastics; and, when carbide-tipped, in ceramic tile.

The carbide-tip masonry bit, when used with an electric drill, drills holes in masonry brick, stone, plaster, slate, etc. The carbide tip resists dulling and may be sharpened on a bench grinder using a silicon-carbide grinding wheel.

5. Electric Saws

Plumbers use electric saws of one type or another a great deal. There are many different makes of electric saws, Figures 19-12 to 19-16 illustrating some that are used in the plumbing trade.

The heavy-duty circular saw (Figure 19-12) is used for making cuts along a marked line.

The heavy-duty electric chain saw (Figure 19-13) is a practical tool if used with care. Flush cuts are easily made with this chain saw.

The reciprocating saw (Figure 19-14) is very popular with plumbers. It cuts almost any shape provided that the correct blade is used. Many types have more than one speed.

The jig saw (Figure 19-15) is a very useful tool for cutting openings in combustible flooring, etc., after the roughing-in openings have been marked, as well as in sink and basin counter tops.

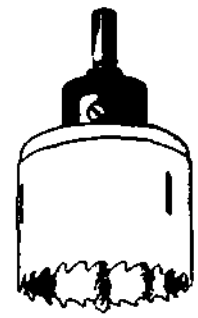


Figure 19-10. High-Speed Hole Cutter

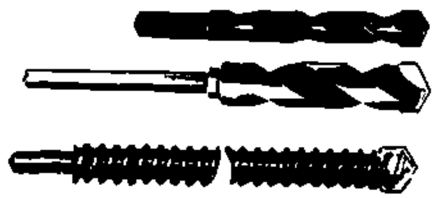


Figure 19-11. Carbide-Tip Masonry Bits

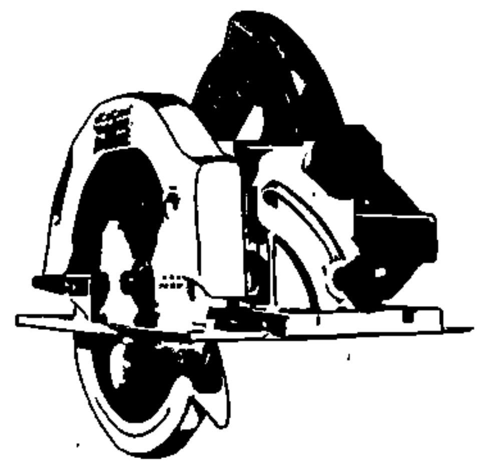


Figure 19-12. Heavy-Duty Circular Saw

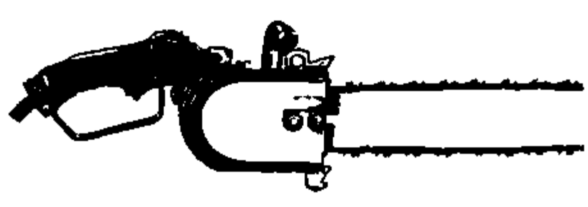


Figure 19-13. Heavy-Duty Electric Chain Saw

Figure 19-14. Reciprocating Saw

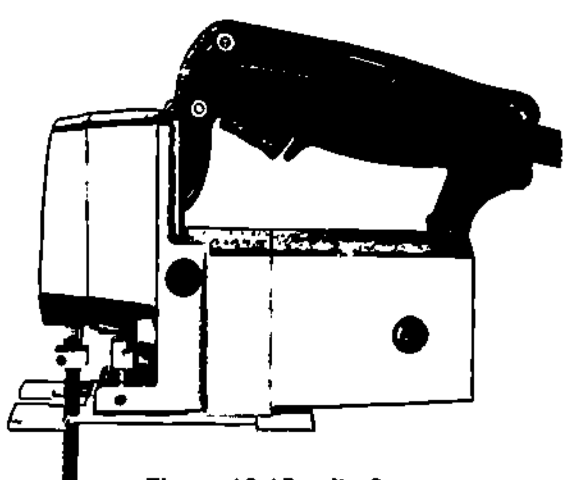


Figure 19-15. Jig Saw

The portable electric band saw (Figure 19-16) cuts large pipe to 90 mm OD and cuts within 25 mm of floor, wall or ceiling.

6. Grinders

a) Grinders used in the plumbing trade are classified as portable grinders and bench grinders.

b) Illustrated in Figures 19-17 to 19-19 are the two basic types of portable grinders and a typical bench grinder.

c) The manufacturer's instructions and the Workers' Compensation Board regulations must be rigidly observed when using grinders.

d) Safety goggles are mandatory when operating this machine.

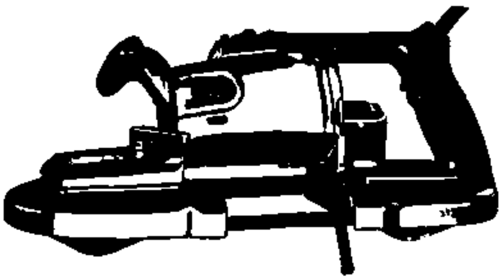


Figure 19-16. Portable Electric Band Saw

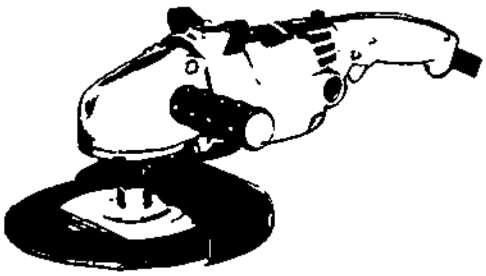


Figure 19-17. Portable Disc Grinder

Figure 19-18. Portable Wheel Grinder

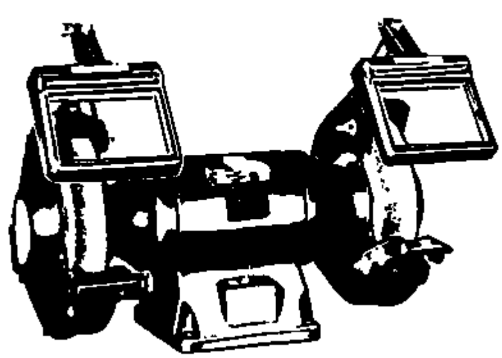
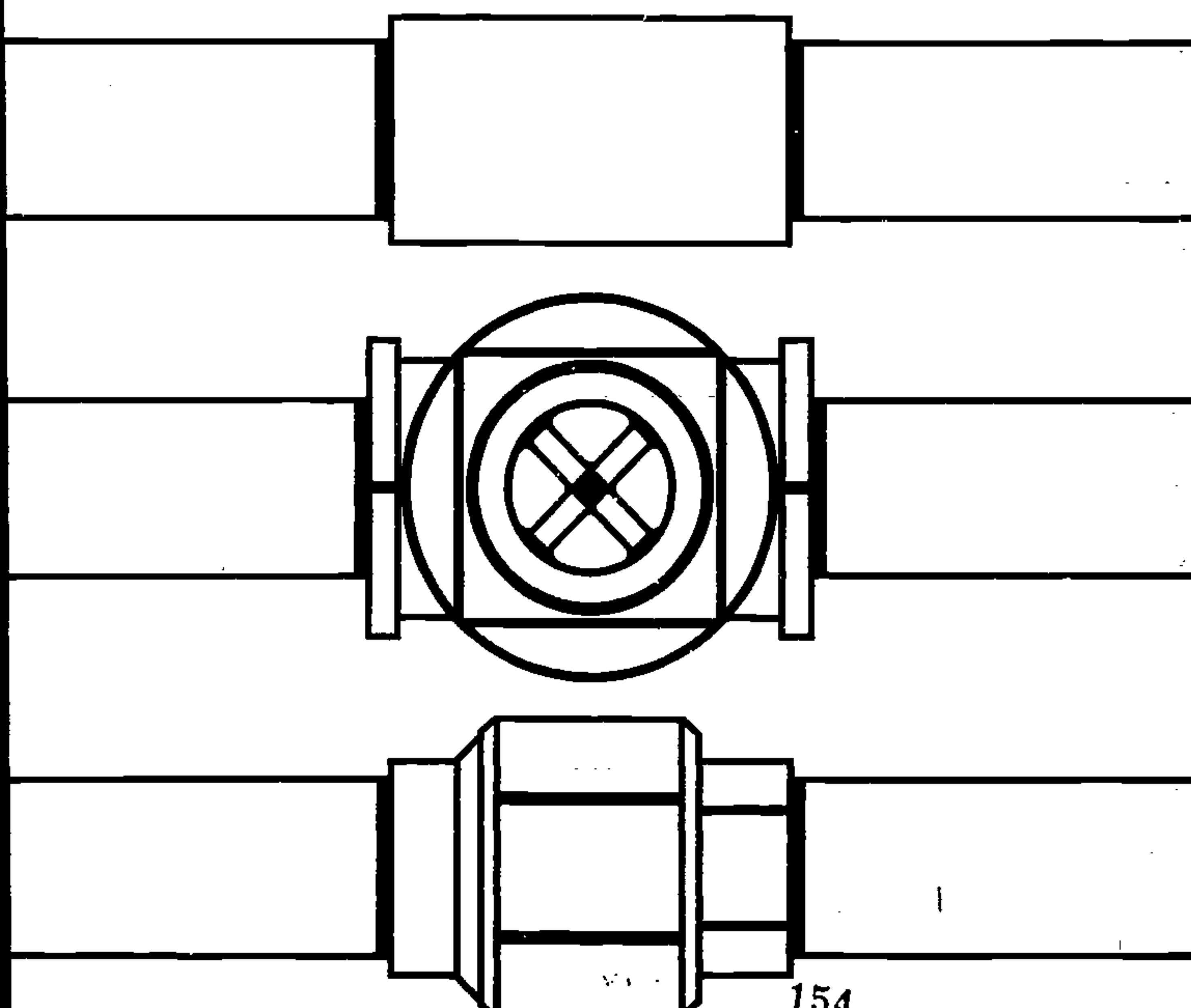


Figure 19-19. Typical Bench Grinder

Powder-Actuated Tools 20



PART 20
POWDER-ACTUATED TOOLS

POWDER-ACTUATED TOOLS

1. General Information

a) Several powder-actuated tools are used in the plumbing trade for inserting fasteners into concrete, steel, etc.

b) Do not try to use this equipment unless you are qualified to do so and hold an operator's card.

c) The possession of an operator's card for one manufacturer's powder-actuated tools does not authorize you to use another manufacturer's powder-actuated tools.

d) Each company has designed a short course of instruction in the use of its particular powder-actuated tool, and only that course should be used to qualify students.

e) Regardless of all other recommendations cited in these pages, the safety precautions and requirements of the Workers' Compensation Board regulations take precedence.

2. Safety Precautions

a) The following precautions are based on one company's recommendations for using its type of powder-actuated tool:

Read and fully understand the operating instructions for the tool before using it.

Operate the tool only if you have a qualified operator's card.

Use only fasteners and powder loads that are manufactured for the particular tool being used.

Do not place your hand over the end of the barrel.

Stand at the back of the tool when firing.

Observe the same precautions that you would around firearms. Never point the tool at yourself or anyone else.

Operators and helpers should always wear safety goggles.

Exercise extreme caution while working in close quarters.

While working on ladders and scaffolds do not get off balance by leaning out too far, or by not properly bracing yourself.

Keep the tool at right-angle to the work surface.

Do not use the tool in an explosive atmosphere.

Store powder loads in a container used for this purpose. Do not mix powder loads with other objects or carry them in pockets.

Never attempt to use powder loads or fasteners in firearms.

Keep other workers out of the line of fire.

Never leave the tool untended or loaded, as some curious person may try to fire it. Always keep it locked up when not in use.

Be sure you know the material you are fastening into, especially on older buildings where the base material may be concealed. Never guess. Check constantly to avoid firing into unsuitable material. Provide a back-stop when firing into thin materials. Be sure no-one is on the other side.

Do not attempt to install fasteners into materials such as glass block, tile, hardened steel, solid rock, slate, terra cotta, granite, glazed brick, cast iron, brick, or marble.

Fasteners should not be used on hollow concrete block.

Never fasten into unsound or cracked concrete, concrete less than 65 mm thick, steel less than 5 mm thick, or less than 50 mm from a weld or a vertical mortar joint.

Never fasten into concrete closer than 75 mm from the edge, or 50 mm from the edge when fastening other material such as a two-by-four to concrete.

Never fasten into steel closer than 12 mm from the edge.

Never use a powder load having more strength than is needed.

Never drive a fastener through a hole without a special adapter.

Never fasten closer than 75 mm to where a former fastener had failed.

When not in use, the tool and cartridges must be kept unloaded in a locked container.

3. Fasteners

a) The three basic types of fasteners are shown in Figure 20-1. Consult your manufacturer's instructions for the types, sizes, and charges that are available for the particular tool you are using.

b) The point of the fastener is designed to force the base materials aside just enough to let the fastener penetrate and seat properly, but not enough to cause excessive deformation. This produces a compressive force by the base material that squeezes the shank of the fastener and provides its holding strength, as illustrated in Figure 20-2.

c) The thread shown in Figure 20-3 is a modified Unified National Thread form that increases the strength of some fasteners. The modification consists of a large radius at the root of the thread; this removes the sharp corners that produce local stress concentrations under loads.

d) Some types of fasteners have two types of guides: plastic and metal washer. The metal washer guide increases the bearing area of the fastener head, giving it greater holding strength (Figure 20-4). It also prevents the fastener from over-penetration in soft material.

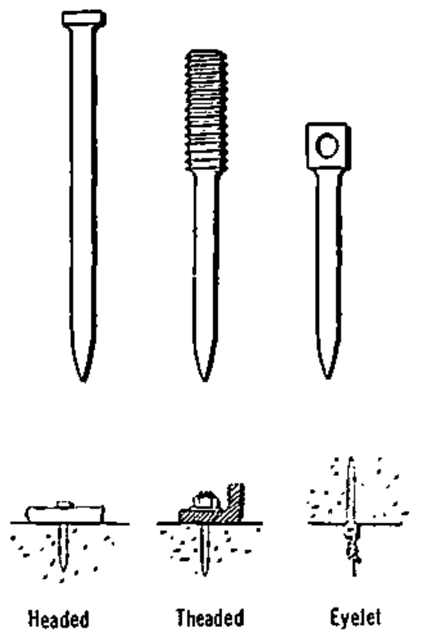


Figure 20-1. Three Basic Fasteners

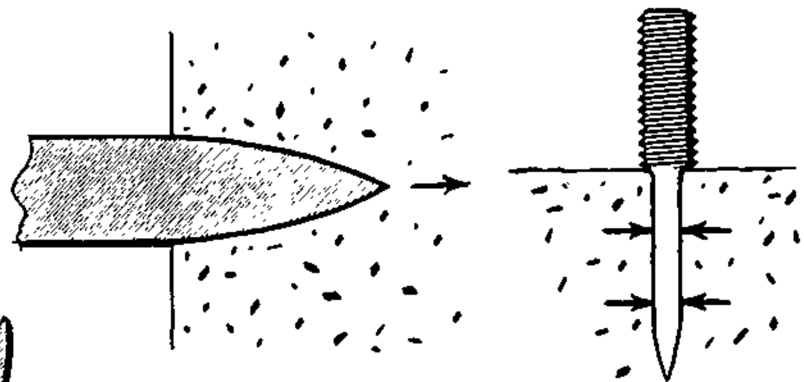


Figure 20-2. Penetration and Holding Power of Fastener

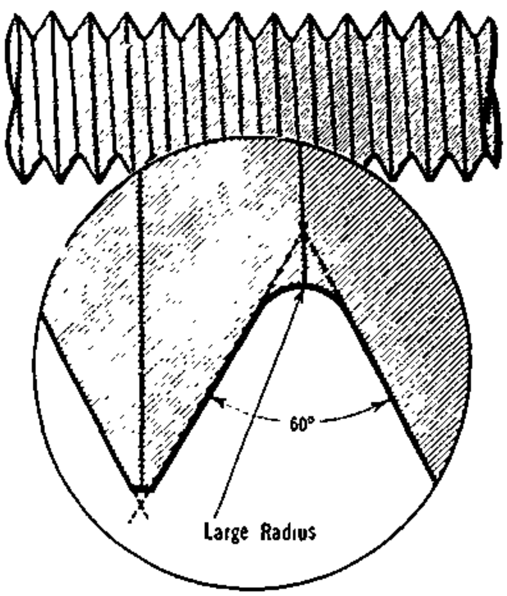


Figure 20-3. Modified Threading to Increase Strength of Fastener

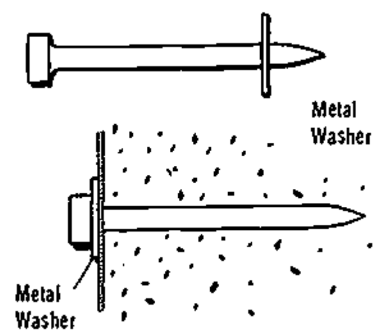


Figure 20-4. Use of Metal Washer with Fastener

e) Some of the applications for powder-actuated fasteners are shown in Figure 20-5.

f) Always follow the manufacturer's instructions when using a particular make of powder-actuated tool.

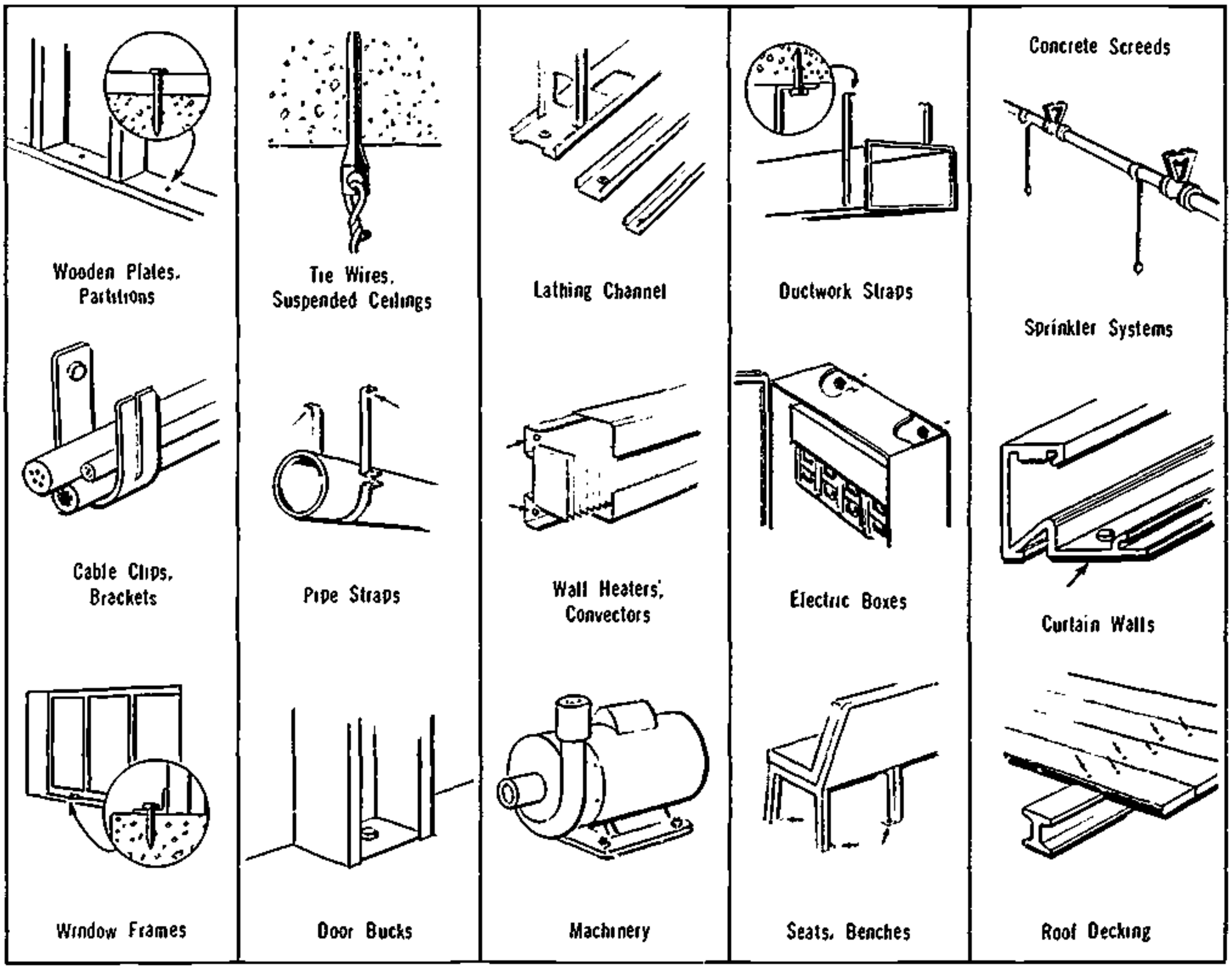
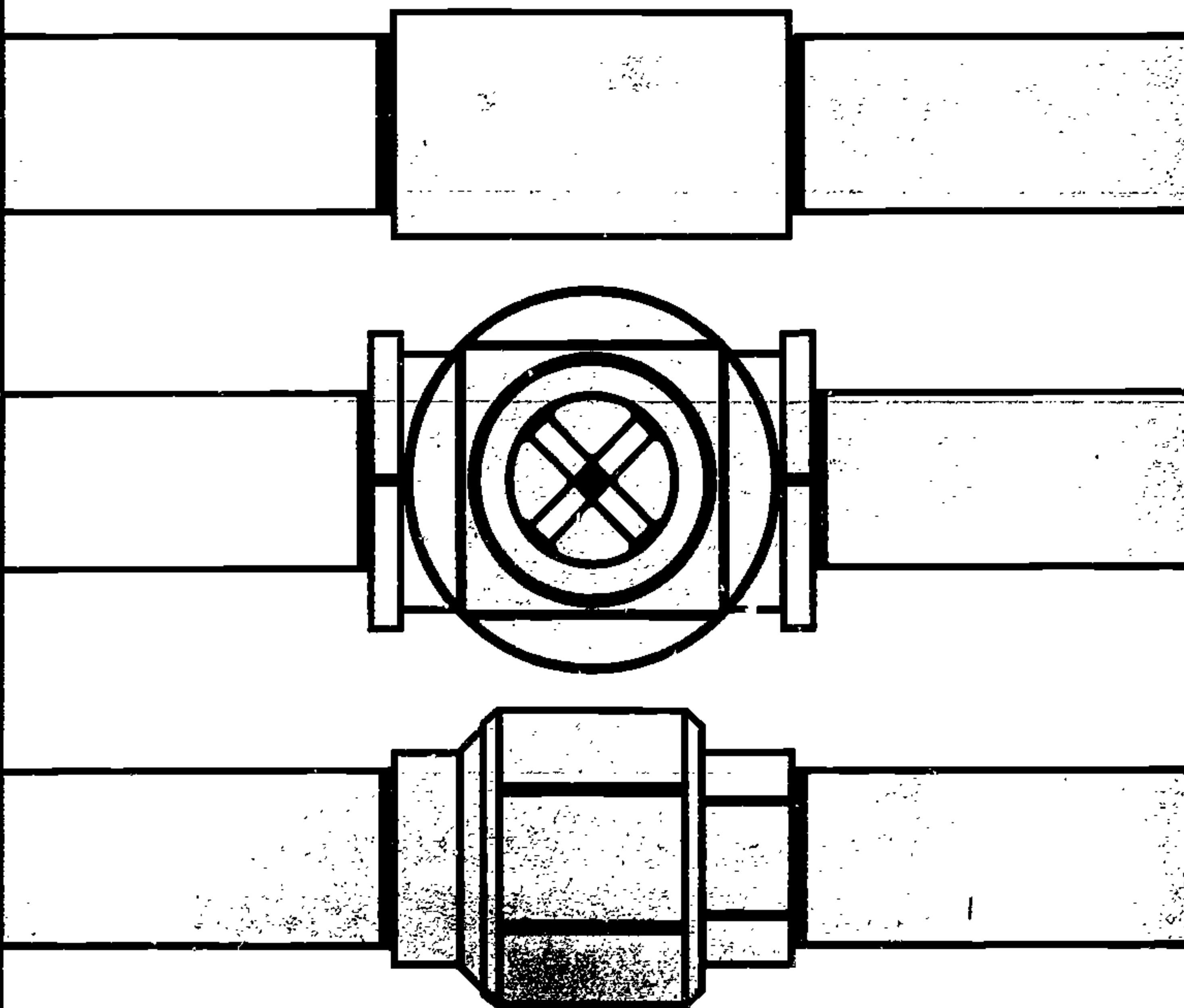


Figure 20-5. Examples of the Uses of Powder-Actuated Fasteners

Plastic Sewer Pipe, Fittings, and Joints 12



PART 12

PLASTIC SEWER PIPE, FITTINGS, AND JOINTS

1. Plastic Sewer Pipe

a) Plastic sewer pipe should be used only under ground for gravity-type drainage of sewage and other liquid wastes.

b) The plumbing code governs the locations whe. this pipe may be used in a plumbing system.

c) Chemicals commonly found in industrial waste lines may be too highly concentrated for satisfactory performance of plastic sewer pipe over an extended period.

d) The pipe and fittings must conform to the standard specified in the appropriate plumbing code.

e) This pipe is available in 3 m lengths that do not include a bell end or coupling.

f) The pipe may be solid or perforated. The latter type is suitable for use in septic-tank disposal fields, foundation drains, and sub-soil drains.

g) The solid pipe is available in NPS 2, 3, 4, 5, and 6.

h) The perforated pipe is available only in NPS 3 and NPS 4, the NPS 4 being the most popular size in some areas.

i) The pipe material may be a composition of polyvinyl chloride or rubber-modified styrene, and may contain stabilizers, lubricants, fillers, modifiers, and pigments.

2. Fittings

a) The fittings used with plastic sewer pipe are bends, sanitary tees, Ys, couplings, cleanouts, adapters, bushings, and caps.

b) The fittings generally have hubs into which the pipe is inserted.

3. Joints

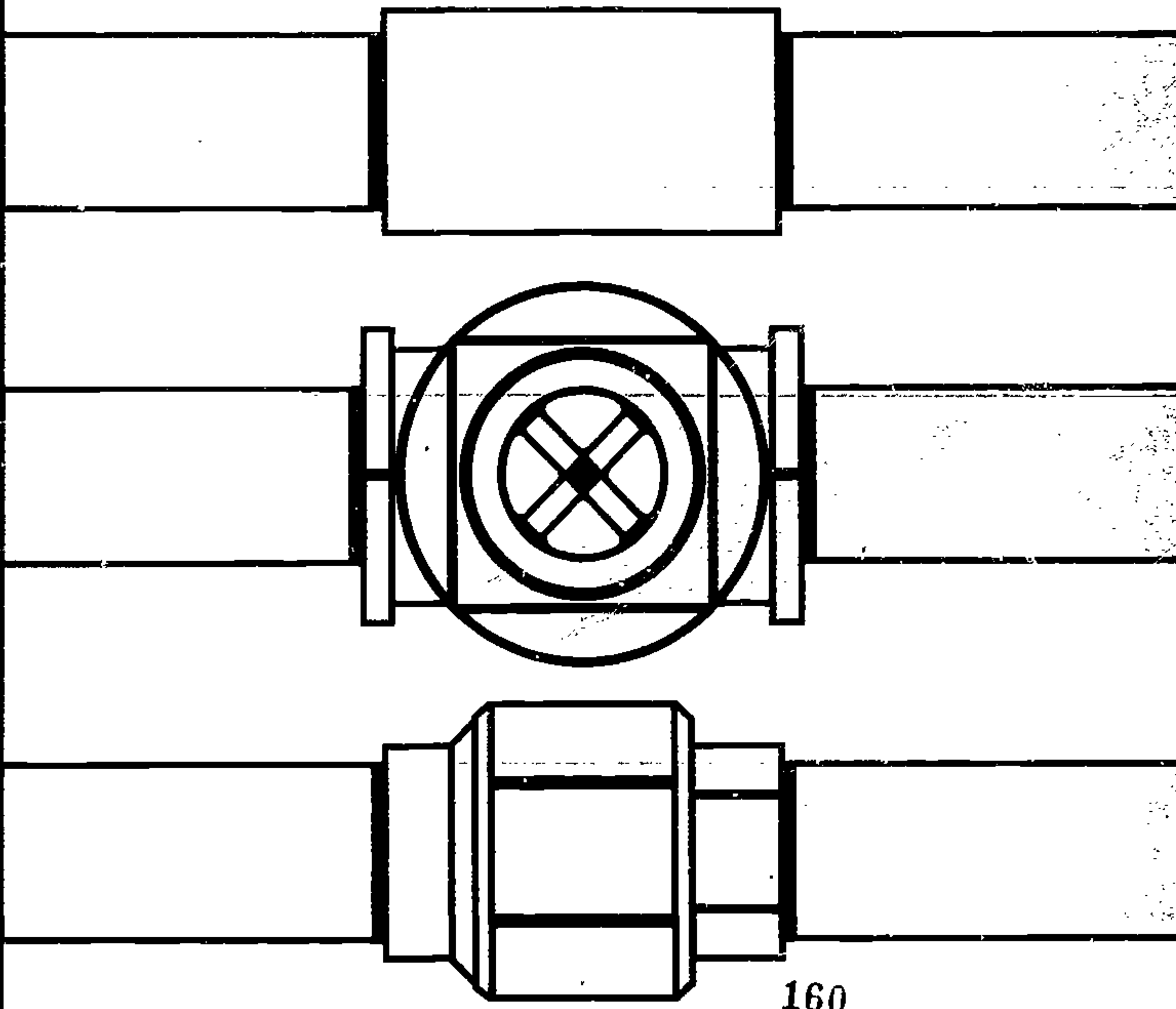
a) Joints on a plastic sewer pipe are made watertight with a solvent cement compound.

b) The solvent cement and thinners should be of the types recommended by the manufacturer of the pipe and fittings.

c) The labels on the containers of solvent cement compound and thinners should specify the manufacturer's name, the type of material they can be used on, the recommended procedure for their use, and the safety precautions to be observed.

d) A plastic sewer pipe is cut and the joints made in the same manner as that for other plastic pipes utilizing solvent cement compound joints.

The Victaulic Grooved Piping Method 13



PART 13

THE VICTAULIC GROOVED PIPING METHOD

1. General Information

a) Victaulic grooved piping is a method of joining pipe for a wide variety of piping services. It offers the advantages of easy handling and assembly. The Victaulic method provides expansion, flexibility, and vibration reduction with a union at each joint. It can be applied to black or galvanized steel, stainless, aluminum, wrought iron, plastic — almost any pipe of NPS dimensions (See Figure 13-1.)

b) Based on a groove machined into the pipe end, the system is joined by ductile or malleable-iron housings that engage into the grooves enclosing a synthetic rubber gasket to create the seal.

c) The housing segments are precisely cast of ductile or malleable iron. The housing key engages into the pipe grooves around the entire circumference, joining the pipes in a positive connection.

d) The gasket is designed to seal under pressure or vacuum. Moulded of various synthetic elastomers, the gasket is designed to provide long life for the intended service.

e) The oval-neck steel track bolts seat into the bolt recesses, permitting assembly with a single wrench.

f) The groove permits joining of the pipes without clamping. This provides the controlled flexibility and permits rapid assembly. Pipe is available from mills or distributors already grooved for Victaulic couplings. A complete line of portable tools adds versatility for easy on-site grooving.

g) Victaulic pipe groovers are covered in Part 1 and should be used according to the manufacturer's instructions.

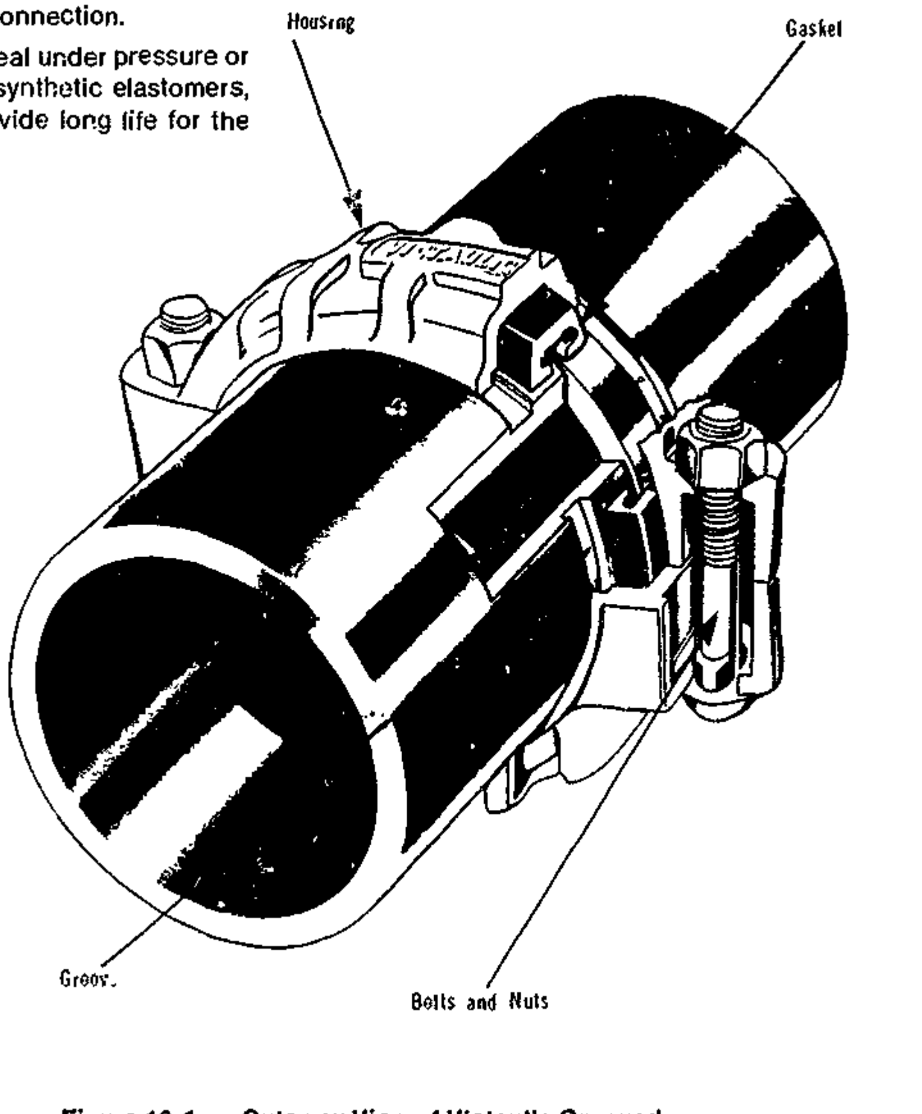
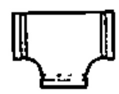
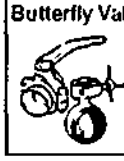


Figure 13-1. Cutaway View of Victaulic Grooved Piping Method

2. Product Selection

As shown in Table 13-1, Victaulic couplings, fittings, and valves are identified by a style number, and in some cases by a special product trade name as indicated by an asterisk. Various styles are designed for steel-pipe dimensions, others for AWWA cast-pipe sizes, still others for special pipe sizes. For complete product data, refer to the Victaulic general catalogue or the Victaulic piping-design manual.

Table 13-1. Identification of Victaulic Couplings, Fittings, and Valves

STYLE NUMBER	NPS RANGE	DIMENS. CHARAC.	STYLE NUMBER	NPS RANGE	DIMENS. CHARAC.	STYLE NUMBER	NPS RANGE	DIMENS. CHARAC.	STYLE NUMBER	NPS RANGE	DIMENS. CHARAC.
Style 77 Style 71 	¾-24	NPS	Style 72 Outlet 	2x¾ to 6x2	NPS	Style 31 Standard Cast 	4-24	AWWA CAST	Style HP-70 ES Endseal* 	2-12	NPS (lined)
Style 75 	2-8	NPS	Style HP-70 Rigid 	2-12	NPS	Style 341 Style 342 Vic-Flange* 	4-24	AWWA cast	Style 77-A Aluminum 	2-12	NPS aluminum
Style 78 Snap Joint* 	1-8	NPS	Style 920/921 Mechanical T* 	2x¾ to 8x4	NPS	Fittings Cast Iron 	3-24	AWWA cast	Style 78-A 	10	NPS aluminum
Style 750 Reducing 	2x1½ to 8x6	NPS	Fittings Standard 	¾-24	NPS	Style 22 Vic-Ring* 	17-60	Vic-Ring*	Style 77-S Stainless 	2-12	NPS stainless
Style 741 Vic-Flange* 	2-12	NPS	Style 742 Vic-Flange* 	14-24	NPS	Style 41 Vic-Ring* 	30-66	Vic-Ring*	Fittings Aluminum Stainless 	2-12	NPS
Butterfly Valves 	1½-12	NPS	Check Valves Series 710 	2½-10	NPS	Style 44 Vic-Ring* 	4-60	Vic-Ring*	Style 775 Plastic 	2-12	NPS plastic

* Victaulic tradename

3. Preparation of the Pipe

a) The pipe may be grooved by cutting material out of the pipe wall, either with a square or radiused bottom corner, or by cold-rolling the groove into the pipe wall.

b) The selection of the general pipe-grooving method is shown in Table 13-2.

Table 13-2. Selection of Grooving Method

TYPE OF PIPE	STANDARD SQUARE-CUT GROOVE	STANDARD ROLL GROOVE	STANDARD RADIUS-CUT GROOVE
Standard Steel	X		
Lightwall Steel		X	
Heavywall Steel	X		
Stainless Steel	X	X	
Aluminum	X	X	
Cast/ Ductile			X
Plastic PVC Sched. 80			X
Plastic PVC Sched. 40		X	
Lined	X	X	

c) Grooving dimensions are very important. The groove provides for coupling engagement to lock the joint, yet there also must be enough wall thickness under the groove for pressure service. This is easily done by ensuring that all grooves are in accordance with dimension standards published in Victaulic catalogues and grooving-tool instruction brochures (see Figure 13-2).

Dimension A. or distance from pipe end to groove, provides the gasket seating area. This distance also controls the allowable amount of pipe movement and end gap.

Dimension B, or groove width, controls expansion and angular deflection by the distance it is located from the pipe end and its width in relation to the housing "key" width.

Dimension C is the proper diameter at the base of the groove. This must be within diameter tolerance and concentric with the OD for proper fit of the coupling.

Dimension D is the nominal depth of the groove and is only a reference dimension. This dimension is affected by variations in the OD of the pipe. This dimension must be altered if necessary to keep dimension C within the stated tolerance. The groove must conform to the C dimension.

Dimension T, minimum wall, is the lightest grade or thickness of pipe suitable for cut grooving, or for roll grooving. Pipe of less than minimum wall for cut grooving may be roll-grooved or adapted for Victaulic couplings with applied Vic-Rings. Vic-Rings can also be used on pipe of less than minimum wall, on pipe too large to groove, or for abrasive services. Contact the company for details.

Dimension R is the radius necessary at the bottom of the groove to eliminate a point of stress concentration for cast pipe (grey and ductile) and PVC plastic pipe.

d) Standard Steel Pipe

The pipe ends must be square cut. The nominal outside diameter of pipe to be grooved must not vary more than: NPS ¾ through NPS 2½—plus 1 per cent or minus 1 per cent; NPS 3 through NPS 5—plus 1 per cent or minus 0.8 mm; NPS 6 and up—plus 1.6 mm or minus 0.8 mm.

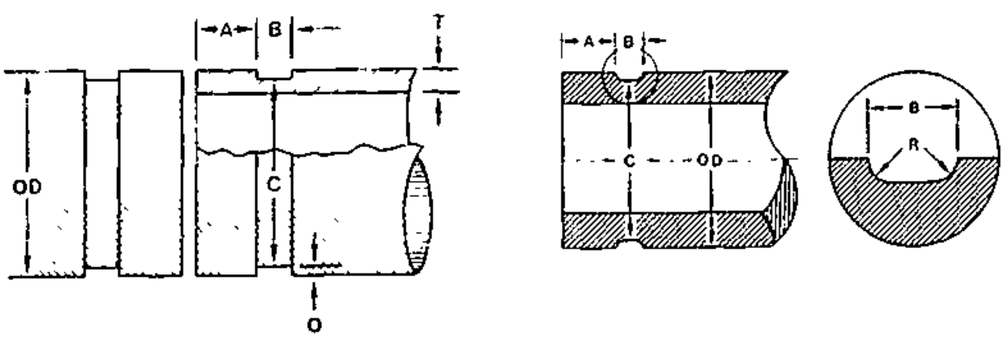


Figure 13-2. Dimension Standards

Any internal or external weld bead or seams in the groove area must be ground smooth and flush. The internal end of the pipe must be cleaned of coarse scale, dirt, or other material that might interfere with or damage the internal roll of the grooving tool.

e) Cast Pipe (Grey and Ductile)
The outside surface of the pipe between the groove and the pipe end must be smooth and free from deep pits or swells to provide a leak-tight seat for the Victaulic gasket. All rust, loose scale, oil, grease, and dirt must be removed. Peened surfaces may require corrective action to provide a leak-tight gasket seal.

4. Installation and Assembly of the Victaulic Joint

a) Maximum service life is dependent upon proper gasket selection and installation. Be sure to check the grade and style of the supplied gasket to make certain it is suited to the intended service.

b) Table 13-3 provides general service recommendations for standard Victaulic gaskets. Gaskets are color-coded for easy identification. For more detailed information, consult the Victaulic Gasket Selection Guide or contact the company.

Table 13-3. General Service Recommendations

Grade	Temp. Range	Compound	Color Code	General Service Recommendations
E*	-34°C to 110°C	EPDM	Green Stripe	Recommended for hot water service within the specified temperature range plus a variety of dilute acids, air without hydrocarbons, and many chemical services. *Not recommended for hydrocarbon services.*
T	-29°C to 82°C	Buna-N	Orange Stripe	Recommended for petroleum products, air with oil vapors, vegetable and mineral oils within the spec ' ed temperature range — except hot dry air over +60°C and water over +66°C. *Not recommended for hot water services.*

*Grade H chlorinated butyl (white code) may be supplied and is interchangeable for most grade E services, except hot water above 93°C. Hot water applications must be noted on all orders.

c) Refer to the latest Victaulic Gasket Selection Guide for specific recommendations and other available gaskets.

d) Always use ample lubrication for proper coupling assembly.

e) Thorough lubrication of the gasket exterior, including the lips and pipe ends and housing interiors, is essential to prevent pinching of the gasket. Lubrication assists proper gasket seating and alignment while easing installation.

f) Use Victaulic lubricant for installation. Other compatible materials such as silicone may be used, but petroleum-based lubricants must not be used on grades E and H gaskets.

g) Assembly of couplings — styles 22, 31, 41, 44, 71, 75, 77 — is shown step-by-step in Figures 13-3 to 13-8.

Step 1 The pipe must be free from indentations, projections, or roll marks on the exterior from the end to the groove (Figure 13-3) to ensure a leak-tight seat for the gasket.

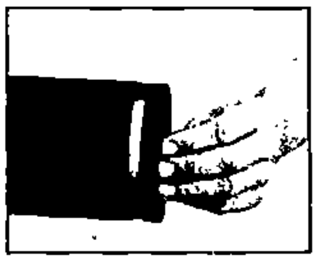


Figure 13-3. Checking Pipe Ends

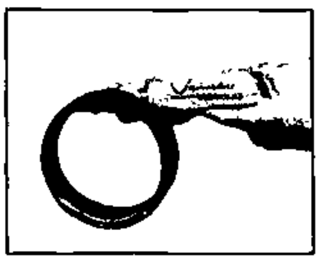


Figure 13-4. Checking Gasket and Lubricating

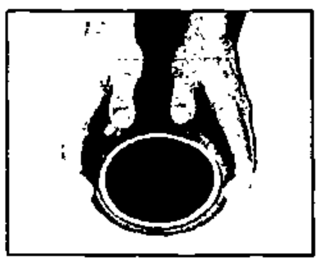


Figure 13-5. Installing Gasket

Figure 13-6. Aligning Pipe Ends

Figure 13-7. Placing Housings Over the Gasket

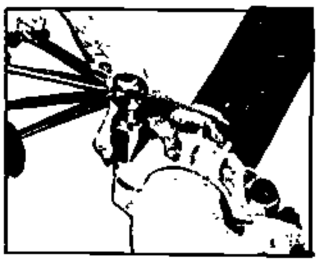


Figure 13-8. Tightening Nuts

Step 2: Check the supplied gasket to be certain it is suited to the intended service. The color code identifies the gasket grade. Apply a thin coat of Victaulic lubricant, or silicone lubricant, to the lips and the outside of the gasket (Figure 13-4).

Step 3: Place the gasket over the pipe end, being sure the gasket lip does not overh--- the end (Figure 13-5).

Step 4: Align and bring the two pipe ends together and slide the gasket into position centred between the grooves on each pipe. No portion of the gasket should extend into the groove on either pipe (Figure 13-6).

Step 5: Place housings over the gasket, making sure the housing keys engage into the grooves. Insert the bolts and apply the nuts finger-tight (Figure 13-7).

Step 6: Tighte ... lternately and equally until the housing ... are firmly together — metal to metal (Fi... . Excessive nut-tightening is not nece... y. C... ION: Uneven tightening may cause the gasket to pinch.

h) Assembly of style HP-70 Rigid coupling and style HP-70ES coupling is shown in Figures 13-9 to 13-14.

Step 1: The pipe must be free from indentations, projections, or roll marks on the exterior from the end to the groove to ensure a leak-tight seat for the gasket (Figure 1...).

Step 2: Check the gasket supplied to be certain it is suited for the intended service. The color code identifies the gasket grade. Apply a thin coat of Victaulic lubricant, or silicone lubricant, to the gasket lips and outside of the gasket (Figure 13-10).

Step 3: Place the gasket over the pipe end (Figure 13-11), being sure the gasket lip does not overhang the pipe end. (For "ES" gasket see sub-section "i").

Step 4: Align and bring the two pipe ends together and slide the gasket into position centred between the grooves on each pipe (Figure 13-12). No portion of the gasket should extend into the groove on either pipe.

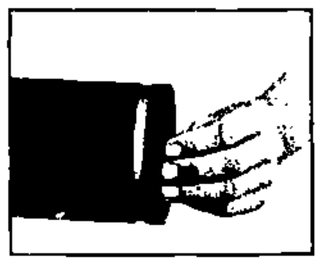


Figure 13-9. Checking Pipe Ends

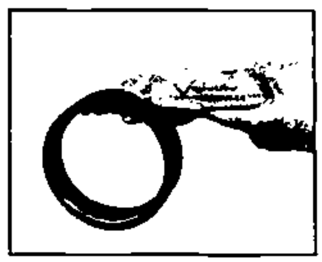


Figure 13-10. Checking Gasket and Lubricating

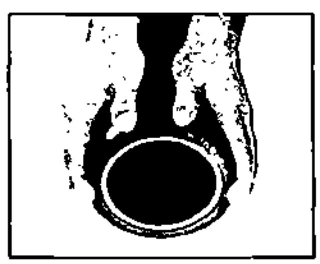


Figure 13-11. Installing Gasket

Figure 13-12. **Aligning Pipe Ends**

Step 5: Place housings over gasket, being sure the housing keys engage into the grooves. Insert bolts and apply the nuts finger-tight. Tighten nuts alternately and equally until fully tight (Figure 13-13). **Caution:** Uneven tightening may cause the gasket to pinch.

Step 6: Note: HP-70 and HP-70ES housings have a tongue and recess feature and must be properly mated, tongue to recess (Figure 13-14). Failure to properly mate the tongue and recess can cause joint failure.

i) HP-70ES with ES gasket:

The HP-70ES gasket is moulded with a central leg that fits between the pipe ends for plastic or cement lining protection (Figure 13-15). Check to be certain the proper gasket has been supplied.

Note. For proper application of Endseal gaskets and HP-70ES couplings, the pipe must be prepared to Victaulic "ES" groove specifications.

With Endseal gaskets, slide the gasket over one pipe end only up to the central gasket leg.

Slide the adjoining pipe end into the gasket until the pipe end touches the central gasket leg.

Note: HP-70ES bolts must be torqued to 80 N.m to 110 N.m.

j) To achieve maximum expansion-contraction allowance, the joints must be installed with the proper pipe-end spacing. This can be done in several ways, the most popular being as follows:

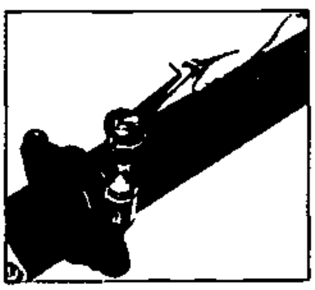


Figure 13-13. **Applying Housing and Tightening Nuts**

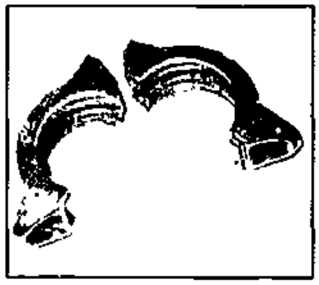


Figure 13-14. **Tongue and Recess Housing**

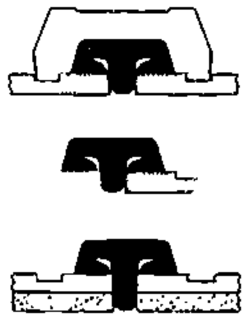


Figure 13-15. **Endseal (ES) Gasket**

For Maximum Expansion:

Method 1: Vertical systems can be assembled as the pipe is lowered, coupling the joints into position using the weight of the pipe to pull the pipe ends open. Use a gap gauge of the appropriate size to check end gaps (see the following section entitled Groove/Coupling Gapping).

Method 2: Anchor the system at one end, then install the joints and proper guides. Cap the system, pressurize it to fully open the pipe ends, then anchor the other end with the joints fully opened.

Method 3. Install the joints using a "come-along" to pull the pipe for full end separation, then secure the pipe to maintain the opening (Figure 13-16).
13-16.

For Maximum Contraction:

Method 1: In vertical systems, stack the pipe using the weight of the pipe to butt the pipe ends, then anchor the pipe to retain the butted position.

Method 2: In horizontal systems, install the joints with the pipe ends butted by using a "come-along" to draw the pipe ends together, if necessary; then secure the pipe in position (Figure 13-17).

For Expansion and Contraction:

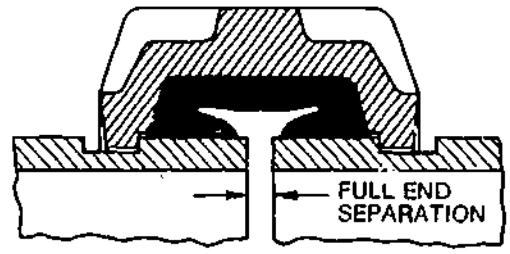
Alternate the above procedures in proportion to the need for expansion or contraction.

Groove/Coupling Gapping:

The pipe-end separation and related maximum allowable pipe-end movement bear a relationship with the visible gaps on either side of the coupling housing between the housing and rear edge of the groove. These visible gaps can be used as a check for ensuring proper installation of most couplings for maximum movement (Figure 13-18).

Where pipe expansion is required, the pipe ends are assembled in the full-open gap position (G), which leaves one-half the gap allowance (G/2) visible at each side of the coupling. For pipe contraction, no gap should be visible at the outside of the coupling.

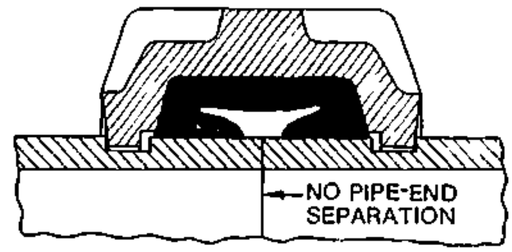
FOR MAXIMUM EXPANSION



JOINTS MUST BE ASSEMBLED WITH FULL PIPE-END SEPARATION

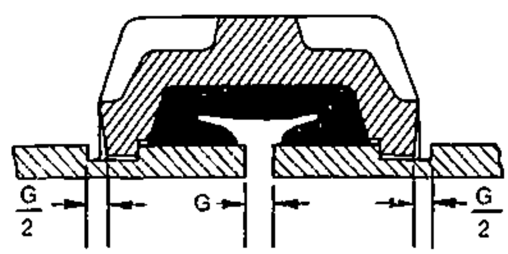
Figure 13-16. **Pipe-End Spacing for Maximum Expansion**

FOR MAXIMUM CONTRACTION



JOINTS MUST BE ASSEMBLED WITH PIPE – ENDS BUTTED

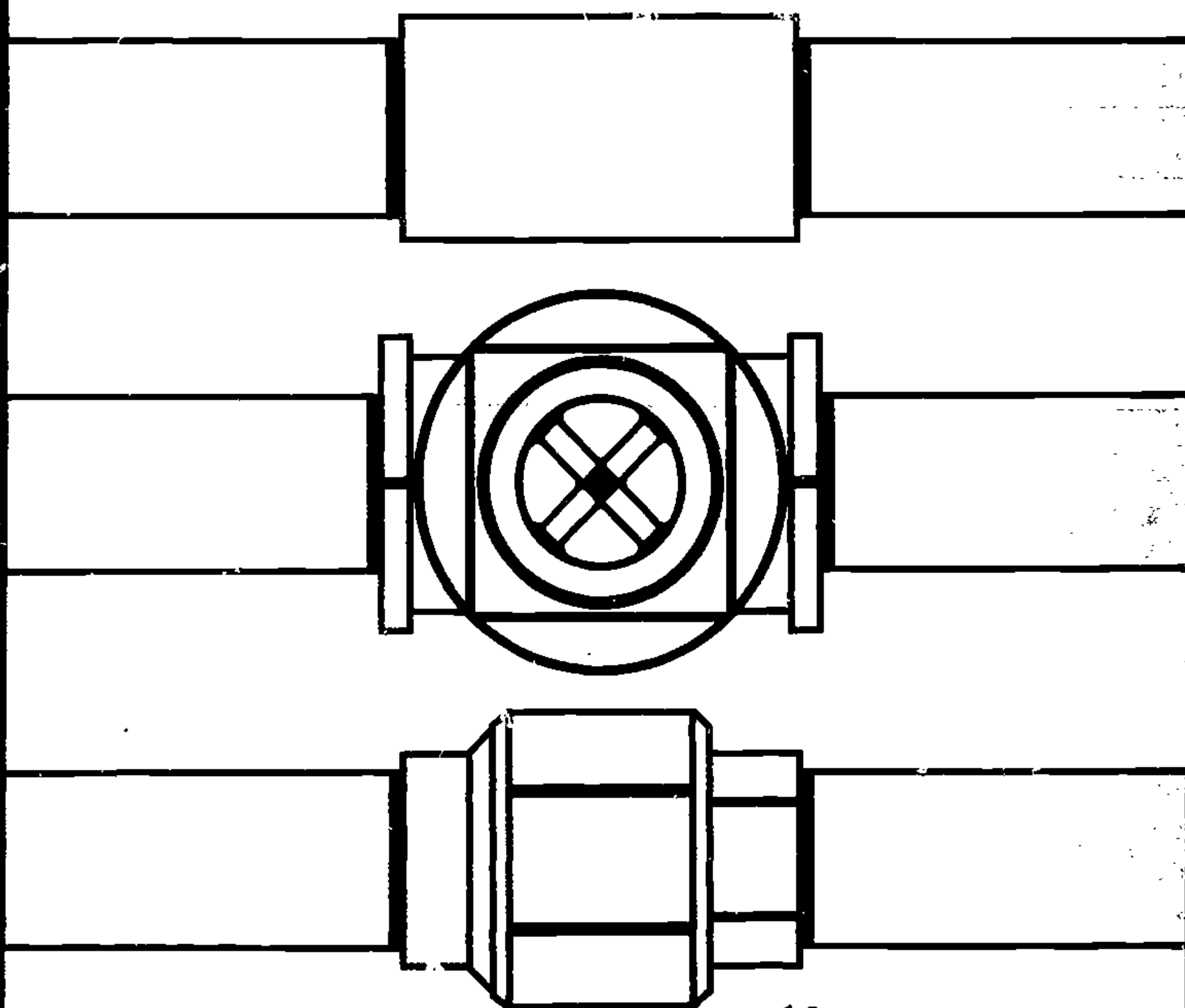
Figure 13-17. **Pipe-End Spacing for Maximum Contraction**



$\frac{G}{2}$, $\frac{G}{2}$ Maximum Allowable Pipe-End Movement

Figure 13-18. **Groove/Coupling Gapping**

Ductile Iron Pipe Fittings, and Joints 14



DUCTILE IRON PIPE, FITTINGS, AND JOINTS

1. Ductile Iron Pipe

a) Ductile iron pipe, first introduced and manufactured in Canada in 1961, is made of cast iron with the addition of a magnesium alloy. It is noted for these four major characteristics:

Ductility: The ability to stretch or deform when stressed beyond its yield point.

Strength: Superior tensile strength to withstand severe external loads and high internal pressures.

Toughness: Excellent resistance to shock or impact from improper handling, water hammer, and unstable soil conditions.

Corrosion Resistance: Equal or superior to grey cast iron.

b) Ductile iron pipe is made in NPS 4, 6, 8, 10, 12, 14, 16, 18, 20, and 24.

c) It is made in six different classes, namely 50 to 56. The higher the class the greater the pipe weight per linear metre.

d) In Canada it is supplied in 5.5 m lengths.

e) It once was available with mechanical joints but this line has been discontinued.

f) The pipe and fittings mostly in use are assembled with a compression joint, which the pipe manufacturer calls Tyton Joint, as illustrated in Figure 14-1.

2. Fittings

a) Cast iron fittings available for use with ductile iron pipe:

Various types of bends from 11¼° to 90°

Tees and crosses.

Ys.

Reducers and plugs, etc.

NOTE: Consult the manufacturers' catalogues for further information on pipe and fittings.

3. Compression Joints

a) The recommended procedure for making a compression joint (Tyton Joint) between ductile pipe and fittings is as follows:

Make sure the spigot end of the pipe and the inside of the fitting or pipe hub are clean and free from foreign matter that could cause a leak.

Insert the gasket with the gasket groove over the bead on the inside of the hub as illustrated in Figure 14-2.

Wipe a film of the lubricant recommended by the manufacturer over the inside of the gasket (Figure 14-3).

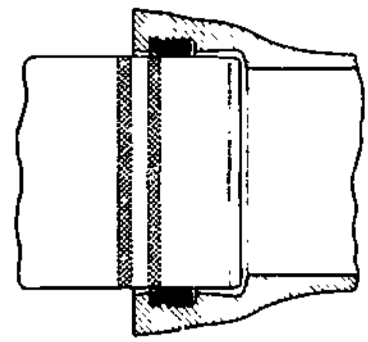


Figure 14-1. Cross-Sectional View of Tyton Joint

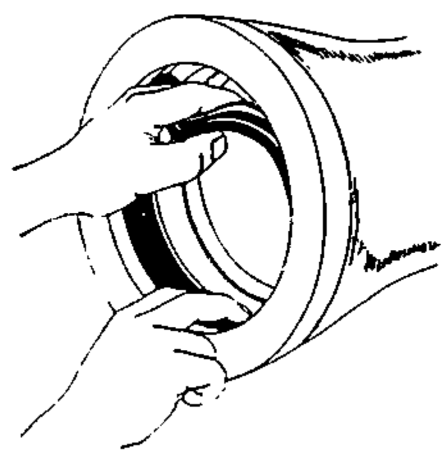


Figure 14-2. Installation of Gasket

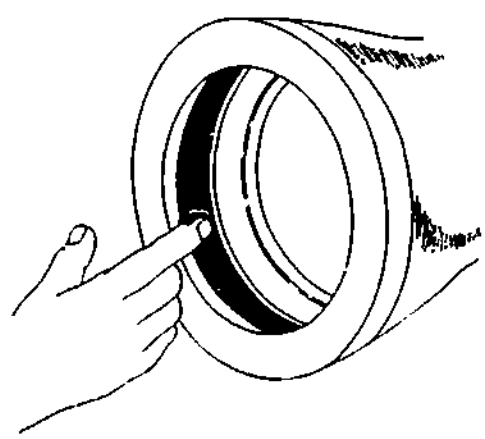


Figure 14-3. Application of Lubricant

Insert the spigot end of the pipe until it touches the gasket as shown here. Note the two painted stripes on the pipe end (Figure 14-4).

Push the entering pipe until the first painted stripe disappears and the second stripe is about flush with the face of the hub. (See Figure 14-1 in this part of the manual.) The joint is now ready for testing.

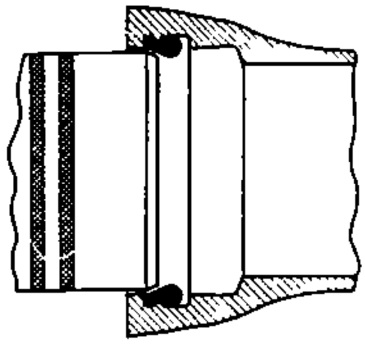


Figure 14-4. Joining the Pipes

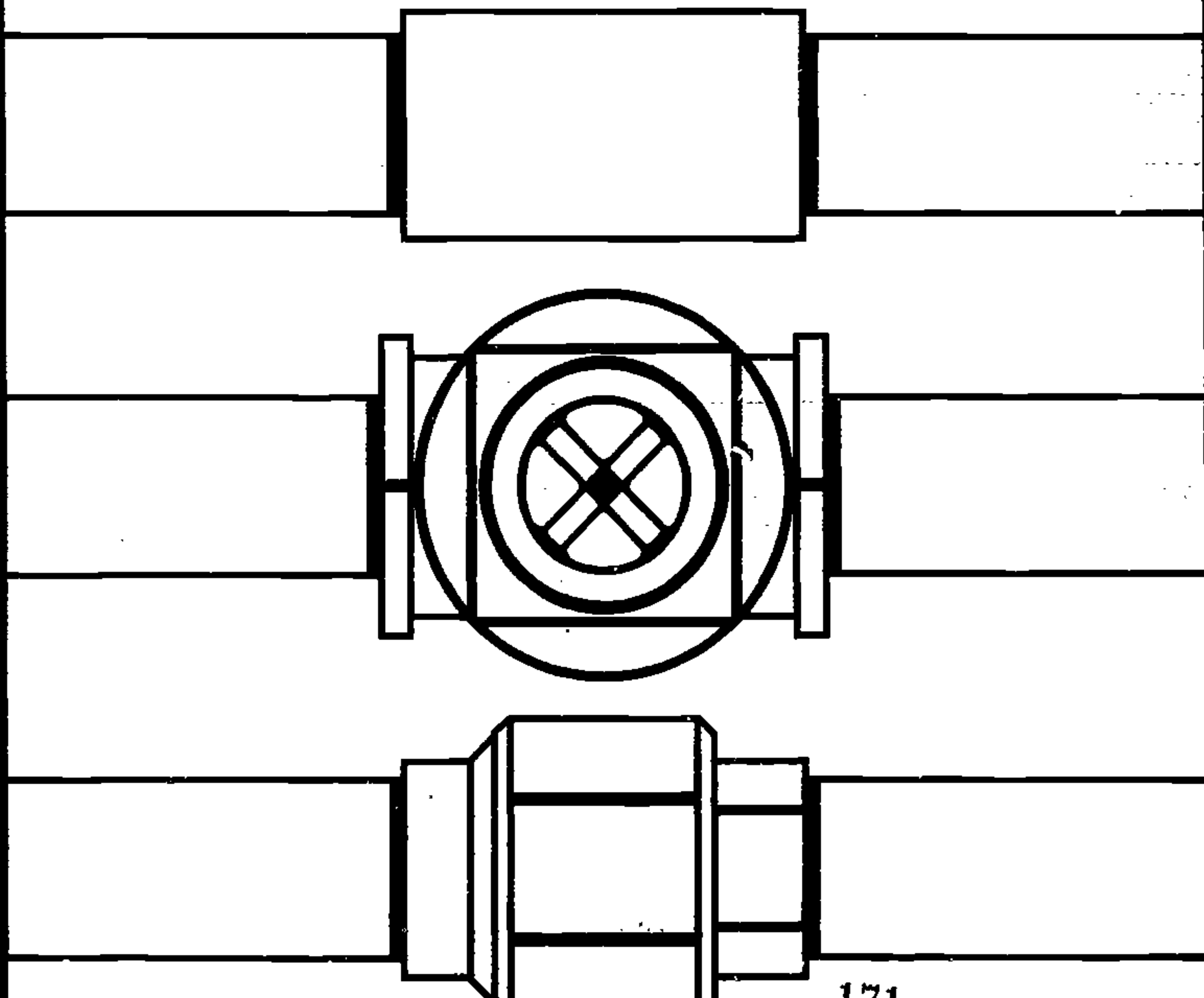
4. Cutting Pipe

Ductile iron pipe should be cut by abrasive wheel saws or milling wheel saws. The cut ends and rough edges should be ground smooth and the cut ends bevelled slightly.

5. Thrust Blocks

Thrust blocks at fittings should be located where the resultant force of the thrust is directed. Thrust blocks are generally made of good-quality concrete; however, hardwood and stone are occasionally used. *Consult your local inspection authority for details.*

Vitrified Clay Pipe, Fittings, and Joints 15



PART 15
VITRIFIED CLAY PIPE, FITTINGS, AND JOINTS

1. Vitrified Clay Pipe

a) "Vitrification" is defined as a method of changing clay into a glass-like substance.

b) Clay is a fine-grained earth that is found in several colors and is plastic when wet. It is used in the manufacture of vitrified clay pipe.

c) Vitrified clay sewer pipe is manufactured from several different types of clay, and sometimes from a combination of several types. It is moistened and moulded into the desired shape and then exposed to a high termperature.

d) Vitrified clay sewer pipe manufactured or sold in Canada must conform to the requirements specified in the plumbing code.

e) The applicable standard covers the manufacture of vitrified clay pipe in NPS 100, 125, 150, 200, 225, 250, 350, 375, 400, 450, 500, 525, 600, 675, 750, 825, and 900 mm, although not all of these sizes may be readily available.

f) The lengths of pipe available must be at least 900 mm but in many cases they are much longer.

g) Take care in handling vitrified clay pipe and fittings because, although the material is very hard, it is also very brittle and will shatter if dropped on a hard surface, knocked against another pipe or fitting, or struck with a metal tool.

h) The pipe may be of the bell-and-spigot type or the plain-end type. It may be glazed or unglazed.

i) Glazing may be done by the salt-glazed process or the ceramic-glazed process.

j) The manufacturer must legibly mark each length of pipe with the company's name and location of the plant for identification purposes.

k) Vitrified clay pipe is made in two strengths: standard strength and extra strength.

l) The pipe may be cut with a snap-type cutter or with a cold chisel and hammer, using very light blows.

m) Years ago the joint between the end of the pipe or fitting and the bell was made by packing it with a few strands of oakum and filling the balance of the joint with a cement mortar composed of equal parts of clean, sharp sand and portland cement.

n) There are now three basic types of flexible joints used, or permitted for use, in assembling vitrified clay pipe and fittings, as follows:

A factory-made coupling for plain-end pipe consisting of a butyl rubber or neoprene sleeve incorporating corrosion-resistant bands and tightening mechanisms for mechanically joining the ends of the pipe.

A joint for plain-end pipe consisting of a suitable resilient-type plastic material factory-applied to both ends of the pipe and a separate rigid external sleeve coupling for joining the pipe together. The pre-formed spigot components and the internal contour of the sleeve coupling must be designed to form a compressed mating surface when the pipes and couplings are telescopically assembled.

A factory-applied joint for bell and spigot pipe made from resilient-type plastic material attached to both the bell and spigot ends of the pipe. Different types of plastic material may be used in the bell and spigot ends, and the resilient material of one joint surface may be harder than that in the other one.

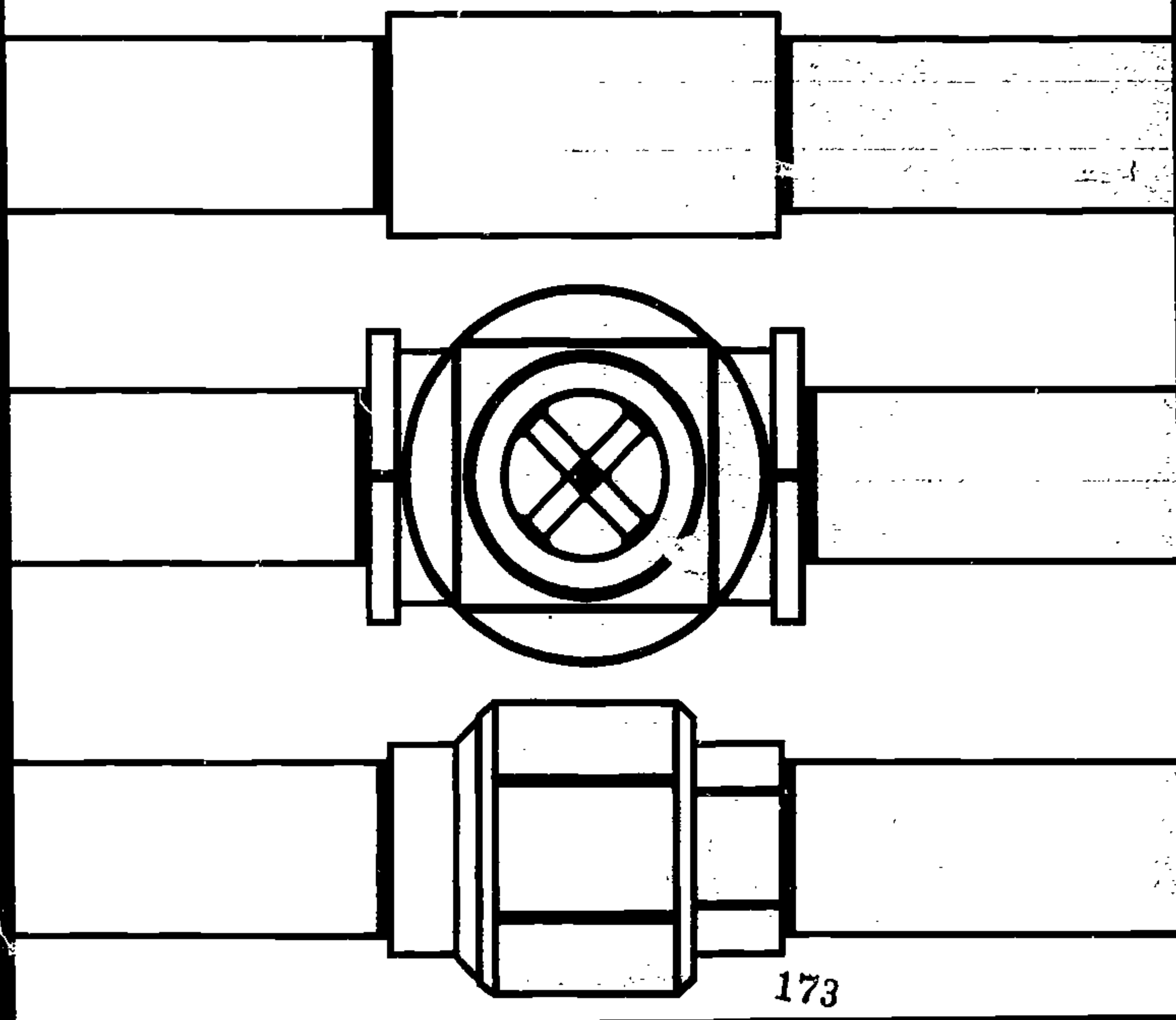
o) Care must be taken when installing vitrified clay pipe. The bed on which the pipe is laid should be free of rocks—preferably a few inches of sand backfilled with rock-free soil and tamped to a depth of 300 mm above the pipe.

2. Fittings

a) Bends of various degrees, sanitary tees, double sanitary tees, Ys, double Ys, increasers, and traps are available.

b) Channel or split pipe, bends, and branches are also available for use in such places as manholes.

PVC Pipe for Pressure Applications 16



PART 16
PVC PIPE FOR PRESSURE APPLICATIONS

1. PVC pressure pipe is made for such applications as water mains, water-service piping, and process piping.

2. The plumbing code governs where it may be used in a plumbing system.

3 It is classified by schedules and series numbers as follows:

PVC Schedule 40	PVC Series 125
PVC Schedule 80	PVC Series 160
PVC Series 80	PVC Series 200
PVC Series 100	

The series number on a PVC pressure pipe, which denotes the psi rating, when multiplied by seven equals the approximate working pressure in kilopascals for that particular pipe when used with cold water.

4. PVC pipe for pressure applications must conform to the standard specified in the appropriate plumbing code.

5. PVC pressure pipe is made in NPS ⅛, ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 3½, 4, 5, 6, 8, 10, 12. The availability of sizes depends mainly on the demand for them.

6. The pipe is available in 6.0 m length with plain ends unless otherwise specified by the purchaser.

7. Moulded Schedule 80 PVC fittings and adapters for solvent welding are generally available in all sizes up to NPS 8 and with flanges up to NPS 12.

8. Fabricated fittings can be obtained with Victaulic grooved ends.

9. Adapters are generally available to connect PVC pressure pipe to other types of pipe. Compression couplings, such as Dresser couplings, may also be used.

10. Depending on the application, telescoping-type PVC expansion joints and fabricated expansion loops are available.

11. PVC valves for up to and including NPS 4 pipe are generally available.

12. Joints are generally made with a solvent welding compound made for the specific purpose, and in the same manner as that described in this manual for ABS and PVC pipe.

13. Threaded PVC pipe is not recommended as a general rule. Where threaded joints are preferred, only Schedule 80 pipe should be used. Threading is done by standard metal-cutting threaders with clean, sharp dies. Hand threaders are preferred and thread-cutting lubricants are not required. Do not make the thread longer than standard because this will make it impossible to screw fittings on far enough to make a tight seal.

14. Do not mate male-threaded components to PVC sockets because this may cause joint failure owing to the different expansion factors of the materials.

15. Extra design and installation considerations should be given for systems that are to operate with a water temperature above 24°C or below freezing.

16. This type of pipe should be isolated from sources of severe vibration.

17. Following are some advantages of PVC pressure pipe:

It is strong and resists high pressures and mechanical abuse.

It is highly resistant to many chemicals and immune from attack by electrolytic corrosion.

Low head loss is maintained throughout its service life, there is no pitting of pipe walls, and it resists scaling and fouling of the bore.

It does not support fungi, algae, or bacterial growth.

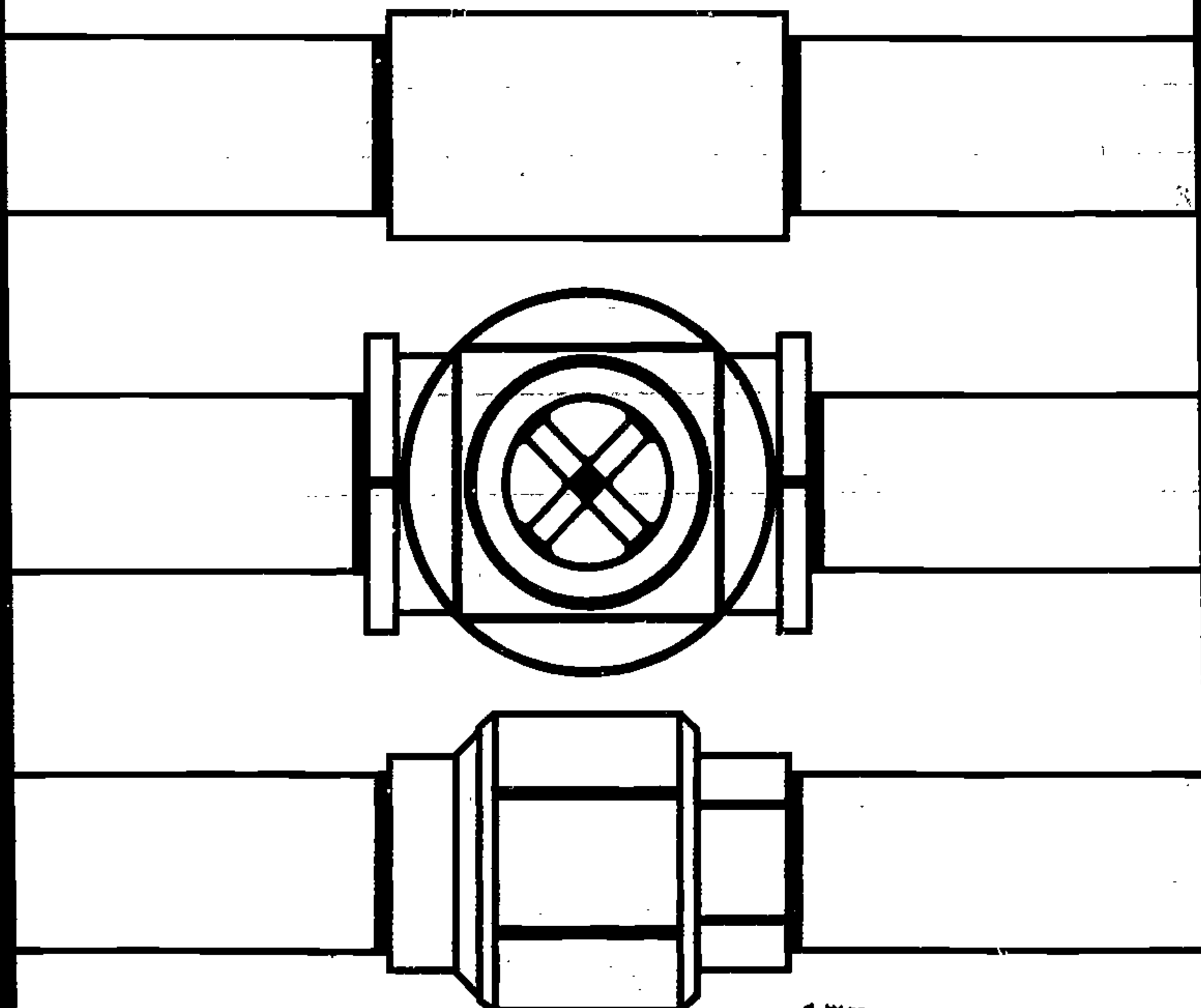
It allows high velocities and is highly resistant to abrasion.

Its flexibility reduces stresses caused by water-hammer factors and absorbs normal vibration and shock.

It has low thermal conductivity, which reduces the risk of sweating.

Pipe Hangers and Supports

17



PART 17

PIPE HANGERS AND SUPPORTS

1. Hangers and Supports

a) There are innumerable types and makes of pipe hangers, but only the more popular types are covered here.

b) The location of hangers is mainly governed by the plumbing code and the plumber's knowledge of the materials to be supported.

c) The pipe strap shown in Figure 17-1 is widely used by plumbers. It is generally available in galvanized steel and copper, cast malleable, and plastic. It is used on vertical and horizontal pipe installations, and is available in NPS ½ to NPS 4.

d) The adjustable clevis hanger shown in Figure 17-2 is also popular for plumbing installations. It comes in black, galvanized, and copper plated, the black being the one most used. The hanger load nut above the clevis must be tightened securely to ensure proper performance. When an over-size clevis is used, a nipple or short piece of pipe should be placed over the clevis bolt as a spacer to ensure that the lower U-strap will not move in on the bolt and create a sag in the pipeline. The adjustable clevis hanger comes in a wide range of pipe sizes from NPS ½ to NPS 30.

e) The steel ring with bolt shown in Figure 17-3 was a popular hanger years ago and is still available. It is recommended for use on pipelines where expansion and contraction are not considerations. Its finish is black, and it comes in pipe sizes from NPS ½ to NPS 12.

f) The solid-ring hanger is also popular. It may be either the long or the short type, as illustrated in Figure 17-4, and is available with a black or a galvanized finish, and with a pipe range from NPS ½ to NPS 2. It is recommended for the suspension of non-insulated stationary pipelines where no adjustment is necessary.

g) The adjustable swivel ring (Figure 17-5) has a solid ring as opposed to the split-ring type shown in Figure 17-6. It comes in pipe sizes from at least NPS ¾ to NPS 8. When properly installed, it supports loads of up to 4.4 kN depending on the ring size. An NPS ¾ hanger in some cases has a recommended maximum load of 1.8 kN.

h) The adjustable swivel with split ring (Figure 17-6) is similar to the solid-ring type except that it can be opened and placed around the pipe. This enables the hanger to be installed before installation of the pipe. The off-centre hinge permits seating of the pipe during installation.

Figure 17-1. Pipe Strap

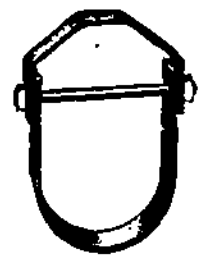


Figure 17-2. Adjustable Clevis Hanger

Figure 17-3. Steel Ring-and-Bolt Hanger

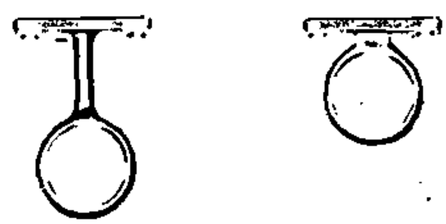


Figure 17-4. Long and Short Solid-Ring Hangers

Figure 17-5. Adjustable Solid-Ring Swivel Hanger

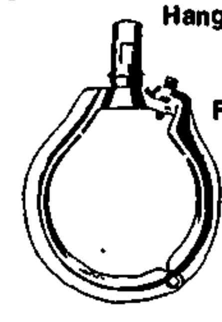


Figure 17-6. Adjustable Split-Ring Swivel Hanger

i) An extension bar, shown in Figure 17-7, is used with a ring and bolt-type hanger. It is often formed into a ring-type hanger by bending it around the pipe. It is available in copper, black, and galvanized steel. It is correctly referred to as hanger iron, strap iron, grabble iron, or perforated band iron. Depending on the width and thickness, it comes in straight lengths and coils.

j) Steel rods play a vital part in the installation of many types of wire pipe hangers. They vary in diameter from ¼" to ¾" with NC (National Coarse) thread, or from 6 mm to 20 mm with ISO thread. The threads are generally NC standard bolt threads. When ordering the rod illustrated in Figure 17-8 the dimensions of A, B, and T must be specified.

k) The U-hanger shown in Figure 17-9 comes in two designs.

l) The all-threaded rod (Figure 17-10) has a continuous thread and it may be cut to any length. When ordering it, dimensions A and B must be specified.

m) The coupling shown in Figure 17-11 may be used with threaded rods.

n) The welded-eye rod (Figure 17-12) is often used where the upper end of the rod is to be bolted to an object. (Eye rods on which the eye is bent but not welded are also available, but they do not have the strength of the welded-eye bolt.) When ordering them, dimensions A, C, D, and T must be specified.

o) Turnbuckle tie rods with one or more turnbuckles (Figure 17-13) are obtainable in at least ¼" to 2" diameter with NC thread, or 6 mm to 50 mm diameter with ISO thread. Any length of rod may be developed. One end of the rod has a right-hand thread, and the other a left-hand thread.

p) The welded linked-eye rod shown in Figure 17-14 is recommended for heavy-duty service where pivoted connections are required. When ordering this type of rod, the dimensions of A, C, D, L, and T must be specified.

q) The coach-screw and machine-thread rod shown in Figure 17-15 is available in many diameters and lengths. The machine thread is generally a National Coarse thread. This type of rod is generally used where the end of the coach-screw can be screwed into a wood member of a building and a hanger attached to the other end.

Figure 17-7. Extension Bar

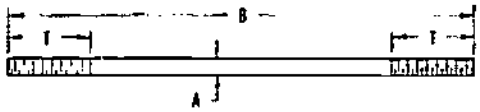


Figure 17-8. Steel Rod with Threaded Ends

Figure 17-9. U-Hanger

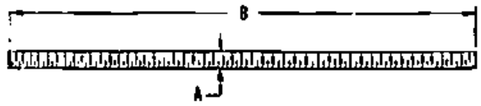


Figure 17-10. All-Threaded Rod

Figure 17-11. Rod Coupling

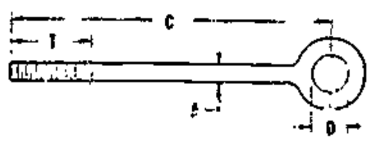


Figure 17-12. Welded-Eye Rod

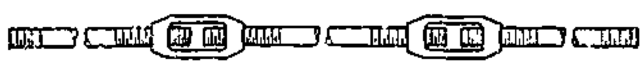


Figure 17-13. Turnbuckle Tie Rods

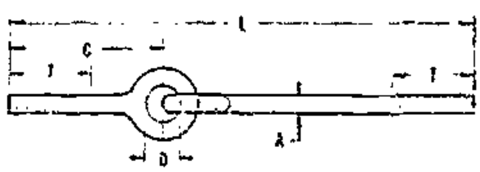


Figure 17-14. Welded Linked-Eye Rod

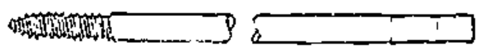


Figure 17-15. Coach-Screw and Machine-Threaded Rod

r) The pipe-hanger flange (Figure 17-16) is also popular for attaching a pipe hanger to the ceiling or elsewhere.

s) Four of the many different types of beam clamps for use with hanger rods are illustrated in Figure 17-17.

t) A riser clamp is essentially a vertical pipe hanger. The standard riser clamp (Figure 17-18) is suitable for use on vertical steel pipe or cast iron soil pipe and, when properly insulated, on copper tubing. The clamp grips the pipe and forms a solid support. It may be tack-welded to steel pipe if desired.

u) Space does not permit listing all the different hangers and supports, but several other types of hangers are shown in Figure 17-19.

Figure 17-16. Pipe-Hanger Flange

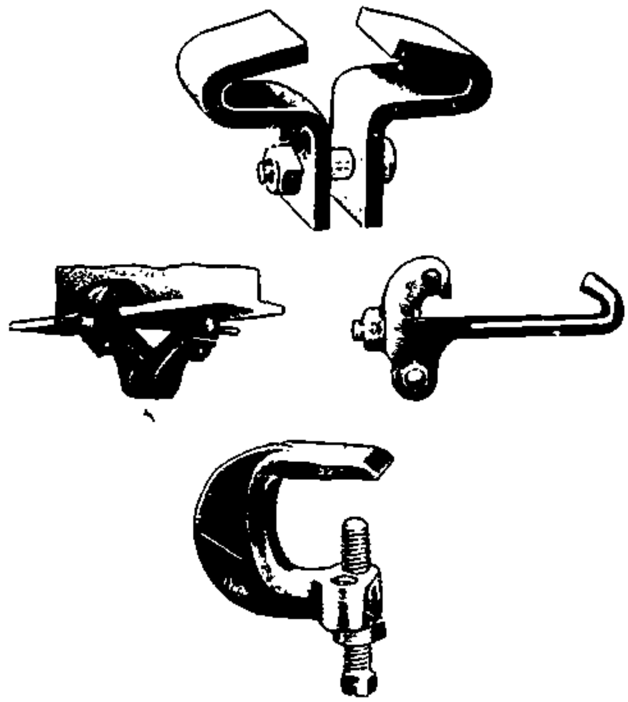
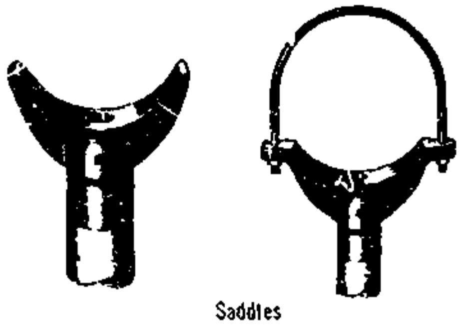


Figure 17-17. Various Styles of Beam Clamps

Figure 17-18. Standard Riser Clamp



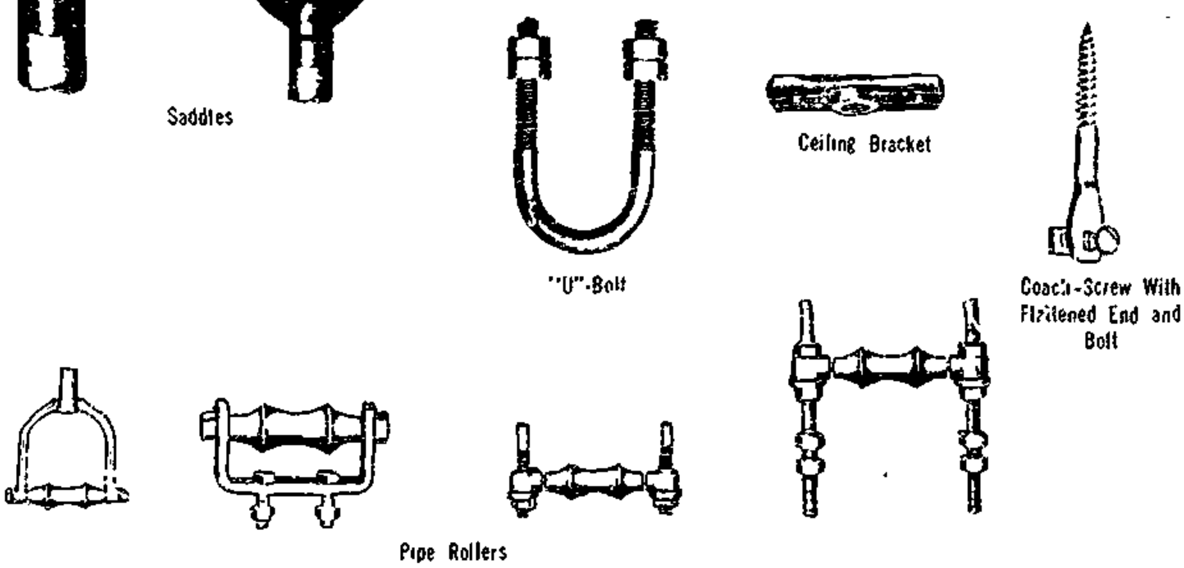


Figure 17-19. Other Types of Hangers and Supports

2. Nuts and Bolts (General Information)

a) No attempt is made to list all the nuts and bolts available, nor the many different materials from which they are made. Only those believed to be general use are covered in this section.

b) Nuts and bolts are a system of fastening objects into a set position by the leverage of the thread. They fasten pipes, fixtures, equipment, etc., into position and allow for their removal. The general materials of nuts and bolts used in the plumbing trade are black steel, galvanized steel, stainless steel, and brass. Both square-headed and hexagon-headed nuts and bolts are in general use.

c) National Coarse threads (NC) are the most commonly used for nuts and bolts where easy assembly is required and are in general use by plumbers.

d) Unified National Coarse threads and Unified National Fine threads (UNC and UNF) are interchangeable with NC and NF and will no doubt eventually replace them.

e) Threads are normally right-hand unless specified otherwise.

f) The fit between two mating parts is the relationship between them with respect to the degree of clearance or interference present when they are assembled.

g) "Class 1 fit" (loose) designates screw threads in which the threads must assemble easily, and where an allowance is required to permit ready assembly, even when the threads are slightly bruised or dirty

h) "Class 2 fit" designates a high-quality commercial screw-thread product and is recommended for the major portion of interchangeable screw-thread work, for finished and semi-finished nuts and bolts, and for machine screws, etc., where no allowance is required.

i) "Class 3 fit" is the same as "Class 2 fit" except that its tolerances are smaller. It is intended to apply to interchangeable screw-thread work requiring the smallest practical tolerances. Tapped holes with Class 3 tolerances are difficult and expensive to produce commercially.

j) All nuts and bolts for general-purpose use are a "Class 2 fit."

k) Nuts and bolts are available in the following finishes:

Unfinished: Not machined on any surface except the threads.

Semi-finished: Machined or otherwise formed or treated on the bearing surface to provide a washer face for bolt heads and nuts.

Finished: As in semi-finished, except that surfaces other than the bearing surface have been treated to provide a special appearance.

l) The length of a bolt is measured from under the head to the end, except with counter-sunk head bolts that are measured over-all.

m) Carriage bolts (Figure 17-20) have an NC thread and a square nut unless ordered otherwise.

n) The machine bolt (Figure 17-21) has a square head and a square nut. The thread is an NC thread. Machine bolts with hexagon heads and nuts are available.

o) A flat-head, slotted stove bolt with square nut is shown in Figure 17-22. It has an NC thread and may be made of steel or brass, etc. It is available in a variety of sizes and lengths.

p) A round-head, slotted stove bolt with square nut is shown in Figure 17-23. It also has an NC thread and may be made of steel, brass, etc. It is available in a variety of sizes and lengths.

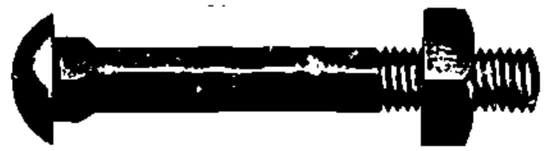


Figure 17-20. Standard Carriage Bolts

Figure 17-21. Machine Bolt

Figure 17-22. Flat-Head, Slotted Stove Bolt

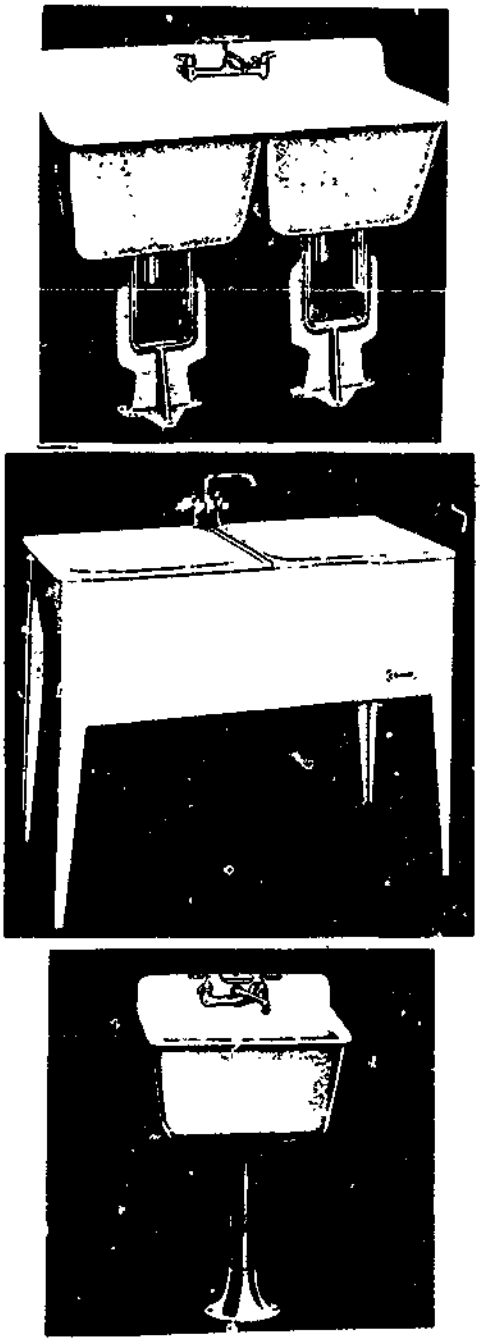
Figure 17-23. Round-Head, Slotted Stove Bolt

2. Laundry Tubs (Or Trays)

Laundry tubs are made of many different materials, including cast iron, steel, plastic, and concrete. Figure 22-14 shows some of the available types.

b) Various types of faucets are used on laundry tubs, a few of which are seen in the fixtures in Figure 22-14.

c) The laundry tub must be trapped and properly vented in accordance with the plumbing code. The P trap is generally a trap similar to those already described.



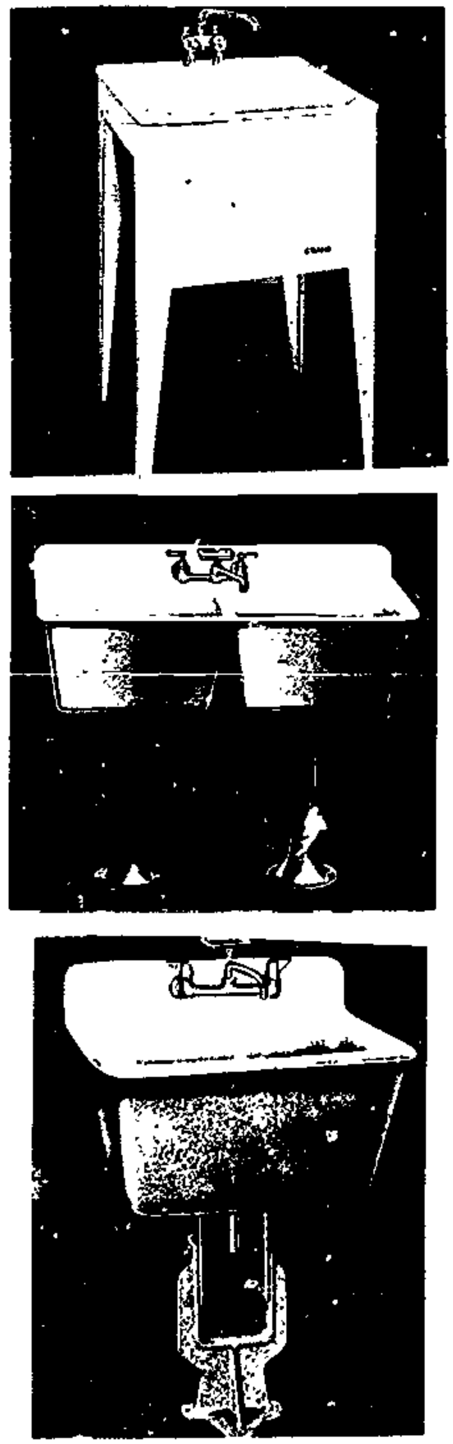


Figure 22-14. Various Types of Laundry Tubs

3. Service Sinks

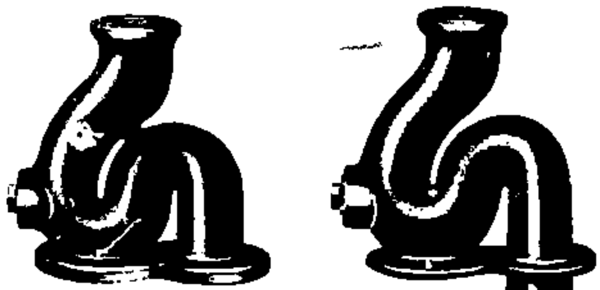
a) Most service sinks appear to be manufactured from cast iron.

b) Figure 22-15 shows two types of service sinks often seen in the cleaner's room. They may have a P trap standard (Figure 22-16), or an S trap standard (Figure 22-17).

c) Two different types of S trap standards are shown in Figure 22-17.

d) Figure 22-18 shows typical roughing-in measurements for a service sink with a trap standard, adapted from Crane Canada Ltd. literature. As stated in Part 21, this company's handbook stresses that unless otherwise specified in their sketches, all dimensions given may vary plus or minus ¼" or 7 mm, and are subject to revision. This cautionary note applies also to all other similar Crane roughing-in sketches in this manual.

Figure 22-16. "P" Trap Standard (IPT)



Use with Lead Stub and Flange or Similar Connection

Use with Cast Iron Caulk Joint

Figure 22-17. "S" Trap Standard

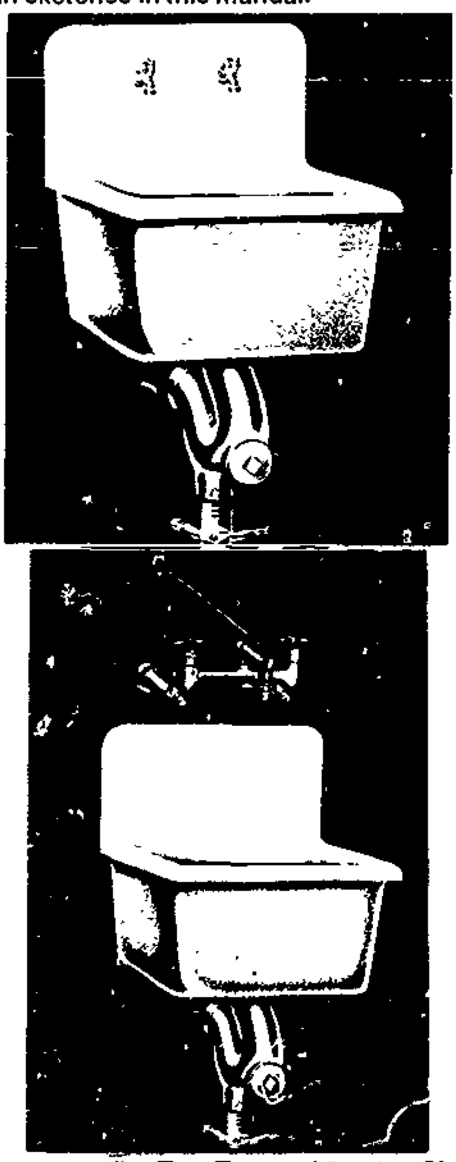


Figure 22-15. Two Types of Service Sinks

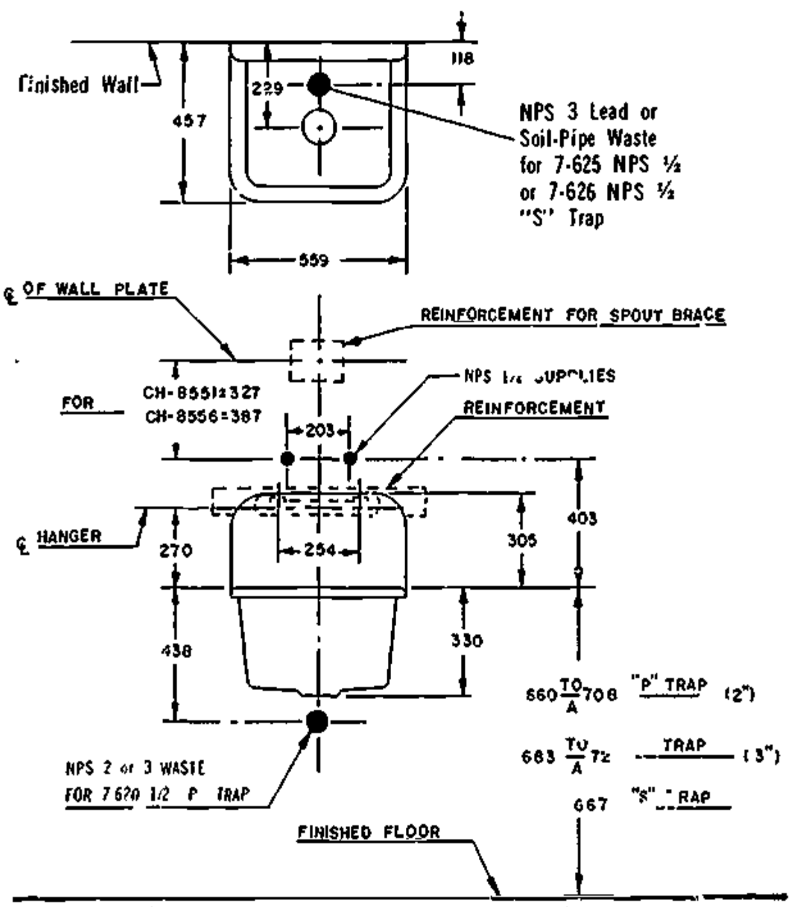
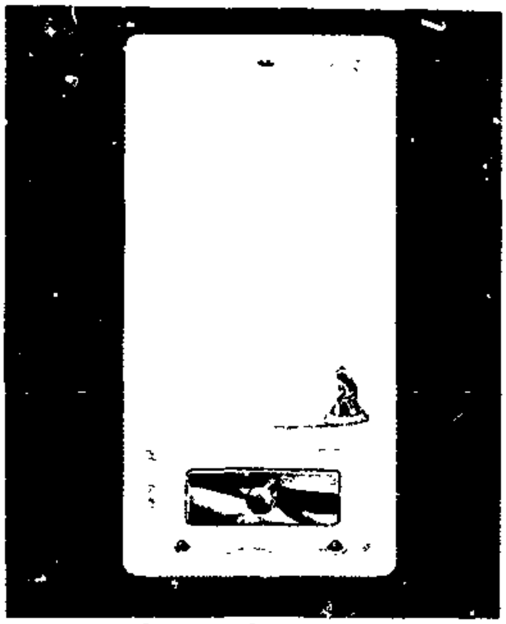


Figure 22-18. Service Sink Roughing-In Measurements

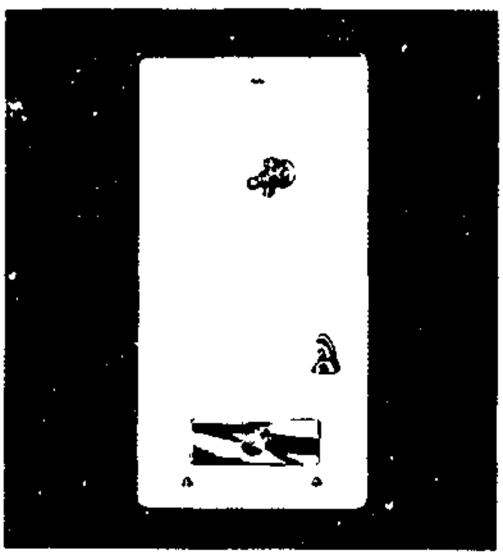
4. Drinking Fountains

a) Drinking fountains come in many different designs, and are generally made of vitreous china or fibreglass.

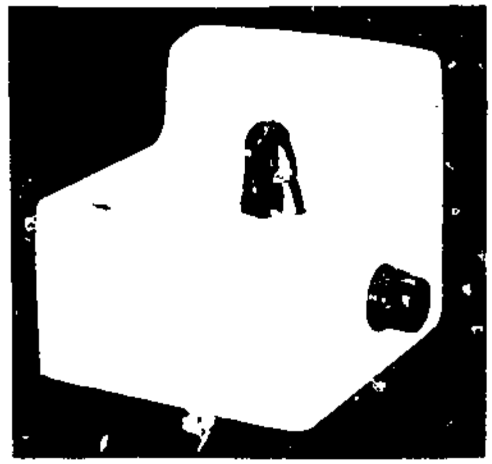
b) The drinking fountains illustrated in Figure 22-19 are made of vitreous china and are supported by a wall bracket or are installed in a recess in the wall.

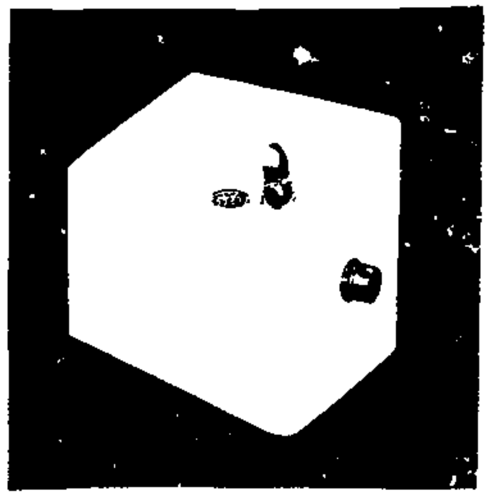


Coolstream Fully Recessed



Coolstream with Ice-Water Faucet





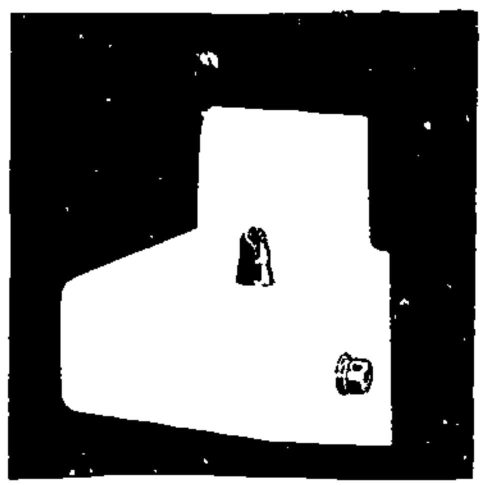


Figure 22-19. Various Vitreous-China Drinking Fountains

c) Figure 22-20 shows some types of fibreglass drinking fountain.

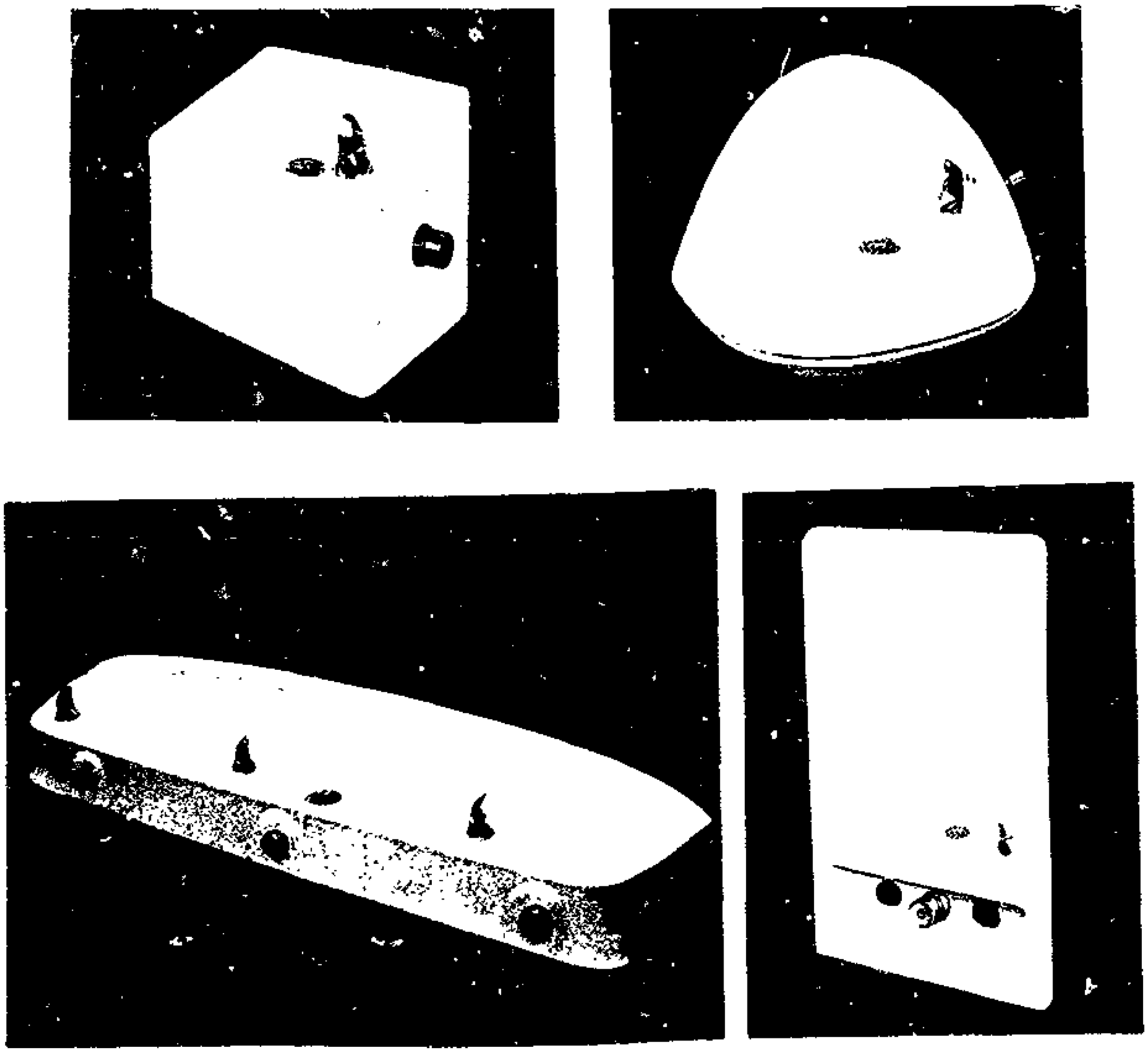
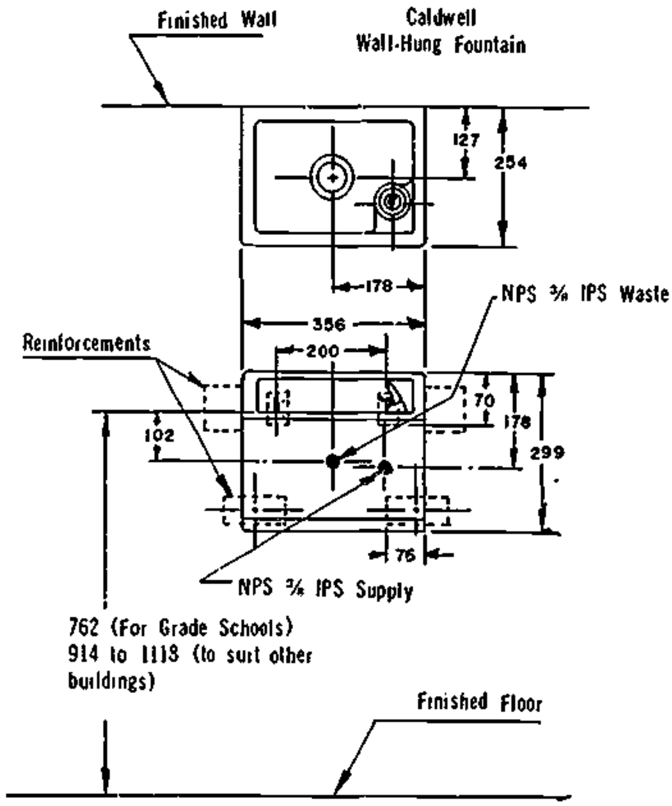
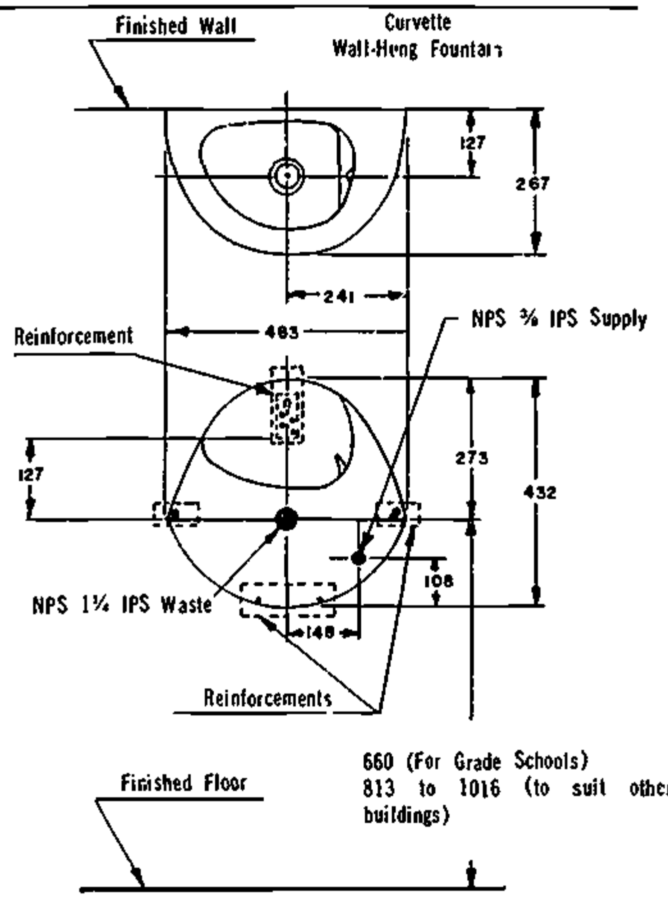


Figure 22-20. Various Fibreglass Drinking Fountains

d) Figure 22-21 shows examples of roughing-in measurements for drinking fountains.





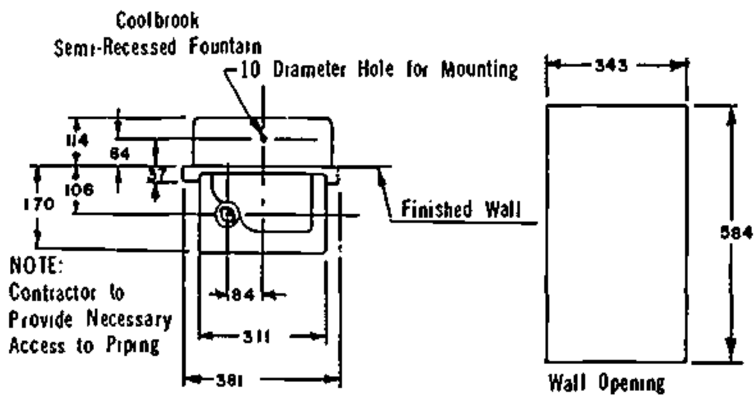
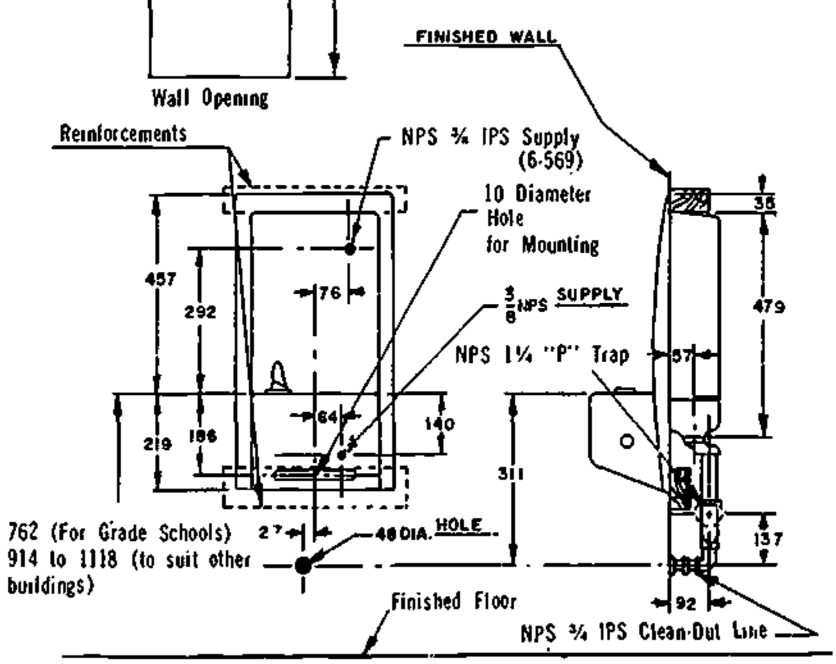


Figure 22-21. Fountain Roughing-In Measurements



e) Figure 22-22 shows four types of fountain bubblers.

f) Four of the many different types of fountain stops are shown in Figures 22-23 and 22-24

g) Automatic stream regulators, as shown in Figure 22-25, provide a uniform, balanced water supply despite fluctuation of water pressure in the supply line.

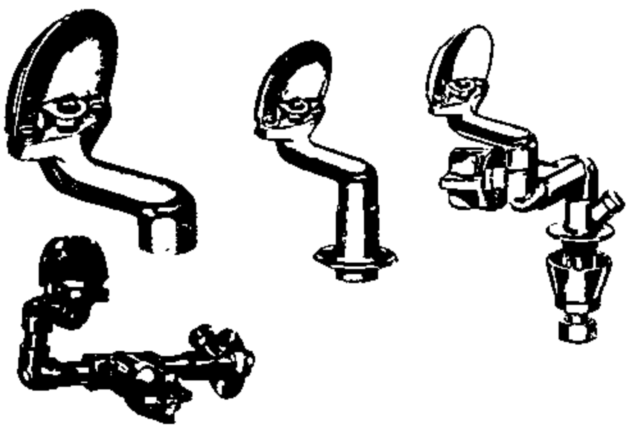


Figure 22-22. Four Types of Fountain Bubblers

Figure 22-23. Two Types of Self-Closing Stops

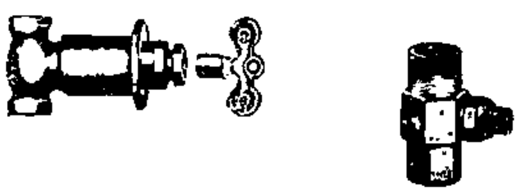


Figure 22-24. Loose-Key and Screwdriver-Slot Stops

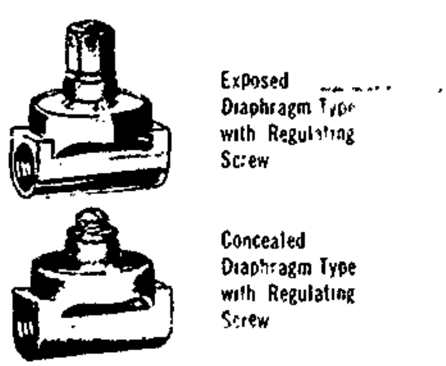


Figure 22-25. Two Types of Automatic Stream Regulators

5. **Shower Stalls**

a) Shower stalls are made of several different materials, including sheet metal and fibreglass

b) The fibreglass shower stall is becoming a leader in this field.

c) In some cases, shower stalls may be constructed of various on-site materials, but in others, plumbing codes specify the materials to be used for this purpose.

d) Shower heads and controls are often installed along a wall, with or without partitions between the heads and controls. In somes cases, one drain serves a number of shower heads. See the plumbing code for requirements.

e) Generally a shower stall comes complete with shower head, controls, and outlet spud and strainer, but this should always be confirmed.

f) The roughing-in measurements and the installation procedure vary according to the material and make. In all cases, the roughing-in details should be available before starting the work, and the manufacturer's installation recommendations should be followed.

g) Described in Figure 22-26 are roughing-in requirements for a shower valve and head for other than a stall shower.

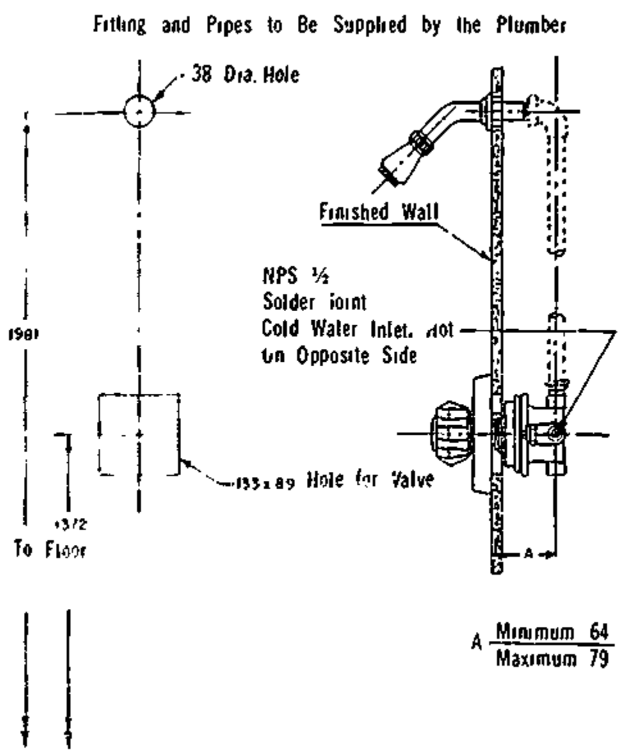


Figure 22-26. Pressure-Compensating Valve with Shower Fitting

6. **Urinals**

a) Urinals are generally made of vitreous china, but some plumbing codes permit them to be constructed on-site.

b) Working on a urinal waste pipe without rubber gloves can subject you to infectious disease.

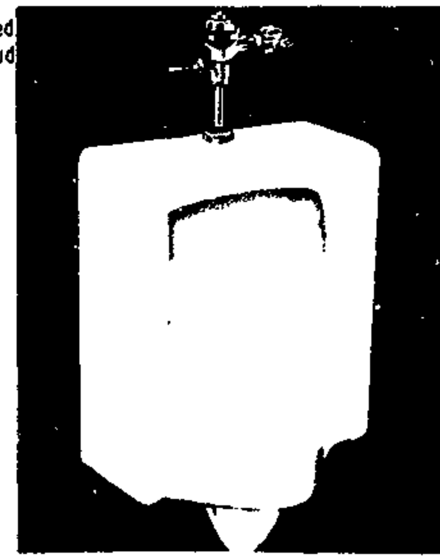
c) Automatic flushing devices are the best because of negligence on the part of many users.

d) Urinals must be installed according to the plumbing code and the manufacturer's instructions.

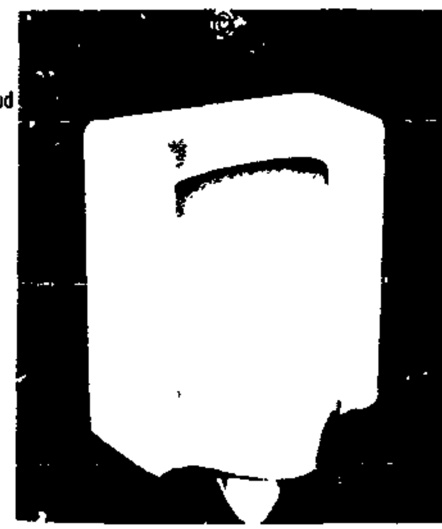
7. **Types of Urinals**

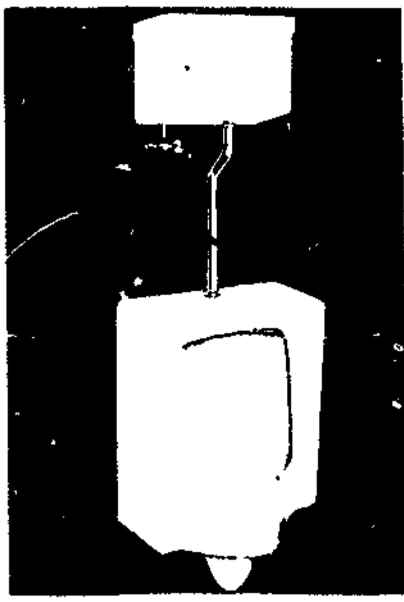
A few of the different types of urinals, flushing devices, and strainers are shown in Figures 22-27 to 22-33.

Chrome-Plated Exposed Flush Valve, Top Spud



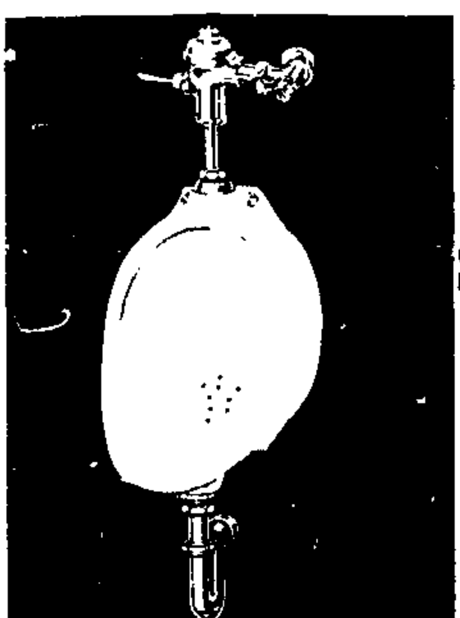
Concealed Flush Valve, Back Water Supply Spud





Flush Tank with Bottom Supply, NPS 1½ Top Spud

Figure 22-27. Vitreous-China Blowout Wall-Hung Urinals, Each with Integral Trap, NPS 2 Female-Outlet Connection, and Supporting Steel Hangers



Chrome-Plated Exposed Flush Valve

Flush Tank With Bottom Supply, Concealed Flush Pipe

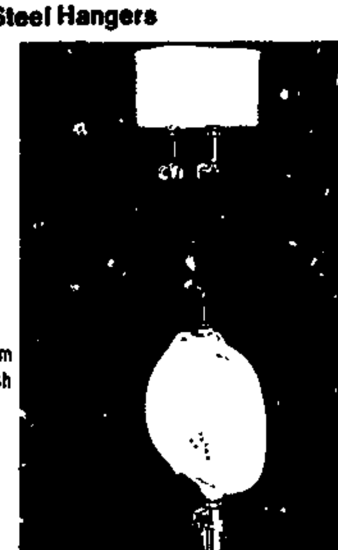
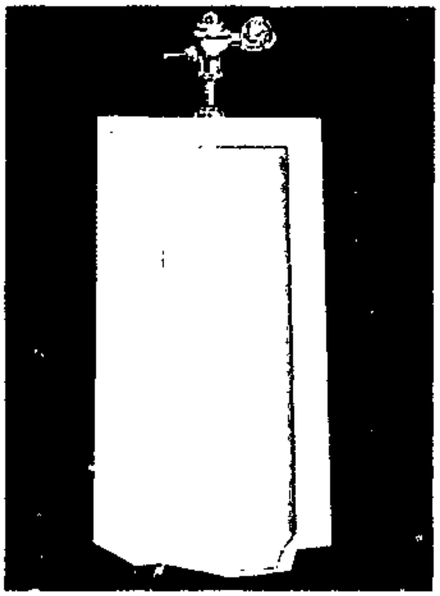
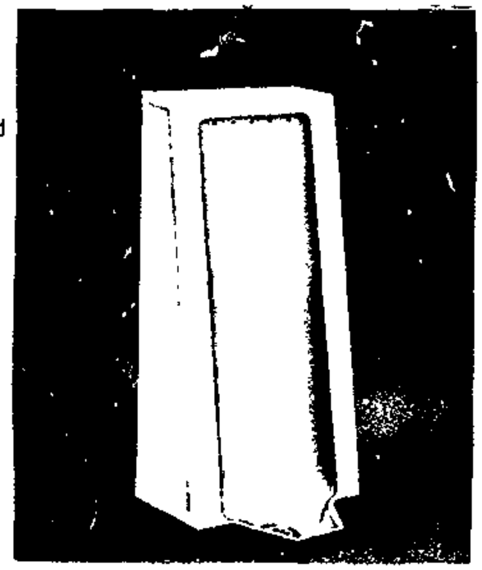


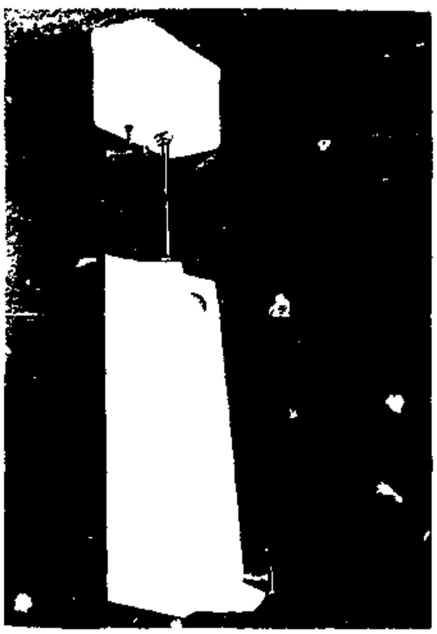
Figure 22-28. Vitreous-China Washout Wall-Hung Urinals, Each with Integral Strainer, Top Spud, OD 38 mm Chrome-Plated Tailpiece



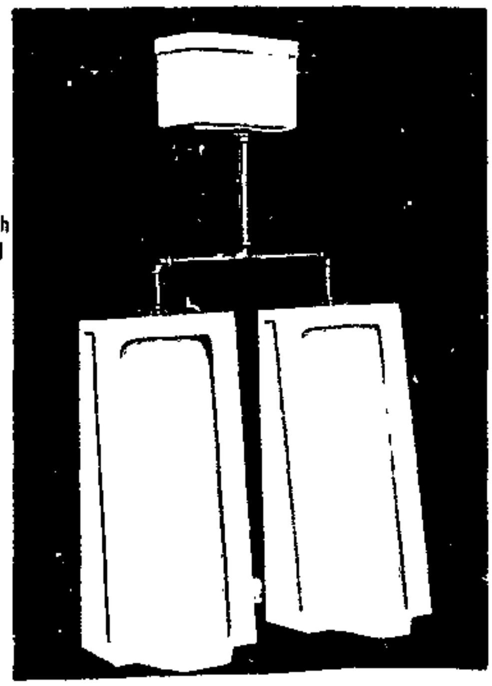
Chrome-Plated Exposed Flush Valve and Top Spud



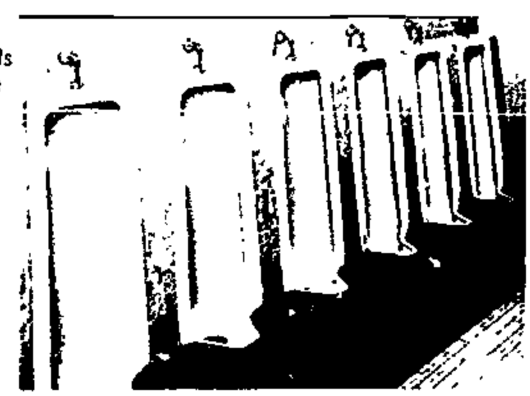
Concealed Flush Valve and Back Supply Spud



Flush Tar Exposed Flush Pipe and Top Spud

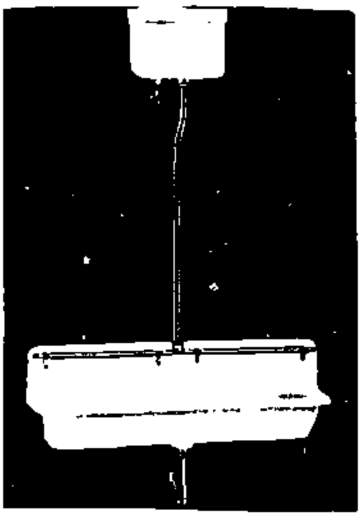


Two Urinals with Single Tank and Flush Assembly

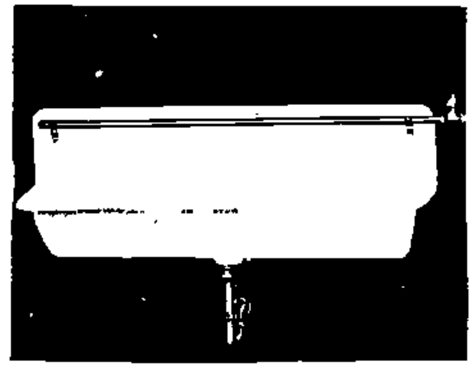


Battery of Six Stall Urinals with Concealed Flush Pipe Assembly and Concealed Flush Tank

Figure 22-29. Vitreous-China Slope-Front Stall Urinals, Each with Integral Flushing Rim, Chrome-Plated Strainer, and Gasket and Locknut Connection for NPS 2 Lead, Iron, or Soil Pipe

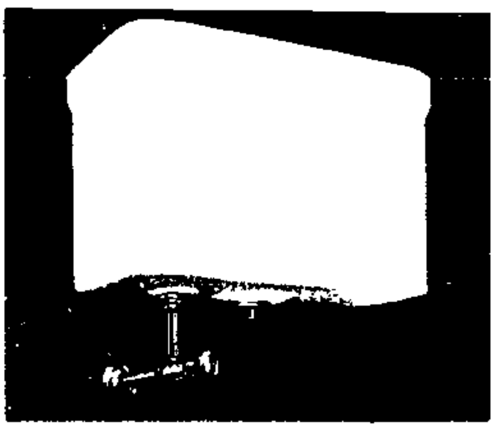


Trough Urinal with Flush Tank. Not Permitted by Many Plumbing Codes.

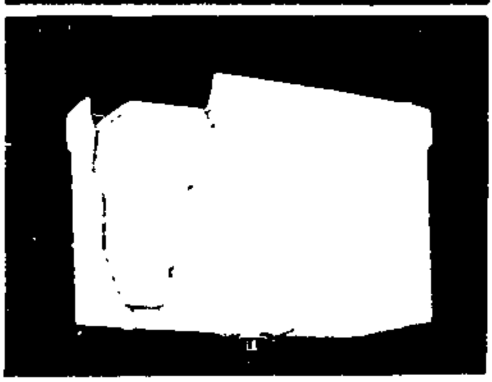


Trough Urinal with Perforated Pipe and Control Valve. Not Permitted by Many Plumbing Codes.

Figure 22-30. Two Types of Trough Urinals. Not Permitted by Many Plumbing Codes

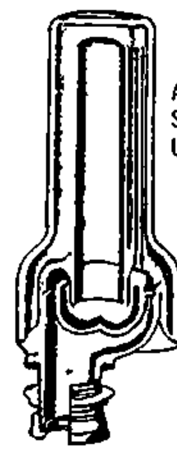


Urinal flush tank with bottom supply connection. The over-rim supply is possibly more popular because it eliminates any possibility of cross-connection



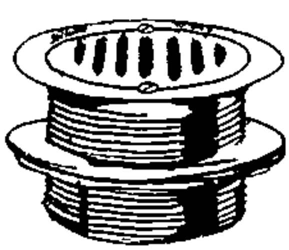
With Anti-Sweat Liner. (Overhead Supply Connection Eliminates Possibility of Cross-Connection)

Figure 22-31. Two Types of Urinal Flush Tanks



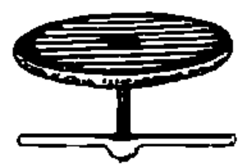
An Automatic Siphon Valve for Urinal Flush Tanks

Figure 22-32. Automatic Siphon Valve for Urinal Flush Tanks

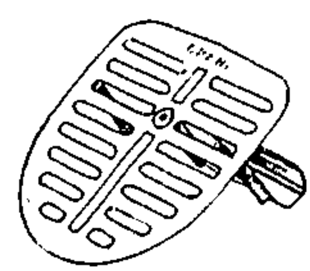


For a Stall Urinal

A Beehive Strainer for a Trough Urinal



A Cross-Bar Strainer for a Wall or Stall Urinal



Another Type of Cross-Bar Strainer for Urinals

Figure 22-33. Various Types of Strainers for Urinals

8. Direct-Flush Valves

Figure 22-34 shows some types of direct-flush valves used on urinals.

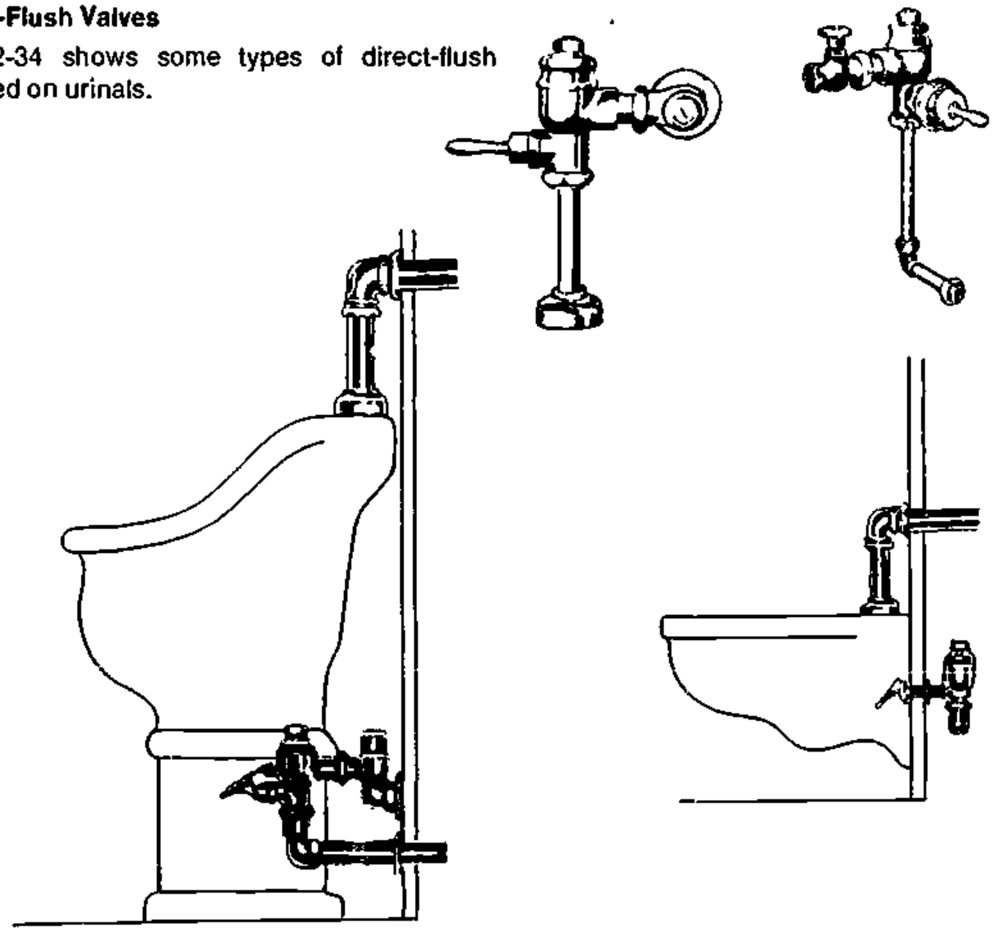


Figure 22-34. Various Types of Direct-Flush Valves

9. Flush-Pipe Assemblies

Figure 22-35 shows some types of urinal flush-pipe assemblies.

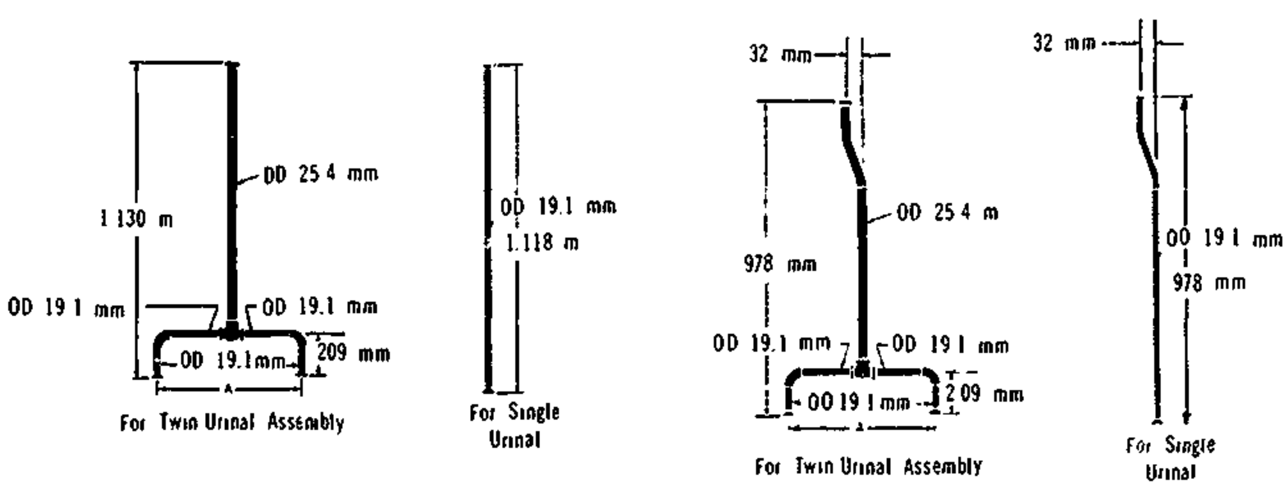
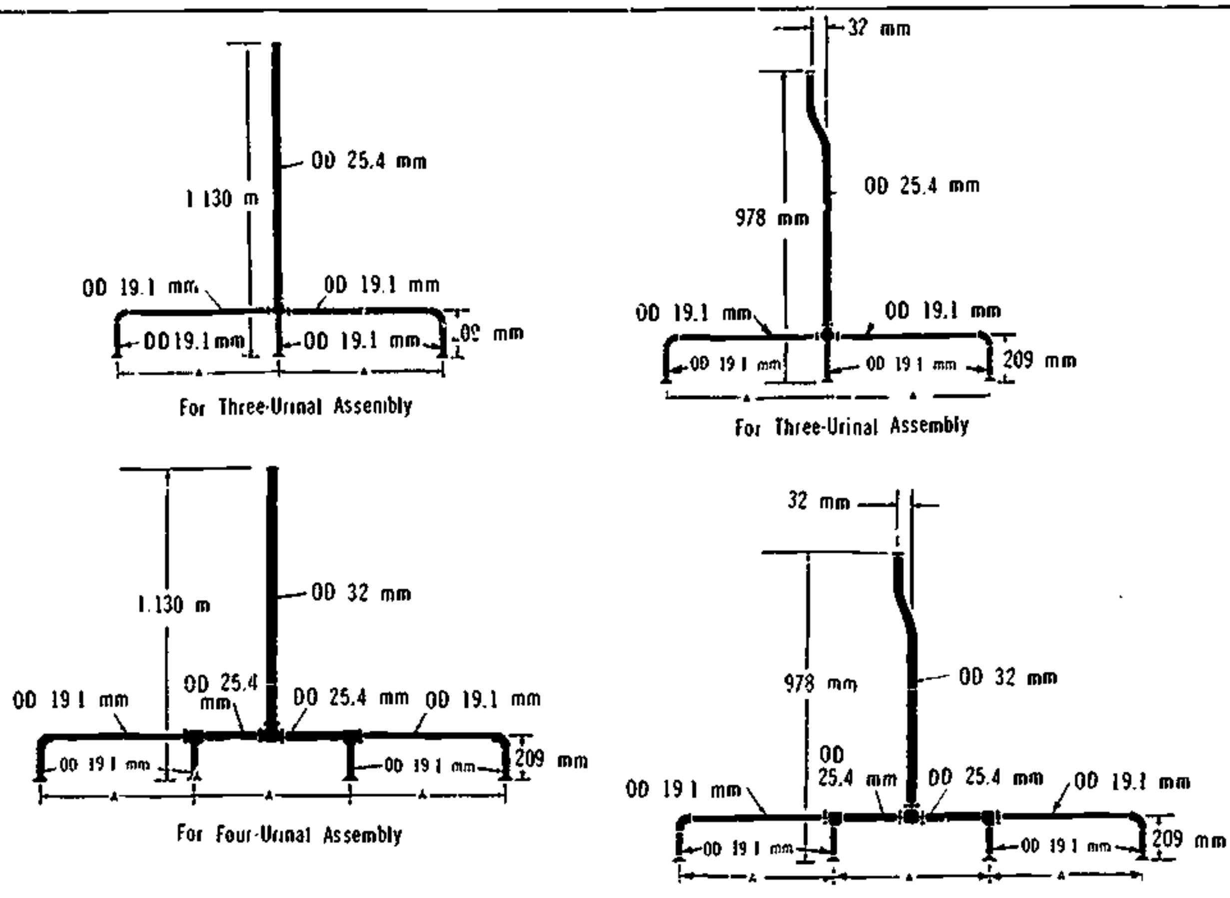


Figure 22-35. Various Urinal Flush-Pipe Assemblies *(continued)*



Concealed Flush-Pipe Assemblies Are Also Available

For Four-Urinal Assembly

Figure 22-35. Various Urinal Flush-Pipe Assemblies

10. Roughing-In Measurements and Installation

a) Below are one manufacturer's instructions for the installation of a stall urinal:

Stall urinals, because of the composition of the material from which they are made, require careful handling and a knowledge of the usual installation procedure. Damage to the stalls because of strains will be greatly reduced or avoided if the following suggestions are used as a guide. Refer to Figure 22-36.

A — The finished floor should be sloped to drain into the lip of the urinal.

B — A pit should be provided in the rough floor of sufficient depth to allow the lip of the urinal to set flush with the edge of the sloped finished floor, with a sand cushion of not less than 25 mm under the stall.

C — A space of not less than 13 mm should be allowed between the edge of the pit in the rough floor and the stall. The waterproof strip, furnished with the urinal, should be placed around the urinal as shown in Figure 22-36.

D — A space of not less than 3 mm, filled with plastic waterproof compound, should be provided between the finished floor and stall.

E — Universal strainers are available with outlets to caulk lead, iron, or soil pipe.

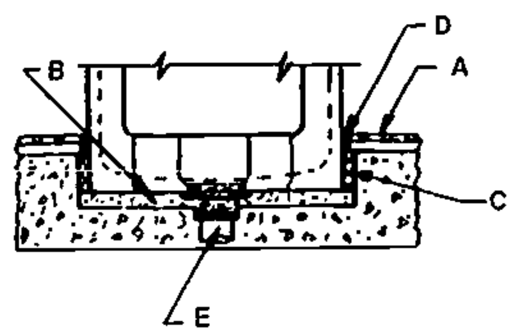


Figure 22-36. Cross-Sectional View of Drain Area

b) Figure 22-37 shows typical roughing-in measurements for different types of urinals, as adapted from Crane Canada Ltd. literature.

c) Always follow your particular manufacturer's instructions provided that they do not contravene the plumbing code.

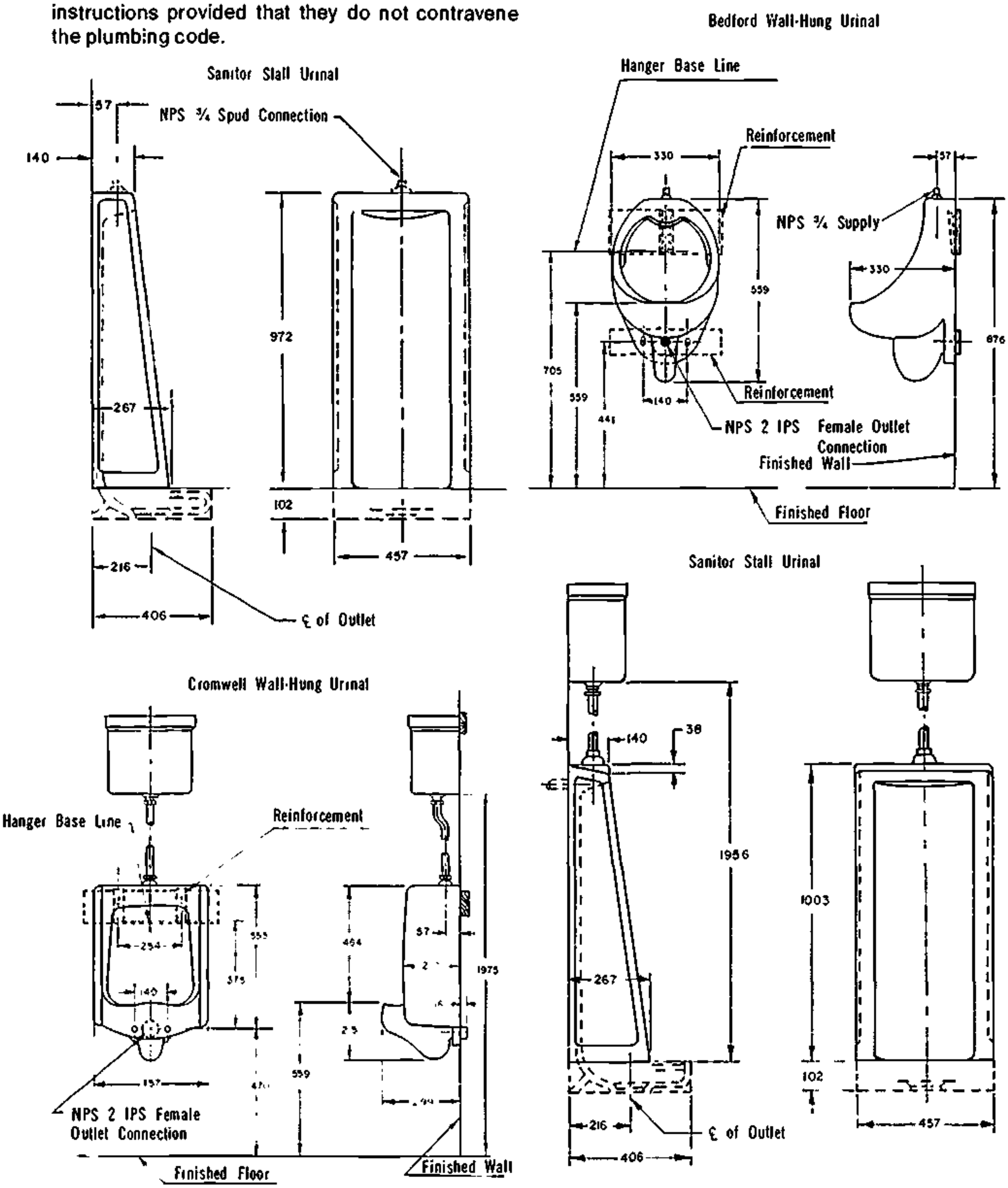
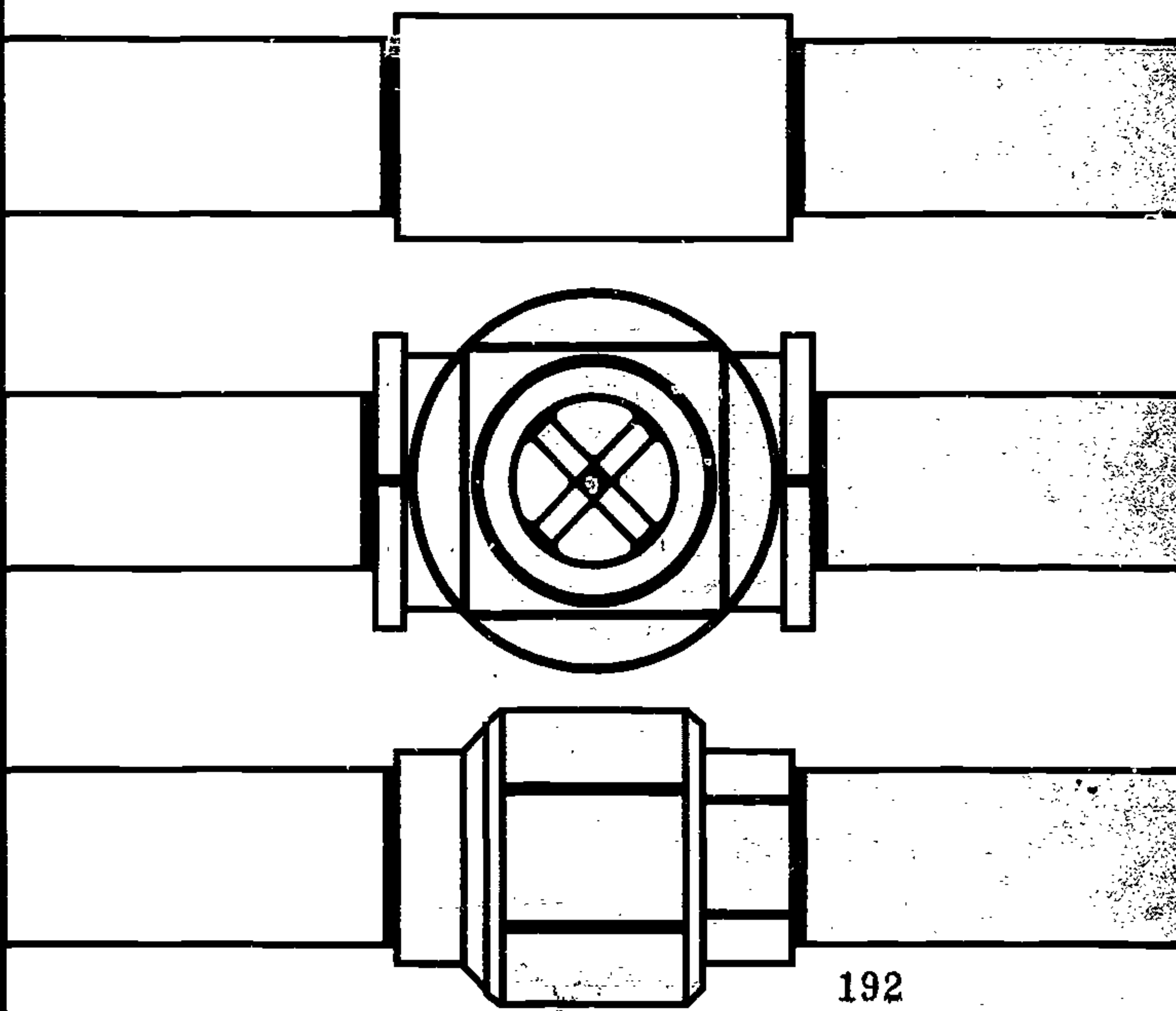


Figure 22-37. Urinal Roughing-In Measurements

Maintenance of Plumbing Systems 23



PART 23
MAINTENANCE OF PLUMBING SYSTEMS

Repairing Faucets and Valves

A leaking faucet can waste up to hundreds of litres of water in 24 hours. The following procedures cover the most important aspects of repairing faulty faucets and valves:

1. Repairs to the basic compression-type faucet shown in Figure 23-1 require only a few tools and the necessary materials.

2. Leaks from this type of faucet are frequently caused by a worn seat washer at the end of the stem.

3. To replace the seat washer on this type of compression faucet, proceed as follows:

   Turn off the water supply and open the faucet all the way.

   Use an open-end adjustable wrench to unscrew the packing nut at the top of the faucet body.

   Turn the faucet handle anti-clockwise to remove the valve stem.

   Remove the brass screw holding the seat washer in place at the end of the stem.

   Remove the old washer and insert a new one of the same size.

   Replace the small brass screw if it is corroded or damaged and tighten it so that it holds the washer firmly in place. A loose washer will often result in a noisy faucet when opened.

   Replace the stem after ensuring that the stem washer or packing is in good condition.

   Screw the packing nut back into position, turn on the water, and check for leaks.

4. If a new washer does not stop a leak, the trouble could be a scored valve seat, caused by gritty matter in the water. In some types of faucets the valve seat can be removed with a valve-seat tool, shown in Figure 23-2, and a new seat screwed into place.

5. Bevelled or flat compression-type faucet washers (Figure 23-3) come in sizes from 6.4 mm to 19 mm.

6. A scored compression-faucet seat can be ground quite smooth with a faucet-seat dresser, two types of which are shown in Figure 23-4.

7. Always follow the directions furnished with the faucet-seat dresser (also referred to as a valve re-seater). Generally, the procedure is to remove the valve stem, replace it with the valve re-seater, then turn the handle to obtain the desired cutting action on the damaged seat.

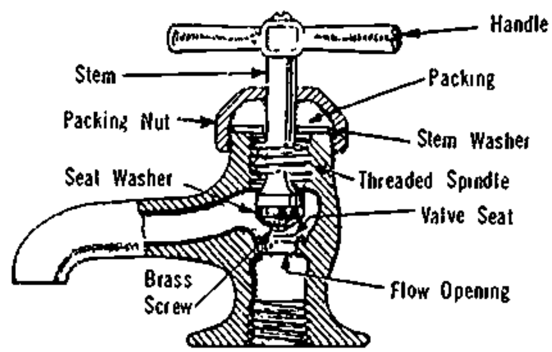


Figure 23-1. Components of the Basic Compression-Type Faucet

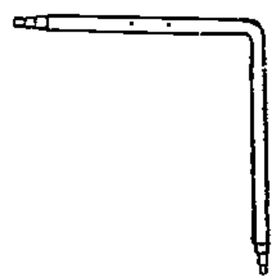


Figure 23-2. Valve-Seat Tool

Figure 23-3. Four Types of Washers

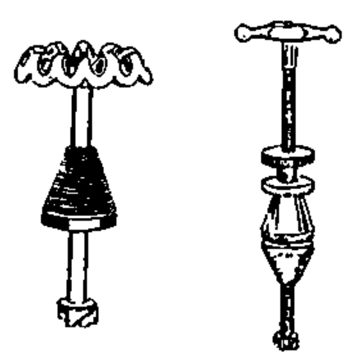


Figure 23-4. Two Types of Faucet-Seat Dressers

8. If a faucet leaks around the handle or packing nut when turned on, the trouble could be a loose packing nut; if not, it will be necessary to remove it and replace the packing or stem washer. It is normally necessary to remove only the handle and the packing nut, leaving the stem in place. Always leave the valve partly open when tightening a packing nut.

9. The above procedure also applies to repairing similar types of compression stops such as those shown in Figure 23-5.

10. There are many other types of faucets, a few of which are described. The first is one of several types of the Dial-Ese faucet made by Crane (Figure 23-6).

11. Following are identifications of the numbered components in Figure 23-6.

1. Locknut
2. Gasket
3. LH Dial-Ese Cartridge
4. Friction Ring
5. Union Ring
6. Jam Nut
7. Shank Washer
8. Body
9. Aerator
10. LH Centrepiece
11. O-Ring
12. Sleeve
13. Seat Ring
14. LH Stem

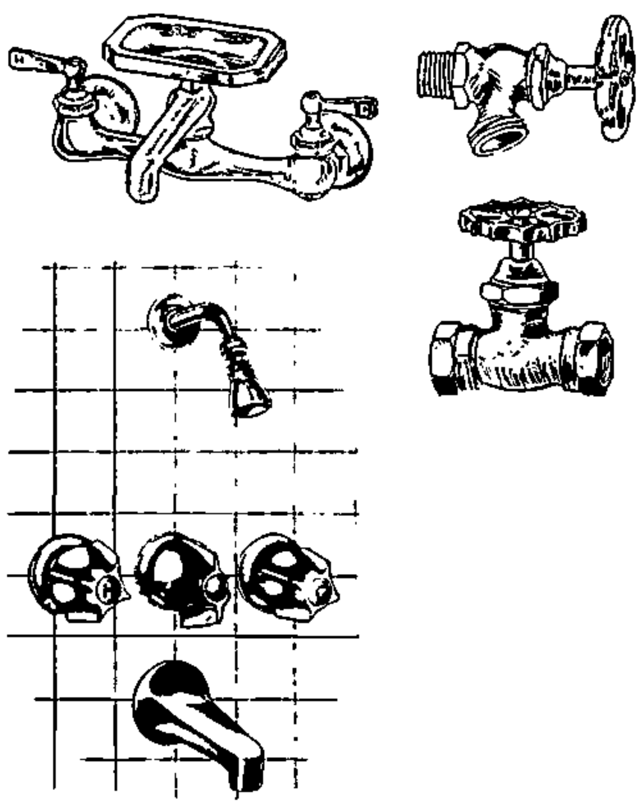


Figure 23-5. Various Types of Compression Stops

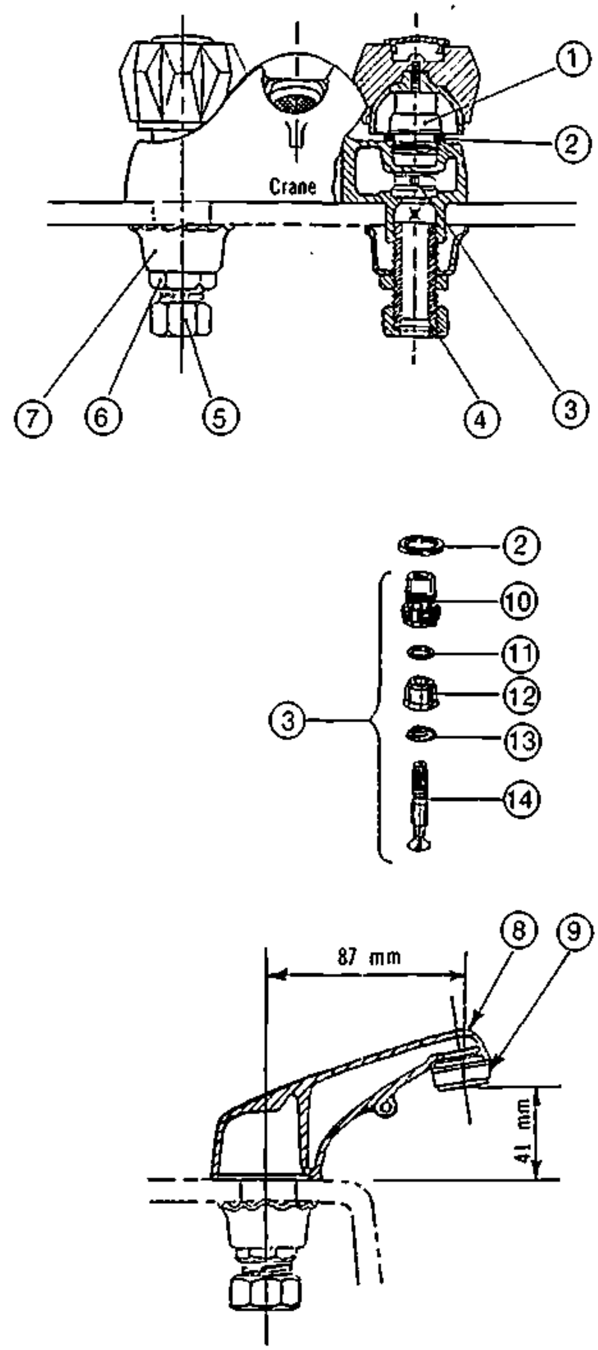


Figure 23-6. Crane Dial-Ese Faucet

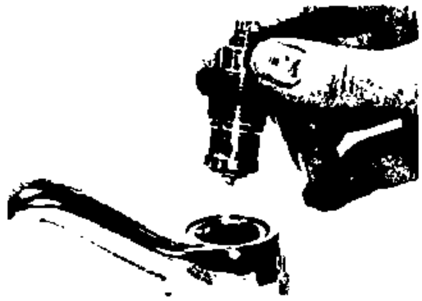
12. Figure 23-7 (on this page and page 232) shows the procedures for stripping, repairing, and re-assembling the Dial-Ese faucet.

1. Carefully pry off the indexed handle button (or cover plate in the case of a lucite handle), remove the Phillips head screw, and lift off the handle (If lucite, also remove skirt.)

2. Position the larger end of the Dial-Ese wrench over the flats of the locknut, turning counter-clockwise

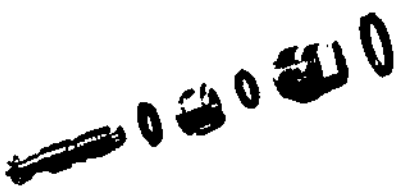
3 Remove locknut

4 Position smaller end of the wrench over the flats on the centrepiece, turning counter-clockwise

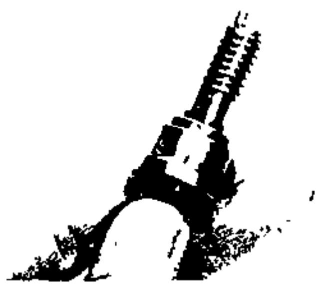


5. Remove complete cartridge from faucet body.

6. Position lug on bottom of stem in small slot in centre of wrench, hold in position by sleeve, turn centrepiece counter-clockwise for RH unit and clockwise for LH unit.



7. Remove stem and disassemble cartridge in sequence — stem, seat ring, sleeve, 0 ring, centrepiece and cork gasket. If tapered seat of stem is pitted or wire drawn, replace stem.



8. Place new Genuine Crane DIAL-ESE seat ring in position on stem, raised lettering facing threaded end of stem, then slide sleeve into position so that bottom end covers seat ring.

Figure 23-7. Step-by-Step Procedures for Disassembling, Repairing, and Re-assembling the Dial-Ese Faucet

(continued)

9. Smear a light layer of lubricant over "O" ring and stem threads, position "O" ring in recess of centerpiece, holding stem as shown in Step 6, then screw centerpiece into position.

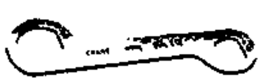
11. Replace cork gasket, then screw locknut into position and tighten.

10. Replace cartridge in faucet body and tighten.

12. Replace handle assembly

Figure 23-7. Step-by-Step Procedures for Disassembling, Repairing, and Reassembling the Dial-Ese Faucet

13. The Crane Company recommends that only its genuine Dial-Ese seat rings be used for replacement. Overhaul kits are available for repairing Dial-Ese faucets.



CRANE MAGICLOSE FAUCET

14. Crane also makes a faucet similar to the Dial-Ese from the exterior, but which is called a Magiclose faucet (Figure 23-8). Components of the Magiclose cartridge are as follows:

1. Top Cam	7. Gasket
2. Top Cam Spring	8. Centrepiece
3. Cap	9. O-Ring
4. Bottom Cam	10. Sleeve
5. Spring	11. Seat Ring
6. Locknut	12. Stem

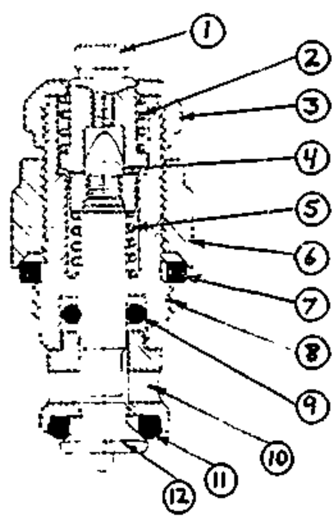


Figure 23-8. Cross-Sectional View of Crane Magiclose Faucet

DELTA FAUCETS

15. Another popular faucet is the Delta ball faucet shown in Figure 23-9. It is a single-lever type for kitchen sinks, lavatories, and bathtubs.

16. Figure 23-10 shows an exploded view of a Delta deck-model faucet.

This model is available in the Delta series 100-300-400, with or without spray and dispenser.

Installation Procedure

Carefully bend the copper tubing straight down. If the faucet is equipped with a spray, it is easiest to attach the hose to the faucet before installing the faucet on the sink.

After installation, remove the aerator and flush both the hot and cold lines before operating the spray. Replace the aerator and check the spray operation.

NOTE: A small stream of water from the spout during the spray operation is normal.

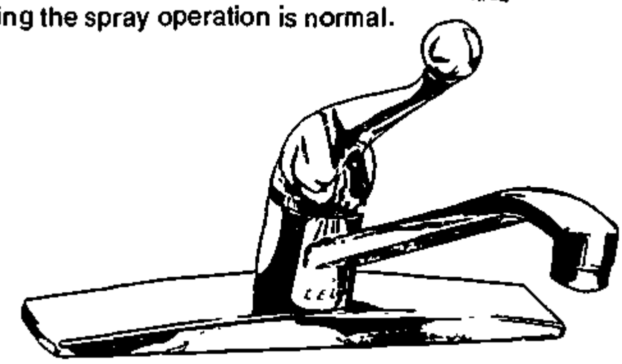


Figure 23-9. Delta Ball Faucet

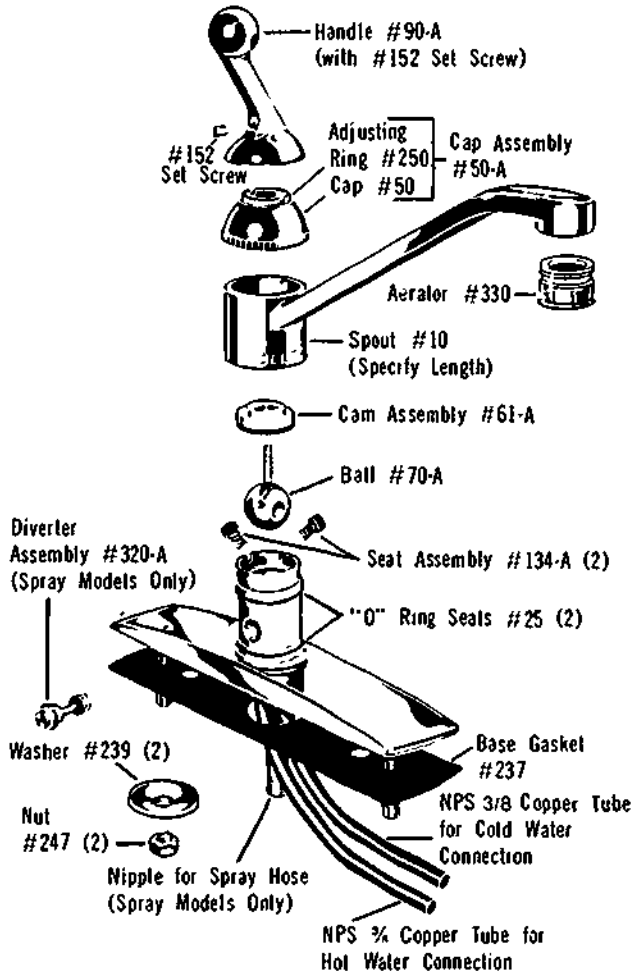


Figure 23-10. Exploded View of Delta Deck-Model Faucet

17. Following is the procedure for stripping, repairing, and re-assembling a Delta faucet. (Refer to illustrated steps in Figure 23-11.)

a) If the faucet leaks from under the handle, disassemble through step 1, and make adjustments as shown in step 2.

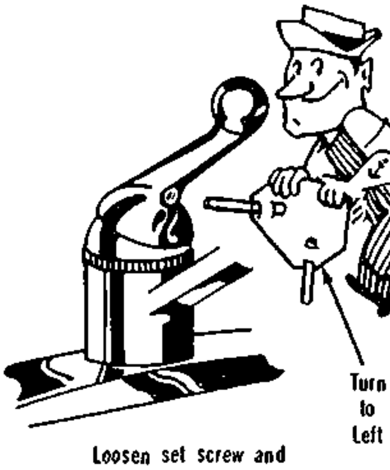
b) If the faucet drips at the spout outlet, disassemble through step 4 and replace the rubber seats and springs. Replace the ball if a sharp edge or roughness is found around either of the two small holes. Make adjustment as shown in step 2.

c) If the faucet leaks from either the bottom or top of the spout, disassemble through step 5 and replace the two body O-rings.

d) If the water volume from any spray model decreases, or if the spray ceases to function, disassemble through step 6 and flush out the diverter assembly and the cavity in the body so that, when re-assembled, the diverter moves freely. Delta faucets are designed to tolerate normal scale, grit, etc., but particles of abnormal size cause the diverter assembly to cease operating.

e) Remove the aerator from the end of the spout, and the nozzle from the spray, then wash out the sediment.

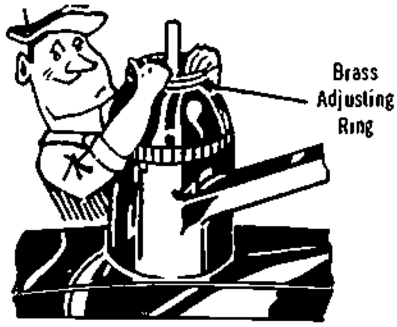
STEP 1



Loosen set screw and pull off handle.

STEP 2

Note: Tighten adjusting ring until no water will lea‹ around stem when faucet is "ON" and pressure is exerted on the handle to force the ball into the socket.

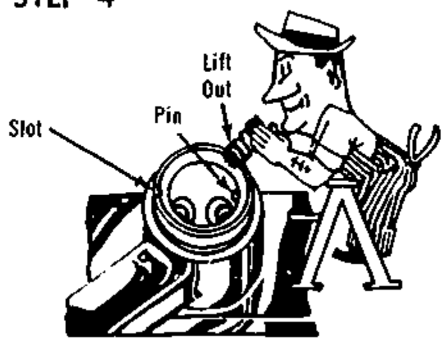


To disassemble, unscrew and remove cap assembly.

STEP 3

Pull up on ball stem to remove cam and ball assembly

STEP 4

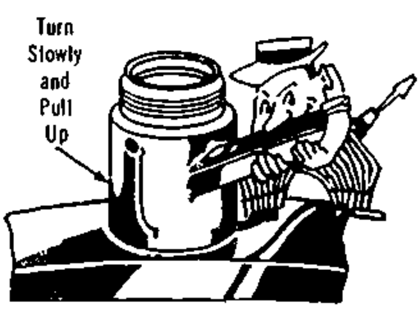


Note: If leak is from spout outlet, replace rubber seats and springs. Check ball and replace if sharp edge or roughness is found around either of two small holes. Make adjustment shown in step (2) above

Lift Rubber Seat and Springs Out Of Pockets In Body.

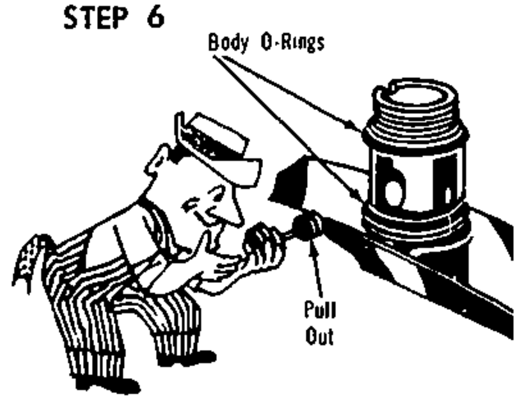
Note: Re-assemble in reverse order, making sure that Slot in side of ball is Inserted Over Pin inside body and Lug on side of cam is Inserted Into Slot on side of body Tighten cap Tight

STEP 5



To check the "O" rings and diverter, pull up on spout and remove

STEP 6



Note: If the leak is from the top or bottom of the spout body, replace body "O" rings Pull out the diverter unit to clean

Figure 23-11. Step-by-Step Procedures for Repairing a Delta Faucet

EMCO TIME DELAY SELF-CLOSING FAUCET

20. Following is a description of the Emco Time Delay Self-Cleaning Faucet and a maintenance guide. This faucet was designed primarily to conserve water: it flows for a pre-set time and shuts off automatically. The company recommends the installation of its line stops 3127 or 3128 (Lock-shield style) and in-line filters in supply lines.

Installation Procedure

21. Connect the faucet to the supply lines. Remove the aerator or spray face plate. Operate the faucet three or four times to flush the line. Replace the aerator or spray face plate. Operate tne faucet. The time-delay cycle should be repetitive and may be adjusted. (See maintenance guide, Table 23-1, for instructions.)

A spacer, as shown in Figure 23-12, is supplied for installation below the small hole between the base plate and the deck to prevent distortion.

How the Time Delay Faucet Operates

22. When the handle is pushed, the stem forces the seat assembly down (see Figure 23-13), allowing water to pass through the seat opening and out the spout. Water in chamber A is expelled up, past the piston cup.

The force of the spring acting upward causes a low-pressure area in chamber A. Since the pressures inside chamber A and outside are unequal, the low pressure in chamber A draws water through the strainer (felt washer), up the threads of the regulating screw, and into the chamber, equalizing the pressures. With equal pressures, the spring is then able to force the stem seat closed, shutting off the water.

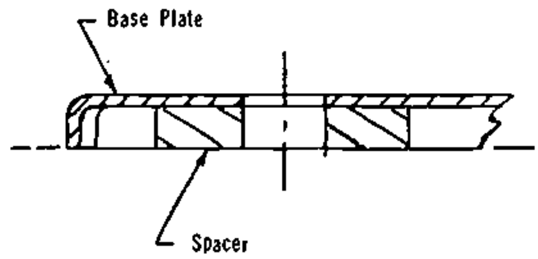


Figure 23-12. Spacer to Support Base Plate

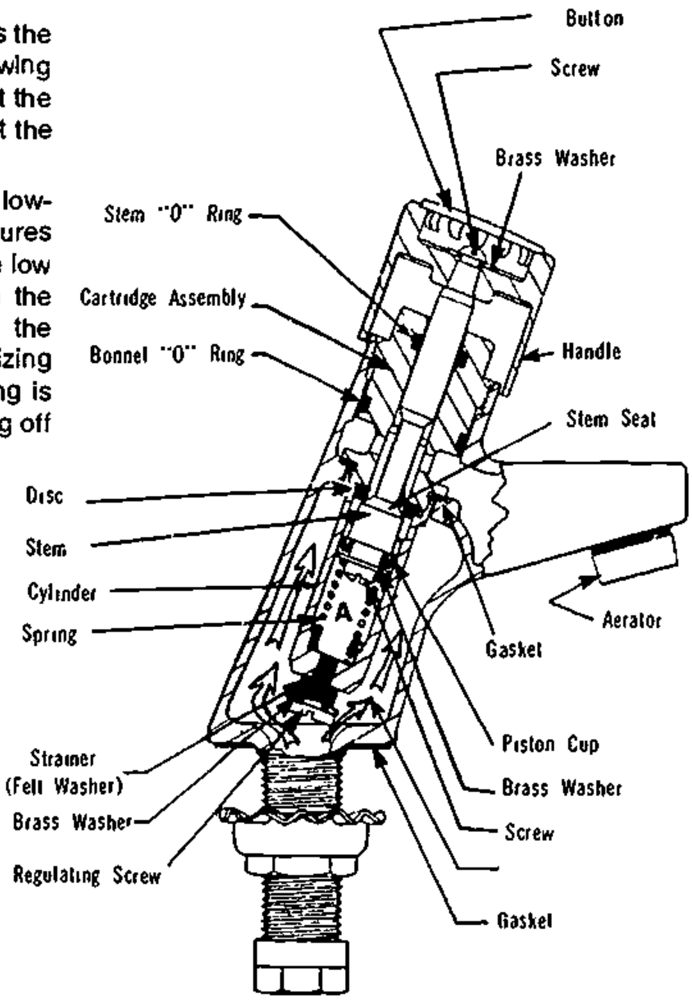


Figure 23-13. Cross-Sectional View of Emco Time Delay Faucet

Maintenance Guide

23. The Emco Time Delay Self-Closing Faucet may require periodic maintenance to ensure trouble-free operation. Table 23-1 is the manufacturer's recommended maintenance guide.

Table 23-1. Maintenance Guide for Emco Time Delay Self-Closing Faucet

SYMPTOM	CAUSE	REMEDY
Longer delay cycle than desired	a) Regulating screw improperly positioned	a) *For adjustment:* Turn regulating screw slightly out (located on bottom of cartridge) *Caution:* Slight regulating screw movement alters cycle considerably
	b) Felt washer clogged	b) Clean or replace felt washer and reset delay cycle
Shorter delay cycle than desired or no delay	a) Regulating screw improperly positioned	a) *For adjustment:* Turn regulating screw slightly in (located on bottom of cartridge) *Caution:* Slight regulating screw movement alters cycle considerably
	b) Piston cup worn or damaged	b) Replace piston cup
	c) Felt washer damaged	c) Replace felt washer and reset delay cycle
Discharges continuously	a) Regulating screw improperly positioned	a) Turn regulating screw out slightly
	b) Felt washer clogged	b) Clean or replace felt washer and reset delay cycle
	c) Bonnet gasket damaged	c) Replace bonnet gasket
	d) Seat disc damaged	d) Replace seat disc
	e) Stem seat worn or damaged	e) Replace stem
Insufficient flow	Aerator clogged	Clean aerator
Leakage from between handle and body	Stem O-ring worn or damaged	Replace stem O-ring

THE REPAIR AND MAINTENANCE OF VALVES

24. Different types of valves are needed in a plumbing system to control the volume and direction of the flow of water. This section is therefore limited to general valve repair and maintenance. If you understand and apply the instructions given in this manual, you should have little trouble, when they are combined with further study and job experience, in learning repair and maintenance procedures for specific types of valves commonly installed in plumbing systems.

25. The frequency of inspection of valves will depend on how often the valves are operated — for instance, every few minutes, once or twice a day, or only several times a year.

26. A very important rule is to never use a pipe wrench on the valve. Use only an open-end adjustable wrench, an open-end wrench, or a socket wrench.

27. A very important step in proper maintenance of the various types of valves is to ensure that they are properly installed. Make sure the ports of threaded or flanged-end valves are thoroughly cleaned and that foreign matter is removed from the interior by flushing out with water or by blowing out with air. Then close the valve, if not required to be open, to prevent accumulation of dirt on the disc or seat.

28. Whenever possible, a valve should be installed with the spindle, or stem, pointing straight upward. If it points downward, scale or other foreign matter may collect in the bonnet. In water lines subject to freezing temperatures, water trapped in the bonnet may freeze and rupture the valve.

29. Not all valve difficulties are the results of faulty installation. A valve that has been in constant service will eventually require gland tightening, re-packing, cleaning, or a complete overhaul of all parts and possibly replacement of the valve.

30. Most valve troubles fall into one of the following categories:

a) Leakage through the valve.

b) Leakage at the stuffing box.

c) Valve stem sticking.

d) Loose valve disc.

31. Leakage through a valve is often caused by dirt or scale on the seat preventing the disc from seating properly. When the valve is closed, the dirt will score the bearing surfaces of the disc and seat. Even a small pinhole leak at a valve can cause much loss of air, steam, or water because erosion will result in a rapid increase in the amount of leakage.

32. Damaged seats in some types of valves can sometimes be repaired by using a valve re-seating tool. In other cases, a replaceable seat and disc may suffice. As a last resort, the valve may have to be replaced.

33. Leakage at the stuffing box — that is, the box that holds the packing to seal the valve from leaks around the stem — can be corrected by tightening the packing nut or re-packing. Persistent leaking indicates that the valve stem may be bent or scored. In most cases, leaks around the stem can be stopped by tightening the packing gland. When you tighten it, be sure the drawing-down or tightening procedure is forcing the packing down evenly. If you tighten the gland unevenly it will become cocked from the uneven pressure and the valve stem will stick and wear.

34. A gland will have to be re-packed after long service. The gland nut must be removed, and the old packing taken out using the 90° hooked end of a scriber or similar tool. Clean the valve stem and inspect it for corrosion or wear. A worn or corroded stem must be repaired or replaced. Wipe all parts and re-pack the stuffing box. If you use split-ring packing material, stagger the bevelled splits so that a leak cannot develop through them. Tamp the packing down evenly, using the packing gland as a tamping tool. String packing is merely wound around the stem in the same direction in which the gland nut turns, but the ends should be tapered to make a smooth seating.

35. After all packing is in place, a squirt or two of oil around the stem will help to wear it in. An occasional shot of oil while the valve is in service will help to reduce valve-stem wear.

36. Sticking of the valve stem may be caused by any one of several conditions. The stem may be bent, or there may be some accumulation of paint or rust on it. The stuffing box may be packed too tightly, to relieve this pressure simply slacken the gland. The stuffing-box gland may be cockbilled; this can be remedied by adjusting the setting of the gland nuts.

37. The valve may have been jammed open while cold and become bound in this position when it expanded with subsequent heating. Usually, the valve can be loosened with a wrench. A good precaution against a valve's binding open is to open it wide, then turn the stem a half revolution in the closing direction.

38. If too much pressure is applied in attempting to move a stuck valve, the threads of the stem may become burred. If the burrs are discovered before they become stuck in the yoke or in the bonnet threads they can be dressed smooth with a file. In extreme cases it may be necessary to remove the bonnet, cut the stem out of the yoke or bonnet, and replace it. In some cases the entire valve must be replaced.

39. A loose valve disc may be caused either by failure of the securing device or by corrosion through the stem. Tightening the securing device, or using more care in re-assembling the valve parts, will eliminate trouble from the first-mentioned cause.

40. The use of split pins of nickel-copper alloy, rather than of iron or steel, will prevent corrosion of valve discs in water lines. When valve stems have shown signs of corrosion it is advisable to make periodic inspections so that replacement can be made before valve failure occurs.

41. Many valves you will repair will have replaceable discs and seats. Repairing this type is not difficult. simply take the valve apart and substitute the replacement part or parts. These replacement parts (seat and disc) are available for valves used in hot and cold water and in air, oil, and gas lines The proper replacement part must be used if the valve is to hold for any length of time.

42. Install air chambers close to quick-closing valves to prevent "water hammer" and consequent damage to the piping system.

43. In repairing valves, the most important factor is experience. Examine and study every valve you see around the shop. Each manufacturer makes a slightly different design and you must be familiar with the differences.

MAINTENANCE OF WATER CLOSETS

44. Water-closet bowls are almost stoppage-proof when properly installed and used.

45. When a stoppage occurs, it may be cleared with a force cup or a closet auger similar to those illustrated in Figures 23-14 and 23-15.

Figure 23-14. Force Cup

Figure 23-15. Closet Auger

46. For the best results with a force cup, insert it into the outlet of the closet bowl filled with water to as near the top as possible, then push down sharply on the handle and draw it back quickly. Repeat as needed.

47. Do not use a force cup to clear blockage in a water-closet bowl when you suspect that a large or irregularly shaped object is the cause of the stoppage. A closet auger may be used if the obstruction cannot be forced through the trap with the force cup. Use the closet auger as in Figure 23-16.

48. The closet auger is a cane-shaped tube with a coiled-spring "snake" inside. Its handle rotates the coiled hook on the end of the snake. To put the closet auger into the trap, first draw the coiled spring all the way up into the cane-like curve of the auger. Hook the cane end, with its projecting hook, into the trap (see Figure 23-16). Begin turning the handle to rotate the coiled spring as it is pushed down into the trap. Continue to rotate the handle until the snake reaches the obstruction, then turn the handle slowly until the obstruction is caught on the coiled hook of the auger. Continue rotating the handle while pulling back to bring the obstruction up into the bowl where it can be removed. Often the obstruction has been pushed through the bowl and into the drain pipe, thus it is not easily recovered.

49. When it appears that the obstruction has been cleared, put several large wads of toilet paper into the bowl and flush them through the fixture to make sure it is clear. The closet auger will often clear a passage around an object such as a toothbrush or a pencil, but the bowl will again become blocked after being used a few times.

50. If an obstruction cannot be removed with a force cup or a closet auger, the bowl must be removed and the obstruction forced out from the other end of the trap. Shut off the water supply and empty the tank. Then disconnect and remove the closet tank; also remove the nuts from the closet-bowl bolts and screws, if applicable. Lift the bowl and rock it so that most of the water is discharged into the drain, and drain the rest by dumping it into another fixture or by swabbing. Lift the bowl and place it upside down on a newspaper or other protective material; in this position, the discharge opening and the trap are accessible for clearing. After clearing the stoppage, replace the bowl using new gasket material, then install and test the tank.

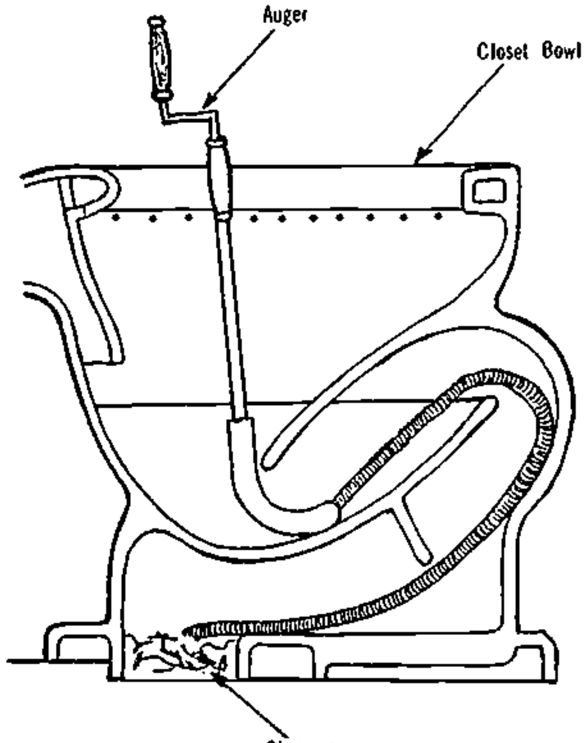


Figure 23-16. Use of Closet Auger

51. Knowledge of the principle on which a flush tank operates will help you to locate the source of trouble. Study the flush tank shown in Figure 23-17, keeping in mind that there are many different types of flush tanks and flushing mechanisms.

52. Before we discuss the repairing of the flush tank, consider what goes on inside this mechanism during the flushing. For clarity, refer to the preceding sketch as you read, again keeping in mind that it is only one type of flushing arrangement and that there will be variations in the method of operation according to the type of flush tank installed.

53. When you trip the lever outside the flush tank, the rubber stopper ball — also called the tank-seat ball — is raised from the valve seat to release water into the bowl. During this emptying process, the float ball drops as the water level recedes. Movement of the float arm causes a plunger in the inlet valve assembly — also called a ballcock or float valve — to open, admitting a new supply of water through the supply pipe. The stopper ball seats as the water flows from the tank, and the incoming water helps to hold the ball in position; hence the new supply of water is held for the next flushing. As the water level rises during refilling, the float ball rises with it. The buoyancy of this ball provides the force needed to lower the plunger to shut-off the water as the tank becomes filled.

54. Note in Figure 23-17 the small refill tubing that feeds into the overflow pipe. During the refilling process, water passes through this tubing and into the overflow pipe, thence to the bowl trap. This tubing ensures replacement of water in the trap, which is essential as a safeguard against sewer gases entering the room through the bowl.

55. When water still runs into the bowl after the flush tank is full, the trouble is generally in some part of the inlet valve assembly. The water in the tank has risen above the overflow pipe and is running into the pipe and down to the bowl. In checking for the source of trouble, look for these defects: a leak in the float ball, a bent float arm, or a worn washer or seat in the inlet valve assembly (float valve, or ballcock).

56. It is often better to replace the entire float valve rather than only certain components.

57. Figure 23-18 shows the flushing mechanism for the water-closet tank. Again, it is emphasized that all flush valves are not the same.

58. The flush elbow shown in Figure 23-18 is not required when a close-coupled tank and bowl are installed, as shown in Figure 23-19.

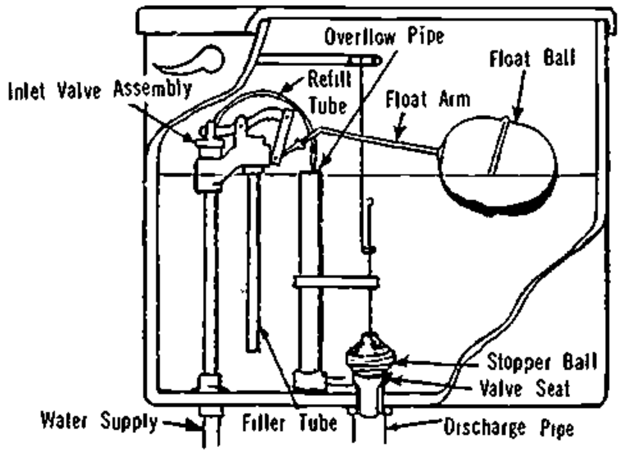


Figure 23-17. Components of Flush Tank

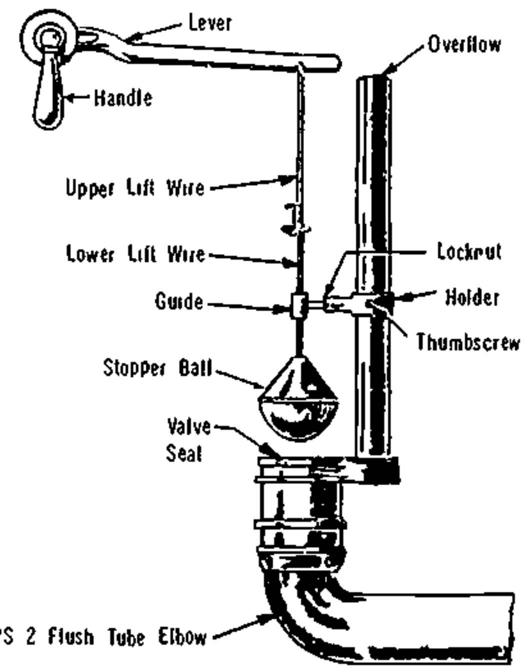


Figure 23-18. Flushing Mechanism

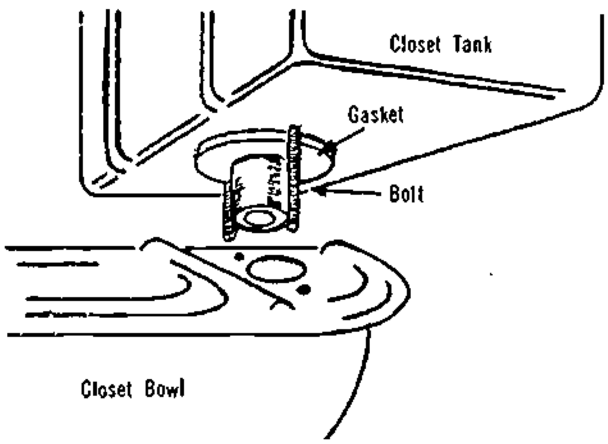


Figure 23-19. Close-Coupled Tank and Bowl

59. Another common disorder in a water-closet tank is when the water continues to run into the bowl after flushing but the tank does not refill. This indicates that some part of the flushing mechanism is at fault, the result being that the valve is not closing properly. To locate and correct the trouble proceed as follows:

a) Stop the inflow to the tank by holding up the float ball, then drain the tank by raising the rubber stopper ball. (See Figure 23-18.)

b) Examine the stopper ball to see if it has become worn, is out of shape, or has lost its elasticity. If one of these is the problem, unscrew the lower lift wire and replace the ball.

c) Make sure the lift wires are straight and plumb. The lower one is easily fitted over the centre of the valve by means of the adjustable guide-holder. By loosening the thumbscrew you can raise, lower, or rotate the holder about the overflow tubing. The horizontal position of the guide can be fixed exactly over the centre of the valve by loosening the lock-nut and turning the guide screw. These adjustments are very important.

d) The upper lift wire must loop into the lever armhole nearest to a vertical from the centre of the valve.

e) A tank should empty within 10 seconds. Owing to lengthening of the rubber ball and insufficient rise from its seat, the emptying time may be longer and the flush correspondingly weaker. This may be overcome by shortening the loop in the upper lift wire.

f) A drop of lubricating oil on the lever mechanism will make it work more smoothly.

DIRECT-FLUSH VALVES

60. Figure 23-20 illustrates a diaphragm-type direct-flush valve.

61. Several companies make direct-flush valves, each differing slightly in operation.

62. The diaphragm-type flushing valve is a compact and efficient device for delivering water under pressure to the water-closet bowl.

63. Because a large-diameter water-supply pipe is required (generally NPS 1), direct-flush valves are not common in residences.

64. A vacuum breaker must always be installed with a direct-flush valve to offset the possibility of cross-connection and backflow into the domestic water system.

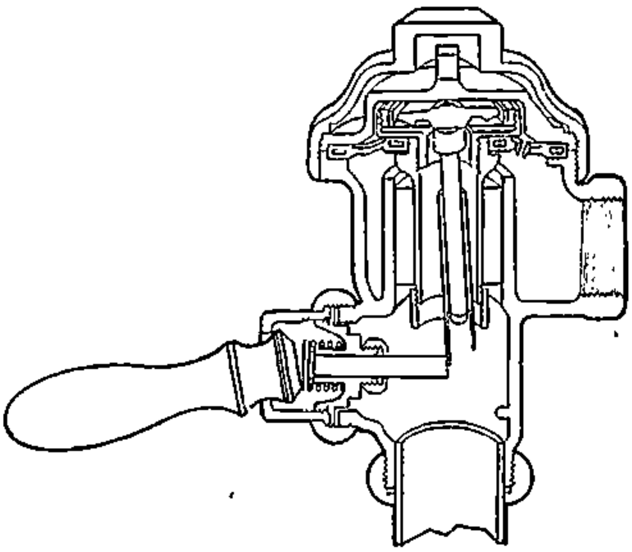


Figure 23-20. Diaphragm-Type Direct-Flush Valve

65. The diaphragm-type direct-flush valve comprises two chambers separated by a relief valve. The upper chamber is directly connected to the main water supply by a small by-pass; and the lower, or flushing, chamber is connected to the water-supply line (generally of NPS 1). Pressure applied to the handle releases the water on the inlet side off the relief valve.

The resultant unequal pressure will lift the diaphragm and let water flow into the bowl. At the same time, water forces itself around the by-pass and equalizes the pressure on the two sides of the diaphragm, forcing the diaphragm down on its seat and shutting off the flow of water to the bowl. Other than simply cleaning the components and unblocking the by-pass opening, the manufacturer's recommendations on repair materials should be followed.

66. Two major difficulties could occur with a direct-flush valve. The valve may run continuously, instead of shutting off at the right time, or it may not deliver the desired amount of water to flush the bowl. Since it is to avoid waste that a direct-flush valve is installed, the proper maintenance is important.

67. The continuous flow of water through a piston-type flush valve is almost always caused either by failure of the relief valve to set properly or by corrosion or blockage of the by-pass valve. In either case there is not enough force on the piston to drive it down onto the seat.

68. If the relief valve fails to seat properly, the leakage may be enough to prevent the upper chamber of the valve from filling, and the piston will remain in the open position. Inspect the relief-valve seat for dirt or other foreign substances that may be causing the valve to tilt; disassemble the piston, wash the parts thoroughly, and re-assemble it. Replace worn-out washers, making sure that the surface on which a washer sets is perfectly clean; then scrape off old rubber if any has adhered to the metal surface.

69. If pipelines in a new installation are not thoroughly flushed out before being put into operation, the pipe dope or dirt accumulated in them can plug the by-pass valve.

DRAIN AND SEWER CLEANING

70. There are many different types of equipment for cleaning drains and sewers, but only a few of them can be covered here.

71. The portable electric drain cleaner shown in Figure 23-21 is one of the types used to clean small-diameter drains such as are installed for lavatories, laundry tubs, bathtubs, and shower stalls. It can be inserted through such openings as a PO plug on a lavatory and operates as easily as an electric drill. The manufacturer claims it will clean small-diameter drains without having to remove the trap.

The operating procedure is to loosen the chuck, pull a foot of cable from the drum, tighten the chuck, squeeze the trigger gently, and feed the bulb auger slowly into the line. Then let the high-speed motor do the work. Continue feeding the cable until the obstruction is cleared.

72. The manufacturer of the compact drain-cleaning machine claims it will speed-clean NPS ¾ to NPS 3 pipelines up to 30 m. (See Figure 23-22.) It is available with a detachable drum or guide hose. It spins 7.6 m of 8 mm, 10.6 m of 9.5 mm, or 30 m of 16 mm sectional cables with speed coupler.

73. The accessories shown in Figure 23-23 are for the compact drain cleaner. They include:

16 mm cable kit complete.

9.5 mm cable adapter with 10.6 m of 9.5 mm cable with bulb auger.

8 mm cable adapter with 7.6 m of 8 mm cable with bulb auger.

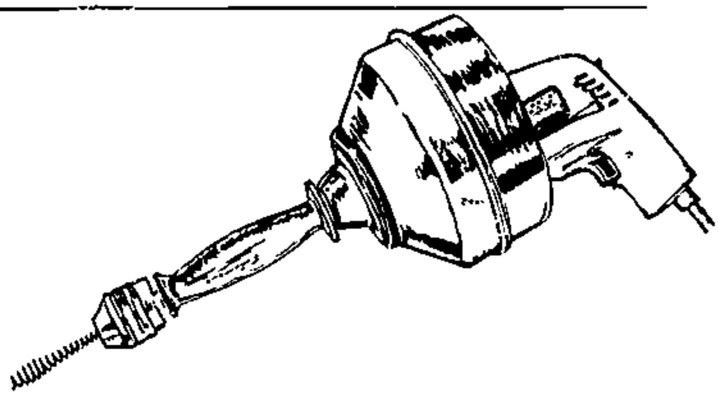


Figure 23-21. Portable Electric Drain Cleaner

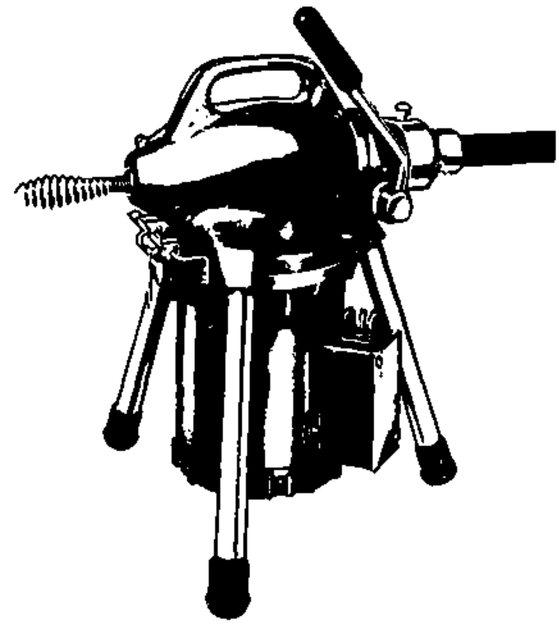


Figure 23-22. Compact Drain-Cleaning Machine

Figure 23-23. Accessories Shown with Compact Drain Cleaner

74. The drain-cleaning machine shown in Figure 23-24 is of a heavier type than those on preceding pages. The manufacturer claims that it will speed-clean NPS 1¼ to NPS 4 pipelines up to 30 m. It spins both 16 mm (for NPS 1¼ to NPS 3 lines) and 22 mm (for NPS 3 to NPS 4 lines) sectional cable with speed coupler.

75. The one-piece flat-steel sewer tape shown in Figure 23-25 has been used by plumbers for many years. It is available in widths from 6 mm through 32 mm, and in lengths ranging from 7.6 m to 30 m. Some types of tapes may be joined by a coupler, and the manufacturers claim they can be used manually for clearing lines up to 90 m.

76. Many different types of cutters are available for drain-cleaning tapes. In some cases one end cutter or roller may be removed and a different type attached to the tape.

77. In large sewers, a self-propelled nozzle is often attached to an NPS 1½ to NPS 2½ hose and, by using a fire hydrant as a supply, the nozzle is propelled through the pipeline, cleaning the sewer as it progresses. The nozzle is generally inserted into the sewer downstream of the portion to be cleaned.

78. In some cases, a large-capacity tank truck supplies the water to the nozzle. In these cases, pressures of 7 MPa are often developed by the pump on the tank truck, and with this degree of pressure the self-propelled nozzle will do an excellent cleaning job.

79. Two types of self-propelled nozzles are shown in Figure 23-26. One has a cutter blade attached for cutting roots, etc.; the other is similar but without the cutter. The pressure and flow of water from the rear of the nozzle cause it to revolve as it is pushed through the pipeline.

80. There are many other types of good drain-cleaning equipment, also some good drain-cleaning compounds that are used by homeowners and the plumbing trade.

81. Large sewers are often examined for cracks, breaks, and faulty joints by floating a special TV camera through the sewer from a manhole. Wires attached to the camera relay pictures to the above-ground TV screen. The operator can stop the camera at any spot to closely observe a section of the sewer pipe.

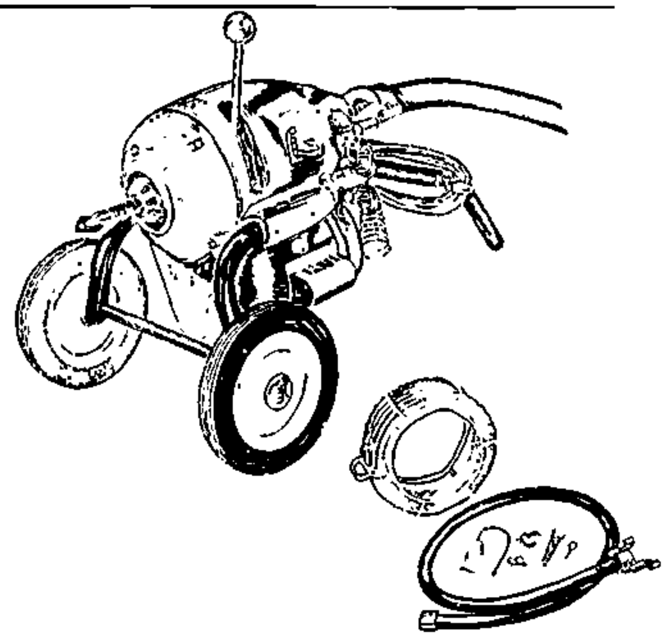


Figure 23-24. Heavy-Duty Drain-Cleaning Machine

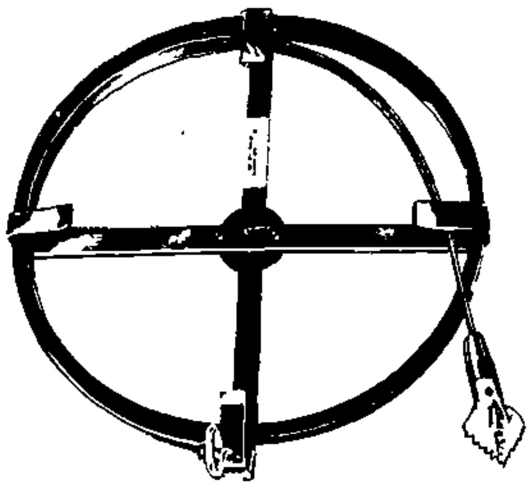


Figure 23-25. Flat-Steel Sewer Tape

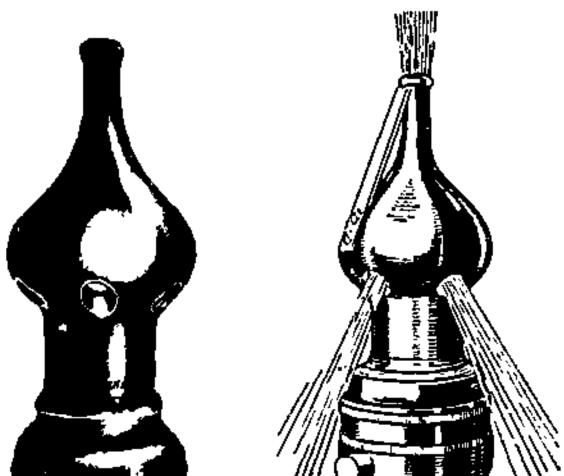


Figure 23-26. Two Types of Self-Propelled Nozzles

CLAMPS FOR REPAIRING WATER PIPE

82. Permanent repairs can be made to water lines from NPS ½ to NPS 8 with clamps or couplings.

83. Illustrated in Figure 23-27 are two examples of clamps and sleeves being used to repair an underground water main.

84. These repair clamps, sleeves, or couplings come in many different styles and are made of several different materials:

a) For smaller pipe sizes from NPS ½ to NPS 2, a galvanized coupling is available with a compression nut and molded gasket on each end. With this repair method, a short section of pipe is cut out of the line and the loose couplings and gasket are placed over each end of the cut pipe. The body of the coupling is then positioned with the ends of the pipe inserted in the body of the coupling and the loose couplings tightened onto the body, thus compressing the gasket so as to make a watertight connection This type of coupling could replace a union in many cases.

b) Clamps or sleeves are made of several materials, including cast iron and stainless steel, and are used on plastic, steel, and asbestos cement and cast iron pipe. The types in general use for the repair of water mains are similar to those shown in Figure 23-27.

THAWING FROZEN SYSTEMS

85 Freezing presents a major problem to water-supply systems in temperate and frigid zones. Wells, pump bearings, and p'..es may freeze. The most serious and frequent problem is the freezing of pipelines.

86. Pipes must be insulated and heated where the ground is permanently frozen.

87 Where freezing occurs only in winter, pipes should be buried below the frost-penetration depth.

88. Storage tanks are also subject to freezing and must be protected.

89. The freezing of pipelines creates a dual problem. Not only is the service disrupted, but also there is always the danger of a fire in the affected area.

90. The use of an open flame around combustible construction or other materials should be avoided.

91. Rising temperature in enclosed areas will thaw frozen pipes, but this is a slow process.

92. Where the frozen pipes are in an accessible area and an open flame is prohibited because of the presence of combustible material, rags dipped in hot water and placed around the frozen pipes are often effective.

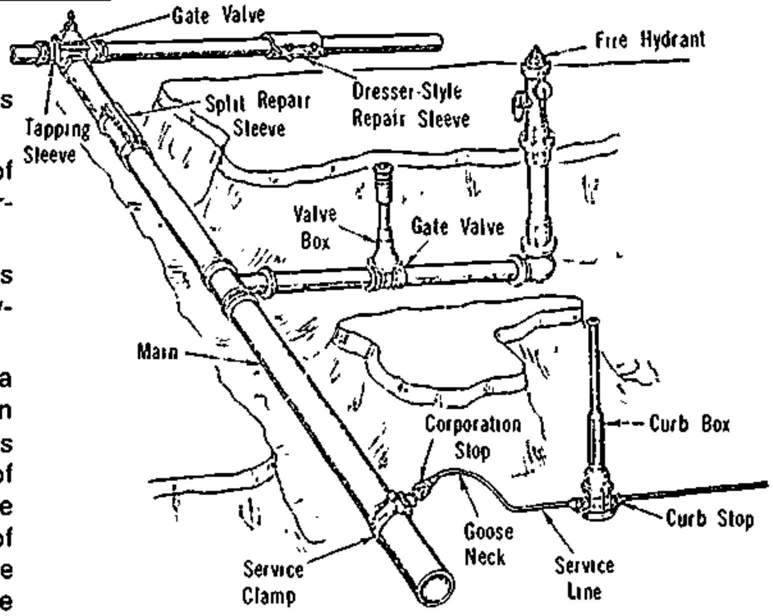


Figure 23-27. Clamps and Sleeves on Underground Water Mains

93. Steam-thawing is one of the best methods for underground sewers and hydrants. The steam from a portable boiler can be injected into a sewer pipe or hydrant with a long steam hose. The steam not only thaws the frozen pipe or hydrant, but also heats the pipe so that the earth around it is also thawed.

94. Electric thawing of frozen pipes is in general use and is relatively inexpensive and convenient. The electrical current can be obtained from electric thawing machines, or from a direct-current generator, such as a welding unit, or an AC transformer.

95. In electric thawing, a complete circuit consists of the voltage source, a length of frozen pipe, and two insulated wires connecting the voltage source and the pipe.

96. As the current flows through the pipe, the heat is generated owing to the resistance of the pipe and ice within the pipe melts. Once the water starts flowing the rest of the ice will melt.

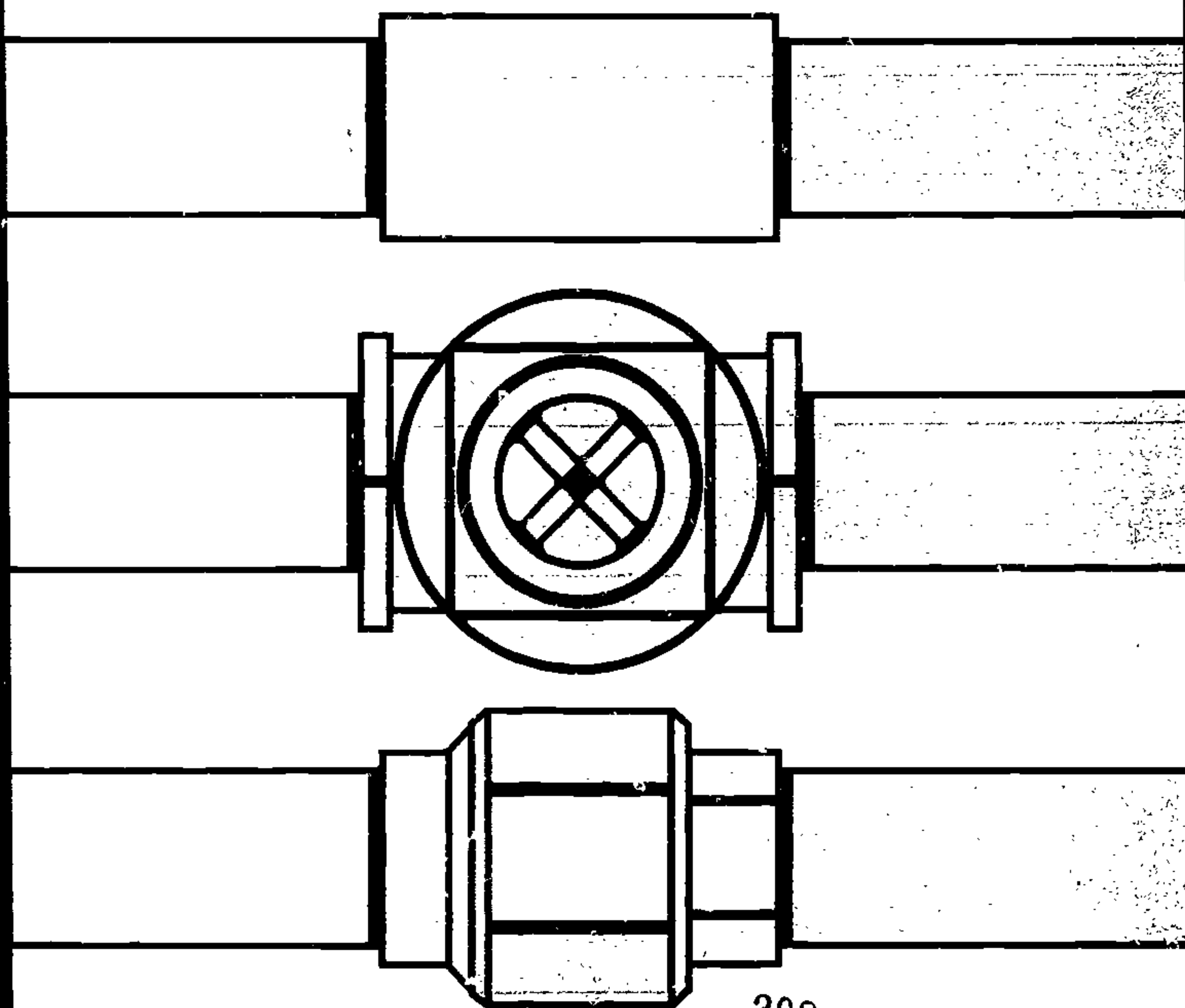
97. Wires from the thawing machine may be connected to the pipe at hydrants, valves, or exposed points at each end of the section to be thawed.

98. Only fully trained operators should be in charge of electric thawing machines.

99. Electric thawing machines cannot be used to thaw frozen pipes or material that is not a conductor of electricity, for example: plastic pipe, asbestos cement pipe, or cast iron pipe that is assembled with mechanical joints or compression joints using a neoprene or rubber gasket.

100. Cast iron pipe with insulating gaskets can be thawed in short sections between the joints with an electric thawing machine.

Private Sewage-Disposal Systems 24



PART 24
PRIVATE SEWAGE-DISPOSAL SYSTEMS

1. Rural Sewage Disposal

a) Sewage is the liquid-borne waste from human habitation frequently containing human excrement. It is a putrid fluid that is dangerous to health if not efficiently treated, and must be disposed of in such a way as to avoid hazard to health and odor offensiveness to people in the vicinity. In metropolitan and smaller cities that have an efficient sewerage system, disposal is not a great problem for the property owner In some rural districts and summer resorts, however, disposal is generally the responsibility of the property owner.

b) The design of an individual, or private, sewage-disposal system should take into account the proximity of wells or other sources of water supply, topography of the ground-water table, soil characteristics, area available, and the use and maximum occupancy of the building being served.

c) The system should be designed to receive all sewage, including laundry and kitchen wastes, but not roof-water or other storm-water drainage It should consist of a septic or settling tank with or without a siphon compartment, discharging into either a sub-surface disposal field or one or more seepage pits. Where soil or other conditions do not permit the use of either a field or seepage pit, approval of an alternative design must be obtained from the local authority Local codes, as always, take precedence in these matters.

d) The unregulated discharge of sewage into lakes, rivers, and streams is prohibited in many localities.

e) Drinking water in rural districts usually comes from wells. Free water may be found in a porous layer of sand or gravel, the upper limit of which is called a water table. The lower limit of the layer is usually adjacent to an impervious layer, such as limestone. Since these water-bearing layers often reach the surface, codes specify that the disposal areas for sewage must be located sufficiently distant from a well to ensure that the well water will not become contaminated by sewage seeping through the water table.

f) Persons wishing to install a private sewerage system should apply for a permit to the local health authority.

2. Septic-Tank Digestion Process

a) A septic-tank is essentially a water-tight storage retainer into which raw sewage is discharged and retained until a large proportion of the solids it contains has been changed by the action of certain bacteria into liquid form, thus simplifying its disposal. This fluid is called sewage effluent. It is discharged into a disposal area specially designed to provide a safe method of disposal.

b) It must be clearly understood that the septic tank does not, by some biological action, purify the sewage in any way. On the contrary, actual tests have shown that the effluent coming out of a septic tank contains more undesirable bacteria than it had before it entered the septic tank.

c) The septic tank accomplishes its main function of liquefying or digesting much of the solid contents of sewage through the action of anaerobic bacteria called anaerobes, which are always present in body wastes. They thrive in an environment that is dark, warm, moist, and devoid of fresh air.

d) The septic tank simply allows the sewage to rest for 24 hours under conditions that promote rapid multiplication of bacteria. Because the bacteria that accomplish this digestion can multiply many thousands of times in the septic tank, so also can the disease-producing bacteria in the sewage be expected to multiply. This digestion eventually occurs spontaneously in a septic tank receiving normal household sewage, provided that temperatures are not extreme and suitable conditions prevail in the tank. Digestion proceeds, however, through a sometimes prolonged, smelly acid stage before reaching alkaline conditions under which digestion proceeds most effectively and with the least odor nuisance. Either seeding with sludge or adding lime (not chloride of lime) will reduce the foul smell and provide alkaline conditions for the most effective septic action. These additions are sometimes called starters. A tank started in cold weather should be partly or wholly filled with hot water, and also be inoculated with active sludge at a ratio of 23 L of sludge to each person using a domestic system. The growth of the bacteria generates heat.

e) Contrary to popular belief, scientific tests show that the addition of yeast does not appear to accelerate sludge digestion in the tank. However, seeding with digested sludge appears to be advantageous.

f) In the process of consuming the suspended solids, the anaerobic bacteria change the solids into gases and chemical compounds. Some of these gases, which may be harmful and even dangerous, escape through the ventilation system. However, when the tank is to be repaired or cleaned the manhole or other cover must be removed well in advance of such work to ensure the worker's safety. It should be remembered that some of the gases are flammable No open flame, such as from a match or a lighter, must be used in the tank. If an extension-cord lamp socket is required, all its parts must be insulated.

3. The Septic Tank — Formation of Sludge and Scum

a) Not all suspended matter in the raw sewage is digested (or liquefied) in septic tank. Sand. soil, seeds, fruit skins, and similar materials settle and become sludge in the bottom of the tank. Grease, oily substances, soap curds, and fats rise to the surface of the sewage and form a thick scum. The digestion process and the growth of the anaerobes in the settled sewage produce tiny bubbles of gas that, as they drift upward, entrain minute particles of suspended solids in the sewage. This also contributes to the scum. The scum, being buoyant, floats partly above the water line.

b) The accumulated scum averages roughly half the volume of the accumulated sludge. The scum should not be unduly disturbed between cleanings as it provides a layer of insulation against heat loss and also seals the air from the anaerobes. The rate of accumulation of sludge plus scum is considerably greater during the first and second years of operation. Thereafter, probably owing to the compaction and digestion, the rate of accumulation drops from about 93 L per person a year for the first year to a fairly constant rough average of 41 L per person a year after five years.

c) Septic tanks built according to modern specifications and operated under average conditions need to be cleaned of sludge and scum every three to five years. A properly designed septic tank provides a sludge storage capacity of about 159 L per person, slightly more sludge than would settle in eight years with normal use. Local factors, such as increased soap accumulation from the use of hard water, cooking habits, and the use of certain soaps or detergents, will affect the above rate of accumulation.

d) A septic tank should be checked each spring or early summer to determine the amount of accumulated sludge and scum. A tank of insufficient capacity for the number of people using it should be cleaned annually. It is not necessary to thoroughly scrub and flush the septic tank chamber until it is visibly clean, since the small amount of sludge that will remain on the floor and walls when the tank is emptied will re-seed it and contribute to the re-establishment of its normal operation.

e) Vacuum-pumped sewage hauling trucks are available commercially to clean septic tanks. This equipment does an excellent cleaning job without spillage. Those who improvise equipment to do their own cleaning should be extemely careful to avoid spillage and to thoroughly cleanse and sanitize themselves, their clothing and their equipment.

f) Checking and servicing the sewage-disposal system should be part of the regular spring clean-up of the premises so that bacterial action will have a chance to re-establish normal action and temperature before the cold weather begins in the fall.

If the septic tank is not cleaned soon enough, the detention period that it will provide for the sewage will continue to decrease. Consequently, more and more suspended solids will be carried into the disposal system, and the percolation surface of the soil will become clogged and eventually cause blockage and failure of the system.

g) Many disease-producing bacteria in sewage are capable of becoming spores, in which state they can withstand extreme cold or heat and extended drying conditions. For this reason, sewage effluent or sludge from the septic tank should not be used to water or fertilize vegetable gardens.

h) If the content of a septic tank or cesspool is spread on a field of summer-fallow, it will soon become inoffensive and turn into a good fertilizer. If not used for this purpose, it should be spread and covered in an approved, isolated location.

4. Construction Features of a Septic Tank

a) The location for a septic tank should be chosen wisely and according to local codes. The codes have been prepared mainly to ensure that the owner and neighbors are protected against contamination of their food or water supply, or against offensive odors.

b) Some authorities recommend locating the septic tank adjacent to the bathroom and on the opposite side of the house from the water supply. If the arrangement permits, the south side of the house is preferable to the north side. The surface drainage from the septic tank and effluent disposal system must be away from the water supply and buildings.

c) Venting of septic tanks is not a general practice, and certainly is inadvisable in very cold areas. Ventilation for the equalization of air pressure is provided through the open-topped tees and the building drain to the main plumbing stack. If fresh air were admitted through septic-tank vents, it could have a retarding effect on the anaerobic bacteria. A convection current would be set up and draw cold air continually into the septic tank and out through the stack. This chilling of the contents of the septic tank in cold weather would lower the temperature of the effluent and greatly contribute to the freezing of the whole disposal system.

5. Elevation for Building Drain and Septic-Tank System

a) In building a sewage-disposal system, there are several inter-related factors that greatly influence both the design of the system and the level of the building drain. They include the natural levels and size of the property, the kind of soil, the type and location of the building to be served, the location and type of plumbing fixtures, and the location of all nearby sources of water supply.

For a typical case, suppose that a standard-type, two-section tank and disposal field at a lower level than the house is to be installed, that the level and location of the house-foundation wall have been determined, and that the ground levels of the lot are not to be greatly altered.

b) To determine the level at which the cast iron house drain will leave the foundation wall, proceed as follows: Using a builder's level or, if necessary, a spirit level as shown in Part 1 of the manual, find the average ground level just outside the wall of the house and the level at the start of the proposed area. The difference between these two levels represents the drop between these two points. Add to this figure the depth that the field tile will be laid below the ground level in the disposal field. The total is represented by distance A in Figure 24-1.

Now add the fall (1) in the building drain (and building sewer, if any) between the wall of the building and the wall of the septic tank; the drop (2) between the inlet and outlet inverts in the settling chamber of the septic tank; the drop (3) between the inlet and outlet inverts of the siphon chamber; the drop (4) in the building sewer between the septic tank and the beginning of the disposal area. The sum of these four items is indicated as B. A minus B will then be the distance from the surface of the ground at the wall of the house to the invert of the building drain where it emerges from the wall. On occasions, the building drain outlet must be at such a level with respect to the septic-tank system that a pump is necessary.

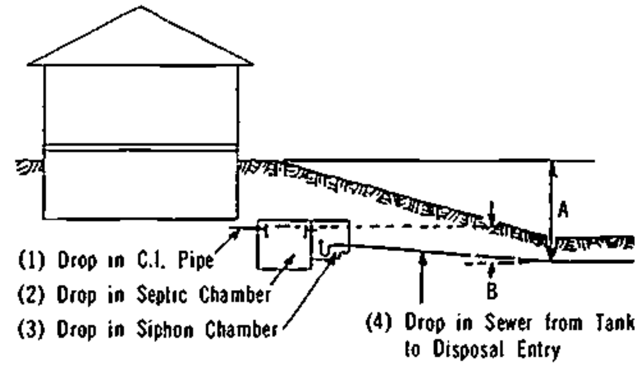


Figure 24-1. Determination of Level at Which House Drain Leaves Foundation Wall

c) If a closet is desired in the basement and the building is located near a hillside, a comparatively simple sewerage system, if approved, may be installed as shown in Figure 24-2. A point worth remembering is that by eliminating the siphon chamber, with its 560 mm drop, a simpler installation may be made if conditions are suitable. (See Section 8 in this part of the manual.)

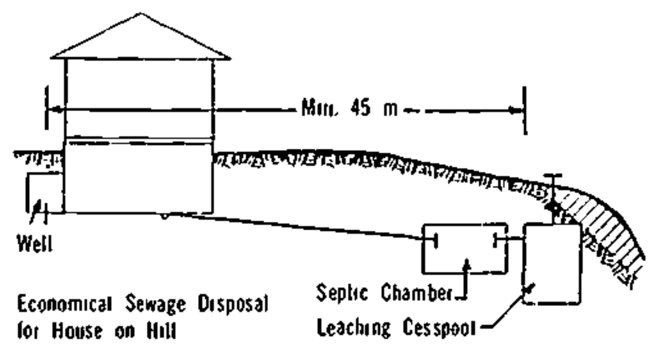


Figure 24-2. A Simple Sewerage System Near a Hillside

6. Pumped Sewage

a) If a rural building is located on elevated ground, it is obvious that a gravity out-flow of sewage from the building to the septic tank is possible.

b) When plumbing fixtures are in the basement of a building located on a fairly level lot, the sewage must be elevated by means of a pump to provide flow into the tank. Moreover, the septic tank must be located with its outlet at a height above the disposal bed sufficient to provide the necessary flow of the effluent.

c) If the basement plumbing comprises only such fixtures as a floor drain, laundry tubs, a shower, and a sump (pit), an automatic electric sump pump (see

Figure 24-3) may be installed. This will raise the waste water to the level of the building drain and discharge it into the private sewage-disposal system. To eliminate the stale, musty odor that may arise wherever soapy water is permitted to lie in a sump, a vent pipe should connect into the sump above the water line. It is also recommended that after the laundry is completed the fixtures and sump be flushed with clear water to which as been added a tablespoonful of a household hypochlorite, such as Javex or Perfex.

d) If the basement fixtures of a building on level ground include a water closet, it is much more economical and trouble-free to install the septic tank low enough to receive the raw sewage by gravity, and to pump only the effluent up to the necessary disposal level (Figure 24-4). It is important that the pump be leak-proof.

e) This effluent pump is automatically controlled by two floats suspended from it on a fine stainless steel wire. This control is much the same as the control and floats used on many sump pumps. Figure 24-4 shows how the switch is set in a sealed chamber to protect it against corrosive conditions of the effluent chamber. It also illustrates the protective pipe for the floats, the venting of the effluent, and how the vent outlet can also act as a safety outlet should the sewer freeze.

f) If it is necessary to pump all the raw sewage to a level high enough to enter the septic tank, a pump capable of handling solids is required.

7. Sizes of Septic Tanks

a) The size of a septic tank depends on the following factors. The amount of raw sewage received from an establishment in a 24-hour period, the need for a sufficient space to accommodate the normal accumulation of sludge in a one-to-three-year period, and the need for an increase in the tank size over the normal size when garbage grinders and automatic washers are used.

b) The amount of sewage received in 24 hours is governed by the size and type of building or establishment being serviced, together with variations in the number of people occupying it.

c) The space to be allowed for sludge depends to some extent on the newness of the tank, and of course on the frequency of the cleaning operations. These factors point up the need for intelligent inspection and care. Table 24-1 shows the probable daily flow of raw sewage from various establishments.

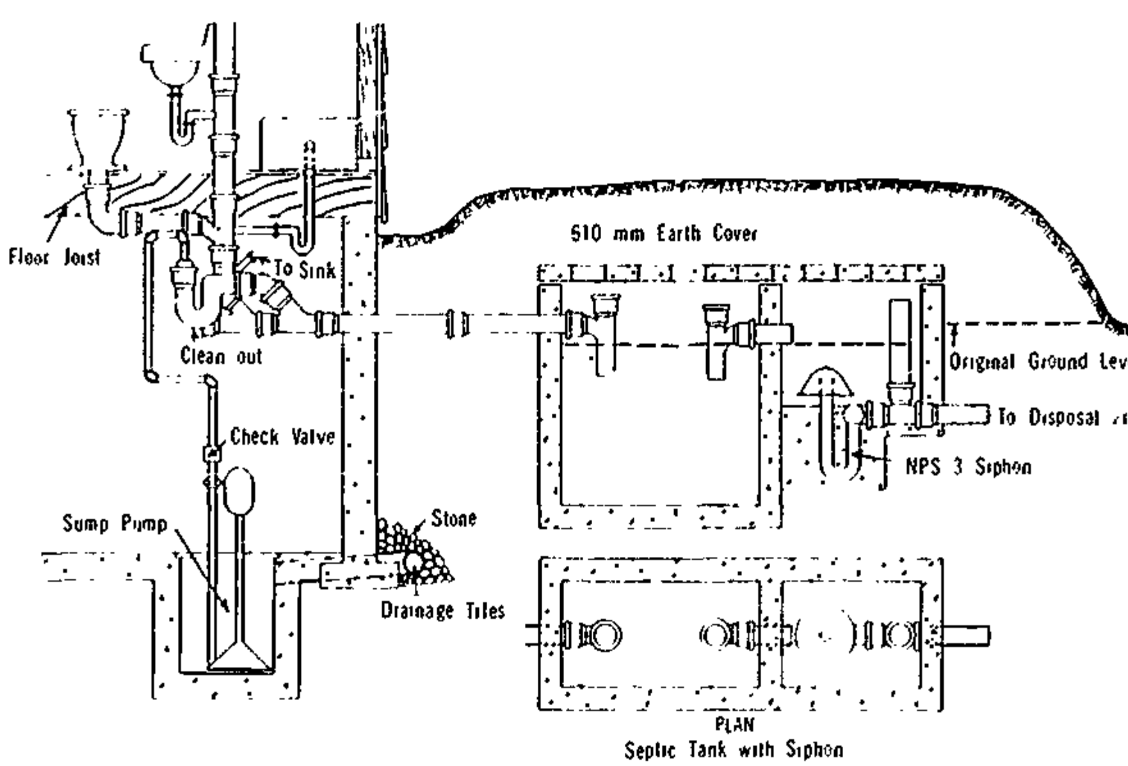


Figure 24-3. Addition of Automatic Electric Sump Pump

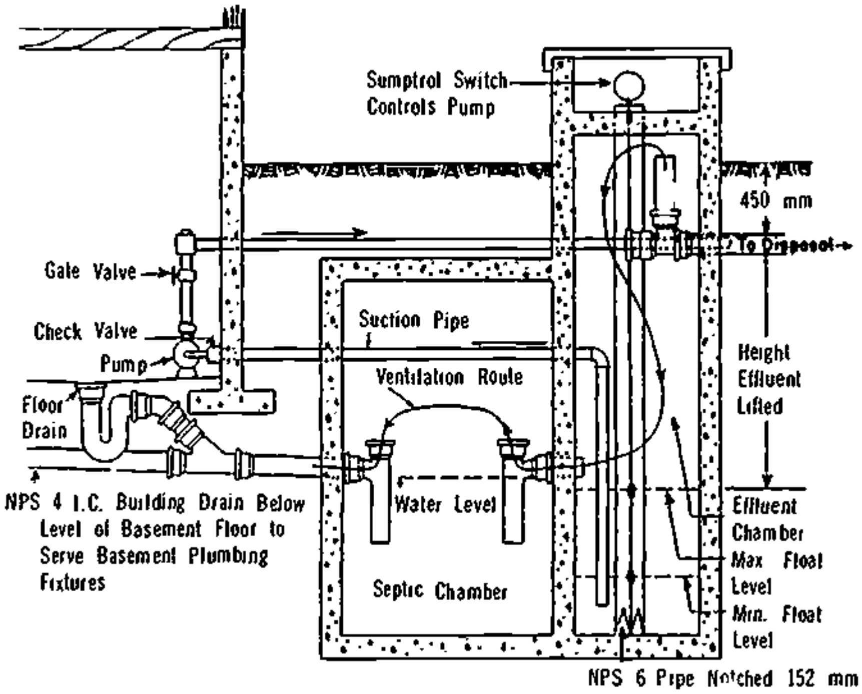


Figure 24-4. Pumping Effluent to Proper Disposal Level

Table 24-1. Daily Sewage Flow

Dwellings, boarding schools, residential buildings	159 L per capita
Small hospitals (up to 15 beds)	455 L per bed
Day schools	45 L per pupil
Tourist camps, trailer parks	91 L per capita
Drive-in theatres	14 L per car

8. Protection Against Frost (The Siphon Chamber)

a) A siphon chamber aids in combatting the frost problem because of its intermittent discharge of a tankful of effluent into the cold sections of a disposal field (see Section 10 in this part of the manual). Without it, the discharge would be a trickle and more likely would freeze in cold weather

b) Frost boxes should be used to protect any sewer less than 1.20 m deep when it is under a road, path, or driveway.

c) The liberal use of coarse gravel under laterals, and the open spaces for the ends of field tile, permit the effluent to seep away quickly, thus aiding in preventing a frozen field.

d) Frosty air may cause considerable freezing in the system because, if freely admitted, it can be drawn along through the stack. Therefore vents on cesspools, access pipes, and manholes should be tightly covered.

e) The disposal field should also be covered by straw, potato vines, or manure, and be given a snow cover by the planting of hedges or the erecting of snow fences. Trampling the snow causes a packing of the snow cover with a resultant greater tendency toward freezing in the field.

f) The admittance of hot water or steam into the field vent in the siphon chamber will often thaw a minor freeze-up. A septic-tank system that is installed in frosty weather may not function properly.

9. Single-Compartment Septic Tanks

a) Septic tanks having no siphon chamber may be used for domestic-size installations where it is not necessary to flush the effluent. They are in common use where there is little danger of freezing the disposal field, or where the soil is suitable for a leaching cesspool.

b) If the siphonless tank is used with a disposal field, the layout should be such that all the laterals will receive an equal amount of the effluent Figure 24-5 shows a disposal-field layout using a single distribution box.

c) The total loss in elevation in a single-compartment tank is only 75 mm compared with 635 mm for a tank with a siphon Thus it makes possible the lowering of the building drain by 560 mm, which

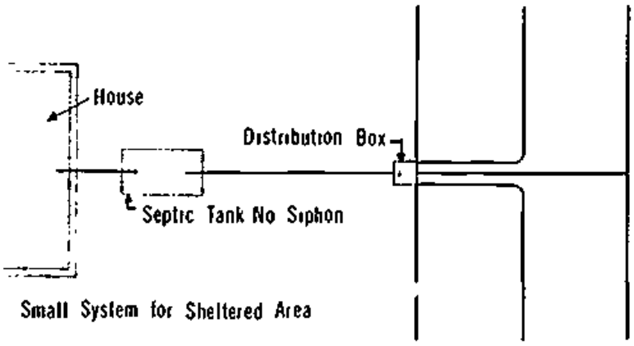


Figure 24-5. Disposal-Field Layout with a Single Distribution Box

may be enough to permit the installation of plumbing fixtures or a floor drain in the basement. If it is necessary to have the building sewer near the surface, between the single-compartment tank and a leaching cesspool, a frost box should be used.

d) Pre-cast concrete septic tanks are extensively used in some areas. They are frequently made in the single-compartment type, but where a siphon chamber is required, such units are also available. Their reinforced construction and closely compacted concrete make them more resistant to deterioration than some poured-in-place tanks. They should never be placed on filled ground, and must of course meet provincial requirements. They are available in sizes at least from .9 to 4 m^3. Where a grease trap is necessary, such units are available.

It is quite practical and economical to use several of the small standard-size tanks, connected as shown in Figure 24-6, to obtain the necessary volume. Advantages claimed for this arrangement are increased efficiency in separation of solids and a probability that one unit can function even if the others do not, thus permitting operation during repairs. Figure 24-7 shows a typical 2 m^3 tank.

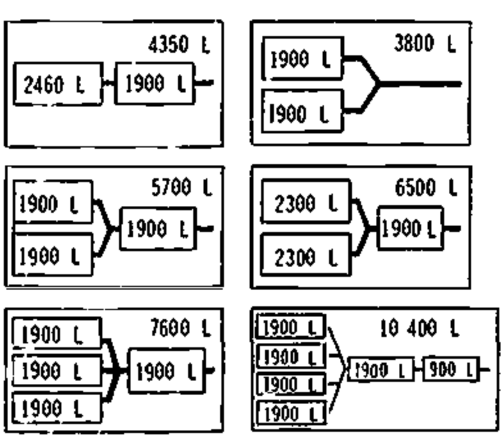


Figure 24-6. Interconnecting Small Standard-Sized Tanks

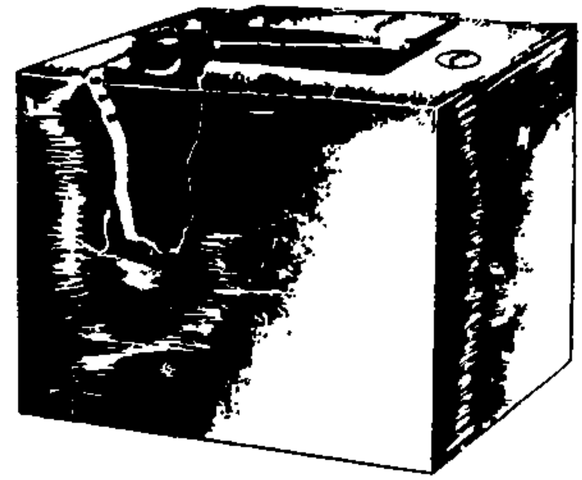


Figure 24-7. Typical 2 m^3 Tank

10. Theory of Disposal Fields

a) The sewage effluent that leaves a septic tank is best disposed of through a disposal field. The septic-tank effluent contains minute particles of suspended solids, and great numbers of intestinal and pathogenic (disease-forming) bacteria, and purification of the effluent is necessary to safeguard the owner and neighbors from disease or discomfort. When the effluent is percolated into the ground, these impurities are attacked by countless biological organisms that thrive on organic materials, oxidizing them in the process into safe and stable compounds. The purification of sewage effluent in the soil is thus a stage in the "nitrogen cycle" in which the complex organic proteins are broken down into simple and stable inorganic compounds.

b) The biological organisms that perform this miracle are aerobic, that is, they require the oxygen in the air for life. Their natural habitat, therefore, is the surface and the upper layers of the soil. This explains why lighter soils and shallow disposal fields are the most efficient.

The siphon chamber, with its intermittent flushing, permits an air space to form in the laterals (branches). Moreover, the volume of one flush should never fill all the tile in the absorption trench. The equal distribution of the effluent resulting from the use of a distribution box (Figure 24-3) tends to increase the efficiency of the system by admitting air into the soil around the tile. Any installation in which the soil becomes constantly saturated and sour is devoid of air. The suspended solids in the effluent accumulate rapidly, plugging the tiny spaces between the particles of soil and rendering the system inoperative.

c) To ascertain the absorption qualities of any disposal field, a percolation test must be made. This is done by digging a hole in at least four different locations in the area to a depth at which it is proposed to lay the *tile*. The holes may be 300 mm square or, if preferred, 100 mm auger-bored holes. Thoroughly saturate the soil around the hole with clear water at a minimum depth of 300 mm above the bottom.

This operation should cover several hours, or overnight. After the rate of drop in the water level seems constant, check the time required for the water level to drop 25 mm. This can be done by standing a yardstick vertically in the hole or by measuring down from a board placed across the hole to the surface of the water. The percolation time obtained in this way may then be used to find the data necessary for installing the whole system.

d) The required information includes the proper length of weeping tile for the disposal field for the number of people normally using the system. The pattern for the layout of the tile, the trench details, and the desirability of using a distribution box must also be determined. A design for a trench is shown in Figure 24-8. Note the rectangular shape of the cross-section of the excavation, also the grade board and the supporting stakes for maintaining the proper levels for the tile, and the location and material for the various kinds of fill.

Figure 24-9 shows a longitudinal section of a trench that is also recommended. Note the extra layer of building paper over the top layer of gravel.

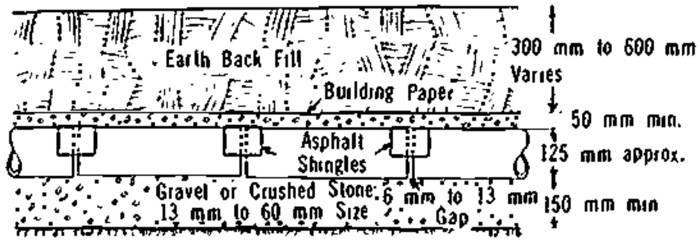


Figure 24-9. Absorption Trench, Longitudinal Section

11. Disposal Field — Location, Types, Trenching

a) The disposal-field layout and installation must be approved by the appropriate health department, which will require minimum distances from any water supply, dwelling, river, lake, stream, and possibly from large trees in some cases.

b) Avoid hard-packed yards, driveways, and paths. If the sewer or header must cross under such a bare spot, use a frost box. The disposal field should be constructed on elevated, well-drained ground. In particular, the field must not be located in low areas subject to flooding. The natural drainage of the area must be away from the source of the domestic water supply. A sheltered, well-drained, sunny location where the snow lies deep in the winter and the grass is kept cut in the summer is ideal — for instance, a lawn or a garden. High vegetation growth must not be allowed to shade the area over the field.

c) A disposal field is a system of sub-surface tile with a header or main feed line from the septic tank feeding into laterals. Perhaps the oldest and most common pattern is the "herringbone" seen in Figure 24-10. Note the siphon chamber, since it is not used in all cases; also the leaching cesspool, a

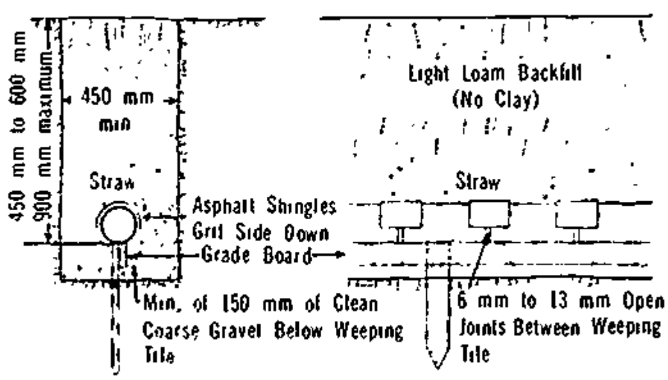


Figure 24-8. Cross-Sectional View of Trench

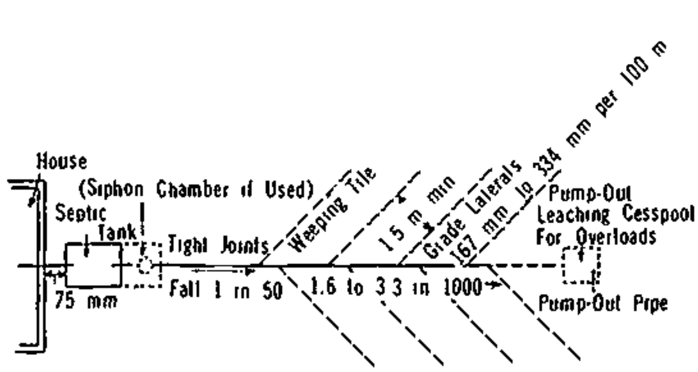


Figure 24-10. Clay Tile Disposal System for Level Ground

safety device that is sometimes added in case of overloading. The end of the header should be tilted up 60 mm where it enters the cesspool.

d) Three other patterns for disposal-field tile, all using distribution boxes, are shown in Figure 24-11. Diagrams A and B in Figure 24-11 show patterns suitable for a level residence yard and a sloping site respectively; diagram C shows a pattern notable for its fan-shaped layout and circular distribution box.

e) Headers are laid in absorption trenches deep enough to provide adequate protection against frost, yet not so deep that the aerobic organisms would be unable to produce the oxidizing and purifying action on the effluent.

f) Trenches vary in width from 450 mm to 900 mm, and in depth from 600 mm to a maximum of 900 mm. The sides may be vertical or widen out to 900 mm or more at the top in heavy clay soils. See Figure 24-12 for a suggested absorption trench cross-section.

g) The fall or slope for the laterals varies from 1.6 to 3.3 in 1000 but may be level when laid on a steep slope.

h) The fall in the header is rather steep, being 1 in 50 as it leaves the septic tank but levelling out to 1.6 to 3.3 in 1000 where the laterals connect. The laterals should be of 100 mm field tile with end spaces of

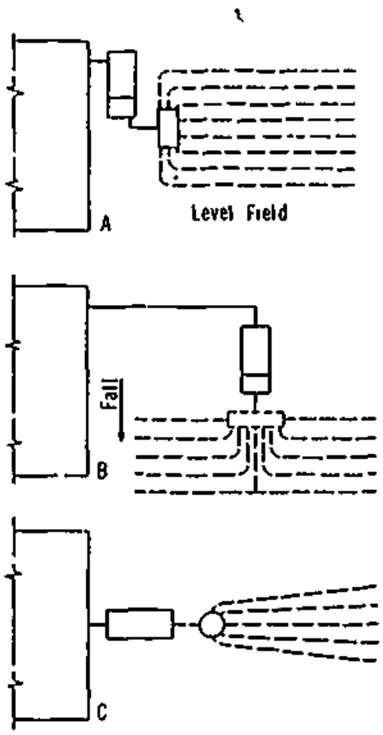


Figure 24-11. Various Patterns for Disposal-Field Tile

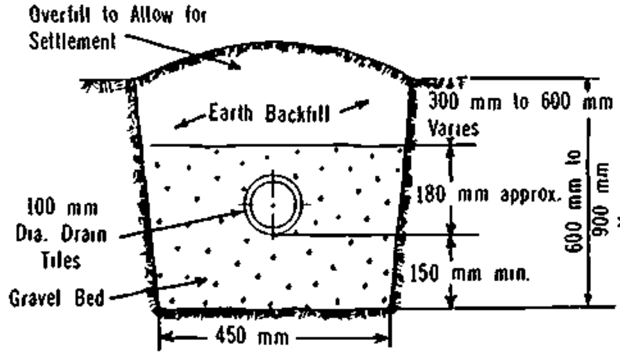


Figure 24-12. Cross-Sectional View with Typical Specifications for Absorption Trench

6 mm to 13 mm, or of perforated bituminous fibre tile. For the header, use 100 mm sewer tile with cemented joints extending to and from the distribution chamber and to the start of the straight runs of the laterals.

i) The backfill preferably should be sandy loam and overfilled to allow for settlement.

12. Disposal-Field Distribution Boxes

This section outlines the relationship of the siphon chamber and the distribution box to the sewage-disposal system.

a) Although the siphon chamber is usually an integral part of the septic tank, its function is related more to the effluent-disposal system than to the digestion of the raw sewage. It provides for even distribution of the effluent for the whole field, an important rest period during absorption of the liquid, and some protection against freezing in that the effluent is discharged from the siphon chamber in sizable quantities and not as a constant trickle.

b) Authorities agree that a distribution box is desirable in supplying all laterals equally, particularly where a siphon chamber is not used. Figure 24-13 shows details of one type of distribution box.

c) Figure 24-14 shows a somewhat differently constructed distribution box. Notice the difference between levels of the inlet pipe in both types. The outlets in the one in Figure 24-13 are located so that no liquid could remain in the box. There are advantages in both designs. It is important that all pipes in the box be cemented in place to make them watertight. A different-shaped box is shown for sloping disposal fields (Figure 24-15).

d) Figure 24-16 shows a circular distribution box made from a section of 600 mm concrete pipe. This box may be used when only three outlets and one

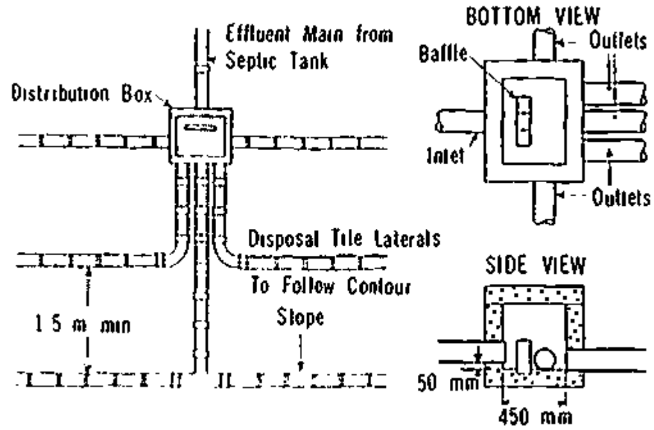


Figure 24-13. Field Design for Equal Distribution to All Laterals — for Hillsides or Non-Flushed Disposal Fields

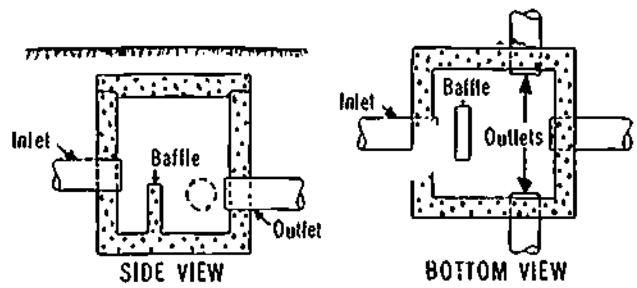


Figure 24-14. Distribution Box for Fairly Level Ground Conditions

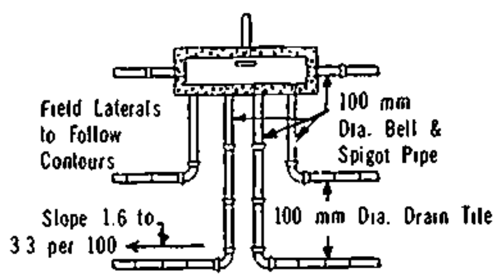


Figure 24-15. Distribution Chamber for Sloping Ground Conditions

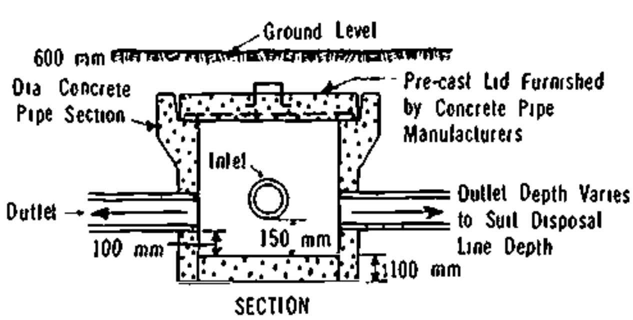


Figure 24-16. Cross-Section of Distribution Box with Three Outlets

inlet are required. The best operation results when the inlet opening is about 150 mm above the floor level and the outlets about 100 mm above it.

e) Since the box should distribute the liquid evenly in the outlet lines, care must be taken to get all the outlets on the same level. A pre-cast lid can usually be obtained. Care must also be taken in forming the bottom to make it watertight.

13. Leaching Cesspools

a) A leaching cesspool is a means of disposing of sewage effluent rather than of purifying it. Its location therefore must be chosen with great care so that ground waters will not be contaminated, making sure that the surrounding soil is kept constantly saturated and the aerobic organisms that purify the effluent are excluded from the cesspool itself. (See Figure 24-17.)

b) Cesspools are not permitted in most provinces.

c) *Artificial sand filters* are permitted in some localities where the filtered effluent may be discharged into a permissible natural outlet. The sand around the upper distributing tile (Figure 24-18) may become clogged and require replacement from time to time. A minimum of 760 mm of sand is necessary to filter the effluent sufficiently before it enters the lower line of tile (one line of tile is directly above the other). The profile or longitudinal section shows the relative positions of the tile in the hillside, with the cast iron pipe projecting into the gulley. The trench section at the left of Figure 24-18 illustrates how the field tiles with covered open-end joints are arranged in a bed or stone with a layer of sand between.

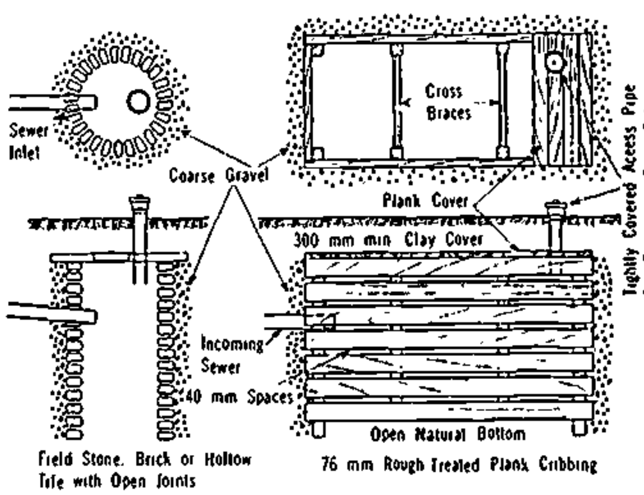


Figure 24-17. Two Types of Leaching Cesspools

d) In congested areas where regulated distances cannot be adhered to for the usual forms of disposal, it may be necessary to install a watertight tank from which the sewage would be pumped periodically by a septic-tank service contractor. Because of high operating costs, this method should be used only where absolutely necessary and only when approved by the local health authority.

e) *An above-ground filter,* as shown in Figure 24-19, may, if approved, be used where the water table is very high or the soil is exceptionally impervious.

14. Use of Septic Tank Disposal Systems

a) Provided that both the design and construction of the septic-tank system have been properly carried out, there should be no operating difficulties. Often, however, there is uncertainty whether some types of waste may be discharged safely into the septic-tank system, and whether a grease trap is necessary.

b) With normal domestic systems, the amount of grease from the kitchen would not be enough to warrant construction of a separate grease trap. Similarly, detergents, lye, or other household cleansers in normally used quantities would not hinder the bacterial action in the septic tank. Care should be taken, however, to ensure that excessive quantities of these materials do not enter the system. Where water conditioners or softeners are

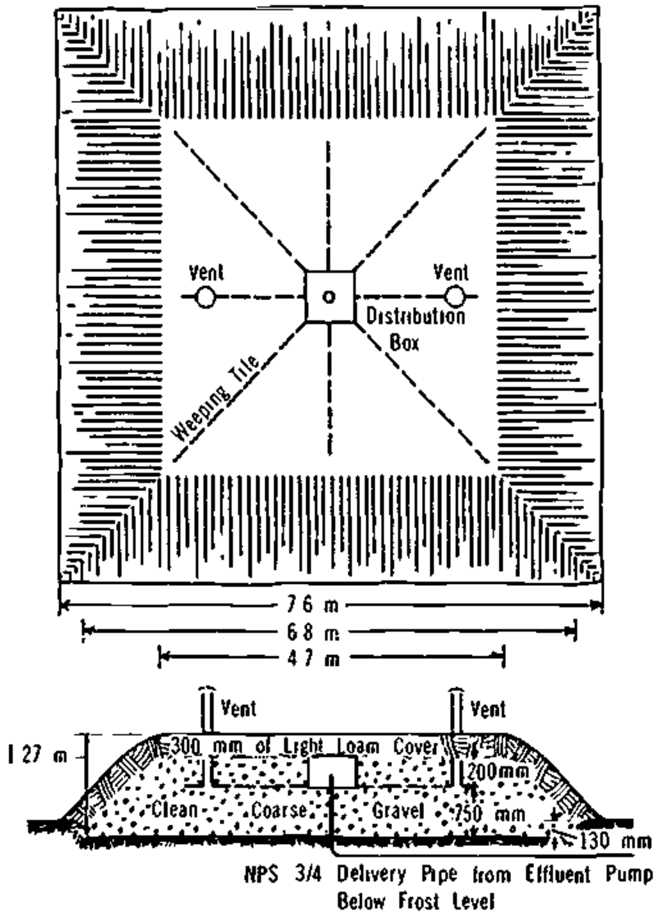


Figure 24-19. Domestic Installation — Above-Ground Filter

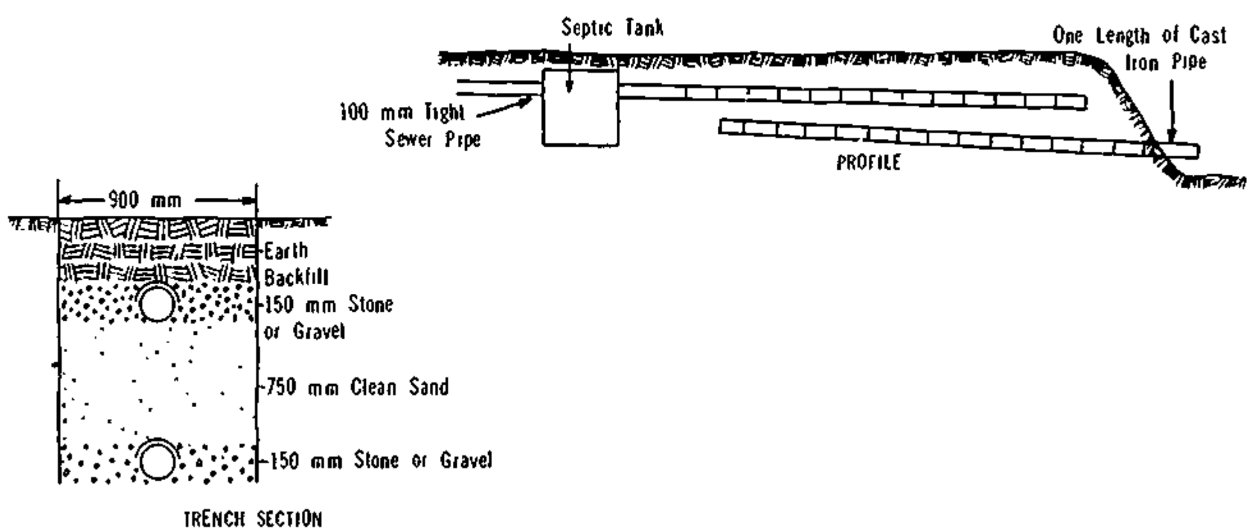


Figure 24-18. Artificial Sand Filter

used, the waste from the re-charging cycle should be kept out of the septic system.

c) Trouble sometimes is experienced with septic-tank systems after large house parties. On such occasions, abnormal quantities of liquid can overload the system. Similarly, a field-tile disposal bed can become overloaded if excessive watering is done on a garden in the vicinity.

d) With proper construction and operation, disposal systems need very little maintenance. With the tank capacities given above, it should not be necessary to clean a tank more than once every three years. It should, however, be inspected at least once a year and cleaned if necessary.

e) An excessive volume of cold water from any source may wash away and seriously deplete the bacteria population in a tank because the operating temperature is definitely lowered.

f) Laundries, hospitals, or large public kitchens contribute volumes of wastes that would be better handled in a different manner. An engineer should be consulted on these and other unusual cases.

g) Small amounts of hypochlorites or household bleaches, such as those used to disinfect water supplies or to sterilize dishes, will not reduce the septic action, but the habitual entry of large quantities could be detrimental.

h) Trouble could arise in some part of a sewage-disposal system that would require excavation of the earth-cover from the trouble spot. To readily locate the pipelines, septic tank, or distribution box, a chart of the entire layout should be made at the time of installation showing where each item is located in relation to a reasonably permanent object, such as a building wall. Figure 24-20 gives some of the necessary dimensions in a typical disposal system.

i) In addition to charting the layout of the septic-tank system, a running record of cleanings and pump-outs of tanks and cesspools should be posted in a visible location.

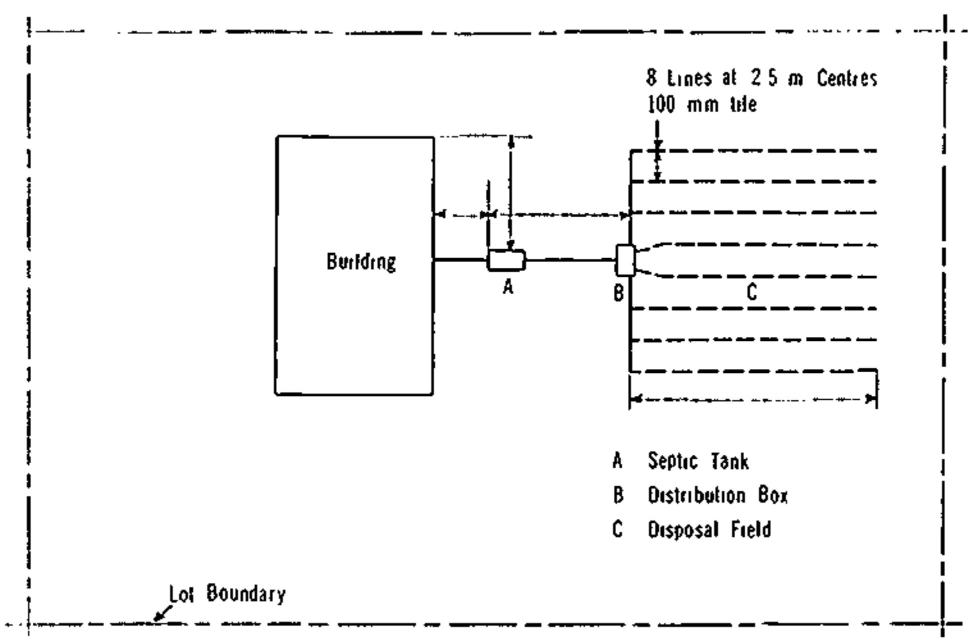
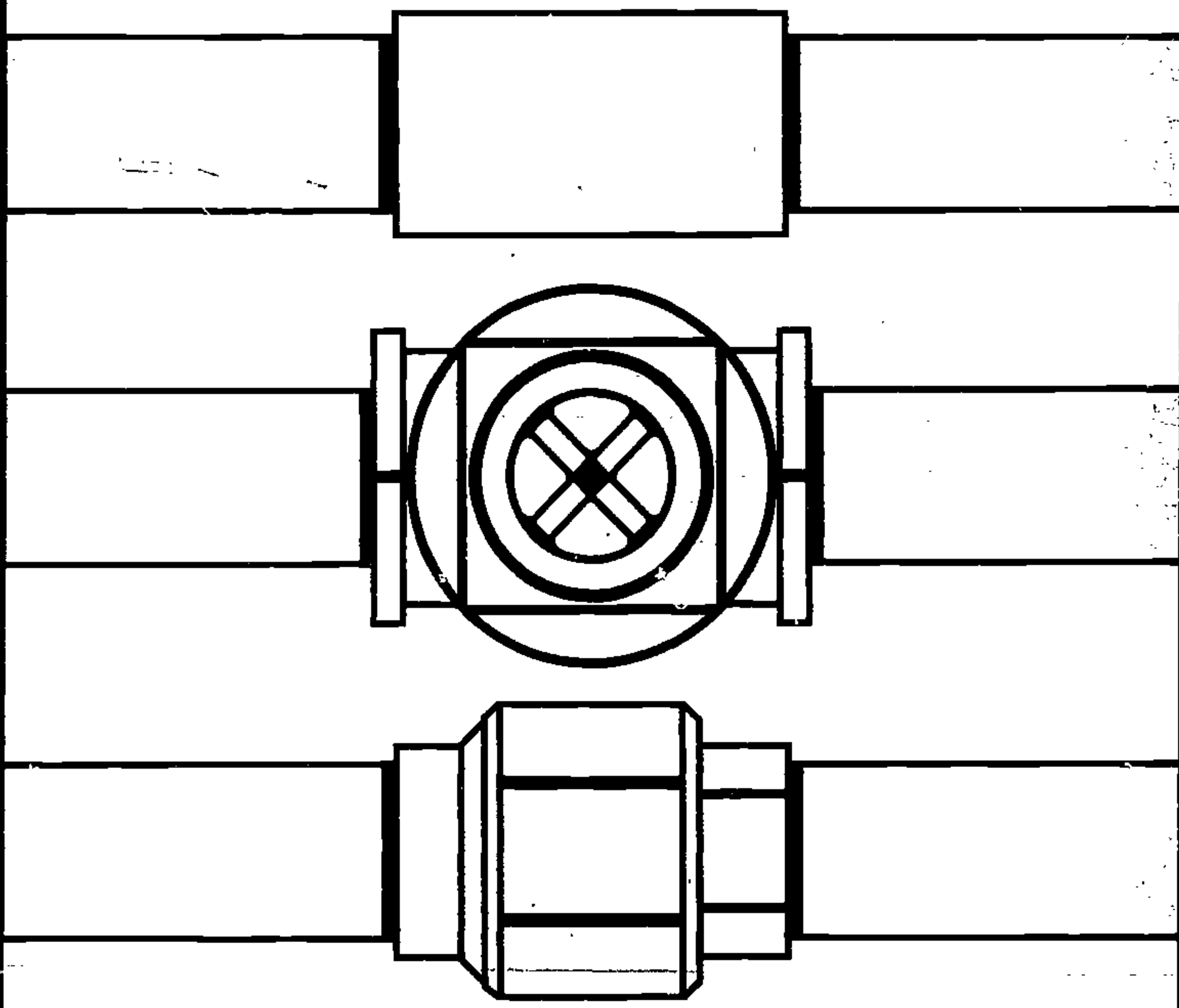


Figure 24-20. Typical Disposal System

Public Underground Water-Distribution Systems 25



PART 25
PUBLIC UNDERGROUND WATER-DISTRIBUTION SYSTEMS

Description of Systems

1. A public water-distribution system comprises pipes, fittings, valves, and hydrants that convey water from the supply source to the property line of non-public property.

2. The type of distribution system depends on the layout of the streets, the location of the pump house or supply works, and the storage facilities. Most distribution systems are of the grid type or looped-grid type (see Figure 25-1) although some of the older systems employ loops and feeders for areas as needed.

3. The branch-type system also shown in Figure 25-1 is not desirable nor recommended, for the following reasons:

a) It has dead ends that must be drained periodically.

b) It has flow from only one direction, and in the event of a line break would isolate all areas beyond the break.

4. The grid system has the advantage of having flow to any spot from more than one direction and has no dead ends.

5. The grid system is strengthened by the installation of a loop, or belt, feeder system as shown on the left-hand side of Figure 25-1.

6. A loop system approximately doubles the capacity of the grid when compared to the central feeder type on the right of Figure 25-1.

7. The piping in a water-distribution system is generally cast-iron (ductile) asbestos-cement pressure pipe, plastic pressure pipe, and sometimes galvanized steel pipe. The smaller pipes serving the water-service pipes to buildings are generally made of copper or plastic.

8. A community water-distribution system may comprise one or more feeder lines and grids, and one or more storage areas. (See Figure 25-1.)

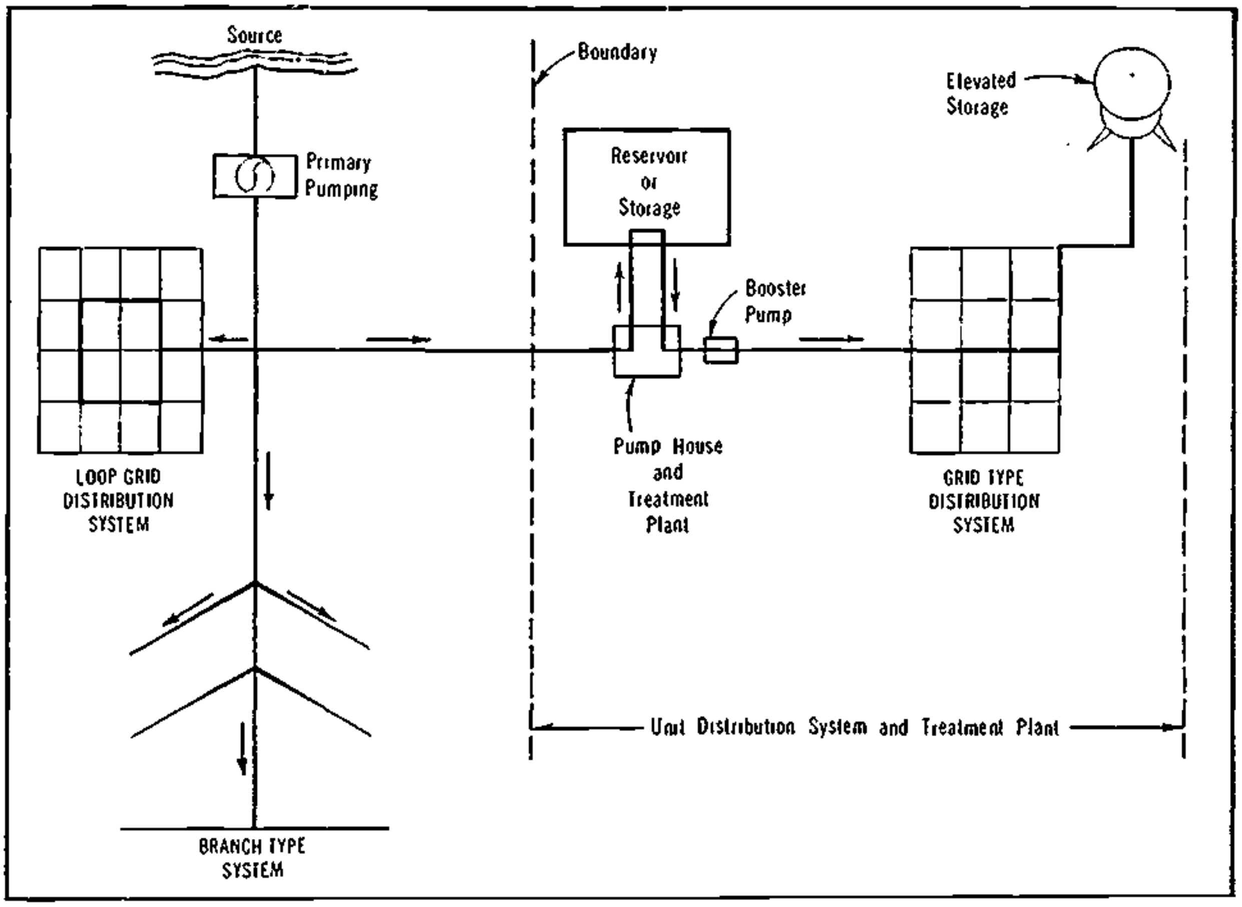


Figure 25-1. Schematic Diagram of Water-Distribution Supply Systems

9 In communities where the topography is such that one system would not adequately service both high-elevation areas and low areas, a separate system for each may be required. If more than one system is used, additional gate valves must be installed for emergency use.

10. The normal pressures in the distribution system are 400 to 500 kPa, although 280 kPa gauge is adequate for residential areas. In some areas, high pressures are maintained in the mains, and pressure-reducing valves are installed in or close to each building.

11 For fire-fighting purposes, fire-booster pumps are used to increase the pressure to about 700 kPa gauge in the mains serving hydrants.

12. A complete public water-distribution system, starting at the supply line, generally comprises:

a) Storage tanks.
b) Purification works.
c) Distribution lines.
d) Service lines to buildings.
e) Supply lines to hydrants.

NOTE: Hydrants are covered in Part 28.

13. Where topography permits and where the water demand fluctuates, storage tanks are used to supplement peak demands and to cope with emergencies, such as fire and pump failure. Elevated storage tanks are used in some cases to provide the necessary head for distribution.

14. The capacity of a storage reservoir or tank will depend on the water-demand characteristics of the installations. In general, storage capacity should be sufficient to satisfy both the domestic requirements and a full fire flow. In some cases, the mains may be large enough to eliminate the need for intermediate storage, and peak demand may be met direct from the source of supply.

15. Single mains generally have three valves at crosses, two at tees, and one on single branches (for a hydrant, etc.).

16. A single main is often located on the north and east sides of the street for protection against freezing.

17. On dual-main systems, service headers are added on the south and west sides of the streets and valves generally are installed as follows: one on each main at intervals of two blocks; one at the junction of the service header and the main; one on each side of the two branches to hydrants.

18. The advantages of the dual-main systems over single-main systems are mostly local in extent because service headers do not increase the amount of water available in their own block. The important fact is that breaks in mains do not cut off hydrants and do not make dead ends in dual-main systems.

19. The portion of the water supply lying between the main and a building is known as the service line, or water service pipe. (See Figure 25-2.)

20. The service pipe is either connected rigidly to the street main or is a flexible goose neck, fastened by means of a corporation stop tapped into the main. (See Part 27.) The goose neck is used to avoid breakage of the line resulting from sudden shocks or settlement.

21. The materials used in the water-service pipe from the curb stop into the building are governed by the plumbing code.

22. The curb stop is generally installed close to the property line, and a cast iron curb box is generally installed as shown in Figure 25-2.

Disinfection of Water Mains

23. The disinfection of new water mains should form part of the contract specifications and should be carried out before the system is taken over from the contractor.

24. Only a thoroughly experienced person should be in charge of disinfecting water mains or parts that have been repaired.

25. When an old pipeline is opened by tapping or by a split in the line, etc., there is always the danger that contamination from the surrounding material will enter the water main, especially when the water is turned off in the main. For this reason, it is not advisable to lay sewer and water pipes in the same trench.

26. The following procedure applies particularly to breaks that involve partial or complete de-watering of the mains. In the case of a minor leak or break being repaired with a clamping device, the leak should remain exposed while the clamp is being applied. The gasket that comes into contact with the break should be disinfected with a strong hypochlorite solution before being clamped into position. A recommended calcium hypochlorite solution is 20 to 25 parts per million.

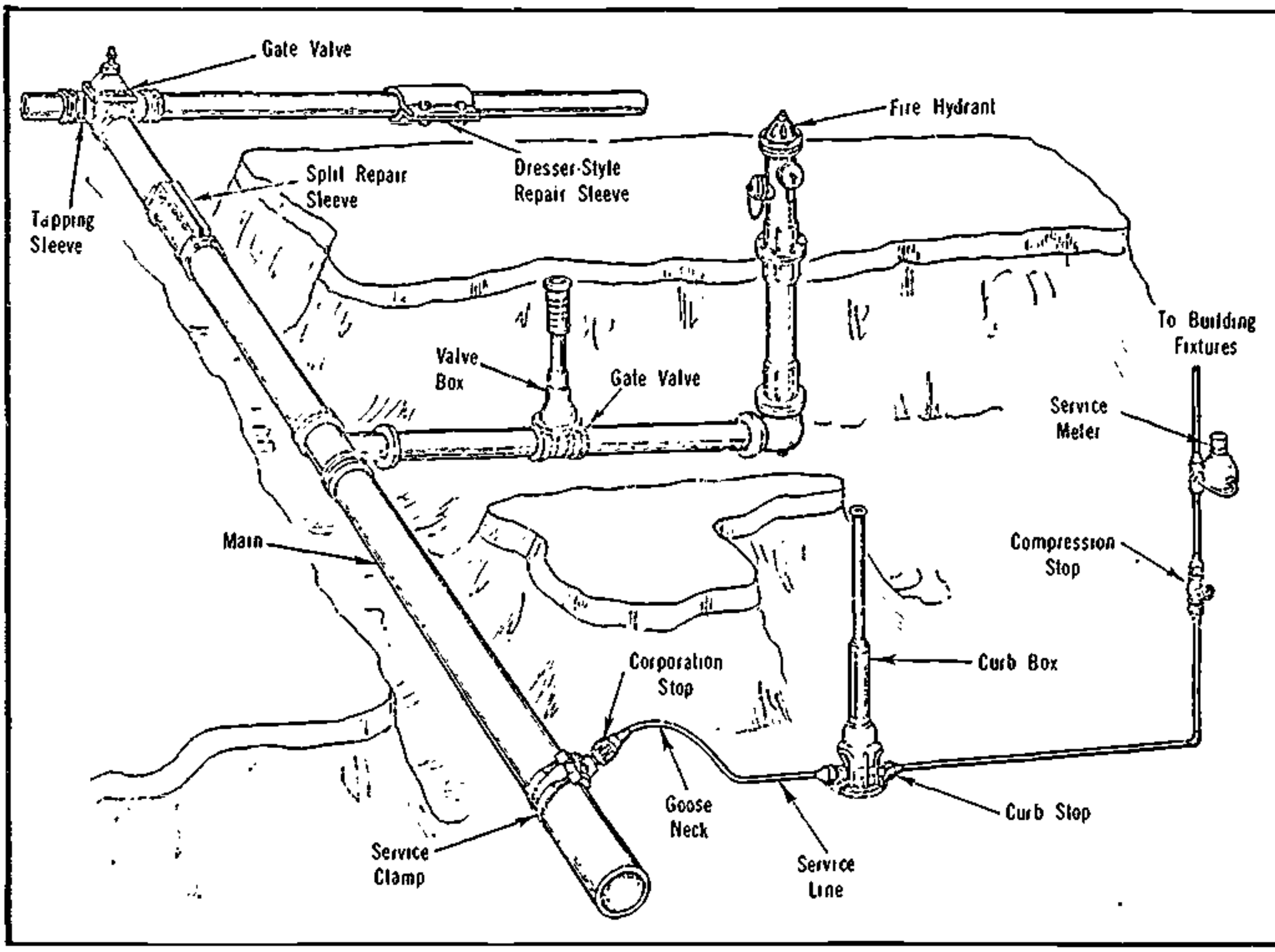


Figure 25-2. Some Components of a Water-Distribution System

27 The need for haste in putting the line back into service will depend on the importance of the area served by the water main. The time factor will often dictate the type of disinfection used, whether liquid or compound, and in what strength.

28. The pipe fittings and packing material should be disinfected with a 25 ppm solution of calcium hypochlorite. Chlorinated lime can also be used at 50 ppm. Fittings and packing material can be soaked in the chlorine solution, and the inside of the pipe should be swabbed with the same solution.

29. Where the direction of flow is known and where tests show that the water that will flow into the newly installed section and fittings has a free chlorine residual of about 0.5 ppm, it is likely that no contamination would reach the user, but the distance to the fixtures must be considered.

30. The chlorine solution may also be introduced into the water main through a tapping in the main that was made for that purpose and is located upstream from the new or repaired section. This is additional to the initial disinfection of the pipe during installation The section should be shut off and the chlorine solution allowed to remain in the pipeline for 24 hours. The water is then flushed out before putting the pipe into service.

31. Table 25-1 shows the amount of chlorine compounds required for disinfecting either repaired water lines or extensions to existing lines.

32. As the new water main is filled, the chlorine is fed into it. The water pressure in the main should be kept at a minimum. While the chlorine is being applied, the water should be allowed to escape from the end of the main until an orthelidin test shows a deep orange color. The chlorinated water should be allowed to remain in the line for 24 hours, then the main should be thoroughly flushed and the service put into use.

33. Unsatisfactory biological tests may be the result of contaminated jute, hemp, or other material used in the joints. Only sterilized material should be used. (Refer to paragraph 28.)

Table 25-1. Chlorine Compounds Required for Disinfecting Water Lines

Product	Amount of Compound	Volume of Water (Litres)
Calcium hypochlorite (chlorine 65-70%)	1.6 kg	100 L
Chlorinated lime (chlorine 32-35%)	3.2 kg	100 L
Liquid laundry bleach (chlorine 5.25%)	2.2 L	10 L

NOTE: Each of the above makes a 1% solution (10,000 ppm).

34. Table 25-2 gives the chlorine requirements for 100 m lengths of various sizes of pipe.

Table 25-2. Chlorine Requirements per 100 m Lengths of Pipe

Pipe Size (NPS)	Volume of 100 m of Pipe	Amount of 1% Solution Required to Insure 25 ppm of Calcium Hypochlorite (= 1/400 of Volume)
4	821 L	2.05 L
6	1684 L	4.21 L
8	3223 L	8.07 L
10	5086 L	12.72 L
12	7297 L	18.24 L

Example:
Disinfection of 300 m of NPS 8 water main would require:

a) 3 X 8.07 = 24.21 L of 1% solution.

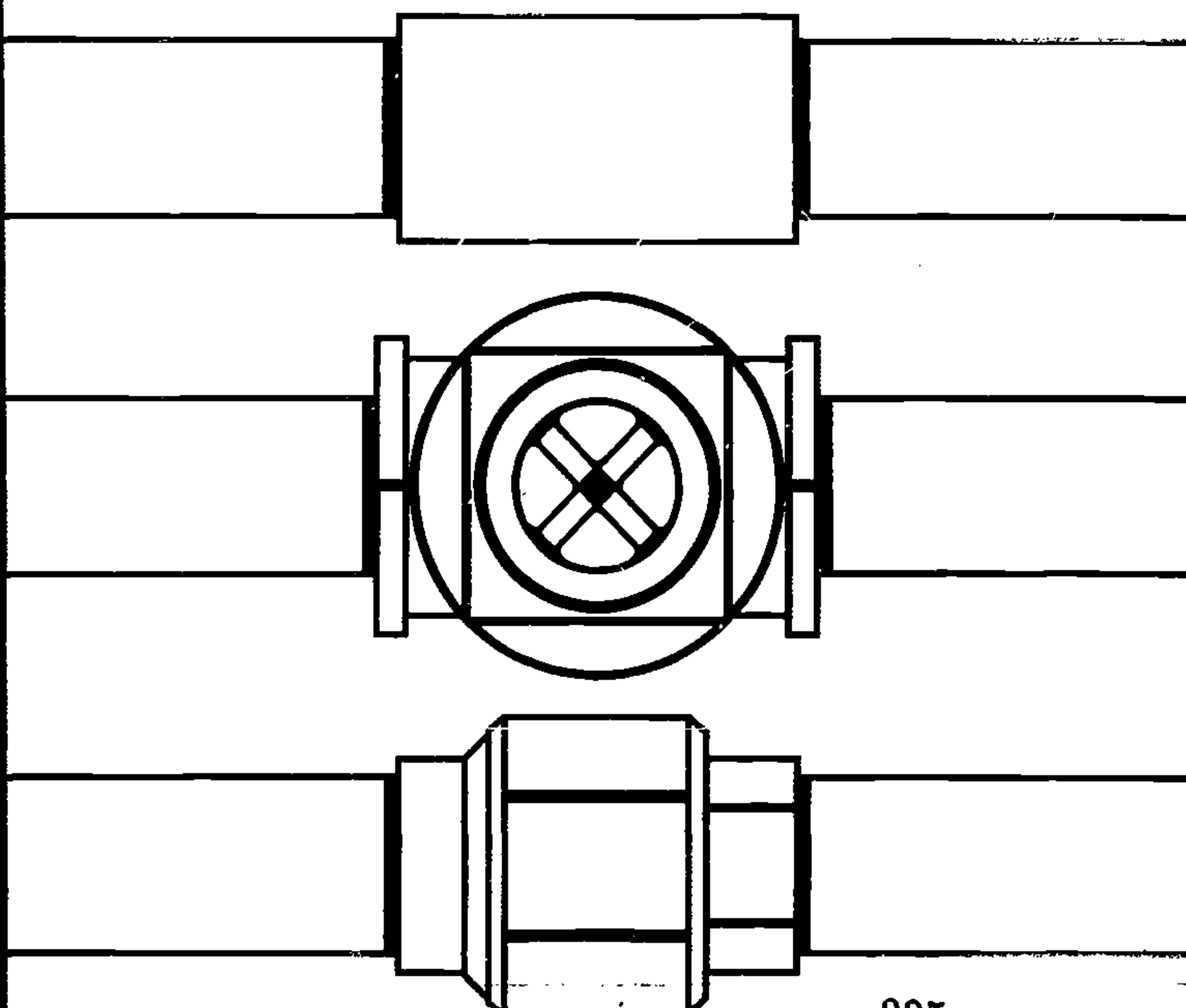
b) 1.6 kg of chlorinated lime mixed with 50 L of water would produce a suitable 1% solution.

Thrust Blocks

35. Where the water mains and components are assembled with a hub, mechanical joint, or any type of compression joint, a concrete thrust block should be cast in place at all dead ends, at changes in direction of the pipeline, and at other places in the piping system where pressure or expansion in the pipe might cause a joint to rupture.

36. The concrete used for thrust blocks should be 15 MPa class or better, and should be placed between the fitting or pipe to be blocked and the solid earth behind it.

Domestic-Water Pumps, Softeners, and Conditioners 26



PART 26
DOMESTIC-WATER PUMPS, SOFTENERS, AND CONDITIONERS 267

This part of the manual deals with water pumps, water systems, and conditioned water. The descriptions and illustrations cover basic fundamentals, selection, and application, and were adapted from the *Home & Farm Water Supply Manual* by courtesy of F. E. Myers (Canada) Ltd.

1. Sources of Water Supply

a) Ponds, Lakes, Streams, Open Reservoirs

It is essential to study the specific needs to be supplied by the water source, such as general household uses, drinking, washing, bathing, fire protection, crop production, and animal watering in barnyard or pasture. The primary considerations in the development of the water supply are purity, quantity, and economy.

Water from ponds, lakes, streams, and open reservoirs is often used for irrigation, stock-watering, fire protection, etc. However, water from these sources usually is not sanitary for human consumption because of possible contamination.

Every water source should be tested if it is to be consumed by humans or animals or used in the preparation of food for sale. Health department officials will gladly co-operate in planning the development of a source and testing ~~it~~ for purity. They have the information needed to determine the depth and ground strata through which the well shaft must pass to reach pure water in the required quantity and volume.

If tests reveal that water is contaminated, the health department or local well driller will recommend methods of purifying it. Small chlorinators may be installed at the pump and do the same work as large chlorine purifiers in city waterworks. Filtration of impure water through gravel, sand, or other materials will not remove bacteria, although it may remove much of the sediment and improve the clarity of the water.

The purity of untested water should never be taken for granted Before it is used, it should be tested or boiled for 10 minutes or more. Typhoid fever, amoebic dysentery, and many other serious diseases may originate in a contaminated water source.

The water sources in Figure 26-1 all receive their supply from rain or snow. As water falls, it may collect to form lakes, rivers, or ponds that are known as surface waters. The remainder of the rainfall that seeps below the surface of the earth may be absorbed by the plant roots or continue until it meets solid strata and accumulates where it is available as natural spring or well water. Each well shown in Figure 26-1 uses a different method for obtaining water from underground sources. Following are the various sources of water supply:

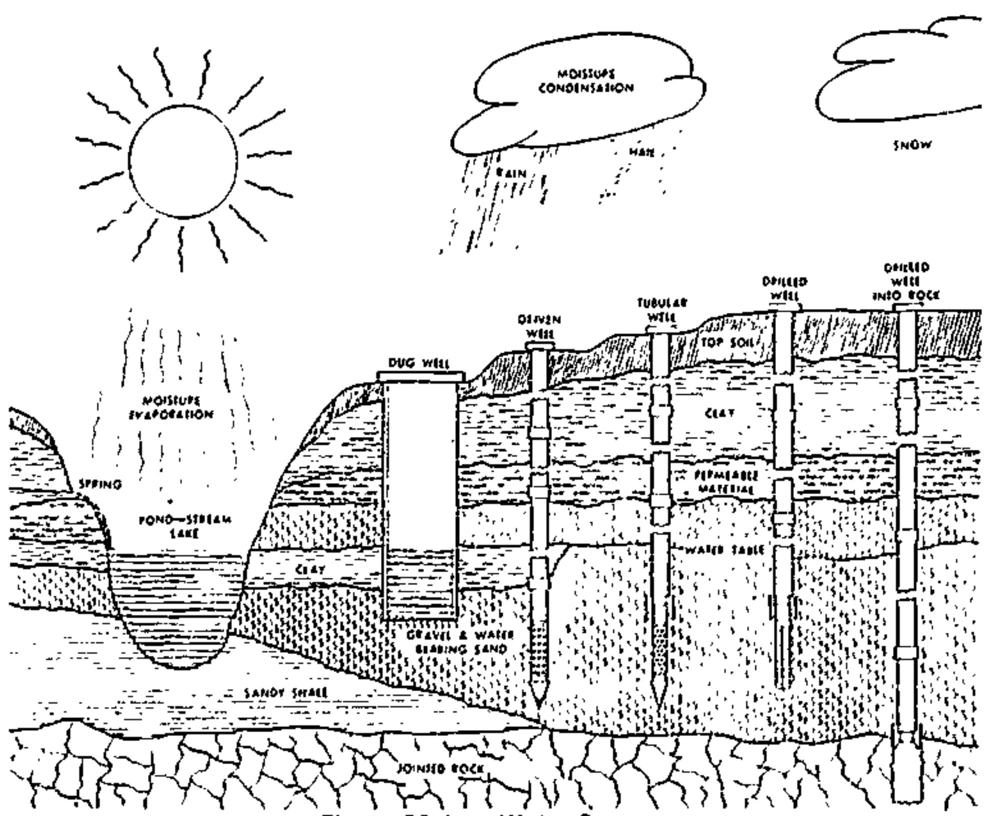


Figure 26-1. Water Sources

b) Cisterns and Reservoirs

Cisterns and reservoirs used for storage of rain water offer a limited source of soft water that should not be used for human or animal consumption unless it is thoroughly boiled or properly treated with chlorine.

c) Springs

Water from springs and pools for domestic use must be periodically checked for purity because the chances of contamination are very great, particularly during periods of drought.

Springs not located sufficiently near the point of use require extensive piping systems and construction of a basin to collect the water for future needs. The collection box or basin should be large enough to impound most of the flow and have slots or openings to admit the water flowing from the spring.

d) Dug Wells

The dug well permits the flow of water into the excavation, furnishing a relatively large quantity of water from a shallow source. The walls of a dug well should be curved or lined with rocks, bricks, wood, or concrete to prevent the entry of surface water and caving. Because of their necessary location in low points of the terrain, close to ground level, dug wells are generally subject to contamination from surface seepage and sub surface drainage.

A high percentage of dug wells now in use are polluted. Every possible precaution should be taken by those using this type of well to guard against pollution. Driven or drilled wells are considered preferable because they give greater assurance of safety against pollution.

e) Drilled Wells

Drilled wells are installed when greater water volume and depth are needed. In the construction of a tubular well, the drilling operation stops at the water-bearing and sand stratum; in the drilled well, the casing or pipe is driven down as the well is drilled and extends either to water-bearing sand or continues to rock.

Other types of driven wells, such as the open-end variety, are less easily clogged with fine particles of sand in areas adjacent to large lakes, but they require special apparatus and equipment for proper development and should be done by experienced well drillers.

When the well goes down to rock, the casing or pipe is driven until rock is reached, then drilling continues into the rock to the water supply. This type of well often does not require a screen. As a guide to the better understanding of a drilled-well installation, typical illustrations of the tubular and drilled wells are shown in Figure 26-1.

A soundly constructed drilled well offers the maximum of efficiency, volume, and purity.

2. Pumping Fundamentals

a) Suction

The function of most pumps is to create a vacuum. When the pump is completely installed, the suction line (the pipe from the pump into the well) is filled with air at atmospheric pressure (the weight of the air around us, usually measured in kPa) from the level of the water in the well to the pump. When the pump is started it sucks the air out of the pipe line, thus creating a vacuum. The atmospheric pressure on the water in the well drives the water into the suction line, then to the pump. This is called suction.

At sea level, the pressure of atmosphere is 100 kPa. This means that a square centimetre column of air from the earth's surface at sea level up to infinity has a mass of 7.03 kg. As stated, a suction pump develops a suction or reduced atmospheric pressure (vacuum) in its suction chamber. When a pipe is connected to this chamber and its other end is submerged in water exposed to atmospheric pressure and the pump is running, an unbalanced pressure condition exists. Pressure on the exposed water surface is 100 kPa at sea level Pressure in the suction chamber can be reduced to approximately a minus 100 kPa; thus the greater pressure on the water surface will force water up the pipe to the suction chamber.

How high can water be raised or lifted by suction (suction lift)? The answer is a height equivalent to the pressure differential established between the 100 kPa of atmospheric pressure on the surface of the water to be pumped and the suction chamber of the pump.

This raises the problem of converting kilopascals to metres. It has been proven that 1 kPa from any source will raise a column of water 0.10 m (or exactly 0.0981). If we can remove all the pressure of atmosphere from the pump suction chamber, the pressure distance becomes 100 kPa; therefore a perfect vacuum would cause water to rise 0 10 multiplied by 100, or 10.00 m (or exactly 9.8 m). However, owing to hydraulic and mechanical losses in a suction pump, 7.6 m is considered the maximum practical suction lift at sea level. At altitudes higher than sea level, total suction lift will be reduced 1 m for each 1000 m of elevation. As a practical matter, it is advisable to deduct 1.2 m from the manufacturer's specifications for every 1000 m above sea level.

b) Friction Loss

The movement of water through a pipe develops friction similar to that of a brake. The amount of pipe friction depends upon the diameter of the pipe, its length, and the rate of flow of water in litres per minute (The age of steel pipe also has a bearing on the amount of friction loss, because the inside diameter becomes smaller with rust and scale.) The degree to which the flow of the water is retarded by the pipe is known as friction loss.

The use of a pipe that is too small will result in an unsatisfactory flow of water, pressure loss, and higher pumping costs. The figures in the first column of Table 26-1 show litres per minute, and the figures in the other columns show the friction loss for each 100 m of pipe of the various sizes given.

For example, 20 L per minute through 100 m of NPS 1 pipe results in a friction loss of 3.58 m. The same 20 L per minute through 100 m of NPS ¾ pipe results in 11.59 m of friction loss, and 45.61 m of friction loss through NPS ½ pipe. If the pipe lengths were doubled, then the friction loss also would be doubled.

Friction loss *must* be taken into consideration when pipe is selected for a water system.

The friction loss shown in Table 26-1 for 17-year-old pipe should be the determining factor for selecting new pipe. Since all water is corrosive, by following this suggestion allowance will be made for corrosion and this will result in an adequate flow of water after several years' service.

To arrive at friction loss for new pipe, multiply readings by 0.6.

The friction loss through copper tubing, plastic pipe, and new galvanized pipe is practically the same. Friction loss for 30 L per minute through 100 m of NPS 1, 17-year-old pipe equals 7.58 m; multiply this by 0.6 and the friction loss through 100 m of NPS 1 copper tubing and plastic pipe is 4.55 m.

Friction loss is also created by the use of plumbing fixtures such as tees, elbows, and valves. These retard the flow of water.

Table 26-1. Loss of Head in Metres Due to Friction, Per 100 m of 17-Year-Old Steel Pipe. For New Pipe Multiply Readings by 0.6—For 25-Year-Old Pipe Multiply Readings by 1.2

	NOMINAL PIPE SIZE												
Litres	½	¾	1	1¼	1½	2	2½	3	4	5	6	8	10
1	0.18	0.05	0.01										
2	0.64	0.16	0.05	0.01									
3	1.36	0.35	0.11	0.03	0.01								
4	2.31	0.59	0.18	0.05	0.02								
5	3.50	0.89	0.27	0.07	0.03								
6	4.91	1.25	0.38	0.10	0.05								
7	6.53	1.66	0.51	0.13	0.06								
8	8.35	2.12	0.65	0.17	0.08	0.02							
9	10.39	2.64	0.81	0.21	0.10	0.03							
10	12.63	3.21	0.99	0.26	0.12	0.04							
15	26.77	6.80	2.10	0.55	0.26	0.08							
20	45.61	11.59	3.58	0.94	0.44	0.13	0.06						
25	68.95	17.52	5.40	1.42	0.67	0.20	0.08						
30	96.64	24.56	7.58	1.99	0.94	0.28	0.12	0.04					
40		41.85	12.94	3.40	1.60	0.47	0.20	0.07	0.03				
50		63.26	19.52	5.13	2.42	0.72	0.30	0.10	0.04				
60		88.67	27.41	7.20	3.40	1.01	0.40	0.15	0.05				
70			36.39	9.57	4.51	1.34	0.57	0.19	0.07				

(continued)

Litres	½	¾	1	1¼	1½	2	2½	3	4	5	6	8	10
			NOMINAL PIPE SIZE										
80			46.60	12.26	5.77	1.71	0.72	0.25	0.08				
90			57.90	15.25	7.19	2.13	0.90	0.31	0.08	0.03			
100			70.38	18.53	8.74	2.59	1.09	0.38	0.10	0.03			
150				39.26	18.53	5.48	2.31	0.81	0.21	0.07			
200				66.89	31.57	9.35	3.93	1.37	0.36	0.12			
250				101.12	47.73	14.13	5.95	2.06	0.55	0.18			
300					66.90	19.81	8.34	2.89	0.77	0.26			
350					89.00	26.35	11.08	3.85	1.02	0.34			
400						33.75	14.20	4.93	1.31	0.44			
450						41.97	17.66	6.13	1.63	0.54			
500						51.02	21.46	7.45	1.98	0.66			
550						60.87	25.61	8.89	2.37	0.79			
600						71.51	30.09	10.45	2.78	0.92			
650						82.93	34.90	12.11	3.22	1.07			
700						95.14	40.03	13.90	3.33	1.23			
750							45.49	15.79	4.20	1.40	0.57		
800							51.26	17.80	4.74	1.58	0.64		
850							57.36	19.91	5.30	1.76	0.72		
900							63.76	22.13	5.89	1.96	0.80		
950							70.48	24.47	6.51	2.17	0.88		
1000							77.50	26.90	7.16	2.38	0.97		
1200								37.71	10.04	3.34	1.36		
1400								50.17	13.35	4.44	1.81		
1600								64.24	17.10	5.69	2.32		
1800								79.90	21.27	7.07	2.89		
2000								97.12	25.85	8.60	3.51		
2200									30.84	10.26	4.19	1.10	
2400									36.23	12.05	4.92	1.29	0.43
2600									42.02	13.98	5.71	1.50	0.50
2800									48.20	16.03	6.55	1.72	0.57
3000									54.78	18.22	7.44	1.95	0.64
3500									72.88	24.23	9.90	2.60	0.86
4000									93.32	31.03	12.68	3.33	1.10
4500									116.07	38.60	15.77	4.14	1.37
5000										46.92	19.17	5.03	1.66
5500										55.98	22.87	6.01	1.98
6000										65.76	26.87	7.06	2.33

Based on Williams & Hazen Formula with Constant C = 100

c) Conversion Factors

As will be seen, in selecting a water system you must convert kilopascals of pressure to metres, and vice versa. To do this, you must use what are known as conversion factors. They are as follows:

To convert kilopascals to metres of head, multiply by 10.2.

To convert head in metres to kilopascals, multiply by 0.098.

These factors are arrived at by the simplified method accompanying Figure 26-2. Their use is necessary to determine the required pneumatic tank pressures to overcome pipe friction loss or elevation. When the necessary pressure is known, the water system can be selected.

In Figure 26-2, the container has a depth of 1 m and a base area of 1 m^2 and is filled with water. Its mass equals 1000 kg and it exerts a pressure of 9.807 kPa on the base; that is, the pressure of 1 m of water equals 9.807 kPa. The unit of pressure in SI metric is known as the pascal (symbol Pa), but since the pascal is a very small unit of pressure, the kilopascal (symbol kPa) is more frequently used.

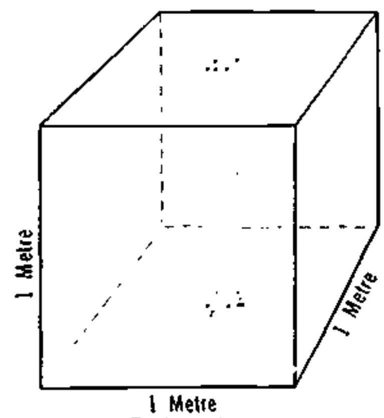


Figure 26-2. Determination of Conversion Factors

The pascal equals a force of 1 N (newton) distributed over an area of 1 m^2:

1000 Pa equals 1 kPa
1000 kPa equals 1 MPa

1 kPa equals 0.145 pounds per $inch^2$
1 pound per $inch^2$ (or 1 psi) equals 6.895 kPa

1 kPa equals 0.102 kg force per m^2
1 kg force per m^2 equals 9.807 Pa

1 m depth of water equals 9.807 kPa
1 foot depth of water equals 2.989 kPa
(The last two conversions vary with temperature)

1 atmosphere equals 101.3 kPa, which equals 14.7 pounds per $inch^2$

The unit of force is known as the newton (symbol N). Mass (or weight) and force are different. In the SI metric system, mass is measured in kilograms, whereas force is measured in newtons.

To accelerate a mass of 1 kg to a speed of 1 m per second in 1 second requires a force of 1 N, which equals 0.2248 pounds force and in metric terms this equals 0.102 kilograms force:

1000 N equals 1 kN
1 kg force equals 9.807 N
1 N equals 0.102 kg force
1 lb force equals 4.448 N

The following paragraphs describe a typical example of the application of conversion factors in selecting a water system:

A water system, including the tank, is installed at the well in a frost-proof, well-ventilated pit. The pump has a capacity of 30 L per minute. The dairy barn is located 80 m from the well, with an elevation of 8.00 m above the location of the water system intake. After referring to Table 26-1, the NPS 1¼ pipe has been selected, with friction loss of 1.99 m per 100 m (80/100 m x 1.99 m of friction loss equals 1.59 m). Thus 1.59 m of friction loss plus 8 m of elevation equals 9.59 m of friction loss and elevation.

It now is necessary to find the required pressure to overcome 9.59 m extra head. This is done by multiplying 9.59 m by 9.807, the factor used in converting metres of water to kilopascals (kPa) of pressure. This gives 94.05 kPa, which means that this much pressure is required to move the water to the dairy barn, and when it arrives there it will have no further pressure.

In most cases, when water leaves the pressure tank it is desirable that it be at a minimum pressure of 138 kPa and a maximum pressure of 276 kPa. In the above example, therefore, you would have to add the 94.05 kPa to the 138 kPa and also the 276 kPa to determine the corrected setting of the pressure switch for this installation.

(The pressure switch starts the pump motor when the pressure in the tank has dropped to the minimum, and stops the motor when it has reached the maximum.) Therefore the pressure-switch setting for this example would be, in round figures, 230 kPa minimum and 370 kPa maximum.

Now assume that in the above example NPS 1 pipe is used instead of NPS 1¼ pipe. On referring to the friction Table 26-1, we note that NPS 1 pipe at 30 L per minute would create 7.58 m friction per 100 m of pipe. Multiplying this by 0.8, the friction loss in 80 m of NPS 1 pipe in the example would be 6.06 m. With NPS ¾ pipe, the friction loss would increase to 19.64 m.

Obviously, the proper pipe size for the above installation is NPS 1¼. This example clearly shows that when there is excessive pipe-friction loss, as would be the case with NPS ¾ pipe, the pumping cost would be much greater. Therefore, always use a pipe size large enough to keep pipe-friction losses to a minimum.

The above examples assume the use of steel pipe. As stated, plastic and copper pipe do not create as much friction loss as does steel.

d) Total Head

The total head is the load on the pump designated in metres.

When reciprocating-type or plunger-type pumps are to be used, you need to know the total head to determine the size of electric motor to place on the pump. The loading of motors on submersible and ejector-type pumps is covered on a later page.

The total head is the sum of the vertical lift from the water to the pump, plus friction loss, plus the distance the water is to be elevated after leaving the pump, plus the friction loss in the discharge lines (pipes leading from the pump to the storage tank or point of discharge), plus any desired pressure at the point of discharge.

Here again the pipe-friction loss must be taken into consideration. The more friction loss in both suction and discharge lines, the greater the total head of the pump load.

3. Pump Operating Characteristics

Table 26-2 illustrates some pertinent characteristics of various types of pumps used in domestic water systems. The limits shown on the chart are general. Careful study of the basic considerations and pump characteristics should be made before selecting the pumping equipment.

There are no general rules for the best type of pump for a given installation. Each type has it particular advantages and limitations. As new pumps are developed and old ones improved, the range of best usefulness changes.

It is recommended that the operating capacity of the pump not exceed the capacity, or yield, of the source — whether adequate or limited. This is very important because over-pumping a well can cause serious damage to it or the pumping equipment.

There are several ways to prevent over-pumping. Some are as follows:

a) Select a pump that will produce no more than the source will yield at the desired operating conditions.
b) Use 9.0 m of tail pipe below the jet on deep-well jet installations.
c) Use a 9.1 m vertical suction pipe on shallow-well jet installations.
d) Use a higher setting of the pressure switch to reduce output to match yield of source, within the limits of the pumping equipment.
e) Use low-pressure cut-off switches and low-water-level cut-off switches.
f) Use flow control devices.

With a limited capacity source, the two-pump system (Figure 26-1) is recommended. The capacity of the first, or well, pump should not exceed the well capacity in flow. (See above methods to prevent over-pumping.) The function of this pump is to deliver water from the source to a tank that is open to atmospheric pressure. A control automatically operates the well pump.

A second pump, of the shallow-well type, delivers water from the atmospheric tank to a hydropneumatic tank. This pump, operating between two tanks, delivers the capacity and pressure.

TABLE 26-2. Pump Characteristics

OPERATING CHARACTERISTICS		TYPE OF PUMP: SUBMERSIBLE	JETS: Shallow Well	JETS: Deep Well	RECIPROCATING: Shallow Well	RECIPROCATING: Deep Well
Practical Limit — Suction Lift		Pump Submerged	7.6 m	6.1 m Below Jet	7.6 m	7.6 m
Usual Well Pumping Depth		To 150 m	Up to 6 m	7.6 to 90 m	Up to 7.6 m	Up to 150 m
Flow		Even	Even	Even	Pulsating	Pulsating
Effect of Increasing Head	Capacity	Decrease	Decrease	Decrease	Small Increase	
	Power	Decrease	Decrease	Decrease		
Effect of Shutting Discharge Valve	Pressure	Increase	Increase	Decrease	Increase to Destruction if No Relief Valve Used	
	Power	Decrease	Decrease	Decrease		

4. Types of Pumps

a) Centrifugal Ejector Single-Stage Pump

The ejecto pump combines two principles of pumping, that of the centrifugal pump and that of the ejector assembly. The centrifugal pump has been manufactured in one form or another for many years. Using steam as the drive fluid, ejectors were used years ago to put water into boilers of the old steam threshing engines. Both are pumps, and when combined the ejecto pump was the result.

Shallow-well units are limited to a maximum pumping depth of approximately 7.6 m, the practical depth limit of lifting water into an evacuated space by the use of atmospheric pressure. These shallow-well units have the ejectors placed inside or next to the casing of the centrifugal pump.

Deep-well units are used when the pumping level of the well is more than 7.6 m below the pump location, beyond the limits of the shallow-well units. In this system. the ejector is submersed in the well water and connected to the pump with two pipes, known as the pressure pipe and the delivery pipe.

The pressure pipe carries pressure water from the discharge section of the centrifugal pump down to the nozzle in the ejector assembly. The delivery pipe is threaded to the top of the venturi assembly on the ejector and carries the re-circulating water, plus the well water, up to the pump. This operation is smooth and continuous.

b) Principle of Operation

An easy way to describe the operation of a centrifugal pump is to compare it with swinging a pail, partly filled with water, in a circle. The water stays in the bottom of the pail. Centrifugal force keeps it there.

Had a hole been punched through the bottom of the bucket, as in Figure 26-3, a stream of water would be released. The distance the stream would have carried would have depended entirely upon the speed at which the bucket had been revolved. The faster the bucket was swung around, the greater the velocity at which the water would leave the hole in the pail. This is true of the centrifugal pump.

However, instead of using a pail, the water enters the hub or eye of the impeller and is thrown out at the rim of the impeller. This means that the diameter of the impeller and its revolutions per minute determine the velocity of the water as it leaves the rim of the impeller. The greater the velocity the higher the pressure that the pump will develop. The release of the water at the impeller rim creates a vacuum at the impeller hub.

Figure 26-4 shows a cross-section of an impeller hub in the centre and the several vanes running out through which the water is discharged.

Figure 26-5 again shows cross-sections with the impellers cut in half. Both are of the same diameter. The wider impeller will pump much more water because of a larger hub or intake and a larger cross-section for the water to pass through the impeller. However, since the impellers are both of the same diameter, when operated at the same speed, they will develop approximately the same pressure.

100 mm	200 mm
3500 RPM	1750 RPM

Figure 26-6 shows a 100 mm impeller operated with a 3500-rpm motor and a 200 mm impeller operated by a 1750-rpm motor. Even though the 100 mm impeller is only half the diamter of the other one, it is operated at twice the speed, causing both impellers to have the same rim speed, and resulting in the same pressure.

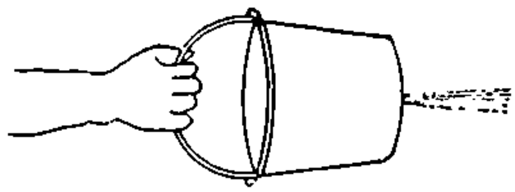


Figure 26-3. Example of Centrifugal Force

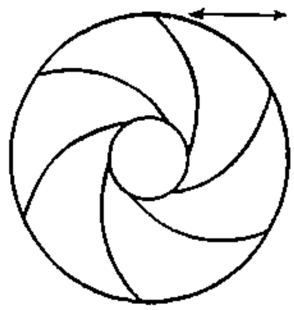


Figure 26-4. Impeller Cross-Sectioned

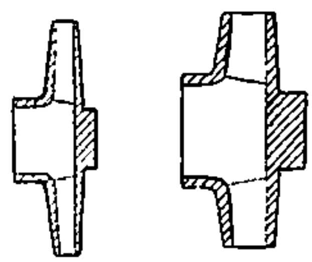


Figure 26-5. Impellers of Same Diameter

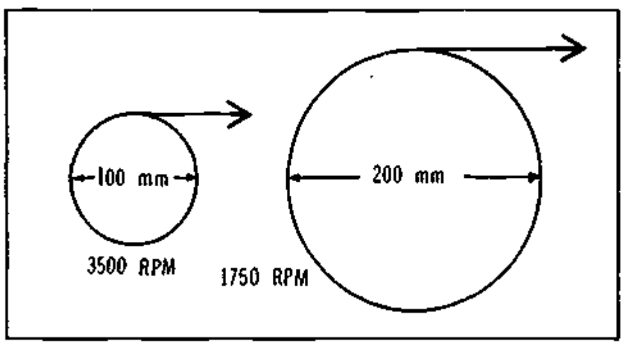


Figure 26-6. Equal Rim Speeds

Generally, there are two types of centrifugal pumps. Figure 26-7 shows the volute type, in which water leaves the impeller rim at high velocity into the volute case. The volute case increases in cross-sectional size until it has reached its maximum at the pump outlet. The purpose of this case construction is to convert the high velocity and low water pressure coming from the impellers to low velocity and a useful high water pressure.

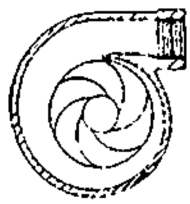


Figure 26-7. Volute-Type Centrifugal Pump

The turbine-type pump in Figure 26-8 changes the high velocity of the water to low velocity as it leaves the rim of the impeller, and to high pressure by discharging water into numerous vanes in the diffuser plate. These vanes have a narrow cross-section where the water enters from the impeller and is much wider at the rim of the diffuser plate. This causes the high velocity water to be changed into useful pressure. The velocity of the water as it leaves the rim of the impeller determines the pressure the pump will develop.

Figure 26-8. Turbine-Type Centrifugal Pump

Because of its smooth, non-pulsating flow, a centrifugal pump is ideally suited to booster-pump service. An example of booster-pump service is shown in Figure 26-9. Since the first pump has a capacity of 60 L at 140 kPa pressure, this water will enter the inlet to the second pump at 140 kPa pressure. The second pump will use the incoming pressure and add it to its own pressure. The water then leaves the second pump at 270 kPa pressure. If a third pump were added, the final discharge pressure would be 410 kPa. There would be no change in the amount of water discharged, which would remain at 60 L per minute.

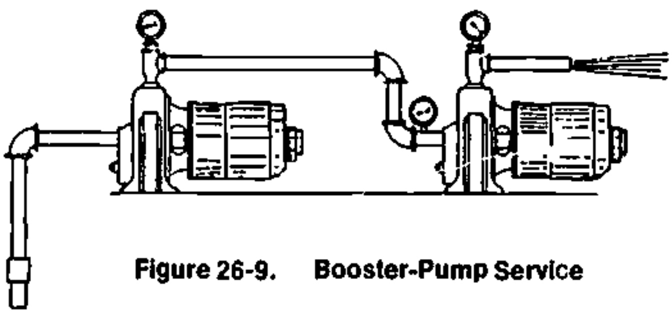


Figure 26-9. Booster-Pump Service

Figure 26-10 shows the ejecto pump, consisting of an ejector assembly and a centrifugal pump. When the discharge pressure of the combination is 270 kPa, the ejector assembly will be putting water into the hub of the impeller at 70 kPa pressure and the centrifugal pump will be developing 200 kPa, giving a discharge pressure of 270 kPa.

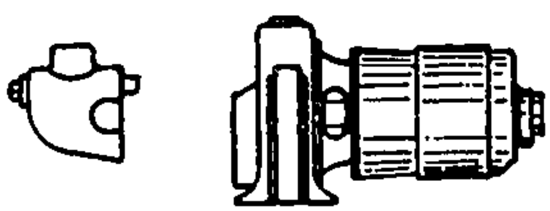


Figure 26-10. Ejecto Pump

High velocity of the water has been mentioned in describing the operation of the centrifugal pump. Where velocity increases pressure decreases. Figure 26-11 shows a fire-hose nozzle. When it is in action and the high velocity stream leaves the nozzle tip, most people think of high pressure. Actually, however, there is a low pressure and high velocity in the nozzle stream. If it were possible to have a pressure gauge on the hose where the nozzle is attached and it registered 700 kPa when the water entered the tapered nozzle, the velocity would increase and the pressure would dissipate. If it were possible to have a pressure gauge at the nozzle tip, the pressure would be practically at zero.

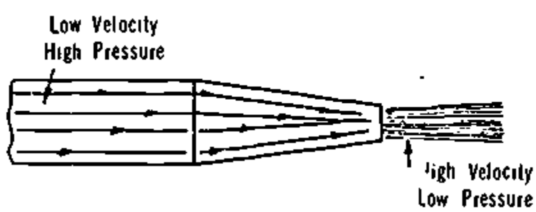


Figure 26-11. Fire-Hose Nozzle

Figure 26-12 shows a venturi tube as used with all ejecto pumps. The water enters the nozzle, which is just below the throat of the venturi tube. This water is at high pressure and leaves the nozzle at high velocity and low pressure. Because of the high velocity of the water as it leaves the nozzle tip, a low pressure or partial vacuum is created. Atmospheric pressure in the well then drives water through the foot valve at the end of the water intake pipe (See Section 5i) in this part of the manual) and into the venturi tube with the nozzle stream. Since the venturi tube now flares out, just the reverse of the fire nozzle, there is a change back to low velocity and useful pressure. This carries the re-circulating water and the well water to within suction distance of the centrifugal pump when the pump is operating at its minimum operating pressure. Maximum pump flow is now possible.

Figures 26-13 to 26-15 show three ejector assemblies typical of all makes of jet pumps. Figure 26-13 is designed for a maximum setting of 18 m and, when at its operating pressure, will discharge 1 L of water for every 1.3 L circulated. Figure 26-14 is designed for settings of from 18 m to 27 m and requires approximately 1.7 L of circulated water for each litre delivered. Figure 26-15 is designed for lifts of from 27 m to 36 m and requires approximately 2.5 L of circulated water for each litre delivered.

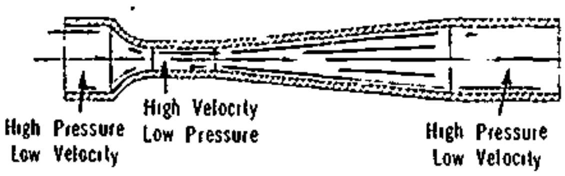
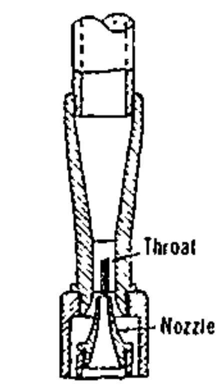
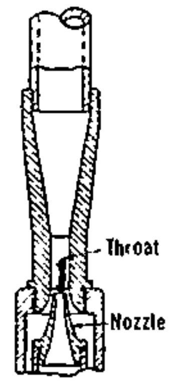


Figure 26-12. Venturi Tube



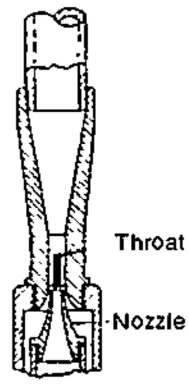
$\frac{\text{Area of Throat}}{\text{Area of Nozzle}} = 2.75$

Figure 26-13. Type A Ejector



$\frac{\text{Area of Throat}}{\text{Area of Nozzle}} = 2.1$

Figure 26-14. Type B Ejector



$\frac{\text{Area of Throat}}{\text{Area of Nozzle}} = 1.6$

Figure 26-15. Type C Ejector

Figures 26-16 to 26-18 show the discharge and suction lifts when the pumps are operating at 140, 175, and 210 kPa pressure. The total head is the sum of the suction lift and discharge head when operating at the lower pressures.

In Figure 26-16 the pump is operating at 140 kPa pressure, which equals 14 m (140 x 0.100) of head and a suction lift of 7 m. The circulating water leaves the pump at 140 kPa pressure, and since the ejector is installed at 14 m, there is 140 kPa gravity pressure (14 x 10). This causes the circulating water to enter the ejector nozzle at 280 kPa pressure. The high-velocity nozzle stream jumps from the nozzle tip to the venturi throat, which creates a vacuum in that area allowing atmospheric pressure to drive water through the foot-valve into the ejector body. As this water passes through the throat of the venturi, along with the circulating water, it is slowed down to useful pressure and carried up to within suction distance of the pump.

Figure 26-17 shows 170 kPa discharge pressure which, when added to the gravity pressure of 140 kPa, circulates water through the jet nozzle at 310 kPa pressure. Again, the venturi tube changes this high velocity back to useful pressure, which now carries the water up to within 3.60 m of the impeller. The total head is now the same as before. However, the discharge head is 170 kPa and the suction lift is 3.60 m.

When the discharge pressure is 210 kPa, as shown in Figure 26-18, the circulating water leaves the pump at 210 kPa, picks up the 140 kPa gravity pressure, and circulates through the ejector nozzle at 345 kPa pressure. Again, the venturi changes the high-velocity stream back to useful pressure, which carries the water to the impeller of the pump at zero pressure, and the discharge head is now 21 m (210 x 0.10).

When the example in Figures 26-16 to~26-18 is operating at 280 kPa (a common pressure-switch setting), the water enters the impeller at 70 kPa. The pump adds its 210 kPa, the pressure it will develop, and the final discharge pressure is 280 kPa.

c) Performance Characteristics

A distinctive feature of the ejecto pump is that the norsepower requirement remains practically constant regardless of discharge pressure or well lift. A given size of pump and motor will furnish generous amounts of water from well lifts of from 9 to 55 m. This is accomplished only by using different ejector assemblies.

All ejector-pump manufacturers make an assortment of ejector assemblies to fit varying well conditions. Each ejector assembly is designed for a certain maximum lift.

This brings up another characteristic: The deeper the pumping level, the more water that has to be circulated; and, as the circulating water increases, the pump capacity that is delivered decreases. In this case, attention should be called to the possibilities of the ejector pump when used on weak-producing wells.

When properly installed, the ejector pump meets the conditions of the weak well better than any other type of deep-well pump. (See Figure 26-19.) Assume that these are the known conditions: The well capacity has proven inadequate for normal pumping; the well is 28 m deep with water standing at 6.7 m below ground level; the well is 100 mm inside diameter or larger.

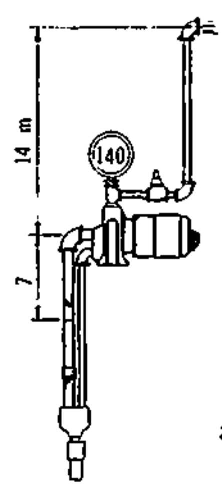


Figure 26-16. Pump Operation at 140 kPa Pressure

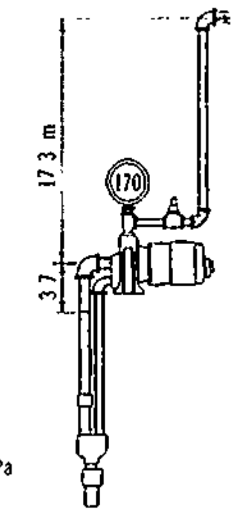


Figure 26-17. Pump Operation at 170 kPa Pressure

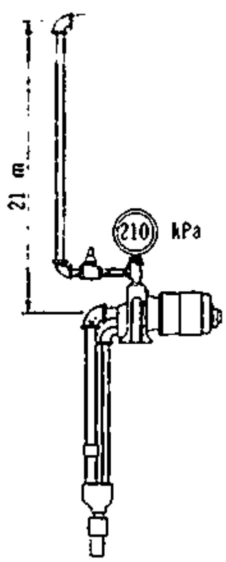


Figure 26-18. Pump Operation at 210 kPa Pressure

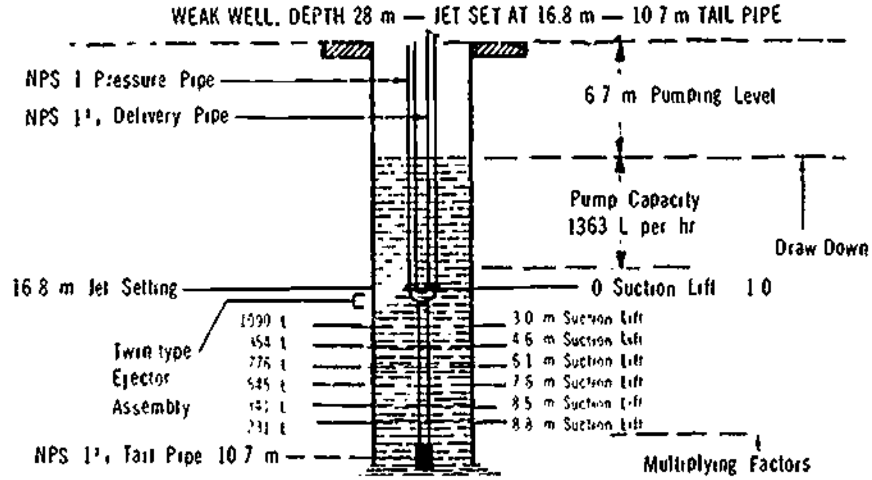


Figure 26-19. Weak-Well Tail Pipe Usage

The solution to this problem is to install a foot valve on the bottom end of 10.7 m of NPS 1¼ pipe and lower it into the well. Next, secure a twin-type ejector assembly to the tail pipe, then add 16.8 m of NPS 1 pressure pipe and NPS 1¼ delivery pipe above the ejector assembly. The pump can now be brought into service.

When properly installed, this provides the maximum water from a weak-producing well since the regular pump capacity will be available until the pumping level drops below the ejector-assembly setting. Then, as the water lowers in the tail pipe, the pump capacity becomes less and less until the water is about 9 m below the ejector assembly. Loss of priming cannot occur because no pump can exhaust all the water from a 10.7 m tail pipe.

These performance characteristics must be considered when selecting the correct pump for a particular type of installation. Where there is considerable elevation between the pump location and the places where the water is to be used, the necessary pressure must be checked and, if too high for efficient ejector pump operation, a reciprocating, a dual-impeller ejector pump, or a submersible should be selected. Pipe-friction loss must also be figured since excessive friction loss will result in reduced delivered pressures.

Regardless of the make of the ejector pump, the pressure-switch settings should not be raised higher than shown in the manufacturer's catalogue. When the switch setting is raised, the capacity will be considerably less than adequate.

d) Construction Features

To meet the requirements of the trade, the ejector-type pump is produced in both the horizontal and vertical construction. It is also supplied with single impeller as well as several impellers. (See Figures 26-20, 26-21, 26-24 and 26-25.)

Ejector pumps require no oil or grease, are quiet in operation, need no attention, use non-adjustable rotary seals, can be offset from the well, are safe, have only one moving part, give a smooth discharge flow, and offer low first cost and low upkeep. Plus features include:

- "Fire-cured" epoxy-protected pump parts.
- Standard-brand motors and components with over-load protection built-in.
- Perfectly aligned stainless steel pump shaft.
- Mechanical shaft seal.
- Dynamically balanced impeller.
- Replaceable bronze wear rings.
- Fast-connect flange.
- Automatic pressure regulator.
- Slip-joint coupling on pump discharge.
- Reversible adapter fittings.
- Bronze or epoxy-protected ejector assembly.
- Bronze foot valve.
- Full convertibility if pumping level drops.
- Certified performance.

e) Applications

Capacities to 9275 L per hour; pressures to 550 kPa; ejector settings to 100 m; 250 W to 1.5 kW sizes.

Because of their construction, ejecto pumps need not be set directly over the water source. They may be offset at any reasonable distance. (See Figures 26-22 and 26-23.)

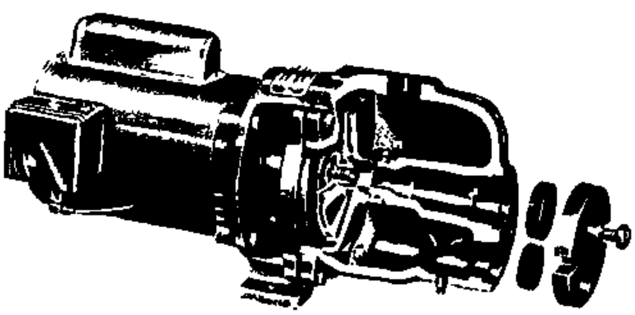


Figure 26-20. Partial Cutaway View of Horizontal Single-Impeller Pump

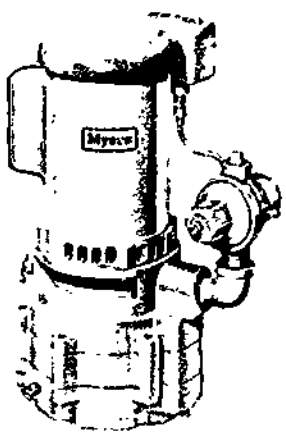


Figure 26-21. Vertical Single-Impeller Pump

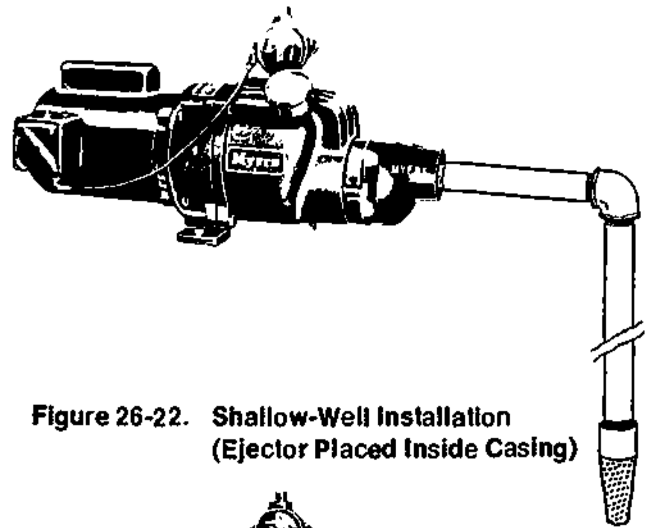


Figure 26-22. **Shallow-Well Installation (Ejector Placed Inside Casing)**

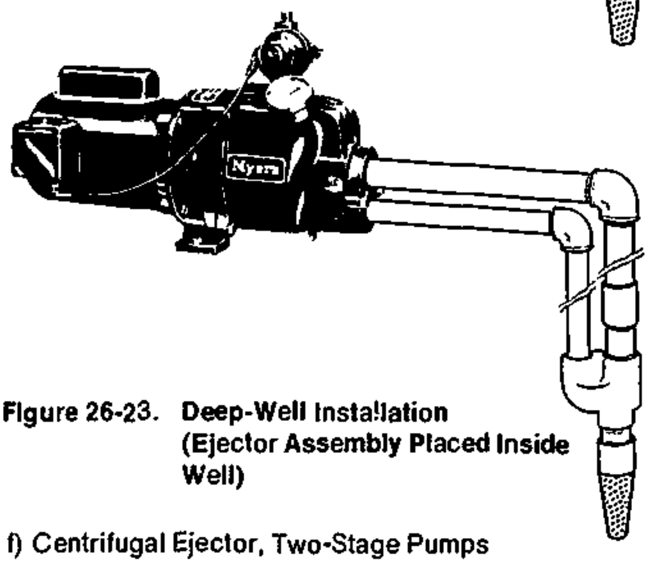


Figure 26-23. **Deep-Well Installation (Ejector Assembly Placed Inside Well)**

f) Centrifugal Ejector, Two-Stage Pumps

The characteristics of the ejecto single-stage pumps also apply to the two-stage, or two-impeller, pumps.(See Figures 26-24 and 26-25.)

The two impellers develop more pressure than is possible with a single impeller of the same horsepower. This higher pressure makes it ideally suited for deeper wells or for installations where a higher discharge pressure is necessary because of elevations or excessive pipe-friction loss.

Although the single-impeller ejector pump is usually limited to lifts up to 37 m because of design considerations, theoretically there seems to be no limit to which a multi-impeller pump could be used. But on the basis of cost and efficiency, it soon loses its appeal because the same work or more can be done for less money by other types of deep-well pumps.

g) Submersible Pumps

Submersible pumps are the most efficient method of securing water from deep wells, and are also used for all kinds of shallow-well service. The submersible in the fractional and smaller integral horsepower sizes is designed for use in 4-inch inside-diameter and larger wells. This accounts for the cylindrical construction as shown in Figure 26-26.

In operation, the entire pump and motor assembly is submerged. The motor runs at about 3450 rpm and drives the pump impellers at the same speed. Water enters at the inlet to the pump and is forced upward through a single-drop pipe to the required point of discharge, which can be into a pressure tank or any other place where the water is needed.

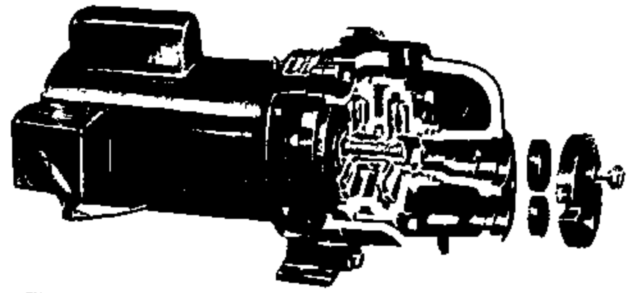
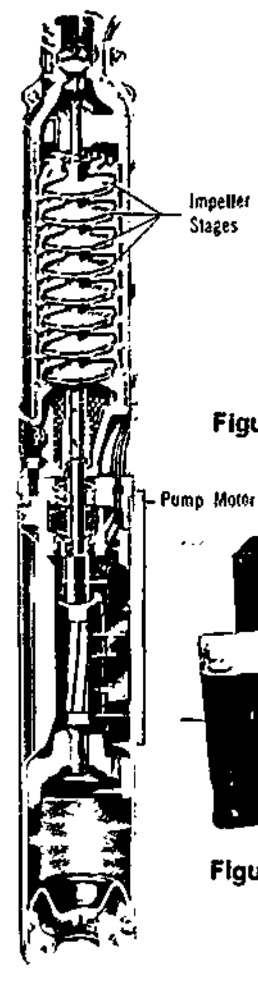


Figure 26-24. **Partial Cutaway View of Horizontal Two-Stage Pump**



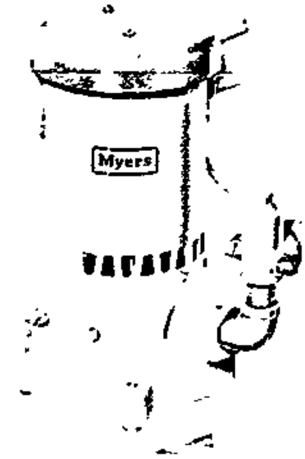


Figure 26-25. **Vertical Two-Stage Pump**

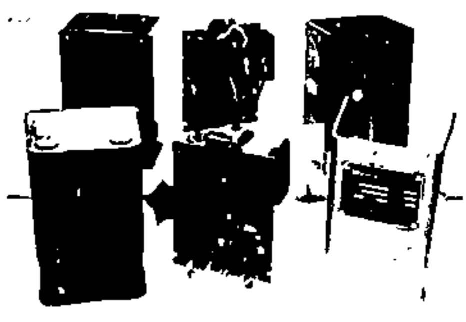


Figure 26-26. **Submersible Pump and Control Box**

The submersible is truly a simple pump, yet one that has required considerable experimental work and development because it is designed to "live" under water, out of sight. It is not a cure-all for every pumping problem, for there is no such a thing; but it has many practical applications.

h) Performance Characteristics

The performance of the submersible pump is the same as that of the multi-stage centrifugal in that as the pressure increases, the capacity and the horsepower requirement decrease. In the range of operation from low to high pressure, or from low to high capacity, there can be no over-loading of the motor on the pump.

A submersible may be designed with emphasis on pressure (for deeper settings) or on capacity, or a combination of both. But either is obtained only at the expense of the other unless the horsepower is increased. Thus a ½-h.p. 375 W pump with 10 impellers (designed primarily for capacity) would deliver greater capacity at 24 m than a 375 W pump with 12 impellers (designed for pressure). But the latter might raise water from an extra 30.5 m of lift. Horsepower alone would not determine the capacity of the submersible, but horsepower plus the number of impellers would indicate the relative capacity and pumping depth.

As with the centrifugal pump, in general the pressure varies with the number of impellers and capacity varies with the design of the impellers.

The electrical characteristics of the submersible motor are similar to those of a surface motor, so the operation is similar on low voltage; that is, the motor speed drops off and the current increases. With a surface motor this increased current means increased heat and causes the overload to trip. With the submersible motor the advantage is that the increased heat, owing to low voltage, does not affect the winding as the heat is easily dissipated to the well water. Too low a voltage will cause the relay to stay in the starting position and, of course, this will increase the current and cause the overload to trip. Generally, however, the submersible operates better on low voltage than does the surface-type motor.

If the incoming power to the motor is correct, the motor will operate at constant temperature, summer or winter, almost regardless of location in the world. The well water is the cooling agent. The unit is practically noiseless, an ideal feature in home use.

i) Construction Features

As indicated, the number of impellers is important for the loading of a submersible motor. The construction of the impellers is also very important.

The submersible operates like any centrifugal multistage pump. Each stage added increases the head or pressure by a set amount. For example, a pump that will deliver 37.8 L per minute each stage, every stage added will increase the head pressure by 69 kPa. There will be no increase in litres per minute.

A stage comprises an impeller, diffuser, and housing (Figure 26-26). The diffuser consists of stationary vanes with tapered sections similar to a venturi tube. The high-velocity water from the impeller is slowed down in these passages and converted into useful pressure. The diffuser also guides the water into the next impeller inlet.

Several types of diffusers are used on a complete line of submersible pumps, and each has certain features that are desirable depending on where they are used.

Figure 26-27 shows the flat, or pancake, type of impeller with mating parts to make up a stage for submersibles when good capacities and high heads are desirable. These are of the direct-diffusion design, which uses a small impeller in relation to the pump shell and gives high efficiency.

With this construction, water discharged from the impeller enters the diffusion ports direct and then into the guide vanes. More impellers are needed to make a given head because the impeller diameters are smaller.

Figure 26-27. Pancake-Type Submersible Stage

Figure 26-28 shows the impeller and diffuser needed when high capacities and medium heads are desirable. This is called a bowl type and is used on larger submersibles and deep-well turbines.

With this construction the water leaves the impeller and is directed into tapered passages that spiral upward in a smooth curve, resulting in high efficiency. It also permits a relatively large impeller to be used in relation to the outside diameter of the pump.

Pump shafts, made of the best grade of stainless steel, should be threaded to the motor shafts by reverse threads. This makes a rigid connection and eliminates the noise from single-phase vibration found in some submersibles that use a splined-type coupling.

j) Motors

Because submersible motors are continuously submerged, the principal design objective is to make them wet-proof. The main difference in such motors is in protecting the windings and providing lubrication for the motor bearings.

There are two general methods of doing this. The first is the canned motor, which is made by encasing the stator winding in a can or a housing. The inner liner is usually stainless steel from 0.13 to 0.25 mm thick. The outer shell and the end caps are also stainless steel. The outer and inner tubes are welded to the end plates. The can is then filled with a plastic compound, and the rotor operates in water or oil emulsion.

The second method (Figure 26-29) is the highly efficient oil-filled motor in which the windings are open and operate surrounded by oil. The rotor, bearings, and seal operate in clean oil.

Because there are two types of construction used in submersible motors, some discussion of their respective features is in order.

The canned motor allows the rotor and bearings to operate in water, hence the motor is not filled with any liquid but the well water. However, one disadvantage is that heat dissipation is poor owing to the plastic filler. It will operate satisfactorily at normal current, but if the current increases because of low voltage or a tight pump, and the overload does not function properly, the plastic swells and causes the inner liner to grab the rotor and stop the motor. Operation under this condition can cause the liner to fail and allow the windings to become wet and fail. Another disadvantage is that many well waters are corrosive, and repairs to the canned motor are expensive.

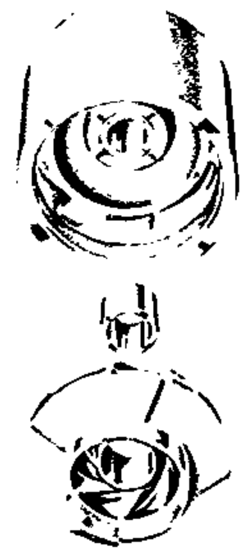


Figure 26-28. Bowl-Type Submersible Stage

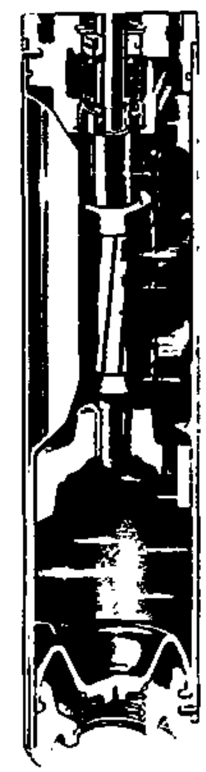


Figure 26-29. Efficient Oil-Filled Submersible Motor

The oil-filled motor in Figure 26-29 has many desirable features, and probably foremost is the use of oil itself. The motor is filled with oil that is always clean and not only provides lubrication for bearings but also prevents corrosion of the motor parts. Oil is a better heat-transferring agent than water and permits cooler operation. The oil does not become contaminated with water or foreign substances. Protection of the windings in this way is the secret of long underground life.

The oil in the motor is pressurized by a spring-loaded diaphragm assembly that keeps the oil around the bearings, rotor, and rotary seal. Since the balance system puts the same pressure inside the motor as the outside well pressure, the rotary seal, O-rings, and stator winding work under a very low differential pressure. It is desirable that the inside pressure against the rotary seal be several kPa higher than that on the outside, hence the spring loading of the diaphragms.

After factory pre-filling, the oil is kept in the motor by a rotary seal that has faces lapped to a guaranteed eleven millionths of an inch (.0003 mm) of being flat. There is sufficient oil in the reservoir for about 15,000 hours of operation or at least 10 years of water-system use, based on about four hours use a day. The pump should be pulled after this period and refilled with oil. However, the liner-type motor will operate correctly on the original oil supply.

The stator in the oil-filled motor is wound with conventional wire having the same type of insulation as used in air-cooled motors at ground level. However, the submersible motor must never be run unless it is submerged in water because it will quickly fail due to a lack of cooling.

k) Single-Phase Motors Need Start Capacitors

Single-phase motors are not inherently self-starting, as are three-phase motors. Therefore, some auxiliary starting method is necessary. In submersible motors, it is usually a starting capacitor connected to a start winding of the motor. The capacitor is used to get the motor started and almost up to running speed. Then a switch disconnects the capacitor and the start winding, and the motor operates on its run windings.

The disconnecting switch is usually a relay, either voltage-operated or current-operated It is placed in a control box together with the starting capacitor and an overload protector. Since the control box is above ground, it requires a three-wire cable to connect it with the motor. This should not be confused with a three-phase system. Nor does the fact that there are three wires leading from the power supply indicate three-phase current, since most 230 V single-phase supplies carry a grounded third wire.

It is very important that the control box be exactly mated to the motor, and that it not be used for the motor of another manufacturer.

Connecting the control box at ground level to the motor submerged in the well water requires the correct-size wire to prevent voltage loss; also, the insulation must be water-resistant. This calls for a three-wire, twisted cable with an oil-resistant polyvinyl chloride insulation. Each of the wires has a different-colored insulation; usually one is red, one is yellow, and the third one is black to correctly match the color-coded wires on the submersible motor.

l) Two-Wire Pumps Have Built-In Capacitors

Some designs have the starting capacitor and switch inside the motor. One example is a mechanical-hydraulic type that operates a mercury switch to disconnect the capacitor. With this type there is usually no control box above the ground, but there may be a small box for the circuit protector. The overload protector may be mounted in a box on the surface or imbedded in the motor winding. This motor requires only a two-wire cable.

Another design has an oil-filled capacitor mounted either inside the motor or on the surface and permanently connected to the start and run windings. The motor starts and runs with this capacitor in the circuit. This motor is called a permanent split-capacitor type. If the capacitor is in the motor, only a two-wire cable is necessary. (See Figure 26-30.) If it is on the surface, three wires are needed between the motor and the surface.

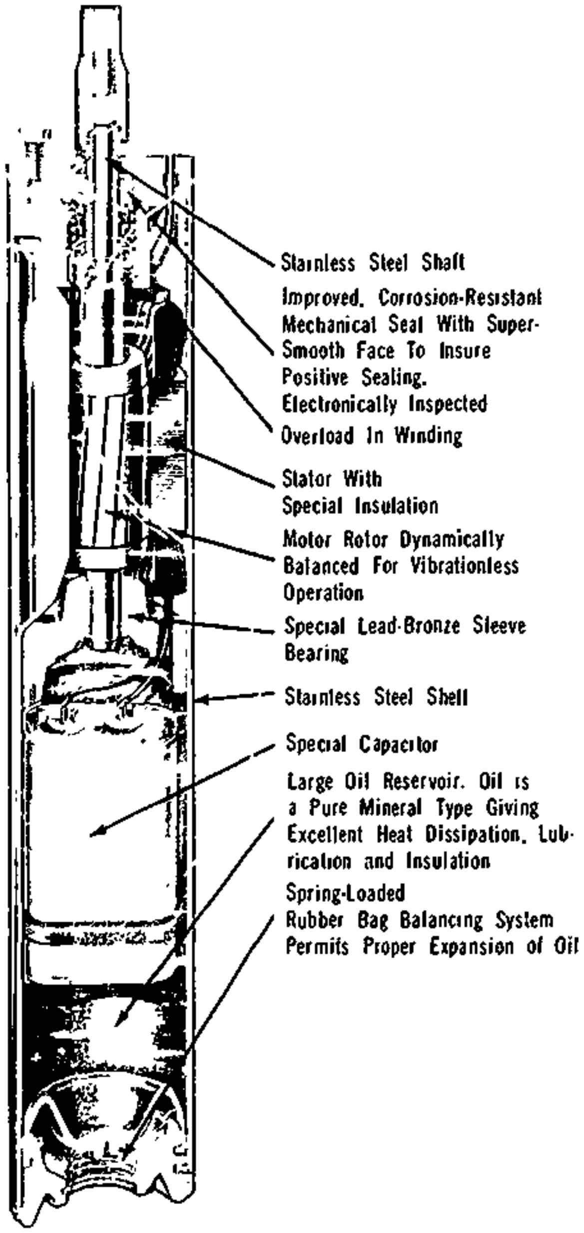


Figure 26-30. Permanent Split-Capacitor Two-Wire Submersible Motor

Submersibles have advantages not available in other types of pump, such as:

- Can be installed at almost any depth.
- Can be installed in crooked wells without damage in operation as occurs in plunger and line-shaft turbine pumps.
- Installation is easier and quicker than with most other deep-well pumps.
- No well pit or pump house is required, only a small opening large enough to remove the pump.
- Only one pipe is used, reducing installation cost.
- The well can be located any distance from the premises.
- No danger of damage to motor from floods or seepage as found in some well pits.
- No priming is required.
- No possibility of air leaks as with jet pumps.
- Positive, fool-proof air-charging system for pressure tanks. Eliminates all normal water-logged conditions as found in other systems.
- Quiet operation. These pumps are practically noiseless. Ideal for homes, hospitals, and other facilities where noise must be kept to a minimum.
- Tamper-proof. No adjustments necessary.
- Maximum performance efficiency. No other type of pump can deliver as much capacity and pressure for a given horsepower size. The reason is that there are no external losses, such as gear and plunger-rod losses in reciprocating pumps, friction and re-circulation losses in jet pumps, and line-shaft losses in deep-well turbines. The submersible pump is a compact direct-driven unit that gives minimum losses. All the power can be used to pump water.
- Lower first cost per litre pumped than any other pump.

m) Applications of Submersible Pumps

Submersible pumps can be used for shallow or deep wells, wherever cool, clean water is to be pumped on an efficient and economical basis — on farms, in suburban areas, industry, and agriculture.

For 100 mm wells, submersibles are made in 1/3 and ½ h.p. sizes for 115 V single-phase, and 1/3, ½, ¾, 1, 1½, 2, and 3 h.p. sizes for 230 V single phase. The 3 h.p. size is for 208-220 V, three-phase current. Capacities of over 11 360 L per hour, pressure to 2380 kPa, and well lifts to 244 m.

For 150 mm wells, submersibles are made in 5, 7½, 10, 15, and 20 h.p. sizes in three phase, 208-220-440 V; and a 5 h.p. size in single-phase, 208-230 V. Capacities to 56.8 m^3 per hour, pressures to 2758 kPa, and well lifts to 274 m.

n) Sizing a Submersible

Since a submersible is a high-capacity pump, the well should be free from sand, and be straight and of sufficient capacity to warrant the installation.

Before installing it, the well should be pumped clean of sand or other foreign matter with a test pump.

Where the water supply is a lake, stream, or spring, an extra screen cage of some kind is needed to keep leaves and other debris from clogging the screen of the pump. Pumps will operate efficiently in a horizontal position in shallow pools.

In sizing a pump, six basic factors must be determined:

- Size of well.
- Depth of well.
- Capacity of well.
- Pumping level.
- Capacity required by user.
- Discharge pressure required.

Well size is very important as most submersibles require a minimum well diameter of 100 mm. Even in a 100 mm well it is necessary that the well be almost straight.

Well depth is also important. The pump must not be lowered into mud, sand, or gravel that might be at the bottom, since both the pump and motor could be ruined.

Well capacity is usually the most important factor in selecting a pump. If a well produces only 4 L per minute, there is no use putting a pump into it that will pump 50 L per minute There are certain applications where this is done, but there must be some type of control to keep the pump from pumping the well dry.

"Pumping level" should not be mistaken to mean static water level. Pumping level is the lowest level of the water in the well with the pump running. In many cases this is not determined until after the pump is installed, but the driller will usually have a good idea where it is. It will vary according to the capacity of the pump.

The capacity required by user usually should be determined by the dealer. Most homeowners do not realize how much water they use. Generally, they expect the dealer to guide them in the selection of a pump after it is determined how much water the household requires for various uses. Always allow for growth, such as additions to the family, additional water-using appliances, etc.

Low pressure is a common complaint among homeowners having outdated water systems. With new appliances coming on the market, the required discharge pressure is constantly increasing. It is not uncommon to find homes with pressures on their water systems of 140 to 340 kPa, or even 280 to 550 kPa, especially if they are two-storey homes with a bathroom upstairs. Pipe sizes used in the plumbing of a house affect the required discharge pressure. Normally, the smaller the pipe size the higher the required pressure-switch setting.

A pump of greater capacity than that of the well should not be installed unless some method of controlling the pump flow is used. If the well draws down to the pump inlet, air enters the pump and can cause air binding and vibration. Damage can result from operation under these conditions.

o) Reciprocating Pumps

In considering the several types of reciprocating pumps used for pumping water, they must be divided into two basic categories — shallow and deep-well pumps.

Shallow-well pumps are those used to raise water (at sea level) from as much as 7.6 m total suction (to include pipe friction) below the pump.

Deep-well pumps are those used to lift water from pumping levels greater than 7.6 m below the pump. Of course, any pump that will raise water from deep wells can also be used for shallow wells.

The shallow-well pump is often referred to as a piston-type pump, since it is a mechanism in which the piston moves back and forth. The rotating motion of the electric motor is transferred to the reciprocating movement of the plunger assembly through the mechanical linkage of the pump.

Figure 26-31 is a sectional view of a small 1500 L per hour reciprocating pump. When the plunger moves to the right a vacuum is created in the left end of the cylinder body, and atmospheric pressure on the water in the well drives the water through the foot valve and into the suction pipe, then through the suction valve, filling the cylinder. When the plunger moves to the left the suction valve closes and the entrapped water is pushed out through the discharge valve. As the plunger is moving to the left, water again fills the right end of the cylinder.

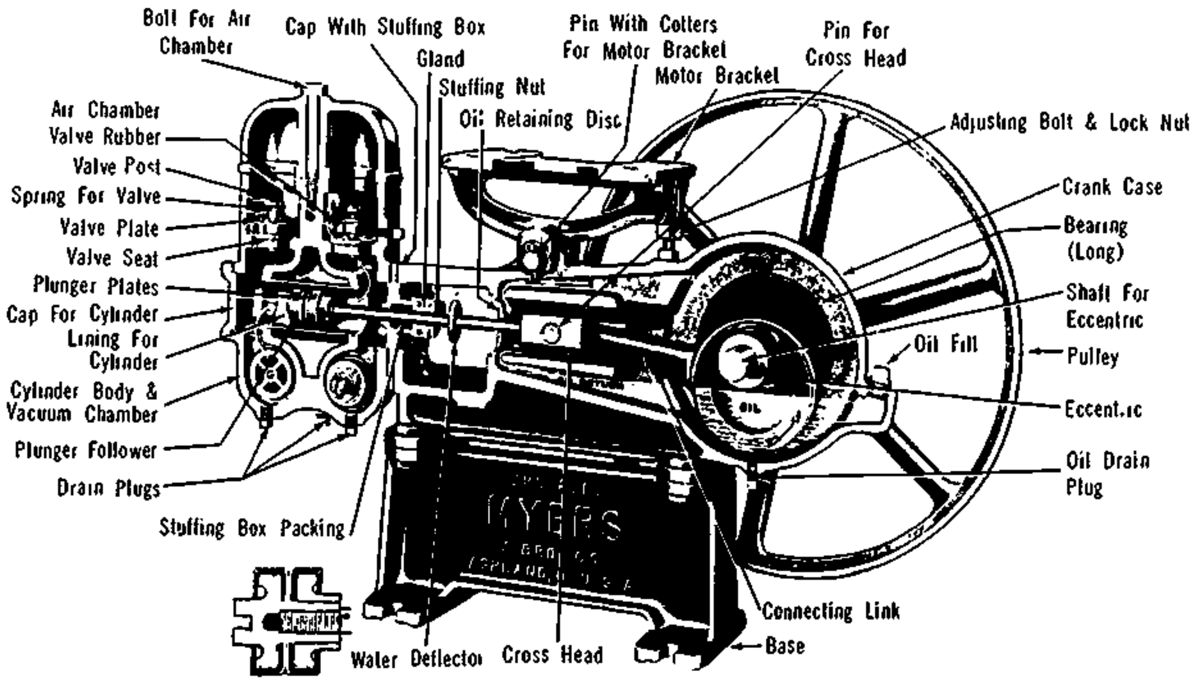


Figure 26-31. Self-Oiling Reciprocating Pump

Thus the pump is double-acting as it discharges water at each forward and backward movement of the plunger.

The characteristics of all plunger pumps are:

a) Capacity is constant regardless of discharge pressure.
b) Capacity is uniform regardless of suction lift or lift from a deep well.
c) Horsepower varies directly with increase in discharge pressure.
d) Efficiency remains practically constant regardless of capacity, discharge pressure, suction lift, or lift from a deep well.
e) Discharge pressure is limited only by horsepower and pump construction.

Reciprocating pumps, because of design considerations, are usually for comparatively low capacities and high head conditions. The shallow-well models are available in capacities to 15 m^3 per hour at pressures to 1700 kPa pump pressure.

It is not economically feasible to fit these pumps with one size of electric motor for all installation conditions, since the total head must be determined on each job and the motor size selected as described in the earlier section titled Pump Operating Characteristics.

Since the life expectancy of these pumps is 15 years or more, they must be well designed and ruggedly built. They must also be installed so that they can be inspected periodically and are accessible for adjusting and repairing.

Although these pumps are self-oiling, the oil should be drained and replaced once a year. Simply maintaining the proper oil level does not ensure good lubrication, since water gets into the oil chamber from condensation and other sources. When this occurs, the oil floats upward and gives a false impression of its quantity.

Construction features include the over-size connecting link and eccentric; over-size crosshead pin; stainless steel piston rod; removable plunger assembly; over-size suction and discharge ports; large and direct waterways; all-brass stuffing-box assembly; and the adjustable motor base. These pumps should be recommended where the capacity is constant at a total head within the limitations of the pump.

p) Deep-Well Reciprocating Pump

The deep-well reciprocating pump (Figure 26-32) is sometimes referred to as a "working head" because it acts merely as a power unit to operate the pumping barrel or cylinder in the well, forcing the water where desired and supplying air when needed. Its most general use is for securing water from lifts in excess of those that can be handled by shallow-well pumps.

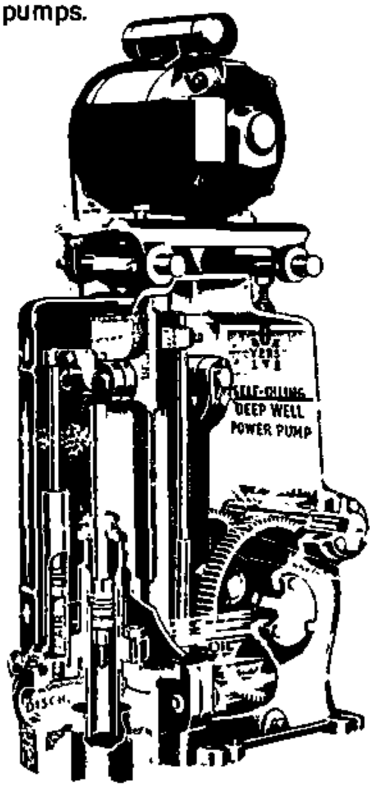


Figure 26-32. Self-Oiling Deep-Well Pump

Years ago these pumps were manufactured in many stroke lengths and for loading to 10 or 15 kW. But the submersible-type pump has eliminated the large units; some weighed as much as 900 kg. The only size now available is the 150 mm stroke for domestic service, which is limited to a 0.75 kW maximum load.

Again, with this type of pump, the rotating motion of the motor is changed to a reciprocating movement of the piston rod through the mechanical linkage of the pump. The 150 mm stroke unit operates at 50 strokes per minute and the motor is top-mounted, making a compact installation.

Since it is necessary to lower the pumping barrel into the well water, it is also necessary to provide a drop pipe and a "sucker" rod for attaching the barrel to the pump. The most serviceable arrangement is the use of a wood sucker rod and a large-diameter drop pipe. (See Figures 26-33 and 26-34.)

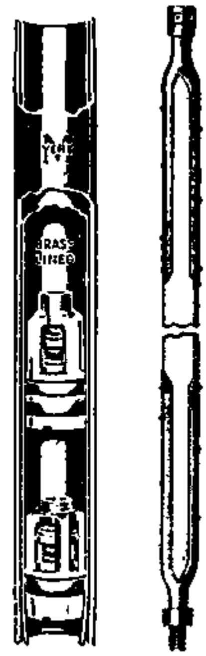


Figure 26-33. Single-Acting Barrel, Octagonal Rod

Figure 26-34. Double-Acting Barrel, Rectangular Rod

It should be noted that both single-acting and double-acting working barrels are available. In many instances the double-acting barrel is selected because it will pump 65 per cent more water than the same size of single-acting barrel, and uses only 15 per cent more power.

q) Performance Characteristics

The self-oiling deep-well pump has much the same characteristics as the shallow-well models except for capacities. Maximum capacity would be 1800 L per hour and 500 kPa maximum pump pressure.

Completely self-oiling, this pump is designed for a lifetime of dependable service. Note the straight upward movement of the connecting link through power applied by double spur-cut gears. The pinions are cut integral with the pinion shaft for maximum strength. Back-gearing of 7 to 1 ensures slow movement of the piston.

Because of its construction, this pump is for installation directly over the well. It cannot be offset.

5. The Modern Complete Water System

The modern complete water system may be described as "a total mechanism designed to automatically bring an adequate amount of water from its source to its points of use under ample pressure." It comprises an electric-motorized pumping unit, a pressure tank, an air-volume control, a pressure switch, a relief valve, and a foot valve.

a) Pressure Tank

Two considerations are important when selecting a tank size. The larger the tank the less often the pump starts and stops, and the smaller the tank the lower the cost and space requirements.

Since water is not compressible, it is necessary to maintain a supply of air in the tank at all times. This is done by means of an air-volume control, which is discussed later. The expansion of the compressed air in the tank drives the water to the points of use.

The amount of air in the tank is important since it determines the amount of water the tank can release before the pump restarts. When a tank contains one-third air and two-thirds water at 280 kPa pressure, it will release approximately 20 per cent of its total capacity before the pressure drops to 140 kPa and the pump restarts. (See Figure 26-35 and Section 5f) in this part of the manual.) On the basis of 760 L of water used daily, the pump would come into service about 25 times when using a 160 L tank. This would not be excessive cycling of the system and would keep cool, fresh water on tap.

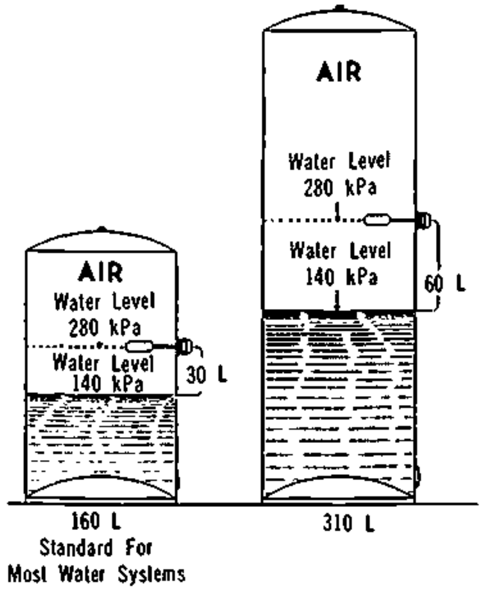


Figure 26-35. Pressure Tanks

A pressure tank of too small a size is undesirable from several standpoints, one of which would be rapid cycling of the electric motor with a consequent high-cost power bill. Another would be extreme wear on the delicate rocker arms and diaphragm in the pressure switch. Still another would be a lack of reserve water supply to provide for peak-load periods when several taps are opened at one time. Actually, unless the water system is to be used only for limited service, such as in a summer cottage, the size of the pressure tank should always be 160 L or larger.

Although galvanized pressure tanks have been standard in the industry for years, a relatively new development in tank coating is the "fire-cured epoxy" that makes the tanks corrosion resistant. The epoxy is used both inside and outside and is bonded tightly for long-lasting protection. (See also AirGuard tank data on subsequent pages.)

b) Air-Volume Controls

An automatic air-volume control maintains the correct volume of air in a pressure tank and is essential to the successful operation of a water system. Unless the correct amount of air is maintained in the tank it will become water-logged, a condition which works a hardship on the motor and the controls the same as a pressure tank of too small a size. Leakage of water at a faucet will then cause the system to frequently start and stop.

The amount of air in a tank gradually diminishes because of absorption of air in the water If air is not replenished from time to time, the tank becomes filled with water and the air under pressure becomes insufficient to force the water through the pipes. This is a water-logged-tank condition.

c) Float Type (Shallow Well)

This control automatically maintains the proper air content in the tank by a float connected to a valve through a diaphragm. (See Figure 26-36.) When water in the tank raises the float, indicating a need for air, the opposite end of the float rod opens the valve on the outside of the tank and allows the pump to secure air. This air travels downward through the copper tube, enters the pump body, is mixed with water in the pump, and then forced into the pressure tank.

When the air in the tank is sufficient, the float never raises and therefore no air will be handled. It should be noted that the shallow-well controls allow air to be handled only when air is needed in the pressure tank.

d) Diaphragm Type

Another air-volume control commonly used for both shallow-well and deep-well ejector pump service is the diaphragm type of the floatless construction seen in Figure 26-37. This control must not be used with reciprocating pumps. It puts a small charge of air into the tank each time the pump stops, but only when air is needed. When the tank contains sufficient air no more is added, as the air merely works back and forth in the control body. This control is generally at a lower location on the side of the tank because it does not use a float.

e) Float Type (Deep Well)

Figure 26-38 shows the air-volume control used on tanks with submersible and deep-well reciprocating pumps, or with any pump where a venting-type control is needed.

The proper volume of air under pressure is maintained in the tank by the float connected to the shut-off valve, the opening and closing of which are controlled by the position of the float in the tank; and a release-air valve, the opening and closing of which are controlled by the air pressure in the tank. When the water raises the float to its maximum height, the shut-off valve is closed and the release valve opens to enable the air to pass through and be vented to atmosphere. As the water level lowers, allowing the float to drop, the shut-off valve opens to admit air.

The pressure in the tank at which the release valve will open is determined by adjusting the tension on the spring that holds the release-valve to the valve set. This is usually pre-set to prevent air below 210 kPa tank pressure. The release valve spring may be adjusted by the adjusting screw so that air will not escape below a pressure sufficient to force water through the service pipes.

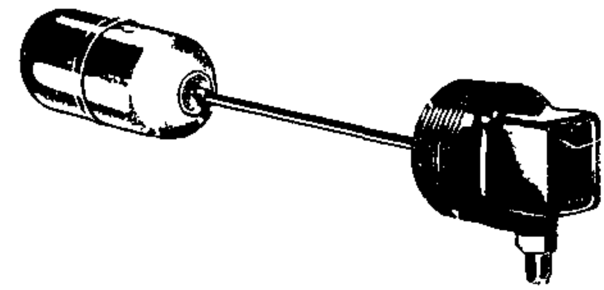


Figure 26-36. Air-Volume Control

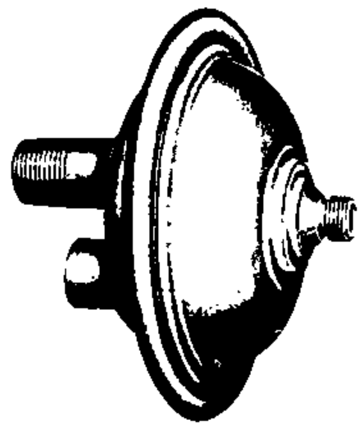


Figure 26-37. Air-Charging Control

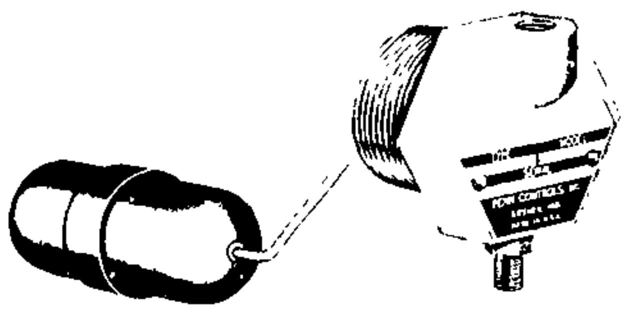


Figure 26-38. ‘‘ Volume Control

f) Pressure Switch

The pressure switch opens and closes an electrical circuit in response to changes to the pressure applied to it. It controls the operation of the pump. By starting the motor when the pressure reaches a predetermined low point, and stopping it after the pressure in the system is built up, a constant supply of water is kept in the tank at suitable pressures. Usually this is 140 kPa cut-in and 280 kPa cut-out, or 210 kPa cut-in and 345 kPa cut-out. The 140 kPa differential between settings is normal.

Figure 26-39 shows a two-pole pressure switch, which comprises a pipe flange, a flexible diaphragm, a range spring and a differential spring, linkage, and electrical contacts and connections. A slight movement of the rubber diaphragm caused by the pressure against it is multiplied sufficiently by the mechanical linkage to open and close the electrical contacts.

g) Pressure Gauge

The pressure gauge (Figure 26-40) is an inexpensive device to indicate water pressure in a complete water system. With the ejector-type system, the gauge is properly mounted on the pump case or the pump side of the pressure-regulator valve (Figure 26-40). This aids in correctly setting the minimum operating pressure to make the deep-well ejecto work most efficiently. On most other types of systems it is mounted on the pressure tank.

h) Pressure-Relief Valve

The relief valve (Figure 26-41) is a spring-loaded safety valve with an adjustable-spring tension, and is installed on the discharge or pressure side of a pump. The spring tension is adjusted usually to about 140 kPa higher than the cut-out setting of the pressure switch. If the pressure switch fails to stop the motor at the proper pressure, the relief valve will open to prevent dangerous pressure build-up in the system.

i) Foot Valve

The foot valve is a combination check valve and strainer used on the submerged end of a suction pipe (Figure 26-42). The check valve holds the suction-line priming when the pump is not running. The strainer prevents large particles and other foreign matter from entering the suction pipe. It is not designed to keep sand from entering the suction

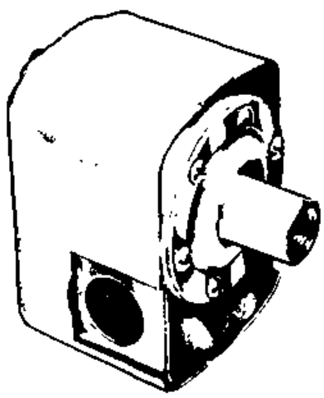


Figure 26-39. Pressure Switch

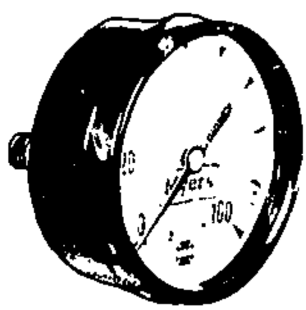


Figure 26-40. Pressure Gauge

Figure 26-41. Pressure-Relief Valve

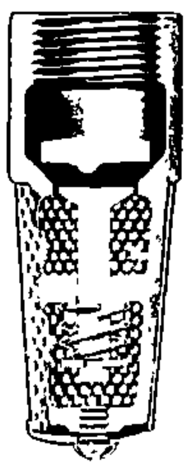


Figure 26-42. Foot Valve

pipe, since a mesh screen small enough to exclude sand would plug up quickly and prevent water from entering.

In the case of a driven well where the well diameter is small, the check valve without a strainer is used to maintain priming.

j) AirGuard Float-Type Pressure Tanks

Millions of pumps have been installed in conjunction with pressure tanks fitted with air-volume controls. The purposes of the air-volume control are to automatically maintain sufficient air in the pressure tanks to allow adequate water pressure where and when wanted, and to prevent too-frequent starting and stopping of the pump owing to water-logging of the tank.

Following are four causes of water-logged pressure tanks:

- Air under pressure in the tank becomes absorbed into the water.
- Mechanical failure of air-pumping equipment resulting from normal use or unfavorable water conditions.
- Average operating pressure on jet pumps can be exceeded and prevent the air-pumping cycle from occurring when needed.
- Flooded suction conditions on shallow-well installations.

The AirGuard tank (Figure 26-43) is fitted with a semi-rigid float that controls water-logging. This air-water barrier floats on the water surface, rising and lowering with the water level in the tank.

The float keeps the tank water and air separated, controlling air absorption into the water. It also has a wiping edge that prevents air-absorbing water from collecting on the tank wall in the air chamber as the float lowers.

It has no mechanical air-volume control to malfunction or fail.

When the AirGuard tank is used with jet pumps, the required average operating pressures for deep-well installations can be raised to reduce pump capacities on low-yield wells. This procedure would normally prevent air-handling and cause water-logging when done with a tank fitted with an air-volume control.

Extremely short suction lifts with shallow-well pumps, or when water actually flows to the suction side of shallow-well pumps, requires that a restricting valve be installed in these suction lines so that a vacuum will be developed. A restriction is not

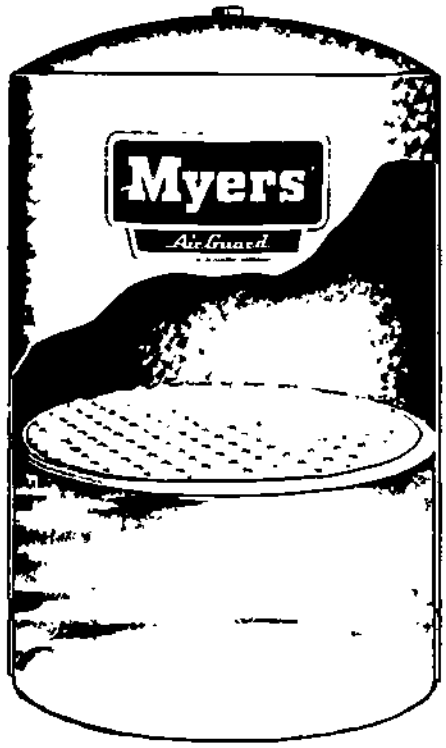


Figure 26-43. AirGuard Float-Type Pressure Tank

needed in a suction line when the AirGuard tank is used.

Another feature of the AirGuard tank is that iron, common to many waters, cannot readily oxidize in the tank because the water does not contact the air.

Figures 26-44 and 26-45 show two different methods of using the AirGuard tank. Figure 26-44 is the "floated" method that has gained acceptance in some areas.

But the AirGuard tank can also be installed in the usual way where the water enters one side and is

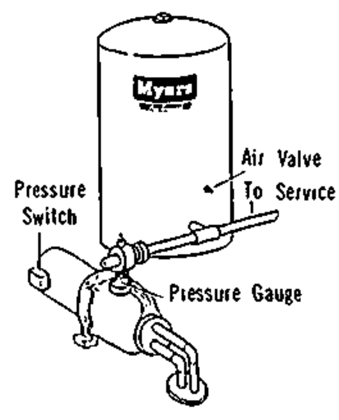


Figure 26-44. Layout for Floated Method

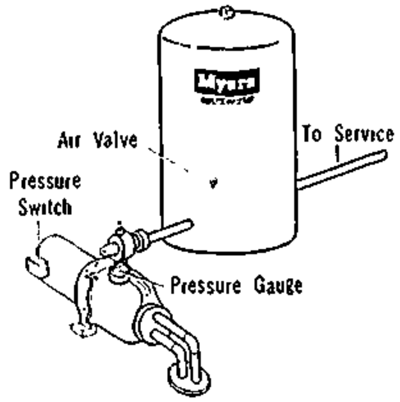


Figure 26-45. Layout for Usual Installation

released through the other, as shown in Figure 26-45. This is very desirable when the well water must be chlorinated and provides retention contact time for the chlorine and water in the tank.

Still another important feature of the AirGuard tank is its pre-charging benefit. By initially placing a supercharge of air in the tank, much more water can be used from the tank before the pump again starts. (See Table 26-3.)

Pre-charging is recommended as it will greatly increase the efficiency of the system by draw-off, and increase the life of the pump and control.

6. Pitless Adapter

A pitless adapter, as part of a complete water system, is a sealed unit that can be substituted for many above-ground well accessories when it is used in conjunction with a submersible pump. It gets its name from the fact that a manhole or pit is not required when the sealed unit is used. (See Figure 26-46.)

In other words, the pitless unit forms an unbroken extension of the well casing from below the frost line, where it is attached to the casing, to above the ground where it is covered by a cap. The water-delivery pipe (service line) is screwed into the pitless unit below the frost line and permanently buried. No heating is required. The ordinary well pit, which may funnel contaminated surface water into the well, is eliminated.

The pitless unit is not a pump. The submersible pump is attached to a drop pipe, which is connected to the bottom of the pitless unit.

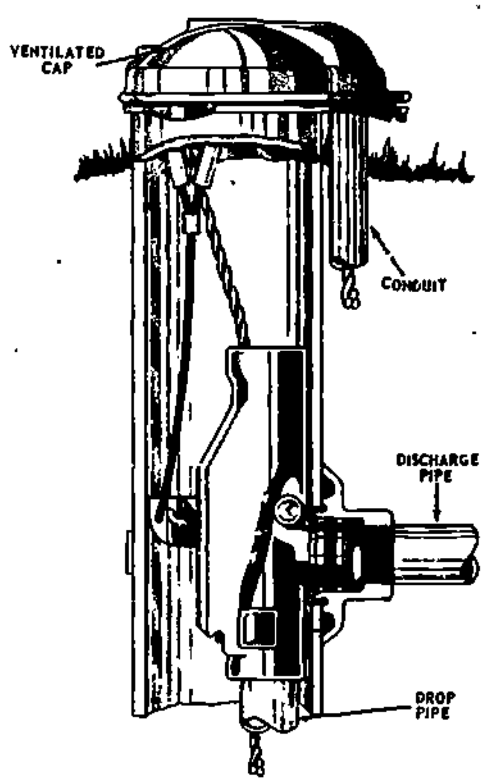


Figure 26-46. Pitless Adapter

TABLE 26-3. Guide for Pre-Charging Tanks

USE THESE CHARTS TO PRE-CHARGE TANKS	Draw in Litres per Pump Cycle							
	140-280 kPa Setting							
	57 L	79 L T	79 L S	114 L	159 L T	159 L S	310 L	454 L
Atmospheric	8.7	10.6	11.4	18.9	20.8	23.1	42.4	63.6
100 kPa Pre-charge	15.1	20.1	22.7	31.0	41.6	43.1	87.1	130.0
140 kPa Pre-charge	16.3	22.7	—	34.1	47.3	47.7	101.0	146.9
	207-345 kPa Setting							
	57 L	79 L T	79 L S	114 L	159 L T	159 L S	310 L	454 L
Atmospheric	4.5	7.2	7.6	11.4	13.6	13.2	28.0	40.1
103 kPa Pre-charge	8.3	13.2	15.1	20.8	28.0	28.0	56.0	68.5
138 kPa Pre-charge	10.2	16.3	18.2	23.5	32.2	33.3	66.2	89.3
172 kPa Pre-charge	12.1	18.2	20.1	28.4	37.1	37.9	75.7	109.8
207 kPa Pre-charge	15.1	20.1	—	31.0	39.7	40.5	81.8	125.7

7. Servicing Water Systems

a) Testing Electrical Characteristics

Every pump installer and repairer should have at least three reliable instruments for testing the electrical characteristics of water systems: an ammeter, a voltmeter, and an ohmmeter.

It is not necessary to have high-grade, delicate instruments intended for laboratory use. Perhaps the most versatile and convenient of all instruments devised for field work is the clip-on or tong-type combination ammeter-voltmeter, which permits quick measurement of current in all lines without the need to break connections. Voltage between lines can also be measured at any uninsulated point without breaking connections.

An ohmmeter with a self-contained battery is also a must. It should have several scales capable of measuring relatively low winding resistance as well as high ground or insulation resistance. *Resistance must never be measured with the power on.* All wires of the device being measured must be disconnected from the power source to prevent damage to the ohmmeter and shock to the user.

Since the modern water system is driven by an electrical motor, it is important to understand basic principles of the electrical circuit. The pump installer should also know how to use these instruments and interpret their readings. Unfortunately, too many feel that electrical instruments should be used only when trouble-shooting and therefore are often not too familiar with their use.

It is important that these instruments be used on every installation to reduce call-backs, as well as to provide practice in their use so that one will be able to recognize a problem when it arises.

b) Operating Principles of Electrical Instruments

Each instrument is designed for a specific purpose, although the basic operating principle is the same for all. A knowledge of this principle is helpful in using and understanding these devices.

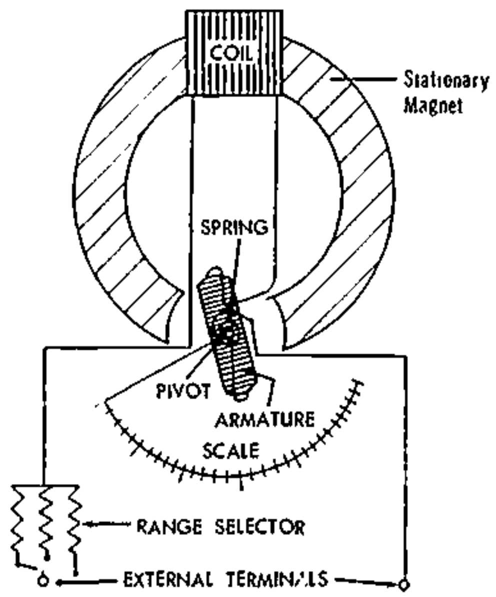
Electrical instruments are electro-mechanical in nature. That is, they operate on the principle of an electromagnet. Figure 26-47 depicts the basic meter construction of all types. The dial is calibrated in the divisions of the electrical quantities it is to indicate, whether volts, amps, or ohms. An indicating needle is attached to an armature that is magnetically activated by a current, suspended between two pivot points and held in a normal "zero" position by a spring. A stationary magnet is mounted so that its magnetic field passes through that of the armature. As current from the electrical circuit flows through the coils, the magnetic field that is set up tends to deflect the armature and needle generally in proportion to the amount of current flowing.

To obtain a range of scale readings, various amounts of resistance can be switched in or out of the meter circuit. The ohmmeter has an internal source of voltage in the form of a battery and an adjusting knob to compensate for the battery as it weakens.

c) Voltage, Current, and Resistance

Understanding an electrical circuit will also help the installer to understand the instruments and what they indicate. An electrical circuit may be compared with a hydraulic or water-system circuit. Voltage is electrical "pressure." It is measured between any two wires or between one wire and ground in the same manner that pressure in a pipe is measured between two places in a piping system or from inside the pipe to outside the pipe. It is this electrical pressure, or voltage, that causes current to flow.

Electrical current may be likened to water flowing in a piping system. It is normally measured in amperes. An ampere is a quantity of electricity (electrons) that flows past a given point in a given period just as litres per minute represent the volume of water flowing through a piping system in a given period.



Arrangement of components in a typical electrical servicing instrument. Current flowing in the armature causes it to deflect in the magnetic field of a permanent magnet. This deflection shows up as movement of the needle across the scale.

Figure 26-47. Basic Meter Construction

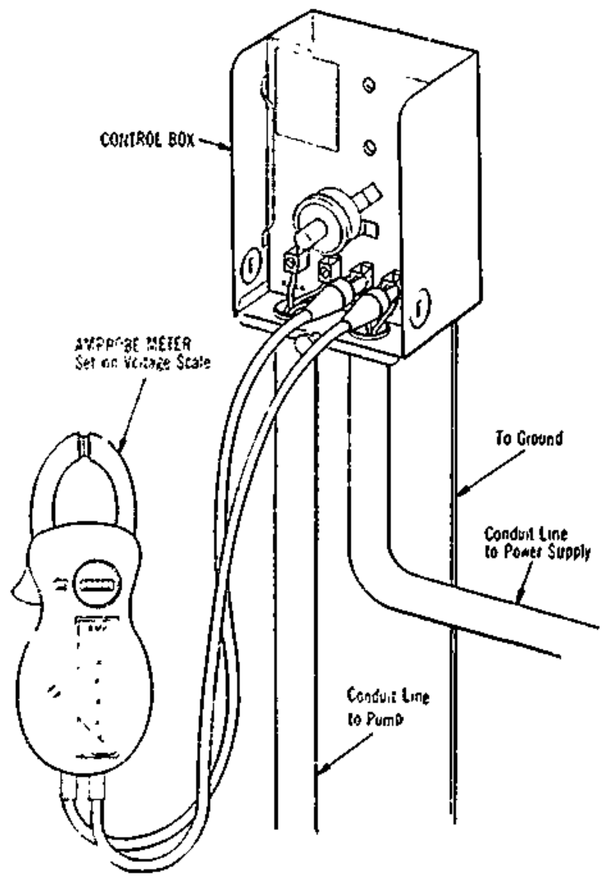
The resistance of an electrical system is measured in ohms, and it may be compared to the pipe friction in a pipe of a given size.

The relationship of voltage (pressure), current (electrical flow), and resistance (friction) is expressed in what is commonly called Ohm's Law.

d) Making Voltmeter Tests

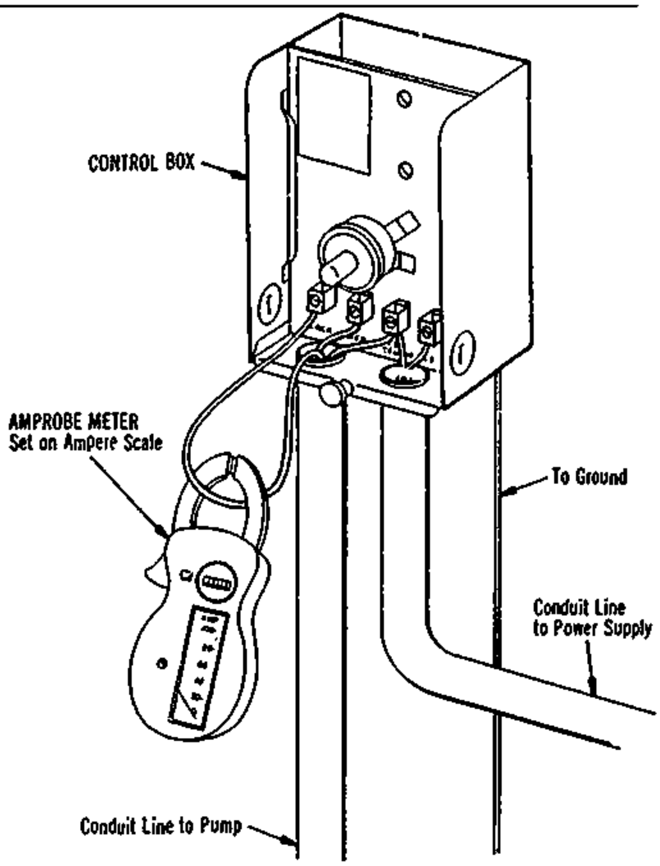
As noted, the voltmeter measures electrical pressure between wires, or from wire to ground. Figure 26-48 shows a reading being taken at the terminals of a typical submersible-motor control box. Note that it is not necessary to have the motor connected or running to obtain a reading. In fact, readings should be made both with the motor off and with it running. A significant difference would indicate an under-sized power-supply transformer or under-sized input wiring.

In making voltage tests, always start with the highest scale setting and work down to a scale that will give a reading between mid-scale and full scale for best accuracy. Never touch bare leads as electric shock could result.



Voltmeter reading being taken at the control box of a typical submersible pump Power supply need not be on when readings are taken

Figure 26-48. Voltmeter Test



Ammeter reading taken at submersible control box. To determine current flow, slip tongs around one wire and read amperage with current on.

Figure 26-49. Ammeter Test

e) Making Ammeter Tests

Since the ammeter measures current flow, the motor must be running to get a meter reading. Figure 26-49 shows a typical use of the tong-type ammeter. For maximum accuracy, follow these steps:

Step 1: Pull the wire being measured away from all other wires.

Step 2: Set the ammeter to the highest scale. (If starting a motor, leave the ammeter on this scale until the current settles down.)

Step 3: Place the tongs of the meter around the wire.

Step 4: Change the meter scale to one that gives the greatest accuracy. This would be a reading between mid-scale and full scale.

Step 5: Compare the reading with the manufacturer's data.

f) Basic Steps in Using the Ohmmeter

Ohmmeter tests are always made with power off and all wires disconnected from the control box or starter. Always follow these general instructions carefully:

Step 1: Turn off the power and disconnect items to be tested from *all* other circuits.

Step 2: Turn the selector knob to a multiplier that will give a reading as close to mid-scale as possible. Most ohmmeters indicate the scale multiplied by RX (a number) to show what the direct scale reading is to be multiplied by for a correct resistance value. For example, RX 10 = scale reading times 10. RX 10K = scale reading times 10,000 (K = 1,000).

Step 3: Clip the leads together and adjust the zero ohms knob until the needle is over the zero (0). Always "zero" the meter before use and every time the selector switch is changed.

Step 4: Unclip the leads and clip them to the wires to be tested.

Step 5: CAUTION: Never allow bare meter leads or any bare wires of the circuit being tested to touch the ground, water, or any part of your body, especially the fingers. Otherwise you will get a false reading.

g) Motor Continuity Test of Motor Windings and Circuit

The motor continuity test, for circuit resistance, is made to determine the condition of the motor windings and circuit. Refer to Figure 26-50 and proceed as follows:

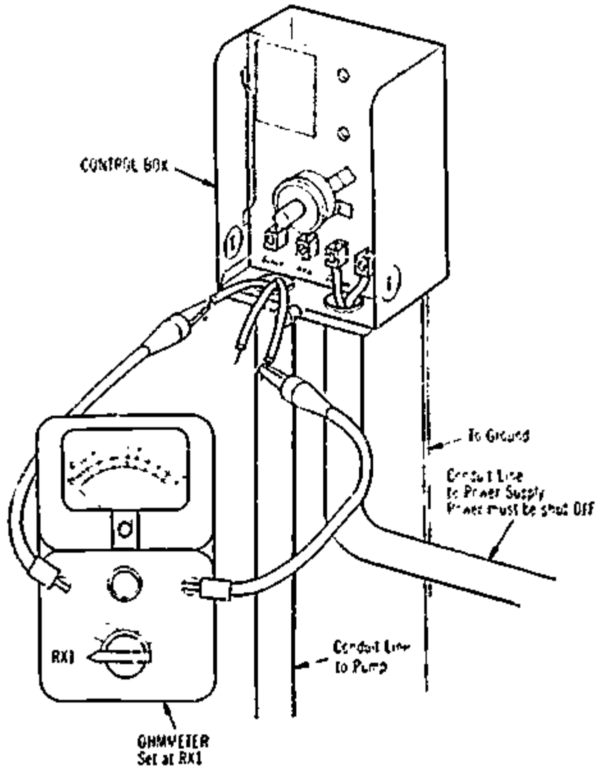


Figure 26-50. Arrangement of Ohmmeter for Motor Continuity

Step 1: Set the selector knob on the lowest scale (RX 1) and follow the general instructions listed above.

Step 2: Attach the ohmmeter leads to two of the three motor leads or cable leads at a time and compare with the readings provided by the pump or motor manufacturer.

Step 3: A reading significantly higher than the manufacturer's indicates a possible burned (open) winding, a loose connection, or a wrong motor (a different horsepower or voltage rating from that being checked for).

Step 4: A considerably lower reading than in the manufacturer's data indicates a possible shorted (burned together) winding, or a wrong motor (a different horsepower or voltage rating from that being checked for).

Step 5: An unbalanced reading for a three-phase motor indicates a burned winding or faulty connection.

Step 6: A correct reading but for the wrong wire-color combination indicates improper matching at the splice. To correct at the surface, take the following steps:

Step 1: Ignore the color of the wires and locate the two wires that give the highest ohmmeter reading. Mark the remaining wire "Yellow."

Step 2: Mark "Black" the wire that in combination with the "Yellow" wire (as determined in step 1) gives the lowest reading.

Step 3: Mark the remaining wire "Red."

(*Note:* Colors are in line with NEMA standards for submersible pump cable.)

h) Insulation or Ground Test Using Ohmmeter

To obtain accurate readings, the supply must be turned off and the motor leads disconnected from the control box. Set the ohmmeter selector knob on RX 100K and adjust the needle to zero (0) after clipping the leads together. After the ohmmeter is adjusted, clip one lead to the well casing or discharge pipe and the other to each motor lead-wire individually, as shown in Figure 26-51. If, after touching any one of the three motor leads, the needle deflects to the right of 1, the pump should be pulled to determine which is causing the ground—the motor, cable, or splice. After the pump-motor unit is pulled out, cut the cable off on the motor side of the splice and check the motor for ground separately. This check is the same as the one explained above except that one ohmmeter lead is clipped to some part of the pump-motor unit and the other to each lead separately If the needle deflects all the way to zero (0), the unit must be replaced. If the motor is not grounded, check the cable and splice.

i) How to Isolate Ground Leakage in Motor and Cable

Submerge the cable and splice in a steel barrel of water with both ends out of water. (See Figure 26-52.)

Set the ohmmeter selector knob on RX 100K and adjust the needle to zero (0) by clipping the ohmmeter leads together. Then ground one lead and clip the other to the various cable leads in turn.

If the needle deflects to zero (0) on any of the cable leads, pull the splice out of the water. If the needle falls back to ∞, or no reading, the leak is in the splice. If tne leak is not in the splice, pull the cable out of the water slowly until the needle falls back to ∞, or no reading. When the needle falls back the leak is at that point.

If the cable or splice is bad it should be repaired with a cable-splice kit.

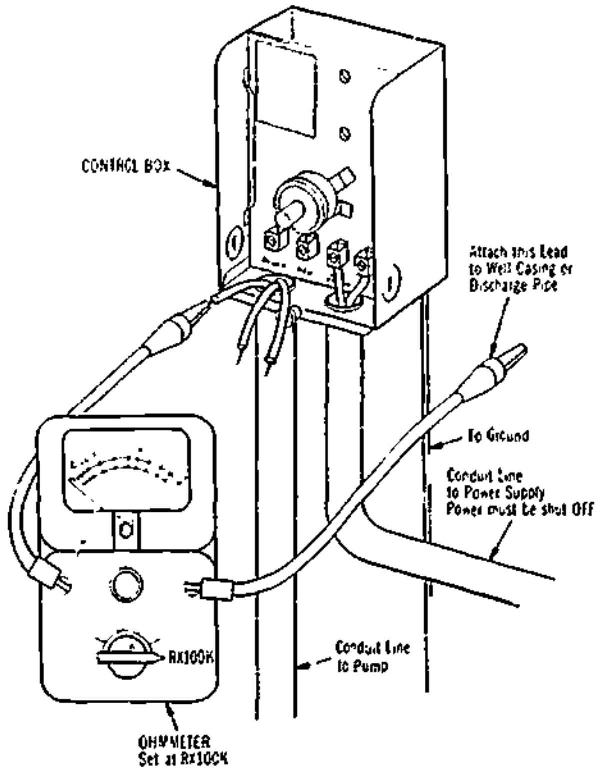
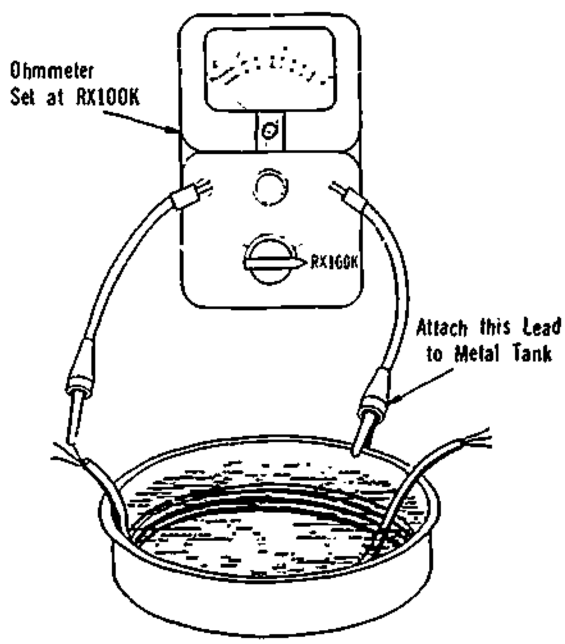


Figure 26-51. To Test Insulation with Ohmmeter

CABLE AND SPLICE TEST FOR LEAKS THROUGH A GROUND



Ground one ohmmeter lead and clip the other lead to cable wire. Gradually withdraw wire from water. When resistance jumps to infinity, leak is just above water level.

Figure 26-52. To Locate Leaks in Cable

j) Weakness in Insulation Detected by Megger

Another form of ohmmeter is an insulation tester known as the megohmmeter, more commonly called the megger. It is used only for measuring insulation resistance and has only one scale. It has a much higher source of internal current, usually 250 V or 500 V. The megger is either powered by a generator, which is driven by a hand crank, or by an internal battery using a vibrator and coil similar to the old Model-T Ford spark-coil system.

The megohmmeter is more accurate than the standard multi-ohmmeter because of its higher-voltage power supply. This tends to show weak insulation spots that may not be indicated by an instrument of lower voltage.

k) Watt-Hour Meter Indicates Input Power

Another handy electrical instrument that is always on the job is the power company's watt-hour meter. If all other power-using devices are turned off, a motor-power-input reading may be made from this meter. All such meters have a disc constant K (sometimes K^h) stamped on the face plate. This shows the number of watts per hour that are flowing through the line for one revolution of the disc. By counting the number of disc revolutions in a measured period and using the following formula, the power input determination may be made.

$$kW = \frac{3.6 \times K \times R}{T}$$

R = Revolutions of disc

T = Number of seconds for "R" revolutions

K = Disc constant (K^h)

kW = Kilowatts (1000 watts)

Remember that the power figure in the above formula is input motor power and not output, or rated, motor power. To obtain rated motor power or motor output power to the pump, the input power must be multiplied by the motor efficiency expressed as a decimal.

l) Several Pressure Gauges and Compound Gauge Also Needed

In addition to the electrical instruments described above, several pressure gauges of varying ranges and a compound pressure-vacuum gauge should be carried in your service kit.

m) How Gauges Can Show Rotation of Three-Phase Motor

The pressure gauge can be used to determine proper rotation in the case of a three-phase motor. To do so, first run the pump at shut-off and measure the discharge pressure. Then stop the pump and reverse any two of the three power cables. Run the motor again at shut-off and measure the discharge pressure. The cable arrangement that gives the highest discharge pressure runs the motor in the correct rotation.

n) Vacuum Gauges For Checking Jet-Pump Performance

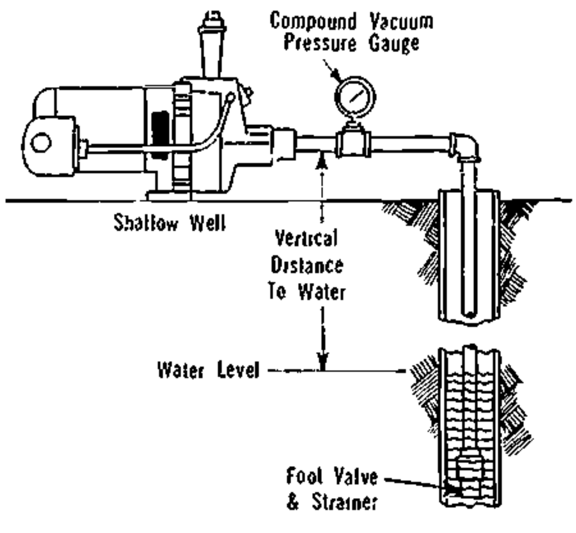
A centrifugal or jet pump in good operating condition should be capable of pulling a vacuum up to 85 kPa, which is equivalent to 8.5 m of water. But because capacity decreases quite rapidly with an increase in lift, these pumps are normally not operated beyond 75 kPa or 7.6 m of water. Conversely, the more water the pump is handling the lower the vacuum reading will normally be in the suction pipe.

Because there always are conditions where the suction line will be subject to pressure, a combination pressure-vacuum gauge (called a compound gauge) should always be used to avoid gauge damage.

o) Vacuum-Gauge Installation on Shallow-Well Pump

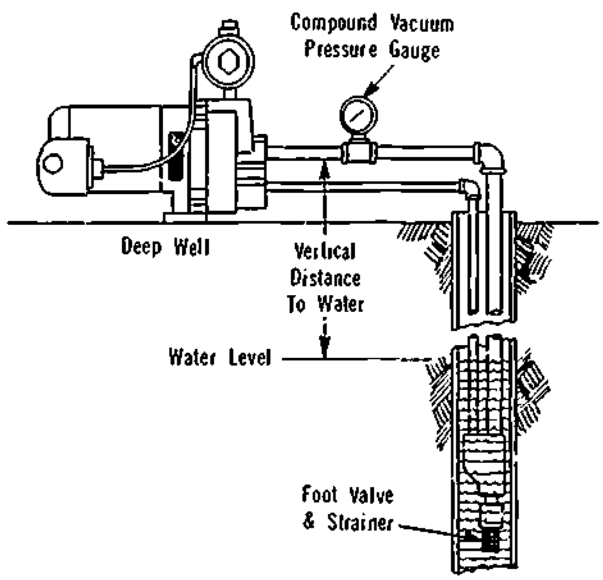
When installing a vacuum gauge, make certain that it is located *ahead* of the ejector. (See Figure 26-53.) Some units have a tapped opening for attaching the air-volume control, located between the ejector and the impeller. Installed here, the gauge does not show total suction lift. A vacuum gauge located at the pump suction will register the total suction lift at which the pump is operating. This includes vertical distance to water as well as friction loss in the foot valve, strainer, pipe, and fittings. When the pump is stopped, the gauge will record storage-tank pressure if the line is equipped with a foot valve. If not, the gauge will record the vertical distance to the water level.

Most shallow-well performance problems centre on a loss of capacity. Generally, low capacity coupled with a higher vacuum-gauge reading than is warranted by the estimated water level indicates a restriction in the suction pipe. This may result from a plugged strainer or foot valve, or from excessive friction loss. It could also indicate a water level lower than estimated.



In shallow well jet installation, vacuum gauge is located ahead of the ejector as shown here

Figure 26-53. Location of Vacuum Gauge



Compound vacuum gauge installed on deep-well jet pump is located on the suction line.

Figure 26-54. Location of Compound Vacuum-Pressure Gauge

Low capacity accompanied with a lower vacuum reading than warranted would indicate either an air leak in the suction line or excessive impeller wear-ring clearance allowing too much recirculation.

Examples:

Conditions: Pump located 1.2 to 1.5 m above water with short offset (0.6 to 0.9 m) delivers little or no water. Vacuum gauge shows, for example, 67.73 kPa, or 68 kPa vacuum.
Cause: Strainer or foot valve plugged.

Conditions: Pump located 6.1 m to water; pumps no water; vacuum gauge shows 34 kPa, or 3.45 m of water head.
Causes: Air leak in suction line or excessive impeller wear-ring clearance.

Conditions. Pump located within limits of suction lift but shows high vacuum and is pumping less than rated capacity.
Causes: Excessive offset, too small a suction line, or a partly plugged strainer.

p) Compound Vacuum Gauge Used with Deep-Well Jets

A compound vacuum gauge installed as shown in Figure 26-54 will indicate some of the pumping problems encountered with deep-well jet pumps. Since part of the pump capacity is recirculated through the pressure pipe back to the ejector in the well, it is not possible to determine the water level with the gauge reading. It is possible to develop a positive pressure simply by changing the setting of the regulating valve. Some manufacturers indicate the most efficient point of operation of their jet pump at a given suction-line value, and the regulating valve can be set using the gauge and this information. Generally, this value would range from 5.5 to 7.6 m of suction head at the pump as indicated by the gauge.

Following are some indications of pump problems and their probable causes:

A vacuum gauge showing a high reading but pumping no water would indicate:

a) Water level is beyond the range of ejector setting.
b) Friction in the lines is too great owing to an excess of fittings, too great an offset, ejector submerged too much, too small a pipe for the length of run.
c) Plugged nozzle or strainer.
d) Pump discharge pressure is not high enough because the regulating valve is set too low.

Pumping lower than rated capacity would indicate:

a) Pressure regulating-valve setting is too low.
b) Excessive friction.
c) Wrong ejector.
d) Excessive submergence.

q) Compound Vacuum Used to Check Air-Volume Control

The compound vacuum gauge can also be used to determine the amount of suction in the line available for operating the air-volume control on the pressure tank Most vacuum-operated AVCs require a minimum of 16 9 to 20 3 kPa vacuum during pump operation and a zero or slight pressure reading when the pump is stopped. Problems are often encountered with shallow-well installations where the water level is near the surface. A gauge connected to the AVC tapping in the pump case will determine if conditions are favorable to operating the control If not, vacuum boosters are available.

Again, the importance of using the instruments on every installation must be emphasized. Continual practice will assist the installer in recognizing problems as they occur It will also build confidence in the use of the instruments and save hours of service time.

8. Servicing Jet Pumps

The jet pump is still the most popular type of domestic water pumping system. A thorough understanding of the component functions of this system enables the installer to better handle servicing problems. For the purpose of jet-pump servicing, the water system can be separated into four main groups: the centrifugal pump, the jet, the air controls (including the tank), and the electrical group comprising the motor and pressure switch. The functions of each of these groups are covered in other sections.

In this section, the service problems are charted, each chart dealing with a specific malfunction, listing the possible causes, and giving procedures for checking and correcting it. (See Tables 26-4 to 26-8.)

Table 26-4. Jet Pump Won't Start or Run

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Blown fuse.	Check to see if fuse is OK.	If blown, replace with fuse of proper size.
2. Low line voltage.	Use voltmeter to check pressure switch or terminals nearest pump.	If voltage under recommended minimum, check size of wiring from main switch on property. If OK, contact power company.
3. Loose, broken, or incorrect wiring.	Check wiring circuit against diagram. See that all connections are tight and that there are no short circuits because of worn insulation, crossed wire, etc.	Re-wire any incorrect circuits. Tighten connections, replace defective wires.
4. Defective motor.	Check to see that switch is closed.	Repair or take motor to service station.
5. Defective pressure switch.	Check switch setting. Examine switch contacts for dirt or excessive wear.	Adjust switch settings. Clean dirty contacts with emery cloth.
6. Tubing to pressure switch plugged.	Remove tubing and blow through it.	Clean or replace if plugged.
7. Impeller won't turn.	Turn off power, then use a screwdriver to try to turn impeller or motor.	If the impeller won't turn, remove housing and locate the source of binding.
8. Defective start capacitor.	Use an ohmmeter to check resistance across capacitor. Needle should jump when contact is made. No movement means an open capacitor; no resistance means capacitor is shorted.	Replace capacitor or take motor to service station.
9. Motor shorted out.	If fuse blows when pump is started (and external wiring is OK) motor is shorted.	Replace motor.

Table 26-5. Motor Overheats and Overload Trips Out

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Incorrect line voltage.	Use voltmeter to check at pressure switch or terminals nearest pump.	If voltage is under recommended minimum, check size of wiring from main switch on property. If OK, contact power company.
2. Motor wired incorrectly.	Check motor-wiring diagram.	Re-connect for proper voltage per wiring diagram.
3. Inadequate ventilation.	Check air temperature where pump is located. If over 38°C, overload may be tripping on external heat.	Provide adequate ventilation or move pump.
4. Prolonged low-pressure delivery.	Continuous operation at very low pressure places heavy overload on pump. This can cause overload protection to trip.	Install globe valve on discharge line and throttle to increase pressure.

Table 26-6. Pump Starts and Stops Too Often

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Leak in pressure tank.	Apply soapy water to entire surface above water line. If bubbles appear, air is leaking from tank.	Repair leaks or replace tank.
2. Defective air-volume control.	This will lead to a water-logged tank. Make sure control is operating properly. If not, remove and examine for plugging.	Clean or replace defective control.
3. Faulty pressure switch.	Check switch setting. Examine switch contacts for dirt or excessive wear.	Adjust switch settings. Clean dirty contacts with emery cloth.
4. Leak on discharge side of system.	Make sure all fixtures in the plumbing system are shut off. Then check all units (especially ballcocks) for leaks. Listen for noise of water running.	Repair any leaks.
5. Leak on suction side of system.	On shallow-well units, install pressure gauge on suction side. On deep-well systems, attach a pressure gauge to the pump. Close the discharge line valve. Then, using a bicycle pump or air compressor, apply about 210 kPa to the system. If the system will not hold this pressure when the compressor is shut off there is a leak on the suction side.	Make sure above-ground connections are tight. Then repeat test. If necessary, pull piping and repair leak.
6. Leak in foot valve.	Pull piping and examine foot valve.	Repair or replace the defective valve.
7. Loss of pre-charge in float-type tanks.	Check water level in tank by sweat line or feel the tank with your hand — the cooler part is water. If water line is above approximately two-thirds the height of tank, re-charge with air.	Add air to tank according to manufacturer's instructions.

Table 26-7. Pump Won't Shut Off

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Wrong pressure-switch setting or setting "drift."	Lower switch setting. If pump shuts off, this was the trouble.	Adjust switch to proper setting.
2. Defective pressure switch.	Arcing may have caused switch contacts to "weld" in closed position. Examine points and other parts of switch for defects.	Replace switch if defective.
3. Tubing to pressure switch plugged.	Remove tubing and blow through it.	Clean or replace if plugged.
4. Loss of prime.	When no water is delivered, check prime of pump and well piping.	Re-prime if necessary.
5. Low well level.	Check well depth against pump performance table to make sure pump and ejector are properly sized.	If under-sized, replace pump or ejector.
6. Plugged ejector.	Remove ejector and inspect.	Clean and re-install if dirty.

Table 26-8. Pump Operates but Little or No Water is Delivered

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. System incompletely primed.	When no water is delivered, check prime of pump and well piping.	Re-prime if necessary.
2. Air lock in suction line.	Check horizontal piping between well and pump. If it does not pitch upward from well to pump, an air lock may form.	Re-arrange piping to eliminate air lock.
3. Under-sized piping.	If system delivery is low, the piping and/or plumbing lines may be under-sized. Re-figure friction loss.	Replace under-sized piping or install a pump with higher pressure.
4. Leak in air-volume control or tubing.	Disconnect air-volume control tubing at pump and plug hole. If capacity increases, a leak exists in the tubing of control.	Tighten all fittings and replace control if necessary.
5. Pressure regulating valve stuck or incorrectly set. (Deep well only.)	Check valve setting. Inspect valve for defects.	Reset, clean, or replace valve as needed.
6. Leak on suction side of system.	On shallow-well units, install a pressure gauge on the suction side. On deep-well systems, attach a pressure gauge to the pump. Close the discharge line valve. Then, using a bicycle pump or air compressor, apply about 210 kPa to the system. If the system will not hold this pressure when the compressor is shut off, there is a leak on the suction side.	Make sure above-ground connections are tight. Then repeat test. If necessary, pull piping and repair leak.
7. Low well level.	Check well depth against pump performance table to make sure pump and ejector are properly sized.	If under-sized, replace pump or ejector.
8. Wrong pump-ejector combination.	Check pump and ejector models against manufacturer's performance tables.	Replace ejector if wrong model is being used.
9. Low well capacity.	Shut off pump and allow well to recover. Re-start pump and note whether delivery drops after continuous operation.	If well is weak, lower ejector (deep-well pumps), use a tail pipe (deep-well pumps), or switch from shallow-well to deep-well equipment.
10. Plugged ejector.	Remove ejector and inspect.	Clean, if dirty, and re-install.
11. Defective or plugged foot valve and/or strainer.	Pull foot valve and inspect. Partial clogging will reduce delivery. Complete clogging will result in no water flow. A defective foot valve may cause the pump to lose prime, resulting in no delivery.	Clean, repair, or replace as needed.
12. Worn or defective pump parts or plugged impeller.	Low delivery may result from wear on impeller or other pump parts. Disassemble and inspect.	Replace worn parts or the entire pump. Clean parts if needed.

9. Servicing Submersible Pumps

The simplicity of operation, ease of installation, and improved electrical and mechanical design of the submersible pump have contributed much to its popularity. To gain this acceptance, the manufacturers have had to do much educational work. It was necessary to teach the installer how to handle and service the electrical parts of this system. The installer was also required to purchase and learn to use such electrical instruments as an ohmmeter, an ammeter, and a voltmeter. The proper use of these instruments and an adequate knowledge of the function of the electrical components have overcome much of the fear of installing and servicing this equipment. The instruments are necessary to locate the source of trouble and avoid pulling a satisfactory unit.

Once the instruments and the procedures for checking a unit have been mastered, you have only to follow the steps outlined in the following charts.

These charts cover 95 per cent or more of submersible servicing work. Most of the checking can be done without touching the pump. It is always desirable to make all above-ground checks before the pump is pulled from the well.

Like all mechanical equipment, submersible pumps are subject to a certain amount of servicing work. But the servicing problems on today's submersibles are far fewer than they were a few years ago.

Since much of the check-out work on submersibles entails electrical tests, the servicing contractor must be thoroughly familiar with the electrical components of the water system. But the tests are not complicated and manufacturers' service literature generally includes explicit instructions for making electrical tests. Generally, only two instruments are needed, a combination amprobe with voltage scale and an ohmmeter, both inexpensive and obtainable from most water-systems suppliers. Once these instruments are mastered — and they can be in an hour or so — you have only to follow a systematic trouble-shooting procedure to diagnose almost all servicing troubles that might be encountered with submersibles.

The data in Tables 26-9 to 26-14 outline the procedure for tracing the source of a major trouble.

Table 26-9. Fuses Blow or Circuit Breaker Trips When Motor is Started

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Incorrect line voltage.	Check the line-voltage terminals in the control box (or connection box in the case of the two-wire models) with a voltmeter. Make sure the voltage is within the range prescribed by the manufacturer.	If the voltage is incorrect, contact the power company to have it corrected.
2. Defective control box:		
a) Defective wiring.	Check all motor and powerline wiring in the control box, following the wiring diagram found inside the box. Make sure all connections are tight and that there are no crossed wires, worn insulation, etc.	Re-wire any incorrect circuits. Tighten loose connections. Replace worn wires.
b) Incorrect components.	Check all control-box components to make sure they are the type and size specified for the pump in the manufacturer's literature.	Replace any incorrect component with the size and type recommended by the manufacturer.
c) Defective starting capacitor (skip for two-wire models)	Using an ohmmeter, determine the resistance across the starting capacity. When contact is made, the ohmmeter needle should jump at once, then move up more slowly. No movement indicates an open capacitor (or defective relay points); no resistance means that the capacitor is shorted.	Replace the defective starting capacitor.

(continued)

d) Defective relay (skip for two-wire models).	Using an ohmmeter, check the relay coil. Its resistance should be as shown in the manufacturer's literature.	If coil resistance is incorrect or points defective, replace the relay.
3. Defective pressure switch.	Check the voltage across the pressure-switch points. If less than the line voltage determined in "1" above, the switch points are causing low voltage by making imperfect contact.	Clean the points with a mild abrasive cloth or replace pressure switch.
4. Pump in crooked well.	If wedged into a crooked well, the motor and pump may become misaligned, resulting in a locked rotor.	If the pump does not rotate freely it must be pulled and the well straightened, or in some cases install a jet pump.
5. Defective motor or cable:		
a) Shorted or open motor winding.	Check resistance of the motor winding by using an ohmmeter on the proper terminals in the control box (see manufacturer's wiring diagram). The resistance should match the ohms specified in the manufacturer's data sheet. If too low, the motor winding may be shorted; if the ohmmeter needle doesn't move, indicating high or infinite resistance, there is an open circuit in the motor winding.	If the motor winding is defective — shorted or open — the pump must be pulled and the motor repaired.
b) Grounded cable or winding.	Ground one lead of the ohmmeter onto the drop pipe or shell casing, then touch the other lead to each motor-wire terminal. If the ohmmeter needle moves appreciably when this is done, there is a ground in either the cable or the motor winding.	Pull the pump and inspect the cable for damage. Replace damaged cable. If cable checks OK, the motor winding is grounded.
c) Tight motor.	Using an amprobe, check the amperage draw. If the reading is higher than the manufacturer's recommendation the pump has to be pulled.	Pull pump, repair or replace the motor.
6. Pump sandlocked.	Using an amprobe, check the amperage draw. If the reading is higher than the manufacturer's recommendation the pump has to be pulled.	Pull pump, disassemble and clean. Before replacing, make sure that sand has settled in the well. If the well is chronically sandy, a submersible should not be used.

Table 26-10. Pump Operates But Delivers Little or No Water

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Pump may be air locked.	Stop and start the pump several times, waiting about one minute between cycles. If the pump then resumes normal delivery, the air lock was the trouble.	If this test fails to correct the trouble, proceed as below.
2. Water level in well too low.	Well production may be too low for pump capacity. Restrict flow of pump output, wait for well to recover, and start the pump.	If partial restriction corrects the trouble, leave valve or cock at restricted setting. Otherwise, lower the pump in well if depth is sufficient. Do not lower if sand clogging might occur.
3. Discharge-line check valve installed backward.	Examine check valve on the discharge line to make sure that arrow indicating direction of flow points is in the right direction.	Reverse the valve if necessary.
4. Leak in drop pipe.	Raise the pipe and examine for leaks.	Replace damaged section of drop pipe.
5. Pump check-valve jammed by drop pipe.	When the pump is pulled after completing "4" above, examine connection of the drop pipe to pump outlet. If threaded section of the drop pipe has been screwed in too far, it may be jamming the pump's check valve in the closed position.	Unscrew drop pipe and cut off a portion of threads.
6. Pump intake-screen blocked.	The intake screen on the pump may be blocked by sand or mud. Examine.	Clean screen. When re-installing the pump, make sure it is located 3.05 m or more above the well bottom.
7. Pump parts worn.	Abrasives in the water may result in excessive wear on the impeller, casing, and other close-clearance parts. Before pulling the pump, reduce the setting on pressure switch to see if the pump shuts off. If it does, worn parts are probably at fault.	Pull the pump and replace worn components.
8. Motor shaft loose.	Coupling between the motor and pump shaft may have worked loose. Inspect for this after looking for worn components, as in "7" above.	Tighten all connections, set-screws, etc.

Table 26-11. Pump Starts Too Frequently

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Pressure switch defective or out of adjustment.	Check setting on the pressure switch and examine for defects.	Reduce pressure setting or replace switch.
2. Leak in pressure tank above water level.	Apply soap solution to entire surface of the tank and look for bubbles — indicating air escaping.	Repair or replace tank.
3. Leak in plumbing system.	Examine the service line to house and distribution branches for leaks.	Repair leaks.
4. Discharge-line check valve leaking.	Remove and examine.	Replace if defective.
5. Air-volume control plugged.	Remove and inspect air-volume control.	Clean or replace.
6. Snifter valve plugged.	Remove and inspect snifter valve.	Clean or replace.

Table 26-12. Fuses Blow When Motor is Running

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Incorrect voltage.	Check line voltage terminals in the control box (or connection box in the case of two-wire models) with a voltmeter. Make sure the voltage is within the minimum-maximum range prescribed by the manufacturer.	If voltage is incorrect, contact power company for service.
2. Overheated overload-protection box.	If sunlight or other heat has made box too hot, circuit breakers may trip or fuses blow. If box is hot to the touch this may be the problem.	Provide ventilation or shade box, or remove from source of heat.
3. Defective control-box components (skip this for two-wire models).	Using an ohmmeter determine the resistance across the running capacitor. When contact is made the ohmmeter needle should jump at once, then move up more slowly. No movement indicates an open capacitor (or defective relay points): no resistance means that the capacitor is shorted. Using an ohmmeter, check the relay coil. Its resistance should be as shown in the manufacturer's literature. Re-check ohmmeter reading across running capacitor. With a good capacitor, no movement of the needle indicates relay points are open or defective.	Replace the defective components.

4. Defective motor winding or cable.	Check the resistance of the motor winding by using an ohmmeter on the proper terminals in the control box (see manufacturer's wiring diagram). The resistance should match the ohms specified in the manufacturer's data sheet. If too low, the motor winding may be shorted; if the ohmmeter needle doesn't move, indicating high or infinite resistance, there is an open circuit in the motor winding. Ground one lead of the ohmmeter onto the drop pipe or shell casing, then touch the other lead to each motor-wire terminal. If the ohmmeter needle moves appreciably, there is a ground in either the cable or the motor winding.	If neither the cable nor the winding is defective — shorted, grounded, or open — the pump must be pulled and the problem corrected.
5. Pump becomes sand-locked.	If the fuses blow while the pump is operating, sand or grit may have become wedged in the impeller, causing the rotor to lock. To check this, pull the pump.	Pull pump, disassemble, and clean. Before replacing, make sure that sand has settled in the well. If the well is chronically sandy, a submersible should not be used.

Table 26-13. Pump Won't Shut Off

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Defective pressure switch.	Arcing may have caused the pressure switch points to "weld" in closed position. Examine points and other parts of switch for defects.	Clean points or replace switch.
2. Water level in well too low.	Well production may be too low for pump capacity. Restrict flow of pump output, wait for well to recover, and start pump.	If partial restriction corrects trouble, leave valve or cock at the restricted setting. Otherwise, lower pump in well if depth is sufficient. Do not lower if sand-clogging might occur.
3. Leak in drop line.	Raise the pipe and examine for leaks.	Replace damaged section of drop pipe.
4. Pump parts worn.	Abrasives in the water may result in excessive wear on the impeller, casing, and other close-clearance parts. Before pulling the pump, reduce the setting on the pressure switch to see if the pump shuts off. If it does, worn parts are probably at fault.	Pull the pump and replace worn components.

Table 26-14. Motor Does Not Start, But Fuses Do Not Blow

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Overload protector or cut out.	Check fuses or circuit breaker to make sure they are operable.	If fuses are blown, replace. If breaker is tripped, reset.
2. No power.	Check power supply to the control box (or overload-protection box) by placing a voltmeter across incoming power lines. Voltage should approximate nominal line voltage.	If no power is reaching the control box, contact power company for service.
3. Defective control box.	Examine wiring in control box to make sure all contacts are tight. With a voltmeter, check voltage at motor-wire terminals. If no voltage is shown at terminals, wiring in the control box is defective.	Correct faulty wiring or tighten loose contacts.
4. Defective pressure switch.	With a voltmeter, check voltage across the pressure switch while it is closed. If the voltage drop is equal to the line voltage, the switch is not making contact.	Clean points or replace switch.

10. Servicing Reciprocating Pumps

At one time, the deep-well working head and horizontal piston pumps were the only motorized units available for domestic water systems. With the advent of the jet pump and the more recent submersible, the reciprocating pump has decreased in popularity although there is still a limited demand for it. These, plus thousands of units still in use, will require service.

Although installers may not handle this type of equipment, they will often be called on to service these "work horses" of the pump industry.

In this section, the service problems have been set up in seven charts, each chart dealing with a specific malfunction, listing the possible causes, and giving procedures for checking and correcting it (See Tables 26-15 to 26-21.)

Table 26-15. Pump Won't Start or Run

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Blown fuse.	Check to see if fuse is OK.	If blown, replace with a fuse of proper size.
2. Low line voltage.	With pump motor energized, use voltmeter to check at pressure-switch terminals nearest the pump.	If voltage is under recommended minimum, check size of wiring from main switch on the property. If OK, contact power company.
3. Loose, broken, or incorrect wiring.	Check the wiring circuit against diagram. See that all connections are tight and that there are no short circuits because of worn insulation, crossed wires, etc.	Re-wire any incorrect circuits. Tighten connections and replace defective wires.
4. Defective pressure switch.	Check the switch setting. Examine switch contacts for dirt or excessive wear.	Adjust switch settings. Clean dirty contacts with emery cloth.
5. Tubing to pressure switch plugged.	Remove tubing and blow through it.	Clean or replace if plugged.
6. Pump mechanically bound.	Turn off power and turn the pump by hand.	Locate source of the binding and repair.
7. Defective start capacitor.	Disconnect capacitor from motor. Use an ohmmeter to check resistance across the capacitor. Needle should jump when contact is made. No movement means an open capacitor; no resistance means capacitor is shorted.	Replace capacitor or take motor to service station.
8. Motor shorted out.	If fuse blows when the pump is started (and external wiring is OK), the motor has shorted.	Replace motor.
9. Overload protector cut out.	Check manual overload protector.	Correct cause of overload, reset overload protector.

Table 26-16. Pump Runs But Does Not Deliver Water

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Low line voltage.	With the pump motor energized, use voltmeter to check at pressure-switch terminals nearest the pump.	If voltage is under recommended minimum, check size of wiring from main switch on the property. If OK, contact power company.
2. Loss or prime (piston pumps).	When no water is delivered, check the prime of pump and well piping.	Re-prime if necessary.
3. Broken rod (working heads).	Disconnect rod from the pump and see if it can be lifted easily — an indication of a broken rod.	If the rod is broken, remove upper part. Then fish for lower part or pull drop-pipe. Repair break.
4. Low well level.	On piston pumps, make sure the water level is no more than 7.6 m below the pump (less if at elevated altitudes).	If the water level is below 7.6 m, the piston pump won't work. Replace with submersible or deep-well jet pump.
	On working heads, lower the well cylinder by adding more drop-pipe and rod. If this results in water delivery the cylinder was above water level.	Leave the cylinder at lower level.
5. Air lock in suction line (piston pumps).	Check horizontal piping between the well and pump. If it does not pitch upward, an air lock may form.	Re-arrange piping to eliminate air lock.
6. Suction valves stuck in open position (piston pumps).	Remove cover from water end of the pump and inspect valves.	Clean out any foreign matter between valves and valve plate. Make sure a watertight closure can occur.
7. Leak in suction line (piston pumps or drop-pipe working heads).	On piston pumps, install a vacuum gauge on the suction side and start the pump. Low vacuum means a leaky suction line.	Repair leaks as necessary.
	On working heads, attach a pressure gauge to the discharge line upstream of the main valve. Close the valve. Then, using a bicycle pump or air compressor, apply about 210 kPa of air to the system. If this pressure isn't held, there is a leak in the drop-pipe.	Repair leaks as necessary.
8. Open foot valve (piston pumps) or cylinder check valve (working heads).	Fill the drop pipe or suction line with water. If the water level drops, the lower valve may be defective. Pull the drop pipe and inspect the foot valve (piston pumps) or cylinder check valve (working heads).	Clean and repair or replace as necessary.
9. Clogged drive point.	If a drive point was used in the well, pull the suction line and examine.	Clean drive point and re-install.

Table 26-17. Low Capacity

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Under-sized piping.	If system discharge is low, the discharge piping and/or plumbing lines may be under-sized. Re-figure friction loss.	Replace under-sized piping or install a pump with higher discharge pressure.
2. Low well capacity.	Stop pump and allow the well to recover. Re-start pump and note whether delivery drops after continuous operation. (On working-head units, low well capacity is indicated by a violent jarring of the drop pipe after continuous operation. This indicates that air is entering the well cylinder.)	If possible, lower the suction line or well cylinder to permit greater draw-down. If this cannot be done, throttle the discharge line so that delivery matches the well recovery time.
3. Leaky relief valve (piston pumps).	Examine the built-in relief valve for defects.	If the relief valve is leaking, repair or replace it.
4. Worn parts.	On piston pumps, examine valves and valve plate, plunger leathers, and gaskets. On working-head units, pull rod and examine the leathers.	Replace worn or defective parts.

Table 26-18. Pump Loses Prime (Piston Only)

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Suction valves stuck in open position.	Remove cover from the water end of the pump and inspect valves.	Clean out any foreign matter between valves and valve plate. Make sure a watertight closure can occur.
2. Leak in suction line.	On piston pumps, install a vacuum gauge on the suction side and start pump. Low vacuum means a leaky suction line.	Repair leaks as necessary.
	On working heads, attach a pressure gauge to the discharge line upstream of the main valve. Close the valve. Then, using a bicycle pump or air compressor, apply about 210 kPa of air to the system. If this pressure isn't held, there is a leak in the drop pipe.	Repair leaks as necessary.
3. Defective relief valve.	Examine the built-in relief valve for defects.	If the relief valve is leaking, repair or replace it.

Table 26-19. Pump Starts and Stops Too Often

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Leak in pressure tank.	Apply soapy water to entire surface above the water line. If bubbles appear, air is leaking from the tank.	Repair leaks or replace tank.
2. Defective air-volume control.	This leads to a water-logged tank. Make sure the control is operating properly. If not, remove and examine it for plugging.	Clean or replace the defective control.
3. Pressure switch.	a) Remove tubing. Inspect the pressure-switch opening for restrictor. Determine if switch is of the jet or reciprocating type. b) Check pressure differential.	a) Insert restrictor or replace the switch if jet type. b) Adjust pressure differential to 140 kPa.
4. Leak on discharge side of system.	Make sure all fixtures in the plumbing system are shut off. Then check all units (especially ballcocks) for leaks. Listen for noise of water running.	Repair leaks as necessary.
5. Leak in suction line (piston pumps) or drop pipe (working heads).	On piston pumps, install a vacuum gauge on the suction side and start the pump. Low vacuum means a leaky suction line.	Repair leaks as necessary.
	On working heads, attach a pressure gauge to the discharge line. Then, using a bicycle pump or air compressor, apply about 210 kPa of air to the system. If this pressure isn't held, there is a leak in the drop pipe.	Repair leaks as necessary.
6. Leak in foot valve (piston pumps).	Fill the drop pipe or suction line with water. If the water level drops, the lower valve may be defective. Pull the drop pipe and inspect the foot valve (piston pumps) or cylinder check valve (working heads).	Clean and repair or replace as necessary.

Table 26-20. Pump Won't Shut Off

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Wrong pressure-switch setting or setting "drift."	Lower the switch setting. If the pump shuts off, this was the trouble.	Adjust the switch to proper setting.
2. Defective pressure switch.	Arcing may have caused switch contacts to "weld" in closed position. Examine points and other parts of the switch for defects.	Replace the switch if defective.
3. Tubing to pressure switch plugged.	Remove the tubing and blow through it.	Clean the tubing or replace it if plugged.
4. Loss of prime (piston pumps).	When no water is delivered, check the prime of pump and well piping.	Re-prime if necessary.
5. Low well level.	On piston pumps, make sure the water level is no more than 7.6 m below the pump (less if at elevated altitudes).	If the water level is below 7.6 m, the piston pump won't work. Replace it with a submersible or deep-well jet pump.
	On working heads, lower the well cylinder by adding more drop pipe and rod. If this results in water delivery, the cylinder was above the water level.	Leave the cylinder at the lower level.

Table 26-21. Excessive Operating Noise

CAUSE OF TROUBLE	HOW TO CHECK	HOW TO CORRECT
1. Water-logged tank or air chamber.	Make sure the control is operating properly. If not, remove and examine it for plugging.	Clean or replace the defective control.
2. Under-sized suction line (piston pumps).	Check the manufacturer's recommendations for sizing the suction line.	Replace the suction line with one of a larger diameter if it is under-sized.
3. Sticking suction valves (piston pumps).	Remove cover from the water end of the pump and inspect valves.	Clean out any foreign matter between valves and valve plate.
4. Rod slapping against drop pipe (working heads).	Feel the rod for "play," especially if it is made of steel.	Install rod guides at 3 m intervals or replace the steel rod with wood.
5. Low well level.	On piston pumps, make sure the water level is no more than 7.6 m below the pump (less if at elevated altitudes).	If the water level is below 7.6 m, the piston pump won't work. Replace it with a submersible or deep-well jet pump.
	On working heads, lower the well cylinder by adding more drop pipe and rod. If this results in water delivery, the cylinder was above water level.	Leave the cylinder at the lower level.
6. Sticking or noisy cylinder valves (working heads).	Pull the cylinder and examine the valves.	If the valves operate sluggishly, install a cylinder with spring-loaded valves. If noise is the problem, switch to a cylinder with rubber-faced valves.

11. Selecting a Complete Water System of Adequate Capacity

The first requirement of any water system is to provide enough capacity to meet both present and future needs. People should grow into their water system and not out of it. It is unwise to install a system to meet only present water needs since per capita water consumption increases every few years.

But it would also be unwise to install a pump rated in excess of the ability of the well to produce. Data must be available on the diameter of the well, total depth, its yield, and pumping level.

The lack of sufficient pump capacity (20 L per minute at 210 kPa) for minimum fire protection is often overlooked.

Unless the well flow is less than 20 L per minute, this volume of water should be the absolute minimum for any water system. Preferably, the system capacity should be from 30 to 40 L per minute. Usually the difference in cost between a low-capacity and an adequate-capacity water system is insignificant.

It would be difficult to set up a formula to arrive at adequate capacities for all installations; but a time-proven rule that works well is based on estimated daily requirements and the fact that 80 per cent of the water used in a farm home is drawn during a two-hour or three-hour period. Table 26-22 gives the average quantities of water needed daily for the different services demanded of such a water system.

Table 26-22. Estimated Farm Home Daily Water Requirements.

Each member of the family, for all purposes including kitchen, bath, laundry	190 L
Each horse	45 L
Each milk-producing cow	130 L
Each hog	15 L
Each 100 chickens	15 L
One hour of lawn sprinkling, garden irrigation, flushing, etc.	1140 L

Based on the foregoing table, Table 26-23 gives the daily water needs for a typical farm installation to serve 6 family members, 5 horses, 10 milk-producing cows, 30 hogs, 200 chickens, and an hour of sprinkling, etc.

Table 26-23. Estimated Farm Installation Daily Requirements.

The family	1140 L
Horses	225 L
Cows	1300 L
Hogs	450 L
Chickens	30 L
One hour of hose use	1140 L
Total daily need	4285 L

To provide 80 per cent of this farm's typical daily water requirements within two hours, the pump should be able to deliver at least 28 L of water per minute. To cover surges, however, an added capacity margin must be included. Now add estimated additional water needs for the next 10 years or more and the result will be a properly selected water system.

Obviously, the foregoing table will not serve correctly for a non-farm home. To select the proper pump capacity, the peak load for water should be the governing factor: How many outlets will be open at one time?

For example, a one-bathroom home, along with water for the kitchen, laundry, and outside sill cock, should never have a water system with a capacity of less than 30 L per minute. A tub or shower bath requires about 19 L, thus with a capacity of 30 L per minute this would leave 11 L for the kitchen. A two-bathroom home should have a capacity of from 45 to 57 L per minute to serve peak-load needs.

It costs no more to pump a given amount of water with a larger system than with a smaller one. And because the larger unit need not run so long each day or year, the maintenance cost will be less.

12. All Water Needs Conditioning

Whatever the source, water always contains impurities in solution or suspension. It is the presence of these impurities that makes water conditioning essential.

These impurities can be many, and depend upon the source of the water such as rain, surface water, or ground water. "Pure" water is tasteless, colorless, and odorless and is one of the most universal solvents, that is, more things dissolve in water than in almost any other liquid. Because "pure" water is such a good solvent it presents problems.

Each second, 14 500 000 tonnes of water is being precipitated in the world and a like amount is being evaporated. Figure 26-55 shows the water cycle as a continual precipitation-evaporation process.

13. The Convenience of Conditioned Water in the Home

a) Cooking and Drinking

Green vegetables, when cooked in hard water, absorb the hardness minerals, which causes them to shrink and become tough and inedible. This is noticed particularly in peas, beans, and other legumes.

Hard water also robs canned and other boiled foods of their natural flavor and color, hence the National Canners Association recommends fully softened water for canning.

Use only softened water to brew truly good coffee and other beverages. The scale in metal percolators is a deposit of hard-water salts that retains some of the fat from the coffee grounds, eventually becomes rancid, and detracts from the flavor.

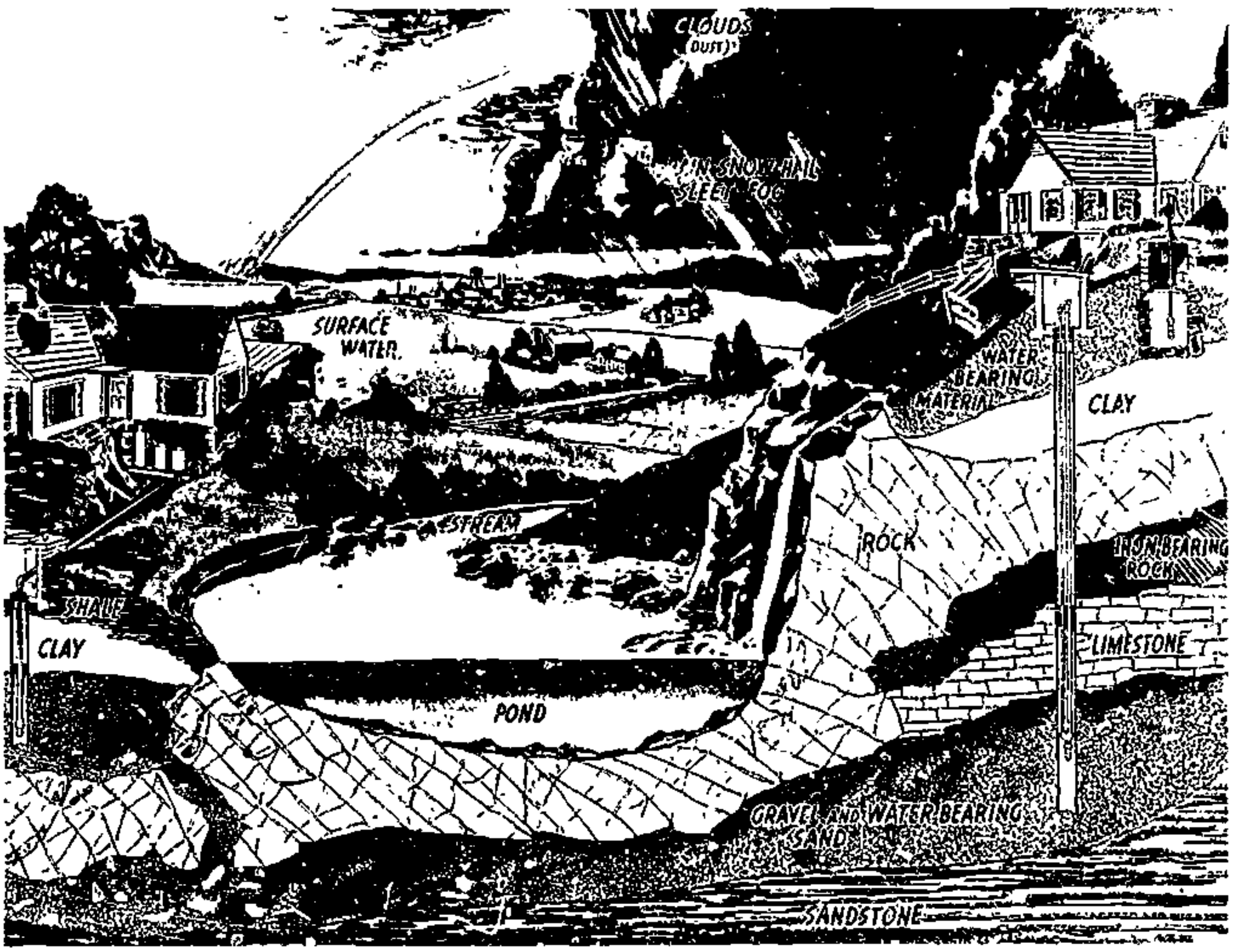


Figure 26-55. The Water-Cycle Process

b) Personal Grooming

The dull film that cannot be washed off the hair is caused by the sticky curd produced by hard water. Under this condition, hair loses its lustre by as much as 60 per cent, eventually becomes brittle, and loses even its natural wave.

Soft water leaves the color and texture as they were meant to be — soft and fluffy, yet easily managed, with natural color and lustre. The hair also dries faster Soft water keeps the skin smooth and fresh.

c) Laundering

Since no precipitates will form when clothes are washed in soft water, the clothes will look and feel cleaner and softer than before. No precipitates will form during the rinse cycle either, thus a cleaner, evener ironing with the use of modern starches results.

The life expectancy of fabrics increases as much as 50 per cent when using soft water, depending on the hardness minerals that were formerly present. In an effort to eliminate "tattle-tale gray," the hard-water user will wash more frequently with stronger and harsher agents, yet fabric life is directly related to the number of launderings.

With soft water, the annual savings on soap and detergent alone could be considerable, depending on the former hardness of the untreated water.

Soft water leaves a baby's clothes soft and sweet-smelling. Diaper rash has been cleared up by switching to soft-water laundering of diapers and bedding, because this eliminates the hardness that can scratch and irritate a baby's tender skin.

d) General Cleansing

With soft water there is no scale or grime to remove from tubs and basins Transparent glassware presents a challenging problem whenever hard water is used The filmy, streaky appearance is caused by grease and soap scum that hard water cannot wash away This condition prevails regardless of the washing method — hand or machine, air dry, or wiping. Hard water also can scale and clog a dishwasher, causing extra maintenance expense.

e) Heating and Plumbing

When hard water is heated, the calcium and magnesium minerals in the water are converted to another less soluble form These salts come out of the water as solids and gradually build up a layer of hard, scaly material on the inside of pipes and other equipment. (See Figure 26-56 for a cross-sectioned piece of hot-water pipe.)

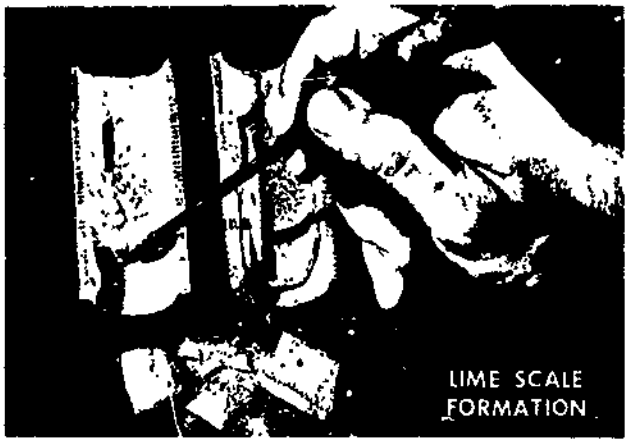


Figure 26-56. Typical Loose Scale, Mainly Calcium and Magnesium Carbonated in Water-Heating Piping

As little as 3 mm of hard water scale in water-heater coils can boost heating bills as much as 16 per cent and reduce heating efficiency by more than 20 per cent. This scale also acts as an insulator that, rather than passing heat along to the water, develops hot spots that destroy the pipe The build-up also creates friction losses and a pressure drop in the house — sometimes a complete stoppage.

These costly conditions can be prevented by simply softening the water.

f) Miscellaneous Uses

Cleansing of dairy equipment is much easier when soft water eliminates milk film, the chalk-like residue formed when dried milk combines with calcium and magnesium in hard water.

Many water devices in the modern home simply cannot operate at their designated efficiency without properly conditioned water. These include steam irons, humidifiers, and some types of air conditioning equipment, all of which require completely mineral-free (not only soft) water.

14. Unconditioned Water

The sources of unconditioned water can be classified as follows:

Rain water: cisterns.

Surface water brooks, creeks, rivers, ponds, lakes, reservoirs.

Ground water: springs, deep wells, shallow wells.

a) Rain Water

Water precipitated from the atmosphere high above the earth is chemically pure. However, it does not remain pure very long since water is one of " universal solvents. It will dissolve a little of ever,-thing it contacts. As water falls, oxygen, nitrogen, and carbon di: ide (the normal gases in the atmosphere) are d ss lved. Rain water also encounters dust, smoke, and fumes that are dissolved or retained in suspension. Bacteria in the spores of microscopic organisms may be picked up.

b) Surface Water

Water obtained from surface streams, ponds, etc., may be turbid owing to the presence of clay and silt. Agricultural land may contribute to the organic matter and may pollute the water with animal waste. Swamps may discharge their water during floods and carry decay and vegetable matter, color, and microscopic organisms into the streams and ponds. Surface water is also exposed to pollution by animals and humans, the sewage of cities, and the waste of industry. Generally, surface water does not contain as much hardness or other minerals as does ground water, since it usually is not in contact with rock formations.

c) Ground Water

In falling and percolating through the upper layers of soil, rain absorbs carbon dioxide with which it forms carbonic acid. This action increases the solvent power of the water so that it dissolves a certain amount of the mineral matter of the soil or rock that it contacts. The rock and sand in the soil are made up of many kinds of minerals and chemical substances. Each area contains different rock formations, so the nature and kinds of impurities vary in different sections of the country. The most common minerals are lime-stone, and dolomite—a natural rock containing calcium and magnesium, the hardness particles. The quantity dissolved depends upon the length of contac and solubility of the materials.

Deep-well water is usually clear and colorless owing to the filtration taking place through the layers of rock and sand. Usually, shallow-well water does not contain as high an amount of hardness or other dissolved minerals as deep-well water Shallow wells may at times be turbid, however, especially after heavy rain. Spring water is usually similar in characteristics to water obtained from shallow and deep wells in the area.

Impurities in a water supply can be divided into suspended and dissolved solids. Suspended solids are those that do not dissolve in water but can be removed or separated by filtration. Hardness in a water supply is an example of dissolved solids. Gases may also dissolve in water, but unless they combine chemically, with other impurities also in solution they will be expelled from the water on boiling and are not considered as dissolved solids.

15. Hard Water

Hardness is the most common impurity in water. It is defined as calcium and magnesium salts, such as lime, gypsum, epsom, in solution. Water hardness is the result of the ability of the water to dissolve, and hold in solution, compounds of calcium and magnesium that have been absorbed from limestone deposits in the earth's crust. While it is true that all water supplies are not extremely hard, it is also true that there is almost no water supply that is absolutely soft.

"Hard water" is many things to many people. To the housewife, it is the soap curd and the ring around the bathtub, and it makes laundering and cleaning difficult. The curd adheres to cloth fibres, glassware, and dishes. To the breadwinner, hard water means scale in the water heater that increases fuel bills. It clogs pipes and reduces water pressure. To the laundry operator, it is water that requires extra amounts of soap to produce working suds. It leaves a gray scum on the wash and in the wash wheel. To the chemist, it is water that contains an appreciable concentration of calcium and magnesium.

The calcium and magnesium salts, in order of their average abundance in various water supplies, are carbonates, sulphates, chlorides, and nitrates. The carbonates are by far the most abundant. Usually, calcium salts are about twice as abundant as magnesium salts. As soon as the carbon dioxide in the water comes into contact with the limestone, a chemical reaction occurs and calcium carbonates and magnesium carbonates are formed.

Hardness is measured in terms of milligrams per litre or parts per million (ppm) of calcium carbonate or its equivalent. For example, 1 mg per litre equals 1 part per million. In areas where the hardness is 0.2 parts per million or less it is hardly worth while reducing it to zero. It is difficult to show much benefit from treating such water when it is this near to zero hardness. The areas needing softeners are those where the hardness is over 120 parts per million. It is usually not economical to soften water with hardness of over 100 parts per million.

16. Iron in Water

Iron in water is extremely undesirable as it tends to discolor everything it touches. It is one of the most common elements in the earth's crust and is generally in two forms iron oxide and iron bacteria.

Iron in nature usually occurs as an insoluble oxide. When conditions in the earth are favorable, the iron is converted to a soluble form and then dissolved in waters with which it comes in contact. For this reason, iron is present to some extent in almost all natural water supplies, particularly in well water.

Chemically, iron can be seen as occurring in wate in both ferrous oxide and ferric oxide states. In the ferric state, the iron is completely oxidized, whereas in the ferrous state it is only partially oxidized. Ferrous oxide is soluble and therefore colorless, while ferric oxide is completely insoluble and red, which accounts for the familiar red stains.

In surface water, iron is in the ferric state, in well water, it is usually in the ferrous form. Upon removal from the well and exposure to air, carbon dioxide is released and the iron in the water is converted to the ferric state.

Iron bacteria are living organisms that feed on the pump, piping, tank, and iron fixtures causing damage and adding to the actual iron content of the water. They also build slimes on tanks, toilet water closets, etc.

From this it is seen that iron occurs in many forms and in varying amounts, and it is impossibe to establish one specific method of conditioning iron-bearing water. When iron is present in an amount exceeding 0 3 ppm, it is usually considered objectionable for both industrial and municipal supplies The U.S. Public Health Service Standards recommend a limit to the iron content in acceptable drinking water to 0.3 ppm. There is no evidence to prove a greater amount is physically harmful, but this limit was based upon the appearance and taste of the water.

The iron content of the great majority of iron-bearing well waters is in the range below 5 ppm. A few wells have in the range of from 5 to 15 ppm, and fewer still have more.

a) How to Correct Iron in Water

Water Softener:

The simplest method of removing iron in solution from clear water, if the upper limit does not exceed 3 ppm, is by using a water softener. Such iron is usually in the form of ferrous bicarbonate and is exchanged for sodium bicarbonate in exactly the same manner as hardness is removed.

What makes iron so troublesome in wells is the fact that while the iron is usually in complete solution (as ferrous bicarbonate) as it comes from the well, it comes in contact with air under pressure in the pressure tank. This oxidizes part of the iron before it reaches any filter or softener.

A softener will filter suspended iron, including ferric iron, but must be thoroughly backwashed and cleaned regularly The ferric or oxidized iron will tend to foul the softener bed and bleed iron through. Since iron is heavier than the softener mineral, the job of backwashing the iron out becomes very difficult.

A water softener, then, can be used to remove small amounts of iron that are in solution.

Manganese Zeolite Filters.

The operation of a manganese zeolite filter is to oxidize the iron in order to precipitate it and then filter it out in the same unit. The mineral bed contains manganese dioxide (in manganese green sand), which converts the ferrous oxide to ferric oxide, thus precipitating the iron The oxygen in the filter is replenished by putting in potassium permanganate. These filters remove iron in the ferrous or ferric states up to a maximum of about 10 ppm of iron. They will not remove organic iron or iron bacteria. (See also Section 31a) in this part of the manual.)

Chlorination:

A chlorinator (Figure 26-57) should be used when organic iron compounds or iron bacteria are present. A chlorinator will also oxidize the ferrous oxide. Then a slow sand or carbon filter is necessary following the chlorinator to filter the iron and excess chlorine from the water. By using a chlorinator and a filter, all types of iron can be removed. (See also Section 32 in this part of the manual.)

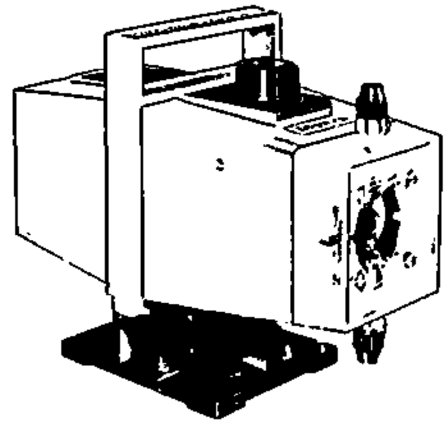


Figure 26-57. The Chlorinator

Summary:

If iron, ferrous or ferric, is not over 3 ppm, use a softener only

If ferrous and/or ferric iron is between 3 ppm and 10 ppm, use a manganese zeolite iron filter.

If ferrous and/or ferric iron is above 10 ppm, use a chlorinator and a filter.

For removing organic iron compounds, use a chlorinator and a filter.

For iron bacteria, use a chlorinator and a filter.

17. Sulphur in Water

"Sulphur water" is primarily hydrogen sulphide dissolved in water. Hydrogen sulphide imparts a characteristic "rotten egg" odor and taste. It will combine with other impurities in the water to form iron sulphide or black water.

Waters containing 1 ppm or more of hydrogen sulphide are definitely objectionable, but those containing less than 0.5 ppm usually are not. Generally, hydrogen sulphide concentrations are below 10 ppm but occasionally waters are found to contain 50 to 75 ppm.

Hydrogen sulphide may be present naturally in a water supply, but it is usually caused by certain types of bacteria in the water table. Sulphur may also be in the water from contamination from mine fields. Usually it is caused by bacteria reducing the sulphur.

With the exception of enterprising commercial establishments that bottle it or operate sulphur baths, the majority of people with sulphur water in their homes are extremely anxious to get rid of it. Coffee, tea, ice cubes, and cooking suffer substantially from it and some liquors even turn black.

Hydrogen sulphide is very corrosive and will eat away pump parts, piping, tanks, water heaters, fixtures, and anything of iron, steel, or copper alloys. It can also ruin paint and wallpaper. Silverware turns black almost instantly.

18. How to Correct Sulphur in Water

Following are the three main methods of removal, or partial removal, of the sulphur problem:

a) Aeration

Aerators mix water with air to provide oxygen atoms to precipitate the sulphur. Aeration must be followed by filtration. Aeration is recommended only on consideration of sulphur content, water pH, and equipment limitations.

b) Maganese Zeolite Filter

This is the same unit discussed under iron removal. It has an upper limit of about 5 ppm of sulphur. and does a good job if properly operated. The completely oxidized sulphur is tasteless, odorless, colorless, and non-corrosive.

c) Chlorination

The best and most widely practised method with small water systems is the use of automatic chlorination. The chlorine chemically oxidizes the hydrogen sulphide, iron sulphide, and other sulphides, thus eliminating them. The chlorine also kills the sulphur bacteria and any disease bacteria. The result is safe, sulphur-free water. Because sulphur contc ` varies and reasonable chlorine residues are required to kill bacteria in small water systems, it is necessary to de-chlorinate the water for household use.

It is important to remember that it is the chlorine that kills the sulphur problem, so that there is no "rotten egg" odor or taste, no sulphur corrosion, and no black sulphur water in the house. De-chlorinating filters contain carbon that absorbs the excess chlorine and thereby eliminates all odor and taste. (See also *Section 32e*) in this part of the manual.)

Activated carbon will also absorb hydrogen sulphide in small quantities. The main difficulties with this filter in eliminating all sulphur problems are the small quantity it will remove, and the fact that the carbon cannot be regenerated, so that once it is used up it must be replaced.

19. Acid and Corrosive Water

Water is acid, neutral, or alkali·e in nature.

To denote its nature, an artificial symbol, pH, has been established. The pH scale is a measure of acidity and alkalinity (Figure 26-58). Therefore pH is a number between 0 and 14 indicating a degree of acidity or alkalinity. Neutral water has a pH of 7. Values below 7 and approaching zero are increasingly acid, while values from 7 to 14 are increasingly alkaline. In addition to this important relationship, one other point must be kept in mind: each pH step away from 7 (nuetral) indicates 10 times greater strength than the preceding step because the scale is logarithmic. For example, water at pH of 5.0 is 10 times more acid than at a pH of 6.0 and a pH of 4.0 shows 100 times more acid than a pH of 6.0. Similarly, a pH of 9.0 shows 10 times more alkali than a pH of 8.0.

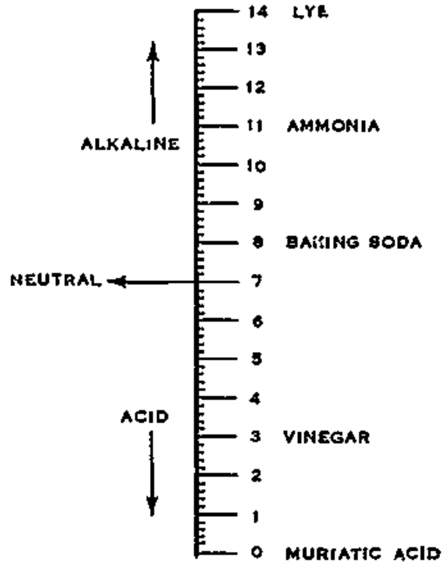


Figure 26-58. pH Scale

Examples of an alkaline solution are baking soda with a pH of about 8, washing soda and ammonia with a pH of about 11, and lye with a pH of about 14. Examples of acidic solution are vinegar with a pH of about 3 and muriatic acid with a pH of about 1.

Acid water, as referred to in well water, is water containing carbon dioxide. Carbon dioxide in water is caused by the decay of organic matter, absorption from the air and ground by the rain water as it falls and then passes through the ground to the water table.

The pH value of most natural water will fall within the range of 6.0 to 8.0, although more acid conditions and lower pH occur where the water contains high concentrations of free carbon dioxide or acid mine drainage. pH values above 8.0 are seldom encountered except where solutions by alkaline industrial waste exist, or where the water has been chemically treated, such as by the lime-soda process. Acid water is mostly found in areas where the hardness content is below 60 ppm.

Acid water corrodes or eats away metal components of the water system — including the pump, piping, tank, water heater, and fixtures — resulting in costly leaks and equipment failure. Acid waters attack copper piping and plumbing, causing a blue or green stain on fixtures and on clothes. It attacks galvanized piping and tanks, causing red stains on fixtures and clothes.

In addition to causing corrosive damage to the water system, acid water may prevent complete precipitation of iron before filtration. Iron will not oxidize readily in acid water. Therefore, in the removal of iron by a manganese zeolite filter or by chlorination, it is also necessary to correct for pH. In correcting acid water during removal of iron, it is advisable to raise the pH to at least neutral or over.

20. How to Correct Acid and Corrosive Water

Following are the main two methods of raising the pH of small water systems:

a) Neutralizing Filters

Elevation of the pH by passing the water through a filter bed of limestone chips has been used with moderate success. These chips are calcium carbonate and combine with the carbon dioxide in the water and thus raise the pH. Some of the calcium carbonate will dissolve into the water and increase the hardness. The removal of all carbon dioxide produces what is known as unstable water, which means it is super-saturated with calcium bicarbonate and precipitation of calcium carbonate beyond the neutralizing filter can easily occur. The disadvantage of the increase in hardness is overcome by a water softener installed following the neutralizing filter.

b) Soda Ash Feeding

The most satisfactory way of eliminating the acid-water problem is by feeding soda-ash solution into the water automatically whenever the water pump is running. It is best to feed this solution through a small tube down the well to the end of the pump drop pipe (or to the pump itself in the case of a submersible pump), or into the pump suction pipe to provide protection of the pump and its piping.

Soda ash (formula Na_2CO_3) is a highly alkaline compound used in water treatment by many municipalities. The soda ash chemically combines with the acid water to completely neutralize it. Thus the soda-ash feeder can be adjusted to feed the correct amount to raise the water to whatever pH is desired. The important advantage of soda-ash feeding is that it can be accomplished together with automatic chlorination equipment without raising the hardness. Thus the automatic chlorinator will chlorinate for safe water (and iron or sulphur precipitation where applicable) in combination with soda-ash feed to eliminate the acid-water problem simultaneously. (See also Section 32i) and Table 26-27 in this part of the manual.)

21. Turbidity, Suspended Matter, and Color

Turbidity is a measurement of the obstruction of light passed through a water. Suspended matter is the quantity of material in water that can be removed by filtration. Water may be dark in color but still clear and not turbid. Turbidity, or suspended matter, is the lack of clearness or brilliance in a water and should not be confused with color.

Turbidity and suspended matter may be in the form of oxidized iron, fine sand, clay, organic matter, or microscopic organisms. Water taken from a river or turbulent stream usually contains appreciable quantities of turbidity. Water from lakes and ponds generally is less turbid because of the settling action in these bodies. Springs and wells are usually low in turbidity because of filtering action of the ground through which the water flows

Color in water may originate from coal or peat seams, swamps, and iron-bearing strata. Color in natural water is generally caused by the tannin in solution (from decaying vegetable growth) or from various industrial wastes. Water usually varies from colorless to a deep brown.

These problems are easy to recognize since you will see suspended matter in the water or the water will have a distinct color. The U.S. Public Health Service drinking-water standard recommends that the turbidity of drinkable, or potable, water be less than 10 ppm of silica. It also recommends that the color of potable water be less than 20 standard units. These standards indicate the degree of color intensity.

Turbidity can be removed by a conventional sand filter in most cases If the suspended matter will not settle out, applications of filter alum will coagulate the fine suspended matter and may be necessary before filtration. This coagulation will enlarge the particles so they will be retained on the filtering medium of the sand and gravel.

Chlorination, followed by activated carbon filtration, is the most common method of removing color from household supplies.

22. Taste and Odor in Water

Taste is a relative problem because it involves individual preference. Although taste and odors may have no bearing on the hygienic safety of a water supply, they can, when sufficiently strong, make the water exceedingly distasteful. In any event, it is a good plan to have a bacteriological examination made by the appropriate local or provincial health authority.

Taste in water is caused by organic matter, dissolved gases, and minerals. A bitter taste may be caused by iron, manganese, large amounts of sulphate, or excess lime. Water containing a large amount of sodium bicarbonate is often described as tasting faintly inky or sometimes soapy. Waters containing an unusual quantity of salt will have a brackish taste.

Sodium salts are commonly found in most water supplies along with those of calcium and magnesium. These natural salts exist in large quantities in the earth's surface, and the kind and quantity in a particular water depend on the composition of the ground over and through which they flow. Sodium sulphate, or glauber salt, may have a laxative effect if present in large quantities.

Objectionable odors are many. They may be caused by microscopic plant and animal organisms, decaying organic matter, dissolved gases (including hydrogen sulphide and sulphur dioxide), waste from industrial plants, and chlorine used for disinfection.

23. How to Correct Taste and Odor

An activated carbon filter is the most practical method of removing taste and odors. However, it is not applicable to the removal of salt from water or of large quantities of hydrogen sulphide. Salty or soda taste caused by excessive mineral composition can be corrected only by reducing the concentration either by distillation or demineralization. There is no practical way to correct these problems in household water supplies. Metallic tastes, such as those caused by soluble iron, may be eliminated by ion exchange or precipitation. A common method of removing taste and odor caused by organic matter is chlorination, followed by activated carbon filtration. Chlorination alters the taste-producing organic matter and activated carbon serves to remove both the residue and the excess chlorine.

24. Impure Well Water

Well-water contamination is becoming a very serious threat. We must face the fact that perhaps our well waters are not safe for drinking.

A well that has been used for years is not necessarily still safe. It can become infected in many ways and this can happen overnight, so it should be protected at all times. Water that is not continuously treated has no safeguard whenever disease organisms enter the system.

When we speak of contaminated water in referring to the sanitary quality of the water, we mean water containing sewage wastes that enter the well from the contaminated ground water When people are informed that their water is contaminated, it is difficult for them to understand because they may have been drinking the water for some time. Actually, they can drink water contaminated with sewage and be exposed to only the diseases that the people had whose sewage is contaminating their water.

Most untreated water supplies have periods when they are free from water-borne disease, but other periods when they show sewage contamination. It is this lack of dependable safe water in an untreated water system that has prompted a high percentage of municipalities to chlorinate their water. Thus, for complete protection, it can be assumed that the continuous sanitary quality of each water system is not assured unless a proper amount of chlorine is kept in it automatically.

Bacteria are tiny living organisms about 0.001 mm. They are relatively easy to kill with chlorine. Not all bacteria are harmful, but even the harmless serve no useful purpose in the home water-supply system. Examples of water-borne disease are typhoid fever, cholera, and dysentery.

A virus is a minute living organism smaller than a bacterium. Much research work has been done on viruses, but current information indicates that it takes from four to six times as much chlorine to kill viruses as it does to kill bacteria. Examples of virus diseases are polio and jaundice (infectious hepatitis, one of the most prevalent contagious diseases).

Cysts are crustaceans somewhat like tiny shell fish. An amoeba forms a hard shell, called a cyst, around itself when it is in unfavorable surroundings. When it is taken into a human body it comes out of its shell form and enters the human system. Cysts are much larger than bacteria and can be filtered by certain kinds of fine filters. To kill cysts, a higher than normal chlorine residue must be maintained. The most common water-borne disease transmitted by the cyst is amoebic dysentery, a serious disease for which there is yet no universal cure.

In both shallow and deep wells, the water originally comes from the earth's surface. It reaches the water table through cracks in the earth, septic-tank tile fields, excavations, rock outcroppings, abandoned wells, sink holes, tree roots, animal borings, and percolation through the ground. The water comes directly from rain on the earth's surface, or from lakes, rivers, ponds, etc. As it travels these routes to the water table, it carries with it whatever bacteria, viruses, and cysts it picks up. Little is known as to whether this ground filtration is of any value where viruses are concerned.

Generally, shallow wells are the least satisfactory from a sanitary and water-quality standpoint. Because water in rock travels for great distances with no ground filtration, wells in rock water are generally very poor health risks. Some people say their wells are in solid rock, but if the rock were solid it would have no water in it. Actually, water-bearing rock has thousands of small cracks and solution channels acting as tiny pipelines that can carry contamination for miles from where it enters the rock water to any one of the previously mentioned paths to the water table.

A water supply is safe for drinking only if it has been tested by the appropriate local or provincial health authority.

There is no simple method of testing for bacteria as you would test for iron or hardness. To confirm the presence of disease organisms is a long and costly laboratory process, and in some cases (such as hepatitis virus) the organism cannot be isolated at all. Therefore, a simpler indicator laboratory test has been devised that takes from only 24 to 48 hours to perform.

The principle of this test is based on the fact that human and warm-blooded animals grow in their intestines a family of bacteria called coliform bacteria. These organisms are usually harmless and testing for them is relatively easy and inexpensive. Since coliform bacteria are present only in human and animal excrement, whenever a sample of water shows the presence of coliform the water is immediately assumed to contain human sewage and is therefore declared unsafe for human consumption.

In testing water, the frequency of tests is of extreme importance, yet well-water testing for private systems is seldom done on a regular basis. In the majority of cases only one sample is taken, and if it comes back "safe" no tests are ever run again. In many instances this one test is made on a new well (chlorinated just before by the well driller, but the well has not yet had an opportunity to become developed). Unfortunately, water testing indicates the safety of the submitted sample only and gives no guarantee of the safety of the water five minutes, five days, or five months later. Well water should be tested at least once a year for bacteria.

25. How to Correct Impure Water

Continuous protection from a water-born disease when it enters a water system is an absolute necessity. Proper location, proper construction, and proper automatic chlorination will ensure safe water continuously.

A water source should be located as far as possible from all sources of contamination. It is impossible to establish arbitrary distances from farm yards, septic sewage, contaminated streams, and so forth. In an area of fine sandy soil, 15 m may be enough; in an area of rock wells, 1500 m may not be enough.

Every water source should be constructed according to accepted standards for safeguarding it.

It is obvious that the sanitary quality of the water in a water system is dependent upon the quality of the water at its source. Thus, if the water table or other source becomes contaminated, location and construction will not make the water safe. Therefore, a third important safeguard must always be present. chlorine. By maintaining the proper amount of chlorine in the water system automatically, water-born bacteria and virus will be killed. In most wells, chlorine is injected by positive-displacement-feed pumps called chlorinators.

In many areas it is either impossible or undesirable to drill for water. These areas are therefore being used as a source of surface supplies for domestic water. For all practical purposes, however, they should be considered as unsafe without proper continuous disinfection. Some people are using this water for all household purposes except drinking and are not disinfecting it. This is an unsafe practice because of the danger that the contaminated water will inadvertently be consumed. To treat surface waters, large amounts of chlorine are usually fed in and a carbon filter is then used to eliminate the chlorine taste. (See Table 26-24.)

26. The Water Softener

a) How It Operates:

This section describes how a water softener operates chemically. Basically, it contains a mineral that is able to change hard water into soft water. Before discussing this mineral, a brief explanation of ion exchange is necessary.

b) What Is an Ion?

All things, living or non living—whether gas, solid, or liquid—are made up of minute particles known as ions These are attracted to each other electrically, forming atoms. Atoms differ in the number of particles they contain, in size and in weight. The atoms, in turn, combine a vast variety of proportions and types to form larger units called molecules.

The distinctive feature of a molecule is that it consists of the smallest group of atoms by which we can identify the specific substance. Thus a molecule of salt, which is composed of a sodium atom and chlorine atom, is no longer salt but is broken down into sodium and chlorine. The molecule is held together by electrical attraction.

Many substances whose atoms are held together by ionic forces have a characteristic way of reacting,

Table 26-24. Water Problems and Remedies

Impurities	Problem	Remedy
Hardness (calcium and magnesium)	Scale in pipes and water heaters. Causes insoluble soap curd on dishes and fabrics.	Removal by ion-exchange water softener.
Iron	Discolors waters, stains plumbing fixtures and fabrics, causes deposits in heaters.	Removal by a softener or by an iron filter when large amounts are present. Also removed by chlorination and filtration.
Acid Water (low pH)	Corrosion. Attacks piping and tanks. red stains from galvanized pipe, blue-green stains from copper.	pH raised by neutralizing filter or by soda ash food.
Hydrogen Sulphide	Taste and odor, tarnishes silverware.	Removal by oxidizing filters or chlorination and filtration.
Mud, Clay, Silt (dirty water)	Suspended matter in water cloudy; dirty water.	Sand Filter
Taste and Odors (organic matter)	Water unpalatable.	Carbon Filters — In some cases chlorination and filtration.
Sodium Salts	Salty or alkali taste.	Cannot be economically treated.
Bacteria	Source of disease, unfit for human consumption.	Chlorination and filtration.
Algae	Taste, odor, color.	Chlorination and filtration.

called ionization, when they are dissolved in water. The water separates the molecule into its component ions The ions that have positive electrostatic charges are called cations, those having a negative charge are called anions.

The fact that some substances ionize in water is a key to softening water by ion exchange. There are some ions in water, particularly calcium and magnesium, that present costly and troublesome problems in laundry operations. The most practical way to solve these problems is to remove these ions before they do their damage Ion exchange performs this chore.

c) Ion Exchange

Ion exchange in water-conditioning is the process of removing calcium and magnesium, the hardness producing ions, and substituting sodium, a less objectionable ion.

Remember, then, that it is an exchange. Since these ions are positively charged, or cations, the mineral is a cation exchanger During the exchange two sodium ions are released for each calcium or magnesium ion received. This is because each calcium or magnesium ion has a charge of 2, whereas sodium has only a charge of 1. The balance must be maintained.

The transaction takes place because the exchanger attracts new ions more strongly than the ions it already holds The new ions therefore can displace the original ions from the exchanger and occupy the site they vacated.

Although the "zeolite" family of ion-exchange substances are found in nature, it is more economical to use man-made materials of higher exchange values These ion-exchange materials are fine bead-like balls about the size of a pin head and are quite porous They are manufactured from various petroleum by-products by special processes and are organic in nature.

d) Regeneration

A resin can perform millions of transactions simultaneously over long periods before its supply of sodium ions must be replenished. When the exchanger can no longer produce soft water, the exchanger is considered exhausted. Fortunately, the absorption capacity is only temporarily lost, since it is replaced by regeneration.

Regeneration is basically a reversal of the absorption process. It means the restoration of the original capacity of the softener to again soften hard water after the original capacity has all been used. A good softener lasts for many years.

Regeneration is accomplished by treating the exchanger with a concentrated solution of the sodium ions, in the form of common salt, sodium chloride, NaCl. This releases the calcium and magnesium ions, which are discarded.

Regeneration therefore renews the ion-absorption powers of the exchange material and permits the exchanger to be re-used for virtually countless absorption cycles.

It is important to remember that 1 kg of salt is required for each 75 400 parts of the hardness exchange; thus, 4.54 kg of salt would be needed to regenerate a softener rated at 20 000 grains capacity (or 20 000 x 17.1 equals 342 000 parts of hardness exchange).

27. Operation of Softeners in General

In the normal course of softening water, the mechanics of operation are much the same regardless of whether the unit is fully automatic or manually operated. The unsoftened water enters the top of the mineral tank and flows downward through the mineral, becoming soft water, which the units were designed to deliver.

As the water flows downward through the softener tank, the mineral performs two duties. One is to act as a filter and catch any debris from the hard water; the other is to soften the water. The first step in regeneration, then, is to backwash the mineral for about 10 minutes to loosen deposits and flow them to the drain. On completion of the backwash, the salt or brine is added and a slow rinse of about 60 minutes will restore the mineral to its original state.

Whether this process is done automatically or manually depends on the type of softener selected. The fully automatic method is very popular since it not only is completely satisfactory but also is a good-looking, streamlined, and inexpensive addition to any home.

a) The Fully Automatic Softener

Figures 26-59 and 26-60 show the fully automatic softener, which requires no attention except to add salt to the brine tank occasionally. The adjustable timer and valve do the regeneration while the owner sleeps. The regeneration times can be set to function at intervals of one-, two-, three-, or six-day cycles, depending on the water make-up and customer requirements. An exclusive valve design maintains proper regeneration for any water pressures between 140 and 860 kPa when correctly installed.

The polyethylene brine tank eliminates corrosion and salt deposits. The storage capacity is 140 kg.

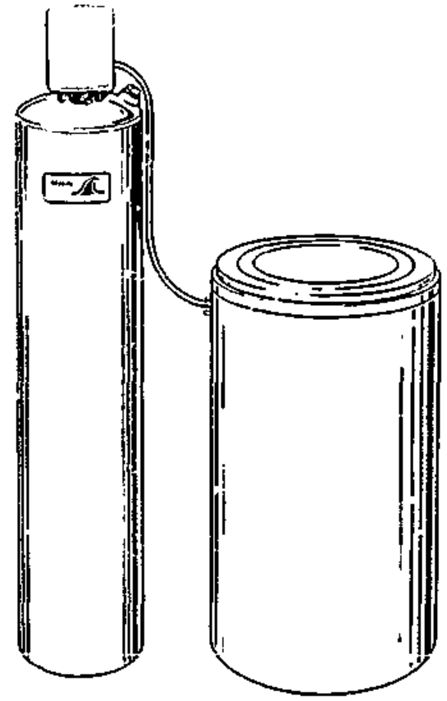


Figure 26-59. Free-Standing Fully Automatic Softener

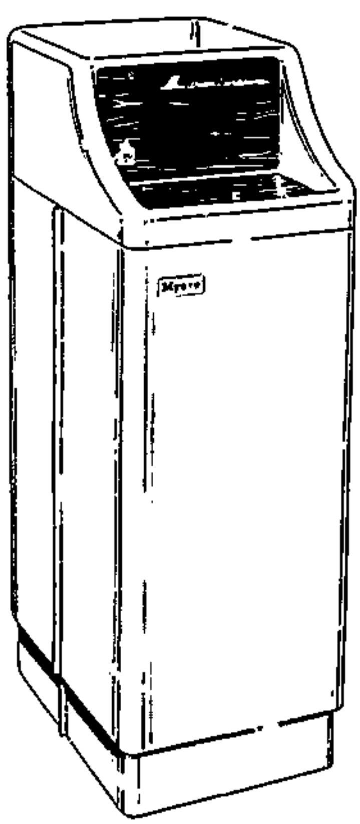


Figure 26-60. Fully Automatic Cabinet Softener

b) The Manual Softener

Figure 26-61 shows the manual softener, which contains more ion exchange mineral in the tank than does the fully automatic softener. This lengthens the regeneration periods for the convenience of the owner.

Even though the water may still be soft at the end of 30 days, the softener must be regenerated at least once a month. If the water is dirty or contains suspended particles the softener should be backwashed every seven to fourteen days, even though regeneration may not be necessary at that time. This prevents fouling of the mineral bed. If too dirty, a filter should be installed ahead of the softener.

An outstanding feature of this softener is the safety tank cap, which cannot be removed while the unit is in service or when there is pressure in the mineral tank. This prevents messy conditions.

Another feature is the time-proven valve assembly. It is a rugged, all-bronze valve with a minimum of movable parts and designed to keep any pressure drop to a minimum.

The four-step procedure for back-washing and regenerating the manual softener is explained in Figure 26-62.

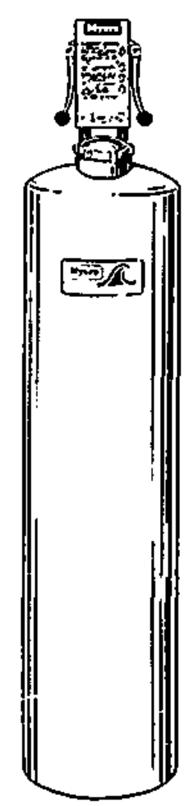


Figure 26-61. Manual Softener

Step 1 Backwash: Pull the right lever up. Allow the softener to backwash a minimum of 10 minutes or until the water runs clear of the drain Return the right lever to the down position.

Step 2 Rinse: Pull the left lever up. Allow a five-minute rinse.

Step 3. Salt: Pull both levers up. Remove the tank cap. Pour in an appropriate quantity of PELLET salt. Replace the tank cap.

Step 4: Rinse: Return the right lever to down position. Rinse for 60 minutes. Return left lever to down position. The softener is now in service.

It is important to note that all softeners are designed to provide adequate water even during the regeneration period.

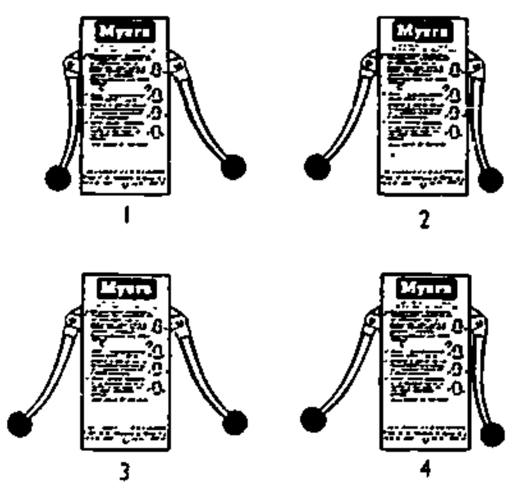


Figure 26-62. Back-Washing and Regenerating Procedure

28. Salt for Regenerating the Softener

The salt used in regenerating water softeners is an important factor in their successful operation.

Just any salt should not be used in a water softener since many commercial grades of salt contain a large amount of dirt and insoluble material. The dirt in salt will cause trouble in a water softener. In a brine tank, this insoluble material will build up a sludge in the tank and foul up the brine injection

There are really only two kinds of salt. evaporated salt and rock salt. Evaporated salt is made from brine of two kinds. surface brine and brine from wells. Both evaporated salt and rock salt may be produced from the same rock-salt deposit. Rock salt comes from under the ground in large lumps, which are crushed, screened, and graded to the various commercial sizes needed. All evaporated salt is refined salt. (Flake salt is a type of evaporated salt.)

Some companies are producing a pellet-type water-softener salt for recharging water softeners where iron oxide or rust is present in the water supply. This salt contains an iron fluidizing agent that dissolves the iron and rust accumulation and washes it down the drain at the time the water conditioner is recharged to restore its softening capacity. The pellets are used in the same manner as regular water-softener salt.

Always follow the water-softener manufacturer's recommendation for the type of salt used in its particular unit.

29. Effects of Salt on Septic Tanks

What harmful effects does salt have on a septic tank? The answers, adapted from literature of the Water Conditioning Foundation, are as follows:

Brine from the regeneration of a household water softener may be safely discharged into the average septic tank. Organic matter in septic tanks is converted by bacterial action into water-soluble products. Bacteriologists tell us that salt in low concentrations is not harmful to bacterial growth in action. In fact, salt has been added to culture media for favoring a growth of bacteria. High concentration of salt, however, might inhibit this growth. That condition is the basis for the statement made by others that salt brine should not be discharged into septic tanks. The question then becomes that of estimating the concentration of salt that may result from discharge of brine into the tank.

Septic tanks vary in size. Many jurisdictions require a minimum of 1900 L. A small one holds 1100 L of fluids or about 1100 kg. The salt used for regeneration of the softener may amount to 23 kg, which would produce a 2 per cent solution in the small septic tank, if no water were added at the same time. About 570 L of water would be used for brining and rinsing the salt from the softener. The resulting low concentration of salt would have no effect on bacteria activity.

A proof of this conclusion is that there are thousands of water softeners that discharge salt into household septic tanks, and it is likely that no trouble has ever been reported. If bacteria action were slackened by the salt, it would become quite normal again after one day's discharge of solids and fluids from the household.

30. Water for Irrigation

Ion-exchange softened water is not recommended for watering lawns, gardens, or flowers.

Most growing plants require special soil conditions for healthy and thrifty growth. Many flowering plants demand slightly acid soil or they wither and die. Others are quite susceptible to high concentrations of soluble salt in the soil water. Common salt, for example, kills most grass.

Softened water carries only sodium salt. The average sprinkling of flowers, garden, or lawn wets only about 25 to 50 mm of the soil. Much of the water is lost by evaporation. This leaves the sodium salts in the soil. After several successive waterings, there may be accumulated a sufficient amount of sodium salt in the soil to retard the growth of the plant.

Therefore, the use of softened water is not recommended for irrigation. A by-pass or separate line carrying raw or hard water should be provided for this purpose.

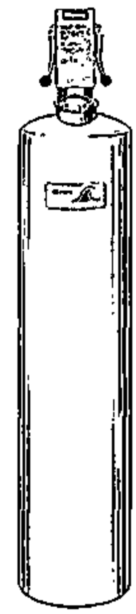


Figure 26-63. Manual Filter

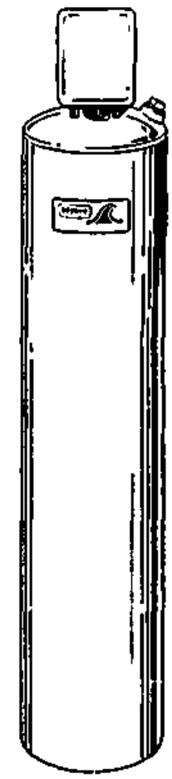


Figure 26-64. Automatic Filter

31. Filters

A filter is a device for separating solid particles, impurities, etc., from a fluid by passing it through a porous substance such as sand, charcoal, etc. Filters supplement the water-softener line and, in outward appearance, are identical to softeners. They remove iron and sulphur, increase pH values, remove visible dirt or suspended matter, and remove disagreeable tastes and odors.

Filters have the same general appearance as a softener except that no brine tank is required. The main difference is in the filling material in the tank. Figure 26-63 shows a typical manual-type filter, whereas Figure 26-64 illustrates an automatic type. *Note:* Iron filter is available only in the manual model.

a) The Iron Filter

An iron filter is designed to remove inorganic iron (ferrous and ferric) and sulphur from water. This is done by oxidizing all the iron to the ferric or insoluble state and then filtering it out. The mineral called manganese zeolite will do this.

Manganese zeolite, a black material, is made from processed green sand zeolite. Green sand zeolite is made by refining and stabilizing mined, so-called green, sand.

Manganese zeolite is primarily used for the removal of iron and manganese from water, and to a lesser extent the removal of hydrogen sulphide. Upon the passage of water containing iron or manganese in ferrous or manganous states (in solution — in other words, invisible) through a bed of manganese to the ferric and manganic state (insoluble — precipitated — visible), the removal process occurs.

These insoluble oxides are precipitated out and filtered in the bed or manganese zeolite and must be removed by frequent back-washing. When the oxidized capacity of the bed is diminished, the manganese zeolite is regenerated with potassium permanganate and rinsed free of potassium compounds. In this way, available oxygen is once again restored within the bed of manganese zeolite, and the filter is ready to resume its job of removing iron, manganese, or sulphur.

In operation, the water passes down through the manganese zeolite, which oxidizes the iron and then filters it. When it is time to regenerate, the first step is to backwash, which is a reversal of flow of water through the tank. This removes the iron and dirt collected on top of the bed. Frequent back-washings are needed. When the zeolite is exhausted, it must be regenerated with potassium permanganate, which in turn is reduced as it gives up oxygen to the manganese zeolite.

Potassium permanganate is placed in the tank and the unit slowly rinsed down-flow. This chemical recharges the mineral with oxygen, in a manner similar to that of salt recharging a softener.

Follow this procedure:

Step 1: Backwash and rinse the filter every week (without fail).

Step 2: Charge for iron removal each month or week as required.

Manganese zeolite lasts indefinitely What destroys it is misapplication, misuse, and abuse. It has definite limits of application of utmost importance. Following are some of the "musts" to prevent its misuse:

1. Low pH—below 6.8—indicates the free carbon dioxide content of the water is high. It must first be neutralized by a neutralizer or by soda ash fed with a solution feed pump ahead of the iron filter to prevent manganese being picked up from an exhausted bed of manganese zeolite.
2. Maximum iron or manganese in raw water should not exceed 10 ppm.
3. Maximum flow rate in litres per minute should not exceed 120 L per minute per m^2 cross-sectional bed area.
4. A proper backwash rate of 330 L per minute per m^2 cross-sectional bed area is needed to clean the manganese zeolite of the precipitated iron and manganese oxides.
5. Sufficient contact time is needed between the potassium permanganate solution and the manganese zeolite to restore available oxygen. Do not shorten the required slow rinse time below that designated in the operating instructions.

The iron filter, then, is designed to remove the inorganic iron. If organic compounds or iron bacteria are present, chlorination is necessary.

b) The Neutralizing Filter

The purposes of a neutralizing filter are to:

1. Increase the pH value of water.
2. Neutralize free carbon dioxide.
3. Decrease corrosion.
4. Add alkalinity.
5. Remove dirt (turbidity and suspended matter).

The section on corrosion noted that the presence of large amounts of free carbon dioxide gas in solution in water often renders the water acid in character These waters are corrosive to iron, galvanized pipe, brass, and even copper pipe Generally, the corrosion is much greater on hot water piping and tank.

Neutralizers have been designed to combat this expensive corrosion. The tank is filled with a crushed and very carefully graded limestone of a pure type. The carbon dioxide will be neutralized and pH will automatically raise to 7.0 or 7.3, at which pH the action ceases.

A neutralizer needs back-washing occasionally to loosen the material. Pay particular attention to the backwash rate and flow rate on the instruction card. Since the material is heavy, fairly high backwash rates are required to clean the bed. The flow rate is low because retention time is necessary for the above reaction to take place. It is sometimes necessary to use two neutralizers hooked in parallel to provide a proper flow rate.

Some of the material is dissolved and it should be checked and the proper amount added each year. Since a small amount of limestone is dissolved in the water to neutralize the pH, the hardness will increase slightly. The disadvantage of this increase in hardness is overcome by a water softener installed following the neutralizer.

The neutralizing filter automatically raises the pH of the water, and reduces the corrosiveness. In general appearance, this filter is very similar to a water softener. It requires only occasional backwashing and addition of a small amount of neutralizing material each year.

c) The Sand Filter

A sand filter is for the physical removal, by simple filtration, of visible dirt or suspended matter from water—due to silt, sand, organic matter, and rust particles, commonly known as turbidity.

Some waters are clean most of the time, but occasionally become quite muddy or turbid, particularly at the ends of the city mains when something happens to rile the water, such as heavy demand for water. Surface waters from lakes or rivers may be turbid most of the time. A sand filter will remove all suspended matter not in solution and make the water sparkling clean.

The purpose of the sand filter is to remove iron that is in suspension, causing the water to turn brown. If iron is in solution it can be removed by means of a water softener or iron filter. The filter should be backwashed on the average of once a week to remove the accumulation of dirt and keep the filter bed clear.

Whenever the dirt, turbidity, suspended matter, or discoloration in a water supply is not easily settled out or filtered, an alum or filter-aid feeder should be installed in the line ahead of the filter.

Alum or filter-aid reacts with the natural alkalinity in the water to form gelatinous precipitates that absorb or enmesh impurities, resulting in coarse particles known as the floc. This floc, with its absorbed impurities, is then more easily removed by filtration.

Sometimes it is necessary to feed sal soda to the water to compensate for an alkalinity deficiency caused by the use of alum or filter-aid in a re-circulating system If this is necessary, use lump sal soda in a chemical feed pot, or feed soda ash by a liquid feed pump.

d) The Carbon Filter

The carbon filter removes unpleasant taste and disagreeable odor caused by chlorine, industrial waste, and organic matter. Certain water supplies have unpleasant taste and odors. Among them are waters that are chlorinated for bacteriological protection. Likewise, objectionable fishy and marshy tastes are often encountered. Such tastes and odors can be eliminated by the carbon (taste and odor removal filter). But occasional back-washing of the filter is necessary—usually only once or twice a month unless the water is really bad.

Activated carbon literally absorbs large quantities of taste-and-odor-producing impurities from water. It has unusual hardness and durability, fine-grain porosity, and high activation for maximum taste and odor removal.

In the filter, the carbon is supported on a bed of D-size quartz gravel.

Table 26-25. Filter Selection Chart

	Problem		Treatment (use only one type of treatment when more than one are listed)	
pH (corrosion) Control	6.6 to 7.0		Neutralizer	Water Guard Feeder (Soda Ash)
	5.5 to 6.8		Neutralizer	Water Guard Feeder (Soda Ash)
	4.0 to 6.8			Water Guard Fedder (Soda Ash)
	Below 4.0	Treatment Not Practical		
Iron (red water) Control	0.2 ppm to 3.0 ppm (clear when drawn)	Water Softener	Iron Filter	Water Guard Feeder and Filter (Chlorine)
	0.3 to 10.0		Iron Filter	Water Guard Feeder and Filter (Chlorine)
	0.3 to 25.0			Water Guard Feeder and Filter (Chlorine)
	Over 25.0	Treatment Not Practical		
Hydrogen Sulphide (rotten egg odor) Sulphur	Up to 5 ppm	Sulphur Filter	Water Guard Feeder and Filter (Chlorine)	
	Up to 15 ppm		Water Guard Feeder and Filter (Chlorine)	
	Over 15 ppm	Treatment Not Practical		
Turbidity (visible dirt)	Coarse Sediment	Sand Filter		
	Fine Sediment	Alum and Sand Filter		
Taste and Odor	Chlorine, organic, musty, etc.	Carbon Filter		
	Brackish or salty	Treatment Not Practical		
Bacteria	Health Dept. Tests Show Pollution	Water Guard Feeder (Chlorine)		

Since the carbon actually absorbs the unpleasant tastes and odors, it cannot be regenerated or renewed. The occasional back-washing that is necessary is to remove the suspended dirt from the mineral When the carbon has absorbed all the taste and odors it can hold, it must be replaced The period that carbon will last for an average household is estimated at between one and three years, dependent upon the intensity and kind of taste and odor removed, as well as on the volume of water that has been conditioned.

32. Chlorination

Pollution of water supplies is an ever-increasing problem. The solution is to simply add the proper amount of chlorine to the water supply to ensure adequate contact time between the chlorine and water, and to chlorinate in excess of the necessary amount to always leave a residual of chlorine in the water. That portion of the chlorine dosage not used by the chlorine demand is known as the available chlorine residual.

It is necessary to chlorinate in excess of the actual amount needed immediately to provide assurance that the water is and will continue to be safe. The reasons are that it is a means of controlling the chlorine dosage, it represents the only immediate proof that the water is safe, and it is a protective barrier against further contamination.

Generally, 0.2 ppm of chlorine residual is considered as safe for drinking water and 0.5 ppm satisfactory for swimming pools. However, it is recommended that all dealers secure copies of local and provincial codes before proceeding, since some requirements will vary province-by-province.

Once the water supply is adequately chlorinated and the residual established, owners need an easy method of checking this residual or there will be no guarantee of continued safety. The common and inexpensive method is the use of the orthotolodine color test, which is based on color comparisons.

Although hypochlorination can be handled either manually or automatically, the manual method is more difficult and not readily accepted by the codes. We shall discuss only the automatic process (by the positive feeder) that meters the correct amount of injected chlorine. The positive feeder can be installed in various ways and will handle different solutions, as explained later.

The Myers CF-2 Feeder (Figure 26-65), for example, delivers low-cost, positive chemical treatment for drinking water. Each suction stroke draws a precise amount of the treating chemical into the feeder head. On the discharge stroke, the treating chemical is injected in a prescribed amount into the main water-supply line or well. Thus the water treatment is positive and eliminates the possibility of errors.

Designed for water sterilization, taste and odor control, and the elimination of red water, its features are as follows:

1. Can be installed on any private water-supply system.
2. Mounts anywhere—on floor, shelf, or wall.
3. Can be adjusted while in operation.
4. Positive-action valve for foolproof water treatment.
5. Corrosion-proof for long life.
6. Purifies the water supply efficiently and economically.

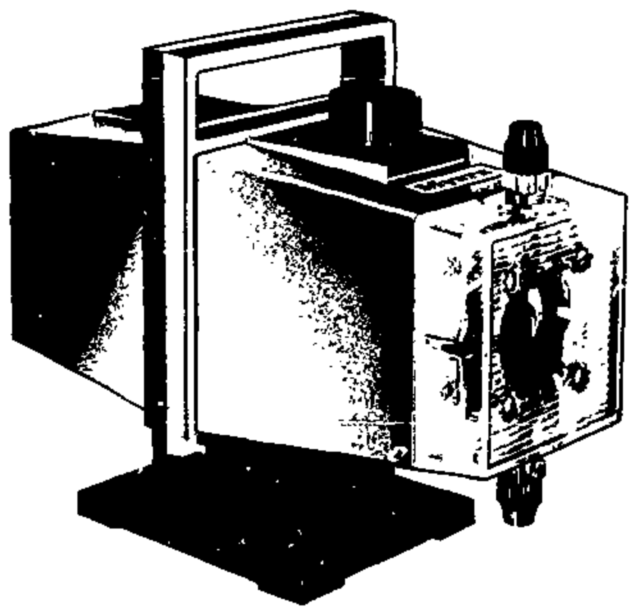


Figure 26-65. Myers CF-2 Chlorine Feeder

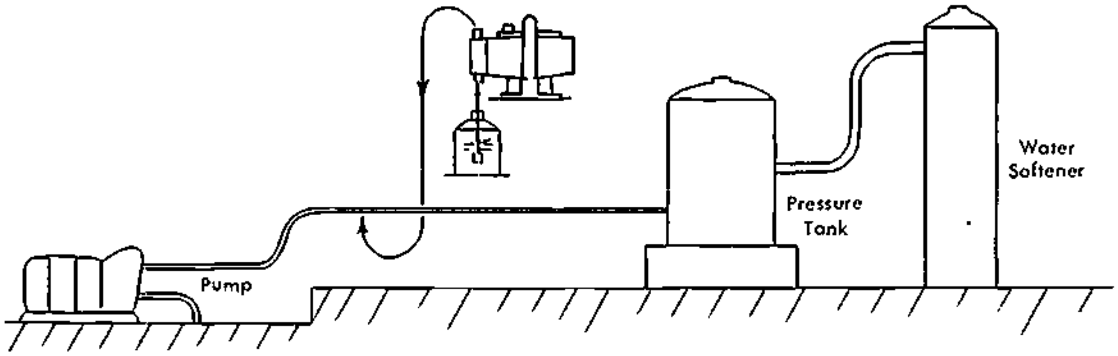


Figure 26-66. Feeder Application

a) Installation and Initial Feed

A contact time after chlorination of 20 minutes is desirable to ensure safe water. Usually, the pressure tank will provide the necessary retention time. The size of tank necessary is 20 times the litres-per-minute pump capacity, plus 25 per cent. If the pressure tank is not large enough, a separate retention tank is needed. This could be provided by a softener if one is needed. (See Figure 26-66.)

Usually, a chlorine feed of 1 ppm is enough to purify well water. This will require 45 g of bleach mixed with 10 L of water for every 100 L per hour of pump capacity. For example, if pump capacity is 2 000 L per hour, mix 20 x 45 or 900 g of bleach with 20 L of water.

b) Checking and Adjusting Chlorine Feed

1. If chlorine residual is less than 0.2 ppm, add more bleach to the solution.
2. If chlorine residual is above 0.5 ppm, add water to dilute the solution.
3. When correct residual is obtained, mix future batches accordingly.
4. Check cold water regularly for chlorine residual.

c) Bacteriological Test

The local or provincial health authority will make a bacteriological test of your water and recommend measures, which may include chlorination, to ensure safe water.

d) Removal of Iron by Chlorination and Filtration

Iron in solution can normally be removed by chlorination and filtration. Chlorine is an excellent oxidizing agent and when fed into the water supply will oxidize and precipitate the iron. This oxidized iron can then be removed by filtration. This filtration can be accomplished by a standard sand or carbon filter. (See Figure 26-67.)

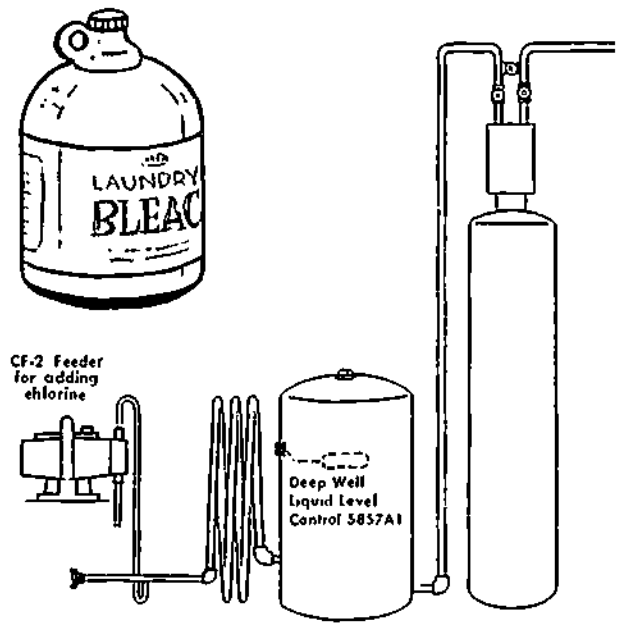


Figure 26-67. Fully Automatic Filter with Air Charger and Chlorinator

In addition to oxidizing the iron in solution, chlorine will also destroy the iron bacteria. These bacteria are plant-like growths that feed on the pump, pipes, etc., causing damage as well as building up slime in the toilet water closets, etc. Iron bacteria cannot be removed by filtration alone.

If water is acidic (pH below 7) the pH must first be raised to neutral. Iron will not readily oxidize in acid water. Soda ash can be mixed and fed with the chlorine solution from the same container.

e) Procedure

One ppm of chlorine will oxidize 1 ppm iron. Sufficient chlorine should be fed to have a residual of at least 0.2 ppm. Purification as well as iron removal will be accomplished.

To prepare a 1 ppm chlorine solution, mix 0.180 kg of household bleach with 40 L of water for each 400 L per hour of pump capacity. If residual chlorine is not 0 2 ppm, increase the amount of bleach until the correct residual is maintained, then use this amount in preparing future solutions.

Example:

Problem. 5 ppm of iron, 2000 L per hour of pump capacity.

Remedy Since 0 18 kg of bleach is required for each 400 L per hour of pump capacity, 0.18 x 5 equals 0.90 kg for 5 ppm of iron, 0.90 x 5 equals 4.50 kg (4.50 L) of bleach will be required for each 40 L of solution.

e) Removal of Sulphur by Chlorination and Filtration

Sulphur can be precipitated by chlorine bleach and then filtered out by a sand filter.

Start with a 2 ppm chlorine feed and increase it until the sulphur odor disappears and the water has a free chlorine residual of 0.5 ppm. For 2 ppm of chlorine feed, mix 0.36 kg of bleach with 40 L of water for each 400 L per hour of pump capacity. For example, if the pump capacity is 2000 L per hour, use 0.36 x 5 or 1.80 kg of bleach in 40 L of water.

f) Iron Stabilization and Corrosion Protection With 2MP91 Polyphosphate

Polyphosphates have been used for years to hold iron in solution, preventing it from oxidizing, precipitation, and staining. Up to about 2 ppm of iron may be treated. Above 2 ppm, complete iron removal is recommended since complete stabilization may not be possible and some staining may occur at higher concentration.

For general household use, a water softener is recommended following the polyphosphate treatment to remove the stabilized iron.

2MP91 polyphosphate is also recommended for corrosion prevention in pumps, tanks, and pipes. It provides a protective film on the metal surfaces.

For best results, the polyphosphate should be fed to the water before the pressure tank so that the iron is not oxidized by air in the tank. Polyphosphate will not prevent iron from staining after the iron has been oxidized.

The polyphosphate then should be fed either into the suction of the pump or into the discharge pipe between the pump and the tank. (See Figure 26-68.) In the case of a submersible pump, it can be fed into the well at the intake of the pump. (See Figure 26-69)

For each ppm of iron present, 4 ppm of polyphosphate must be fed. To prepare 40 L of 4 ppm concentration of polyphosphate for every 400 L per hour of pump capacity, 0.05 kg of 2MP91 polyphospate is required. This is based on 50 per cent capacity of the feed pump, pre-set at the factory.

Example:

Problem. 2 ppm of iron and 1600 L per hour of pump capacity.

Remedy. Since 0.045 kg of 2MP91 polyphosphate is required for each 400 L per hour of pump capacity, 0.045 x 4 equals 0.18 kg for 1 ppm of iron. Because in this example we have 2 ppm of iron, 0.18 x 2 equals 0.36 kg of 2MP91 polyphosphate that will be required for 40 L of solution.

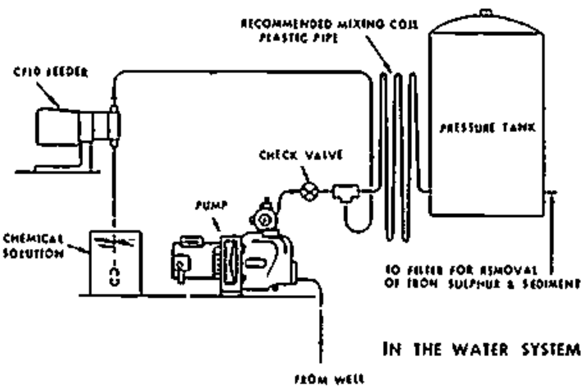


Figure 26-68. Feeding Liquid Solutions, Jet-Pump Installation

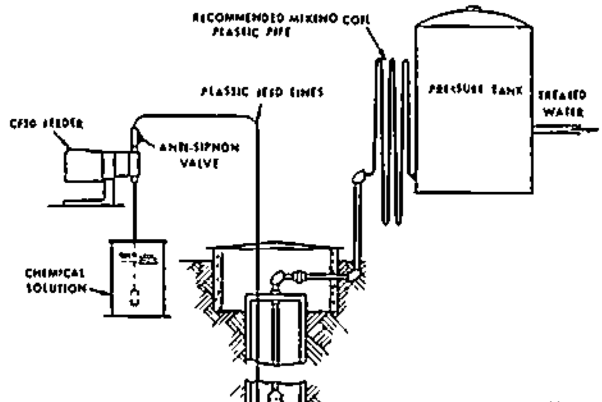


Figure 26-69. Feeding Liquid Solutions, Submersible-Pump Installation

g) Iron Bacteria

Polyphosphate will not prevent staining from iron bacteria. If iron bacteria are present, feed chlorine to destroy the bacteria and oxidize the iron.

h) Neutralizing Acid Waters with Soda Ash

Waters with a pH below 7 are acidic and tend to be corrosive. The acid-water problem can be eliminated by feeding soda ash solution into it by means of a feed pump. Soda ash is a highly alkaline compound used in water treatment by many municipalities. See Figures 26-68 and 26-69 for typical installations.

Soda ash combines chemically with the acid water to completely neutralize it. Thus the soda-ash feeder can be adjusted to feed the correct amount to raise the water to whatever pH is desired.

Start with a 20 ppm feed. To prepare 40 L of 20 ppm soda ash for each 400 L of pump capacity, use 0.235 kg of soda ash. The maximum quantity that can be dissolved in 40 L of water is 4.8 kg.

Soda ash (58 per cent grade) is available in 0.045 kg bags at most chemical supply houses. If soda ash is not obtainable, use sal soda; however, because sal soda is slightly less than half as strong as soda ash, all mixing quantities should be doubled.

i) Feeding Chlorine Bleach with Soda Ash

An important advantage of soda-ash feeding is that it can be accomplished in combination with automatic chlorination equipment. Soda-ash and chlorine-bleach solution can be mixed and feo with one feed pump from the same solution container. (See Tables 26-26 and 26-27.)

When starting, dissolve soda ash in 40 L of water and adjust the solution strength so that the pH is 7.5. Then add bleach and adjust for the correct residual chlorine. This same ratio can then be used to mix a later solution. Always dissolve the soda ash first and then add the bleach.

Table 26-26. CF-2 Feeder-Solution Guide

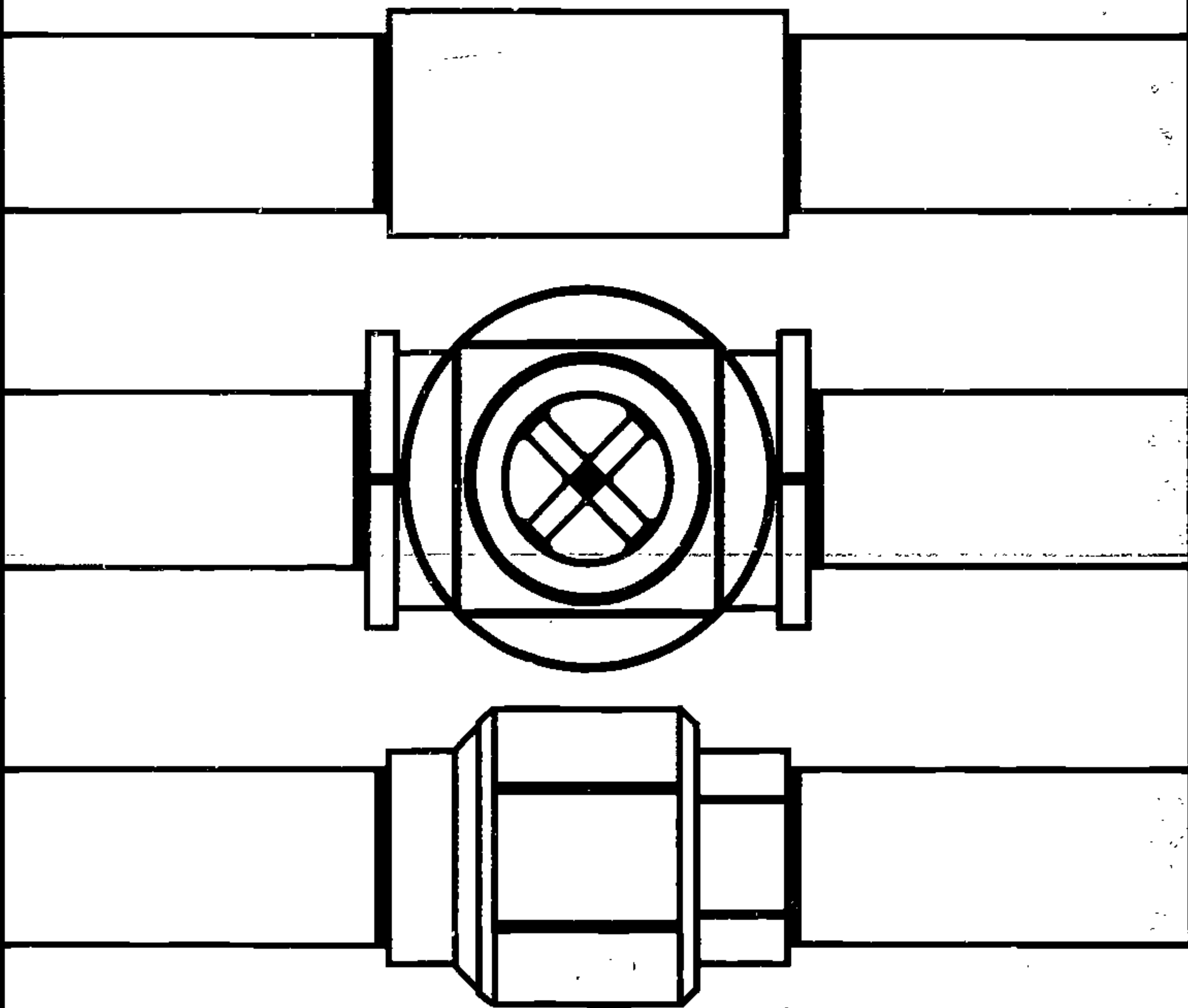
IRON REMOVAL			
WELL PUMP RATE		Household Bleach to Mix With 40 L of Water With a No. 6 Setting On CF-2 Feed Pump For a 1 ppm Chlorine Feed	NOTE: IRON
L per hr.	L per min.		
680	11.4	0.36 kg	For each ppm of iron, 1 ppm of chlorine must be fed. Therefore, multiply the given figure by the number of ppm of iron. Then check the chlorine residual and if it is not between 0.2 and 0.5 ppm, vary the feed solution by adjusting the strokes on the feeder or by adjusting the amount of bleach in the feed solution.
910	15.1	0.54 kg	
1140	19.0	0.72 kg	
1360	22.7	0.84 kg	
1590	26.5	1.00 kg	
1820	30.3	1.14 kg	
2040	34.1	1.20 kg	
2270	37.8	1 43 kg	
2500	41.5	1 67 kg	
2730	45.4	1 80 kg	

Table 26-27. Acid Control

WELL PUMP RATE		Soda Ash to Use With 40 L of Water With a No. 6 Setting on CF-2 Feed Pump pH Reading		NOTE: ACID
L per hr.	L per min.	Below 6.0	Above 6.0	
680	11.4	0.68 kg	0.45 kg	This figure indicates the starting amount. Check pH and if not 7.2 to 7.5, vary the feed solution by adjusting the stroke on the feeder or by adjusting the amount of soda ash in the feed solution. If soda ash is not available, sal soda can be used but the amount must be doubled.
910	15.1	0.90 kg	0.62 kg	
1140	19.0	1.19 kg	0 80 kg	
1360	22.7	1.36 kg	0.90 kg	
1590	26.5	1.60 kg	1.02 kg	
1820	30 3	1.87 kg	1.25 kg	
2040	34 1	2.04 kg	1.36 kg	
2270	37.8	2.33 kg	1.50 kg	
2500	41.5	2.50 kg	1 70 kg	
2730	45.4	2.72 kg	1.81 kg	

Tapping Water Mains Under Pressure

27



PART 27
TAPPING WATER MAINS UNDER PRESSURE

1 There are several types of equipment designed to tap water mains under pressure and permit the installation of valves to control the water supply in the new pipeline; but only a few can be covered here.

2. Years ago, water mains were generally made only of cast iron, but today they also are made of asbestos cement, plastic, and galvanized steel pipe.

3. Figure 27-1 includes a corporation stop that could have been installed without shutting off the pressure in the water main.

4. The various types of tapping equipment permit the installation of valves on water lines ranging from NPS ½ to NPS 12 pipe size.

5. There are two basic types of equipment. One incorporates a double pressure chamber: when securely fastened to the water main it will drill and tap an opening in the water main, retract the drill and tap, and insert the corporation cock and tighten it in place.

The other type employs a flanged or tapped opening in a saddle, which is first attached to the water main and a valve is then attached to the saddle by thread or flange. With the valve open, the drill passes through it and is turned manually or with a power head to drill the required hole in the water main. The drill is then withdrawn and the valve closed before removing the drilling equipment.

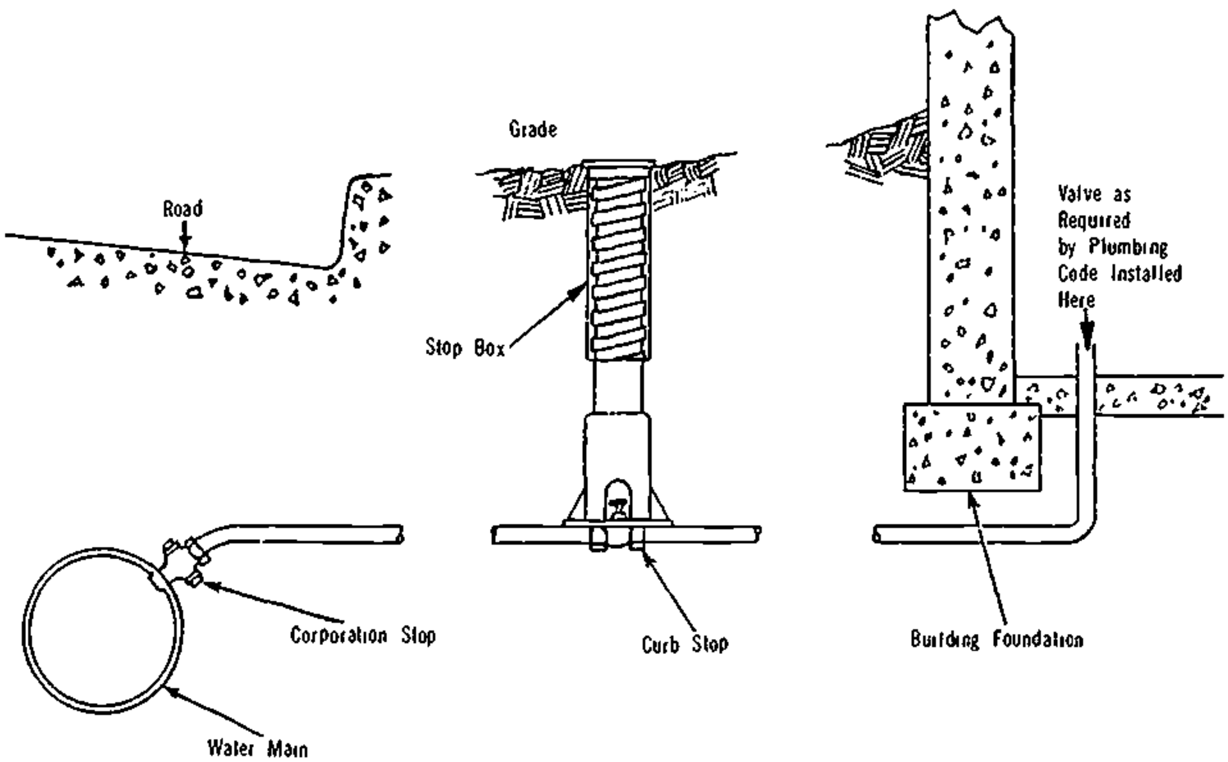


Figure 27-1. Installation Without Shutting Off Pressure

6. The following operating procedure applies to the equipment described with a double pressure chamber (see Item 5), but does not over-rule the manufacturer's instructions if they are available:

Step 1: Dig to expose the pipe at the point where the tap is to be made. This should be as near as possible to the top of the water main.

Step 2: Clean dirt and rust from the pipe.

Step 3: Place the gasket of the self-tapping machine on the pipe and set the saddle of the machine on the gasket. (See Figure 27-2.)

Step 4: Wrap the chain around the pipe and tighten it to clamp the self-tapping machine to the pipe.

Step 5: Remove the cap from the cylinder and place the combination drill and tap of the required size in the boring bar.

Step 6: Re-assemble the machine by putting the boring bar through the cylinder and tightening the cap.

Step 7: Open the flap valve between the compartments.

Step 8: Start drilling by applying pressure at the feed yoke and turning the handle until the drill enters the main.

Step 9: When the tap starts threading the hole, back off the feed yoke to prevent the stripping of the threads.

Step 10: Continue to turn the boring bar until the ratchet handle cannot be turned without extra force.

Step 11: To remove the tap from the hole, reverse the ratchet and back the boring bar out by turning it counter-clockwise.

Step 12: Close the flap valve between the upper and lower compartments.

Step 13: Drain the water from the cylinder through the by-pass.

Step 14: Remove the cap and drill tool and place a corporation stop of the required size in the boring bar. The corporation stop must be closed.

Step 15: Repeat steps 6 and 7.

Step 16: Turn the ratchet handle to screw the corporation stop into the pipe.

Step 17: Repeat step 13.

Step 18: Remove the cap from the cylinder and unbolt the boring bar from the corporation stop.

Step 19: Remove the lower chamber from the pipe.

Step 20: Inspect the installation for leaks.

Step 21: If the corporation stop leaks, tighten it with a suitable wrench.

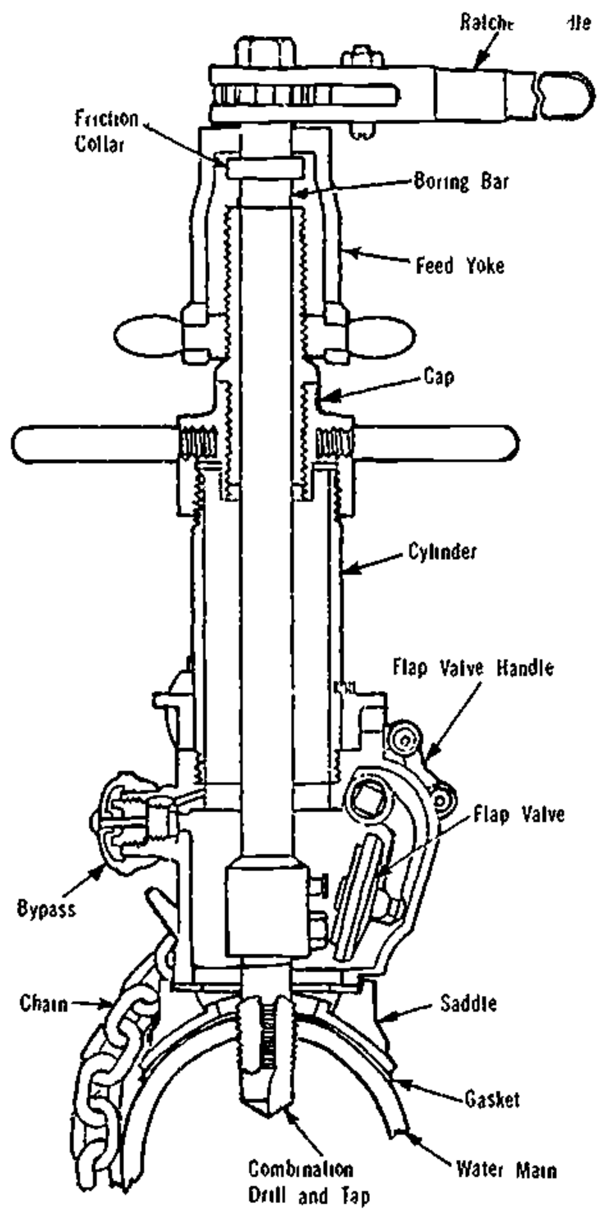


Figure 27-2. Components of a Double Pressure Chamber Tapping Unit

7. The drilling machine shown in Figure 27-3 requires that a clamp with a corporation stop tightened securely into the clamp boss, or a combined clamp and corporation stop, be first attached to the water main in the desired location by screwing both halves together with silicon bronze screws. Each screw is tightened alterately one turn at a time until both are tightened with the same amount of torque. The saddle, or clamp, and the corporation stop are generally made of bronze.

8. The following procedure applies to the second type of equipment described in Item 5 with a flange or tapped opening in a saddle. The procedure covers the installation of the saddle or clamp on a plastic water main, then drilling through the opening in the saddle into and through the wall of the water-main pipe.

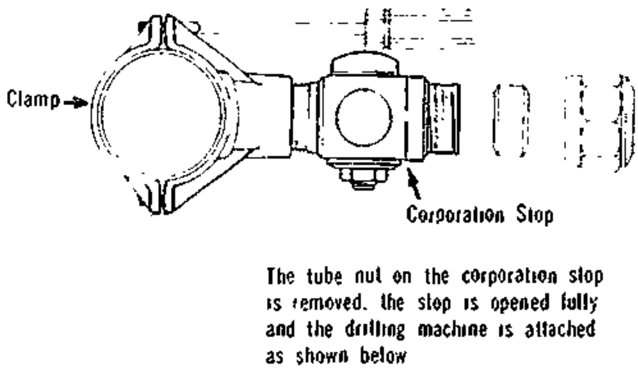


Figure 27-3. **Unit with Corporation Stop Mounted on Clamp**

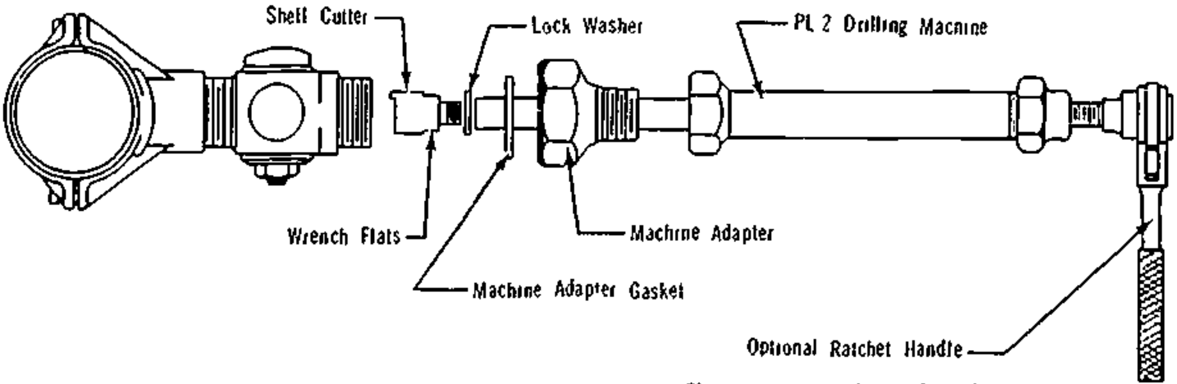


Figure 27-4. **Attaching the Drilling Machine**

a) The tubing nut on the corporation stop is removed, the stop is opened fully, and the drilling machine is attached as shown in Figure 27-4.

b) The proper size of cutter and machine adapter must be used, and they must coincide with the size of the corporation stop.

c) The drilling machine is then attached to the corporation stop, as shown in Figure 27-5, and the boring bar is advanced until the cutter contacts the main; then, with the ratchet wrench, the boring bar is turned clockwise and the cutter drills the required hole in the water main.

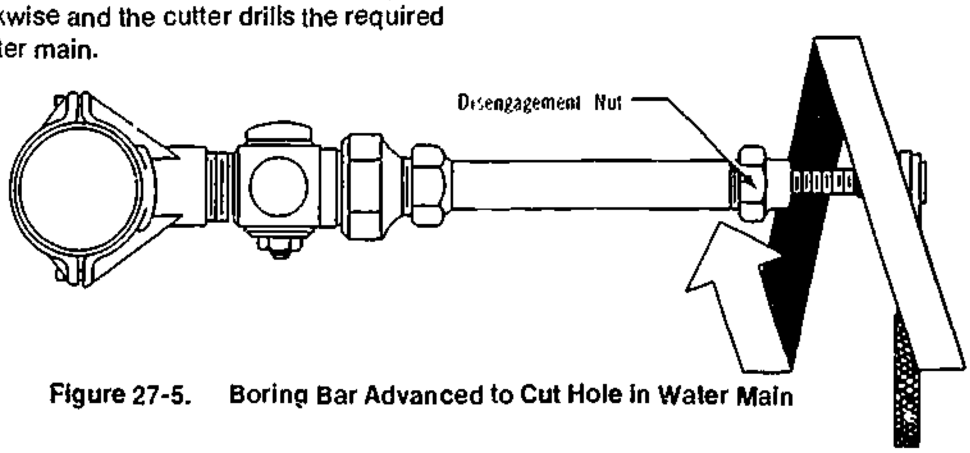


Figure 27-5. **Boring Bar Advanced to Cut Hole in Water Main**

d) When the main has been drilled and the disengagement nut unscrewed from the drilling machine, the pressure in the main will create a piston action that will force the boring bar to its rear-most position. The corporation stop can then be closed and the drilling machine removed as shown in Figure 27-6.

e) When the drilling machine has been removed, the chips must be cleared from the end of the shell-cutter, and the corporation stop opened to flush remaining particles from inside the saddle and the corporation stop.

9. Figure 27-7 shows a power-operated drilling machine for cutting holes in water mains of all types. It is used with a saddle and gate valve for making NPS 2 to NPS 12 connections to a water main. This machine is driven by an air motor that operates on a pressure of 620 kPa.

10. From the foregoing it can be readily seen that there are many different drilling machines and that no single set of rules could govern the use of them all. It is therefore stressed that in each case the particular manufacturer's operating instructions should be followed.

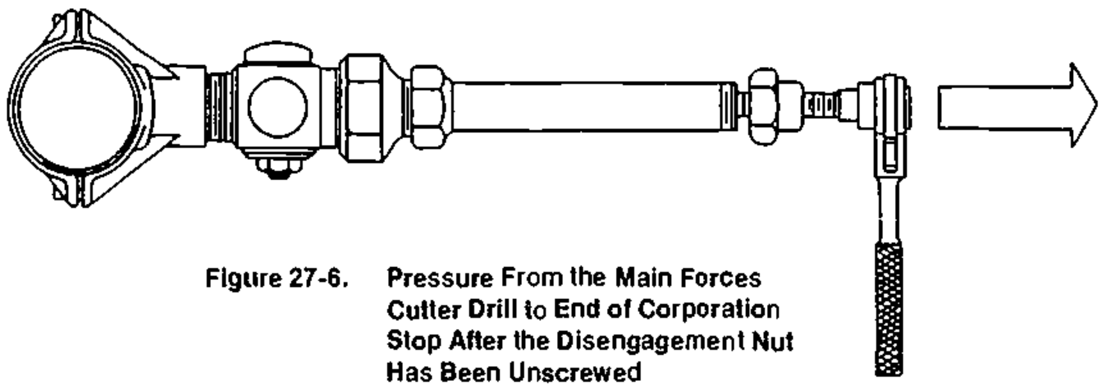


Figure 27-6. Pressure From the Main Forces Cutter Drill to End of Corporation Stop After the Disengagement Nut Has Been Unscrewed

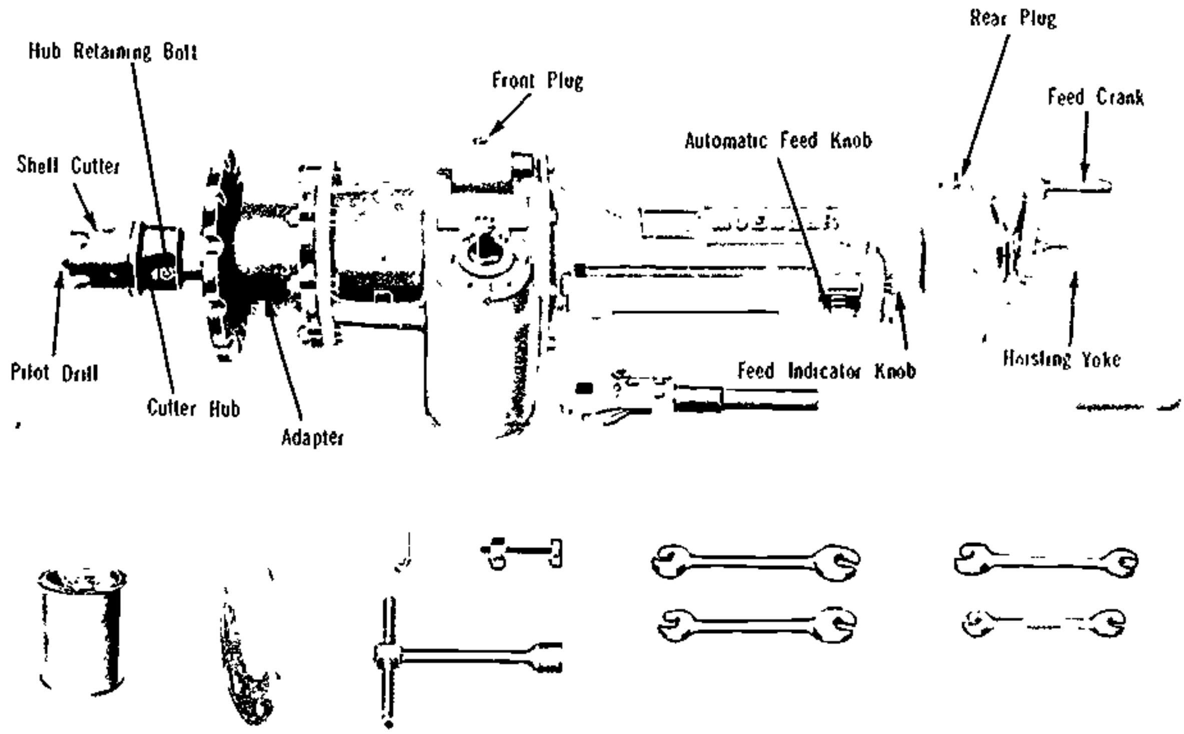
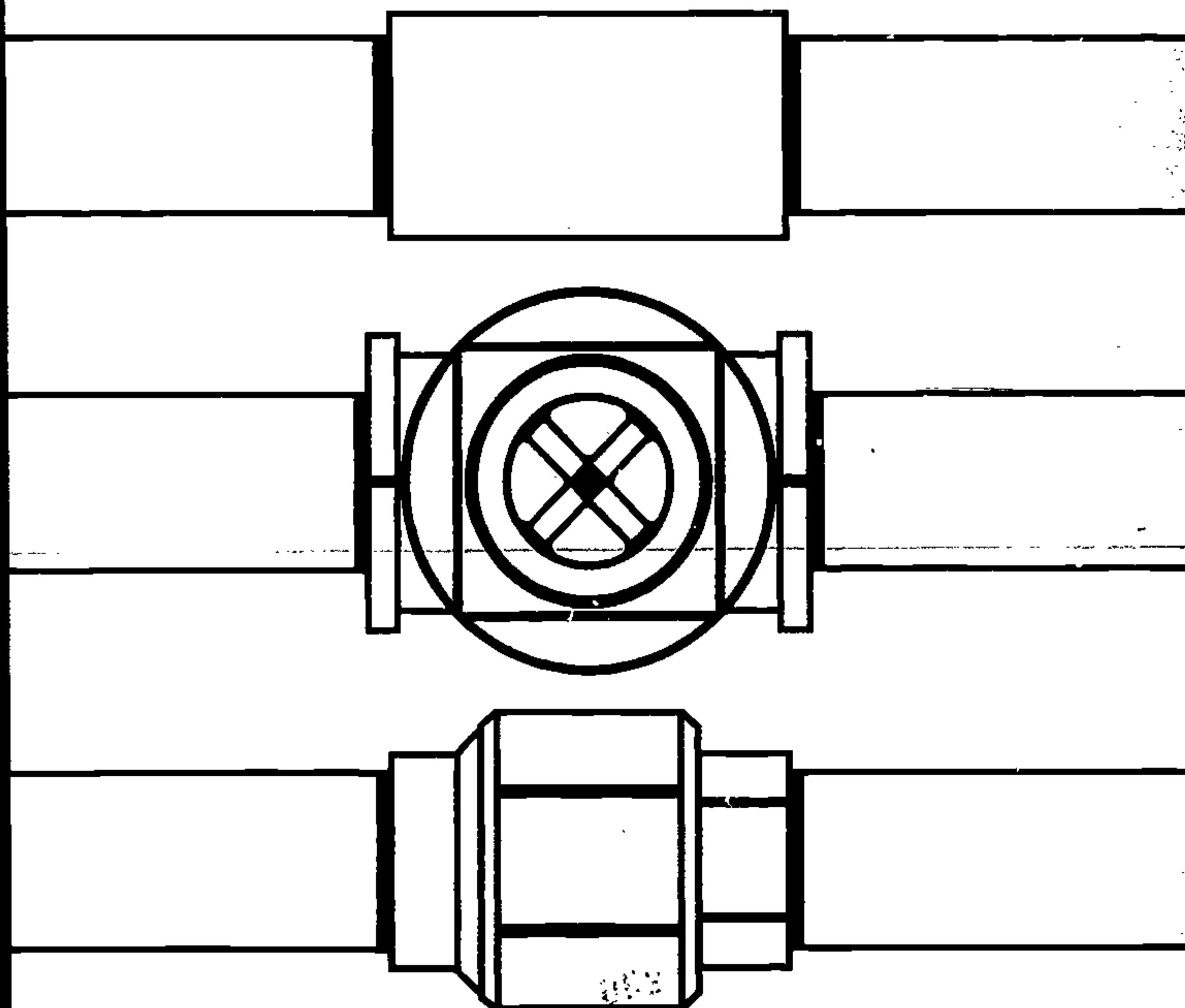


Figure 27-7. Power-Operated Drilling Machine Used with Saddle and Gate Valves

Types of Hydrants and Their Installation 28



PART 28
TYPES OF HYDRANTS AND THEIR INSTALLATION

The several makes of hydrants can generally be identified as belonging to one of the following three types, according to the valve mechanism located in the foot piece:

Compression-type hydrant.

Gate-type hydrant.

Knuckle-joint hydrant.

These types of hydrants and their components are shown in Figures 28-1 to 28-4. Figure 28-5 shows a typical hydrant installation.

The following paragraphs describe the assembly and operation of the types of hydrants most likely found in fire-protection systems. Generally, the bonnet, barrel, and foot-piece of hydrants are made of cast iron. The main working parts are usually made of bronze. Valve facings may be made of rubber, leather, or composition material.

1. Keeping the Barrel Dry

a) Virtually all hydrants are designed so that the barrel remains dry after the hydrant has been in use. This is to prevent freezing of the barrel. As the hydrant valve approaches the closed position, a small valve at the bottom of the barrel opens to allow any water left there to drain out.

b) When a hydrant does not drain properly, first try to clear the drain hole by opening the hydrant one or two turns with the hose outlets closed. If this is unsuccessful, all compression-type hydrants and some of the gate and knuckle-joint types must be dug up to expose the drain hole so that the drain can be cleared with a rod of suitable diameter and length. With other gate and knuckle-joint types, the hydrant can be disassembled and a rod driven through the drain hole.

c) A leak at the valve may be caused by an obstruction or a defective valve-facing or seat ring. Try to remove any obstruction by opening the valve wide and flowing water from the hydrant outlet. If this is unsuccessful, disassemble the hydrant and remove the obstruction. To install a new valve-facing, disassemble the hydrant. To replace a damaged seat ring, the hydrant must be disassembled and, in the case of some compression and all gate and knuckle-joint types, uncovered.

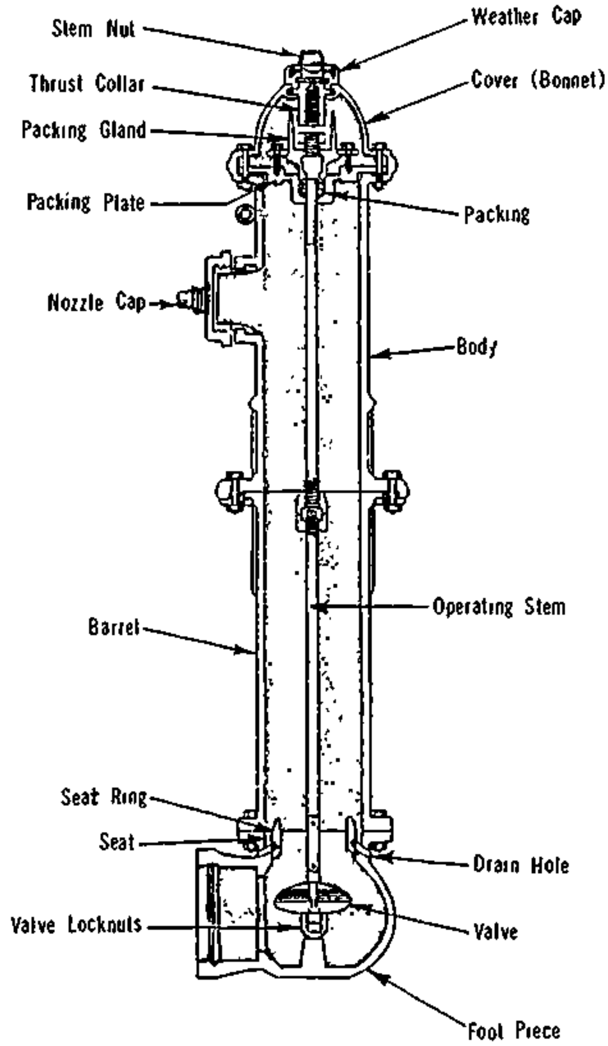


Figure 28-1. Compression-Type (A) Hydrant

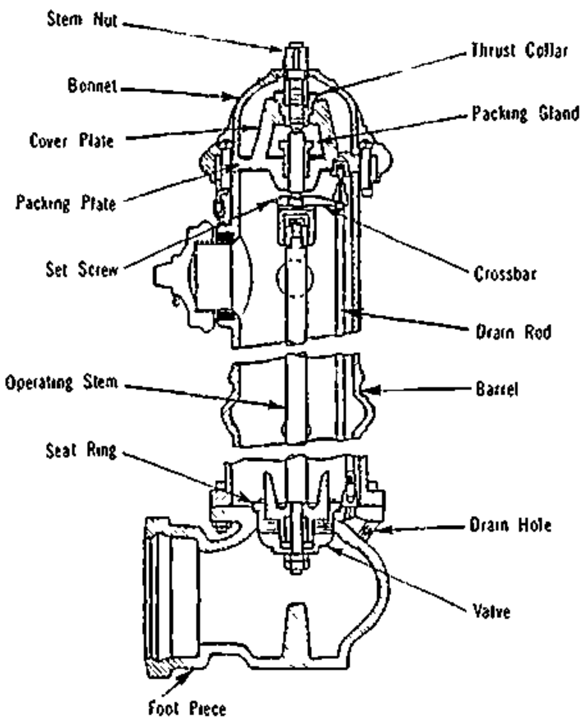


Figure 28-2. Compression-Type (B) Hydrant

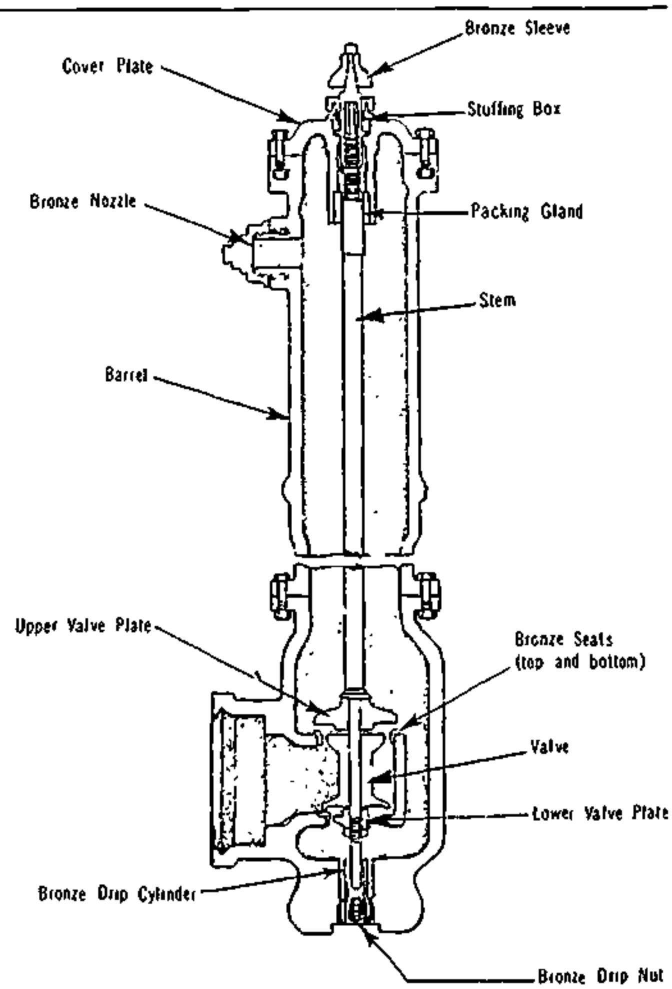


Figure 28-3. Gate-Type Hydrant

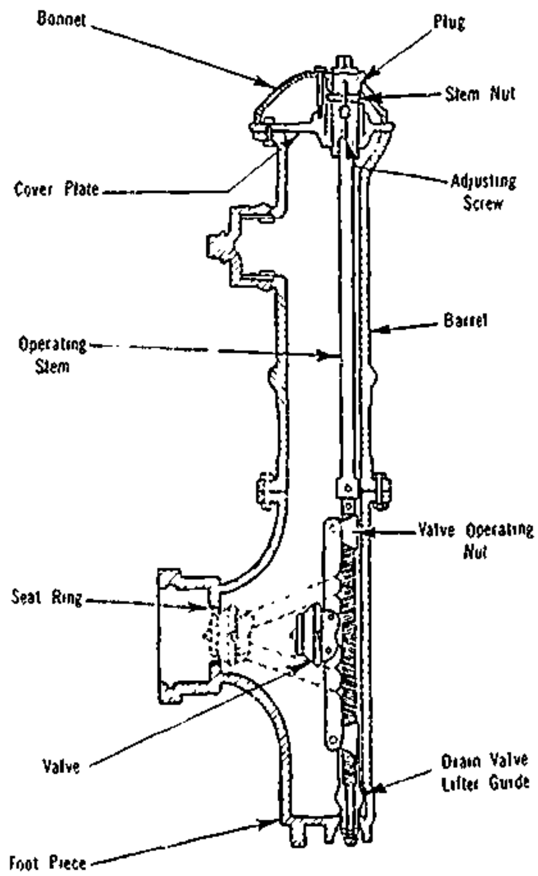


Figure 28-4. Knuckle-Joint Hydrant

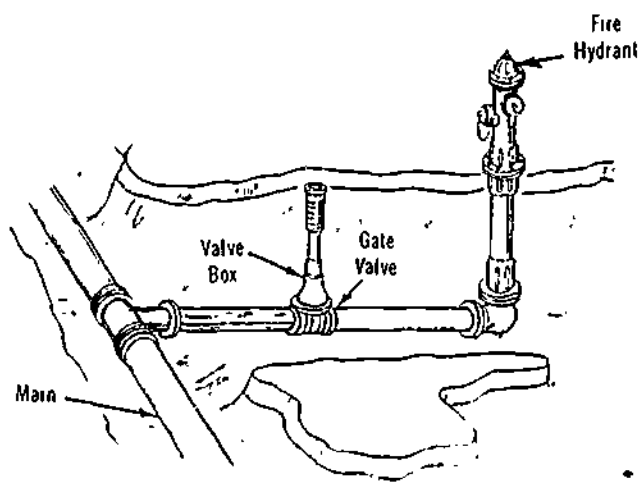


Figure 28-5. Typical Hydrant Installation

d) On certain compression-type hydrants, a special socket wrench supplied by the manufacturer is needed to remove a retainer ring or the seat ring before the hydrant valve mechanism can be removed When such a wrench is unavailable, one can be fabricated by using a suitable length of wrought-iron or steel pipe of the same diameter as the lug circle on the retainer or seal ring. The bottom of this pipe must be slotted to engage the lugs, which are 90° apart.

When the diameter of the lug circle is not a standard size of steel pipe, a small-diameter pipe with bosses of sufficient length to engage the lugs may be used When a wrench is fabricated, a piece of flat steel of the same diameter as the pipe and having a hole that will fit over and centre the operating stem in the barrel must be welded to the top of the pipe The stem nut must be screwed down against this piece of steel so that the pipe cannot slip and burr the lugs. This makeshift valve wrench may be turned by a chain-type wrench. Turning on the stem nut with a wrench is not recommended.

e) To lubricate threads of the stem nut, remove the bolt in the top of the weather cap, or stem nut, and pour oil into the bolt hole. Some hydrants have grease fittings instead of bolts.

f) When a hydrant leaks at the packing, tighten the packing gland or replace the packing.

g) Figures 28-1 to 28-4 give the pertinent data for various types of hydrants. Similar types made by one or more manufacturers are illustrated in these generalized sketches.

2. Disassembly Instructions

a) To disassemble a compression-type (A) hydrant (Figure 28-1), shut off the water, open the hydrant wide, and unbolt the bonnet. Turn the stem nut in open direction until it disengages the operating stem. Lift off the stem nut and bonnet as a unit. Insert a special socket-key wrench into the barrel over the operating stem until the slots in the bottom of the wrench engage the lugs on the seat ring. Lift out the wrench and hydrant mechanism. Re-assemble in reverse order.

b) To disassemble a gate-type hydrant (Figure 28-3) shut off the water, open the hydrant a few turns, unbolt and remove the weather cap. Unbolt the cover plate and lift it and the packing gland as a unit. Lift out the valve mechanism and operating stem as a unit and re-assemble as a unit. Re-assemble hydrant in reverse order.

c) To disassemble a knuckle-joint type of hydrant (Figure 28-4) shut off the water, open the hydrant side and unbolt and lift off the bonnet. Unbolt the cover plate and remove it and the stem-nut assembly as a unit. Re-assemble in reverse order, taking care to hold the drain valve snugly against the back of the barrel while lowering so that it fits into the opening in the base of the foot-piece.

d) To disassemble a compression-type (B) hydrant (Figure 28-2) shut off the water, open the hydrant wide, unbolt and lift off the bonnet. Unbolt the cover plate. Turn the stem nut in open direction until it engages the operating stem, at the same time, hold the cover plate from turning. Lift off the cover plate, thrust collar, and stem nut as a unit. Unscrew the thrust collar and remove the stem nut from the cover plate. Lift out the drain rod, loosen the set screw, and remove the cross bar. Insert the socket-key wrench into the barrel over the operating stem and screw down tightly against the tip of the wrench. Turn the wrench counter-clockwise to unscrew the seat ring. Lift out the wrench and valve mechanism. Re-assemble in reverse order.

3. Hydrant Inspections

Inspect fire hydrants during winter to ensure that they are not subject to freezing, once in spring and once in autumn as follows:

a) Spring and Autumn Test

Inspect the operating nut and replace it if the corners are rounded.

Check the lubrication of the operating nut and if the hydrant does not operate freely, lubricate with oil or grease recommended by the manufacturer.

Check the chains to ensure that paint or rust does not restrict removal of the caps and that the chains are securely anchored to the hydrant.

Check the tightness of outlets where lead is caulked into the hydrant barrel.

Check the threads for damage, wear, or burrs.

Check for leakage in the top of the hydrant, if necessary remove the cover and tighten or replace the packing gland.

Check for leakage through the drain valve, noting whether water comes up around the hydrant when the valve is wide open.

Check for leakage past the gaskets under the caps and replace defective gaskets.

Check for cracks or other evidence of mechanical injury.

Check for accessibility to fire trucks (adjust height of the hydrant so that there is at least 450 mm from hydrant outlet to finished grade).

b) Winter Test

During cold weather, check for a frozen hydrant by moving the spindle through no more than 5° of arc.

Check to see that a standard hydrant marker is properly installed for locating the hydrant during a heavy snowfall.

After fires or other use, particularly in cold weather, a hydrant should be pumped dry with a small hydrant pump. The caps should be wiped dry and a light oil applied to prevent freezing. If a hydrant is frozen, do not exert heavy pressure on the operating nut but inject live steam from a portable thawer or use an electric thawer. (See Part 23.)

A history card should be kept for each hydrant to record inspections and repairs. The hydrant should be numbered for identification and its location shown on a site plan or map.

4. Installation of Hydrants

a) Hydrants are designed to give years of trouble-free service, and normal maintenance can be done without digging.

b) Proper care in the installation of a hydrant can eliminate unnecessary digging at a later date.

c) Extra soil should be excavated around and below the location where the hydrant is to be installed and this space filled with broken stone and coarse gravel. This ensures quick drainage for water left in the hydrant after shut-off, thus preventing freeze-ups.

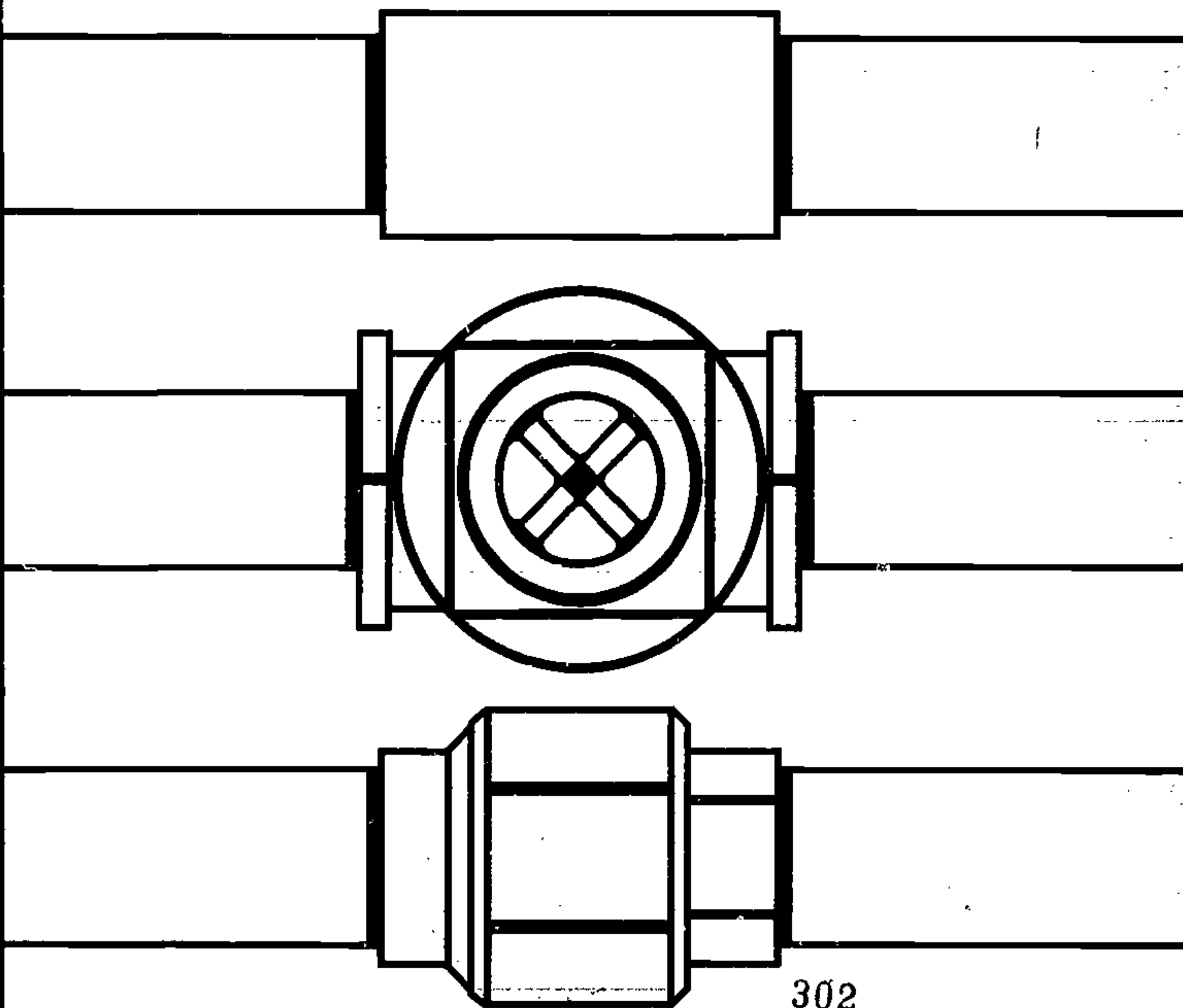
d) Set a flat stone or a pre-cast concrete slab on the gravel to support the hydrant and prevent settling, which would leave it hanging on the pipe. This support also leaves the drain outlet, at the bottom, unobstructed.

e) Every hydrant should be anchored by a concrete thrust block, which is cast in place between the hydrant base and the solid earth behind the hydrant. The concrete should be at least 10.35 MPa or better and shaped so that it does not block the hydrant drain. Alternatively, the hydrant may be anchored to the inlet-supply main with suitable clamps and tie-rods. The tie-rod method should not be used when the water mains and components are assembled with a hub, a mechanical joint, or any type of compression joint unless the tie-rods extend back to a water main that runs at a right-angle to the branch leading to the hydrant.

f) The back-fill should be compacted, and four-way blocking should be provided at intervals to support the hydrant in a vertical position. This blocking will aid the compacted gravel in eliminating any below-ground damage in the event of a traffic accident. The use of coarse gravel for back-fill frees the hydrant from the surrounding soil and helps to prevent frost-heaving.

g) The time and money spent on the proper installation of hydrants is low-cost insurance against the high cost of making a later excavation because of an improper setting.

Corrosion of Metal and Its Prevention 29



PART 29

CORROSION OF METAL AND ITS PREVENTION

1. The most common forms of corrosion that the plumber will encounter include electrolytic processes and chemical reactions.

Electrolytic Processes

2. Galvanic action and electrolysis are both considered oxidation-reduction reactions. Oxidation is the term used to define the loss of electrons from a chemical substance (metal). *Oxygen does not need to be involved.* Reduction occurs when a chemical substance gains electrons. Water, depending on its content of impurities, can act as the electrical conductor ("electrolite" or "solution") for this transfer of electrons.

3. When two dissimilar metals in the same water system contact each other directly or by means of a conductor a transfer of atoms may occur. One of the metals will go into solution, thus corroding.

4. The metal from which this current flows and goes into solution is called the "anode"; and the other to which current flows is known as the "cathode." The anode will corrode and the cathode will be protected.

5. As the purity of water affects the electrolitic property so does temperature. A higher temperature increases the rate of ion transfer. For example, the rate of corrosion at 82°C is about 10 times greater than 10°C.

Galvanic Action

6. Listed in Table 29-1 are various types of metal. Given any combination of metals on the list the metal with a lower number acts as the anode. The cathodic metal always has the higher number. For instance, magnesium has a lower number than steel, therefore the magnesium would be the anode and the steel the cathode. Likewise, if the metals were iron and copper, the iron would be the anode and the copper would be the cathode. Remember that the anode will tend to go into solution and will corrode if the water acts as an electrolitic conductor.

7. A magnesium rod is often inserted into a hot-water tank to give it cathodic protection. The ions of the magnesium anode will go into solution and flow through the water to the metal to be protected. When magnesium rods are used with some types of water, foul odors are often created and in some cases the water becomes discolored. This condition prevails more often in hot soft water than in cold water.

Table 29-1. Order of Electrolytic Action Between Various Metals

1. Magnesium	10. Lead-Tin
2. Magnesium alloys	11. Lead
3. Aluminum	12. Tin
4. Zinc	13. Brass
5. Iron	14. Copper
6. Cadmium	15. Bronze
7. Steel	16. Copper-Nickel
8. Cast iron	17. Silver
9. Nickel	

8. You cannot assume that every time a brass or copper fitting is connected to an iron pipe the pipe will corrode. This is because the electrolite plays an important part in the action.

9. Some plumbing codes require that a dielectric fitting be used between dissimilar metals, while other codes specify that only one type of material may be used in the water-distribution system in a building. ("Dielectric" refers to a non-conducting substance such as plastic.)

Electrolysis

10. Electrolysis is the passage of current through an electrolytic solution. The passage of the current involves a transfer of ions through the solution. Oxidation at the anode and reduction at the cathode occur simultaneously as the current flows from a positive charge to a negative charge, or "ground".

11. Corrosion as a result of electrolysis often occurs in a plumbing system.

12. Stray currents from direct-current equipment such as generators and electric fences may travel through the ground until they reach a metallic pipe and then use the pipe as a conductor. The pipe will corrode along the path of the electrons with corrosive effects showing most where the current leaves it and re-enters the ground

Rusting

13. Rusting is a specific form of chemical corrosion that deteriorates both the internal and external surface of metal pipes. Oxygen elements as in water, H_2O, may react with metal releasing hydrogen gas and causing rust to form on the metal in the form of an oxide. The rust eventually becomes thick enough to partly prevent oxygen from reaching the metal, resulting in a slowing-down of the rusting process.

Chemical

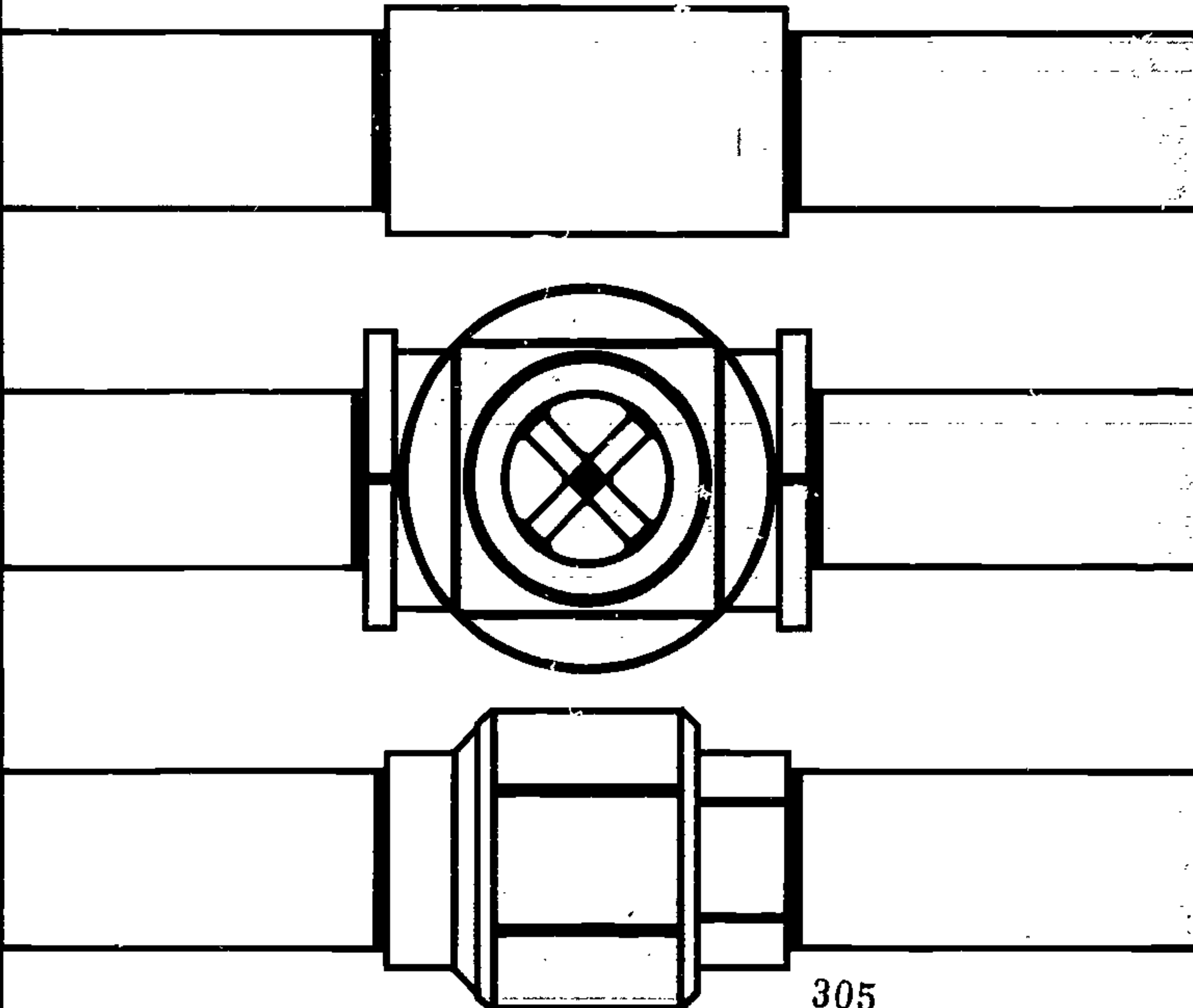
14. Many metals will corrode if placed in contact with acid or fumes from an acid. This applies to many metals exposed to chlorine gas, such as might be found in a building housing a chlorination system for water or sewage treatment.

Corrosion Prevention

15. Following are some of the many different methods of minimizing the corrosion of metals in a plumbing system:

a) Cathodic protection.
b) Using dielectric fittings between different metals.
c) Using only one type of metal in a system.
d) Coating pipe with paint or a similar material.
e) Using galvanized pipe in place of black steel pipe.
f) Encasing pipe in a plastic tube.
g) Wrapping pipe with poly tape, etc.

30 Cross-Connections and Protection Devices



PART 30

CROSS-CONNECTIONS AND PROTECTION DEVICES

CROSS-CONNECTION CONTROL

1. This part of the manual provides information for a better understanding of the basic backflow prevention devices — how and where to use them, and how to keep them in good working order to ensure positive and continuous system protection. This subject is better defined as backflow-return or reverse-flow connection control.

2. A cross-connection is any connection or structural arrangement between a public or a private potable water system and any non-potable or unapproved source or system through which backflow can occur. Cross-connections may be direct or indirect. A direct connection is where the safe water system is joined to a system containing unsafe water and sewage, or other wastewater system. An indirect cross-connection may be a condition where a source of contaminated water may be flown across, sucked, or diverted into a safe water system.

3. Backflow is the flow of water or other liquids into the distribution system or the pipes of a potable water system from any source other than that intended.

4. Causes of backflow: Wherever there is an interconnection between a potable water system and a non-potable system, backflow may result from either "back-siphonage" or "back-pressure."

5. Governing authorities have provided guidelines and pre-qualified requirements for backflow prevention devices. It is essential that only proven devices be used for system protection.

6. In some cases it is better to have no protection than to have unreliable protection, since once a device is installed it is too easy to assume that the system is safe and this sense of false security could promote careless practices.

7. The foregoing indicates the extreme care that is taken to ensure that only tried and proven products that meet exacting standards are installed to protect approved potable water systems. It is recommended that users take full advantage of the standards, and that only approved devices be used. When backflow preventers are used in fire-protection systems, "UL Approval" is granted by the Underwriters' Laboratories after satisfactory completion of their test requirements.

8. Back-siphonage is the drawing of contaminated or polluted water into the potable water supply system owing to a negative pressure in the system. Back-siphonage is caused by negative pressure or reduced pressure in the potable water supply piping. A major cause of back-siphonage is undersized piping. If water is withdrawn from a pipeline at a very high velocity, pressure in the pipe is reduced and, because of this pressure difference, water will tend to flow into the line from other connection sources. Thus, if the connected source is contaminated, the entire system could become polluted owing to back-siphonage.

9. Principal causes of back-siphonage are:

a) Undersized piping.

b) Line break in a low section of the system.

c) Reduced main pressure resulting from a high rate of water withdrawal, typically by a fire-truck booster pump or simply by heavy demand of fire hoses.

d) Reduced main pressure on the suction side of a booster pump.

10. Back-pressure may cause backflow whenever a potable system is connected to a non-potable system containing pumps, a boiler, or any other device that may develop a pressure greater than the potable supply system's minimum pressure. During periods of low supply pressure, contaminated water could be forced into the potable water system if proper protection is not provided.

11. Causes of back-pressure are:

a) Booster or fire pumps.

b) The loss of or a drop in supply pressure.

c) Inter-connection with another system operating at a higher pressure.

d) Thermal expansion caused by boilers.

12. The water purveyor has the responsibility of providing customers at the service connection with water that is safe under all foreseeable circumstances. Thus the purveyor must take reasonable precautions to protect the community distribution system from hazards that originate on customer premises and that could degrade the water in the community system.

13. The water purveyor, in co-operation with health authorities and the local plumbing-code enforcement agency, may insist that measures be taken to ensure positive protection of the potable water supply system. Such measures could include the installation of an approved backflow prevention device.

Vacuum Breakers: Anti-Siphonage Type

14. Vacuum breakers are basically anti-siphonage preventers and should never be used where there is any possibility of back-pressure. They fall into two categories:

a) Atmospheric Type (See Figure 30-1).

b) Pressure Type (See Figure 30-2).

15. The Atmospheric Type Vacuum Breaker is designed only for intermittent service. It should never be installed with a shut-off valve on the outlet side. It should be used only where it will be under pressure for short periods (a maximum of 12 hours in a 24-hour period). Typical applications are washing machines, lawn sprinkler systems, photographic developing tanks, and vending machines.

This type of vacuum breaker is mounted directly in the line and has a limited flow capacity because of the fact that lineflow passes through the vacuum breaker. Several units may be installed in parallel to accommodate high-capacity systems.

16. The Pressure Type Vacuum Breaker is designed to operate continuously under pressure. Typical applications include in-plant lines, which should be separated from the potable water supply.

17. The Pressure Type Vacuum Breaker must be designed to ensure an adequate opening force to offset any tendency of the seat to stick after long periods of closure under positive pressure conditions.

18. All vacuum breakers must be installed at least 152 mm above the highest outlet they are to serve.

Backflow Preventers

19. Backflow preventers fall into three categories:

a) Double Check Valve Type (Figure 30-3).

b) Pressure Type Vacuum Breaker and Check Valve (Figure 30-4).

c) Reduced Pressure Type (Figure 30-5).

20. Backflow preventers are generally used to prevent backflow caused by back-pressure.

21. Double Check Valve: The double check valve type of backflow preventer consists of two independently acting, approved check valves between two tightly closing shut-off valves, with three test cocks arranged for testing tightness of the check valves.

22. Pressure Type Vacuum Breaker and Check Valve: For added security, a Pressure Type Vacuum Breaker is used with the double check valve.

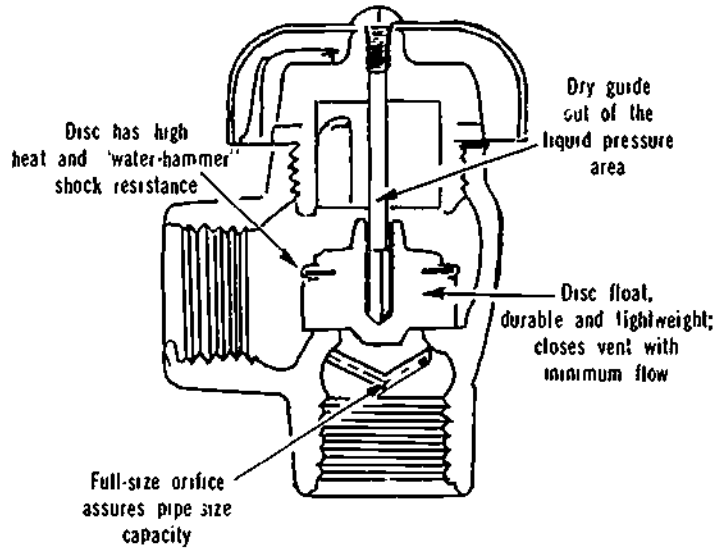


Figure 30-1. Atmospheric Type Vacuum Breaker

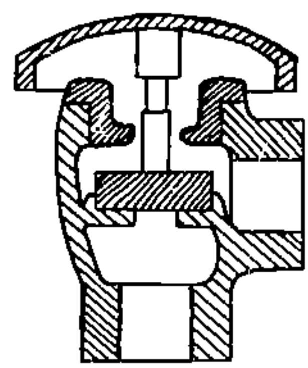


Figure 30-2. Vacuum Breaker Cross-Sectional View, Shown Open to Atmosphere

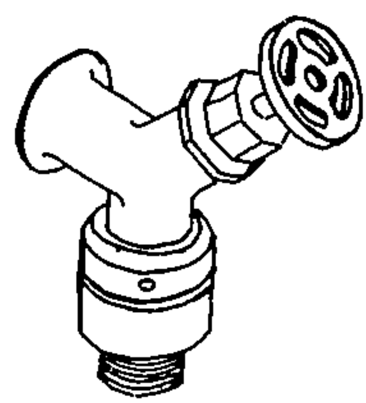


Figure 30-3. Atmospheric Vacuum Breaker, Style for Hose Bibb Application

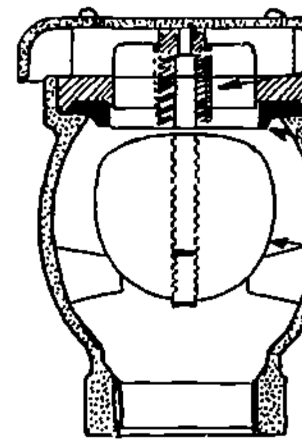


Figure 30-4. **Pressure Type Vacuum Breaker**

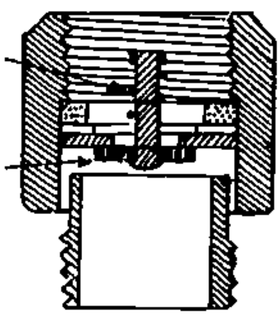


Figure 30-5. **Vacuum Breaker Cross-Sectional View, Shown Open to Atmosphere**

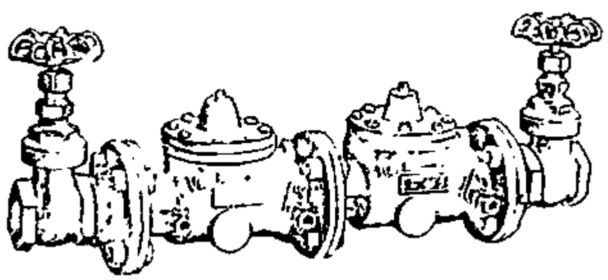


Figure 30-6. **Double Check Valve Backflow Preventer**

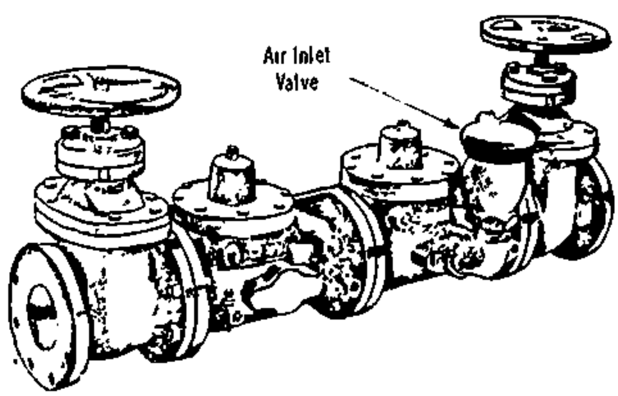


Figure 30-7. **Pressure Type Vacuum Breaker and Check Valve Backflow Preventer**

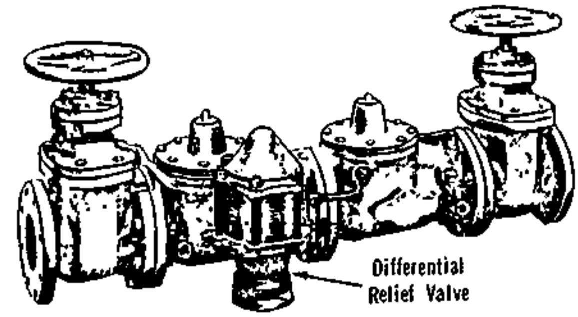


Figure 30-8. **Reduced Pressure Type Backflow Preventer**

23. Reduced Pressure Type: This type of backflow preventer consists of an automatic pressure differential relief valve located in a zone between two independently acting approved check valves, which in turn are located between two tightly closing shut-off valves, with three test cocks for testing tightness of the check valves.

24. The Double Check Valve may be used only to prevent backflow caused by superior back-pressure from plant water systems, or from secondary water-supply systems not considered harmful to public health.

25. The Pressure Type Vacuum Breaker and Check Valve have the same general application as the double check valve; however, they incorporate additional protection for systems where negative pressure can develop on the supply side.

26. The Reduced Pressure Type Backflow Preventers must be used on any high-hazard application to prevent backflow caused by superior back-pressure from plant water systems or from secondary water-supply systems that are considered harmful to public health.

Design and Operational Specifications

27. Double Check Valve Unit: This device includes two independently acting spring-loaded check valves, two shut-off valves, and three test cocks, all arranged so that a test of each check valve can be made. The spring-loading of the check valves must be sufficient to hold at least 7 kPa in the direction of

flow. The head loss across the entire unit must not exceed 70 kPa at the rated flow.

28. Pressure Type Vacuum Breaker and Check Valve. This unit comprises two independently acting spring-loaded check valves, an opening to atmosphere on the discharge side of the second check valve, two shut-off valves, and three test cocks, all arranged so that a test of each check valve can be made. The spring-loading of the check valves must be sufficient to hold at least 7 kPa in the direction of flow. The head loss across the entire unit must not exceed 70 kPa at the rated flow. The opening to atmosphere is arranged so that it begins to open at no less than 7 kPa, and is fully open at atmospheric pressure.

29. Reduced Pressure Backflow Preventer: This preventer is a complete assembly comprising two independently acting spring-loaded check valves and an automatically operating pressure-differential relief valve between the two check valves. The first check valve reduces the supply pressure by a predetermined amount so that during normal flow, and at the cessation of normal flow, the pressure between the checks is less than the supply pressure. In the event of leakage from either check valve, the differential relief valve discharges to atmosphere to maintain the pressure between the checks at less than the supply pressure.

30. The unit includes tightly closing shut-off valves at each end of the device, and three test cocks arranged so that each check valve can be tested.

31. Operation is completely automatic. All parts are removable and replaceable without removing the unit from the line. The total head loss throughout the complete backflow assembly must not exceed 70 kPa at the rated flow.

32. Under a no-flow condition, the pressure within the "zone" should be atmospheric when the pressure on the supply side drops to 14 kPa. When the supply pressure drops below 14 kPa the relief valve opens further and is fully open when the upstream pressure reaches atmospheric or goes below atmospheric.

33. Under a backflow condition, when the upstream pressure is 14 kPa or more, the relief valve discharges from the "zone" to atmosphere the quantities of back-flowing water through check valve No. 2, and the pressure in the "zone" must be at least 3.5 kPa below the upstream pressure.

34. The downstream, or second, check valve is internally loaded, and at all times must be drip-tight in the normal direction of flow, with the inlet pressure ("zone" pressure) at 7 kPa and the outlet at atmospheric pressure.

35. When the upstream pressure is less than 14 kPa, the pressure-differential relief valve must discharge water from the "zone" to atmosphere, and the pressure in the "zone" must not exceed 10.5 kPa.

36. The pressure-differential relief valve opens and closes positively and quietly, and does not discharge water under normal fluctuations (i.e., 21 kPa maximum variation of inlet pressure).

CLASSIFICATION OF HAZARDS AND REQUIRED PROTECTION

37. The risks to the utility system caused by a plant or facility fall into two categories:

a) A non-health hazard, which would cause aesthetic problems or have a detrimental effect on the quality of the water in the system.

b) A physical or toxic hazard, which could be dangerous to health.

Class 1A: Off-taste or odoriferous—sometimes resulting from river water backing up into potable water lines.

Class 1B: Unpalatable—very often caused by backflow during flood stages or heavy storms.

Class 2A: Disease-laden—backflow of water, contaminated by sewage or any other source containing bacteria.

Class 2B: Poisonous—in or near industrial plants or yards where water can be become contaminated by acids or chemicals

38. Where protection against backflow of contaminated water is desirable as a precautionary measure, although the source does not constitute a health hazard (Class 1 hazards), a double check valve is recommended. In certain cases, a Pressure Type Vacuum Breaker and a double check valve should be used.

39. A Reduced Pressure Type backflow preventer must be used for Class 2 hazards.

Table 1. Areas of Potential Cross-Connections and Recommended Protection Devices

IDENTIFICATION OF HEADING NUMERALS:

(1) Air Gap	AG	(5) Atmospheric Vacuum Breaker	AVB
(2) Reduced Pressure Backflow Device	RPBD	(6) Pressure Type Vacuum Breaker and Double Check Valve Assembly	PVB/DCVA
(3) Double Check Valve Assembly	DCVA		
(4) Pressure Vacuum Breaker	PVB		

Type of Hazard on Premises	Minimum Protection at Service Connection						Minimum Options to Isolate Areas of Plant Affected					
	1	2	3	4	5	6	1	2	3	4	5	6
1. Sewage Treatment Plant	X	X					X					
2. Sewage Lift Pumps	X	X						N	O	N	E	
3. Domestic-Water Booster Pump			X			X			X			X
4. Equipment or Containers Manufactured for Industrial Use but Without Proper Backflow Protection:												
a) Dish Washing										X	X	
b) Clothes Washing			X				X			X	X	
c) Food Processing	X	X					X	X				
d) Pressure Vessel		X						X				
e) Tank or Vat Containing a Non-Potable or Objectionable Solution	X	X					X	X				
f) Sinks with Hose Threads on Inlet										X	X	
g) Any Dispenser Connected to a Potable Water Supply										X	X	
h) Aspirator Equipment										X	X	
i) Portable Spray Equipment									X			X
5. Reservoirs, Swimming Pools, Cooling Towers, Circulating Systems		X					X	X				
6. Commercial Laundry	X	X						N	O	N	E	
7. Steam-Generating Facilities and Lines			X			X			X			
8. Equipment Under Hydraulic Test or Hydraulically Operated Equipment	X	X					X	X				
9. Laboratory Equipment:												
a) Health Hazard	X	X						N	O	N	E	
b) Non-Health Hazard			X							X	X	
10. Plating Facilities	X	X						N	O	N	E	
11 Irrigation Systems		X	X			X				X	X	
12. Fire-Fighting Systems		X	X				X	X				
13 Dockside Facilities		X						X			X	

RECOMMENDED INSTALLATION PRACTICE

40. Specific installation requirements apply to each type of de...e. The installation location must be carefully selected. The unit must not be installed in locations subject to corrosive fumes, dust, or sticky or abrasive liquids. The device must be protected against mechanical abuse, and installed so that it is easily accessible for testing and repair.

41. *Premises Isolation With Backflow Preventer Installed at the Property Service Connection.* In many cases, the theory of premises isolation is utilized when correcting cross-connections on premises where there are actual or potential hazards. Thus the entire premises are separated from the utility system by means of a backflow prevention device. In many industrial complexes where the plumbing arrangement is subject to change, or where access is restricted, premises isolation is the only method of system protection available to the water purveyor; however, it does not offer protection for personnel on the premises.

42. *In-Plant Isolation With Backflow Preventers Installed Inside the Property:* When possible, in-plant isolation is preferred because in-plant personnel are protected and, in most cases, the device can be smaller because of smaller in-plant piping.

43. Where there are varying degrees of hazard within the premises, in-plant isolation may be supplemented with additional protection at the service connection. The choice of devices for in-plant protection and protection at the service connection will depend on the degree of hazard.

44. *Installations Requiring Continuous Service.* If a customer requires continuous service and it is impossible to provide water from two service connections, two backflow prevention devices should be installed in parallel so that testing and maintenance for each unit can be conducted without service interruption. They should have the combined capacity to maintain the flow rate of the single service pipe as established by the American Water Works Association specification for that size of pipe. Service to hospitals is a case where this type of installation may be required.

45. *Extreme Health Hazard.* Some processes present an extreme risk to the system and as a matter of normal precaution both in-plant protection and premises isolation are recommended. A sewage treatment plant is an example.

46. *Irrigation and Sprinkling Systems.* Either the Atmospheric Type or the Pressure Type Vacuum Breaker, when properly installed, is preferred for backflow protection on sprinkler systems. Neither, however, is adequate protection in areas where it would be subject to flooding or back-pressure. Where there is a likelihood of this occurring, an internally loaded double check valve may be required.

47. A Reduced Pressure Type Backflow Preventer, or an air-gap separation, should be used where fertilizer or herbicides are injected into the sprinkler system.

48. A suitable strainer (see Figure 30-9) should be installed ahead of all Reduced Pressure, Double Check, and Pressure Type Vacuum Breaker Backflow Preventers to protect them against rocks and other material.

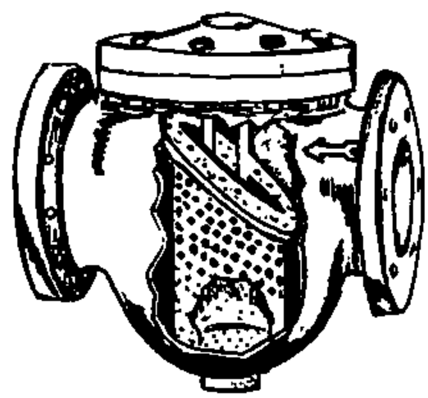


Figure 30-9. Strainer to Protect Device From Foreign Materials

49. These units will not provide complete protection when either check valve fails to close tightly. Check valves are constructed in such a manner that they will not fail under normal operation with clean water. Foreign material can be introduced only from the supply system. A strainer is a good investment since it provides continuous and trouble-free operation and minimizes check valve malfunctioning.

Vacuum Breakers

50. Vacuum breakers introduce air into the system whenever negative pressure occurs. They must be installed at least 150 mm above the highest outlet connection.

51. They must not be installed in pits or locations where they can be flooded. (See Figure 30-6.)

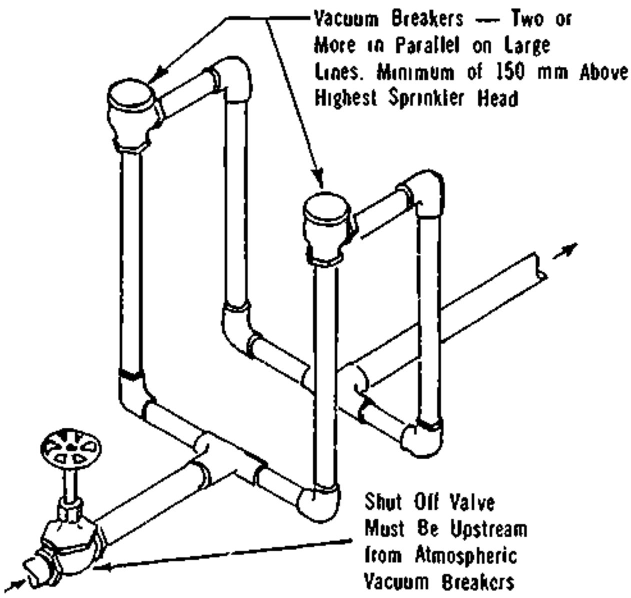


Figure 30-10. Atmospheric Vacuum Breaker. Style for Sprinkler System Application

Backflow Preventers

52. Reduced Pressure and Pressure Type Vacuum Breaker units should be installed above the ground. They may be free-standing in locations without frost. Chambers or houses should be provided for protection against frost and vandalism. (See Figures 30-10 and 30-12.)

53. Underground pit installations should be considered only if the location will not permit above-ground installation. Pit installations can be made only when the pit is allowed to drain to daylight through a drain that will handle the volume of water that can be discharged from the relief valve.

54. Units must be installed with at least 300 mm plus nominal size of the device above the ground or maximum flood level, whichever is highest. The effectiveness of this device is nullified if it is subject to flooding to the level where the relief port becomes covered.

55. A drain line with air gap and funnel must be provided to receive discharge from the differential relief valve on Reduced Pressure Type Vacuum Breaker units. This is not required on Pressure Type Vacuum Breaker units because the vacuum breaker introduces air into the system only to break the vacuum. (See Figure 30-10.)

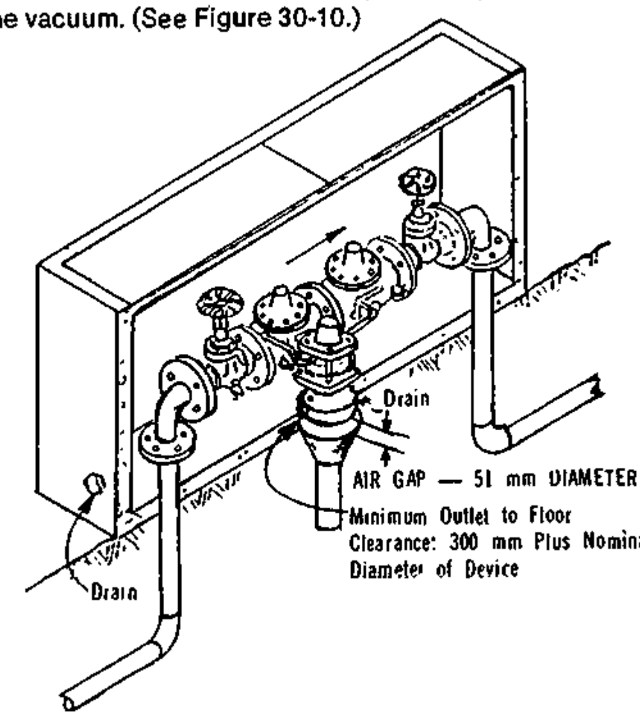


Figure 30-11. Reduced Pressure Type, Also for Double Check with Pressure Type Vacuum Breaker

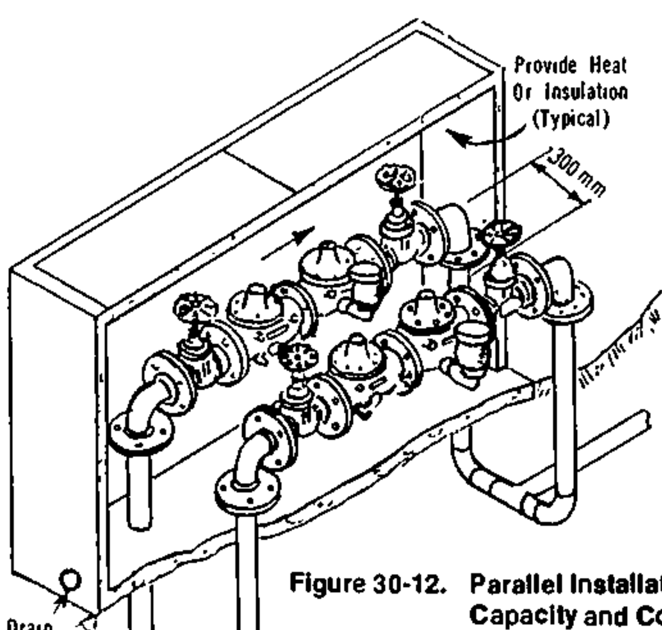


Figure 30-12. Parallel Installation for High Capacity and Continuous Service for Double Check with Vacuum Breaker and Reduced Pressure Type

56. Double check valve units may be installed in a chamber below ground level. Adequate drains must be provided to keep the pit free from water, and the unit must be protected against freezing. (See Figure 30-11.)

57. All installations should provide adequate room for servicing and testing. If a manhole or a hatch-type entrance is used, the chamber should have at least 2 m head room.

MAINTENANCE AND TESTING PROCEDURES

58. To this point, we have discussed the *why*'s and *wherefore*'s of cross-connection control, and the types of backflow preventers to be used to provide system protection.

59. More important to the operating personnel, however, are the maintenance and testing procedures. All backflow preventers are basically simple and reliable devices, most operating problems having been eliminated during the testing and approval periods. When installed correctly, and protected with a suitable strainer, uni equire only a minimum of maintenance and s ..duled testing at least once a year. During the .irst year, however, they should be tested more frequently to familiarize operating personnel with their operation. Problems caused by dirt or other material will show up in the first few months.

60. Suggested test periods for the first year's operation:

a) Immediately after installation.
b) Thirty days after installation.
c) Three months after installation.
d) Six months after installation.
e) Twelve months after installation.

61. After the first year's service, they should be tested at least yearly. However, if operating conditions are severe, tests may be scheduled at three-month or six-month intervals.

62. Backflow preventers are simple mechanical devices compared with other automatic equipment normally used in water and distribution systems.

63. *Field-Test Procedure for Vacuum Breakers.* It is generally assumed that a vacuum breaker is in good working order so long as it does not leak water when the system is under pressure. Leaking, in most cases, results from dirt on the seating surfaces and can be corrected by cleaning or replacing the disc assembly.

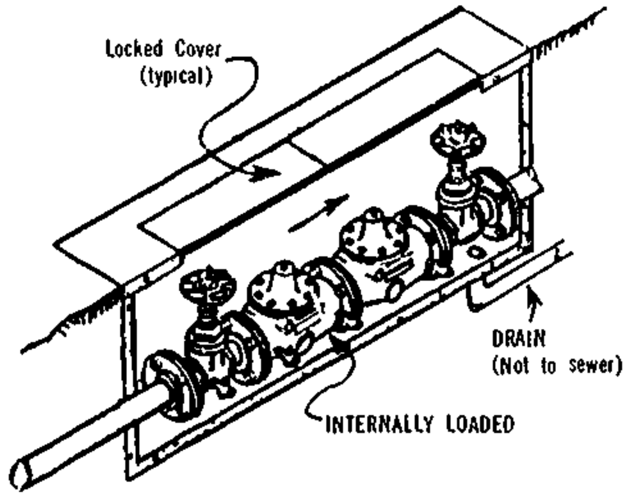


Figure 30-13. Double Check Valve Unit

64. It is important to ensure that the valve is free to open when a negative pressure condition develops. The opening function can be checked by closing the shut-off valve ahead of the vacuum breaker, draining the line, and observing disc action. The disc should open when the line pressure drops to zero.

Field-Test Procedure for Double Check Valve (See Figure 30-14)

65. *Test No. 1*

Purpose: To test No. 2 check valve for proper internal loading and for seat tightness.

Requirement: The valve must be drip-tight in normal direction of flow, with the inlet pressure at 7 kPa and the outlet pressure at atmospheric.

Steps:

a) Install a vertical transparent tube on test cock No. 2. Open test cock No. 2 to fill the tube with water to a height of 710 mm (7 kPa). Close test cock No. 2.

b) Close shut-off valve No. 2, then close shut-off valve No. 1.

c) Open test cock No. 2 fully. Open test cock No. 3 fully. If the water level in the tube holds steady at a height of 710 mm (7 kPa), the check valve is "satisfactory."

d) Close test cocks No. 2 and 3 and remove the tube.

66. *Test No. 2*

Purpose: To test No. 1 check valve for proper internal loading and for seat tightness.

Requirement: The valve must be drip-tight in normal direction of flow with the inlet pressure at 7 kPa and the outlet pressure at atmospheric.

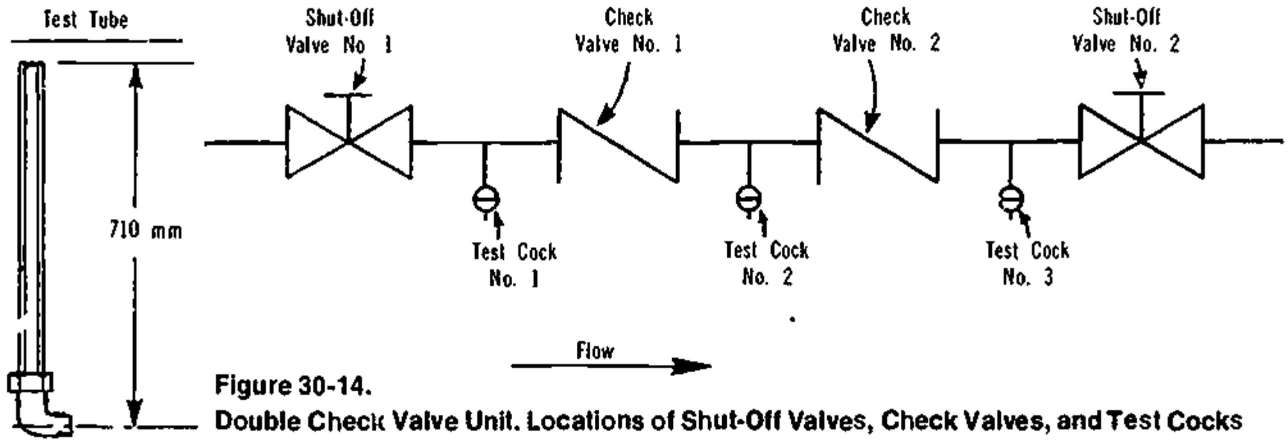


Figure 30-14.
Double Check Valve Unit. Locations of Shut-Off Valves, Check Valves, and Test Cocks

Steps:

a) Install the vertical transparent tube on test cock No. 1. Open test cock No. 1.

b) Open shut-off valve No. 1 until the tube is filled with water to a height of 710 mm (7 kPa). Then close shut-off valve No. 1.

c) Open test cock No. 2. If the water level holds steady at a height of 710 mm (7 kPa), the check valve is to be noted as "satisfactory."

Test Kit for Clayton Model RP Reduced Pressure Backflow Preventers

67. *General Procedure*

a) Make connections as illustrated in Figure 30-15.

b) For all tests, gate valve No. 1 is open but gate valve No. 2 is closed.

c) Vent all air from control piping and differential indicator as follows:

- Open test cocks 1, 2, 3.
- Open test valves A, B, C.
- Alternately open and close bleed valves until

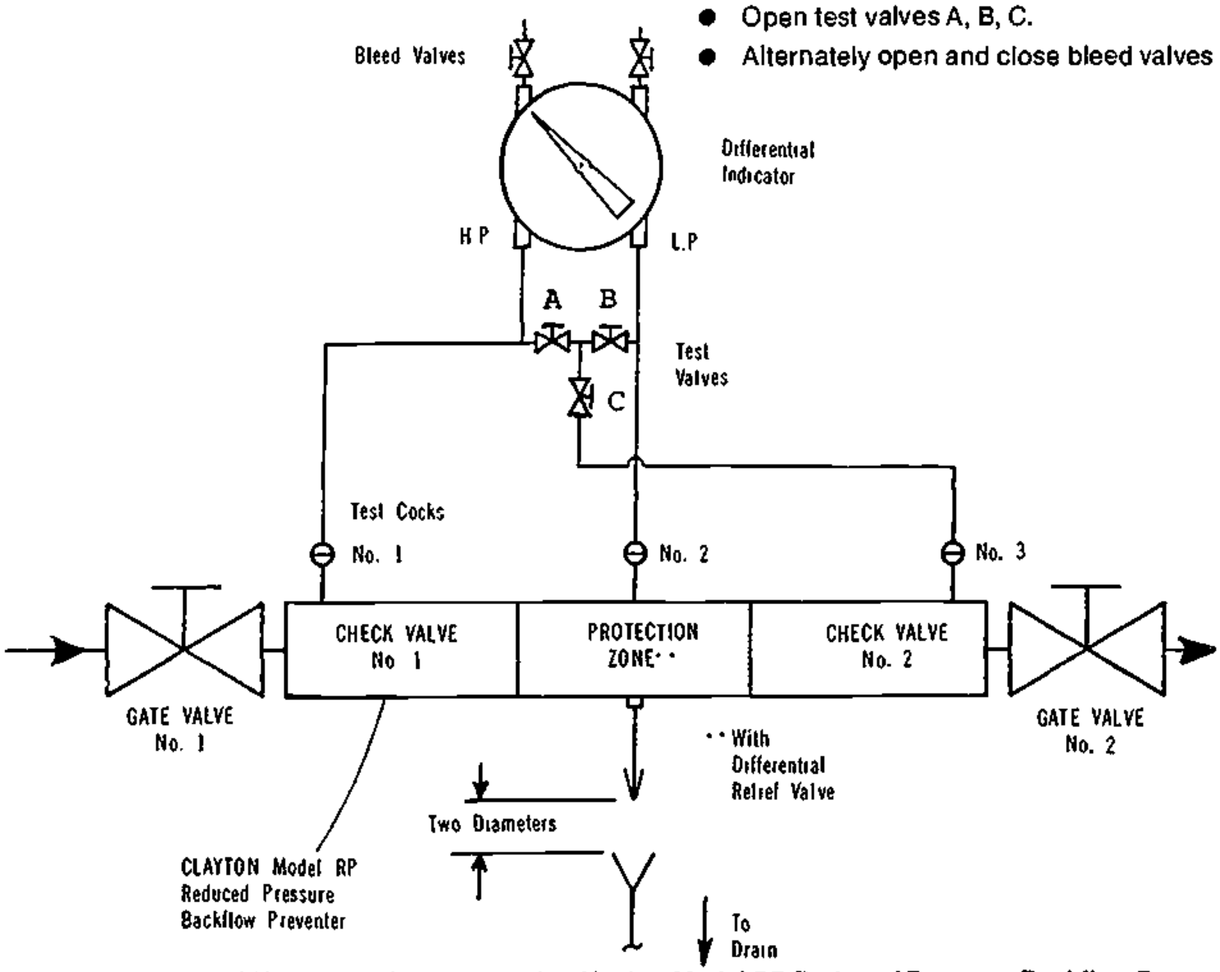


Figure 30-15. Test Kit and Test Procedure for Clayton Model RP Reduced Pressure Backflow Preventers

all air is vented. Close both bleed valves tight.

- Close all test cocks and test valves.

68. *Test No. 1*
Purpose: To test check valve No. 1.

If there is no drainage from the pressure-differential relief valve, with gate valve No. 1 open and gate valve No. 2 closed, No. 1 check valve is closed tight.

To test the differential reading:

a) Open test cocks Nos. 1 and 2.

b) Disconnect the test line at test cock No. 3. Open test cock No. 3 to allow a slight flow to atmosphere until the gauge reading stops rising. Close test cock No. 3.

c) Observe the reading on the differential indicator. The reading should hold above 35 kPa. If the reading decreases, check valve No. 1 is leaking.

NOTE: The differential relief valve will open if the reading drops to 14 kPa.

69. *Test No. 2*
Purpose: To determine the opening or drip point of the pressure differential relief valve.

After completing test No. 1, with the differential reading holding constant above 35 kPa, and with test cocks Nos. 1 and 2 open, proceed as follows:

a) Open test valve A.

b) Open test valve B very slowly until differential indicator reading starts to drop.

Hold test valve B at this position and observe reading. When the first drops of water are released from the relief valve differential reading should not be below 14 kPa.

NOTE: It is important to do this test *very slowly.*

c) Close test valve B. Disconnect the test line at test cock No. 3. Open test cock No. 3 to allow a slight flow to atmosphere until the gauge reading stops rising. Close test cock No. 3 and re-connect the test line.

70. *Test No. 3*
Purpose: To test check valve No. 2.

After completion of test No. 2, with differential reading holding constant above 35 kPa and with test cocks Nos. 1 and 2 open, proceed as follows:

a) Open test valves (A) and (C).

b) Open test cock No. 3.

c) Observe the differential reading, which should not drop below 35 kPa.

If the reading decreases, check valve No. 2 is leaking.

NOTE: The differential relief valve will open if the reading drops to 14 kPa.

Testers of Backflow Preventers

71. It should be the customer's responsibility to ensure that units are kept in good working order.

72. The customer must acquire a qualified tester to perform testing as detailed by the water purveyor, and to perform repairs as required. Typical test-report forms are shown in Figures 30-16 and 30-17.

73. There are three categories of testers: *general, limited,* and *manufacturer's agent.*

74. A *general tester* is one who has taken an approved training program and is qualified to perform periodic testing and repairs on all such devices.

75. A *limited tester* is usually a company employee whose duty is the testing and maintenance of the device in the plant. This person is not recognized as a certified tester outside the company's plant.

76. A *manufacturer's agent* is one who is employed by a manufacturer of backflow equipment and who is restricted to testing and maintaining only that company's product.

77. Courses for the training and certification of testers for backflow preventers are conducted in British Columbia. The program is designed to train personnel for field inspection and periodic testing of backflow-preventer devices.

BACKFLOW DEVICE TEST REPORT

RETURN NO LATER THAN ____________

NAME OF PREMISES ____________

SERVICE ADDRESS ____________

LOCATION OF DEVICE ____________

DEVICE ____________ Manufacturer ____________ Model ____________ Size ____________ Serial No

LINE PRESSURE AT TIME OF TEST ________ kPa

PRESSURE DROP ACROSS FIRST CHECK VALVE ________ kPa

	CHECK VALVE NO. 1	CHECK VALVE NO. 2	DIFFERENTIAL PRESSURE RELIEF VALVE
INITIAL TEST	1 LEAKED ☐ 2 CLOSED TIGHT ☐	1. LEAKED ☐ 2. CLOSED TIGHT ☐	1. OPENED AT ________ kPa REDUCED PRESSURE ☐ 2. DID NOT OPEN ☐
REPAIRS	CLEANED ☐ REPLACED: DISC ☐ SPRING ☐ GUIDE ☐ PIN RETAINER ☐ HINGE PIN ☐ SEAT ☐ DIAPHRAGM ☐ OTHER, DESCRIBE ☐	CLEANED ☐ REPLACED: DISC ☐ SPRING ☐ GUIDE ☐ PIN RETAINER ☐ HINGE PIN ☐ SEAT ☐ DIAPHRAGM ☐ OTHER, DESCRIBE ☐	CLEANED ☐ REPLACED: DISC, UPPER ☐ DISC, LOWER ☐ SPRING ☐ DIAPHRAGM, LARGE UPPER ☐ LOWER ☐ DIAPHRAGM, SMALL UPPER ☐ LOWER ☐ SPACER, LOWER ☐ OTHER, DESCRIBE ☐
FINAL TEST	CLOSED TIGHT ☐	CLOSED TIGHT ☐	OPENED AT ________ kPa REDUCED PRESSURE

REMARKS ____________

THE ABOVE REPORT IS CERTIFIED TO BE TRUE:

INITIAL TEST PERFORMED BY ____________ OF ____________ DATE ____________

REPAIRED BY ____________ DATE ____________

FINAL TEST PERFORMED BY ____________ OF ____________ DATE ____________

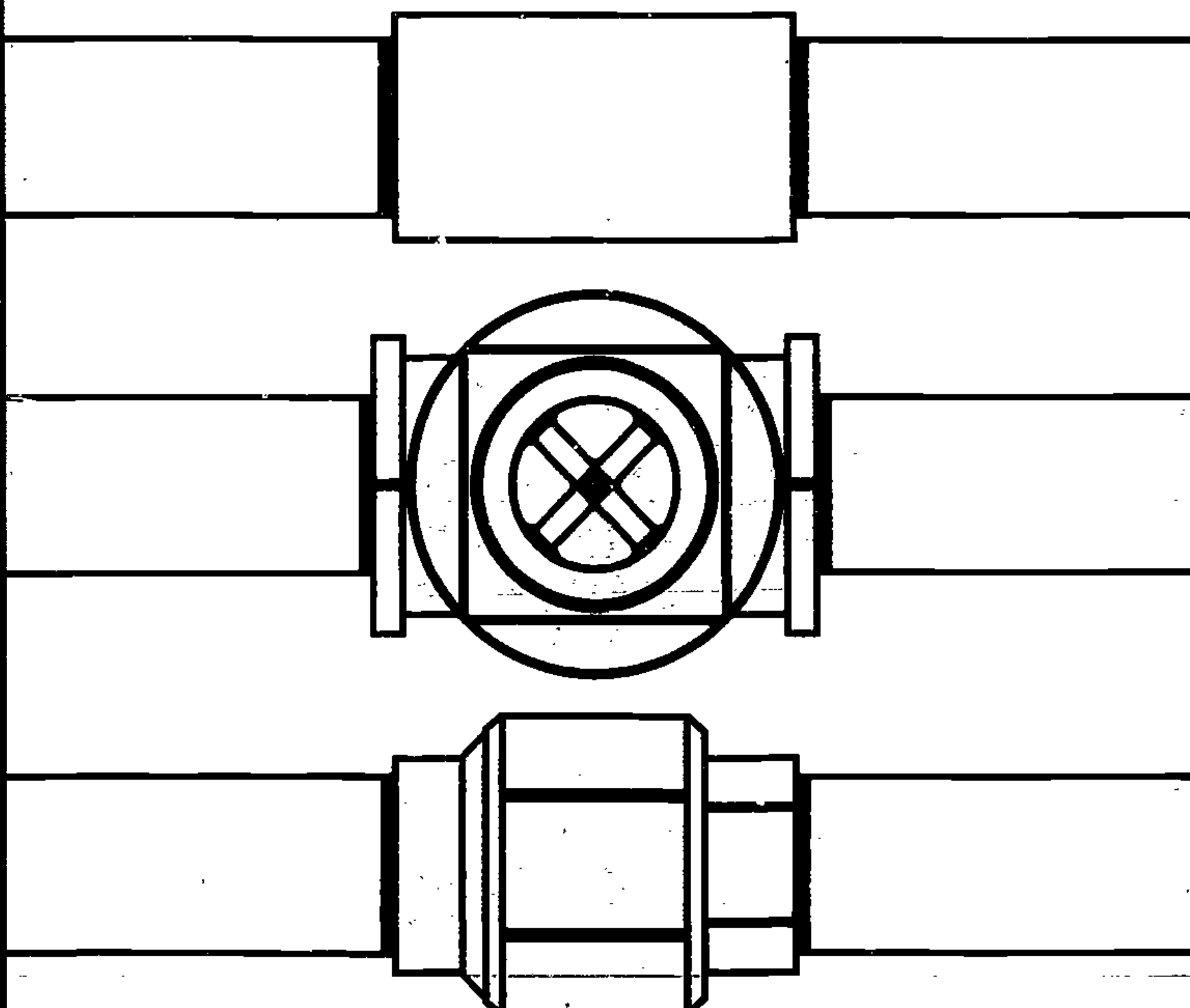
Figure 30-16. Backflow Device Test Report

RECORD OF TESTS AND SERVICES
FOR
CLAYTON MODEL RP REDUCED PRESSURE TYPE BACKFLOW PREVENTERS

Date of Test	Tested By	No. 1 Check Valve		Differential Relief Valve		No. 2 Check Valve	
		OK	Failed	OK	Failed	OK	Failed
If the test indicates failure of any component, repairs must be made immediately and the cause of the failure outlined on the Service Report Form.							

Figure 30-17. Record of Tests and Services

Connecting Hospital Equipment 31



PART 31
CONNECTING HOSPITAL EQUIPMENT

This part of the manual acquaints plumbing students with piping requirements and installation methods that they will encounter in hospital and dental-clinic work.

In addition to having the standard plumbing skills, plumbers must be able to make connections and install piping for oxygen and other gases, air, water, and drainage systems peculiar to the particular area. Sanitation and cleaning requirements are particularly rigid in these areas, hence dangers of cross-connections and contamination are even greater here than elsewhere unless correct initial design is followed by skilled installation and quality control.

Work in these areas is normally done in co-operation with the medical or dental-equipment repair technician, who provides the technical advice on requirements and does the final testing of equipment.

Cross-Connections (General Information)

1. Before covering the specific equipment, a review of some of the basics of cross-connections is in order.

2 A cross-connection is a faulty direct or indirect connection that allows waste, sewage, non-potable water or other liquids and materials, to enter into a potable water supply Direct connections are continuous pipe connections leading non-potable water or other contamination into drinking water. Indirect connections are gaps or air spaces across which, under certain conditions, non-potable water or other contaminants may be sucked or blown into, or otherwise mixed with, the potable water supply.

3 Your awareness of the different types of cross-connections is imperative when installing hospital equipment, such as sterilizers and bedpan washers, to avoid contamination.

Common Types of Cross-Connections

4. The most prevalent types of cross-connections are caused by a submerged orifice on a potable water supply to a fixture, failure to maintain a proper air gap below faucets to a fixture, flexible hoses attached to potable water-supply piping that are long enough to dangle in polluted water, and leaking potable water-supply pipes in the ground near sewer lines.

When a water-supply outlet is located below the flood-level rim of a fixture, the outlet will be submerged when the fixture is filled. This causes a cross-connection between the drainage and the water-supply lines. The contents of the fixture can then be sucked into the potable water line when pressure in the line has decreased below atmospheric pressure. This could occur when a large volume of water is drawn off at a lower point in the building, or when pipes are drained for repair or to prevent freezing. The polluted water can even seep back through a closed faucet if the faucet is leaky, or be drawn up through a hose or spray nozzle submerged in a sink. This reverse flow is called back-siphonage, or backflow. The maintenance of a proper air gap on faucets supplying water to fixtures is essential to prevent cross-connections. (See Part 30, Cross-Connections and Protection Devices.)

Piped Gas Systems for Hospitals

5. The piping of gaseous oxygen is widely accepted in modern hospitals and clinics. Some of its advantages include a need for fewer nursing staff, greater safety due to less frequent handling of cylinders, fewer sprains and strains to medical personnel, space-saving in operating and patient rooms, and less apprehension for the patient who sees a wall outlet instead of the "wheel-in" type of equipment.

6. With the use of anesthetic gases, a gas machine is also used to regulate the flow of gas from a cylinder to the breathing bag. However, there is always the danger that the cylinder could become empty without being noticed immediately; if this occurs the patient could become asphyxiated. Moreover, given the strength-weight factor in handling cylinders, cylinder valves can be knocked off and, with the commonly used 15 MPa contained inside the cylinders, the result is a bottle moving about uncontrolled as if it were jet-propelled.

Commonly Used Gases

a) *Oxygen* — non-flammable, does support combustion. Normal design for 350 kPa at the outlet, with 35 kPa pressure drop,

b) *Nitrous oxide* (laughing gas) — non-flammable, but does support combustion.

c) *Carbon dioxide* — non-flammable and does not support combustion. A normal system delivers 350 kPa at the outlet with maximum pressure loss of 35 kPa in the system.

d) *Ethylene* — highly flammable.

e) *Helium* — non-flammable and does not support combustion.

f) *Cyclopropane* — highly flammable.

Medical Gas Identification

8. When handling the above gases in either a piped system or a cylinder it is important that you observe the following color code:

a) *Oxygen* — Green

b) *Carbon dioxide* — Gray

c) *Nitrous oxide* — Light Blue

d) *Cyclopropane* — Orange

e) *Helium* — Brown

f) *Ethylene* — Red

9. To also prevent casualties caused by the accidental interchange of parts from one gas system to another, the following safety systems have been developed:

a) *Pin Index Safety System*

This system is used to prevent the erroneous interchange of medical gas cylinders with flush-type valves, and is built around the matching of pins and holes. Unless the pins of the equipment line up and enter the two holes drilled in the cylinder valve a connection cannot be made.

b) *Diameter-Index Safety System*

This system was developed by the Compressed Gas Association in order to provide non-interchangeable threaded connections. Diameters differ so that only properly mated parts fit each other.

Codes and Regulations

10. The National Fire Protection Association has prepared two very excellent standards. Although plumbers normally are not too involved in the design, much of the installation data contained in NFPA Standard 56F Non-flammable Medical Gas Systems and NFPA Standard 56G Bulk Oxygen Systems is applicable, and much of the following data derives from these sources.

Warning Systems

11. Operating alarms are fitted to manifold or bulk systems. Alarm signals and pressure gauges are located to ensure continuous, responsible observation. If you are assigned to work on a system so equipped, seek an electrician's help to neutralize the warning devices before commencing work, and to put them back into service after you have completed the repairs.

Pipelines

12. Pipelines must be seamless Type K or L (ASTM B-88) copper tubing. Copper tubing should preferably be hard temper for exposed and concealed locations, and soft temper for underground locations. Pipe sizes must conform to good engineering practice for proper delivery of the specified maximum volumes. Gas piping must not be supported by other piping but with pipe hooks, metal pipe straps, bands, or hangers suitable for the size of pipe, and of proper strength and quality, at proper intervals (so that the piping cannot be accidentally moved from the installed position) as follows:

a) NPS 1½ tubing — every 1.8 m

b) NPS ¾ or NPS 1 tubing — every 2.4 m

c) NPS 1¼ or larger tubing (horizontal) — every 3 m

d) NPS 1¼ or larger tubing (vertical) — every floor level.

13. All fittings for connecting copper tubing must be wrought copper, brass, or bronze fittings made especially for solder or brazed connection.

14. Buried piping must be protected against frost, corrosion, and physical damage. Ducts or casings may be used. Oxygen piping may be placed in the same tunnel, trench, or duct with fuel-gas lines, electrical lines, or steam lines, if they are separated and there is good natural or forced ventilation. Pipelines must not be placed in a tunnel, trench, or duct where they are exposed to contact with oil.

15. Oxygen pipelines located in combustible partitions must be protected against physical damage by being installed within a pipe or conduit. Oxygen risers may be installed in pipe shafts if suitable protection is provided against physical damage, effects of excessive heat, corrosion, or contact with oil. *Oxygen risers must not be located in elevator shafts.*

16. Exposed oxygen pipelines should not be installed in rooms used for storing combustiblo materials, or in kitchens, laundries, and other areas presenting a special hazard. Where installation in such locations is unavoidable, the piping must be protected by an enclosure that will prevent the release of oxygen within the room, should leaks occur in the piping system installed in the enclosure.

17. Protection must be provided for pipelines exposed to physical damage, as might occur during the movement of portable equipment such as carts, stretchers, and trucks in corridors and other locations.

18. The gas content of pipelines must be readily identifiable by appropriate labelling with the name of the gas by means of metal tags, stencil stamping, or adhesive markers, in a manner not easily removable. Labelling must be done on the pipe at intervals of not more than 6 m and at least once in each room and on each storey traversed by the pipeline.

Shut-Off Valves

19. All shut-off valves accessible to other than authorized personnel must be installed in valve boxes with frangible windows large enough to permit manual operation of valves, and labelled in substance as follows:

a) CAUTION! OXYGEN VALVES!
b) DO NOT CLOSE EXCEPT IN EMERGENCY!
c) THIS VALVE CONTROLS OXYGEN SUPPLY TO . . .

20. The main oxygen-supply line must have a shut-off valve readily accessible in an emergency.

21. Each riser supplied from the main line must have a shut-off valve adjacent to the riser connection.

22. If the supply is from outside the hospital, the system should be valved as it first enters the building. There should be no other valves between this point and the branch to the operating rooms. Each operating room should be valved separately, with the valve being located in the corridor outside the operating room Patient areas should be valved at the nursing station controlling the area. In other parts of the hospital, individual areas should be valved separately, with the valve being located near the point of use.

23. Section shut-off valves must be of the packless, diaphragm, double-seating, bronze-bodied type, especially washed for service and installed by means of threaded adapters.

24. Section shut-off valves must be mounted in sectional shut-off valve cabinets located 1.4 m from the floor. The cabinet must be of one-piece drawn 18-gauge steel construction, and so designed that the body of the cabinet may be removed from the wall should it be necessary to service the valve. It must have a 16-gauge polished stainless-steel panel with a door that can be left open as needed.

Service Outlets

25. Wall-type service outlets must be virtually flush with the wall, installed at a centre height of 1.6 m from the floor, and parallel to and flush with the finished wall line. Service outlets must not have threaded connections or threaded parts below the plaster line, since this could result in undetected oxygen leaks. They should be of such a design that should the service valve develop leaks, oxygen would escape into the room and not within a concealed box or within the partition. The service outlets should also be indexed to prevent interchange with other piped services and be of the type that does not require two hands to install or remove secondary equipment.

Each service outlet must be furnished with a cover plate, be delivered completely assembled and pressure-tested, and require no disassembly during installation. It must have a secondary check valve that actuates at the same time as the primary valve and opens and closes each time the outlet is put into use. The secondary check valve must retain pressure if the primary valve is removed, thus making it unnecessary to shut off the entire section when servicing an individual outlet.

26. Service outlets in psychiatric and pediatric areas must accommodate a protection plate that will cover the valve opening and thereby prevent tampering.

27. Ceiling-type outlets for operating rooms must have a male-threaded connection, and the disconnection of the drop-tubing must automatically shut off the flow of gas.

28. There must be a combination multiple outlet station comprising two or more service outlets in any combination of the following services. oxygen, nitrous oxide, vacuum, compressed air, and any other non-combustible gas.

Cleaning

29. Before erecting them, all piping, valves, and fittings — except those supplied by the manufacturer especially prepared for oxygen service and received sealed on the job — must be thoroughly cleaned of oil, grease, and other readily oxidizable materials by washing in a hot solution of sodium carbonate or trisodium phosphate (proportion of 1 kg to 30 L of water). *The use of organic solvents (for example, carbon tetrachloride) is prohibited.* Scrubbing must be employed where necessary to ensure complete cleaning. After being washed, the material must be rinsed thoroughly in clean, hot

water, and particular care must be taken in storing and handling all piping and fittings. They must be temporarily capped or plugged to prevent re-contamination before final assembly. Tools used in cutting or reaming must be kept free from oil or grease, and where such contamination has occurred, they must be re-washed and rinsed.

30. All joints in the piping, except those permitted to be approved brass flared-type gas tubing fittings, and those at valves or at equipment requiring screw connections, must be made with silver brazing alloy or similar high melting point (at least 540°C) brazing metal. Special care must be taken in applying the flux to avoid leaving any excess inside the completed joints. The outside of the tubing and the fittings must be cleaned with hot water after assembly.

31. Screw joints used in shut-off valves, including station outlet valves, must be installed by tinning the male thread with soft solder. Litharge and glycerin, or an approved oxygen luting or sealing compound, are acceptable.

32. After installing the piping, but before installing the outlet valve, the line must be blown clear by means of oil-free dry air or nitrogen.

Testing

33. Before installing service outlets, purge the piping of any accumulation of dust, metal chips, or other foreign matter by blowing it out with water-pumped (oil free) nitrogen or air Be sure all zone valves are open Immediately following the purge, re-cap all line openings

34. *Installing service outlets.* Pressurize the system to 1.0 MPa and check all joints for leaks Use water-pumped (oil-free) nitrogen or air. Maintain pressure and test all joints with soapy water. If leaks are detected, repair the joints and re-test the section Next, perform the following 24-hour standing pressure test: Pressurize the system to 1.0 MPa, seal it, and disconnect the supply Let the system stand for 24 hours and check the line pressure. No pressure drop is allowable except that produced by temperature change.

35. *Installing outlet valves and cover plates* While making the pressure and visual checks, all lines must be checked to ensure that there are no cross-connections that would permit a gas other than indicated on the service outlet from being dispensed from that outlet. To make this check, relieve the pipeline systems to atmospheric pressure and remove all sources of pressure from all systems except the one to be checked. Pressurize the one system only to 350 kPa gauge and, with appropriate adapters matching the outlet labels, check each station outlet of all systems installed to determine that the test gas is being dispensed only from the outlets of this system and that there is no cross-connection to other systems. After making the pressure and visual checks of the first system, remove the source of supply, thus relieving the tested system to atmospheric pressure, and proceed with an identical test of each remaining system.

Design Guidelines for Manifold Room

36. *Location:* Preferably on an outside wall near a loading dock for ventilation and service convenience.

37. *Adjacent Areas:* No door, vent, or other direct communication with anesthetizing location or storage location for combustible agents. If location near a high heat area is unavoidable, sufficient insulation to prevent cylinder overheating is mandatory.

38. *Fire Rating.* The fire-resistance rating of the room must be at least one hour.

39. *Ventilation.* Ventilation to the outside is required.

40. *Security:* The room or area must have a door or gate that can be locked.

Vacuum Systems

41. A central vacuum system is desirable in hospitals — first, to provide the surgeon with continuous removal of fluids from an incision during an operation, second, for post-operative drainage in patient areas, third, in the laboratories for cleaning delicate apparatus and for transferring liquids and gases from one container to another.

42. Vacuum pumping units, usually located in either the basement or the penthouse, provide an uninterrupted suction pressure of from 64 kPa to 85 kPa. Pumping units comprise two vacuum-producer pumps, each being sized to handle the entire (or at least three-fourths) load of the system, and a receiver together with necessary controls. Separate pumping units should be used for the hospital clinical system and the laboratory system.

43. The trend toward central pumped-vacuum systems resulted from the development of an intermittent vacuum regulator. This device cycles the vacuum from a predetermined valve-setting back to atmospheric pressure on terminal devices about every 10 seconds. Consequently, tissue or particles

that might obstruct the operation of a catheter are flushed out during the off-period, and the fluids can drain continuously into the bottle. Because it provides intermittent return to atmospheric pressure, the terminal unit keeps the tubing from clogging with solid particles, thus preventing occlusion damage to tissue areas being drained.

44. If the pumping unit is located in the basement, the horizontal piping from the vacuum drop (the vertical pipe to the room outlet) should pitch downward toward the receiver. If the pumping unit is located in the penthouse, the horizontal branch piping from the vacuum drop should pitch downward toward the vertical riser going to the penthouse so that any liquids entering the system will flow toward the vertical riser Each outlet should be placed in a box, recessed into the wall so that it can be removed, and the vertical drop quickly rodded clean. The exhaust from the vacuum pumps must be piped to the outside.

45. Cleanouts are very important to the piping system. Each connection should be made with a cross rather than a tee, and a removable cap should be placed at the odd opening. Drip pockets should also be provided at the base of each vertical riser.

Alarm Systems: Vacuum

46. An emergency-alarm system must be provided to indicate by audible and visual signals should the vacuum system drop below 27 kPa.

Pipeline Systems: Vacuum

47. Pipelines for vacuum must be similar to those for oxygen, with the following exceptions.

a) Central vacuum systems must not be connected to a sanitary waste system for disposal of patient drainage.
b) Vacuum pipelines must be readily identifiable by appropriate labelling of the word VACUUM.
c) Anti-vibration couplings must be installed between the vacuum pump and the exhaust pipe.

Shut-Off Valves: Vacuum

48. The main vacuum supply line must have a shut-off valve immediately upstream of the receiver on the distribution system side of the receiver, preferably in the same room as the vacuum pumps.

49. Each pump must have a shut-off valve to isolate it from the vacuum system for routine maintenance and repair.

50. Isolation valves to particular areas should be avoided as they create more areas for blockage. Vacuum piping systems can be serviced without shutting down the system.

Washing the Vacuum

51. All pipe, pipe fittings, and valves must be supplied by the manufacturer already washed, de-greased, and sealed. Those not so supplied must be cleaned and de-greased by washing with a hot solution of Oakite No. 24 (tri-sodium phosphate) then thoroughly rinsed with water. Oakite No. 24 solution of 38 g to 50 g of Oakite per litre of water is prepared by mixing one-third of the total volume of water with the total amount of Oakite No. 24 required. When this has dissolved, the remaining water is added. The pipe and fittings must be immersed from five to fifteen minutes or until all deposits are removed. *The use of organic solvents (for example, carbon tetrachloride) is prohibited.*

Blowing Out the Vacuum

52. After installing the piping, but before attaching the vacuum line to the vacuum pumps and before installing the vacuum-alarm switches and service-outlet valves, blow the line clear by means of cylinder water-pumped nitrogen or (oil-free) compressed air.

Testing the Vacuum

53. After installing the service-outlet valves, but before attaching the vacuum line to the vacuum pump and alarm signal-system switches, each section of the piping system must be given a test pressure of 1.0 MPa by means of cylinder water-pumped (oil-free) nitrogen or (oil-free) compressed air. The pressure will be maintained for 24 hours with no allowance for loss except for temperature change. If there is a pressure drop after 24 hours, each joint in the section must be inspected and tested for leaks. After leaks have been repaired, the section must be subjected to another 24-hour test.

Final Test: Vacuum

54. This must be a 24-hour standing pressure test with cylinder water-pumped (oil-free) nitrogen or (oil-free) compressed air at 1.0 MPa to check the completeness of previous joint-pressure tests. After this final pressure test, the system is connected to the vacuum pumps and the alarm-signalling system.

Vacuum System: Good Practice Principles

55. Suction bottles used as a part of patient dispensing equipment should be equipped with an overflow shut-off device to prevent the carry-over of fluids into the piping system.

56. An adequate internal diameter of tubing in all patient suction-dispensing equipment, and in the permanently installed system, is necessary to prevent excessive pressure drop and to provide adequate volume for certain high-flow suction requirements.

57. Flammable solutions, anesthetic gases, and fluids or debris must not be directly introduced into the suction system for disposal.

Vacuum Ratings

58. Vacuum is widely used throughout hospital facilities in patient treatment and in the laboratory. In surgery, it removes fluids from incisions and assists vital post-operative drainage. In the laboratory, it is used to transfer liquids and gases from one container to another. Vacuum systems are designed to provide 64 kPa of mercury at the outlet with a pressure loss of 17 kPa in the system.

59. The rating system for the outlets is different from that for oxygen, in that the outlets in various areas have different flow rates and a diversity of uses.

Compressed Air

60. Compressed air is used primarily in the laboratories and pharmacy. However, the development of new equipment and techniques has expanded its use to areas such as nurseries, delivery rooms, dental rooms, fluoroscopy rooms, lecture rooms, incinerator rooms, and plumbing shops.

61. The piping, valving, and alarm systems for compressed air must be similar to those for vacuum except that isolation valves should be used for specific areas.

62. Equipment necessary to produce the 350 kPa pressure required comprises a duplex compressor and receiver set and the necessary controls. Again, as a means of providing uninterrupted service, two compressors should be installed, each designed to carry the entire load, or at least three-quarters of it.

63. Since most of the outlets require only from 34 5 kPa to 103 kPa pressure, a separate line with a PRV should be used to service them. Outlets requiring higher pressures may be serviced with a separate line from the receiver.

64. In many cases, oil-free air is required, this calls for a specific type of compressor.

Natural Gas

65. Low-pressure natural gas is supplied to hospitals for use in laboratories, kitchens, incinerator rooms, and flame-photometer rooms. The pressure at the meter is 1.5 kPa of water column and the system should be designed to deliver 1 kPa at the fixture.

66. Great care should be taken in the design of the piping system. Pipes should always be pitched, with a dirt pocket at each low point. Vertical risers should also have dirt pockets at their bases. Access panels should be placed for easy cleaning of the dirt pockets. Pipes should never be run in concealed locations where leaks would not be seen, and never under the ground unless placed inside a vented duct. Pipes should not be run in air-handling ducts.

67. Laboratory areas should be valved separately to facilitate shut-downs. The branch to the flame photometer should contain a double check valve to prevent oxygen from entering the gas system.

Hospital Plumbing Fixtures and Equipment

68. Hospital plumbing fixtures are similar to those used in general buildings but with the following main differences:

a) Hospitals use a wide variety of other than hand-operated valves — for example, the elbow-action, knee-action, pedal-operated, and cross-arm types.

b) A greater use of thermostatic mixing valves, which are used to maintain water temperatures within 3°C of any setting and are provided with a protective device to prevent overheating.

c) The addition of special fixtures such as a sitz bath (Figure 31-1), an autopsy table (Figure 31-2), and a combination arm and leg bath (Figure 31-3). In general, the water-supply and drainage piping for hospitals is similar to corresponding components for other buildings. After the installation of water lines, the system must be disinfected.

NOTE: Liaison with the chief surgeon or a delegate is *imperative during* all construction and maintenance work. Proper notification with confirmation at the start of work is the only safeguard for staff and patients. If unable to confirm technical data through hospital staff operating the equipment, check with the closest medical-equipment repair technician. Do not take chances with hospital equipment by experimentation, and *do not attempt to repair equipment after the service connections have been made.*

SPECIAL HOSPITAL EQUIPMENT AND FIXTURES

Sitz Baths

69. Sitz baths are made of vitreous china, vitreous-glazed earthenware, acid-resistant enamelled cast iron, or corrosion-resistant steel. Most are provided with a pop-up waste and overflow waste fitting. (See Figure 31-1.)

Autopsy Tables

70. Autopsy tables are constructed of vitreous-glazed earthenware, acid-resistant enamelled cast iron, or corrosion-resistant steel. The table illustrated in Figure 31-2 is provided with a removable instrument tray and specimen basin. The water supply is provided with a thermostatic mixing valve and a vacuum breaker.

Combination Arm and Leg Baths

71. The typical combination arm and leg bath comprises an oval-shaped, corrosion-resistant stainless-steel tank, electric turbine ejector, dial thermometer, thermostatic water-mixing valve assembly, and a vacuum breaker. The turbine ejector is provided with an aerator and an elevator for lowering and raising. (See Figure 31-3.)

Sterilizers — Connecting Services

72. Because of the multiple systems involved, sterilizers are given the following detailed treatment:

73. Sterilization by moist heat is the method now used in most hospitals for securing the necessary sterile supplies for surgical use. Moist heat is more penetrating than dry heat and kills disease-producing bacteria in a short time without damaging the material being sterilized. It is usually applied in the form of boiling water, free-flowing steam, or steam under pressure. With boiling water or free-flowing steam, a maximum temperature of 100°C can be maintained for any period. Much higher temperatures can easily be obtained by the use of steam under pressure.

74. The degree of heat is dependent upon the pressure that is employed. For example:

Temperature	Pressure
100°C	0 kPa (at sea level)
108°C	35 kPa
121°C	105 kPa
134°C	210 kPa

75. Autoclaves and sterilizers designed to use moist steam as an agent placed under a pressure of 105 kPa to 140 kPa, and using a sterilizing time of 30 minutes, will effectively kill the most resistant forms of pathogenic spore-forming bacteria.

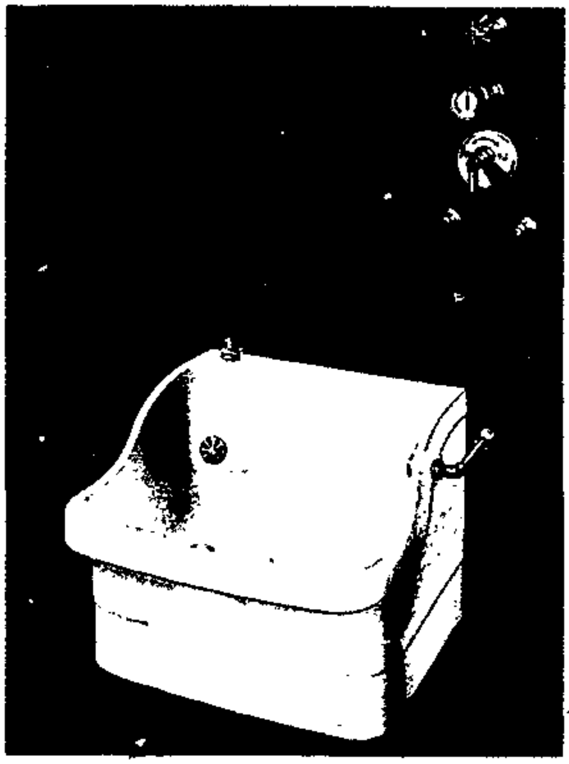


Figure 31-1. Sitz Bath

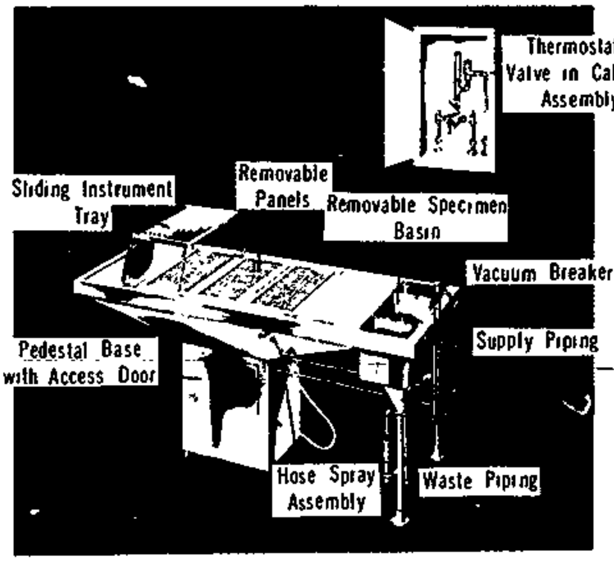


Figure 31-2. Autopsy Table

Principles of Operation

76. All air must be removed from the sterilizing chamber before a thorough penetration of the material by the steam can be obtained. This fundamental property of matter must be considered: No two substances — whether solids, liquids, or gases — can occupy the same space at the same time. For example, when a package of material is prepared for sterilization it is filled with air. This air must be removed before the steam, even under pressure, can occupy its place and penetrate to the centre of the package.

77. To remove the air, high-pressure sterilizers are equipped with an air and condensation ejector. The air in the chamber of an autoclave is relatively cool and more than twice as heavy as steam at the normal operating range. Steam forced into the chamber rises to the top, compressing the air to the bottom. The air and condensate ejector (thermostatic steam trap) is mounted in a line running from the bottom of the chamber and automatically ejects the air.

78. Air in the sterilizing chamber will also affect the maximum temperature obtained in the chamber. It will prevent the temperature from reaching the degree of heat that corresponds to the steam pressure indicated. Dalton's law in physics states that when air and steam occupy the same closet vessel, the total pressure in the vessel is equal to the sum of the partial pressures of both the steam and air present, and that the temperature in the vessel will correspond only to the partial pressure of the steam.

79. Experiments by the University of Wisconsin demonstrated that if air was not removed from a sterilizing chamber and steam allowed to enter until a pressure of 124 kPa was built up, then 41 kPa of that pressure was caused by the air in the chamber. The maximum temperature possible in the chamber was based on only the 83 kPa of steam pressure, or approximately 117°C instead of the expected 124°C.

80. Several methods may be used to determine if the steam has thoroughly penetrated the dressings. One common method uses a small pellet of fusible material enclosed in a small glass tube. The pellet melts and changes color at a temperature sufficiently high to kill all pathogenic spore-forming bacteria. The tube should be placed in the centre of the largest package in the sterilizer chamber. If the pellet has melted when the package is opened at the end of the sterilization period, this is reliable evidence of sufficient steam penetration.

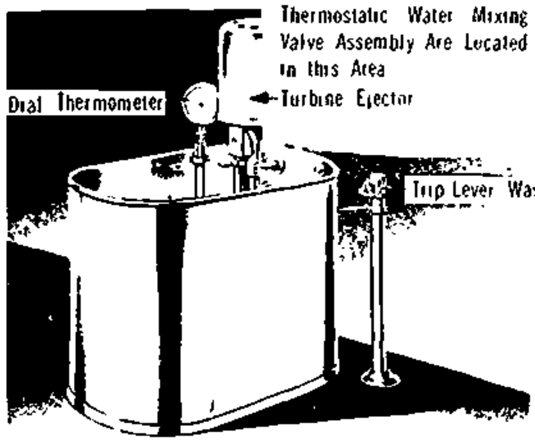


Figure 31-3. Combination Arm and Leg Bath

81. Although materials such as dressings, bandages, sponges, instruments, utensils, and water, as well as solutions, may be sterilized in an autoclave, the steam-under-pressure method of sterilization is considered the best technique and should be used when possible. However, under certain circumstances such equipment may be inconvenient to use or not available to sterilize needles, syringes, instruments, and utensils. In which case, the boiling-water method is used; that is, the items are submerged in boiling water for a specific period The apparatus used for this purpose is known as a non-pressure instrument and utensil sanitizer.

Until recently, this type of apparatus was referred to as a boiling-type "sterilizer" but the term now used is "sanitizer." This change in terminology was due to the fact that spore-forming bacteria are not destroyed in the boiling-water process

82. To ensure maximum results by the boiling-water method, it is of upmost importance that items be completely submerged in the water and remain there for at least 20 minutes. Needles, syringes, instruments, and utensils offer only plane surfaces to the sterilizing medium, so there is no problem of penetration. This, together with the moisture factor (obtained by having the items submerged), makes satisfactory sanitization possible.

Types of Sterilizers and Sanitizers

83. *Pressure.* Autoclaves, or instrument and dressing sterilizers, employ the steam-under-pressure sterilization technique. These are used extensively in military medical-treatment facilities.

84 *Non-pressure* Boiling-water (non-pressure) type sanitizers are further identified as small portable-office instrument sanitizers and installed utensil sanitizers. Both units basically consist of a boiler or container equipped with a cover that is not airtight, and a heat source to heat the boiler or container.

85. The portable-office instrument sanitizer may be either electrically or fuel heated. The boiler is filled by pouring water into it and drained by means of a valve at the bottom. The electrically heated models are equipped with automatic controls to reduce the heat when the water reaches the boiling point and to de-energize the unit should the boiler boil dry.

86. Utensil sanitizers are normally installed and connected to the water-supply and waste lines. An air gap is present between the water-supply valve and the boiler inlet to prevent contaminated water from being sucked back into the water-supply line should a vacuum be created at the valve. Likewise, an air gap is provided between the drain valve and the waste line to prevent polluted water from reentering the boiler. The water inlet to the boiler has a safety feature to prevent any leakage from the water-supply valve from entering the boiler during the sanitization cycle. If even a small amount of water was permitted to enter the boiling chamber during the timed sanitization cycle, the utensils would still be contaminated at the end of that cycle.

87. Various methods are used to prevent excessive steam from being released into the room. Some units employ a condensing chamber with cold water flowing through it, and when the steam comes into contact with the cold water it is condensed and the condensate is drained into the waste line. Some units vent to the atmosphere. Still, other units are used with an automatic control that reduces the heat when excessive steam is present.

88. Utensil sanitizers may be electrically or steam heated. The electrically heated units are usually equipped with automatic temperature-operated switches for excessive steam control and to de-energize the unit should the boiler boil dry. Steam-heated units utilize the building or installation steam system. A coil located in the bottom of the boiler is connected to the building steam system through a pressure-regulator valve and a thermostatic steam trap. Between 280 kPa and 420 kPa of steam pressure is required for efficient operation.

89. *Pressure-type* dressing sterilizers, or autoclaves, have a chamber where material is subjected to steam under pressure. Numerous regulating and safety devices are employed to provide the various techniques necessary for proper sterilization. Some units utilize a sub-boiler or generator where the steam necessary for operation is generated by the application of electric or fuel heat. Other units use the steam system of either the building or the installation.

90. Regardless of steam source, all dressing sterilizers must have essentially the same capability for efficient operation. Each must include a chamber capable of withstanding the required pressure, a method of removing air from the chamber, a system for exhausting steam from the chamber upon completion of the sterilization period, a method whereby a vacuum may be drawn in the chamber, and a system that will permit drying at the end of the sterilization cycle.

91. To understand the operation of dressing sterilizers, you must be familiar with the following components that are used to provide the required capabilities.

92. *Operating Valves.* (Refer to the accompanying appendix.) The operating valve used on most sterilizers is similar to the one shown in Figure 31-7. This type is commonly referred to as a globe valve. It may be of varying size and shape, but operates on the same principle. It may be used to control the steam supply, water supply, exhaust system, etc. The moving parts of an operating valve consist of a valve stem (see component 5), with a disc holder (7), and a disc (8) on one end. Turning the valve knob (1) clockwise forces the valve disc (8) onto the valve seat (9) to stop the flow through the valve. When the valve stem is turned counter-clockwise (opened) all the way, the cone-shaped portion of the stem (11) contacts the backseat (12), which is part of the valve bonnet (6), thus preventing pressure from being applied to the packing (4) when the valve is fully opened. This is why operating instructions for equipment using this type of valve specify that the valve be fully opened.

93. *Automatic Control Valve.* (Refer to Figure 31-8 in the accompanying appendix.) The automatic control valve is installed on the steam supply line and is the last valve through which steam passes before entering the autoclave. This valve may be set to maintain any predetermined pressure in the autoclave. With this valve, a higher pressure for sterilizing dressings and a lower pressure for sterilizing rubber goods and other material may be obtained. The maximum differential between the high and low limit is approximately 140 kPa. Any

desired pressure within these limits may be obtained. Owing to the wide variations in steam pressures at various installations, the valve must be set *after* the sterilizer has been installed.

94. The control valve is designed for a maximum pressure of 480 kPa on the steam supply line. A higher pressure will soon destroy the valve seats and bellows. If the steam supply line exceeds 450 kPa pressure at the sterilizer, a pressure-reducing valve should be installed.

95. The automatic control valve consists of a quick-opening packless valve. This valve is operated by a diaphragm that expands or contracts in proportion to the pressure in the sterilizer. The expansion of the diaphragm is governed by a heavy-compression spring. As the pressure in the sterilizer lowers, the diaphragm contracts, opening the valve and admitting more steam. When properly adjusted, the control valve admits the correct amount of steam to maintain a constant steam pressure in the sterilizer. From the control valve, the steam flows directly into a jacket surrounding the sterilizing chamber. From this point, the steam is further controlled by the operating valve.

96. *Check Valves.* (Refer to Figure 31-9 in the accompanying appendix.) Check valves are used in piping systems to permit flow in one direction but to prevent flow in the reverse direction. They may be used in gas or fluid systems, such as the steam and water systems of sterilizers. When the flow is in the forward direction, the fluid or air causes the valve disc (8) and its holder (7) to swing in the direction of flow, thus opening the valve. When the flow tends to go in reverse, the valve disc is pressed against its seat (22), thus closing the valve to prevent any flow in that direction.

97. *Safety Valves.* (Refer to Figure 31-10 in the accompanying appendix.) The safety valve is usually installed on top of the sterilizer and connected directly to the chamber jacket. If the pressure in the autoclave exceeds the pressure exerted by the compression spring (26), the valve will open and permit the steam to escape into the atmosphere. The safety valve is set to "pop off" between 150 and 170 kPa on a sterilizer operating at 140 kPa. On high-speed autoclaves operating at 190 kPa pressure, the safety valve is set to release at between 200 and 207 kPa.

98. *Thermostatic Steam Trap.* (Refer to Figure 31-11 in the accompanying appendix.) Thermostatic steam traps are installed in steam lines of sterilizers to allow air and water to be expelled from the system. The trap consists of a body (38), a valve operated by an expansion bellows (37), and a cover (21). When the trap is cold the valve is open, permitting air or water to flow through it and into the drain system. Steam passing through the trap heats the expansion bellows, which expands and closes the valve. The closed valve restricts the flow of steam and causes a pressure to build up in the sterilizer.

99. During the sterilization cycle, some steam condenses into water and drains, by gravity, into the thermostatic steam trap. This condensate is cooler than steam and causes the bellows to contract and open the valve. The condensate and a small amount of steam now pass through the trap until the steam again heats the bellows, thus closing the valve. This action continues throughout the sterilization cycle.

100. *Gauges.* Gauges used on sterilizers are standard Bourdon pressure and compound types. The compound type indicates both pressure and vacuum. Pressure enters the gauge through a pipe connection and passes into the Bourdon tubing, which is circular and sealed at one end. This tubing is designed to straighten when subjected to positive pressure, and to coil when subjected to negative pressure. The motion of the Bourdon tubing is transmitted to a pointer and amplified through a movement link assembly. Except for occasional retesting for accuracy, these gauges normally require no servicing.

101. *Vacuum Dryer.* (Refer to Figure 31-12 in the accompanying appendix.) The vacuum dryer is designed to aid the drying process of sterilization by allowing air to enter the chamber and replace the steam. Before entering the chamber, the air is filtered through tightly compressed monel wool to remove foreign matter. A ball-type check valve prevents loss of steam during normal sterilization.

102. *Thermometer.* A thermometer is always found on a pressure sterilizer. It is usually a Bourdon-type gauge that is calibrated to register temperatures from 30°C to 150°C. It is located in the chamber evacuation (condensate) line because this is the coolest point in the sterilizing chamber.

103. *Steam Strainers:* (Refer to Figure 31-13 in the accompanying appendix.) The steam strainer is installed on the incoming steam-supply line to remove any foreign materials in the steam supply. It has a strainer (42) that can be removed and cleaned.

Equipment Operation From Central Steam-Supply Systems

104. The larger sterilizers and sanitizers in fixed hospitals are usually operated from a central steam-supply system. Mobile and field medical units usually use electricity or gasoline burners as a heat source to generate steam for sterilizer operation. Basic information regarding these follows, and electrically heated units are discussed in detail later.

105. *Sanitizers.* Figure 31-14 identifies components of the heating system in a boiling-type sanitizer. The heating coil is in the bottom of the boiler or body. Instruments or utensils are placed in the sanitizer and covered with water. The steam in the coil is used to heat the water to the boiling point. This is one of the significant differences between steam-heated boiling-type sanitizers and autoclaves, or sterilizers. In steam-operated sterilizers, the steam is admitted to the sterilizing chamber.

106. The purpose and operation of the thermostatic steam traps (TST) and the steam-supply valve are as already described. However, operation of the pressure regulator is slightly different from that of the one in Figure 31-8. Instead of regulated steam pressure being applied to the diaphragm, pressure in the assembly of thermobulb and capillary tubing is applied to the diaphragm. The thermobulb, capillary tubing, and diaphragm are filled with a volatile liquid or gas. When the bulb is heated, the liquid or gas expands and exerts pressure on the diaphragm to close the regulator valve. The thermobulb is located at a vent on the unit so that steam from the boiling water flows around it. This results in the regulator valve closing when a small amount of steam is present.

To keep the water in the sanitizer at boiling temperature, a certain amount of steam must be permitted to pass through the valve and through the steam coil. For this purpose there is an adjusting screw on the bottom of the valve that can be screwed against the valve disc to hold the disc off the seat. Thus, by adjusting the screw, a larger or smaller opening can be made for the passage of steam. To increase the amount of steam flowing through the valve, the screw is turned clockwise. If steam leaks around the adjusting screw, tightening the packing nut should correct the leak. This control system, in preventing excessive boiling, keeps the steam that is released to the room air at a minimum. One manufacturer calls this control an Excess Vapor Control Valve.

107. *Sterilizers.* Figures 31-15 and 31-16 in the accompanying appendix provide diagrammatic drawings of the components and connection for a sterilizer operated from a central steam-supply system. The operation of the major components already has been explained. The diagrams in the figures should be studied while your instructor expands upon the various operating principles.

Sanitary Protection of Sterilizer Connections

108. *Water Connections.* When a water line feeding various fixtures in a building is drained, or if too many outlets at lower levels are opened at the same time, a degree of vacuum will exist in the supply line. This is demonstrated in a home when the water-supply line is shut off to make repairs and faucets are opened to relieve the back-pressure or vacuum. The degree of vacuum — that is, the tendency to draw impurities that may seriously pollute the water-supply system into the supply line — is not generally understood. For example, when a 6 m vertical riser of NPS 1 pipe is filled with water and its upper end is closed with a vacuum gauge, drainage of the water causes a vacuum of 50 kPa.

109. When this occurs, if a fixture such as a bedpan washer contains polluted material above the level of an open water inlet, the polluted material will be drawn into the water line. Even if the water level in the fixture is slightly below the water inlet, there is the danger of lifting the polluted water into the supply line if provision to prevent it has not been made.

110. A 50 kPa vacuum in NPS ½ pipe suspended vertically above a surface of water will cause the water to jump a clear air gap of 25 mm. Upon this little-known fact rests the need for much greater protection of water-supply lines than is often provided.

111. Tests were conducted, as indicated in Figure 31-4, in which were noted the minimum vertical air gaps through which water could not be drawn under various degrees of vacuum. Tests were made with 17, 34, 51, and 59 kPa of vacuum as indicated by the dots on the graph, and in each case a 1.6 mm reduction in air gap permitted water to jump the gap.

112. Check valves will not adequately serve the purpose because they often do not provide a complete seal and therefore are not permitted by exacting codes. Safe protection, which is simple and free from failure, lies in the provision of an ample air break in the piping above the fixture. Properly designed and applied, it gives permanent protection. Under vacuum, it vents the supply line so that

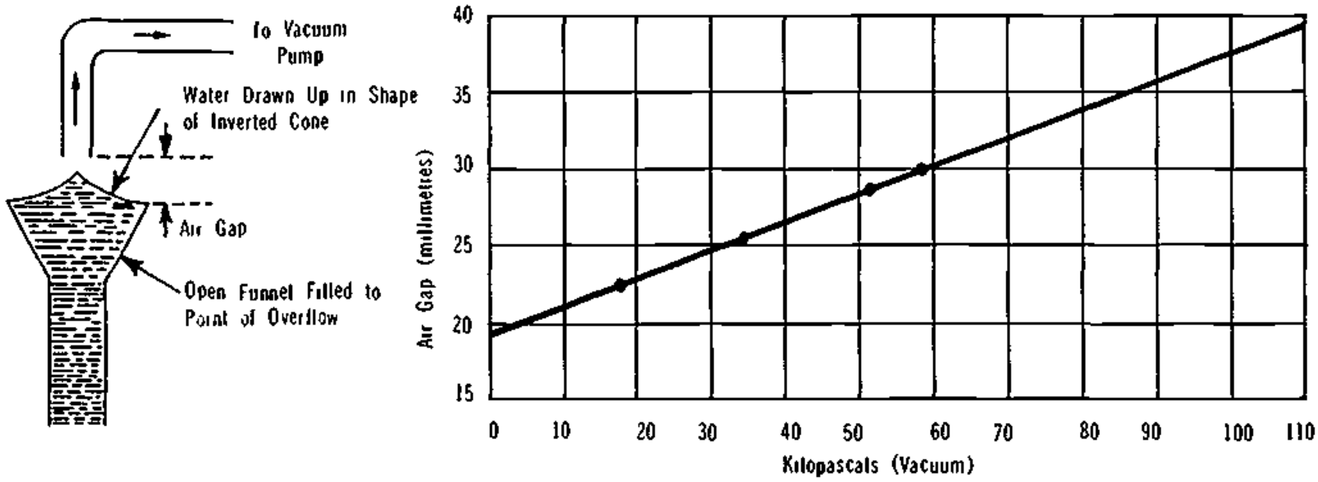


Figure 31-4. Minimum Vertical Air Gaps Unable to Draw Water Under Vacuum

no lifting effort is exerted that might withdraw polluted matter from the fixture. The area of the air break is several times that of the water connection to it. Figure 31-5 illustrates one type of air break. Note that it is part of the construction of the unit.

113. *Waste Connections.* Every waste line is subject to clogging, and this is notably true of older installations in which much smaller piping was employed than is permitted by present standards. Some outfits of surgical sterilizers are still in use in which waste lines are no larger than NPS ½, or NPS ¾. With such connections, sterilizers may easily create enough back-pressure to cause waste material to back up into other units.

114. The waste line should be NPS 1½ and be protected by a funnel break below the sterilizer. Figure 31-5 also illustrates the functioning of the bleeder line, which conducts leakage from the water-filling valve direct to the waste system rather than to the sterilizer.

115. *Connections for Pressure-Steam Sterilizers.* Typical atmospheric exhaust and waste connections for pressure sterilizers are shown in Figure 31-6.

116. The steam-exhaust connection from the top operating valve, and the exhaust from the chamber drain that carries considerable vapor, are both discharged into a common atmospheric vent riser never smaller than NPS 1. The bottom of this common vent riser is drained through an open air-break funnel to the waste. Arrows show the normal movement of steam and air through the sterilizing chamber. (See Figure 31-6.)

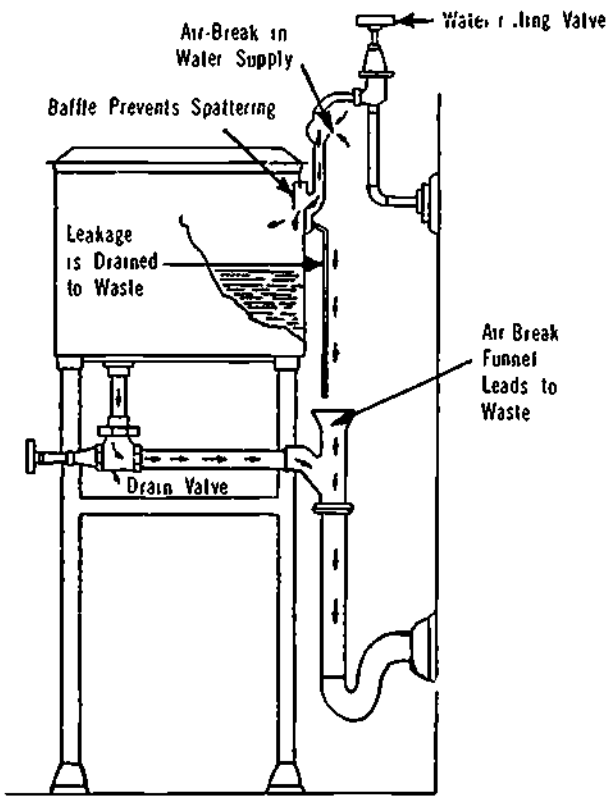


Figure 31-5. Air Break Built Into Unit

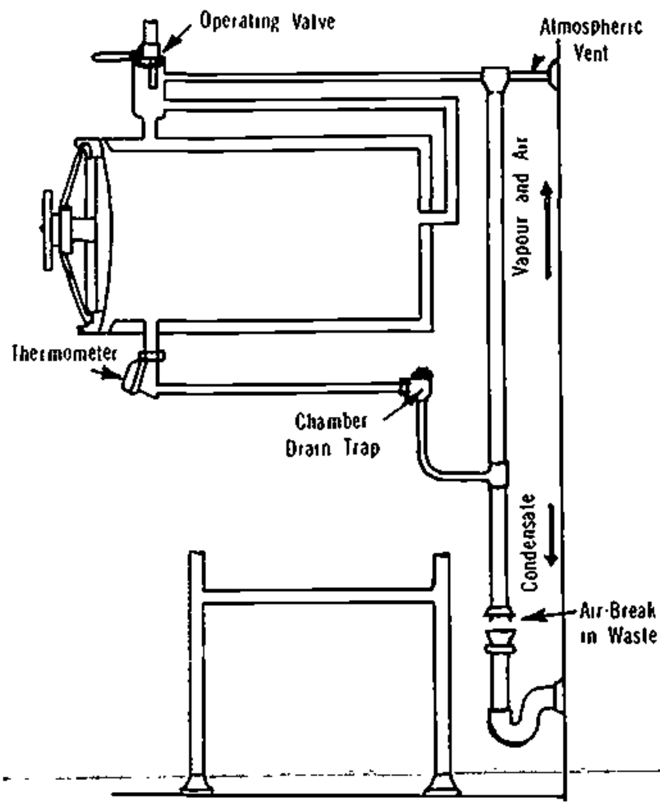


Figure 31-6. Typical Layout for Pressure Sterilizers

117. Even when waste lines are of normal size, there is still the possibility of interruption from some source to free drainage, and no surgical sterilizer should be considered as being protected against pollution from the waste unless it has a properly proportioned open air-break between the sterilizer outlet and the waste trap. With such an air-break, back-pressure will permit polluted material to escape to the floor but the sterilizer will be protected. When the waste line is of adequate size there is little danger of overflow.

118. For non-pressure units, the air gap between the waste outlet and the top of the funnel need not be greater than 6 mm, assuming that the funnel is located below the bottom of the sanitizer. This is true because it is impossible to create any vacuum in such units that might cause waste material, backed up to the point of overflow, to be drawn into the sterilizer. On the contrary, every pressure sterilizer is normally or abnormally subject to vacuum of from 35 to 70 kPa or more. Should a drainage valve leak under vacuum (and they often do leak), the protective air-break in the waste must guard against lifting the water from the level of the funnel top through the gap to the sterilizer.

119. *Atmospheric Vents.* Condensate is created in every vent riser as steam is discharged from the sterilizer, and it is important to prevent its conduction back into sterilizers. Sterilizer atmospheric vents should include an amply sized drain leading from the vent fitting to an air-break waste outlet.

120. The failure of atmospheric vents to protect against voluminous discharge of vapor into rooms can nearly always be attributed to improper vent risers. The riser must be free from long horizontal runs that retard the free passage of vapor. The best riser or atmospheric vent would be one that is installed vertically through the roof; however, this is seldom practical and a compromise is made. When it is necessary to install the vent pipe horizontally through the outside wall, it should be kept as short as possible. For pressure sterilizers, the vent should be NPS 1.

121. *Condenser Vents.* Condenser vents serve the same purpose as do atmospheric vents. Instead of venting excess steam to the outside, they condense the steam then allow it to drain into the waste lines.

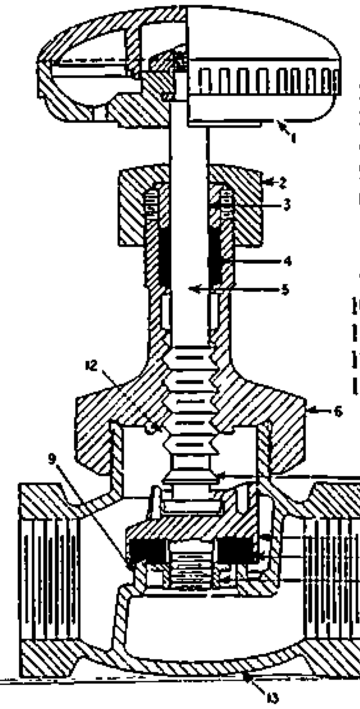
122. The condenser vent consists of a condensing chamber attached to the vent outlet from the sterilizer or sanitizer, through which excess steam is drawn by slight suction created by a small stream of water discharged through a venturi tube. Excess steam is condensed and carried to the waste through a suitably large connection.

123. Properly applied condensers will vent non-pressure sanitizers more effectively than the average atmospheric vent because few atmospheric vents have free access to the atmosphere except through restrictions in the form of horizontal runs that impair the intended natural pull-of-the-chimney effect. Thus condenser vents have largely replaced the atmospheric type.

124. The greatest objection to the use of condenser vents once was that operators would forget to open the condensing water valve, thus filling rooms with steam. This problem was solved by an automatic control that turns the condensing water on and off as the heat is turned on and off.

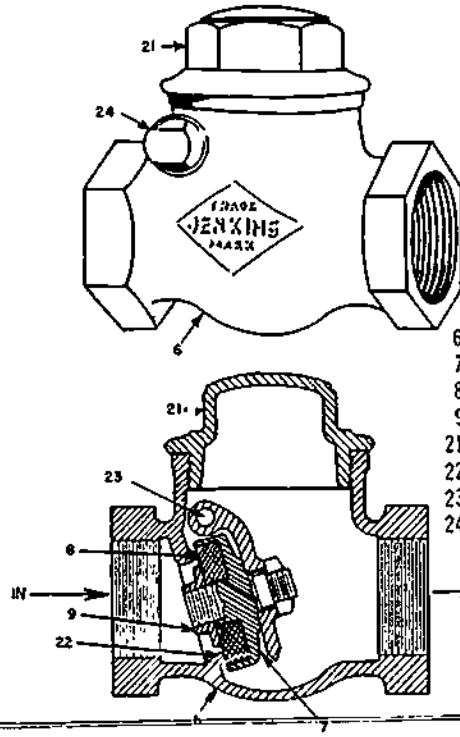
125. Condenser vents on non-pressure units utilize the same air-break protection for the water inlet as that used for filling the chamber with water.

126. The following appendix shows components, schematics, and specialized hospital equipment.



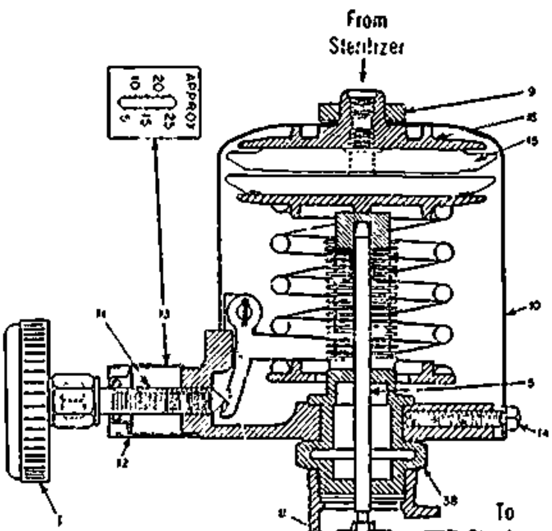
1. Knob
2. Packing Nut
3. Packing Gland
4 Packing
5 Valve Stem
6. Valve Bonnet
7. Valve-Disc Holder
8. Valve Disc
9. Valve Seat
10. Nut
11. Cone
12. Backseat
13. Housing

Figure 31-7. Manually Operated Globe Valve



6. Valve Bonnet
7 Valve-Disc Holder
8. Valve Disc
9 Nut
21 Cap
22. Valve Seat
23. Pivot Pin
24 Pivot-Pin Retainer Nut

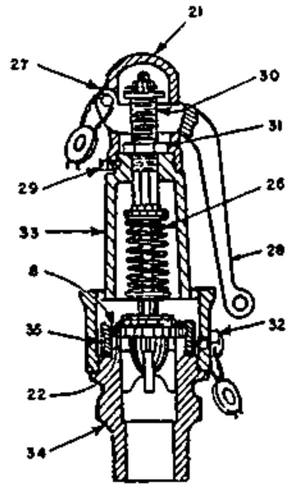
Figure 31-9. Check Valve



Steam
Supply

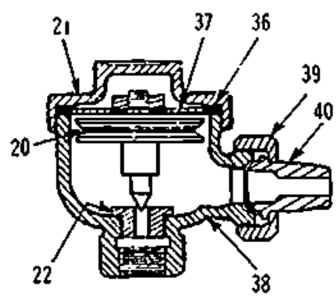
1 Knob
5 Valve Stem
8 Valve Disc
9 Nut
10 Cover
11 Pressure Adjustment Screw
12 Indicator Collar
13 Pressure-Adjustment Scale
14 Set Screw
15 Diaphragm
16 Top Plate
38 Housing

Figure 31-8. Automatic Control Valve



8 Valve Disc
21 Cap
22 Valve Seat
26 Compression Spring
27 Cross Pin
28 Lever
29 Set Screw
30 Adjustment Screw
31 Locking Nut
32 Set Screw
33 Upper Shell
34 Lower Shell
35 Ring Nut

Figure 31-10. Safety Valve



20. Bellows
21 Cap
22 Valve Seat
36 Gasket
37 Diaphragm Assembly
38 Housing
39 Union Nut
40 Union Nipple

Figure 31-11. Thermostatic Steam Trap

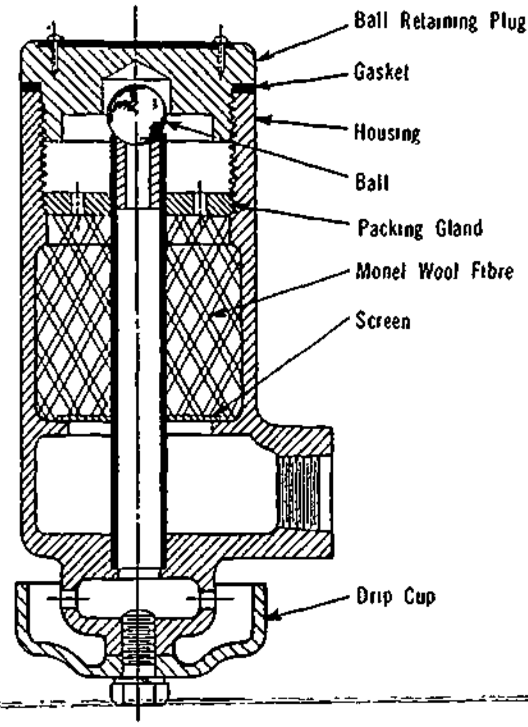


Figure 31-12. Vacuum Dryer

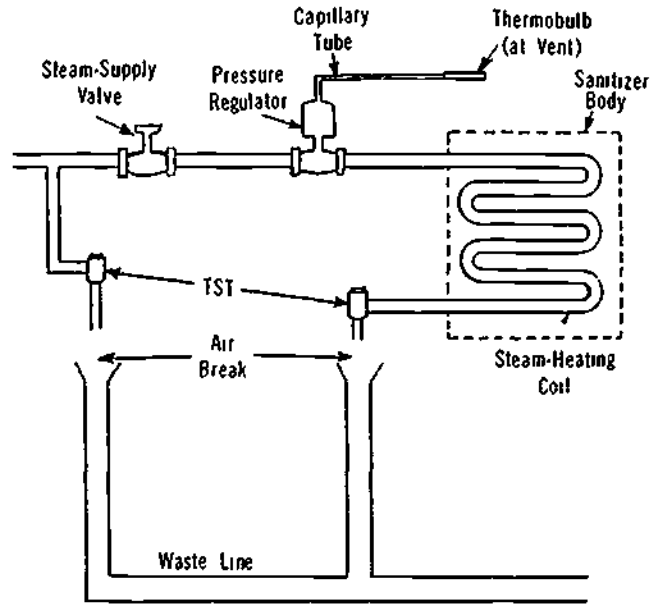


Figure 31-14. Steam-Heated Utensil Sanitizer

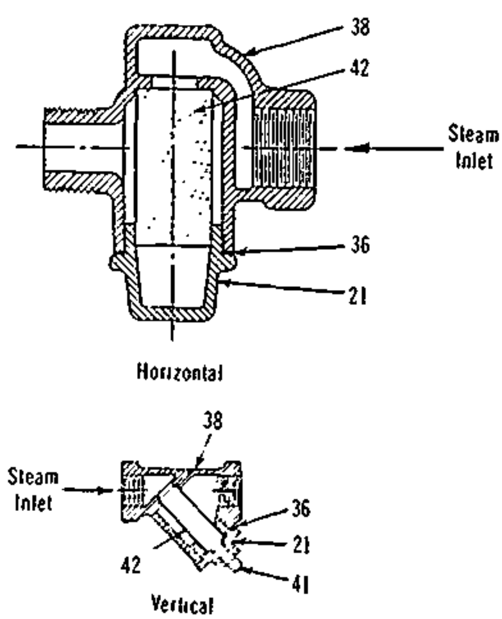
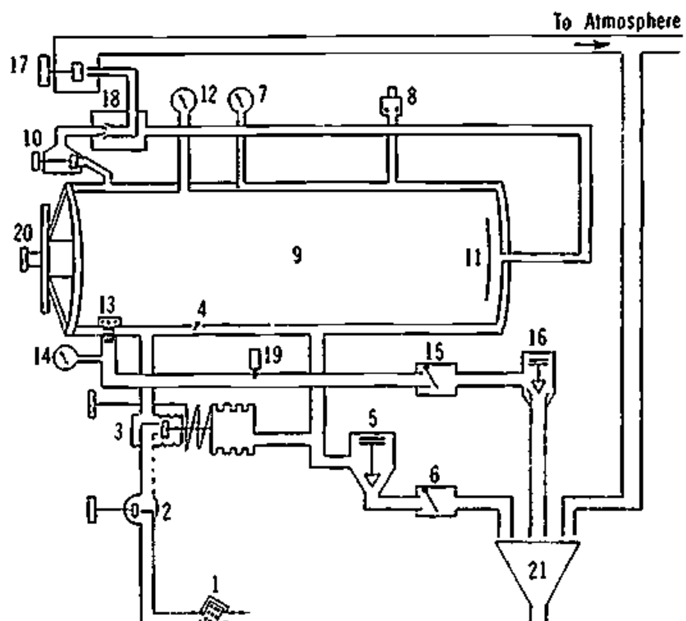


Figure 31-13. Steam Strainers



1 Strainer
2 Steam-Supply Valve
3 Pressure Regulator
4 Jacket
5 Jacket Steam Trap
6 Check Valve
7 Jacket Pressure Gauge
8 Pop off Valve
9 Chamber
10 Steam in Chamber Valve
11 baffle
12 Chamber Pressure Vacuum Gauge
13 Strainer
14 Thermometer
15 Check Valve
16 Chamber Steam Trap
17 Exhaust Valve
18 Venturi
19 Air Filter
20 Door Lock Mechanism
21 Waste Funnel

Figure 31-15. Sterilizer Schematic

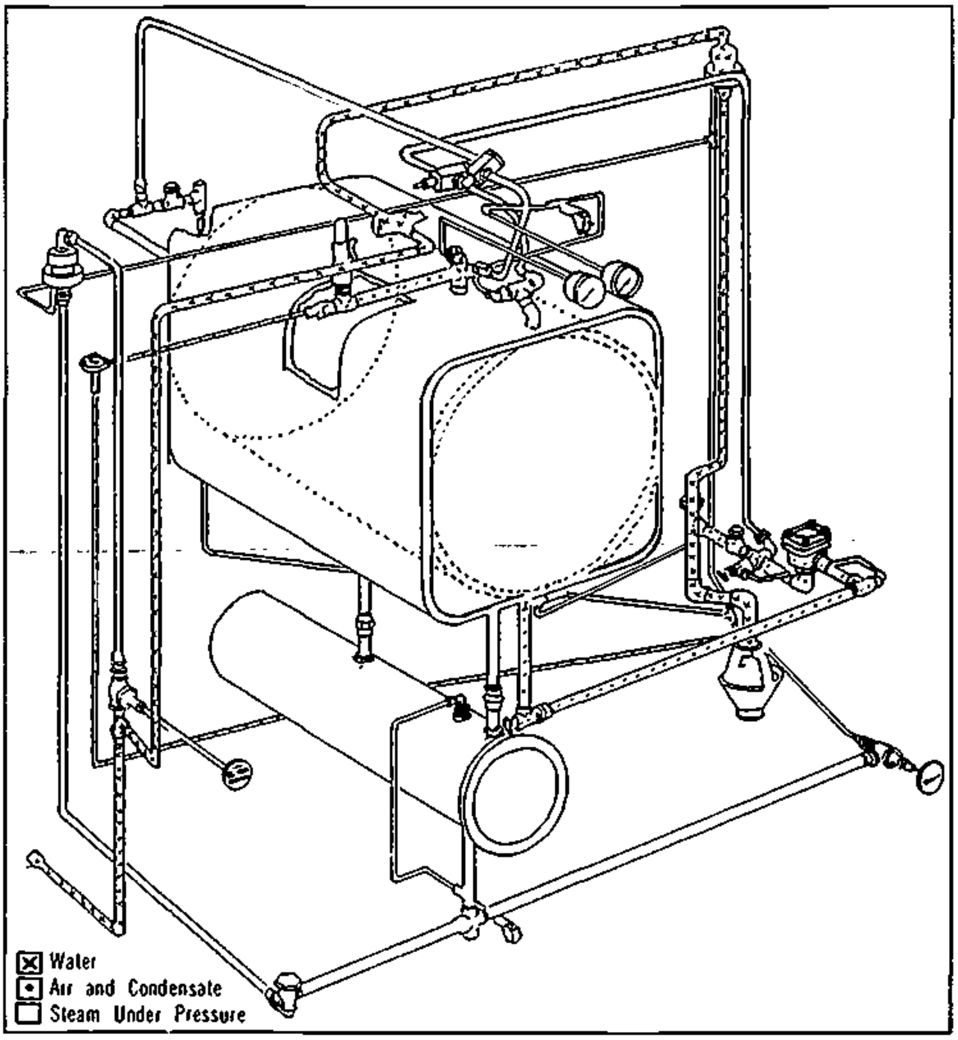


Figure 31-16. Sterilizer at "Sterilize" Position

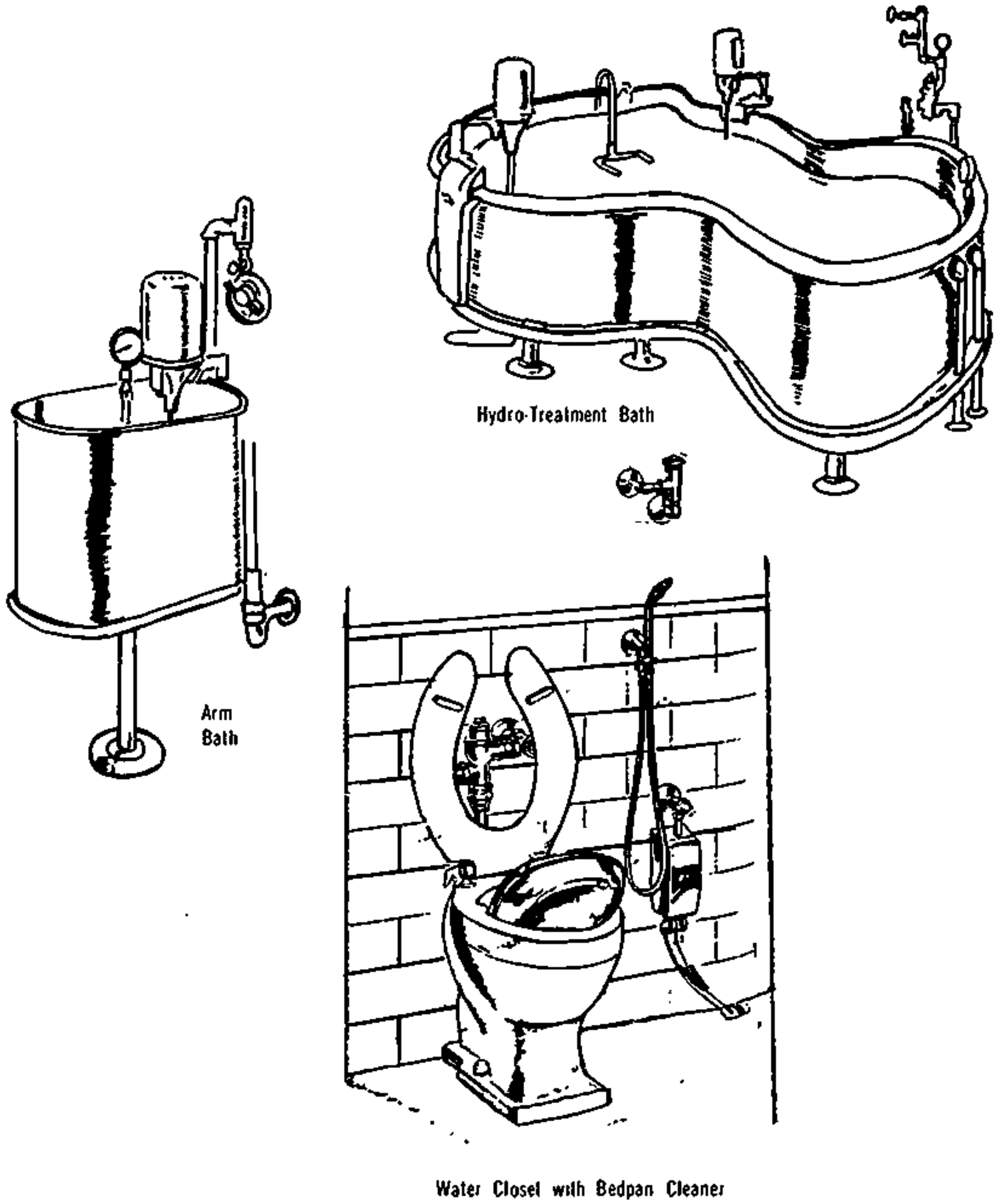
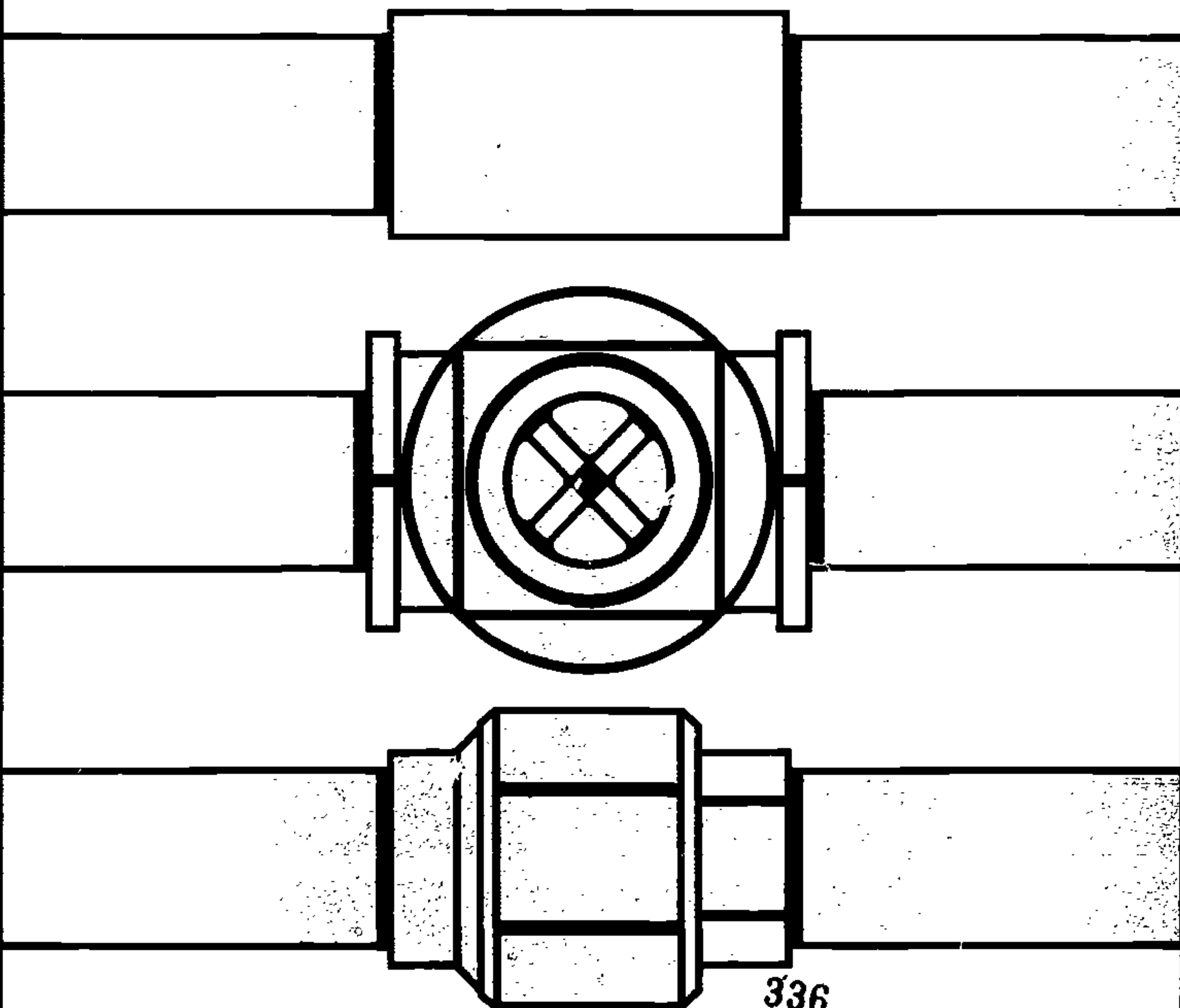


Figure 31-17. Other Types of Special Hospital Fixtures

Compressed-Air Systems 32



PART 32
COMPRESSED-AIR SYSTEMS

1. Compressed-air systems are used for special applications in hangars, hospitals, automobile repair shops, dental clinics, and various types of workshops to operate power-pneumatic tools, dentists' drills, cleaning equipment, and pneumatic controls.

The air is compressed in an electric, gasoline, or diesel-driven compressor and stored into a receiver (tank) until needed. Air is drawn into the compressor where it is reduced in volume and passed through a check valve into the storage receiver. Controls may be of an individual, automatic start-stop type with safety valve, constant-speed control, or dual control, depending on the application.

A regular start-stop control, which is the most commonly used, regulates the operation of the compressor and power unit, and when the volume of air stored in the tank reaches the desired pressure the compressor automatically shuts off. If the pressure-control valve fails to operate, the safety valve automatically relieves the pressure on the tank, preventing it from exploding. In some cases, compressed air is drawn from the tank, when needed, through a reducing valve.

The compressor equipment is usually housed in one centralized location. However, if the piping costs for the distribution of air to the required locations and the pressure-line loss from one source are excessive, two or more compressor units located near the specific load centres may be more economical and efficient.

Types of Compressors

2. Air compressors used in compressed-air systems are generally of the rotary-liquid type or the single-stage or two-stage piston type. The piston may be either the air-cooled or the water-cooled type. Compressors used in hospitals and similar establishments are sometimes an oil-free type. Each compressor is provided with an intake air filter that should be of a type that will also muffle the intake noises.

a) Rotary Liquid-Type Air Compressor

This type of compressor consists of a multi-bladed rotor that revolves in a casing partly filled with liquid and acts as a piston. The motor and compressor may be direct-connected or operated by a v-belt.

b) Piston-Type Air Compressor

This type of compressor (see Figures 32-1 and 32-2) has operating parts of a principle similar to that of a conventional gasoline-operated motor utilizing a crankshaft, pistons, and cylinders. In the two-stage piston type, the compression takes place in two distinct steps in separate cylinders. The finned cylinders are a quick means of distinguishing the air-cooled type from the water-cooled type shown in Figure 32-3.

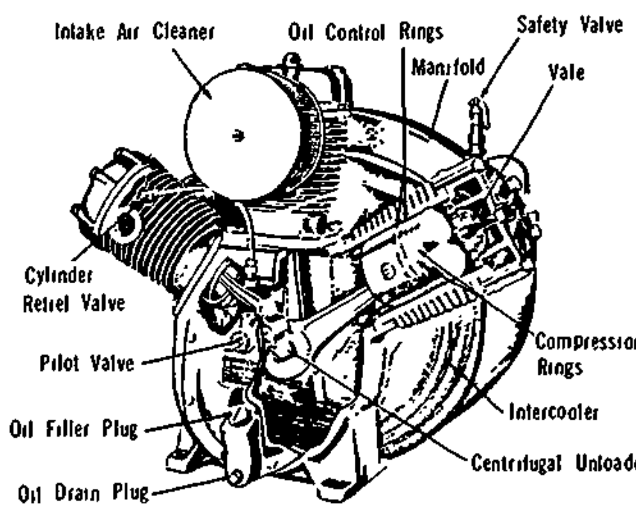


Figure 32-1. Typical Two-Stage, Three-Cylinder Compressor

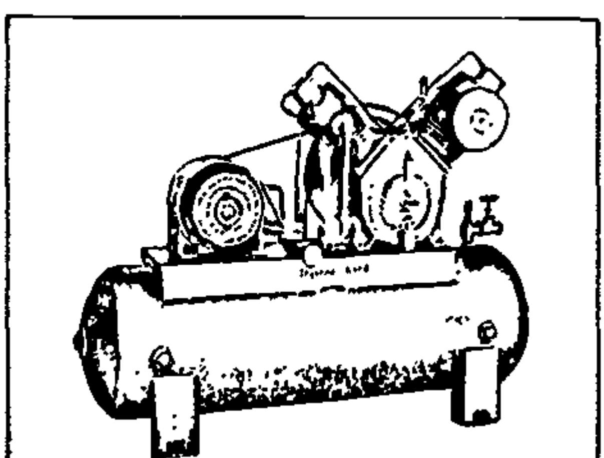


Figure 32-2. Typical Beltwheel-Driven Unit

Personnel Responsibilities

3. The primary responsibilities of trade personnel working on compressed-air systems are the installation and maintenance of piping and fittings between the unit's components and the user's outlets or controlling units, and the weekly servicing of the compressor.

Installation of a Compressor

4. *Cold Climate*. In a cold-climate area, the unit should be installed within a heated building, and positioned in a section that is cool, clean, and allows ample space around the unit for cooling and general accessibility. If there is a belt-drive, this side should face the wall, leaving at least 380 mm for air circulation to the belt-wheel fan. A suitable source of outside air should be available for the unit's suction.

5. *Damp Climate or High Humidity*. A unit that will operate under these conditions should be installed in a well-ventilated location. These atmospheric conditions are conducive to the formation of water in the crankcase; if adequate ventilation is not provided, rusting, oil sludging, and rapid wear on running parts could result. This is particularly true of units operating on short or intermittent applications.

6. *Bases and Foundations*. Although the unit may be placed on any substantial floor or base, a concrete foundation is recommended. It is very important for the unit to sit level and be supported evenly at its base or receiver feet. Shim or grout-up the base to provide equal support and to prevent placing a strain on the unit when the foundation bolts are tightened. The bolts should project above their nuts by a least 13 mm to allow for levelling. After the bolts are tightened, re-check the unit for level. (See Figure 32-4.)

Installation of Piping

7. *Inlet Piping*. Compressors are normally equipped with inlet mufflers and cleaners, but inlet piping is not included. If desired, the inlet may be piped to another room; in any event, the inlet muffler and cleaner must be used, and if the inlet is piped outdoors, it must be hooded to prevent the entry of rain and snow. In areas of heavy snowfall, it should be positioned high enough to be free of drifts. Inlet piping should be as short and direct as possible and as large as, or larger than, the diameter of the inlet connection. It must also increase in diameter at 15 m intervals. If the total length of piping is between 15 m and 30 m, it is recommended that the increase in diameter be made mid-point in the length, that is if the total length is 24 m, increase the pipe diameter at the 12 m point. (See Figure 32-5.)

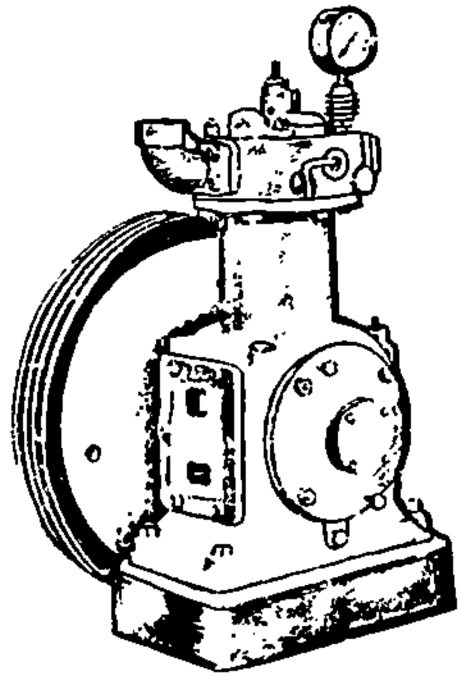


Figure 32-3. Type SA-6 Air Compressor (Water-Cooled)

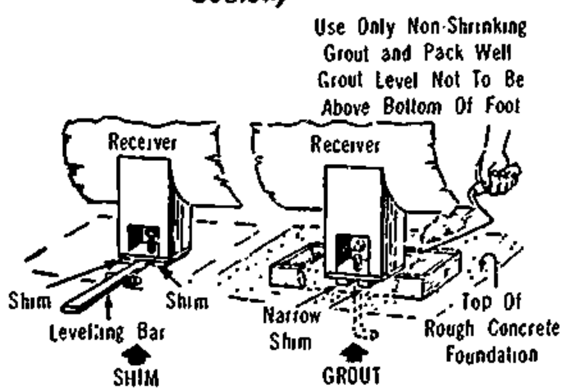


Figure 32-4. Method of Levelling Base

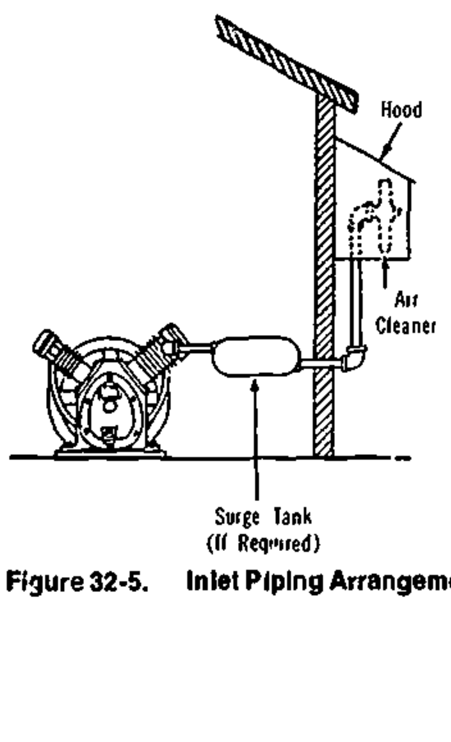


Figure 32-5. Inlet Piping Arrangement

Figure 32-5 shows a typical hookup, with a surge tank, which is required for compressors that are regulated by a constant-speed or dual control fitted into the inlet piping. If a surge tank is not fitted, air surging in and out of the inlet when the compressor is running unloaded (inlet valves open) will cause the inlet piping to heat. Thus, when the compressor loads (inlet valve closed on the compressor stroke), the hot piping will increase the temperature of the inlet air to a degree that would contribute to carbonization and consequent valve trouble. Consult the manufacturer's instructions during installation for the requirement and for the capacity of the surge tank to be purchased if not supplied with the unit.

8. *Discharge Piping.* This piping from the receiver to the equipment is far more important than is usually realized. Small leaks in the discharge system are the greatest single cause of high operating costs in the form of additional maintenance and early replacement of equipment. If a compressor runs longer than you believe it should, the most likely cause is a leaky pipeline. Hangar and workshop areas, valves, outlets, and hoses are especially vulnerable to this condition owing to their constant use. Leaks are quickly located by squirting oil or brushing liquid soap around the joints. The spiral, flexible retracting hoses are also recommended for use because of their long life and durability.

If a compressed-air tank or receiver is part of the system, run the piping down from the compressor discharge to permit condensate to drain into the receiver. If this is not possible, install a drain leg similar to the one illustrated in Figure 32-6. If the air system is large enough in volume so that an air receiver is not needed, a condensate leg with drain valve should be placed in the piping at a joint as far from the compressor as possible and just ahead of the point at which the air is used. The leg should be kept drained by a drain cock, and all the piping should slope toward it. Water in compressed air will cause operating difficulties. Large amounts will cause "water hammer" in pipe lines and reduce the capacity of the lines; it washes away lubricants in pneumatic tools and produces internal corrosion. Oil that is also carried along in suspension with the water must also be removed from the system via the leg drains, or receiver. The drain leg should project down from the compressor discharge and be at least 250 mm. The drain valve installed at the end of the leg should be opened at least weekly under normal operating conditions, and more often in a wet, humid climate.

9. **WARNING!** Never install a shut-off valve (such as a gate or globe valve) between the compressor and the receiver unless a safety valve is put in the piping between the valve and the compressor. (See Figure 32-6.) Safety valves are normally set to release 70 kPa above operating. Safety valves must never be replaced by plugs even for short periods. Figure 32-6 shows a typical overhead installation.

10. Some receiver units are provided with an automatic condensate drain valve, or trap as it is sometimes called. The function of the drain valve is to expel the condensate moisture from the receiver and the aftercooler. (See Section 15 in this part of the manual.) As the receiver pressure rises, condensate in the bottom of the receiver is forced into the drain valve. The drain valve is of the ball-float type, therefore, as the water level in the trap rises the ball also rises and, through a linkage, opens the valve, expelling the water until the water level and the ball drop to a point of re-seating the valve. (See Figure 32-7.)

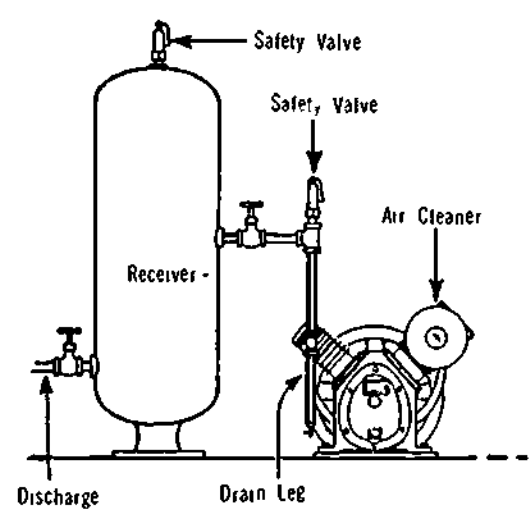


Figure 32-6. Typical Overhead Piping Arrangement for Base or Sub-Base Mounted Units

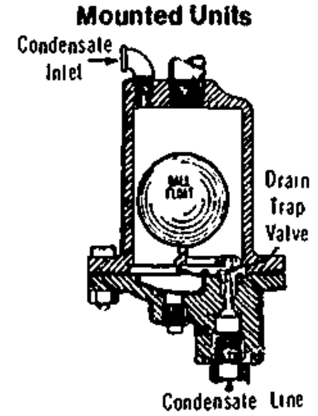


Figure 32-7. Automatic Condensate Drain Valve

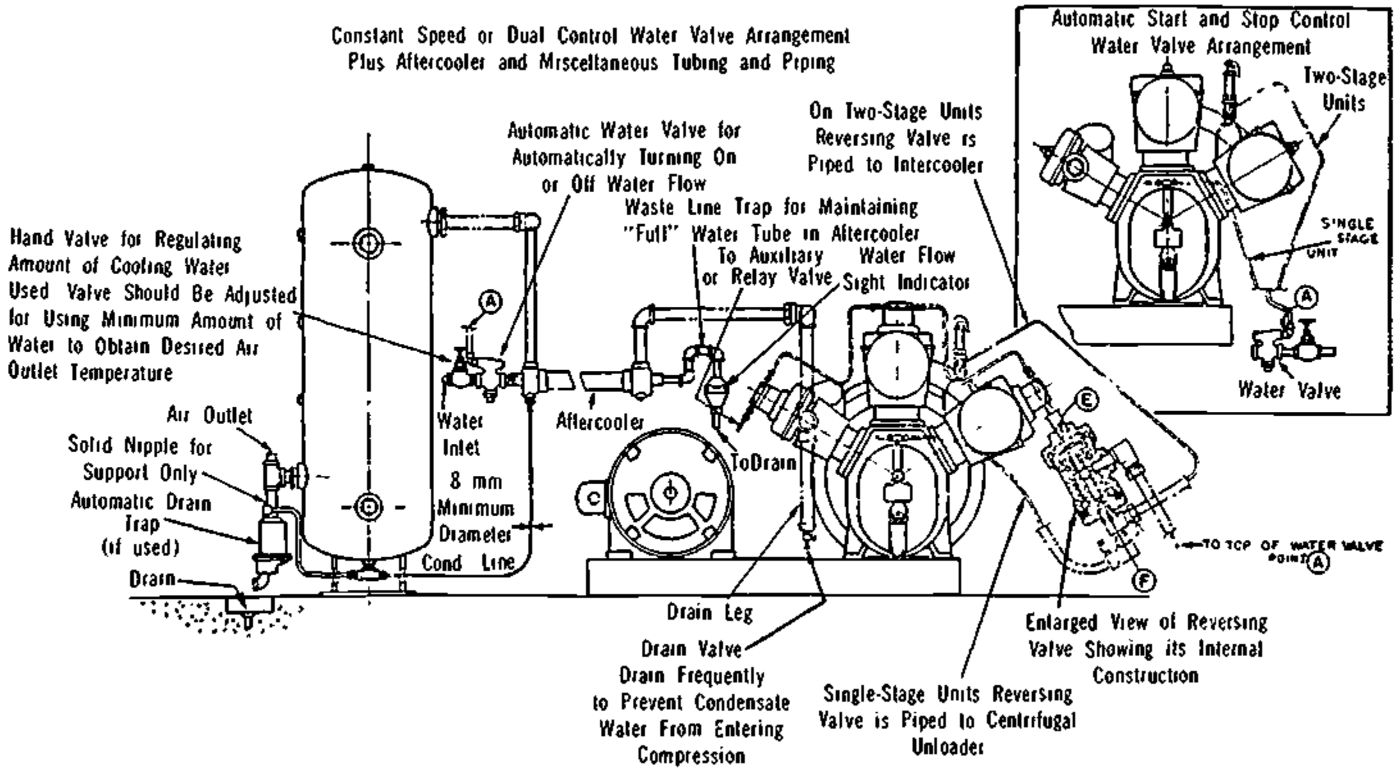


Figure 32-8. Typical Detailed Piping Arrangement for Base-Mounted Units

COMPRESSED AIR PIPING DOES NOT REQUIRE INSULATION

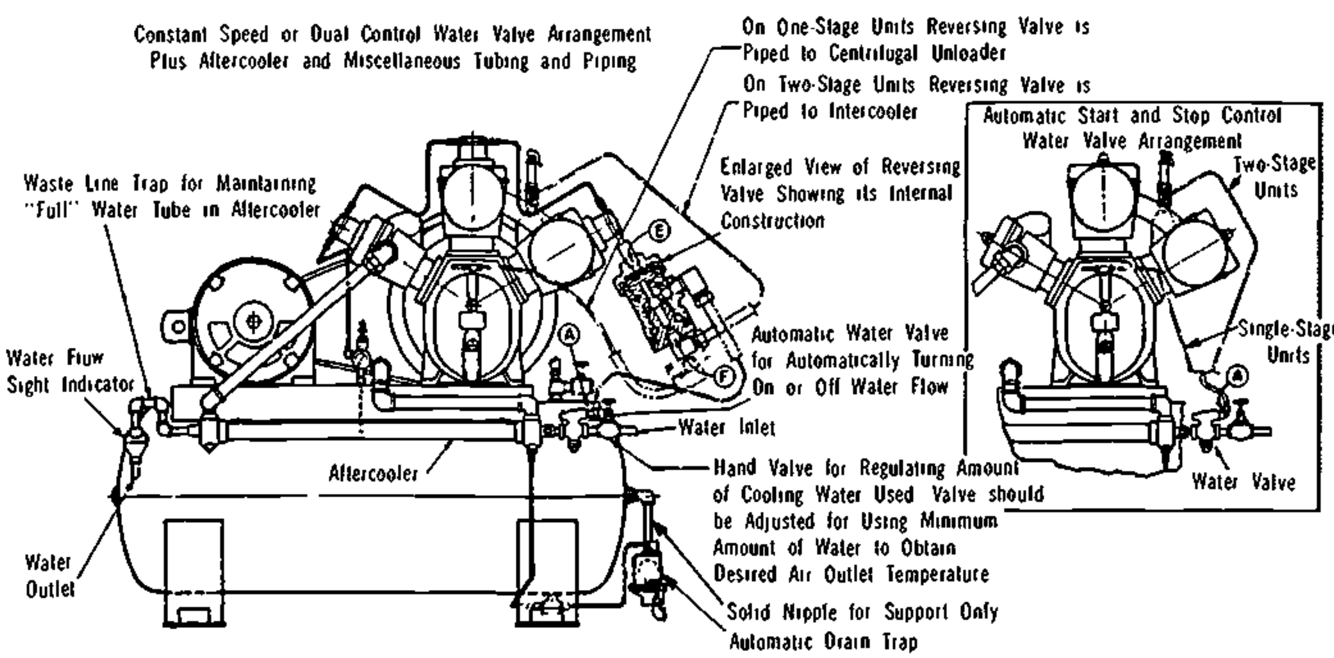


Figure 32-9. Typical Detailed Piping Arrangement for Receiver-Mounted Units

Piping Material and Application

11 Compressed-air piping for laboratories and clinics in hospital and dental buildings is normally copper tubing with sweat or flared fittings, depending on size. (This is covered in Part 8.)

12. Heating-control-system piping is normally in the small-bore range of NPS ⅛ to NPS ⅜ soft-copper tubing. Avoid sharp bends in the tubing to reduce friction losses, protect it from damage in exposed locations, and, when mounting it on irregular surfaces, place a strip of plywood or similar board over the surface and nail it in place before mounting the tubing. With this method, bracketing is easier, better support is given, and an even layout pleasing to the eye is achieved

13. Compressed-air piping for workshops and hangars is normally of steel or wrought iron with threaded malleable-iron fittings. Although the method of installation is similar to that of heating-piping in regard to joint preparation, bracket spacing, etc., good work practices and quality control are necessary because of the vibration factor. Most of the bracketing in these applications is to masonry surfaces; thus the use of the right size of drill for the fasteners, ensuring that the fasteners are full depth, and the use of the correct screws or bolts is especially important to avoid failures. Many of these installations are made in operational work areas, or from scaffolding, and the need to return to repair poor workmanship with consequent re-erection of scaffolding and disruption of services is unacceptable.

Normally the piping materials are specified, but in the case of an extension to an existing system the new materials should match those of the system. Ensure that the pressure rating of the piping to be installed is greater than the safety-valve blowoff pressure, which is normally working pressure + 70 to 175 kPa on the receiver, and water pressure + 70 kPa on the aftercooler, if fitted.

14. *Accessory Piping.* Typical accessory-piping arrangements for both receiver-mounted and base-mounted units are shown in Figures 32-8 and 32-9. These diagrams include a water-cooled aftercooler, an automatic water shut-off valve, and an automatic condensate drain trap. These diagrams are representative and show only relative positions. Actual positioning would be made to suit the installation.

NOTE: Compressed-air piping does not require insulation.

Water-Cooled Aftercooler

15. The function of the water-cooled aftercooler is that of reducing the discharge temperature of the air, thus increasing the efficiency of the system. (See Figure 32-10.)

Figure 32-10. Water-Cooled Aftercooler

Mount the aftercooler as close to the air receiver as possible, using pipe of the same diameter as that for the compressor outlet if the total length is less than 3 m. If it is longer, use the next-larger-diameter pipe. The aftercooler must be rigidly supported from the ceiling or wall. Discharge piping to the aftercooler should preferably load (slope) down, but if overhead piping is used a drain leg to trap condensed moisture should be mounted next to the compressor, as illustrated in Figure 32-8. An automatic drain valve can be fitted, or draining of condensate may be done manually.

Generally made of copper, the cooling tubing is centred inside the shell by multiple quill-like spines. In operation, the hot air passes over the spines in an opposite direction to that of the cooling water that flows through the centre tube. The headers on each end of the aftercooler provide connections for the air, water, and condensate piping.

Automatic Water Shut-Off Valve

16. An automatic water shut-off valve is used on units regulated by constant-speed control, automatic start-stop control, and water cooling. A globe valve is installed in the line ahead of it to control the rate of water flow. The automatic valve is a spring-and-diaphragm type that operates by air pressure. As the valve is activated differently for the various types of regulation, the plumber would, on installation, follow the direction of the appropriate mechanical trades technician and the manufacturer's installation instructions. Figure 32-11 shows a typical valve construction with air pressure over diaphragm B at point A.

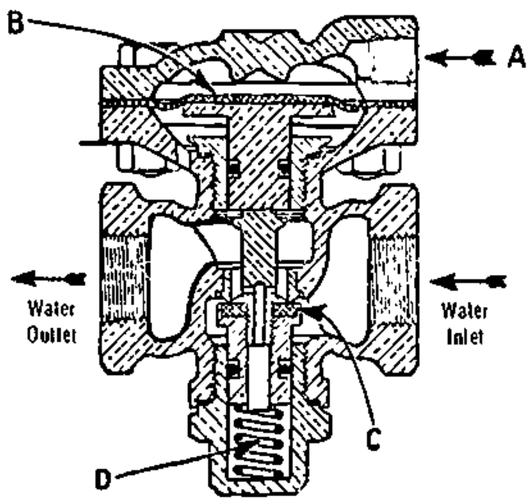


Figure 32-11. Automatic Water Shut-Off Valve

17. *Daily and Weekly Checks.* The greater part of your maintenance on the compressor will involve daily or weekly checks on the heating and equipment rooms. Because of the wide variety of equipment in use there, it is impossible to cover every item in this manual; therefore you must be briefed on the peculiarities of the particular equipment, as well as study and adhere to the manufacturer's instructions.

18. *General Inspection and Servicing.* Routine inspection and service of a compressor will ensure maximum performance and keep repair work, and the consequent costly down-time, to a minimum. Follow the inspection points outlined in your preventive maintenance check list or in the manufacturer's servicing guide.

19. *Crankcase Oil Level.* At least once a week check the oil level in the crankcase, using the level glass, dip stick, or another level indicator. If no record of the type of oil is available on or adjacent to the unit, refer to the manufacturer's instructions.

NOTE: When putting a new unit into service, be sure the preservative oil is replaced with lubricating oil. Some units are shipped dry, so be certain that the crankcase is filled with oil, and ensure during checks that this level is maintained.

CAUTION: Always pull the switch when working close to moving parts, such as drive belts, so that the motor cannot start and trap your clothing or limbs.

20. *Air Receiver.* Unless automatic draining provisions are made, the air receiver and other condensate collectors must be drained once a week, or more often if experience indicates it is necessary, to remove the accumulated condensate. If draining is neglected, water will rise to a point where it passes into the service lines.

21. *Safety Valves.* Manually operate the safety valves to be sure they are in good working order.

22. *Monthly and Quarterly Inspection Service.* Unless the plumber is specifically directed to perform one or more of the following tasks under supervision, they are not normally considered his responsibility. However, if it is observed over a period that a certain item has been missed, the foreman should be informed so that arrangements to do the work can be made. This also applies to vibration, excessive belt wear or oil use, excessive oil observed when draining the air receiver, excessive stopping and starting, and knocks or rattles. Major inspection focusses are:

a) External Cleaning: To maintain maximum cooling efficiency, clean the cylinder and inter-cooler fins with a jet of air at least once a month.

b) Intake Air Cleaner: A clogged, dirty cleaner not only reduces the compressor capacity but also contributes to premature wear on working parts. The cleaner pads should be cleaned or replaced, and the screens should be removed frequently and cleaned with a jet of compressed air.

c) Care of Compressor Valves: Valves must be tight to prevent air leakage. They must be inspected regularly and any dirt or carbon removed. A casual check will not disclose whether this work has been done, but an inspection card will normally reveal whether the person responsible has done the work.

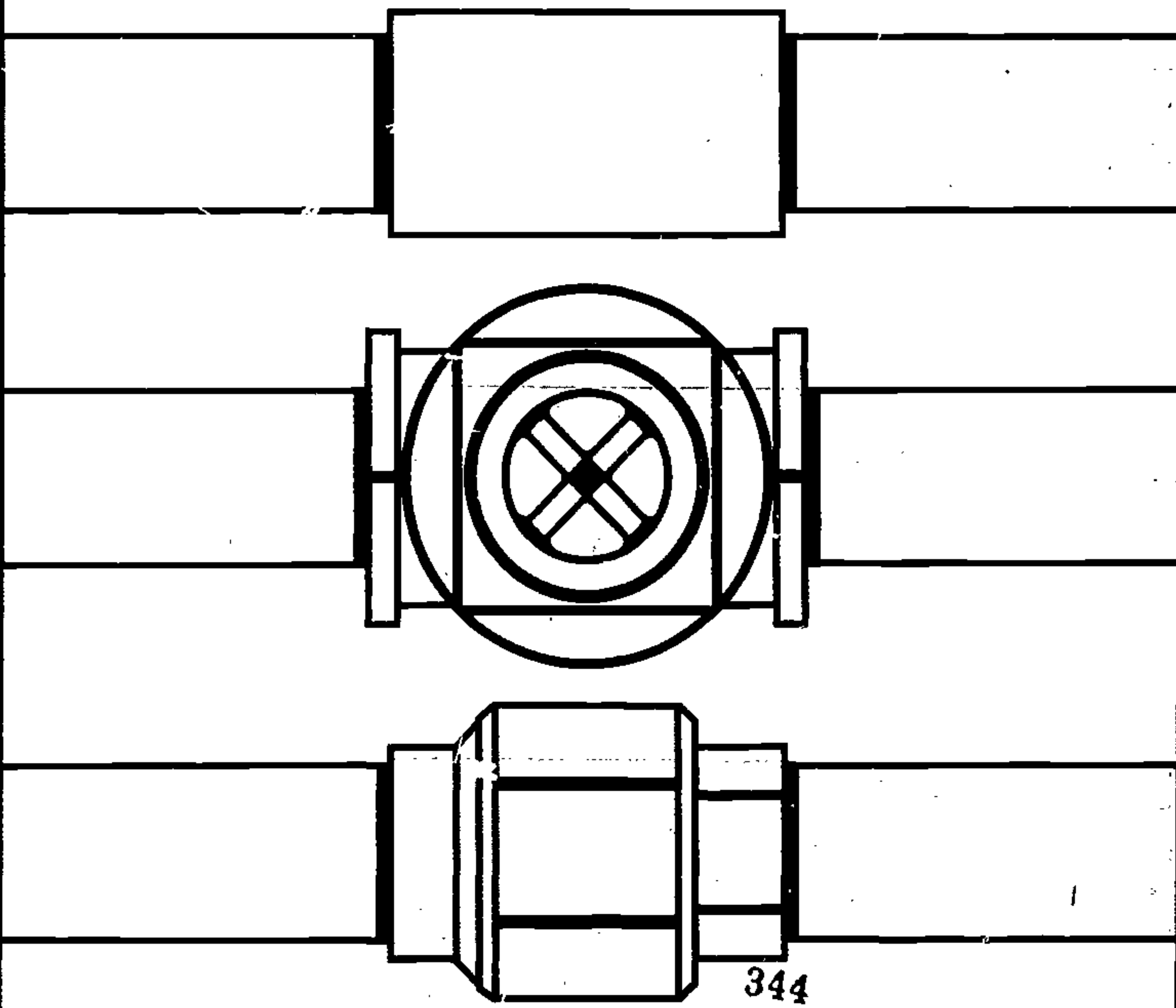
d) Care of Electric Motors: Do not oil the motor unless specifically requested to do so by the electrical shop, because excessive lubrication could cause problems. If the amount of oil and the frequency of oiling are not specified in the inspection folder, obtain qualified help.

e) Crankcase Oil: The oil is normally changed every three months or every 500 hours of operation, whichever occurs first. Longer periods without replacement will cause a build-up of sludge.

CAUTION: Air under pressure should never be used for dusting, or for cooling oneself, or for pranks.

Design of Water-Distribution Systems

33



344

PART 33

DESIGN OF WATER-DISTRIBUTION SYSTEMS

Owing to the specialized nature of the pipes described in this part of the manual, as well as their specialized applications in the design of water-distribution systems, the tables and other references to pipes are given in both SI metric and imperial terminology. This was done to avoid possible confusion, since the SI metric conversions were derived from traditional imperial practice and may be superseded by any changes resulting from the adoption of a fully metricated Canadian Plumbing Code as it becomes available. The key friction-loss graphs can be altered substantially with only minor corrections to assumed average pipe specifications and code factors.

Design Considerations

1. Proper design of the water-distribution system in a building is necessary to ensure that the various fixtures function properly and that failure of the supply under normal conditions will be prevented.

2. The volume of hot or cold water used in any building is variable, depending on the type of structure, its use, the number of occupants, and the occupancy periods.

3 The first step is to obtain all information necessary for establishing a proper basis for sizing the water-supply system for the building. The correct basis is contingent upon the accuracy and reliability of the information being applied; thus it should be obtained from responsible sources, including the appropriate local authorities.

4 You must determine exactly what types of material are to be used in the system. This must be discussed with the owner of the building or an authorized representative, who may be the architect, the engineer, or the contractor.

5 Information on the corrosiveness of a given water supply with regard to various kinds of piping materials and its scale-forming tendency is normally obtainable from most officials, architects, engineers, and contractors in an incorporated water district.

For anyone not possessing such knowledge, the Langelier index and Ryznar Index can be used to interpret data on the water's pH value, CO_2 content, dissolved air content, and carbonate hardness, in order to ascertain the water's corrosiveness and scale-forming tendency The best source for this data is the local authority having jurisdiction over the system supplying the water, or over the wells from which water is pumped from the underground water table.

6. Information on the location and size of the public water main should be obtained from the local water authority. Where a private water-supply source, such as a private well system, is to be used, the location and size as designed for the building must be considered.

7. Information should be obtained on the developed length of the piping run from the source of water to the highest and most remote water outlet on the system. This generally means from the public water main, and includes the length of pipe from the water main to the property line. This normally can be established by measuring the pipe runs on the building plans.

8. Data on the pressure available in the public water main should be obtained from the local authority having jurisdiction over the public system. The maximum and minimum pressures available in the public main at all times should be obtained from this authority, since it is the only recognized source of accurate information. If a private water system is to be used, the maximum and minimum pressure at which it will be adjusted to operate should be known.

9. The relative elevations of the source of water supply and the highest water-supply outlet in the building must be determined. This means the vertical distance from the public water main to the top outlet supplied by the system. This information is obtainable from the building plans.

10. Information on the minimum pressure required at the highest water outlets for adequate, normal flow conditions consistent with satisfactory fixture use and equipment function, as given in Table 33-1 (metric) or 33-2 (imperial), may be deemed applicable.

11. Where the pressure at a water outlet is more than twice the minimum pressure required for satisfactory water-supply conditions, an excessively high discharge rate may occur. Consequently, means of controlling the rate of supply should be provided in the fixture supply pipe wherever the available pressure at an outlet is more than twice the minimum pressure required for a satisfactory supply. For this purpose, individual regulating valves, variable orifice flow-control devices, or fixed

orifices may be provided. They should be designed or adjusted to control the rate of flow to correspond with normal demands for the fixture.

12. The volume demand in a building water-supply system cannot be determined exactly. The demand imposed on a system by intermittently used fixtures is related to the number, type, and likely simultaneous use of the fixtures.

13. In the standard design method, fixtures using water intermittently under various conditions of service are assigned specific load values in terms of water-supply-fixture units (WSFU). The unit is a factor so chosen that the load-producing effects of different kinds of fixtures under their conditions of service can be expressed approximately as multiples of that factor.

Values assigned to different kinds of fixtures are listed in Table 33-1 (metric) or 33-2 (imperial). Note that for fixtures having both hot and cold water supplies, the values for separate hot and cold water demands should be taken as being three-fourths of the total value assigned to the fixture in each case. For example, the value assigned to a kitchen sink in a dwelling unit is 2 WSFU, while the separate demands on the hot and cold water piping thereto should be taken as being 1.5 WSFU.

Table 33-1. Load Values in Water-Supply-Fixture Units (Metric)

Fixture or Device	Minimum Size of Supply Pipe (NPS)	Flow (1) Pressure (kPa) Gauge	Hydraulic Load (In Water-Supply-Fixture Units)	
			Private	Public
Bathroom group:				
a) With flush tank*	NA	NA	6	—
b) With direct-flush valve*	NA	NA	8	—
Bathtub (with or without shower)*	½	50 kPa	2	4
Clothes washer*	½	100 kPa	3	—
Dishwasher, domestic*	½	100 kPa	3	—
Drinking fountain	⅜	100 kPa	½	1
Hose bibb	½	100 kPa	(2)	(2)
Lavatory	⅜	50 kPa	1	2
Sink:				
a) Kitchen, domestic*	½	50 kPa	2	—
b) Kitchen, commercial*	¾	50 kPa	—	4
c) Service	½	50 kPa	—	3
d) Service with direct-flush valve*	¾	100 kPa	—	5
Shower head*	½	50 kPa	2	4
Urinal:				
a) With flush tank	½	50 kPa	—	3
b) With direct-flush valve	¾	100 kPa	—	5
Water closet:				
a) With flush tank	⅜	50 kPa	3	5
b) With direct-flush valve	1	100 kPa	6	10

Notes to Table 33-1

(1) Measured upstream of faucet or supply valve
(2) A continuous load of space 0.38 L/s
NA Not applicable

For fixtures not listed in the above table, and of which the supply-pipe size is as shown here:

Size of Supply Pipe (NPS)	Hydraulic Load (In Water-Supply-Fixture Units)	
	Private	Public
⅜	1	2
½	2	4
¾	3	6
1	6	10

*The fixtures in Table 33-1 marked with an asterisk are to be supplied with both cold and hot water.

The minimum sizes for hot water and cold water supply pipes are the same.

For fixtures with both a hot and a cold water supply, the weights for maximum separate demands may be taken as three-fourths of the total supply-fixture unit value.

Table 33-2. Load Values in Water-Supply-Fixture Units (Imperial)

Fixture or Device	Minimum Size of Supply Pipe (NPS)	Flow (1) Pressure (psi) Gauge	Hydraulic Load (In Water-Supply-Fixture Units)	
			Private	Public
Bathroom group:				
a) With flush tank*	NA	NA	6	—
b) With direct-flush valve*	NA	NA	8	—
Bathtub (with or without shower)*	½	15 psi	2	4
Clothes washer*	½	30 psi	3	—
Dishwasher, domestic*	½	30 psi	3	—
Drinking fountain	⅜	30 psi	½	1
Hose bibb	½	30 psi	(2)	(2)
Lavatory	⅜	15 psi	1	2
Sink:				
a) Kitchen, domestic*	½	15 psi	2	—
b) Kitchen, commercial*	¾	15 psi	—	4
c) Service	½	15 psi	—	3
d) Service with direct-flush valve*	¾	30 psi	—	5
Shower head*	½	15 psi	2	4
Urinal:				
a) With flush tank	½	15 psi	—	3
b) With direct-flush valve	¾	30 psi	—	5
Water closet:				
a) With flush tank	⅜	15 psi	3	5
b) With direct-flush valve	1	30 psi	6	10

Notes to Table 33-2

(1) Measured upstream of faucet or supply valve

(2) A continuous load of space 5 gpm

NA Not applicable

For fixtures not listed in the above table, and of which the supply-pipe size is as shown here:

Size of Supply Pipe (NPS)	Hydraulic Load (In Water-Supply-Fixture Units)	
	Private	Public
⅜	1	2
½	2	4
¾	3	6
1	6	10

*The fixtures in Table 33-2 marked with an asterisk are to be supplied with both cold and hot water.

The minimum sizes for hot water and cold water supply pipes are the same.

For fixtures with both a hot and a cold water supply, the weights for maximum separate demands may be taken as three-fourths of the total supply-fixture unit value.

Table 33-3. Table for Estimating Demand in Litres

Supply Systems Predominantly for Flush Tanks		Supply Systems Predominantly for Flush Valves	
Load	Demand	Load	Demand
(Water-Supply-Fixture Units)	(Litres Per Minute)	(Water-Supply-Fixture Units)	(Litres Per Minute)
1	11.4		
2	18.9		
3	24.6		
4	30.3		
5	35.6	5	56.8
6	40.5	6	65.9
7	44.7	7	75.0
8	48.5	8	84.0
9	51.9	9	93.1
10	55.3	10	102.2
11	58.3	11	105.2
12	60.6	12	108.3
13	62.5	13	111.3
14	64.4	14	114.3
15	66.2	15	117.3
16	68.1	16	120.4
17	69.7	17	123.4
18	71.2	18	126.4
19	72.7	19	129.5
20	74.2	20	132.5
25	81.4	25	143.8
30	88.2	30	159.0
35	94.3	35	166.6
40	99.6	40	174.1
45	104.9	45	181.7
50	110.2	50	189.3
60	121.1	60	204.4
70	132.5	70	219.6
80	143.8	80	231.7
90	155.2	90	243.4
100	164.7	100	255.5
120	181.7	120	276.3
140	198.7	140	291.5
160	215.8	160	306.6
180	230.1	180	323.7
200	246.1	200	340.7
225	265.0	225	361.5
250	283.9	250	382.3
275	302.8	275	395.6
300	322	300	409
400	397	400	481
500	469	500	541
750	644	750	670
1000	787	1000	787
1250	905	1250	905
1500	1018	1500	1018
1750	1124	1750	1124
2000	1230	2000	1230
2500	1438	2500	1438
3000	1639	3000	1639
4000	1987	4000	1987
5000	2245	5000	2245

Table 33-4. Table for Estimating Demand in U.S. Gallons

Supply Systems Predominantly for Flush Tanks		Supply Systems Predominantly for Flush Valves	
Load	Demand	Load	Demand
(Water-Supply-Fixture Units)	(U.S. Gal. Per Minute)	(Water-Supply-Fixture Units)	(U.S. Gal. Per Minute)
1	3.0		
2	5.0		
3	6.5		
4	8.0		
5	9.4	5	15.0
6	10.7	6	17.4
7	11.8	7	19.8
8	12.8	8	22.2
9	13.7	9	24.6
10	14.6	10	27.0
11	15.4	11	27.8
12	16.0	12	28.6
13	16.5	13	29.4
14	17.0	14	30.2
15	17.5	15	31.0
16	18.0	16	31.8
17	18.4	17	32.6
18	18.8	18	33.4
19	19.2	19	34.2
20	19.6	20	35.0
25	21.5	25	38.0
30	23.3	30	42.0
35	24.9	35	44.0
40	26.3	40	46.0
45	27.7	45	48.0
50	29.1	50	50.0
60	32.0	60	54.0
70	35.0	70	58.0
80	38.0	80	61.2
90	41.0	90	64.3
100	43.5	100	67.5
120	48.0	120	73.0
140	52.5	140	77.0
160	57.0	160	81.0
180	61.0	180	85.5
200	65.0	200	90.0
225	70.0	225	95.5
250	75.0	250	101.0
275	80.0	275	104.5
300	85.0	300	108.0
400	105.0	400	127.0
500	124.0	500	143.0
750	170.0	750	177.0
1000	208.0	1000	208.0
1250	239.0	1250	239.0
1500	269.0	1500	269.0
1750	297.0	1750	297.0
2000	325.0	2000	325.0
2500	380.0	2500	380.0
3000	433.0	3000	433.0
4000	525.0	4000	525.0
5000	593.0	5000	593.0

14. To determine the demand in litres (or U.S. gallons) per minute corresponding to any given load in water-supply-fixture units, refer to Table 33-3 or 33-4 in which values have been arranged for convenient conversion of demand from terms of water-supply-fixture units to litres (or U.S. gallons) of flow, or vice versa. Intermediate values may be interpolated for loads between those in the table.

Note in Table 33-3 or 33-4 that the demand corresponding to a given number of water-supply-fixture units is generally much higher for a system in which water closets are flushed by means of direct-flush valves than for a system in which water closets are flushed by flush tanks. The difference in demand between the two systems diminishes as the total number of fixture units of load increases. At 1000 WSFU, the demand in both types of systems is the same, that is, 787 L (or 208 U.S. gallons) per minute.

15. Where a part of the system does not provide water for water closets with direct-flush valves, the demand corresponding to a given number of WSFU may be determined from the values given for a system in which water closets are flushed by flush tanks.

16. Velocity of flow through water-supply piping during periods of peak demand is an important factor that must be considered in the design of a building's water-supply system. Limitations of water velocity should be observed to avoid objectionable noise effects in systems; shock damage to piping, equipment, tanks, coils, and joints; and accelerated deterioration and eventual failure of piping from erosion-corrosion.

17. In accordance with good engineering practice, maximum velocity in supply piping generally should be limited to no more than 2.4 m/s (8 fps). This is deemed essential to prevent such objectionable effects as whistling line noise, cavitation, and associated excessive noise in fittings and valves.

18. Maximum velocity should be limited to no more than 1.2 m/s (4 fps) in branch water-supply piping from mains, headers, and risers to water outlets at which the supply is controlled by means of a quick-closing device, such as a direct-flush valve, a solenoid valve, a pneumatic valve, a quick-closing valve or faucet, or other similar types.

This limitation is to avoid the development of excessive and damaging shock pressures in the piping and equipment when the flow is suddenly shut off. Many items of plumbing equipment and systems are not designed to withstand the very high shock pressures that could result from a sudden cessation of high-velocity flow in piping.

19. Velocity limits recommended by pipe manufacturers to avoid accelerated deterioration of their piping materials due to erosion-corrosion should be observed. Research shows that extreme turbulence accompanying high flow velocities is an important factor in causing erosion-corrosion, and that this is especially prone to occur where the water supply has high carbon content, that is, in excess of 10 ppm, and where it has been softened to zero hardness. Another important factor is very high water temperature, that is, in excess of 66°C (150°F).

20. Following are a manufacturer's recommendations for the control of erosion-corrosion effects in copper water tubing, copper pipe, and brass pipe:

a) Where the water supply has a pH value higher than 6.9 and a positive scale-forming tendency, such as may be shown by a positive Langelier Index reading, velocity should be limited to no more than 2.4 m/s (8 fps).

b) Where the water supply has a pH value lower than 6.9 and may be classified as aggressively corrosive, or where the water supply has been softened to zero hardness by passage through a water softener, velocity should be limited to no more than 1.2 m/s (4 fps).

c) Because of the accelerated rate of corrosion at higher temperatures, the 1.2 m/s (4 fps) velocity limit should be applied to all hot water supply piping conveying water at a temperature above 66°C (150°F).

21. Friction in a building water-supply system must be limited by design to the degree necessary so that the highest water outlets will have available during periods of peak demand at least the minimum pressure required for satisfactory water-supply conditions at the fixture or equipment.

22. The limit to which pressure loss due to friction may be permitted to occur in the main water lines, and in the risers supplying the highest water outlets during peak demand periods, is the amount of static pressure available in excess of the minimum pressure required at such outlets when no-flow conditions exist. This may be calculated as the difference between the static pressure at the highest water outlets during no-flow conditions and the minimum pressure required at such outlets for satisfactory supply conditions.

23. Where the water is supplied by direct pressure from a public main, to calculate the static pressure at the highest outlet, deduct from the certified minimum pressure available in the public water main the amount of static pressure loss corresponding to the

height at which the outlet is located above the public water main, that is, deduct 9.8 kPa for each metre (0.433 psi pressure for each foot) of rise in elevation from the public water main to the highest outlet.

24. Where the water is supplied under pressure from a gravity water-supply tank located at an elevation above the highest water outlet, the static pressure at that outlet is calculated as being equal to 9.8 kPa for each metre (0.433 psi pressure for each foot) of difference in elevation between the outlet and the waterline in the tank. In this case, the minimum static pressure at the outlet should be that which corresponds to the level of the low waterline at which the tank is designed to operate.

25. Among the highest water outlets on a system, generally the one at which the least available pressure will prevail during periods of peak demand is the outlet that is supplied through the longest run of piping extending from the source of supply. Since pipe friction loss is directly proportionate to the length of piping, the most extreme run of piping from the source of supply to the highest outlets on the system should be designated as the "basic design circuit" (BDC) for sizing the main water lines and risers in accordance with the limit to which pressure loss due to friction may be permitted to occur therein.

26. In most systems, the BDC will consist of the run of cold water supply piping extending from the source of supply to the domestic hot water heating unit, and the run of hot water supply piping extending from there to the highest and most remote hot water outlet on the system. However, in systems supplied direct from the public water main and having water closets with flush valves at the topmost floor, the BDC may be the run of cold water supply piping extending from the public water main to the highest and most remote flush valve on the system.

27. Where a water meter, a water filter, a water softener, or an instantaneous or tankless hot water heating coil is provided in the BDC, the friction loss corresponding to the peak demand rate through such equipment must be determined and included in the pressure-loss calculations. Manufacturers' charts and data sheets on their products generally provide such information. They should be used as a guide in selecting the most appropriate type and size of equipment to use, with consideration being given to the limit to which pressure loss due to friction may be permitted to occur in the BDC.

The rated pressure loss through such equipment should be deducted from the friction-loss limit to establish the amount of pressure that may be permitted to be dissipated by friction in pipe, valves, and fittings of the BDC.

28. To facilitate the calculation of appropriate pipe sizes corresponding to the permissible friction loss in pipe, valves, and fittings, the BDC should be designated in accordance with the principle of uniform pipe friction loss throughout its length. In this way the friction limit for the piping run may be established in terms of kilopascals per 100 m (or psi per 100') of piping length. The permissible uniform pipe friction loss is calculated by dividing the permissible friction loss in pipe, valves, and fittings by the total equivalent length of the basic design circuit, then multiplying by 100.

29. The total equivalent length of piping is its developed length plus an equivalent pipe length corresponding to the frictional resistance of all fittings and valves in the piping. When sizes of fittings are known or have been established in accordance with sizes based upon appropriate limitations of velocity, corresponding equivalent lengths may be determined directly from available tables. Two such tables are shown here, each in both metric and imperial equivalents. Table 33-5 (metric) and Table 33-6 (imperial) are for standard thread piping. Table 33-7 (metric) and Table 33-8 (imperial) are for copper water tubing.

Table 33-5. Allowance in Equivalent Length in Metres of Piping for Friction Loss in Valves and Threaded Fittings

	Equivalent Metres of Pipe for Various Sizes							
Fitting or Valve	NPS ½	NPS ¾	NPS 1	NPS 1¼	NPS 1½	NPS 2	NPS 2½	NPS 3
45° elbow	0.36	0.46	0.55	0.73	0.90	1.2	1.5	1.8
90° elbow	0.60	0.75	0.90	1.2	1.5	2.1	2.4	3.0
Tee, run	0.18	0.24	0.27	0.36	0.46	0.60	0.75	0.90
Tee, branch	0.90	1.2	1.5	1.8	2.1	3.0	3.6	4.5
Gate valve	0.12	0.15	0.18	0.24	0.30	0.40	0.49	0.60
Balancing valve	0.24	0.34	0.46	0.58	0.67	0.90	1.1	1.4
Plug-type cock	0.24	0.34	0.46	0.58	0.67	0.90	1.1	1.4
Check valve, swing	1.7	2.6	3.4	4.3	5.1	6.8	8.5	10.2
Globe valve	4.5	6.1	7.6	10.7	13.7	16.8	19.8	24.4
Angle valve	2.4	3.6	4.6	5.5	6.7	8.5	10.4	12.2

Table 33-6. Allowance in Equivalent Length in Feet of Piping for Friction Loss in Valves and Threaded Fittings

	Equivalent Feet of Pipe for Various Sizes							
Fitting or Valve	½ in.	¾ in.	1 in.	1¼ in.	1½ in.	2 in.	2½ in.	3 in.
45° elbow	1.2	1.5	1.8	2.4	3.0	4.0	5.0	6.0
90° elbow	2.0	2.5	3.0	4.0	5.0	7.0	8.0	10.0
Tee, run	0.6	0.8	0.9	1.2	1.5	2.0	2.5	3.0
Tee, branch	3.0	4.0	5.0	6.0	7.0	10.0	12.0	15.0
Gate valve	0.4	0.5	0.6	0.8	1.0	1.3	1.6	2.0
Balancing valve	0.8	1.1	1.5	1.9	2.2	3.0	3.7	4.5
Plug-type cock	0.8	1.1	1.5	1.9	2.2	3.0	3.7	4.5
Check valve, swing	5.6	8.4	11.2	14.0	16.8	22.4	28.0	33.6
Globe valve	15.0	20.0	25.0	35.0	45.0	55.0	65.0	80.0
Angle valve	8.0	12.0	15.0	18.0	22.0	28.0	34.0	40.0

Table 33-7. Allowance in Equivalent Length in Metres of Copper Water Tubing for Friction Loss in Valves and Fittings

	Equivalent Metres of Tubing for Various Sizes							
Fitting or Valve	NPS ½	NPS ¾	NPS 1	NPS 1¼	NPS 1½	NPS 2	NPS 2½	NPS 3
45° elbow (wrought)	0.15	0.15	0.30	0.30	0.60	0.60	0.90	1.2
90° elbow (wrought)	0.15	0.30	0.30	0.60	0.60	0.60	0.60	0.90
Tee, run (wrought)	0.15	0.15	0.15	0.15	0.30	0.30	0.60	—
Tee, branch (wrought)	0.30	0.60	0.90	1.2	1.2	2.1	2.4	—
45° elbow (cast)	0.15	0.30	0.60	0.60	0.90	1.5	2.4	3.4
90° elbow (cast)	0.30	0.60	1.2	1.5	2.4	3.4	4.3	5.5
Tee, run (cast)	0.15	0.15	0.15	0.30	0.30	0.60	0.60	0.60
Tee, branch (cast)	0.60	0.90	1.5	2.1	2.7	3.6	4.9	6.1
Compression stop	4.0	6.4	9.1	—	—	—	—	—
Globe valve	—	—	—	16.1	20.1	27.4	—	—
Gate valve	—	—	0.30	0.30	0.60	0.60	0.60	0.60

Table 33-8. Allowance in Equivalent Length in Feet of Copper Water Tubing for Friction Loss in Valves and Fittings

	Equivalent Feet of Tubing for Various Sizes							
Fitting or Valve	½ in.	¾ in.	1 in.	1¼ in.	1½ in.	2 in.	2½ in.	3 in.
45° elbow (wrought)	0.5	0.5	1.0	1.0	2.0	2.0	3.0	4.0
90° elbow (wrought)	0.5	1.0	1.0	2.0	2.0	2.0	2.0	3.0
Tee, run (wrought)	1.5	0.5	0.5	0.5	1.0	1.0	2.0	—
Tee, branch (wrought)	1.0	2.0	3.0	4.0	5.0	7.0	9.0	—
45° elbow (cast)	0.5	1.0	2.0	2.0	3.0	5.0	8.0	11.0
90° elbow (cast)	1.0	2.0	4.0	5.0	8.0	11.0	14.0	18.0
Tee, run (cast)	0.5	0.5	0.5	1.0	1.0	2.0	2.0	2.0
Tee, branch (cast)	2.0	3.0	5.0	7.0	9.0	12.0	16.0	20.0
Compression stop	13.0	21.0	30.0	—	—	—	—	—
Globe valve	—	—	—	53.0	66.0	90.0	—	—
Gate valve	—	—	1.0	1.0	2.0	2.0	2.0	2.0

30. On the basis of inside surface conditions, pipes are classified as follows:

a) *Smooth.* The pipe surface shows no perceptible roughness. Pipes made of copper, brass, lead, or plastic may usually be classified as smooth.

b) *Fairly Rough.* After a few years of use, all ordinary pipes, such as galvanized steel and cast iron, may be classified as fairly rough.

c) *Rough.* Pipes that have deteriorated fairly rapidly over 10 to 15 years after being laid are classified as rough.

31. Figures 33-1 to 33-3 (in metric) and Figures 33-4 to 33-6 (in imperial) at the end of this section give the pipe friction losses corresponding to the above three classifications for various nominal diameters and velocities.

32. Following is the recommended procedure for sizing pipes in a water-distribution system:

a) Draw a sketch of all pipes in the system from the main in the street to all fixtures to be served and include the hot (domestic) water system.

b) Using Table 33-1 (metric) or 33-2 (imperial) select the unit load for each fixture and enter this information on each supply pipe to fixtures.

c) Determine the total demand in fixture units for each section of pipe in the system and enter this information on the piping sketch.

d) Using the total demand in fixture units for each section of pipe, refer to Table 33-3 (metric) or 33-4 (imperial) and convert each fixture unit load to litres (or U.S. gallons) per minute and enter this information on the piping sketch.

e) Determine the actual length of pipe from the street water main to the topmost fixture. Since the sizes of the pipes are unknown, the exact equivalent lengths of the various fittings cannot be accurately determined, but are generally about 50 per cent of the actual pipe length. The actual equivalent length of fittings can be determined from Tables 33-5 (metric) or 33-6 (imperial) and Tables 33-7 (metric) or 33-8 (imperial) after the initial sizing.

f) Determine the average minimum pressure in the street main and the minimum pressure required for the operation of the topmost fixture. The latter pressure can be obtained from Table 33-1 (metric) or 33-2 (imperial).

g) Calculate, by means of the following metric or imperial equation, the approximate design value of the average pressure drop per 100 m or 100' of piping in the equivalent length determined in sub-paragraph e).

Equation (Metric)

$$p = (P - 9.807H\ mp)\frac{100}{L}$$

where:

p = average pressure loss per 100 m of equivalent length of pipe

P = pressure in street main in kPa

H = height of highest fixture above street main in metres

mp = minimum flow pressure in kPa (from Table 33-1)

L = equivalent length determined in sub-paragraph e)

If the system is that of down-feed supply from a gravity tank, the height of the water in the tank, converted to kPa by multiplying by

9.807, replaces the street main pressure, and the term 9.807H in the above equation is added instead of subtracted in calculating the term *p*. In this case, H will be the vertical distance in metres of the fixture below the bottom of the tank.

Equation (Imperial)

$$p = \frac{(P - 0.43H\ mp)\ 100}{L}$$

where:

p = average pressure loss per 100' of equivalent length of pipe

P = pressure in street main in psig

H = height of highest fixture above street main in feet

mp = minimum flow pressure (from Table 33-2)

L = equivalent length determined in sub-paragraph e)

If the system is that of down-feed supply from a gravity tank, the height of the water in the tank, converted to psi by multiplying by 0-43, replaces the street main pressure, and the term 0.43H in the above equation is added instead of subtracted in calculating the term *p*. In this case, H will be the vertical distance in feet of the fixture below the bottom of the tank.

33. From the expected rate of flow — as determined in sub-paragraph d) and with consideration being given to selection of velocity in the pipe as covered in paragraphs 16 to 22, and to the permitted or available friction loss in head per 100 m or per 100' — pipe sizes can be selected from either the metric set of graphs (33-1 to 33-3) or the imperial set (33-4 to 33-6), based on the type of piping to be used.

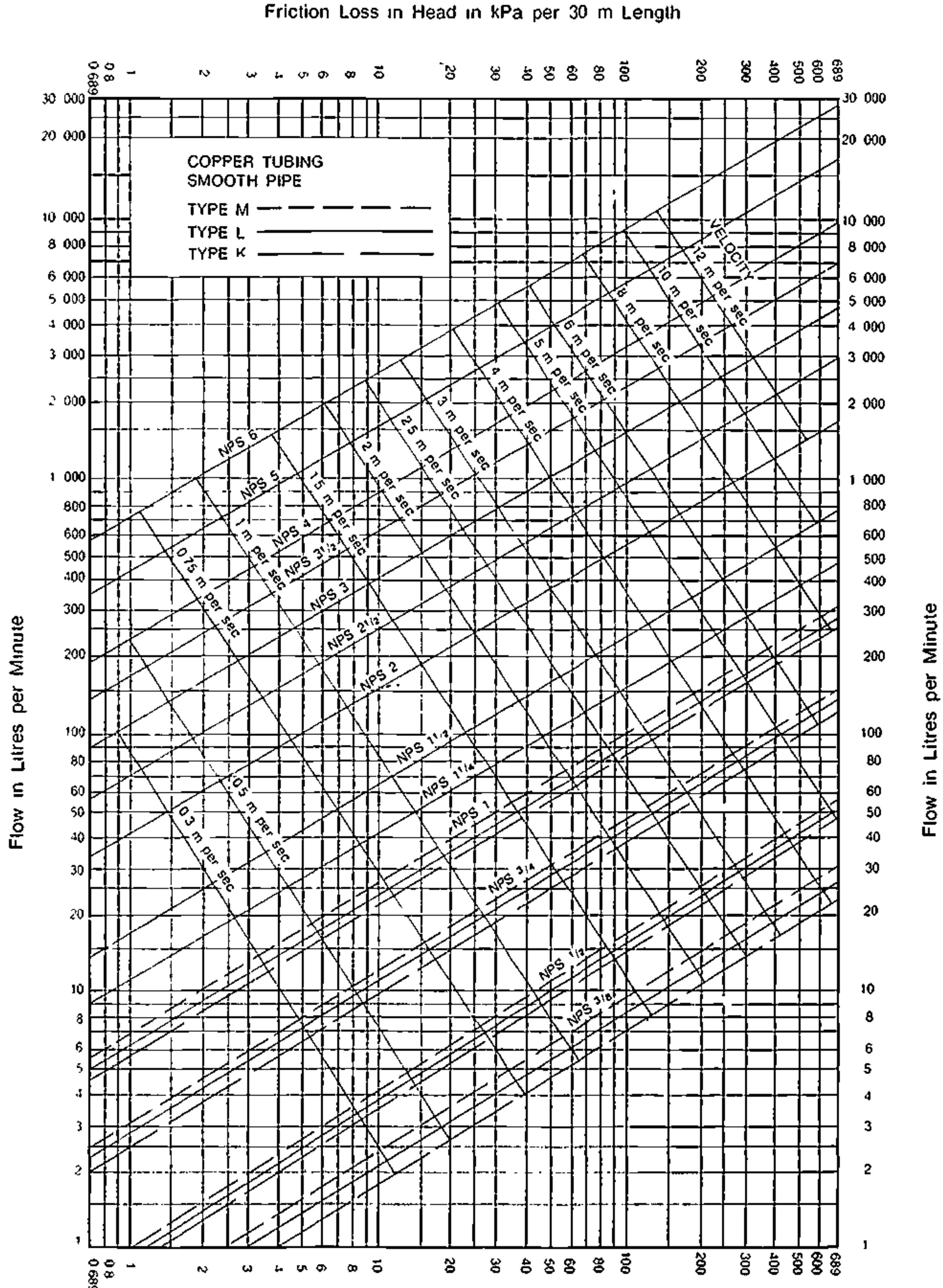


Figure 33-1. Friction Loss in Head in kPa per 30 m Length

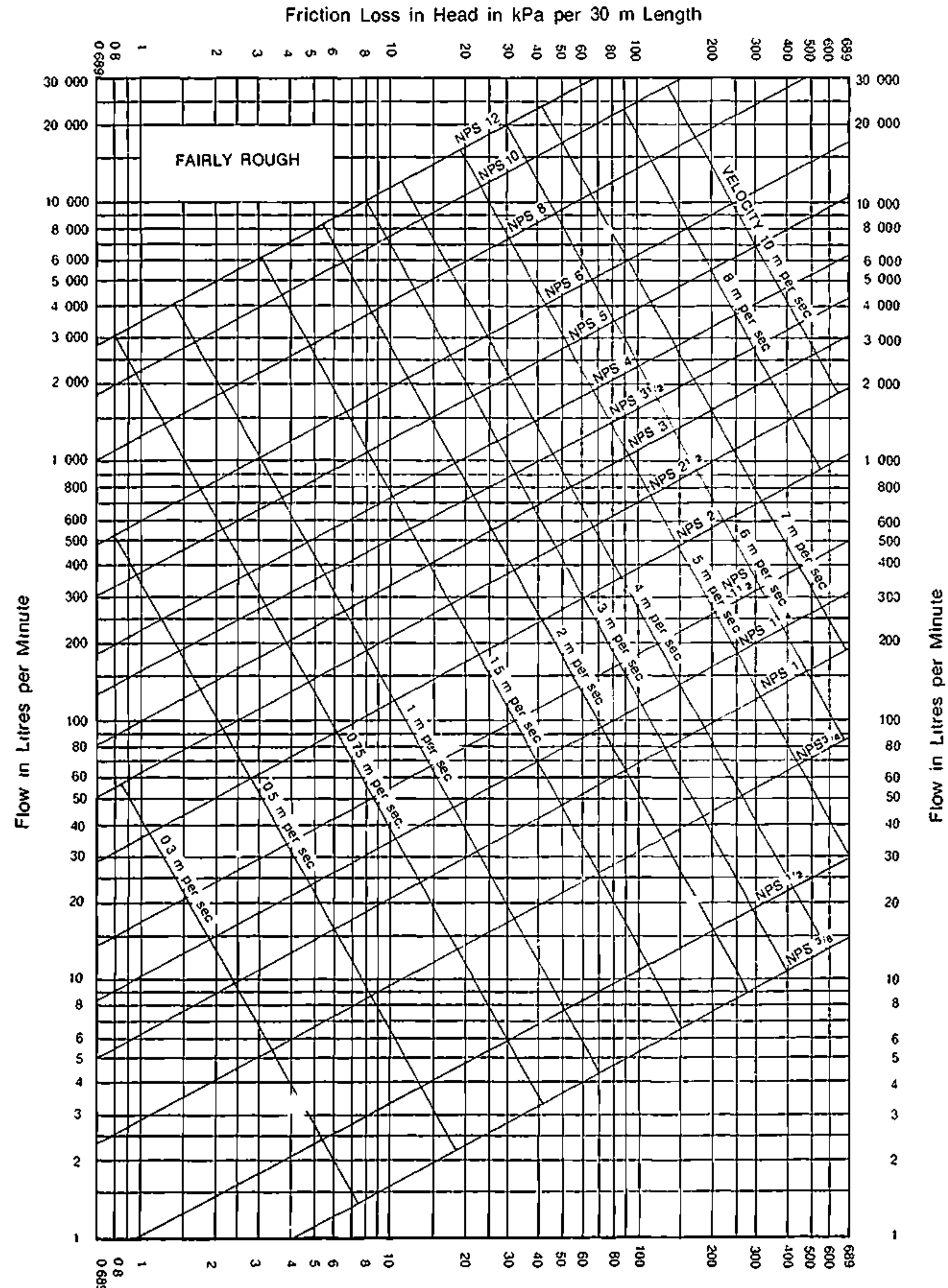


Figure 33-2. Friction Loss in Head in kPa per 30 m Length

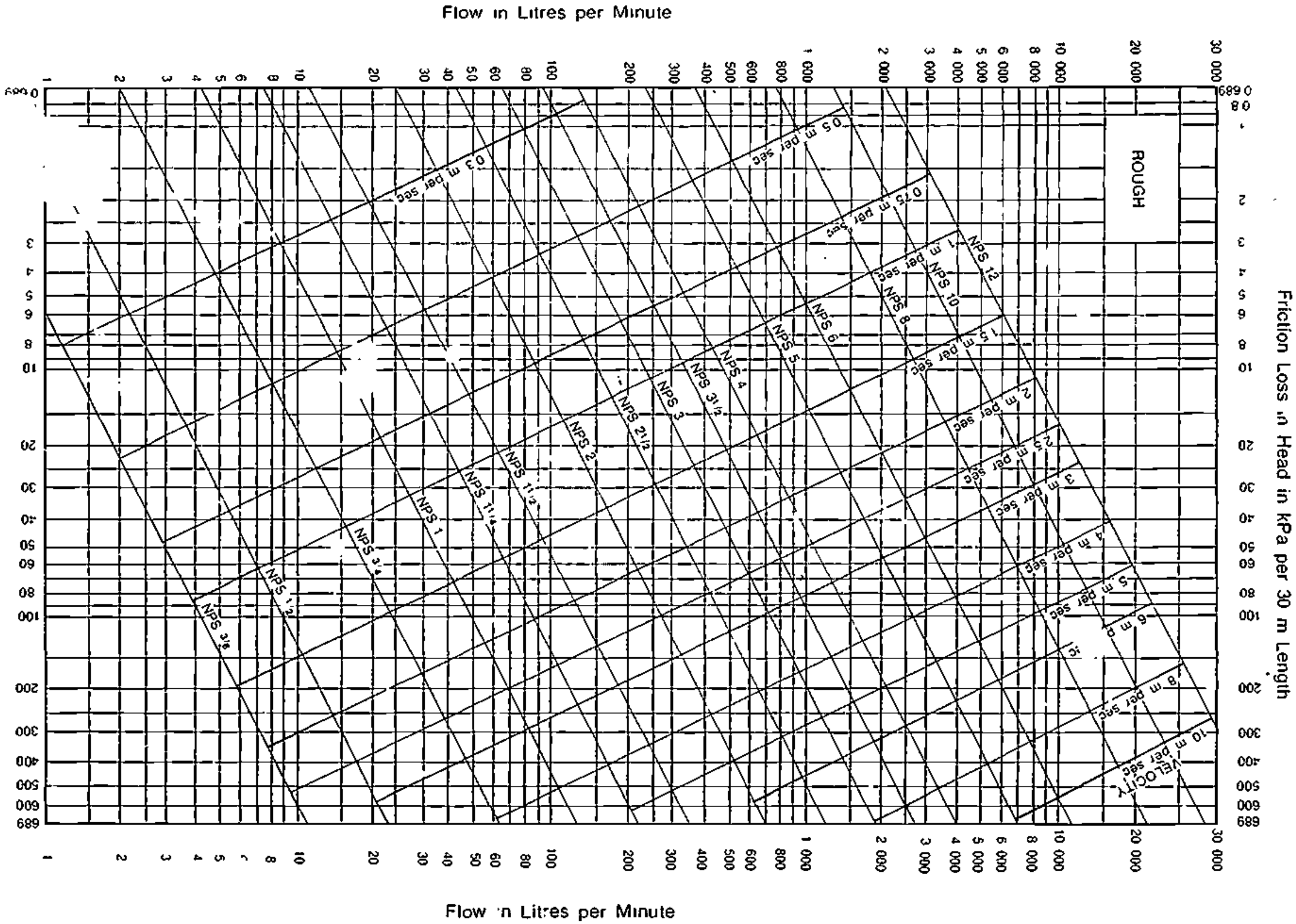


Figure 33-3. Friction Loss in Head in kPa per 30 m Length

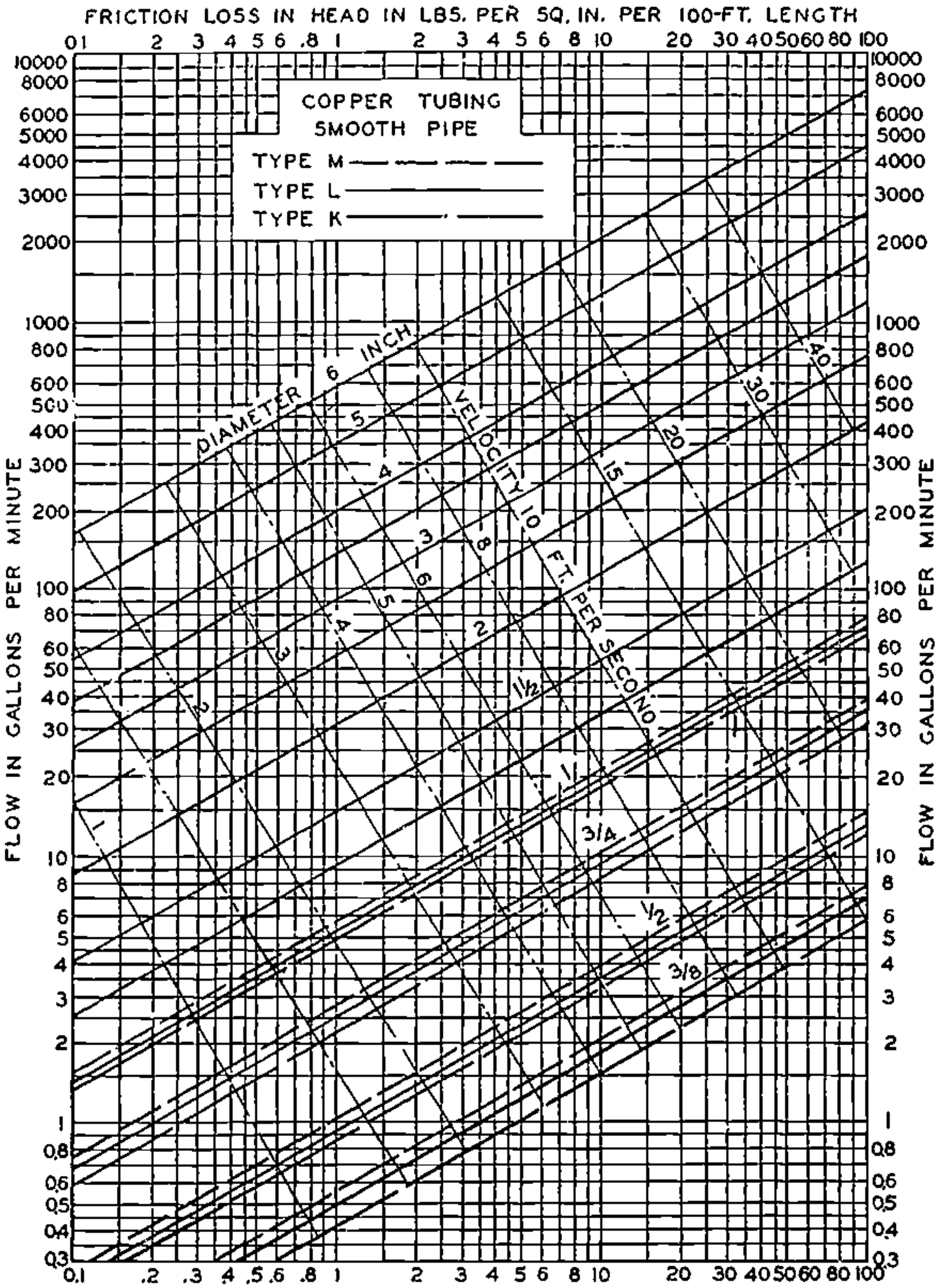


Figure 33-4. Friction Loss in Head in Lbs. per Sq. In. per 100-Ft. Length

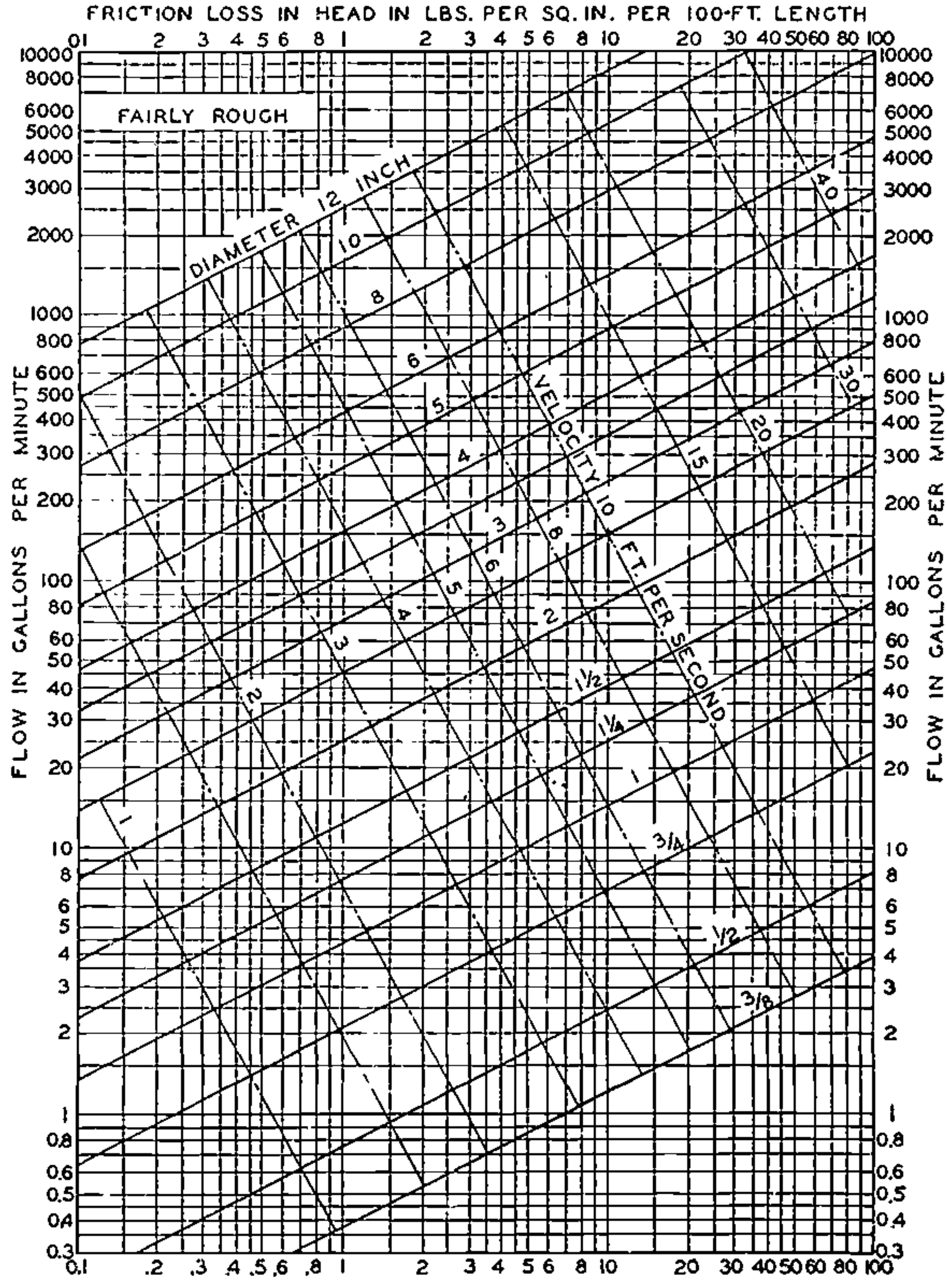


Figure 33-5. Friction Loss in Head in Lbs. per Sq. In. per 100-Ft. Length

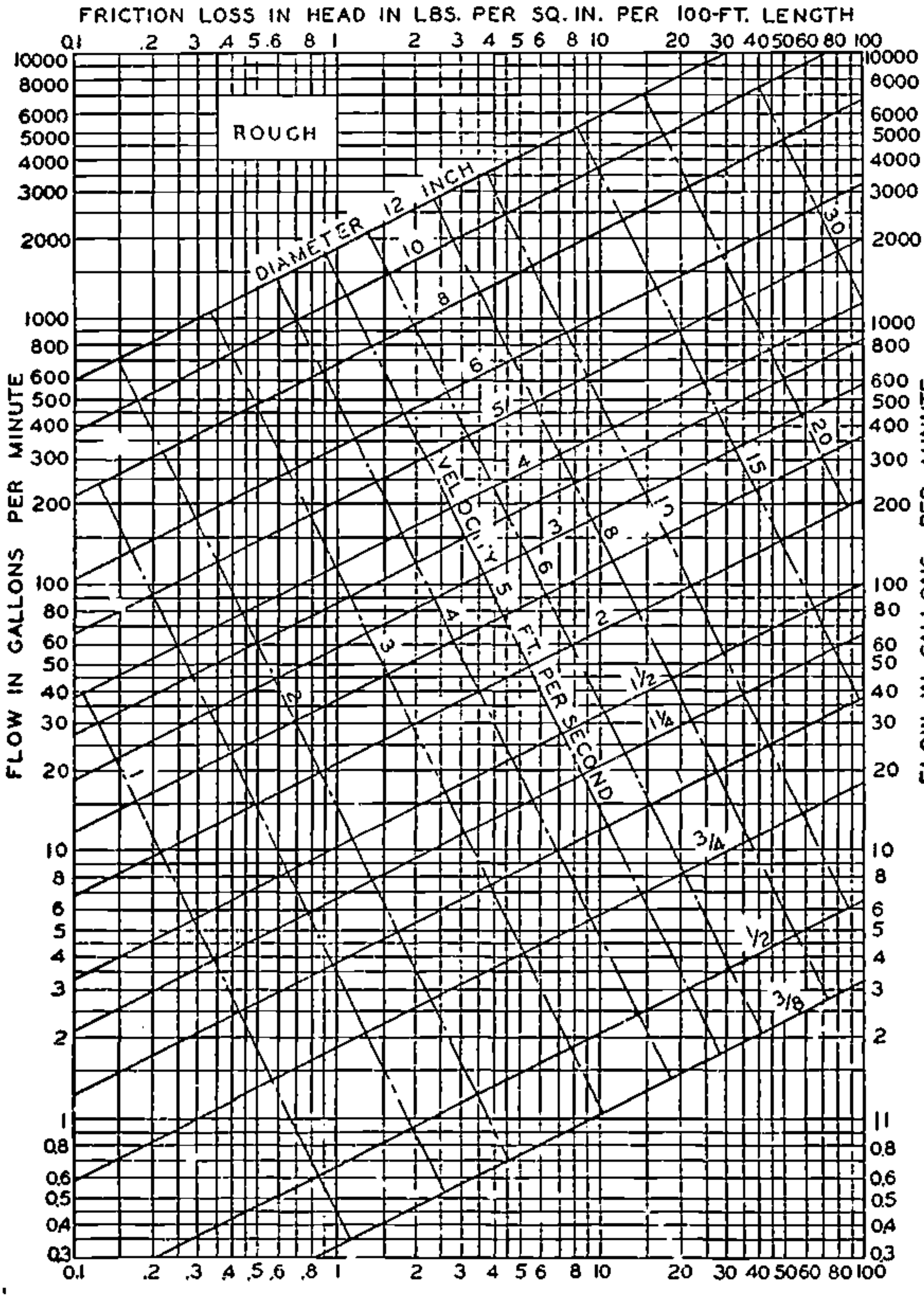
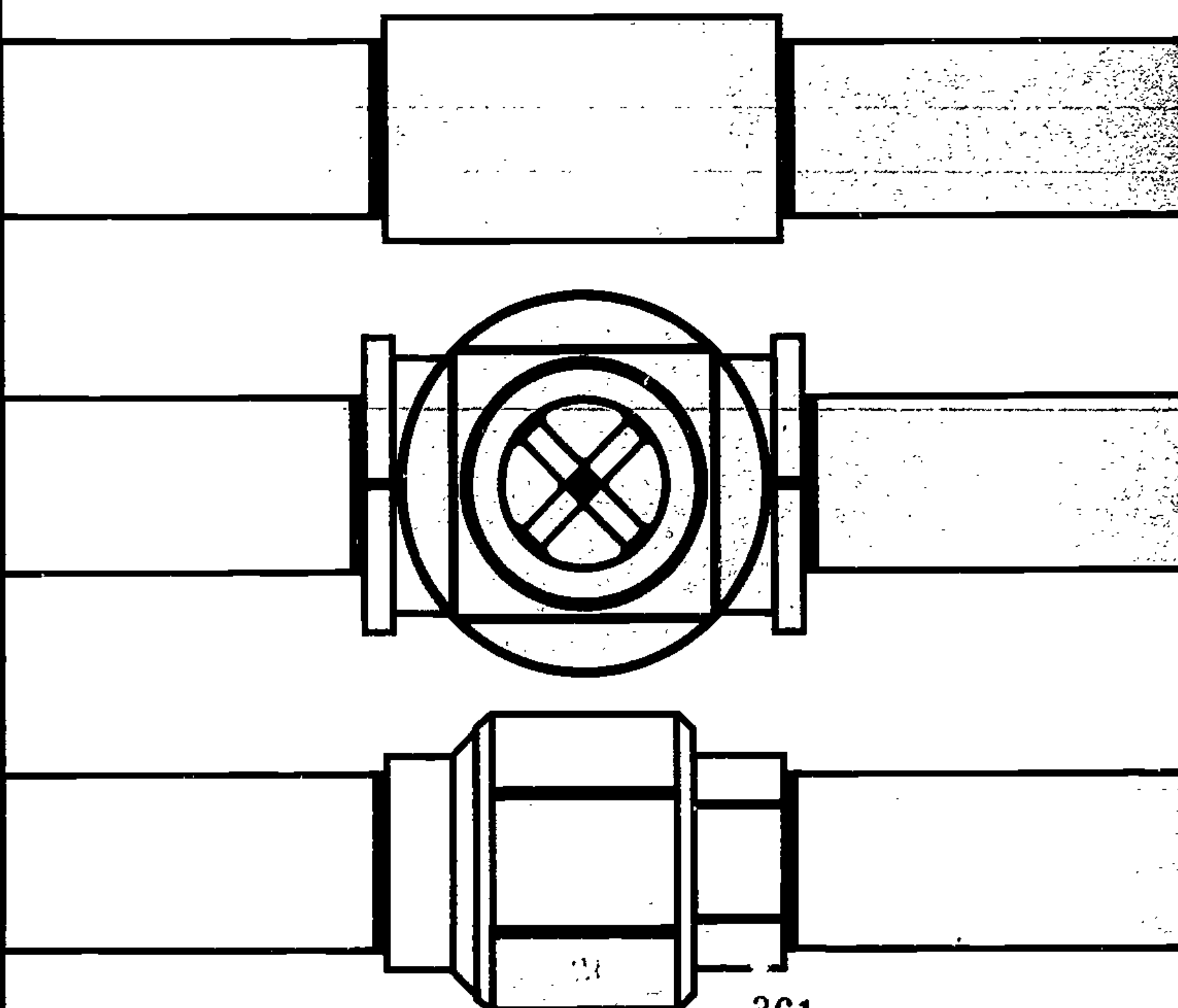


Figure 33-6. Friction Loss in Head in Lbs. per Sq. In. per 100-Ft. Length

Sizing Domestic Hot Water Tanks and Heaters

34



PART 34

SIZING DOMESTIC HOT WATER TANKS AND HEATERS

1 Both the maximum daily demand and the maximum hourly demand for hot water form the criteria for selection of the hot water heater and storage tank

2. Generally, two-thirds of the total daily water consumption is hot water. For residential dwellings, a design value of about 75 to 115 L per person daily may be assumed, but of course the hot water used will depend on the number of rooms and bathrooms.

Table 34-1 gives estimates of the maximum hot water requirements in 24 hours in various types of buildings.

Table 34-1. Maximum Daily (24 Hours) Requirements of Hot Water in Litres

Apartments and Private Homes					
	Number of Bathrooms				
No. of Rooms	1	2	3	4	5
1	230	—	—	—	—
2	260	—	—	—	—
3	300	—	—	—	—
4	340	450	—	—	—
5	380	530	—	—	—
6	450	600	760	—	—
7	530	680	830	—	—
8	600	760	910	950	—
9	680	830	980	1040	—
10	760	910	1060	1140	—
11	—	980	1140	1290	—
12	—	1060	1230	1440	1700
13	—	1140	1320	1590	1890
14	—	—	1420	1740	2080
15	—	—	1510	1890	2270
16	—	—	—	2040	2460
17	—	—	—	2200	2650
18	—	—	—	2350	2840
19	—	—	—	—	3030
20	—	—	—	—	3220

Hotels	
Room with basin	40
Room with bath — transient	190
Room with bath — resident	230
Two rooms with bath	300
Three rooms with bath	380
Public shower	760
Public basins	570
Slop sink	110
Office Buildings	
White-collar workers (per person)	8
Other workers (per person)	15
Cleaning per 1000 m^2	120
Hospitals	
Per bed	300-380

3. In estimating the size of the hot water storage tank, and the needed heating capacity from either a boiler or an independent domestic hot water heater, you need to know the total volume of water to be heated per day and the maximum amount that will be used in any one hour, as well as the duration of the peak load.

4. Where the hot water requirements are reasonably uniform, as in houses, apartment buildings, and hotels, a smaller storage capacity is required than that in factories, schools, and office buildings where almost the whole day's use of hot water occurs during a very short period.

Correspondingly, the heating capacity must be proportionately greater with uniform use of hot water than with intermittent use, where there may be several hours between peak demands during which the water in the storage tank can be brought up to temperature. As a general rule, it is desirable to have a large storage capacity so that the heating capacity, and consequently the size of the heater, or the load on the heating boiler, may be as small as possible.

5. In estimating the hot water that can be drawn from a storage tank, bear in mind that only about 75 per cent of the volume of the tank is available, since by the time this quantity has been drawn off the incoming cold water has cooled the remainder to a point where it can no longer be considered hot water.

6. Two criteria are commonly used in estimating hot water requirements of a building:

a) The number of people.

b) The number of plumbing fixtures installed in various types of buildings.

7. Table 34-2 gives a reasonable estimate of the hot water requirement based on the number of persons and type of occupancy.

Table 34-2. Estimated Hot Water Demand Characteristics for Various Types of Buildings

Type of Building	Hot Water Required Per Person	Maximum Hourly Demand In Relation To Day's Use	Duration of Peak-Load Hours	Storage Capacity In Relation to Day's Use	Heating Capacity In Relation to Day's Use
Residences, apartments, hotels, etc.	150 L per day*	1/7	4	1/5	1/7
Office buildings	8 L per day*	1/5	2	1/5	1/6
Factory buildings	20 L per day*	1/3	1	2/5	1/8
Restaurants	—	—	—	1/10	1/10
Restaurants 3 meals/day	—	1/10	8	1/5	1/10
Restaurants 1 meal/day	—	1/5	2	2/5	1/6

*At 60°C

8. Table 34-3 may be used to determine the size of hot water heating equipment based on the number of fixtures. To obtain the probable maximum demand, multiply the total quantity for the fixtures by the demand factor in line 11 of Table 34-3. The heater, or coil, should have a water-heating capacity equal to this probable maximum demand multiplied by the storage capacity factor in line 12.

Table 34-3. Hot Water Demand in Litres per Hour per Fixture for Various Types of Buildings—Calculated at a Final Temperature of 60°C

Fixtures	Apartment House	Club	Gym	Hospital	Hotel	Industrial Plant	Office Bldg.	Private Residence	School	YWCA/YMCA
1. Basins, private lavatory	8	8	8	8	8	8	8	8	8	8
2. Basins, public lavatory	15	25	30	25	30	45	25	—	60	30
3. Bathtubs	75	75	115	75	75	115	—	75	—	115
4. Dishwashers	60	190-570	—	190-570	190-760	75-380	—	60	75-380	75-380
5. Foot basins	10	10	45	10	10	45	—	10	10	45
6. Kitchen sinks	40	75	—	75	75	75	—	40	40	75
7. Laundry, stationary tubs	75	110	—	110	110	—	—	75	—	110
8. Pantry sinks	20	40	—	40	40	—	—	20	40	40
9. Showers	285	570	850	285	285	850	—	285	850	850
10. Slop sinks	75	75	—	75	115	75	60	60	75	75
11. Demand factor	0.30	0.30	0.40	0.25	0.25	0.40	0.30	0.30	0.40	0.40
12. Storage capacity factor*	1.25	0.90	1.00	0.60	0.80	1.00	2.00	0.70	1.00	1.00

*Ratio of storage tank capacity to probable maximum demand per hour

9. Example using data from Table 34-2:

Determine the heater size and the storage-tank capacity for a residence housing five persons (assume each person needs 150 L per day).

Solution:

The daily requirement would be:

5 x 150 = 750 L per day, and a maximum hourly demand of 750 x 1/7 = 107 L.

The storage tank should have a capacity of 750 x 1/5 = 150 L and the heater a capacity of 750 x 1/7 = 107 L per hour.

10. The conditions shown in the above example may be considered average. It is possible to vary the storage and heating capacity by increasing and decreasing one over the other. Such a condition is explained below.

Example, using data from Table 34-2:
Determine the required heater capacity for an apartment housing 200 persons if the storage tank has a capacity of 3785 L. What heater capacity will be required if the storage capacity is increased to 9460 L?

Solution:

The daily requirement would be 750 L x 40 = 30 000 L.

Maximum hours demand = 30 000 L x 1/7 = 4285 L.
Duration of peak load = 4 hours.
Water required for a four-hour peak load = 4 x 4285 = 17 140 L.
If a 3785 L storage tank is used, the hot water available from the tank = 3875 x .75 = 2906 L.
Water to be heated in four hours = 17 140 minus 2906 = 14 234 L.
Heating capacity per hr. = 14 234/4 = 3560 L.

If, instead of the 3785 L tank, a 10 000 L tank had been installed, the required heating capacity per hour would be 17 140 - (10 000 x .75)/4 = 2410 L.

11. Using data from Table 34-3, the following is an example of how to determine the size of the heater and storage tank for an apartment building, based on the number of fixtures:

60 lavatories	x 8 =	480 L per hour
30 bathtubs	x 75 =	2 250 L per hour
30 showers	x 285 =	8 550 L per hour
60 kitchen sinks ...	x 40 =	2 400 L per hour
15 laundry tubs	x 75 =	1 125 L per hour
TOTAL		14 805 L per hour

Possible maximum demand = 14 805 L per hour.

Probable maximum demand = 14 805 x 0.3 (Demand Factor, as per Table 34-3) = 4440 L per hour.
Heater or coil capacity = 4440 L per hour.
Storage tank capacity = 4440 x 1.25 (allowance based on only 75 per cent of hot water being available) = 5550 L.

12. Although in private dwellings a water temperature of 60°C is reasonable for dishwashing, in public places sanitation requirements and regulations often require 82°C. Most dishwashing machines require 82°C. The volume of 82°C water needed in restaurants per day may be determined as follows:

a) Multiply the number of meals per day by the number of dishes per meal (six for low-price restaurants, eight for medium-price restaurants, and ten for high-price restaurants) to determine the total number of dishes per day.

b) Divide the total number of dishes per day, as determined above, by the average number of dishes per rack to find the number of racks per day.

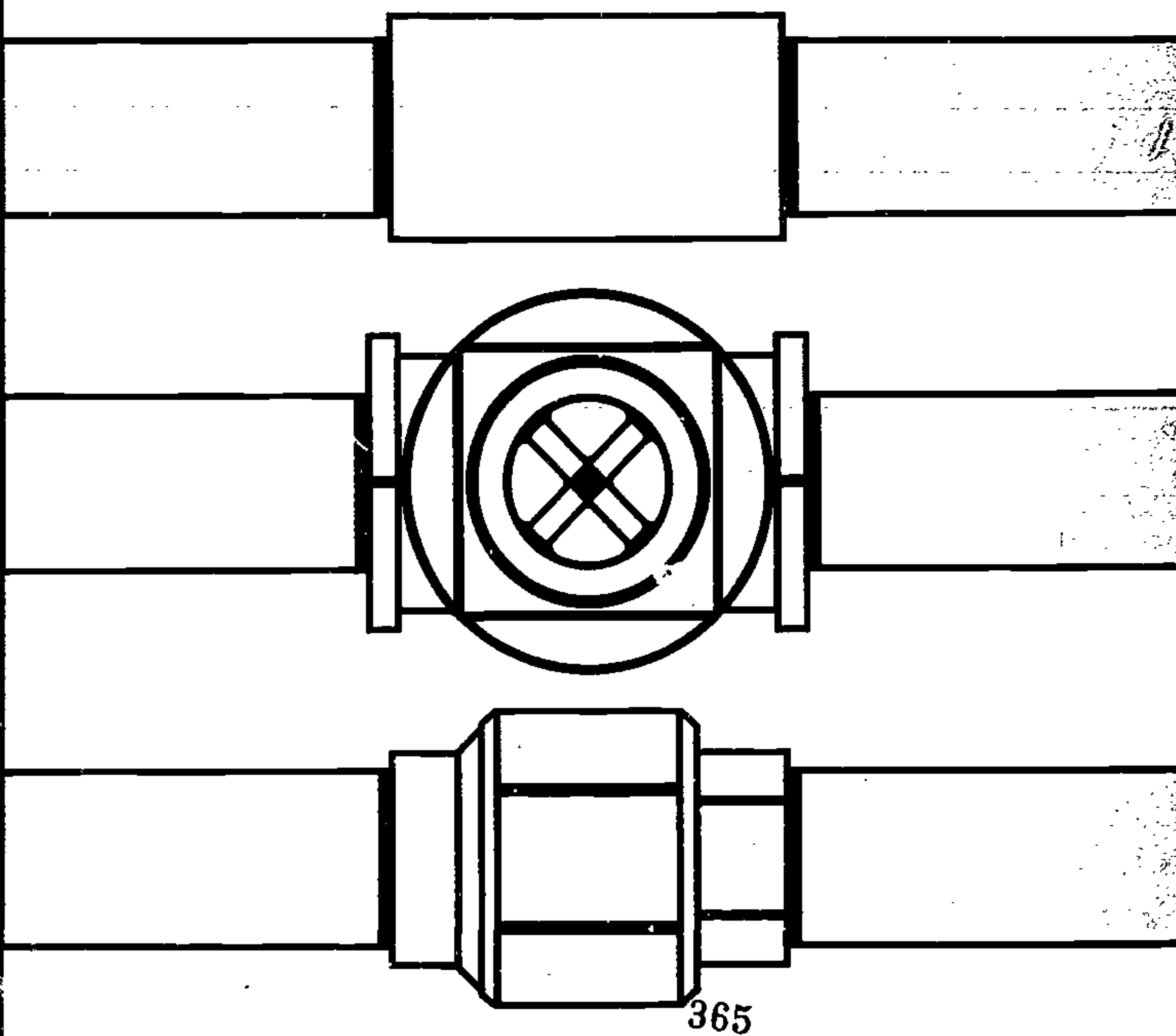
c) Multiply the number of racks per day by the number of litres of 82°C water needed per rack (using 5.6 L for a single-tank machine and 2.8 L for a two-tank machine, or the manufacturer's recommended quantities). The equipment will state the volume of 82°C, or 180°F, water needed per day for rinse sprays.

13. For purposes other than dishwashing in public establishments, a considerable volume of 60°C water is also used. To find the daily 60°C water requirements in restaurants, multiply the total number of meals served per day by the litres of 60°C water per meal. Low-price restaurants on the average use 3.4 L per meal, while medium-price and high-price restaurants use 4.5 and 5.7 L per meal respectively.

14. There are many different types of domestic water heaters, including electric, gas, oil, and heat exchangers. However, it is not practical to cover all types in this manual.

Tempered-Glass Pipe, Polybutylene Pipe, and Fittings

35



PART 35

TEMPERED-GLASS PIPE, POLYBUTYLENE PIPE, AND FITTINGS

The pipes and fittings described in this part of the manual are of two types not already dealt with. The representative product lines shown in the following pages are, in order of appearance, the tempered-glass Kimax line made in the United States by Owen-Illinois Schott Process Systems, Inc., and the polybutylene Qest line manufactured in Canada by MAC-Qest Products Limited. The textual data and illustrations have been adapted from these companies' catalogues.

1. Kimax Glass Drainline and Fittings

a) With few exceptions, Kimax glass drainline is installed in much the same manner as any other drainline system.

b) Tempered-glass pipe and fittings possess good mechanical strength, so you do not need to handle the system with kid gloves.

c) There is no limit to the length or height to which Kimax glass drainline can be installed. It can be encased inside a wall, accessible or not; it can be buried in the ground, under concrete, or inside any trough or sleeve.

d) For an above-ground installation, this pipe is available in 1.5 m and 3 m lengths in diameters from NPS 1½ to NPS 6. For underground use, heavy-schedule 1.5 m lengths come protected in factory-applied expanded polystyrene casing. The system includes a complete line of glass fittings and traps, as well as accessories and hardware to meet virtually any requirement of a chemical waste-disposal system.

e) Since Kimax drainline weighs about one-seventh as much as conventional drainline materials, it is easy to handle, needs fewer hangers and joints, and sections can be pre-assembled and carried to the installation site. Expansion is negligible, therefore expansion joints are not needed, nor recommended.

f) Conventional glass-to-glass connections are made quickly and simply with No. 6650 Kimax couplings. Just as easily, you can join NPS 1½, 2, 3, and 4 glass (beaded-end) drainline to plain-end glass, metal, or rigid plastic pipe using No. 6661 Kimax B/P couplings. (See later details.)

g) When properly installed, both couplings provide leak-free joints, even with line deflections of up to 4°.

h) With B/P couplings and the Kimax portable glass cutter, you can cut and join NPS 1½ to NPS 4 glass drainline on the job site.

2. Making Joints with Kimax Drainline Couplings

Following is the procedure for joining Kimax drainline to Kimax and other glass drainline pipe and fittings using No. 6650 Kimax (bead to bead) drainline coupling. (See Figure 35-1.)

a) Dip the coupling in water or wet it inside with a damp cloth.

b) Snap the coupling over one end of the pipe, then stab the other section into the opposite side of the coupling.

c) Tighten the coupling bolt with a 150 mm ratchet wrench.

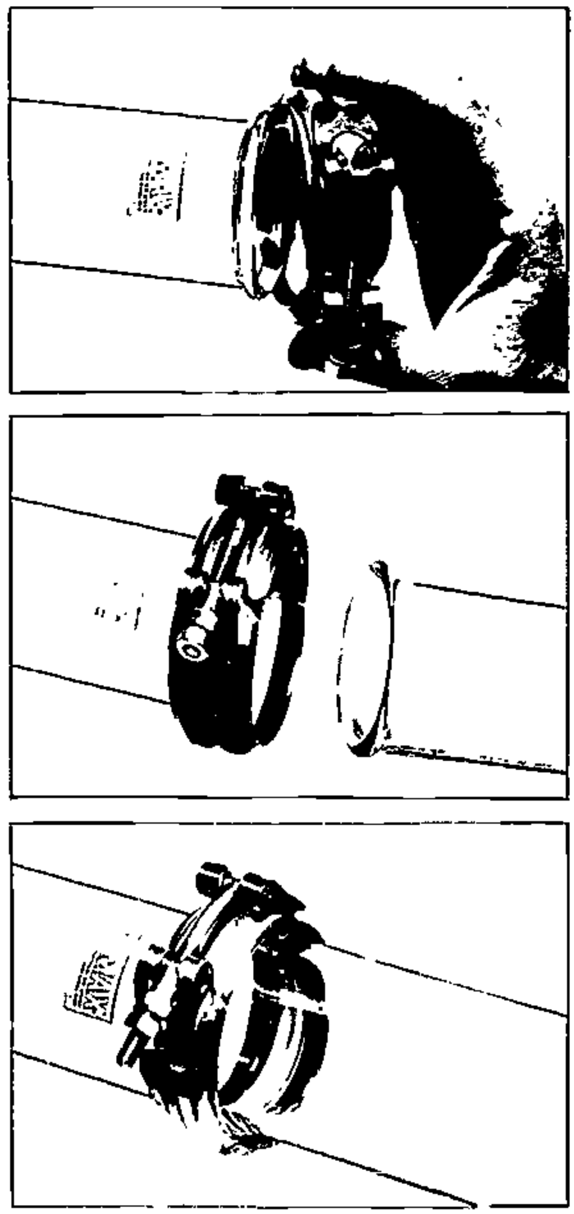


Figure 35-1. Procedure No. 1. — Using Bead-to-Bead Drainline Coupling

Following is the procedure for joining Kimax NPS 1½, 2, 3, and 4 drainline to plain-end glass, metal, or rigid plastic pipe using No. 6661 Kimax B/P (bead-to-plain-end) drainline coupling. (See Figure 35-2.)

d) Wipe the beaded end of the glass pipe with a damp cloth.

e) Snap the coupling over the beaded end of the pipe.

f) Insert, but do not force, the plain pipe into the opposite side of the coupling, making certain that the plain end is fully seated.

g) Tighten the coupling bolt or bolts with a 150 mm ratchet wrench.

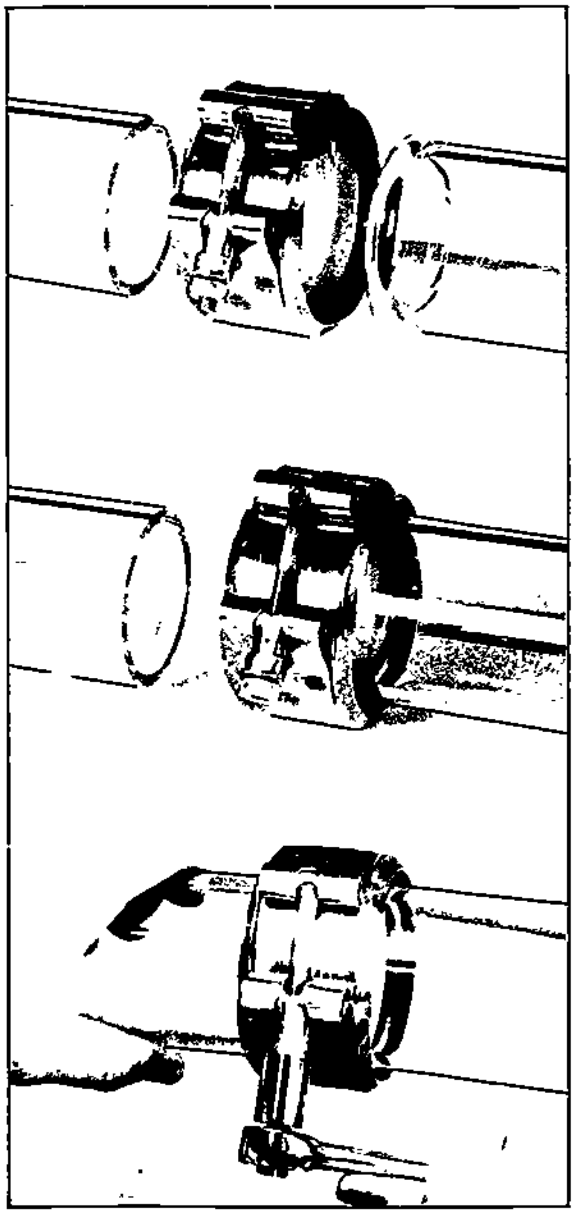


Figure 35-2. Procedure No. 2. — Using Bead-to-Plain-End Drainline Coupling

Figure 35-3. Typical Joint Reference Chart

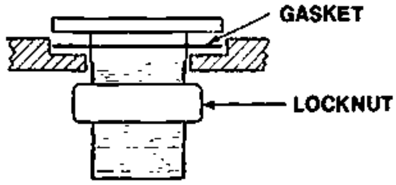
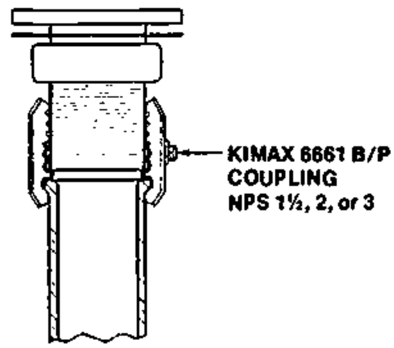
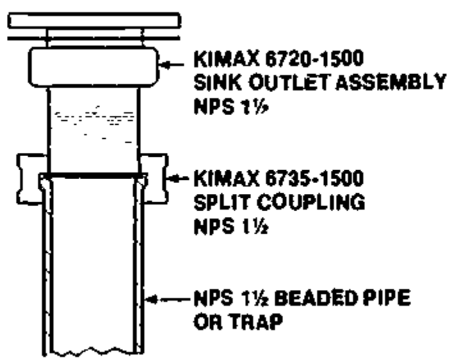
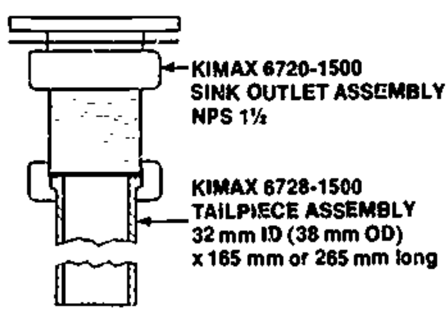
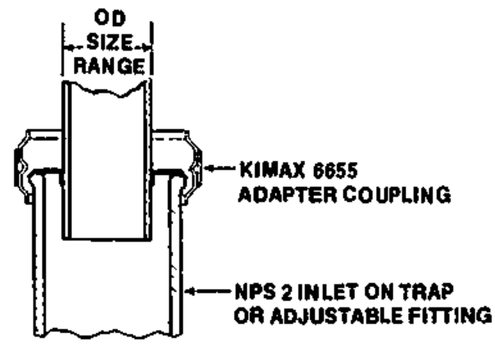
Type of Joint	Materials Needed	Steps to be Taken
Installing KIMAX sink outlet	 Size of Outlet / Hole / Counterbore NPS 1½ / 50 mm / 90 x 8 mm NPS 2 / 64 mm / 105 x 8 mm NPS 3 / 95 mm / 130 x 9 mm	1. Drill hole in sink bottom as indicated for size of outlet being installed. 2. Drill counterbore to proper diameter and depth. 3. Smooth bottom of the counterbore and insert gasket. 4. Remove locknut and insert outlet through sink hole. 5. Screw locknut tight against sink bottom. 6. Seal gap between outlet lip and counterbore with acid-resistant 3M-EC-612 caulking compound or equivalent. **Note:** Install stainless steel in same manner as above.
NPS 1½, 2, or 3 KIMAX sink outlet to KIMAX beaded pipe or trap (same size)		1. Snap coupling over beaded end of pipe or trap. 2. Slide opposite (grooved) side of coupling onto threaded outlet. Do not force but make certain that outlet end is fully seated in coupling. 3. Tighten coupling bolt with a 150 mm ratchet wrench.
NPS 1½ KIMAX (or plastic or metal NPS threaded) sink outlets to NPS 1½ KIMAX beaded pipe or trap		1. Remove clamp from split coupling. 2. Position coupling halves over glass bead. 3. Replace and tighten clamp. 4. Screw coupling onto threaded outlet. **Note:** Use 6739 gasket when connecting KIMAX beaded pipe or trap to metal threaded sink outlet.
NPS 1½ KIMAX (or plastic or metal NPS threaded) sink outlets to NPS 1½ KIMAX tailpiece assembly		1. Slide plastic nut up to top (beaded end) of tailpiece. 2. Screw nut onto threaded outlet. **Note:** Use 6738 gasket when connecting glass tailpiece to metal threaded sink outlet.

Figure 35-3. Typical Joint Reference Chart (continued)

<table>
<tr><th>Type of Joint</th><th>Materials Needed</th><th>Steps to be Taken</th></tr>
<tr>
<td>38 mm KIMAX (or other glass, metal or plastic) plain-end tailpiece or plain-end cupsink to 50 mm KIMAX trap inlet or adjustable fitting</td>
<td>
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1. Snap coupling over beaded end of trap inlet.
2. Slide coupling up over plain-end tailpiece or cupsink to desired height.
3. Tighten coupling bolt with a 150 mm ratchet wrench.

Note: Use KIMAX adapter coupling NPS 2 x NPS 1¾ to connect to Pyrex sink outlet or plain-end cupsink.

<table>
<tr><th>Coupling Size</th><th>Tailpiece Style</th><th>OD Size Range</th></tr>
<tr><td>NPS 2 x 1½</td><td>KIMAX glass tailpipe extension No. 6728, metal tubing, and lead tailpiece extensions</td><td>38 to 39 mm</td></tr>
<tr><td>NPS 2 x 1¾</td><td>Lead, Class D or XL tailpiece
PYREX tailpiece and cupsink</td><td>43 to 45 mm</td></tr>
<tr><td>NPS 2 x 1¾</td><td>Plain end KIMAX Regular Schedule or Heavy Schedule NPS 1½ glass pipe or fittings
Ourcon # SO-2
Duriron # 11713
Lead - Class C or L, B or M
Plastic or steel (NPS 1½)</td><td>46 to 48 mm</td></tr>
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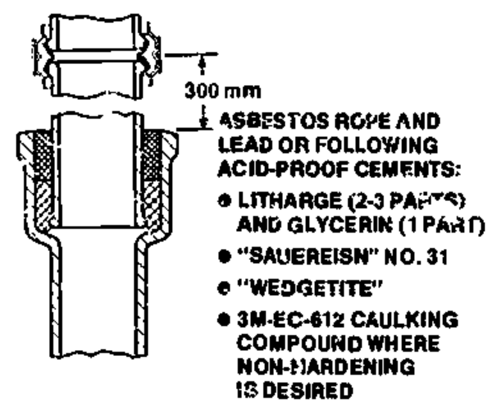
<tr>
<td>KIMAX beaded or plain-end pipe to metal bell and spigot pipe</td>
<td>
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1. For line flexibility, place coupling within 300 mm of caulked joint.
2. If using plain-end glass pipe, smooth external rough edges with fine carborundum stone or 150-grit emery cloth.
3. Insert glass into hub using care not to scratch glass. Pack space between glass and hub firmly with asbestos rope — then back off glass 3 to 6 mm from base of hub.
4. Pour in lead* at lowest pour temperature and caulk lightly — or fill with acid-proof cement.

Note: If lead is used, pre-heat glass first until water drop sizzles.

*Pack with lead wool if joining glass to vitreous tile hub.
</td>
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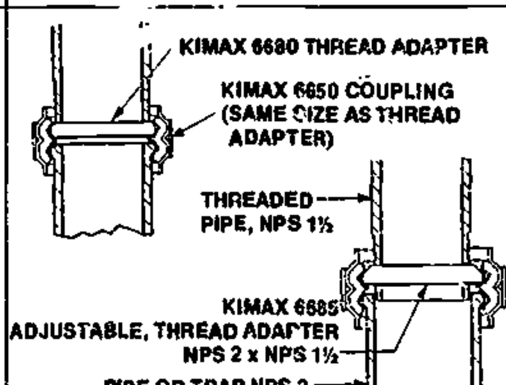
<tr>
<td>Metal or plastic NPS threaded pipe (straight or tapered), NPS 1½, 2, 3, 4, or 6 to KIMAX beaded pipe or trap (same size)</td>
<td>
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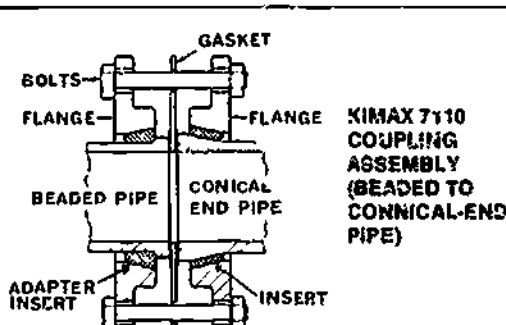
1. Screw thread adapter onto threaded pipe until it "bottoms." With adjustable adapter, screw it into threaded pipe until desired height of adjustment is reached.
2. Snap coupling over adapter.
3. Stab beaded pipe or trap into opposite side of coupling.
4. Tighten coupling bolt with a 150 mm ratchet wrench.

Note: Use 6685 adjustable adapter to join NPS 1½ threaded pipe to NPS 2 KIMAX beaded trap or pipe.
</td>
</tr>
<tr>
<td>KIMAX (conical end) process pipe, NPS 1½, 2, 3, 4, or 6 to KIMAX beaded pipe or trap (same size)</td>
<td>
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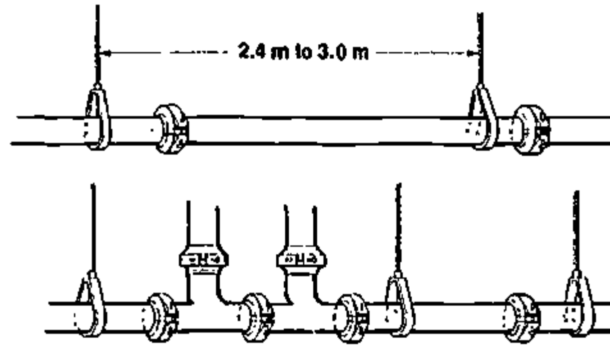
<td>

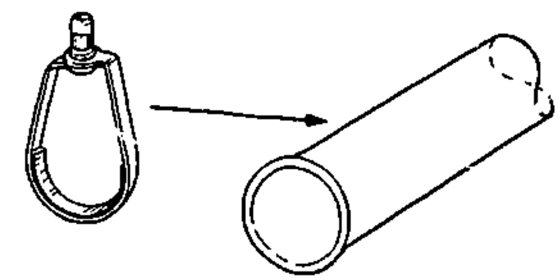
1. Disassemble coupling and remove inserts.
2. Slide proper flange over conical-end pipe and snap in flange insert.
3. Slide other flange over beaded-end pipe and snap in flange adapter insert.
4. Slide both flanges firmly against pipe ends.
5. Inset gasket between pipe ends.
6. Replace bolts and tighten nuts evenly.
</td>
</tr>
</table>

Figure 35-4. Hanging Kimax Drainline — Horizontally

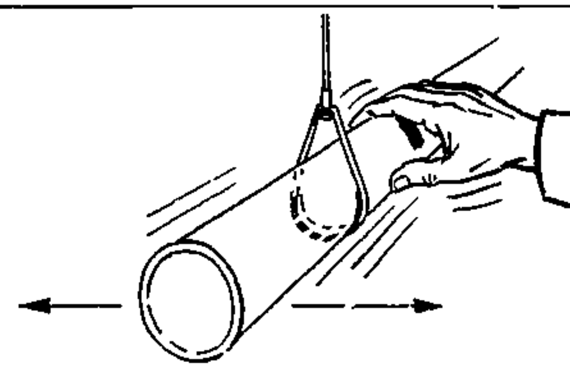
- To prevent glass-to-metal contact, use padded hangers to support lines every 2.4 m to 3.0 m.
- Use extra hanger when three or more couplings fall within 2.4 m to 3.0 m span.



- Do not pull or spring pipe into place. Move hanger to pipe, not pipe to hanger.
- Completely tighten coupling as each joint is made.

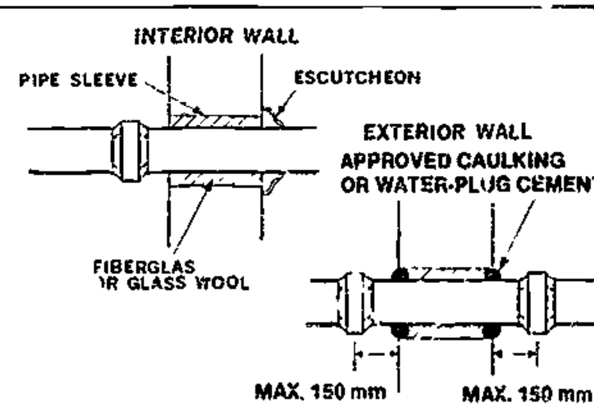


- Keep lines loose. When horizontal lines are hung they should be free to move sideways.



- Pipe passing through walls should be fitted with pipe sleeve at least 50 mm greater in diameter than pipe OD.
- Pack space between pipe and sleeve with Fiberglas or glass wool.

  Note: For fire, water, or explosion-proof walls, pack ends of pipe sleeve with caulking material — and space couplings no more than 150 mm on either side of wall.



- To pitch a line, snug coupling, cock joint to pitch required, and tighten coupling

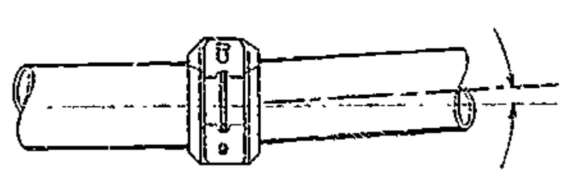
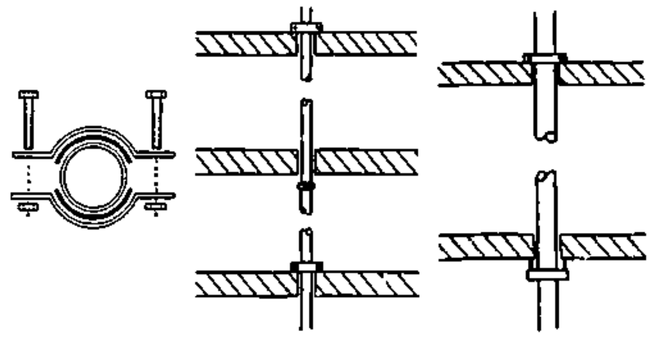
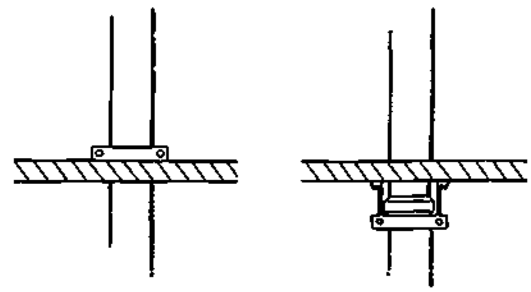


Figure 35-5. Hanging Kimax Drainline—Vertically

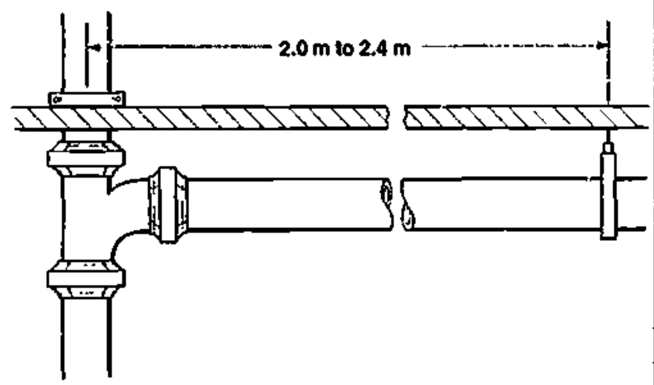
- Use riser clamp lined with 6 mm thick neoprene.
- Support NPS 1½ and 2 stacks at every other floor.
- Support NPS 3, 4, and 6 stacks at every floor.



- Place riser clamps either above or below floor.
- Clamp should be below bottom coupling in stack and, where possible, below coupling on every third floor.



- Do not support vertical stacks with horizontal lines. First hanger should be placed from 2.0 m to 2.4 m from stack.



- Pipe passing through floors or slabs should be fitted with pipe sleeve at least 50 mm greater in diameter than pipe OD.
- Pack space between pipe and sleeve with Fiberglas or glass wool.
- Install coupling within 150 mm of floor or slab to give flexibility.

Note: For fire-proof, water-proof, or explosion-proof floors, pack top of sleeve with caulking material or water-plug cement.

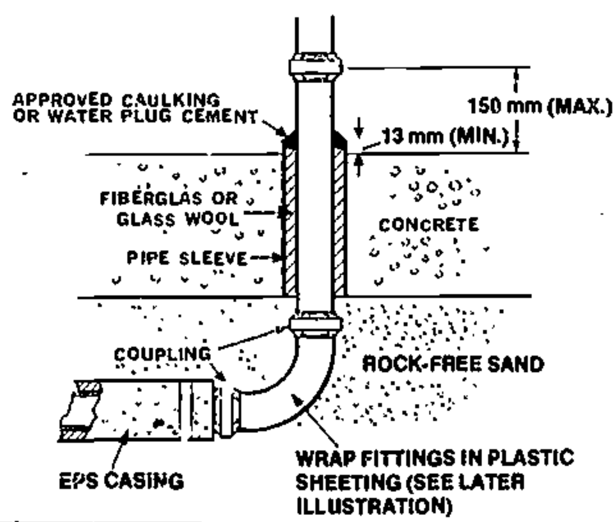


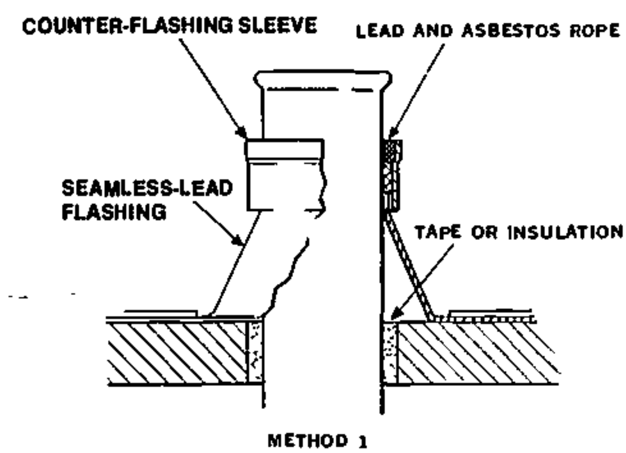
Figure 35-5. Hanging Kimax Drainline — Vertically (continued)

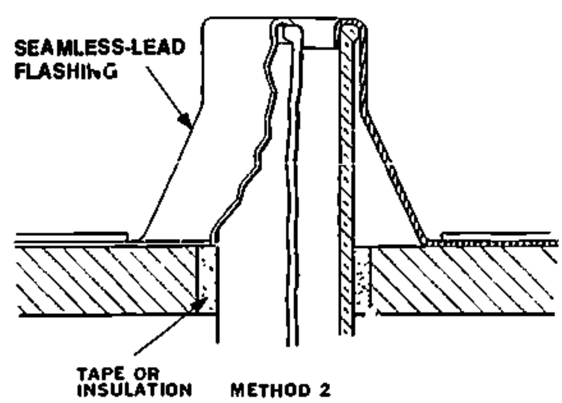
FLASHING THROUGH ROOF

When flashing through a roof, wrap the vent pipe with tape or an insulating material and follow through using either of the methods below:

METHOD 1. Seamless-lead roof flashing with a caulked counter-flashing sleeve.

METHOD 2. Seamless-lead or copper roof flashing.

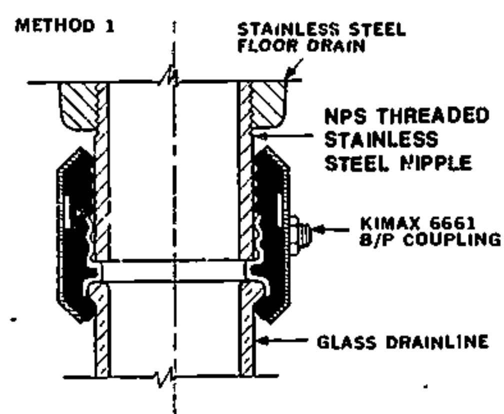




CONNECTING TO FLOOR DRAIN

METHOD 1. Screw NPS threaded metal nipple into outlet of floor drain and join the glass pipe or fitting to nipple using a KIMAX 6661 B/P coupling.

METHOD 2. Cut glass pipe to desired length using KIMAX portable cutting tool. Smooth external sharp edges from cut end and insert into outlet of floor drain. Seal glass in place using asbestos rope and acid-proof cement.



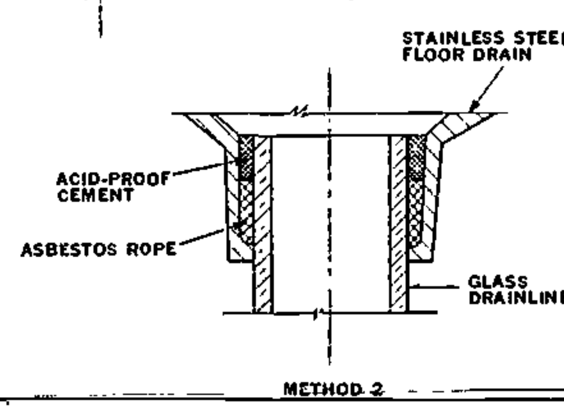
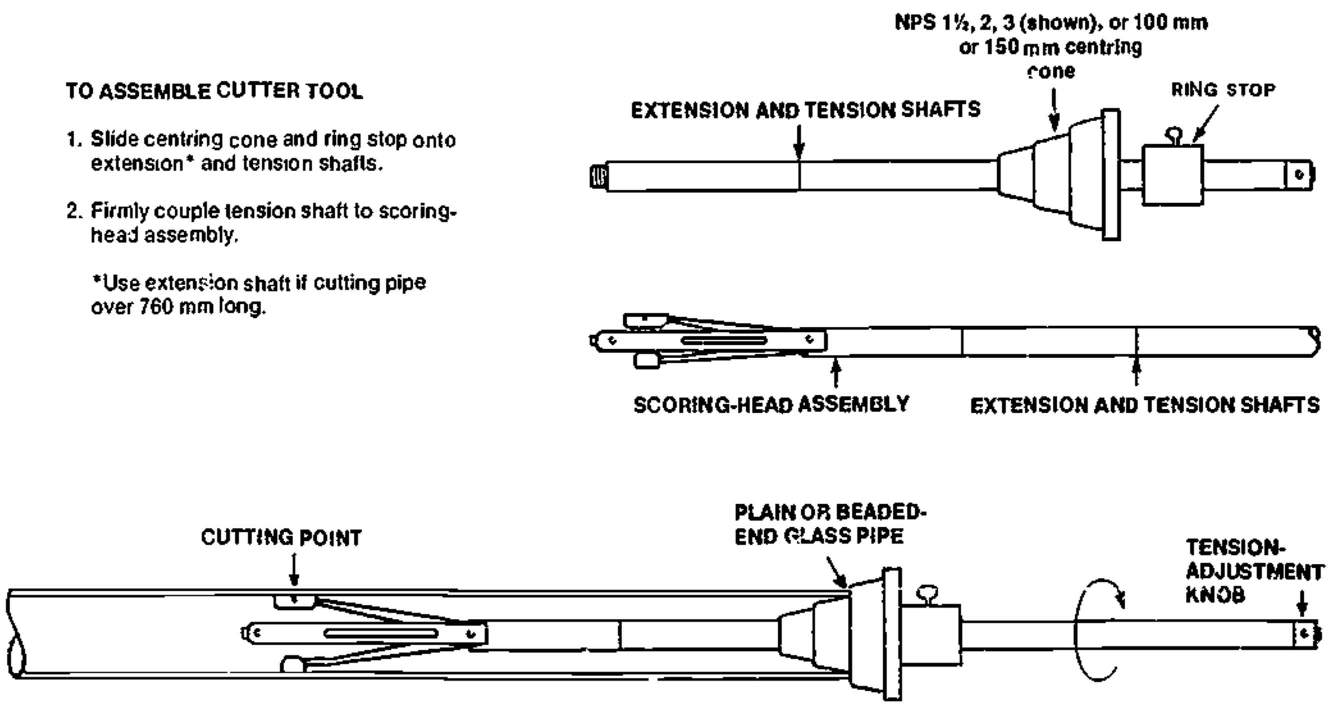


Figure 35-6. Kimax Portable Cutter No. 7310- 56802

TO ASSEMBLE CUTTER TOOL

1. Slide centring cone and ring stop onto extension* and tension shafts.
2. Firmly couple tension shaft to scoring-head assembly.

*Use extension shaft if cutting pipe over 760 mm long.



TO USE CUTTER TOOL

1. Measure length of pipe required and mark cutting point with grease pencil.
2. Insert scoring head into pipe with cutter wheel up.
3. Slide centring cone into pipe until firmly seated against cut or beaded end.
4. Slide ring stop against cone, align cutter wheel with pencil mark, then lock ring stop using thumb scr 'v.
5. Turn tension adjustment knob clockwise until cutter wheel contacts glass Re-check alignment of cutter wheel with pencil mark.
6. Continue turning tension knob clockwise to give sufficient pressure on cutting wheel to score glass (medium to light score is desirable).
7. With pipe firmly pressed onto centring cone (and cone against ring stop), make test score (about 6 mm long) by turning tension shaft. Make final tension adjustment if necessary.

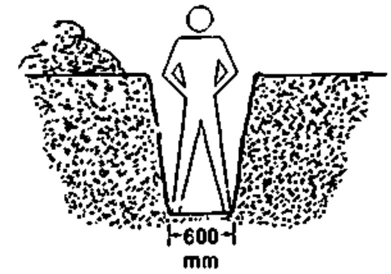
*NOTE: DO NOT ATTEMPT TO CUT WITHIN 200 mm OF A FACTORY-BEADED PIPE END.

8. Complete score by turning tension shaft one full turn making sure not to score beyond starting point.
9. Turn tension knob counter-clockwise to draw cutter wheel away from glass, and remove cutter tool from pipe.
10. Light crack-off torch (Burns-O-. ,· :: or other suitable hand torch).
11. Apply heat on score mark. As pipe starts to separate, follow score mark with flame. You may find it necessary to gently tap one end of pipe on table top to complete crack-off.
    a) If cut end is to be used with KIMAX B/P coupling, smooth external sharp edge at approximately 45° angle with fine carborundum stone or 150-grit emery cloth.
    b) If end is to be beaded on KIMAX beading kit, do not smooth edge but proceed with beading as described in KIMAX Cutting and Beading Manual.

Figure 35-7. Installing Kimax Drainline — Underground

EXCAVATING TRENCH

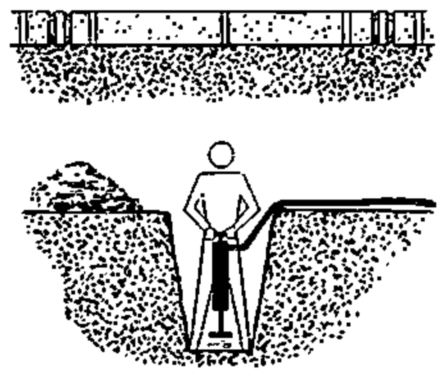
Excavate trench to workable width (600 mm at bottom) and 25 to 50 mm below final grade if clean dirt; or 100 to 150 mm below grade if rocky or clay condition.



TRENCH BEDDING

Trench should have firm bed in order to support pipe uniformly along its full length.

Back-fill to final grade with pea gravel or rock-free sand or soil. Tamp back-fill to assure firm bed and level off mounds or fill depressions with tamped soil.



INSTALLING PIPE

Use 1.5 m lengths of EPS-covered heavy schedule drainline pipe and fittings. Remove EPS end caps only, and couple pipe and/or fittings in usual manner.

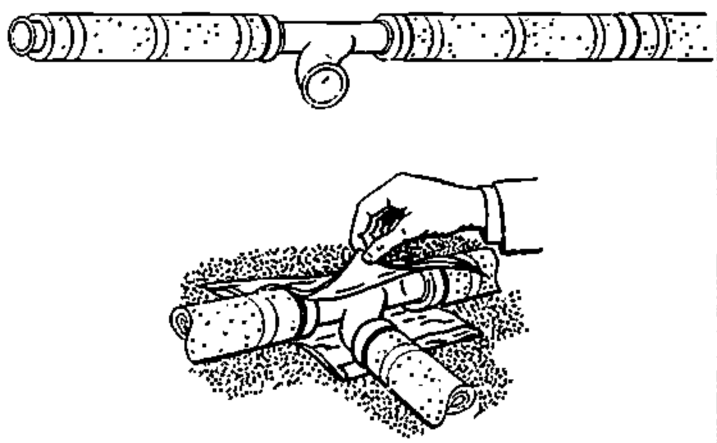
When convenient, assemble several joints to form a section, tighten couplings firmly, and lower section into trench.

Protect fittings by wrapping them in polyvinyl film (0.13 mm), Scotch Wrap, or J-M Trans-Tex or equivalent.

Compact sand under fittings for support.

Check all joints and water test.

Note: When odd lengths of pipe are required, remove EPS casing and field-fabricate the pipe to required length. Cut casing 50 mm shorter than new length and replace on pipe leaving 25 mm of pipe exposed at both ends.



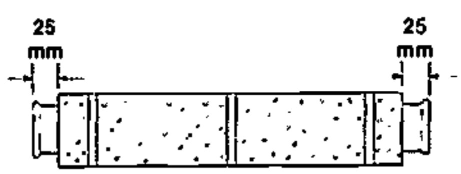


Figure 35-7. Installing Kimax Drainline — Underground (continued)

BACK-FILLING TRENCH
Back-fill the trench with thin layers of rock-free sand or soil to 300 mm above the glass pipe.

Tamp the sand firmly with hand tamper or spray it with water to make sure it is firm.

The rest of the trench can be filled with available soil using mechanical means.

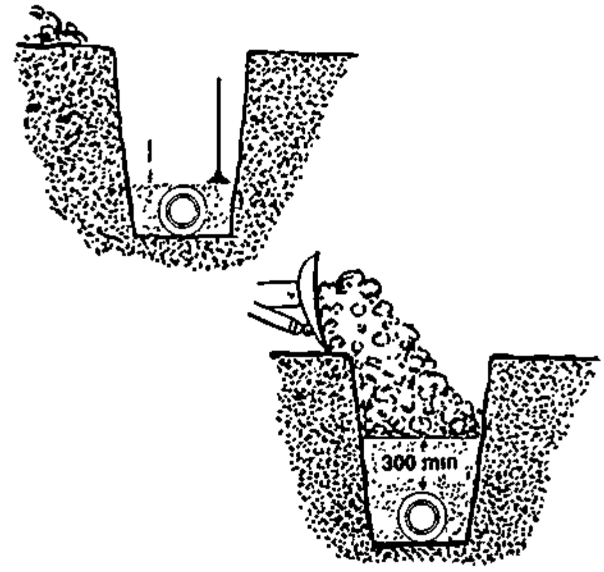


Figure 35-8. Testing and Protecting Glass Drainline

TESTING
Shake lines to make sure there is no strain. There should be some limited movement in both vertical and horizontal lines.

Test lines in accordance with local codes. Air testing should not exceed 35 kPa; water testing should not exceed 15.0 kPa.

IN CASE OF A LEAK
Tighten coupling at the leaking joint.

If the joint continues to leak, remove coupling and make certain that rubber compression liner and TFE seal ring are free from dirt or other obstruction; also that ends of pipe or fittings are properly seated in couplings.

Replace defective couplings and pipe, as well as fittings that have defective beaded ends.

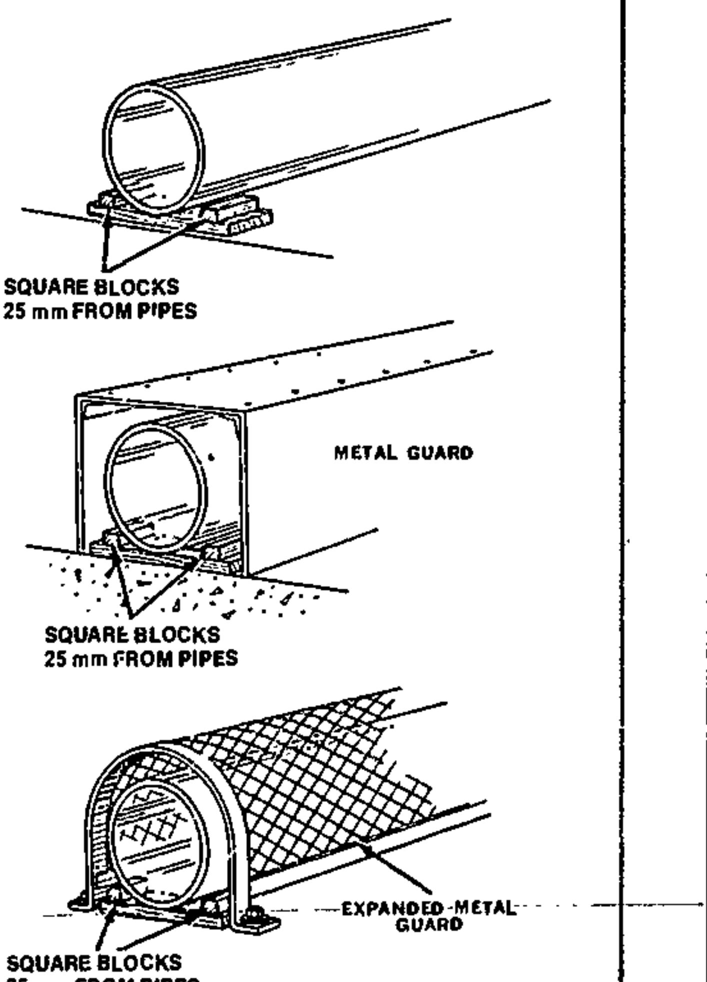
Check for good drainline alignment.

PROTECTING
Avoid scratching the glass by keeping the pipe and fittings in shipping cartons until ready for use.

Avoid spattering the glass while welding. Cover drainline with shipping carton or other protective material.

When exposed to heavy traffic, protect drainline with expanded metal, plywood enclosure, or channel iron.

CLEANING PROCEDURE
To clean the drainline system, clear section of plugged drainline with wooden pole or add chemicals which will dissolve the material causing stoppage.



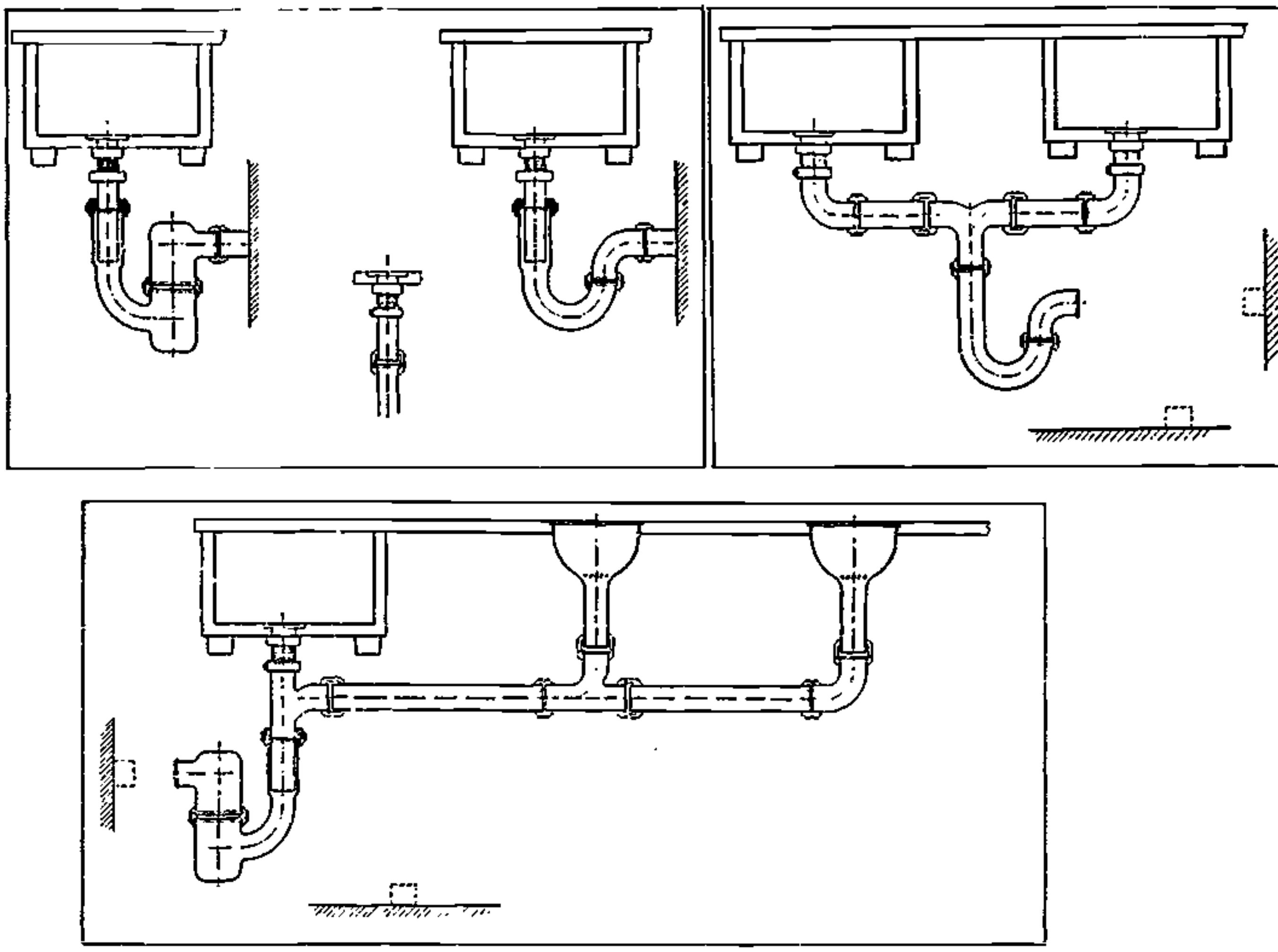


Figure 35-9. Typical Single-Sink and Multiple-Sink Layouts Using Kimax Drainline

Kimax BK-5 Portable Beading Unit

This unit permits simplified field-beading of glass pipe. It is designed so that the operator can form a bead on NPS ½ to NPS 6 pipe that has the same compatibility in coupling as factory-beaded pipe. For operational details, consult the Kimax Cutting and Beading Manual FPS-BK5.

Kimax Portable Glass Cutter

This cutter is for on-the-job scoring and cutting of special lengths of glass pipe. For operational details, consult the Kimax Cutting and Beading Manual FPS-BK5.

QEST POLYBUTYLENE PRESSURE PIPING SYSTEM

This is an all-purpose plastic tubing for both hot and cold water pressure applications. It is extruded from high-strength, high-temperature polybutylene material in conformance with appropriate standards, is available in popular copper-tubing sizes, and is NSF-approved for 82°C (continuous) at pressures of 690 kPa. It is used with approved plastic fittings or brass flare fittings.

1. Qicktite Connections

a) Slip the nut onto the tubing. Position the ring onto the tubing approximately 6 mm from the end.

b) Snap the cone onto and flush with the tubing end.

c) Turn the nut onto the valve thread hand-tight. Take one more turn with a wrench but do not over-tighten it. Polybutylene tubing can be cut with a pocket knife, a plastic tubing cutter, or snips.

d) Direct connection (without adapters) is made to: copper tubing, CPVC tubing, and polybutylene tubing (Figure 35-10).

e) Connection (through adapters) is also made to: galvanize, copper, brass, and CPVC tubing (Figure 35-11).

2. QEST Tubing Particulars

Table 35-1. Coils

NPS	Metres Per Coil	Mass (kg)
¼ ID × ⅜ OD	30	1.1
¼ ID × ⅜ OD	300	11.3
⅜ ID × ½ OD	30	1.8
⅜ ID × ½ OD	300	18.1
½ ID × ⅝ OD	30	2.5
½ ID × ⅝ OD	300	24.9
¾ ID × ⅞ OD	30	40.1

Table 35-2. Straight Lengths

Length (m)	NPS	Bundle Quantity (m)	Mass (kg)
3	¼ ID × ⅜ OD	300	11.3
6	¼ ID × ⅜ OD	300	11.3
3	⅜ ID × ½ OD	300	17.2
6	⅜ ID × ½ OD	300	17.2
3	½ ID × ⅝ OD	300	24.9
6	½ ID × ⅝ OD	300	24.9
3	¾ ID × ⅞ OD	150	20.4
6	¾ ID × ⅞ OD	150	20.4

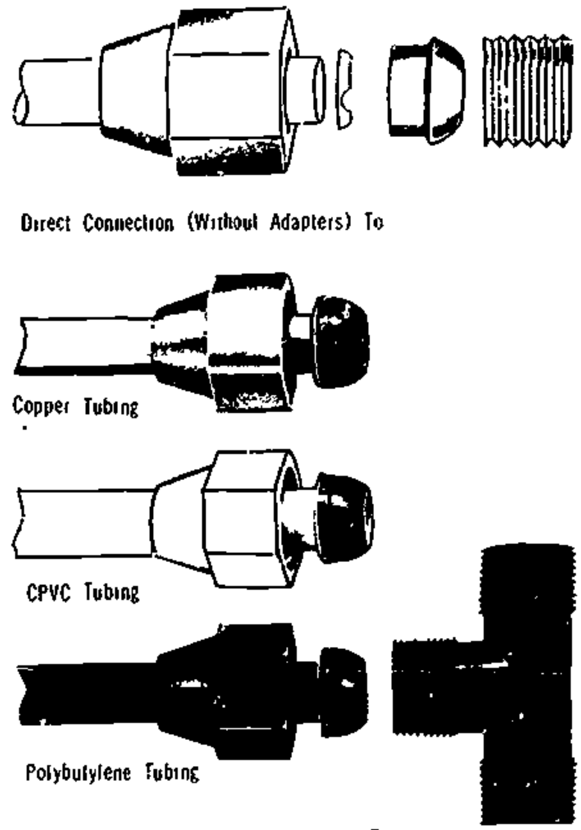


Figure 35-10. Qicktite Direct Connectors

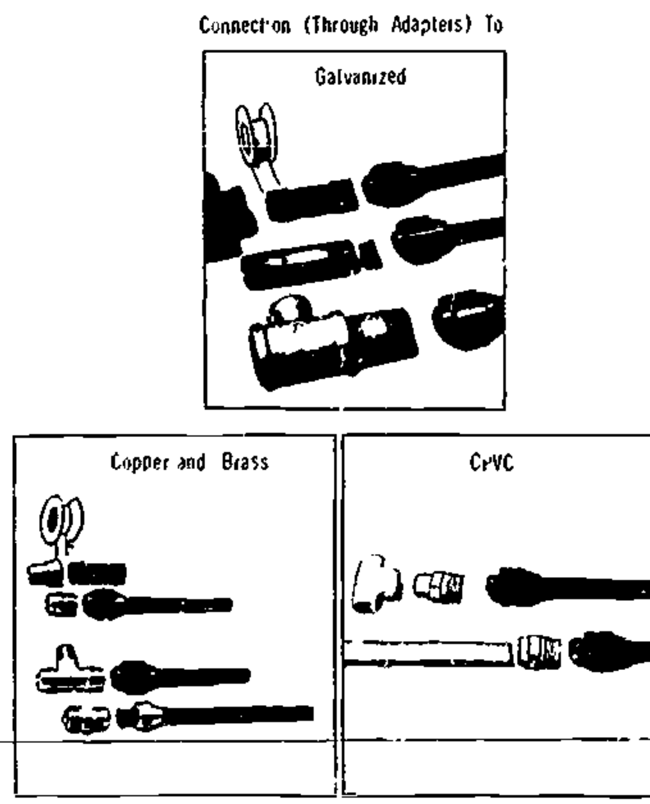


Figure 35-11. Qicktite Connectors Requiring Adapters

3. Qicktite Seating Sets

The manufacturer claims that Qicktite seating sets (cone, ring, and nut) make it possible to obtain professional results without the use of special tools or mechanical skills and that this unique and revolutionary concept provides the ultimate in simplicity. Particulars appear in Tables 35-3 and 35-4.

Table 35-3. Seating Sets

Thread Size (NPS)	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½	100	1.8	1000	15.4
½	100	1.4	1000	14.1
¾	100	2.3	1000	20.9
1	25	0.9	250	8.2

Table 35-4. Qest Size Conversion Chart

Tubing Size	Qest Fitting Thread Size	Use	Qicktite Sealing Set
1438 (100P)	½	→	CRN-1438 (375 FNCR)
3812 (200P)	½	→	CRN-3812 (500 FNCR)
1258 (300P)	¾	→	CRN-1258 (625 FNCR)
3478 (400P)	1	→	CRN-3478 (1000 FNCR)

4. Celcon Fittings (Satin Chrome Color)

The following Figures and Tables give information concerning various fittings made from Celcon providing compatibility with other products.

5. Tees

Table 35-5. Tees

Thread Size (NPS)	A (mm)	B (mm)	C (mm)	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½ × ½ × ½	62	31	31	50	0.9	1000	19.1
¾ × ¾ × ¾	73	37	37	50	1.6	500	14.1
¾ × ¾ × ½	73	37	37	50	1.4	500	14.1
¾ × ½ × ¾	73	37	37	50	1.4	500	14.1
¾ × ½ × ½	73	37	37	50	1.1	500	14.1
½ × ½ × ¾	62	31	37	50	1.4	500	10.9
1 × 1 × 1	92	48	44	20	1.8	200	16.3
1 × 1 × ¾	92	48	44	20	1.8	200	16.3
1 × ¾ × 1	92	48	44	20	1.8	200	16.3
1 × ¾ × ¾	92	48	44	20	1.8	200	16.3

6. Ells

Table 35-6. Ells

Thread Size (NPS)	A (mm)	B (mm)	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½ × ½	31	31	100	1.4	1000	14.1
½ × ⅜	31	31	100	1.4	1000	14.1
½ × ¼	31	31	100	1.4	1000	14.1
¾ × ¾	35	36	50	1.1	500	12.7
¾ × ½	37	37	50	1.1	500	12.7
1 × 1	48	48	25	1.6	250	7.7
1 × ¾	48	48	25	1.6	250	7.7

7. Drop-Ear and Street Ells

Qest Magic Seal Cones are broached into the 13 mm female side to properly seal any direct pipe-thread connection. (See Figure 35-14 and Table 35-7.)

Table 35-7. Drop-Ear and Street Ells

Thread Size (NPS)	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
		Drop-Ear Elbow		
½ F × ½ M	50	1.8	500	18.1
½ F × ¾ M	50	1.8	500	18.6
		Street Ell		
½ F × ½ M	50	1.2	500	11.8
½ F × ¾ M	50	1.3	500	12.7

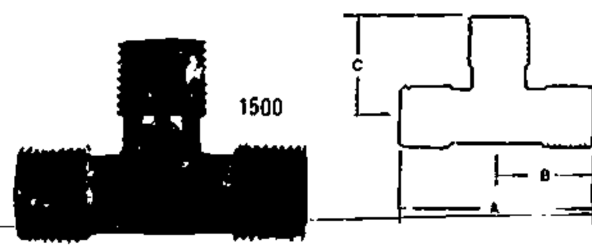


Figure 35-12. Tees

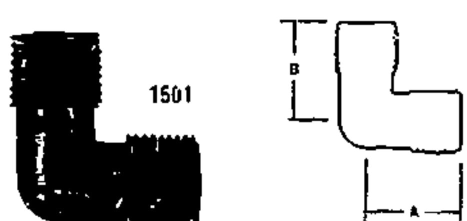


Figure 35-13. Ells

8. Male Couplings

Table 35-8. Male Couplings

Thread Size (NPS)	A (mm)	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½ × ½	44	100	1.4	1000	14.1
½ × ⅜	62	100	1.4	1000	13.2
½ × ¼	62	100	1.4	1000	12.2
¾ × ¾	73	50	1.1	500	11.8
¾ × ½	73	50	1.1	500	11.8
1 × 1	48	25	0.7	2 50	7.7
1 × ¾	48	25	0.7	250	7.7

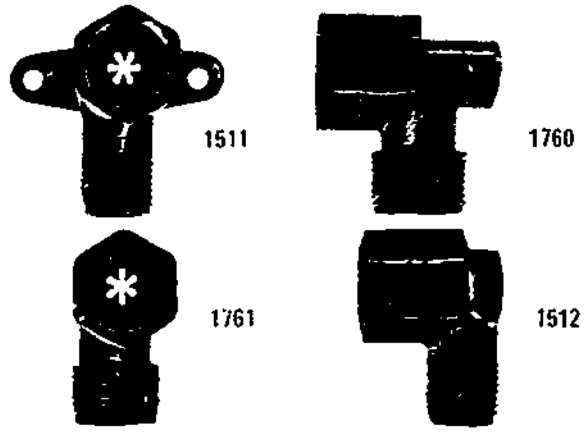


Figure 35-14. Drop-Ear and Street Ell Fittings

9. Female Couplings

Table 35-9. Female Couplings

Thread Size (NPS)	A (mm)	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½ × ½	29	100	1.2	1000	12.7
¾ × ¾	35	100	1.5	1000	15.0

Figure 35-15. Male Couplings

10. Adapters

Table 35-10. Fitting Adapters

NPS	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
¾ MPT × ½ FPT	50	0.6	500	8.4
1 MPT × 1 FPT	25	0.8	250	8.6

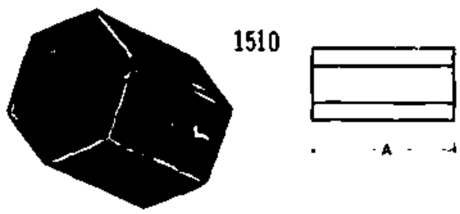


Figure 35-16. Female Coupling

Table 35-11. Slip and Street Fittings
Adapts to CPVC

NPS	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½ Male Thread X ½ Female Slip	100	0.9	1000	9.5
½ Male Thread X ½ Male Slip	100	1.1	1000	11.8

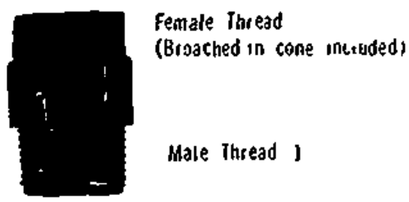


Figure 35-17. Fitting Adapter

Pipe Insert

Table 35-12. Pipe Insert
Adapts to galvanized nipple

NPS	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½	100	0.2	1000	2.3

For connecting NPS ½ galvanized pipe to Qest series 1438 (100P) tubing only.

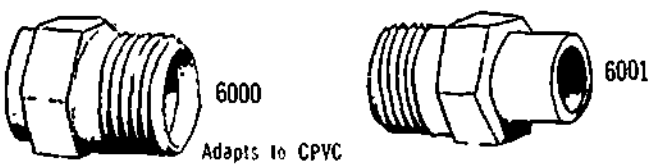


Figure 35-18. Slip and Street Fittings

Cap With Cone

Table 35-13. Cap with Cone

NPS	A (mm)	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½	19	,30	1.2	1000	12.7

Figure 35-19. Pipe Insert

11. Accessories

Table 35-14. Tubing Hanger Straps

NPS	Bag Qty.	Case Qty.	Mass (kg)
For ⅜ OD Tube	100	1000	0.6
For ½ OD Tube	100	1000	0.6
For ⅝ OD Tube	100	1000	0.7
For ⅞ OD Tube	100	1000	0.7
19 mm wide strapping—15 m coils		0.7	

Table 35-15. Check Valve

NPS	A (mm)	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½ × ½	62	100	1.8	1000	18.6

12. Angle and Straight Stop Valves (Satin Chrome Color)

Female × Compression (Supply) Outlet

Rating: 1100 kPa; 82°C. Non-corroding; no freeze damage; non-liming Celcon.

Table 35-16. Angle Stop Valves

Inlet NPS × OD Tube Outlet (NPS)	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
⅜ F.I.P. × ⅜ Compression	10	0.6	100	5.7
⅜ F.I.P. × ½ Compression	10	0.6	100	5.7
½ F.I.P. × ⅜ Compression	10	0.6	100	5.7
½ F.I.P. × ½ Compression	10	0.6	100	5.7

Table 35-17. Straight Stop Valves

Inlet NPS × OD Tube Outlet (NPS)	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
⅜ F.I.P. × ⅜Compression	10	0.6	100	5.9
⅜ F.I.P. × ½ Compression	10	0.6	100	5.9
½ F.I.P. × ⅜ Compression	10	0.6	100	5.9
½ F.I.P. × ½ Compression	10	0.6	100	5.9

For direct connection to standard pipe threads

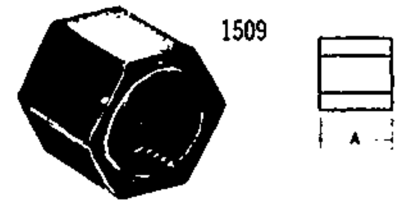


Figure 35-20. Cap with Cone

Figure 35-21. Tubing Hanger Strap

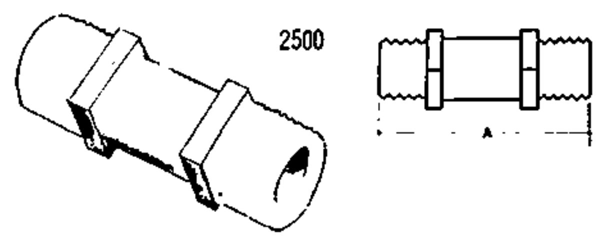


Figure 35-22. Check Valve

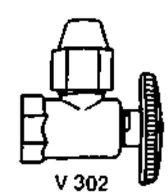


Figure 35-23. Angle Stop Valves

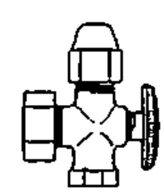


Figure 35-24. Straight Stop Valves

13. Qicktite Connection × Compression (Supply) Outlet

Table 35-18. Angle Valves

Nominal Tube Inlet × OD Tube Outlet	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
⅜ Qicktite × ⅜ Compression	10	0.6	100	5.9
⅜ Qicktite × ½ Compression	10	0.7	100	6.8
½ Qicktite × ⅜ Compression	10	0.7	100	6.8
½ Qicktite × ½ Compression	10	0.7	100	6.8

Table 35-19. Straight Valves

Nominal Tube Inlet × OD Tube Outlet	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
⅜ Qicktite × ⅜ Compression	10	0.6	100	5.9
⅜ Qicktite × ½ Compression	10	0.6	100	5.9
½ Qicktite × ⅜ Compression	10	0.6	100	5.9
½ Qicktite × ½ Compression	10	0.6	100	5.9

For direct connection to polybutylene, copper, or CPVC tubing without transition or adapter fittings.

14. Supply and Drain Valves

Satin chrome color. Non-corroding; non-liming Celcon. For direct connection to standard pipe threads.

Table 35-20. Supply and Drain Valves

Inlet	Outlet	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½ F.I.P.	Hose Thread	10	0.3	100	3.9
½ M.I.P.	Hose Thread	10	0.3	100	3.9
¾ M.I.P.	Hose Thread	10	0.3	100	4.1

15. Qicktite Connection

For direct connection to polybutylene, copper, or CPVC tubing without transition or adapter fittings.

Table 35-21.

Inlet	Outlet	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
⅜ Nom. Qicktite	Hose Thread	10	0.3	100	3.9
½ Nom. Qicktite	Hose Thread	10	0.3	100	3.9

16. In-line Valves

Globe shut-off. Satin chrome color. Rating: 1100 kPa; 82°C. Non-corroding; no freeze damage; non-liming Celcon.

Table 35-22. Male Inlet × Male Outlet

Inlet Thread Size	Outlet Thread Size	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½ MPT	½ MPT	10	1.1	100	11.8
¾ MPT	½ MPT	10	1.1	100	11.8
¾ MPT	¾ MPT	10	1.1	100	11.8

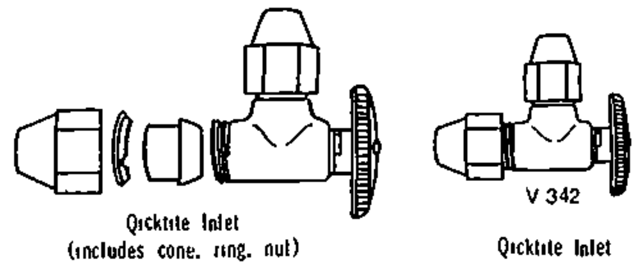


Figure 35-25. Qicktite Angle Inlet Valve

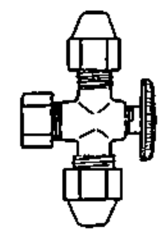


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Figure 35-26. Qicktite Straight Inlet Valve

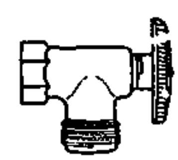

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Figure 35-27. Supply and Drain Valve

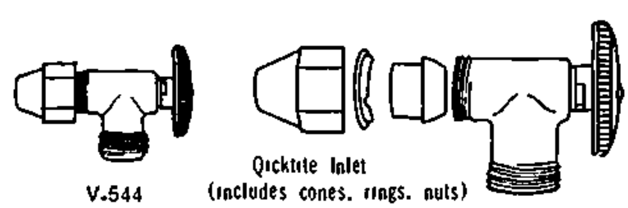


Figure 35-28. Qicktite Connection

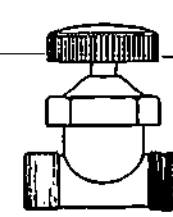


Figure 35-29. In-Line Valves, Globe Shut-Off Valves

17. Qicktite Connection

Table 35-23. Qicktite Connection

Inlet	Outlet	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
¼ Nom. Qicktite	¼ Nom. Qicktite	10	1.5	100	15.4
⅜ Nom. Qicktite	¼ Nom. Qicktite	10	1.5	100	15.4
⅜ Nom. Qicktite	⅜ Nom. Qicktite	10	1.5	100	15.4
½ Nom. Qicktite	¼ Nom. Qicktite	10	1.5	100	15.4
½ Nom. Qicktite	⅜ Nom. Qicktite	10	1.5	100	15.4
½ Nom. Qicktite	½ Nom. Qicktite	10	1.6	100	16.3

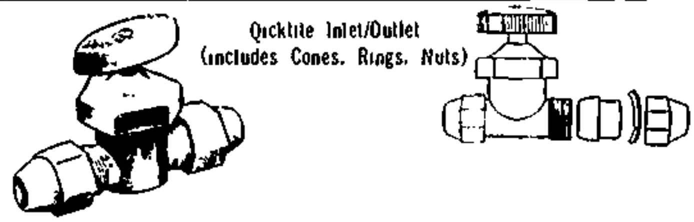


Figure 35-30. Qicktite Connection

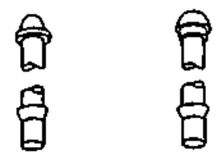


Figure 35-31. Basin/Lavatory Supply Tubing (Ferrules Included), NPS ⅜ OD x 300 mm, to NPS ½ OD x 910 mm

18. Q-Tubing

Satin chrome color. Connects to Qest or any metal stop valve. Rating: 1100 kPa; 82°C, non-corroding; no freeze damage; flexible polybutylene; non-liming.

This line of flexible plastic basin and closet supply tubing features one-piece construction. It is manufactured to rigid specifications from high-strength, high-temperature polybutylene material in accordance with ASTM D3309. Its extreme flexibility permits quick and simple installation even in hard-to-reach areas. Simply connect to faucets or closet tank using the standard nuts furnished with the fixture. Use full length or cut as desired. Connect the trimmed end to the supply fitting using the plastic ferrule furnished with the tubing.

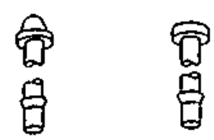


Figure 35-32. Closet Supply Tubing (Ferrules Included), NPS ⅜ OD x 300 mm, to NPS ½ OD x 910 mm

Figure 35-33. Ferrule

Table 35-24. Basin/Lavatory Supply Tubing (Ferrules Included)

NPS OD × Length	Case Qty.	Mass (kg)
⅜ OD × 300 mm	100	1.5
⅜ OD × 380 mm	100	1.9
⅜ OD × 510 mm	100	2.4
⅜ OD × 760 mm	100	3.4
⅜ OD × 910 mm	100	3.9
½ OD × 300 mm	100	2.2
½ OD × 380 mm	100	2.4
½ OD × 510 mm	100	3.5
½ OD × 760 mm	100	4.8
½ OD × 910 mm	100	6.1

Figure 35-34. Deep Bell Escutcheons

Table 35-25. Closet Supply Tubing (Ferrules Included)

NPS OD × Length	Case Qty.	Mass (kg)
⅜ × 300 mm	100	1.6
⅜ × 380 mm	100	1.9
⅜ × 510 mm	100	2.5
½ × 300 mm	100	2.0
½ × 380 mm	100	2.6
½ × 510 mm	100	3.9

Ferrules

Extra compression rings for supply tubing.

Table 35-26.

Description (NPS)	Bag Qty.	Mass (kg)
⅜ Ferrule	25	0.03
½ Ferrule	25	0.03

19. Deep Bell Escutcheons

Table 35-27.

Description (NPS)	Bag Qty.	Mass (kg)
For ½ Galv. Pipe	20	0.03
For ½ Copper Tubing	20	0.03
For ⅜ Galv. Pipe	20	0.03

20. Qest Nuts (For Tailpiece and Ballcock Connections)

Table 35-28.

Description (NPS)	Bag Qty.	Mass (kg)	Case Qty.	Mass (kg)
½ × ⅜ OD Tubing	10	0.1	100	1.2
½ × ½ OD Tubing	10	0.1	100	1.1
Ballcock thread fits both NPS ⅜ and ½ OD supply tubing	10	0.1	100	1.0

21. Coupling (For Single-Lever Faucet Hook-Up to ⅜ OD Supply Tubing)

Table 35-29.

Description (NPS)	Bag Qty.	Mass (kg)
Coupling complete with nuts, rings, and cones for Qicktite connections	10	0.7

22. Tubing Cutter (Replacement Cutter Wheel Available)

Table 35-30.

NPS	Mass (kg)
¼ OD to 1 OD	0.2

Figure 35-35. Qest Nuts

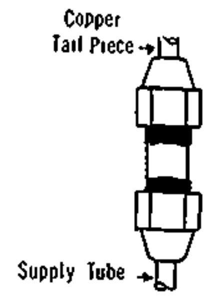


Figure 35-36. Coupling

Figure 35-37. Tubing Cutter

23. Qick/Sert II

A complete pressure plumbing system. Polybutylene tubing and Celcon barb fittings.

*(1) Tees	(7) Stop Valves	*(13) Rings
*(2) Elbows	*(8) Brass Couplers	*(14) Nuts
*(3) Couplers	(9) Brass Swivels	*(15) Coupler Washers
*(4) Drop-Ear Elbow	(10) Brass Flares	*(16) Qickler
*(5) Street Elbow	(11) Brass Thread and Barb Couplers	*(17) Polybutylene Tubing
*(6) Drain-Valve Assembly	(12) Water-Heater Hook-up	

* Illustrated in Figure 35-38.

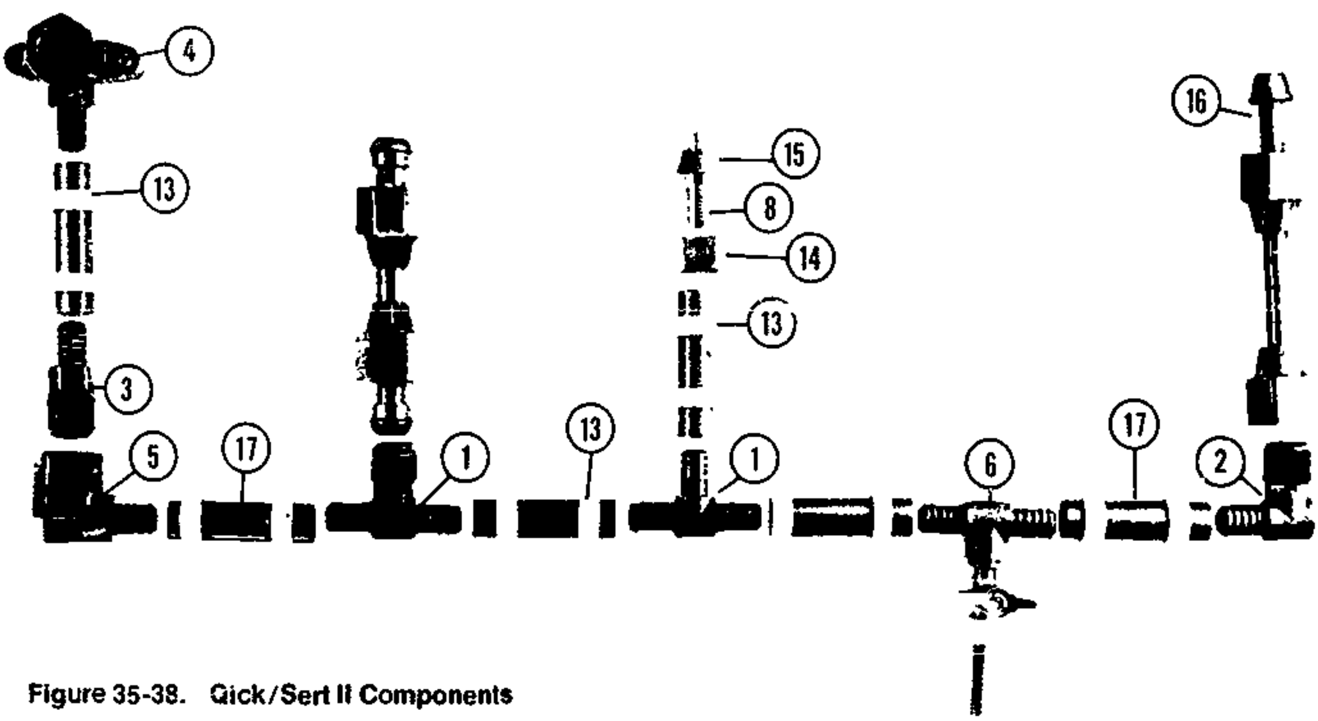
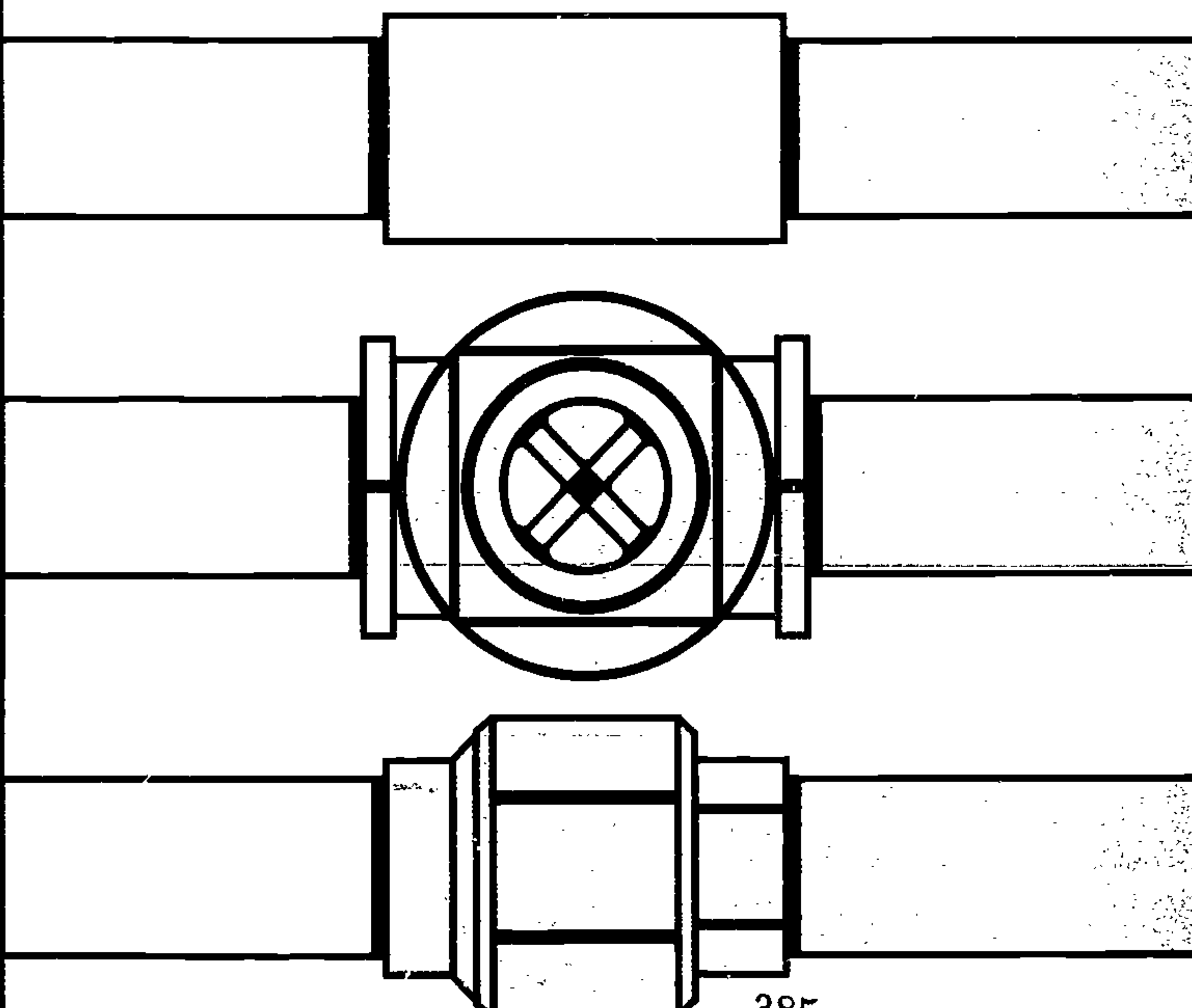


Figure 35-38. Qick/Sert II Components

36 Insulations for Piping, Fittings, and Equipment



PART 36

INSULATIONS FOR PIPING, FITTINGS, AND EQUIPMENT

Insulation prevents loss of heat from hot water pipes, keeps heat out of cold water pipes, prevents freezing water in pipes, and prevents condensation from forming on the outside of cold pipes (the forming of droplets of water when the pipe is exposed to warm air). Insulation is also used to protect people against burns, to minimize noise and vibration from heating or air-conditioning equipment or from water flowing inside pipes (such as the discharge from a water closet). It will reduce expansion and contraction of pipes.

Insulation Materials

1. Several of the following types of insulation are no longer readily available, but maintenance workers often encounter some of them.

2. Air-cell pipe covering was in general use years ago, and many older installations still have this type of insulation. It was made of fine-quality asbestos paper and was generally used to cover low-pressure steam and vapor lines. It was made in such a way that it circled the pipe with a jacket of air (air being a poor conductor of heat). Layers of plain asbestos felt were alternated with corrugated asbestos felt, each layer being about 6 mm thick. Air-cell insulation was supplied in 900 mm lengths unless otherwise ordered, and was covered with a canvas or cheesecloth jacket as shown in Figure 36-1.

3. Sponge-felt paper insulation is made of asbestos paper with a maximum amount of sponge mixed with it. It has from 37 to 40 layers to each 25 mm and is round, rigid, and closely packed. It comes in 900 mm lengths and is 25 to 75 mm thick. For valves and fittings, it is supplied in blocks of straight and perforated shapes, as shown in Figure 36-2, but this insulation is not commonly used today.

4. Moulded-cork pipe covering is a grainy material made by grinding the bark of cork trees. Its construction gives it many advantages and varied uses. The pure, clean cork is pressed and moulded to exact size and shape and finished with a coating of plastic asphalt. It is ideal for covering brine, ammonia, ice water, and all types of cold water lines. It has excellent insulating qualities over a wide low-temperature range; will not rot or burn; and is clean, sanitary, and odor-free. It comes in varied sizes and shapes for different sizes of pipes and fittings. It should be coated with a waterproof material to keep moisture out of the insulation. (Figure 36-3.)

5. Wool-felt, or hair-felt, insulation is made of matted wool fibres or wool and fur or hair, pressure-rolled into a compact material. It is used on cold water service lines and hot water return lines. This material comes in thicknesses of 13 mm to 25 mm, with a canvas jacket, and is available in 900 mm lengths. It is often used with alternated layers of tar paper to provide waterproof insulation. It is also available in rolls without a jacket.

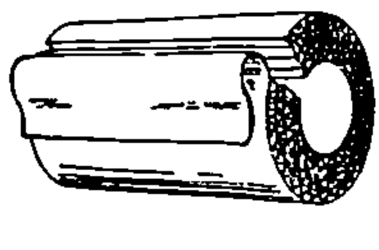


Figure 36-1. Air-Cell Insulation

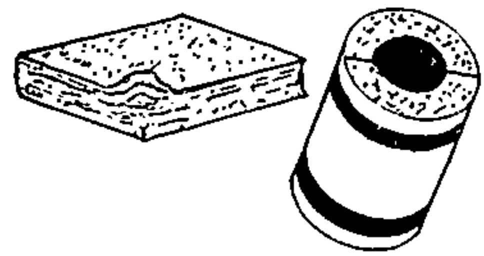


Figure 36-2. Sponge-Felt Paper Insulation

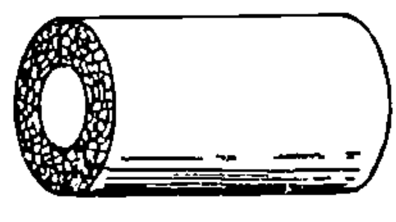


Figure 36-3. Moulded-Cork Pipe Covering

6. Flex-rubber insulation is made of a tough, flexible rubber (Figure 36-4). It has good insulating and cementing qualities, excellent weather-aging qualities, and prevents sweating of cold water lines. It is also resistant to water and fire, and is well suited for covering tubing in refrigeration and cold water lines. It comes in varied lengths with a wall thickness of 9.5 mm to 19 mm and fits pipe up to 100 mm diameter.

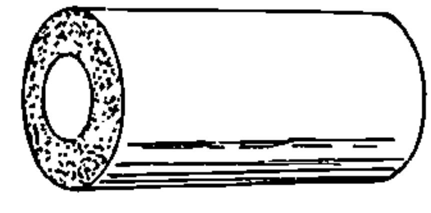


Figure 36-4. Flex-Rubber Insulation

7. Fibreglass pipe insulation is used within buildings perhaps more than any other type of insulation. It is made of very fine glass fibres bound together by an inactive resin-type mixture. It comes as a flexible hollow tube that is slit along its length to be applied to pipes and tubing, and is also shaped to fit small boilers and hot water heaters. Fibreglass insulation comes in 900 mm lengths and in thicknesses of 13 mm to 51 mm. It has long life, will not shrink, swell, rot, or burn, is easily applied, and has the advantages of being lightweight and space-saving (Figure 36-5).

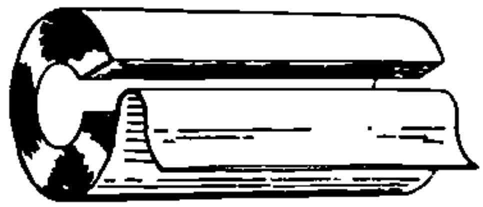


Figure 36-5. Fibreglass Insulation

8. Magnesia pipe insulation is composed of about 85 per cent magnesium and long asbestos fibres bonded into an expanded, light material (Figure 36-6). It has maximum strength and is very suitable for steam and hot water lines or other pipes whose temperature does not exceed 320°C. It has a canvas jacket and may be used on pipes of up to 500 mm diameter. Magnesia insulation is made in 900 mm sections with a standard thickness of 22 mm and a double-standard thickness of 48 mm. It also comes in powdered form (also called "asbestos shorts") to make a cement for fittings or valves, and in block form for insulating boilers.

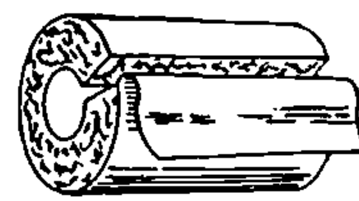


Figure 36-6. Magnesia Insulation

9. Anti-sweat insulation is designed for cold water lines. It keeps water in the pipes colder and, if properly installed, prevents sweating of the pipes. It is made of an inner layer of asphalt-soaked asbestos paper, a 13 mm layer of wool-felt, two layers of asphalt-soaked asbestos felt, and a 13 mm layer of felts combined with asphalt-soaked felts. The outer layer has a 75 mm flap that extends beyond the joint to make a perfect seal. A canvas jacket is placed around each 900 mm length to protect the outer felt covering.

Anti-sweat insulation is also available in rolls and is applied to the pipe in a manner similar to that of applying electrical tape. Figure 36-7 shows one type of anti-sweat insulation.

Figure 36-7. Anti-Sweat Insulation

10. The blanket type of insulation (not illustrated) is made in strips, sheets, and flocks for wrapping around objects that are irregular in shape, and for large, flat areas. It insulates against heat loss and protects against fire. This type is used on boilers, furnaces, tanks, drums, driers, ovens, flanges, and valves. It comes in asbestos-paper rolls, asbestos-cardboard sheets, wool-felt and hair-felt rolls, asbestos-cement blocks, air-cell rolls, aluminum-foil rolls, irregular pre-formed coverings, and asbestos powder flock.

Blanket-type insulation is available in different widths and thicknesses, depending on the equipment to be insulated. It resists vermin (insects, rats, mice) and acid, and is fireproof. Since the asbestos type withstands more heat than others, it should be used on high-temperature equipment or for protection against open flame.

Installation of Insulations

11. Insulations described in sections 2 to 6 are easy to install because each section is split in half and has a canvas cover with a flap for quick sealing. Collars are supplied to cover joint seams on piping that is exposed to outside conditions. Cheesecloth is sometimes used instead of canvas but it must be glued in place. Metal straps should be used to hold the insulation firmly, and they should be of at least 19 mm width and spaced no more than 450 mm apart. A special type of white enamel paint can be applied to insulated pipes where necessary.

Flex-rubber insulation is installed by slipping it over the pipe when it is being assembled or by splitting the rubber length-wise and sealing it with cement. Before flex-rubber insulation is installed on iron or galvanized pipe, the pipe should be painted with an asphalt-based primer to prevent corrosion by condensation.

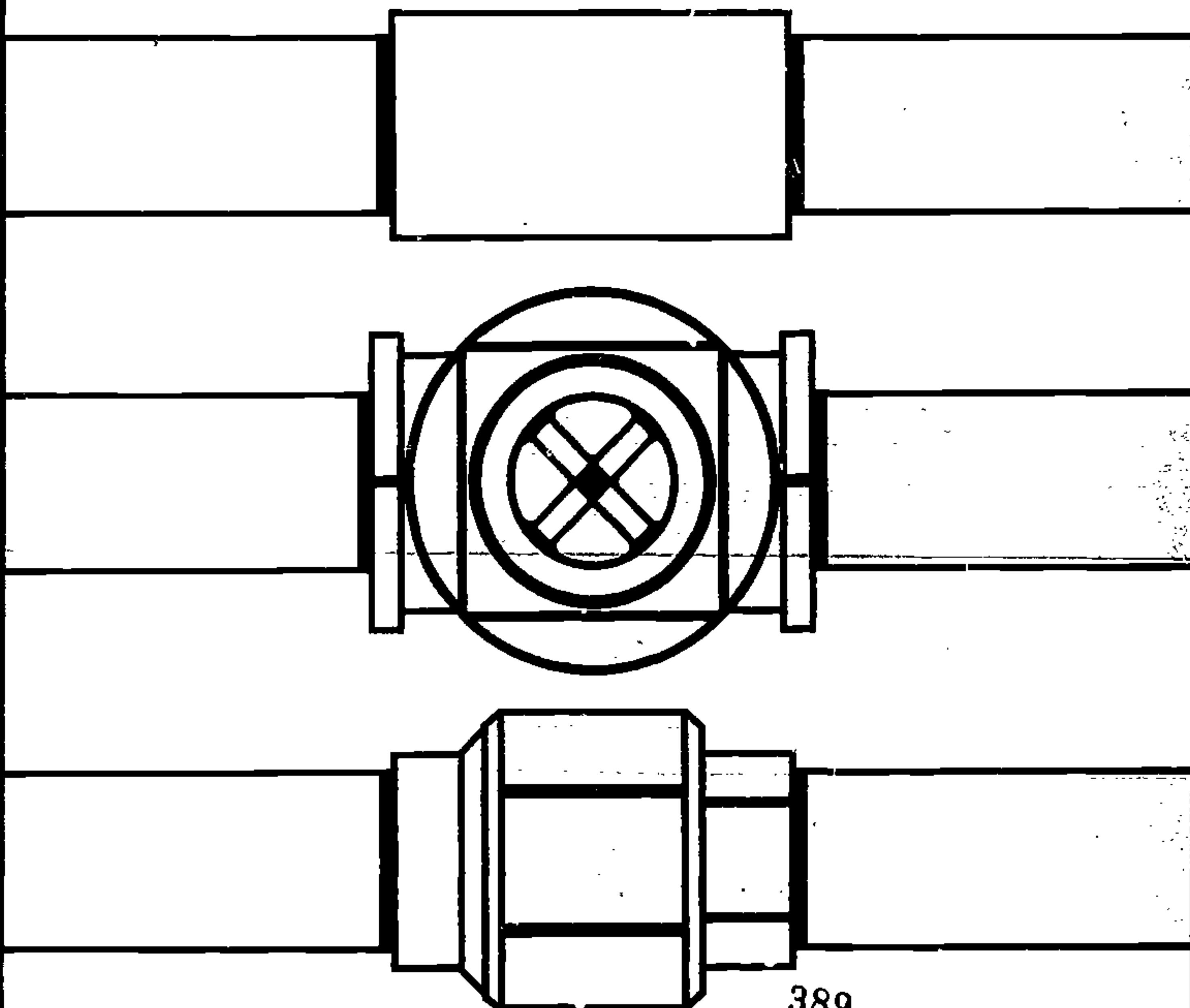
12. Valves and fittings are covered with fibreglass, wool, felt, magnesia cement, or mineral-wool cement to the same thickness as the pipe. These types of insulation are moulded into shape and generally they are covered with cheesecloth to hold them in place. In some cases the pipe covering can be mitred to fit.

13. In certain regions with adverse climate, underground piping must be insulated. In some such applications, the insulation could be similar to that used on piping above the ground, but extra protection against the weather will be needed — that is, the laying of the piping in a concrete trench or tunnel.

There also are granular insulations that are poured around a high-temperature pipe and baked in place with the heat from the pipe. This type of insulation is commonly used on high-pressure underground steam lines from central heating plants.

Also available for underground installation is piping contained within insulated metal tubing. The main drawback of this material is that when a leak develops in the piping it is sometimes very difficult to locate. Moreover, the entire length of affected insulated pipe must be replaced.

37 Proprietary Plumbing Systems



PART 37
PROPRIETARY PLUMBING SYSTEMS

General Information

A proprietary plumbing system may be defined as a plumbing system that does not meet the requirements of the plumbing code in pipe sizing or design but does provide an acceptable type of installation and is of a patented design. This part of the manual is not intended to be used for designing a system, but to familiarize the student with some of the types of proprietary systems.

The Copper Sovent System

1. The copper Sovent single-stack plumbing system is an engineered drainage system for improving and simplifying soil, waste, and vent plumbing in multi-storey buildings. It was invented in 1959 by Fritz Sommer, head of the department for sanitary installation at a vocational training school in Bern, Switzerland. Since 1961 hundreds of multi-storey buildings constructed in Europe have utilized the Sovent system, and many installations have been made in North America and in Japan.

2. The copper Sovent system has certain physical advantages that lead to cost reductions. Its basic advantage is the elimination of separate vents for fixtures, which markedly simplifies the layout. (See Figure 37-1.) The task of cutting and drilling walls and floors is minimized by the absence of vent lines and the reduction in the number of stacks. The sizes of chases can be reduced and there is greater facility in the placement of other services and duct work.

3. Each Sovent system must be designed and installed to meet the conditions under which it will operate, and engineering judgment is required in applying the rules of the basic design to a specific building. The Canadian Copper & Brass Development Association will review Sovent-system designs to help ensure that the design principles are followed.

4. The copper Sovent system has four parts: a copper DWV stack; usually a Sovent aerator at each floor level; copper DWV branches; and a Sovent deaerator at the base of the stack. The two special units — the aerator and the deaerator — are the basis of the self-venting features of the system. Tubing sizing, layout, and choice of fittings for the branches must conform to certain rules and guidelines that apply to the Sovent system.

5. Hundreds of tests were conducted on the Sovent system over many years to determine the maximum capacity of both the stacks and the branches. These determinations were based not only on pressure and vacuum measurements in the system, but also on the more important measurements of trap-seal retention after repeated use. The effects of various flow rates, foaming detergents, toilet paper, disposable diapers, and pump-evacuated appliances were also studied in relation to pressure excursions within the system.

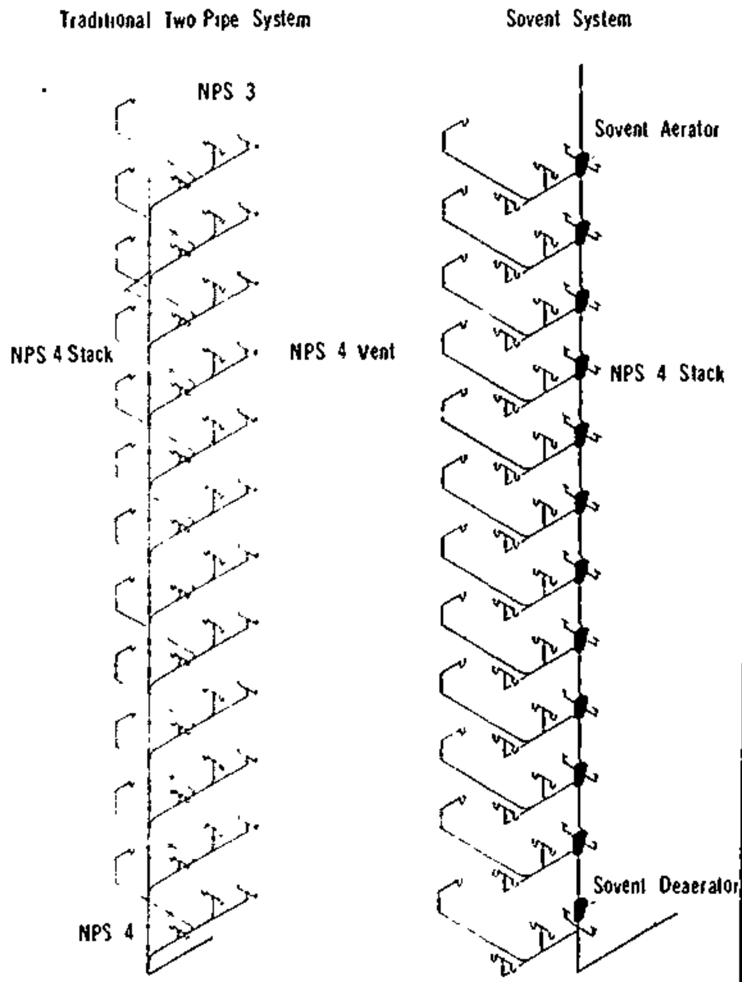


Figure 37-1. Comparison Between Traditional Two-Pipe System and the Sovent System

6. The procedure for the design of a Sovent system meets the principles of good plumbing design that have been developed by the trade over the years, namely:

a) Pipelines and connections must be simple.
b) Horizontal lines must slope properly and their runs must be as direct as possible.
c) The basic principles of hydraulic flow must be adhered to.
d) Thermal expansion and contraction must be essential considerations.
e) Clean-outs must be located according to normal maintenance requirements.

7. In addition to these basic engineering principles, the fundamental rules and guidelines applying to the Sovent system are covered in the following sections. Should the procedure for a particular circumstance not be covered, it may be obtained from the Canadian Copper & Brass Development Association.

8. Two common reactions of those encountering the Sovent system for the first time concern its simplicity and its operating efficiency.

9. Its simplicity makes it very adaptable to extensive prefabrication procedures. Prefabrication reduces installation time and facilitates keeping in step with other phases of construction, important considerations in estimating the installed cost of a Sovent system. Prefabrication also makes possible a repetitive accuracy of dimension, positioning, and degree of "fall" — so essential to a correct plumbing system.

10. The manufacturer states that the system's efficiency was proved by extensive testing during its development It is also a quiet system, the result of its basic concept of aeration and controlled velocity.

The Sovent Aerator

11. The Sovent aerator (Figure 37-2) comprises an offset, a mixing chamber, one or two soil inlets, one, two, or three waste inlets, and one or more baffles.

12. The aerator limits the velocity of both liquid and air in the stack, prevents the cross-sections of the stack from filling with a plug of water, and efficiently mixes the waste flowing in the branches with the air and liquid flowing in the stack.

13. In North America, aerators are regulated by Standard B16.32 of the American National Standards Institute. They are designated by the size of openings in the sequency as shown in Figure 37-2.

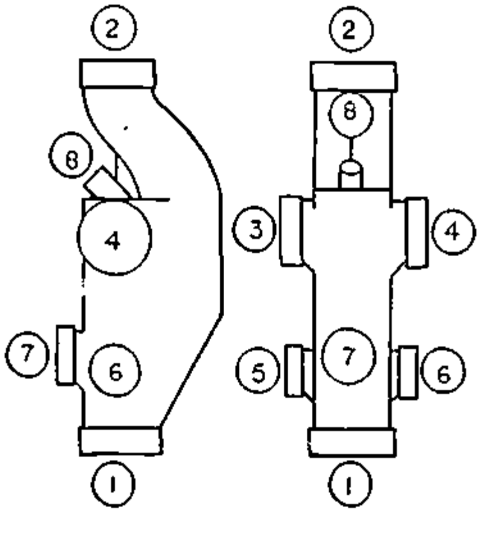


Figure 37-2. Sovent Aerator

Openings 1 and 2 are the stack connections, and the other inlets may be included as necessary for the particular requirements. Aerators are ordered by using the seven (or eight) numbers and inserting on the order form the inlet size required for each, or a zero if no inlet is required.

14. The numbers may be remembered by turning face-inlet 7 toward you and numbering from left to right, taking the upper ones first. Inlet 8 is a pressure-equalizing line (PEL) connection, which is seldom needed. The basic dimensions of common sizes of aerators are shown in Table 37-1. The position of waste inlets 5, 6, and 7 should be taken into account where waste branches cross within drop ceilings. The bracketed numbers in Table 37-1 correspond to those circled in Figure 37-2.

Table 37-1. Common Aerator Sizes

(1)	(2)	(3)	(4)	(5)	(6)	(7)
NOMINAL PIPE SIZE						
3	3	3	3	2	2	2
3	3	2	2	2	2	2
4	4	4	4	2	2	3
4	4	3	3	2	2	3
5	5	4	4	2	2	3

The Sovent Deaerator

15. The Sovent deaerator, shown in Figure 37-3, comprises an air-separation chamber having an internal nosepiece, a stack inlet, a pressure-relief outlet at the top, and a stack outlet at the bottom.

16. The deaerator separates the air in the stack flow from the liquid, ensuring smooth entry of the liquid into the building drain and relieving the positive pressure at the base of the stack. The result is a single stack that is self-ventilating, and the balancing of positive and negative pressures at or near the zero line throughout the system.

17. As well as being used at the base of the stack, a deaerator may be required for some stack offsets, as is shown later.

18. In North America, deaerators, like aerators, are regulated by ANSI Standard B16.32. They are designated by the size of the openings in the sequence shown in Figure 37-3. Openings 1 and 2 are the stack connections and 3 is the pressure-relief outlet. The basic dimensions of common sizes of deaerators are shown in Table 37-2. It will be noted from this table that an NPS 3 deaerator has an NPS 2 pressure-relief outlet, and an NPS 4 deaerator has an NPS 3 pressure-relief outlet. The bracketed numbers in Table 37-2 correspond to those circled in Figure 37-3.

Table 37-2. Common Dearator Sizes

(1)	(2)	(3)
	NOMINAL PIPE SIZE	
3	3	2
4	4	3
5	5	3
5	5	4

19. A summary of Sovent design features is given in Figure 37-4. The incorporation of some of these features is dependent on the individual circumstances. Each Sovent system must be designed to meet the conditions under which it will operate, and engineering judgment is required in applying the rules of basic design to a specific building.

20. The stack must be carried full size through the roof to the atmosphere and must be anchored at every fourth floor. There is no such thing as reducing stack size for the upper floors where the total hydraulic load is less than it is on the lower floors.

21. The size of the stack is determined by the number of fixture units connected, as with traditional sanitary systems.

22. The maximum number of fixture units that may be connected to the Sovent stacks (more than three storeys) is given in Table 37-3.

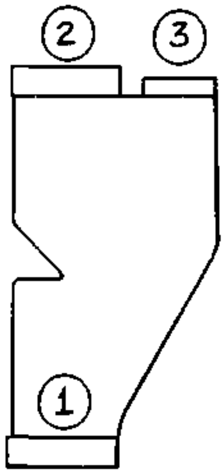


Figure 37-3. Sovent Deaerator

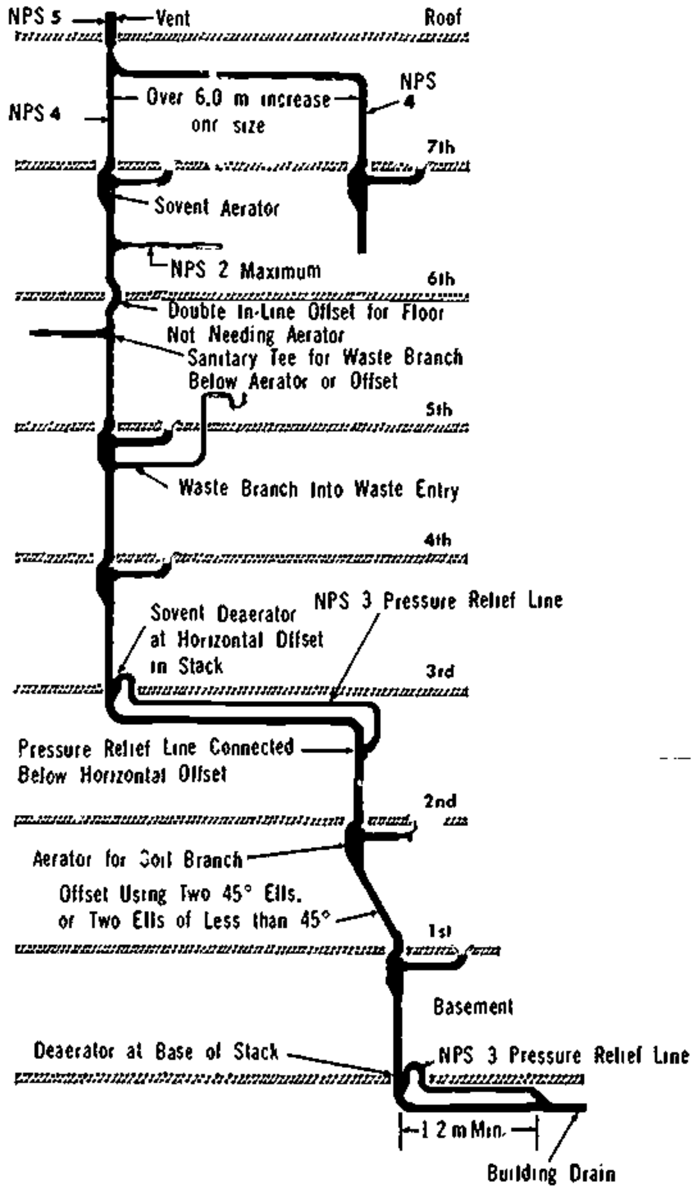


Figure 37-4. Sovent Design Features

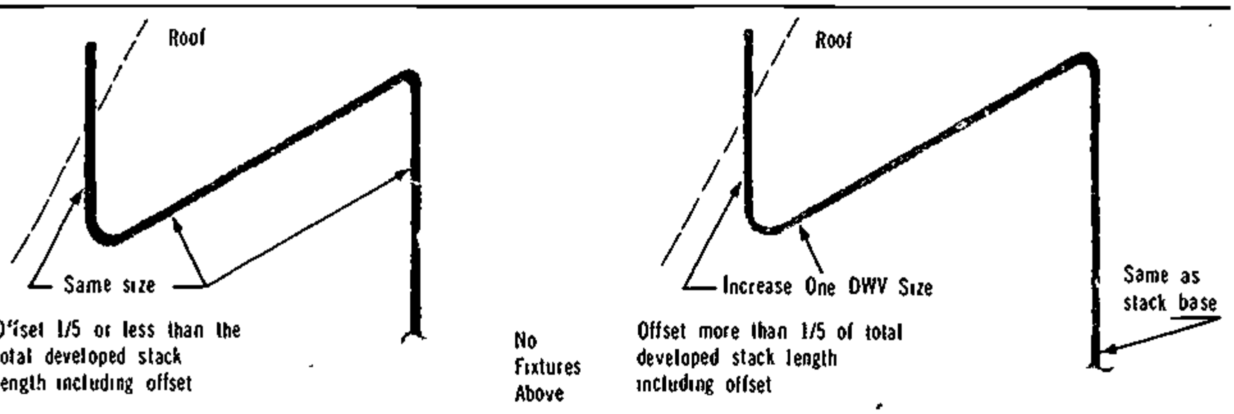


Figure 37-5. Offsetting Top of Stack *(continued)*

Table 37-3. Maximum Number of Fixture Connections for More Than Three Storeys

Stack Size (NPS)	Total Units for Stack	Total at One Floor or Branch Interval
3	64*	16
4	500**	90
5	1,100	200

*An NPS 3 copper Sovent stack will handle a maximum of eight water closets of eight bathroom groups, included in a maximum of 64 fixture units. Normal procedure is to connect the lowest floor below the deaerator at the base of the stack. This means that an NPS 3 Sovent stack can be arranged to handle five storeys of double bathrooms or nine storeys of single bathrooms. If only sinks and floor drains or similar fixtures are involved, an NPS 3 copper Sovent stack can handle up to 102 fixture units. Engineering judgment should be used in cases of certain types of fixtures, or if sudsing is a consideration.

**An NPS 4 copper Sovent stack is rated at 500 fixture units or 530 when distributed over more than seven storeys, which is usually the case. An NPS 5 copper Sovent stack is rated at 1,100 fixture units.

23. Should it be necessary to offset the top of the stack, above the highest fixture, the sizing procedure is as shown in Figure 37-5.

24. Two stacks can be tied together at the top above the highest fixture with only one stack extending through the roof, as shown in Figure 37-6. If the distance between the two stacks is 6 m or less, the horizontal tie-line (with a fall of 1 in 50) can be of the same diameter as the stack that terminates below the roof level.

25. If the distance is more than 6 m, the tie-line must be one size larger than the terminated stack. An inverted long-turn fitting or inverted Y and 45° ell is used at the junction. Then the common stack continuing through the roof must be one size larger than the size of the larger stack below their tie-line.

26. The permitted connections to an aerator are shown in Figure 37-7. Note that soil or waste lines may be connected to the upper inlets known under the designation numbers 3 and 4. But only waste lines may be connected to the lower inlets known under the designation numbers 5, 6, and 7. As mentioned, the PEL connection is seldom used.

27. At any floor level where an aerator is not required, a double in-line offset is built into the stack at the nominal floor interval. This maintains the necessary lowered flow velocity within the vertical stack. In-line offsets are usually made up of a 90° DWV ell, with a 45° DWV ell above and below. (See Figures 37-8 to 37-10.)

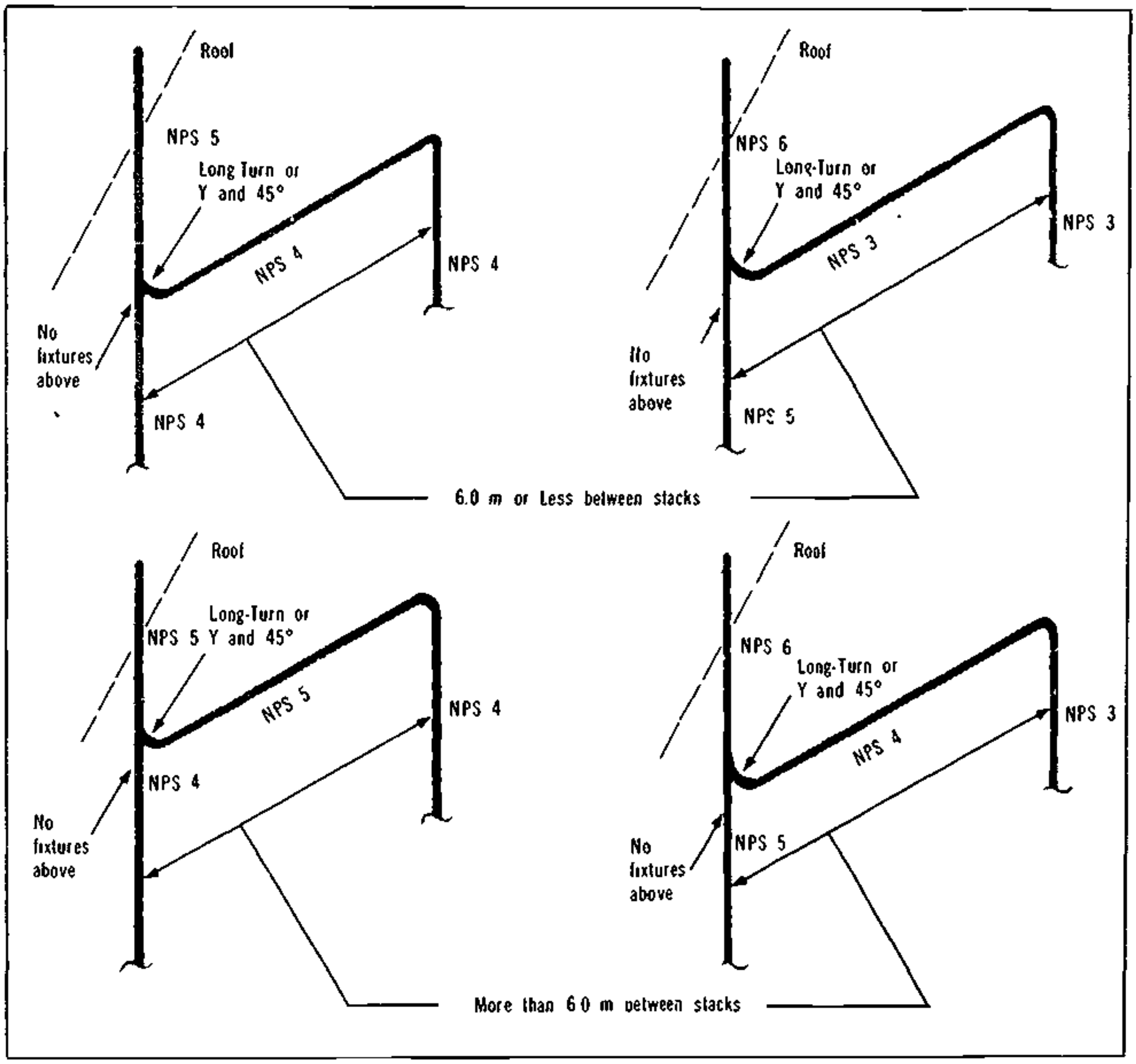


Figure 37-6. Tying Two Stacks Together

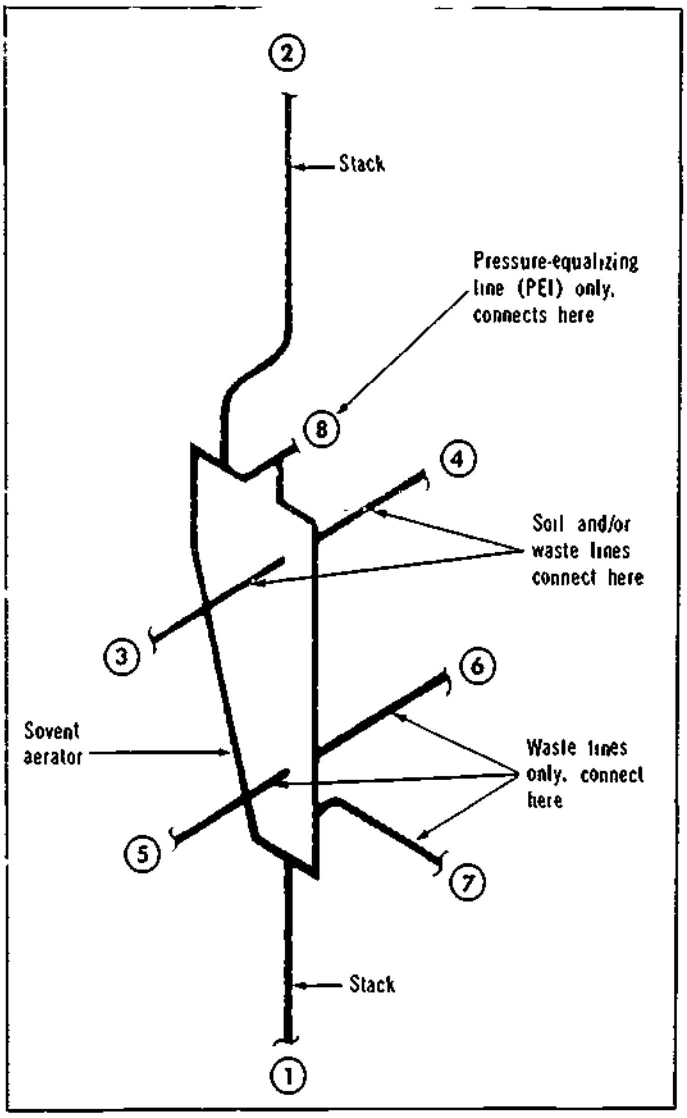


Figure 37-7. **Sovent Aerator Connections**

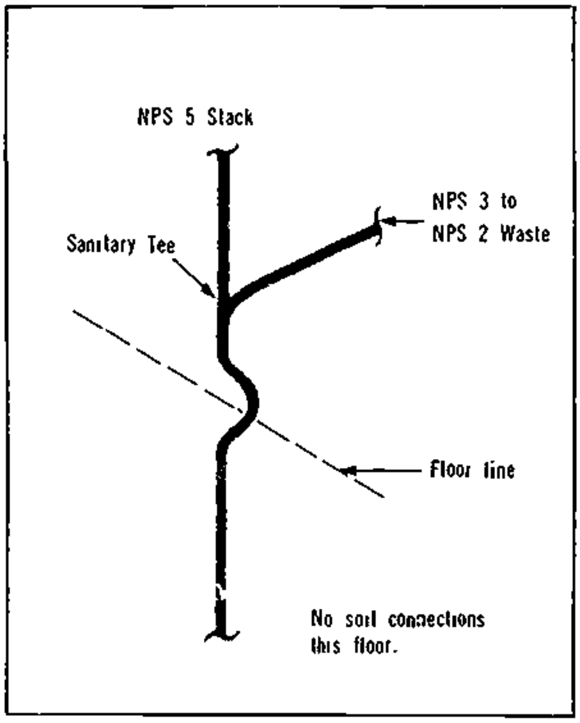


Figure 37-8. Waste Connections No Greater Than NPS 3

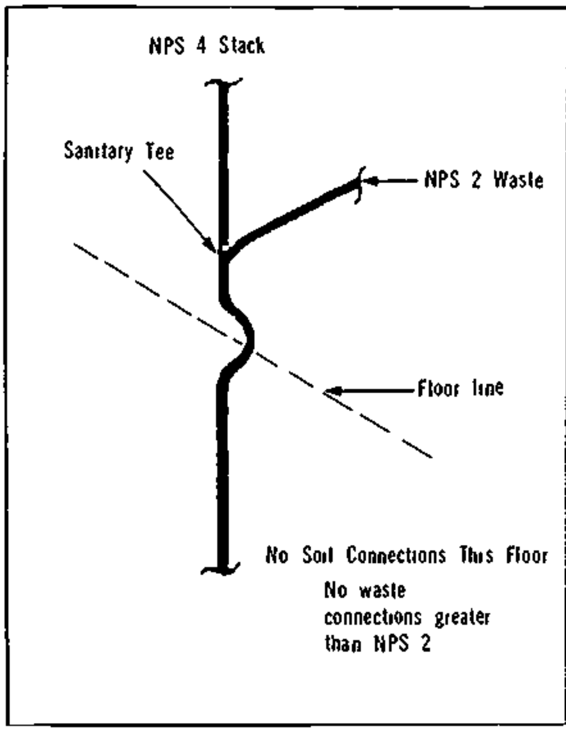


Figure 37-9. Waste Connections No Greater Than NPS 2

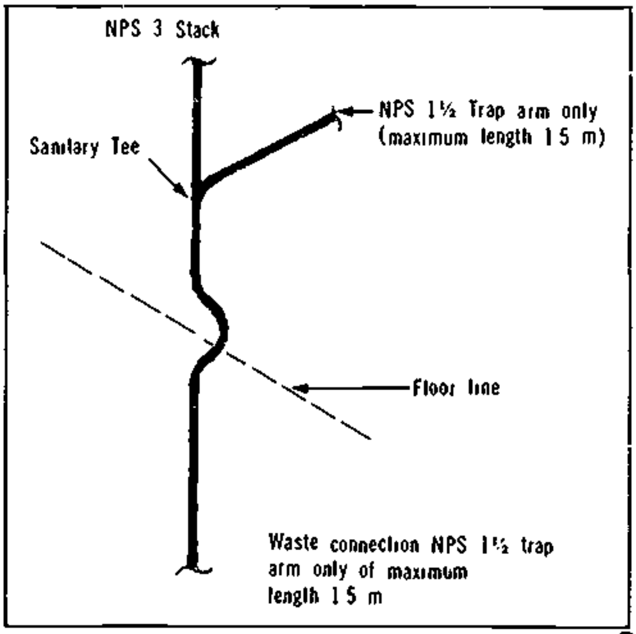


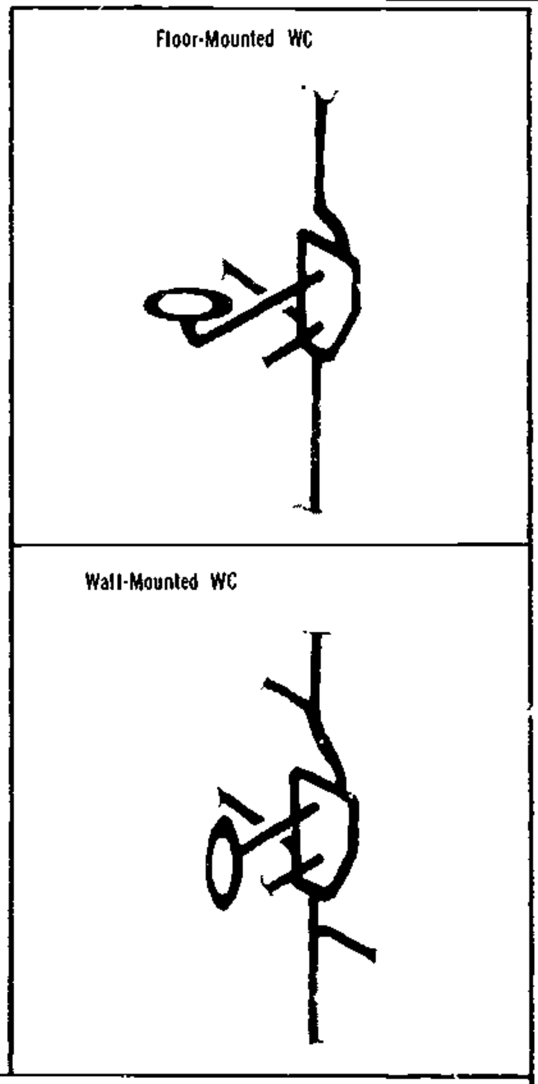
Figure 37-10. Waste Connections NPS 1½ Trap Arm Only to Maximum Length of 1.5 m

Trap Arms for Water Closets

28. Floor-mounted water closets are in common use and are generally more convenient for a Sovent system than the wall-mounted type. When wall-mounted closets are used, the aerator may be raised to permit direct entry to a soil inlet, in which case the raised position of the waste inlets must be taken into account.

29. If the objective is to connect two water closets into one soil inlet, this may done by selecting fittings to prevent cross-flow and two water closets may be connected to an NPS 3 soil branch, as shown in Figure 37-11. Should there be a third water closet, the soil branch must be increased in size.

30. Changes in direction in the horizontal plane, or from horizontal to vertical, should be made with two 45° ells. Immediately below a water closet there is a regular 90° DWV ell, unless the vertical drop exceeds 900 mm, in which case two 45° ells should be used.



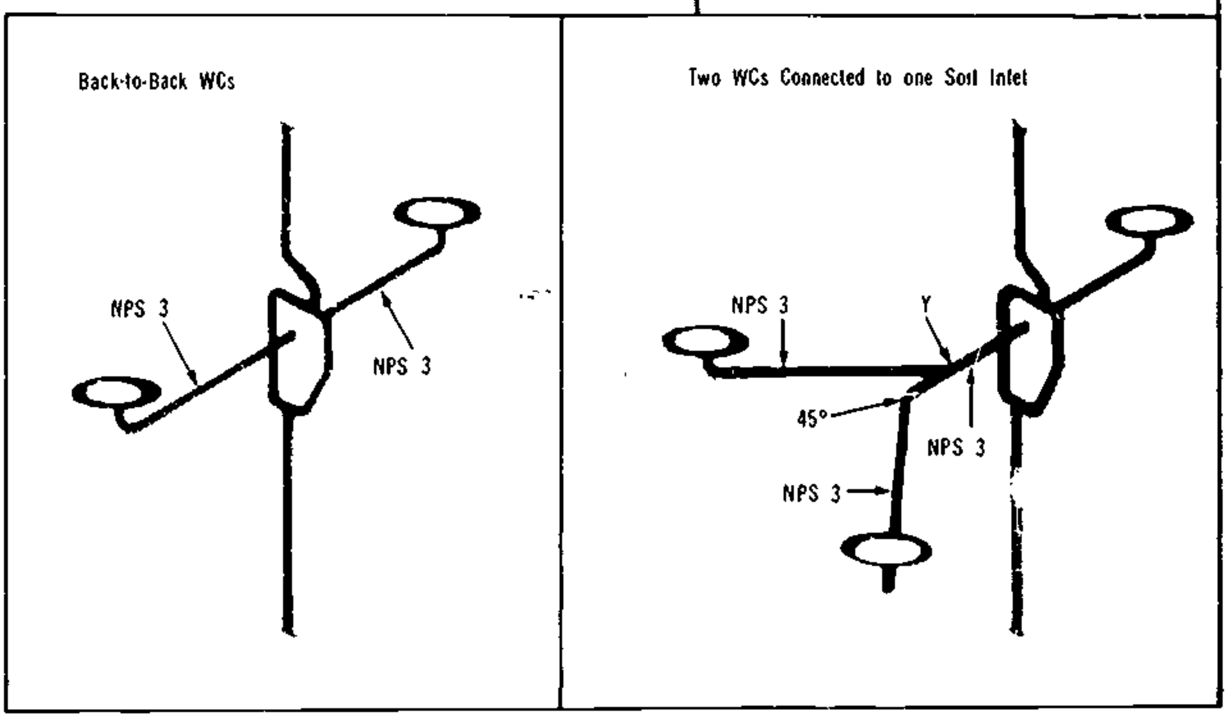


Figure 37-11. Soil Branches

Trap Arms and Branches for Lavatories

31. A lavatory with an NPS 1¼ trap should have an NPS 1½ trap arm, and one with an NPS 1½ trap an NPS 2 trap arm. In the usual case of an NPS 1¼ chrome trap, this increase in size can be carried out at the wall very conveniently by using any of the three ells shown at the bottom of Figure 37-12. Downstream of the ell the branch size should be NPS 2 whether horizontal or vertical.

32. A 90° DWV ell can be used for horizontal and vertical changes in direction of the branch of one lavatory, but two 45° DWV ells should be used if there are two lavatories or more than two 90° changes in direction. Note the details of some typical configurations in Figures 37-12 and 37-13.

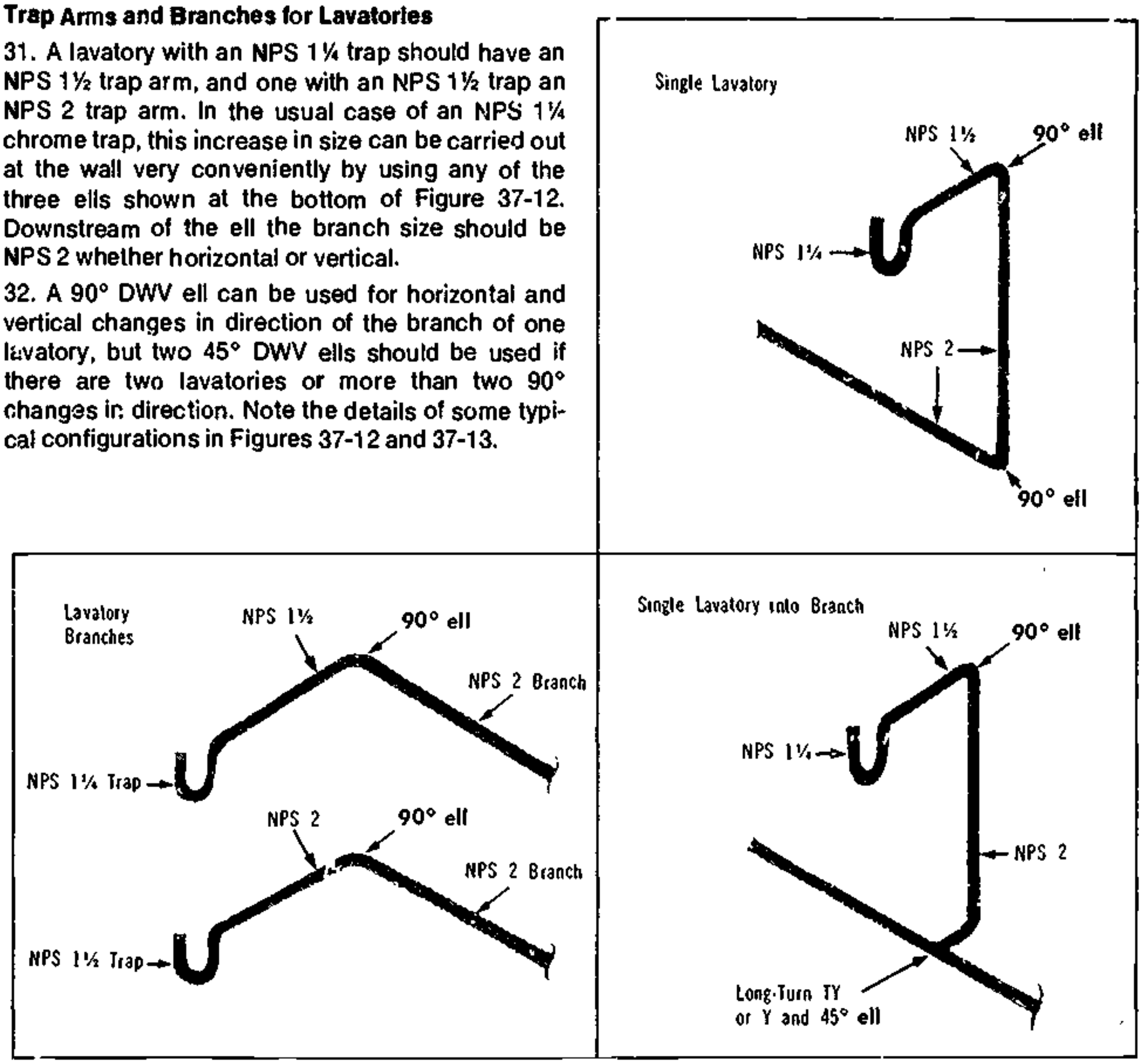


Figure 37-12. Lavatory Trap Arms and Branches

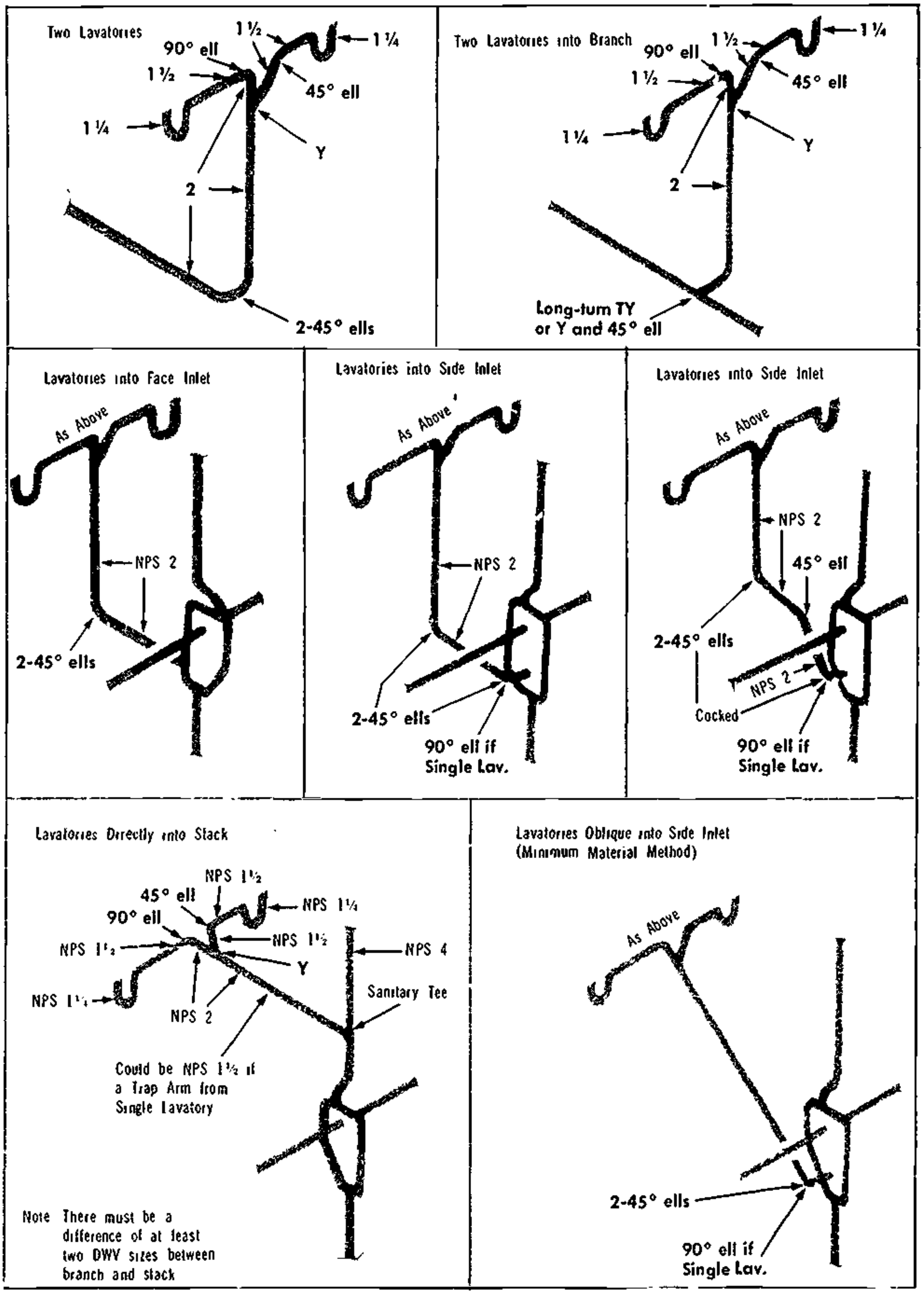


Figure 37-13. Arrangements for Lavatory Branches

Trap Arms for Sinks

33. A sink with an NPS 1½ trap should have a trap arm of NPS 2 diameter, the increase in size to occur as soon as possible. A sink with an NPS 2 trap should have an NPS 3 trap arm.

34. A 90° DWV ell can be used for connecting the trap arm to the vertical or horizontal branch, but all 90° changes in direction downstream of this point should be made with 45° ells, as in the case of bath branches.

35. Where a vertical drop is necessary from the trap arms of back-to-back sinks, each sink should have its own vertical branch, although they can have a common horizontal branch below.

36. Note the details of some typical sink configurations in Figures 37-14 and 37-15.

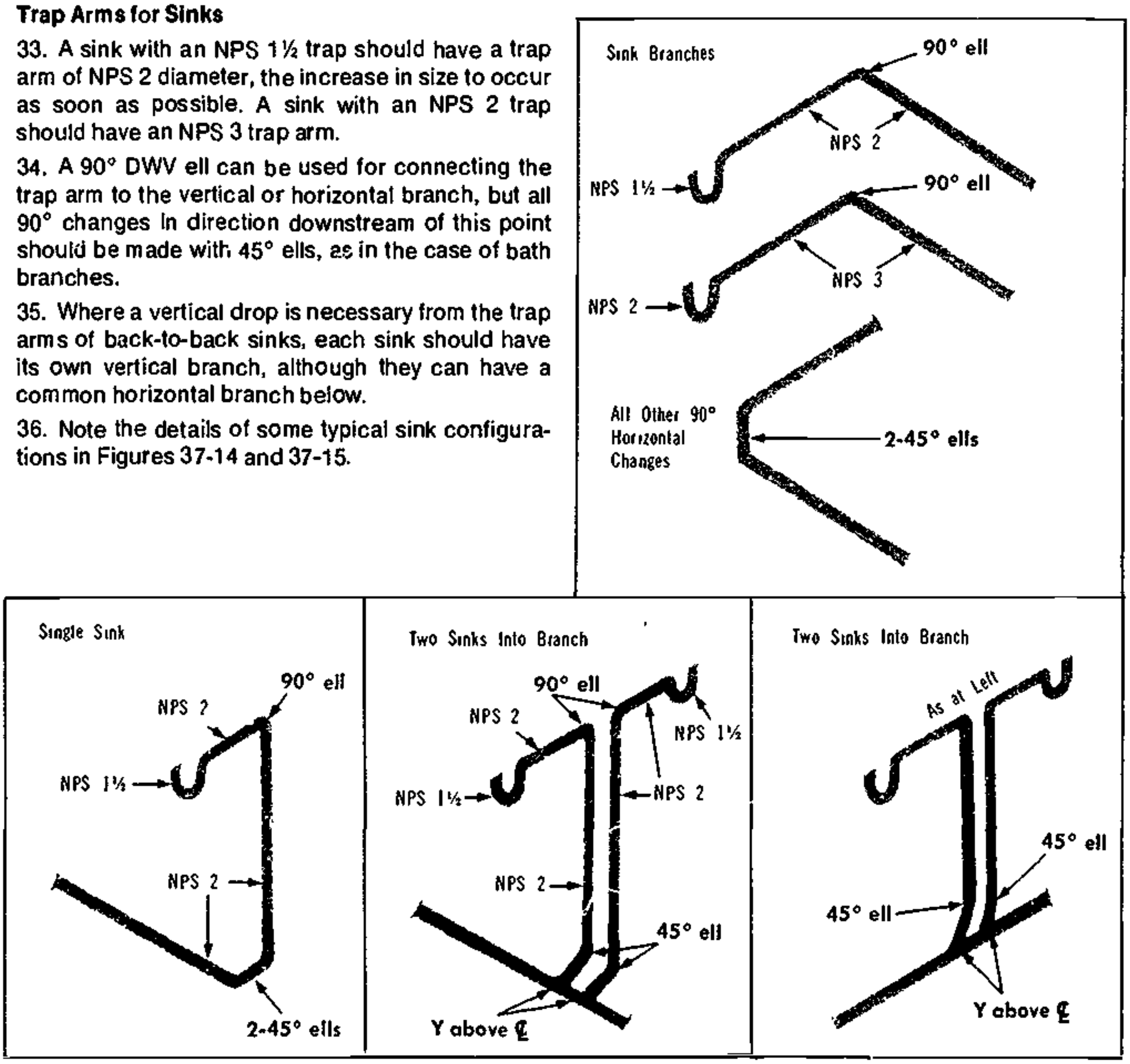


Figure 37-14. Some Typcial Sink Branch Configurations

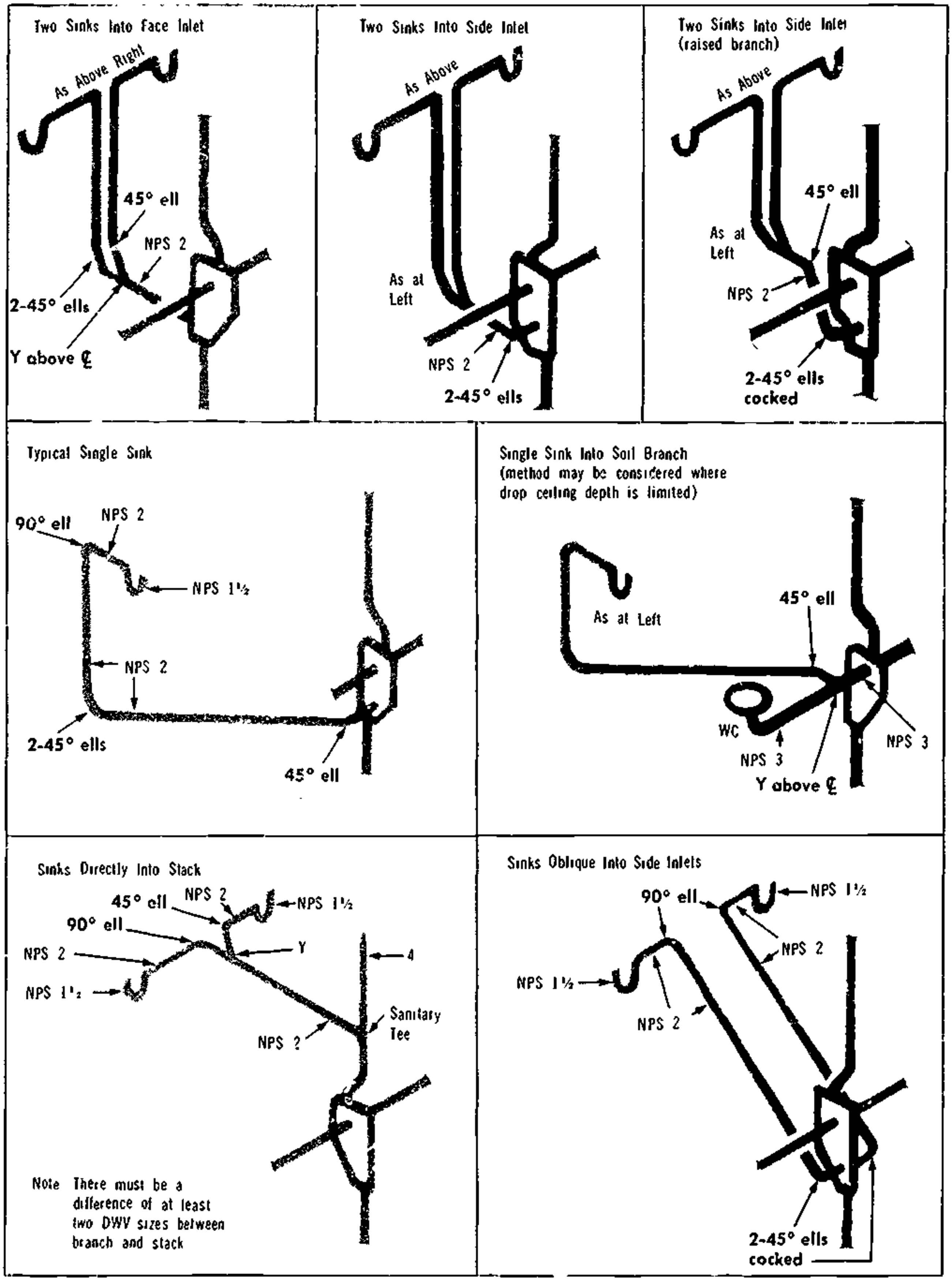


Figure 37-15. Some Typical Sink Branch Configurations

The Base of a Sovent Stack

37. Each Sovent stack normally empties through a Sovent deaerator into the horizontal building drain (Figure 37-16). The deaerator should be installed as close as possible to the building drain. Below the deaerator, 45° ells or Y's are used, usually one of each as this provides for installation of a clean-out. Should a continuous drain pass under the Sovent stack, the stack could enter the top of the drain by a similar procedure. The horizontal building drain should be sized in accordance with local codes.

38. The pressure-relief line (PRL) connects the pressure-relief outlet of the deaerator with the top of the building drain. The connection with the building drain should be through a 45° ell and a Y above the centre line, and be a minimum of 1.2 m downstream from the base of the stack.

39. Fixtures on the deaerator floor may be connected in one of several ways. The usual procedure is to connect water closets and other NPS 3 diameter branches into the drain portion, away from the immediate base of the stack, but before the point of entry of the PRL. Connection is made with a Y above the centre line and a 45° ell. Small fixtures with NPS 2 branches are connected to the PRL, provided that the PRL is at least NPS 3 diameter and always above the centre line on the horizontal portion of the PRL.

40. No branch connections are permitted on the initial vertical portion of the PRL where it connects to the deaerator, nor on the initial horizontal portion. Normal practice is to install a suitable clean-out on any PRL that does not have branches connected to it.

41. The deaerator may be installed one floor level above the base of the stack if design conditions dictate and no fixtures are connected into the stack below the deaerator.

42. It is again emphasized that this part of the manual is only an introduction to proprietary plumbing systems and must not be construed as covering the design of such systems.

43. For further information on the design of the copper Sovent system, contact the Canadian Copper & Brass Development Association, 55 York St., Toronto, Ont., M5J 1R7.

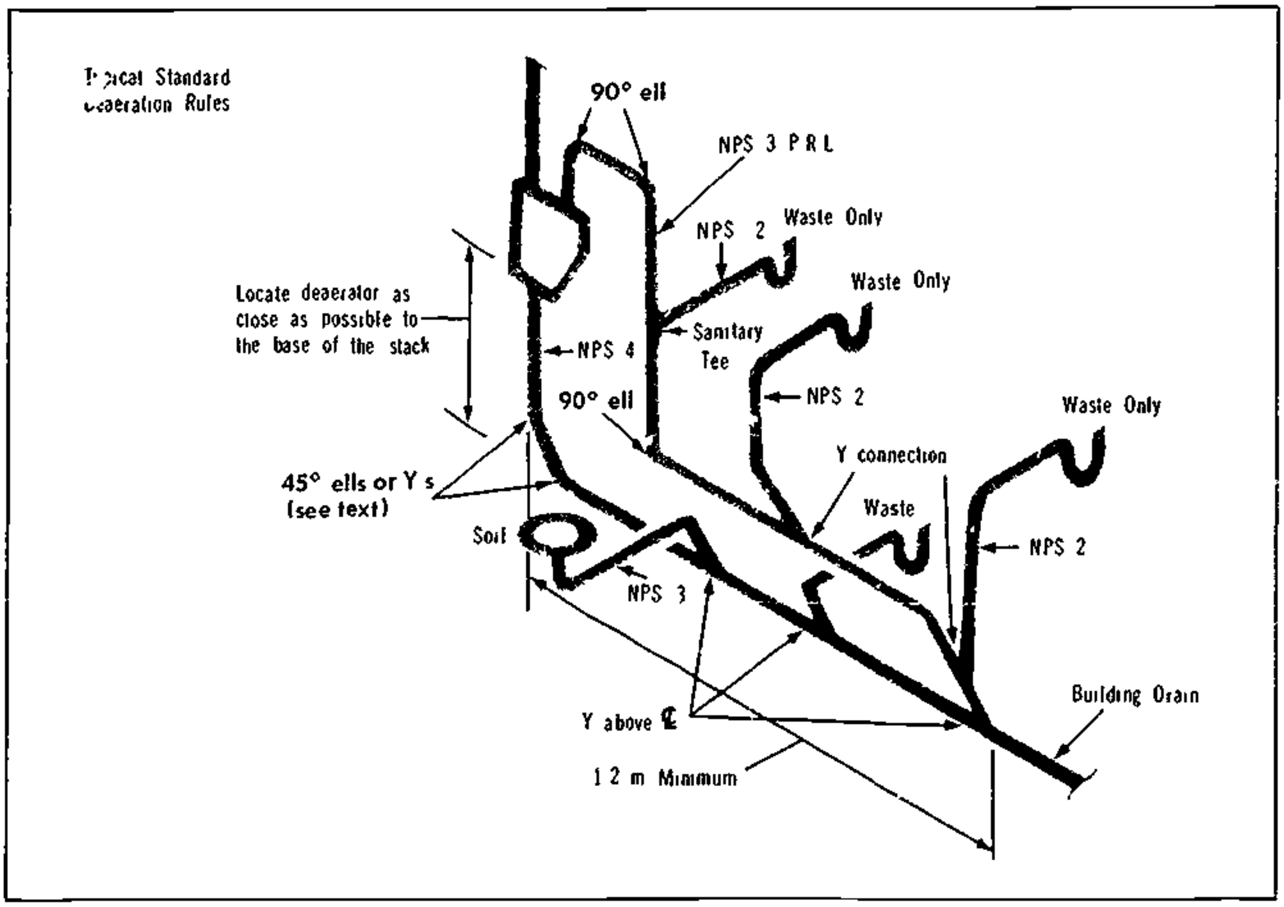


Figure 37-16. Installation of Deaerator Above Base of Sovent Stack

Phelps Dodge Internal Back Vent System

44. The major benefits of the Phelps Dodge Internal Back Vent System (IBVS), described by the manufacturer, are as follows:

a) Every IBVS fixture is individually back-vented.
b) The pre-assembled basic unit means less job-site assembly, less estimating time and work, and less chance of error in take-offs.
c) The system meets model code requirements.
d) Ease of installation.
e) Lower installation costs.
f) Design assistance is provided at no cost.
g) Superior stainless steel coupling.
h) Simplified closet carriers.

45. The Internal Back Vent System is a revolutionary concept in the plumbing industry, utilizing standard production piping and fittings in conjunction with innovative waste and vent fittings.

46. The IBVS controls the air pressure within the vent system, eliminating the need for conventional venting. The system consists of a single stack with special fittings at each floor level that act as both deaerators and mixers.

47. The basic system, except for the between-floor piping and fixture branch arms, is prefabricated by Phelps Dodge in accordance with engineering plans and specifications and shipped intact. The contractor need only figure the additional material and installation costs of fixture arms and between-floor piping.

48. The heart of the IBVS is a special fitting designed to provide an NPS 4 waste stack encased in an NPS 8 shell, allowing for NPS 3 inlets for each major fixture. The inlets are self-vented with an NPS 1½ vent, thus eliminating the need for loop venting. IBVS major-fixture fittings are supplied with quad or dual inlets, according to engineering needs.

49. IBVS minor-fixture fittings come with dual NPS 2 inlets self-vented with NPS 1½ internal vents and are used in conjunction with the major fittings.

50. The final IBVS fitting is an NPS 8 x NPS 4 transitional fitting designed to be installed at the base of the lowest IBVS unit to transfer waste from the NPS 4 IBVS stack to a conventional drain line. The NPS 4 stack terminates within the NPS 8 opening of the transitional fitting, creating aeration and venting the bottom waste line.

51. The Internal Back Vent System is assembled with specially designed neoprene and stainless steel band couplings. A retaining lip on the outside of the shield captures the neoprene gasket and permits it to be compressed without being squeezed out of the coupling and causing loss of torque. When this coupling is torqued to 7 N.m it stays at 7 N.m.

52. A Phelps Dodge general-purpose wall-hung closet carrier completes the system. The closet carrier's outstanding feature is simplicity of adjustment, accomplished by a serrated slot behind the face-plate with a corresponding serrated nut that travels within the slot. Adjustments are fast, accurate, and unlimited.

53. Outlets that are not required can be capped without impairing the system's efficiency. The IBVS unit is easily adapted to floor-mounted and wall-hung closets.

54. Where the IBVS units are desirable but engineering design does not permit stacking, the bottom unit can easily be tied into the top vent unit at the NPS 4 vent branch. The topmost IBVS unit can effect an NPS 8 x 4 transition to a dry vent by using the appropriate brass or cast iron fitting.

55. In all cases, IBVS units on the ground floor require the NPS 8 x 4 transitional fitting at the base of the stack.

56. IBVS couplings are manufactured in accordance with industry standards using 301 stainless steel, and the manufacturer states that they exceed all industry standards for material thickness and weight. These couplings feature a specially designed lip that captures the neoprene gasket and prevents creep and cold-flow, thus preventing the loss of torque. Rigidity is given as another advantage. IBVS couplings are made in sizes NPS 2 to NPS 8. (See Figure 37-17.)

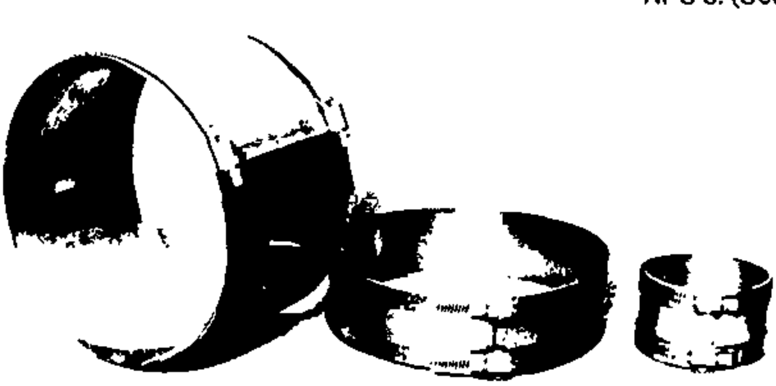


Figure 37-17.
IBVS Stainless Steel Couplings

57. The IBVS gasket is manufactured in accordance with accepted industry standards, using neoprene in conformance with ASTM C-564 standard.

58. The IBVS quad-cluster installation with floor-mounted water closets is shown in Figure 37-18.

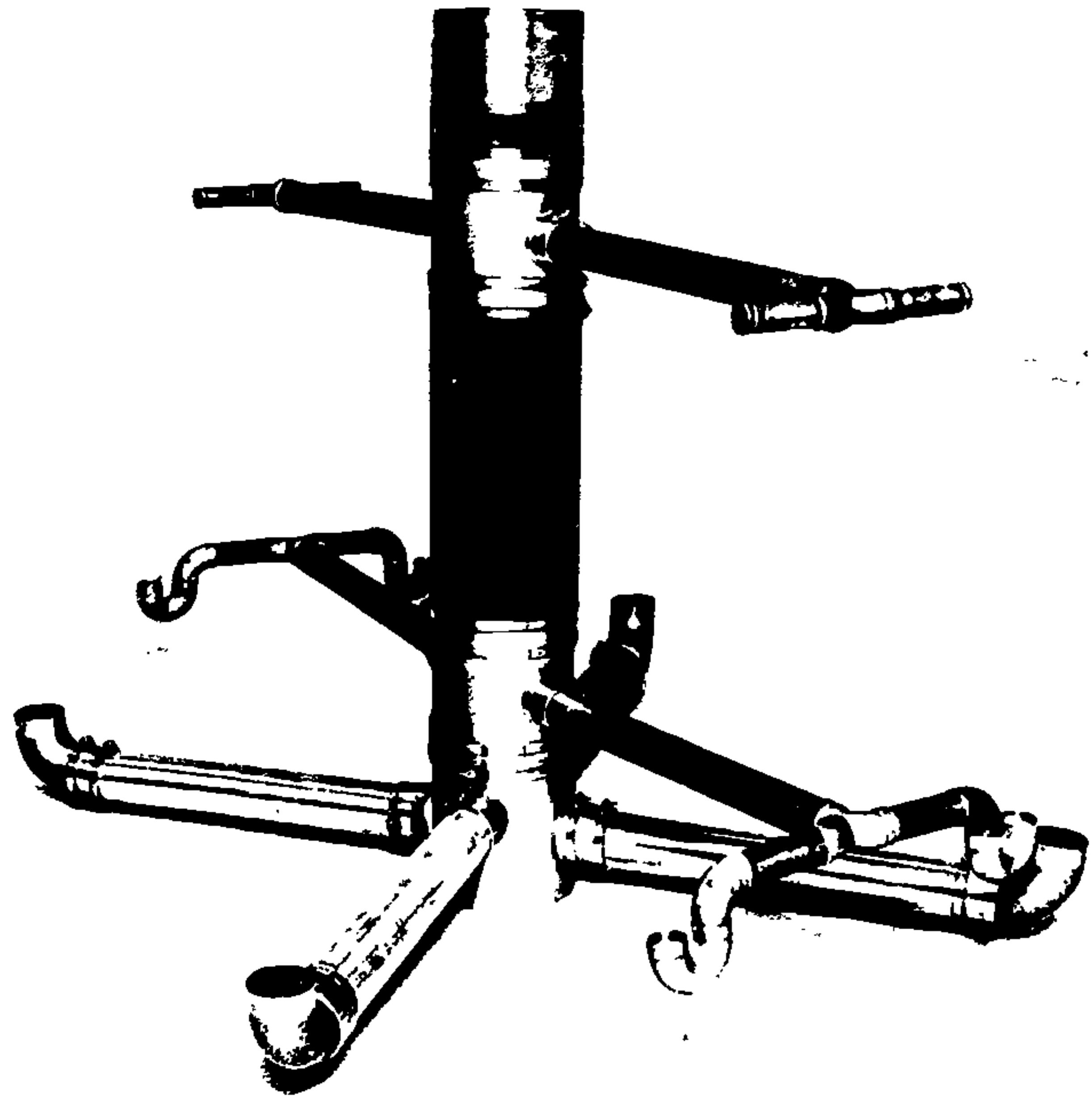


Figure 37-18. IBVS Quad-Cluster Installation with Floor-Mounted Water Closets

59. Components of the pre-assembled IBVS unit are shown in Figure 37-19.

60. The NPS 8 x NPS 4 x NPS 3 IBVS special fitting shown in Figure 37-20 is designed for use in back-to-back, two-, three-, or four-bath installations. Each NPS 3 fixture opening has its own NPS 1½ back-vent. The flexibility of this fitting lends itself to numerous other fixture applications.

61. The NPS 8 x NPS 4 x NPS 2 IBVS special fitting shown in Figure 37-21 is designed to be placed in the stack at any location to serve minor fixtures. This application is possible because the fitting is also internally back-vented. The IBVS fittings have many and varied uses in a plumbing system.

62. The IBVS General Purpose Carrier shown in Figure 37-22 is designed for ease of handling, installation, and adjustment. According to the manufacturer it exceeds all known test requirements for sag allowance and rigidity. The key to its simplicity of adjustment is four serrated slots that accommodate two serrated travel nuts. It is made to be used with DWV copper or cast iron stub-outs. Although developed for use with IBVS, it is adaptable to conventional installations.

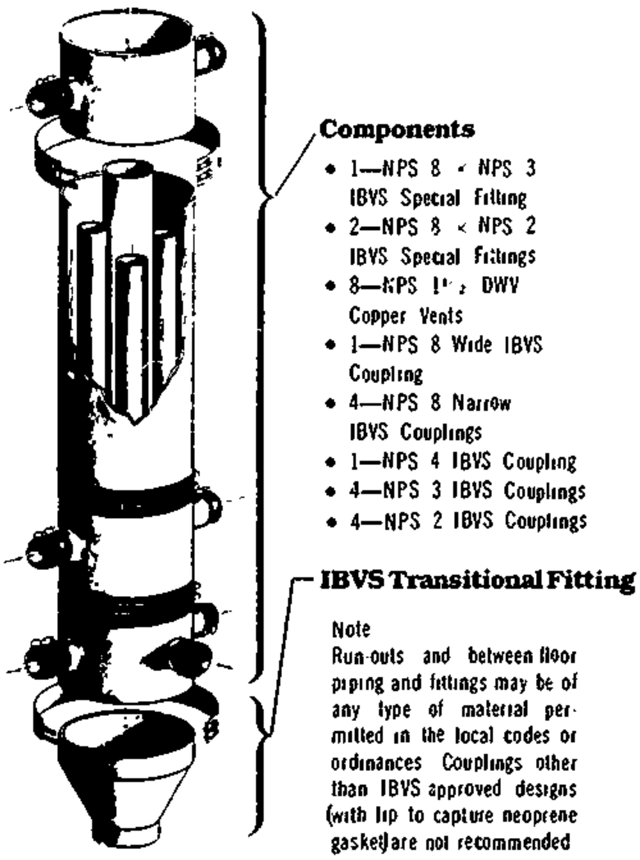


Figure 37-19. Components of Pre-Assembled IBVS Unit

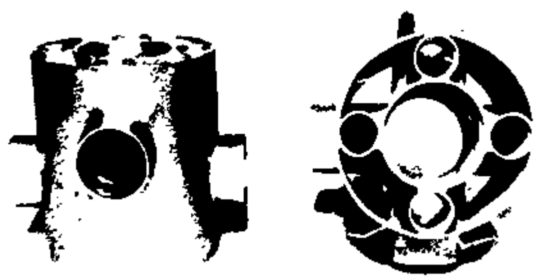


Figure 37-20. NPS 8 x 4 x 3 Fitting Designed for Back-to-Back Two-, Three-, or Four-Bath Installations

Figure 37-21. NPS 8 x 4 x 2 Fitting Designed to Serve Minor Fixtures

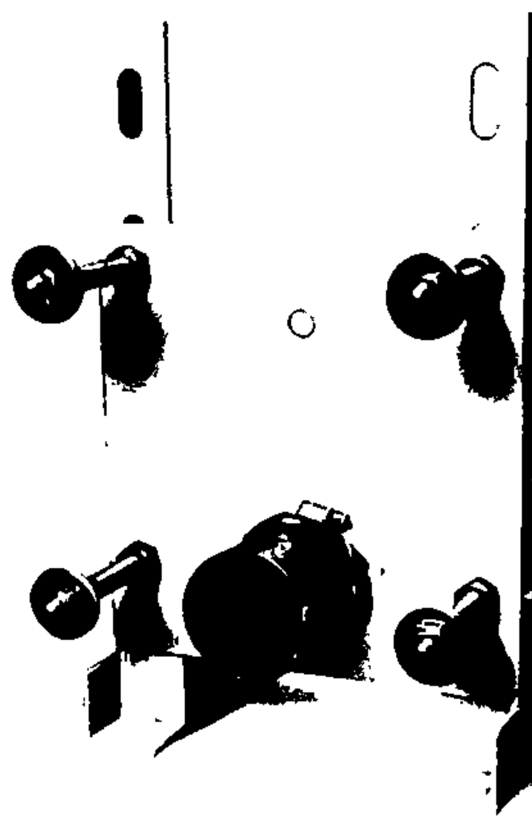


Figure 37-22. IBVS General Purpose Carrier

63. The NPS 8 x NPS 4 IBVS transitional fitting shown in Figure 37-23 is placed at the base of each stack and is designed to aid the entire venting system as well as the building drain.

64. Further information on the Phelps Dodge Internal Back Vent System is obtainable in British Columbia from C-B Supplies Ltd., 4641 Byrne Rd., Burnaby, B.C., V5J 3H6.

The Vacuum-Toilet Sewerage System

65. The vacuum-toilet sewerage system was invented in 1956 by a Swedish engineer, Joel Lilenjdahl. Vacusan Systems Limited of Calgary, Alta., acquired the Canadian licence for the sale and distribution of the system from A. B. Electrolux, of Stockholm, in 1972.

66. The first installation for test purposes was made in early 1957. Since then, hundreds of installations have been made throughout the world.

67. Because of the utmost flexibility of the system, many types of applications have been used, including those for homes, industrial buildings, mobile units, ships, and trains.

68. The basic concept, and the rules for layout and design of the vacuum-toilet sewerage system for various applications, are described hereunder.

69. Following are some of the most common applications of the vacuum-toilet sewerage system:

a) Residential subdivisions.
b) Recreational hotels.
c) Recreational trailer parks and camping sites.
d) Building renovations.
e) Vertical lifts in industrial plants, hospitals, schools, and shopping centres.
f) Single-family homes and cottages.
g) Marine installations.
h) Toilet trailers and mobile cabin units.

Basic Advantages of the System

70. The vacuum system reduces water consumption by more than 45 000 L per person each year. The vacuum toilet requires only 1.1 L of water to a flushing.

71. By reducing the volume of water needed to flush toilets by 90 per cent, about 50 per cent of the total household water consumption is saved.

72. Normal sewage volume is reduced by 50 per cent.

73. Significant savings are gained on the cost and installation of piping in the ground. Because the system's operation is unaffected by grade, the vacuum mains can be laid horizontally or uphill to avoid a high water table or obstacles that would require costly excavation.

74. The vacuum mains can be laid in the same trench with the water mains, without concern for cross-connections, contamination, or infiltration.

75. The use of small-diameter (NPS 1½ to NPS 3) plastic piping provides economies in the installation of piping within a building, with utmost flexibility for the location of plumbing fixtures.

76. The system provides opportunities for sewering areas where other types of systems cannot be economically applied.

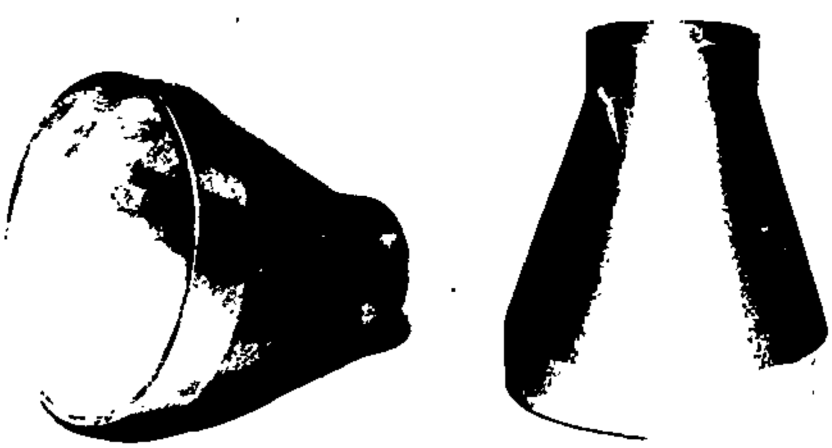


Figure 37-23. Transitional Fitting, at Base of Stack

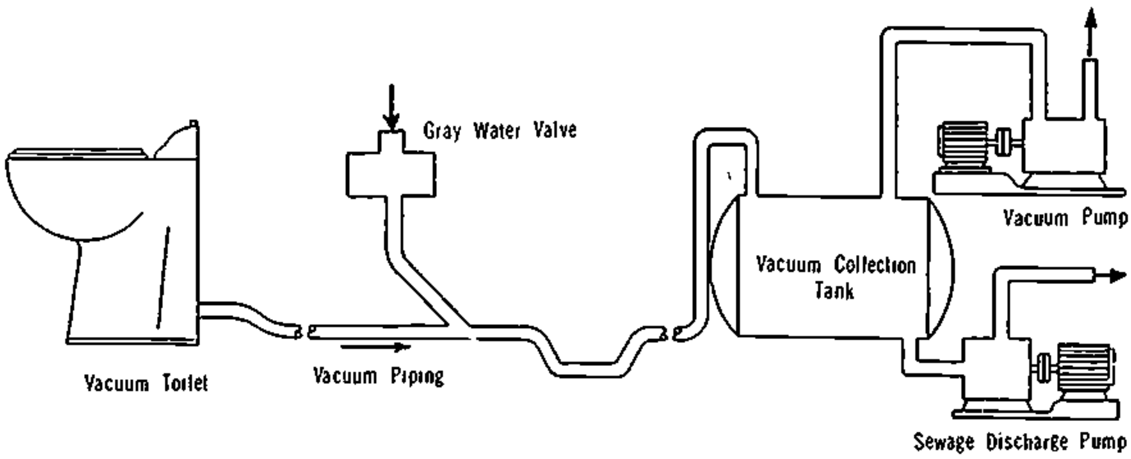


Figure 37-24. Major Components of the Vacuum System

Basic Principles of the System

77. The basic principles of the vacuum system are as follows (Figure 37-24):

a) The use of vacuum toilets and automatically operated valves for urinals to introduce the sewage into the vacuum lines.

b) The use of an interface valve ("gray water" valve) to automatically allow the gray water to enter the vacuum piping.

c) The use of air instead of water to transport the black and gray water.

d) The collection of sewage in a tank.

e) The intermittent and automatic discharge of sewage from the tank to an existing gravity sewage-treatment plant, lagoon, incinerator, or sludge truck.

How the System Operates

78. In vacuum transport, the sewage enters the vacuum piping network (Figure 37-24) through either the vacuum toilet or urinal (black water) or an interface valve for the gray water (all other plumbing fixtures). The small-diameter plastic piping is held under a constant vacuum of about 56 kPa, which is maintained throughout the piping system by the vacuum collecting station.

79. All fixtures are operated by the vacuum in the system and no electricity is required. The system is operated from the central vacuum collecting station, with the sewage (black water and gray water) being transported through the piping network either separately or in one pipe.

80. "Liquid plugs" of sewage, separated by air gaps, enter the system at a predetermined ratio of atmospheric air to waste, and are propelled through the vacuum mains at a high velocity to a central vacuum station. Owing to friction and gravity, the liquid plugs will tend to break down; thus, to re-form these plugs, transport pockets are installed about 60 m apart.

81. The relatively small vacuum collecting station houses the vacuum collection tanks, vacuum pumps, discharge pumps, valves and controls.

82. The total available uphill lift depends on the distance between housing units and the central collecting station. The maximum length of a single pipe-run can be as much as 1.6 km. A single vacuum system usually has several separate pipe-runs and can serve as many as 1,000 houses.

The Conventional Gravity System

83. The conventional gravity system uses the standard flush toilet, which requires from 18 to 23 L of clean water for each flushing. This high volume is needed to flush the solids through the gravity sewer mains, and accounts for at least 50 per cent of the total household water consumption. (See Figure 37-25.)

84. The toilet (and urinal) effluent (black water) is the carrier of almost all the pathogenic bacteria, and is mixed with the relatively harmless water from all the other fixtures (gray water).

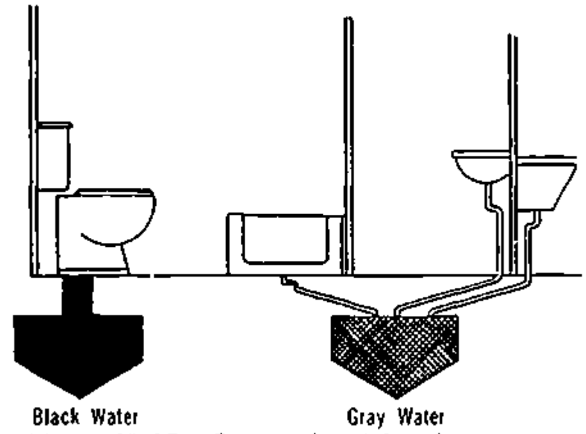


Figure 37-25. Conventional Gravity System

The Vacuum-Toilet System

85. The vacuum system is an advanced method of sewage transportation that utilizes the pressure differential created by maintaining the piping under a constant vacuum of about 56 kPa.

86. With its water consumption of only one litre for a flushing, the vacuum toilet (Figure 37-26) offers these economy advantages:

a) It reduces household water consumption by 50 per cent.
b) It reduces sewage volume by 50 per cent.
c) It allows small-diameter vacuum piping to be run with no concern of the grade.
d) Its major savings are in excavation and piping costs.

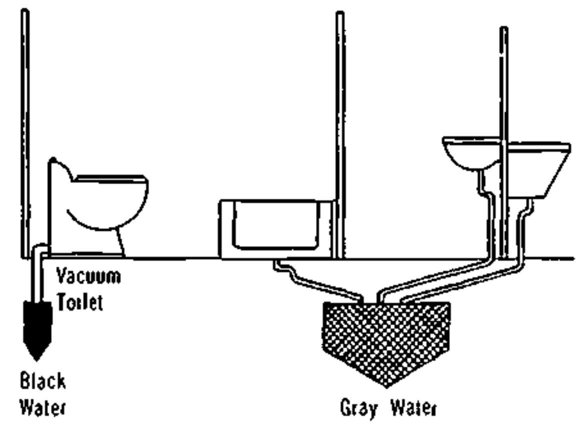


Figure 37-26. The Vacuum-Toilet System

Vacuum System Options

Option A — Vacuum Transport of Black Water and Infiltration of Gray Water

87. This option offers the most economical vacuum system (Figure 37-27). The separated gray water is relatively harmless, containing most phosphates and only 10 per cent of the total nitrogen but practically none of the pathogenic bacteria and viruses found in normal sewage. It can be readily and inexpensively infiltrated into a simple tile bed at each house location. With the gray water being reduced in volume by 50 per cent (and without the black-water contamination), it is easily regenerated through the solid.

88. The black-water sewage from the vacuum toilet produces less than eight litres per person a day. This very low volume is transported to the vacuum collecting station and can be disposed of in the following ways:

a) Collected by a scavenger truck.
b) Incinerated.
c) Pumped to a sewage-treatment plant or a sewer.
d) Treated in a Vacusan lime-batch treatment plant specifically designed for a low volume of highly concentrated sewage.
e) Pumped to a sewage lagoon.

Option B — Vacuum Transport of Black Water and Gray Water in One Pipe

89. This system is used where there is a municipal sewer or a conventional treatment plant.

90. Black and gray water vacuum transport in a single pipe is used in shopping centres, hotels, schools, hospitals, and factories, and for building renovations, wherever the advantage of horizontal piping or vertical lift is required (Figure 37-28).

91. The sewage is automatically discharged from the vacuum collecting tank into a sewer or to a treatment plant.

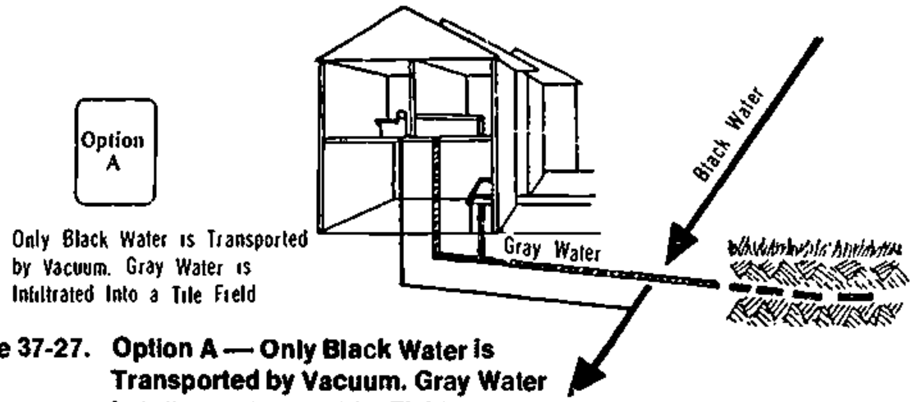


Figure 37-27. Option A — Only Black Water is Transported by Vacuum. Gray Water is Infiltrated Into a Tile Field

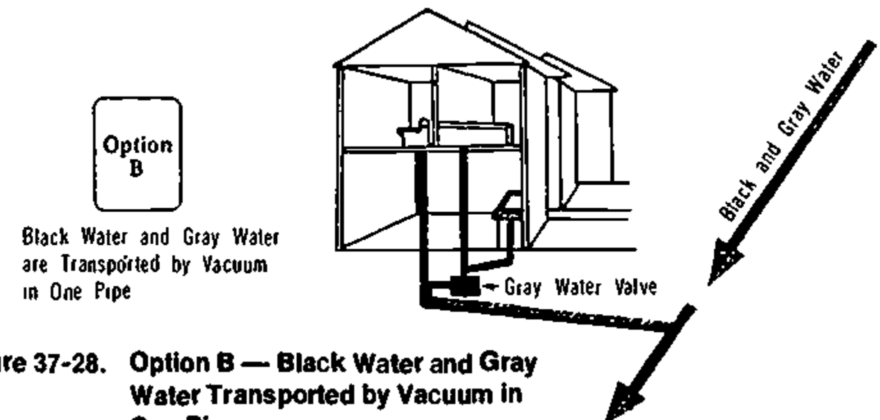


Figure 37-28. Option B — Black Water and Gray Water Transported by Vacuum in One Pipe

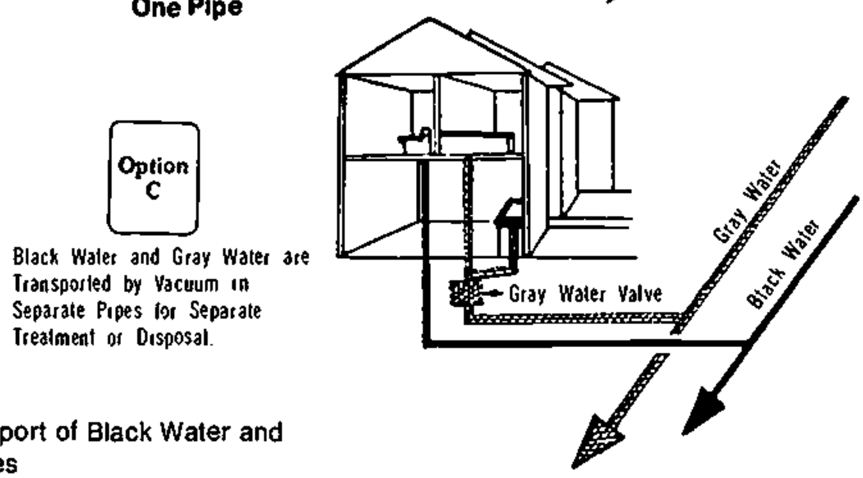


Figure 37-29. Option C — Black Water and Gray Water Transported by Vacuum in Separate Pipes For Separate Treatment or Disposal

Option C — Vacuum Transport of Black Water and Gray Water in Separate Pipes

92. This type of installation (Figure 37-29) is usually made where sewage treatment must be done locally. Through the use of the vacuum toilet, the highly contaminated black water, when collected separately, is reduced to 5 per cent of the sewage volume in a conventional gravity system (refer to Figure 37-25).

93. This very low volume of black water can be efficiently and economically treated with a chemical process in a Vacusan lime-batch treatment plant. (See Figure 37-29.)

Disposal Options

94. The relatively harmless gray water can be treated separately in a very economical and simplified treatment plant, or pumped to a sewer or a treatment plant.

95. The low volume of black water can be handled in the same way as outlined in Option A.

The Vacuum Toilet

96. The vacuum toilet (Figure 37-30) is manufactured from vitreous china exclusively for the Electrolux vacuum sewerage system. It uses only one litre of water for a flushing, mainly to clean the china bowl and maintain a pool of water at the bottom. The vacuum toilet is operated by the vacuum within the system and takes in 0.1 m^3 of air with each flush.

Working Principle

97. The vacuum toilet starts after a moment of pressure on the push button. The operating mechanism performs two simultaneous functions:

a) It opens the discharge v e for about four seconds.

b) It admits water from the fresh-water pressure line via the water valve to the flushing loop.

98. Water flushes for about seven seconds to clean the bowl and to refill it. The vacuum supply hose from a nipple on the vacuum side of the discharge valve is connected to the distributing valve. The two timers, one for the water valve and one for the discharge valve, are mechanical. By changing jets in the two timers, the operating time of discharge and flushing can be adjusted to suit varying conditions.

99. The required space for the vacuum toilet is the same as that for a conventional toilet, including a 100 mm space from the back wall.

Technical Data

100. Following is technical information covering the vacuum toilet:

a) Operating vacuum: approximately 50 per cent.
Minimum operating vacuum: 38 per cent vacuum.
Duration of flushing cycle: water, 5 to 7 seconds; discharge, 2 to 4 seconds.

b) Water consumption: 1 to 1.2 L.
Air consumption: approximately 0.10 m^3.

c) Bowl: vitreous china.
Seat and cover. molded plastic, rigid or flexible.
Cap: polypropylene.
Back-plate: polyestyrene.
Operating mechanism: polyacetal, ABS, and polypropylene.
Rubber components: cloropene.

d) Net weight: 25 kg.
Shipping weight: 26 kg.
Shipping volume: 0.15 m^3.

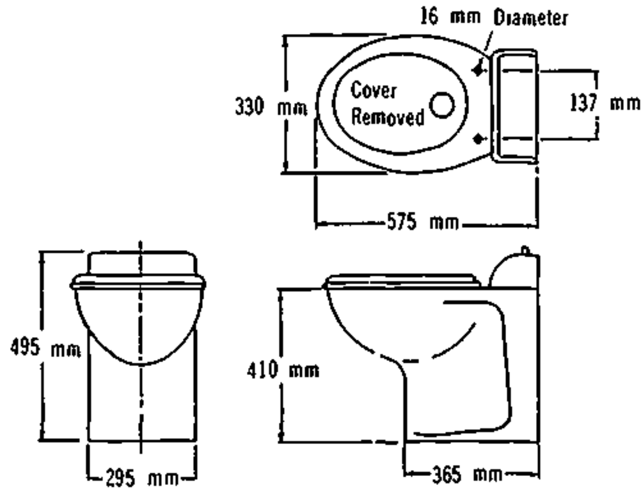


Figure 37-30. Vacuum Toilet

Installation

101. The vacuum toilet can be connected to the vacuum line with either a straight rubber coupling or a rubber elbow. (See Figure 37-31.) The bowl is screwed to the floor by four chrome-plated wood screws. The fresh-water supply connection on the back of the toilet is an NPS ½ male pipe nipple. If required by regulations, a vacuum breaker can be installed. A shut-off valve must be installed on the water-supply line. No vent piping is required for the vacuum toilet.

Urinal and Urinal Valve

102. Conventional-type urinals made from vitreous china or stainless steel can be connected to the Vacusan system with the urinal valve. Urinals should be flushed with manually operated self-closing supply valves to reduce water consumption.

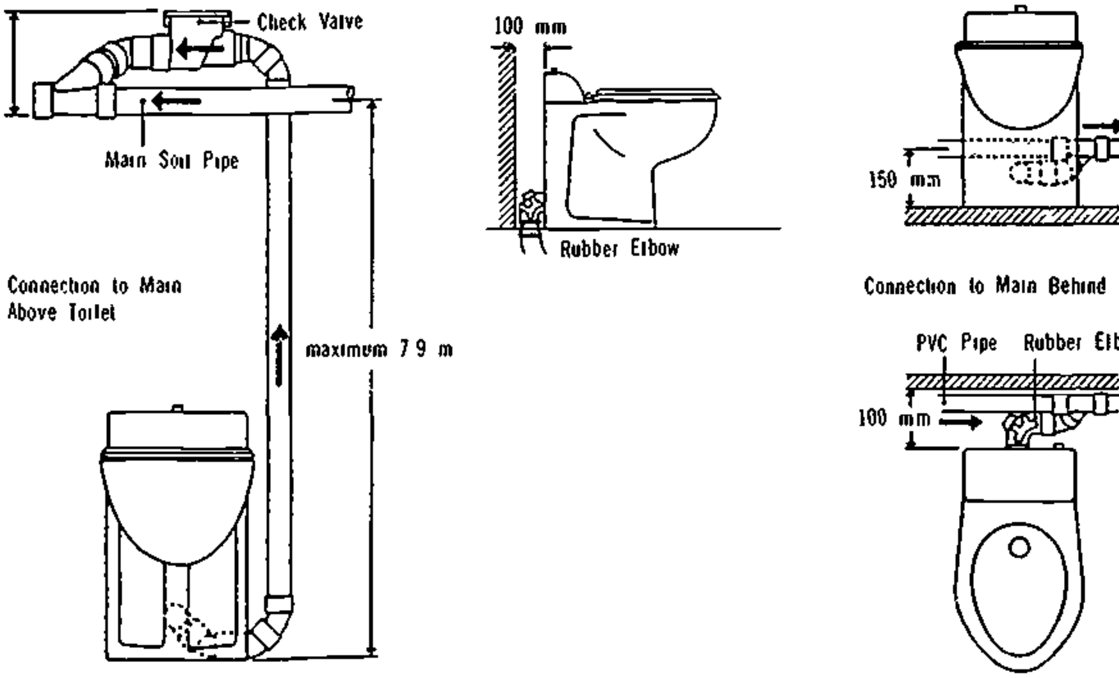


Figure 37-31. Installation Layout for Vacuum Toilet

Working Principle

103. The urine and water are collected in float activator 1 via gravity line 2 from the urinals. (See Figure 37-32.) When the liquid has reached a certain level the float activates vacuum valve 3, which opens the vacuum connection to the top of discharge valve 4. The discharge valve will open and liquid and air are sucked into vacuum pipe 5. As the level in the float activator lowers, the float closes the vacuum valve. Each discharge transports about two litres of water.

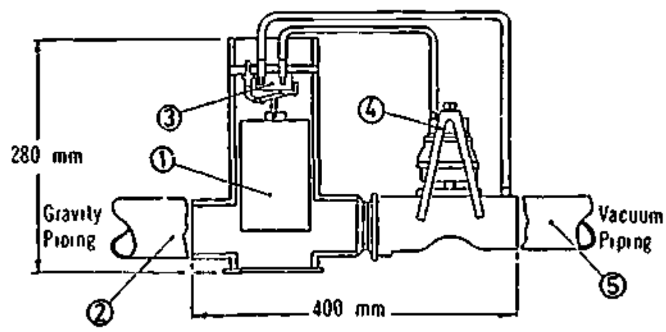


Figure 37-32. Operation of Urinal Valve

The Vacusan On-Line Vacuum Sewerage System

104. The Vacusan On-Line vacuum sewerage system (Figure 37-33) employs the principles of vacuum transport to collect sewage from houses and other buildings containing normal plumbing. The normal flows of sewage are drained by standard gravity methods to an interface point. Located at this point is a gravity-to-vacuum interface unit (IFU), which comprises a sewage sensor and valve, both of which are vacuum-operated with no electrical connections.

The interface unit is normally located below ground level in a protective chamber. The pipe leading from the IFU is always under vacuum, or suction; is normally smaller than the gravity service (NPS 2 versus NPS 4); and is connected to the street sewer, also under vacuum.

Vacuum street sewers, varying in size from NPS 3 to NPS 8, run to a central vacuum station where the vacuum pumps, receiving tanks, etc., are located. Usually, a main street line handles up to 100 houses and a central station has several incoming main lines.

105. The Vacusan On-Line System, as shown in Figure 37-33, takes the mechanization right to the homeowner's lot or basement. Essentially, it comprises three major components:

a) *The interface unit*, to collect sewage from homes or other sources (Figure 37-34).
b) *The vacuum piping network*, to transport sewage and distribute vacuum (Figure 37-35).
c) *The collecting station*, to create vacuum and to receive and discharge sewage (Figure 37-36).

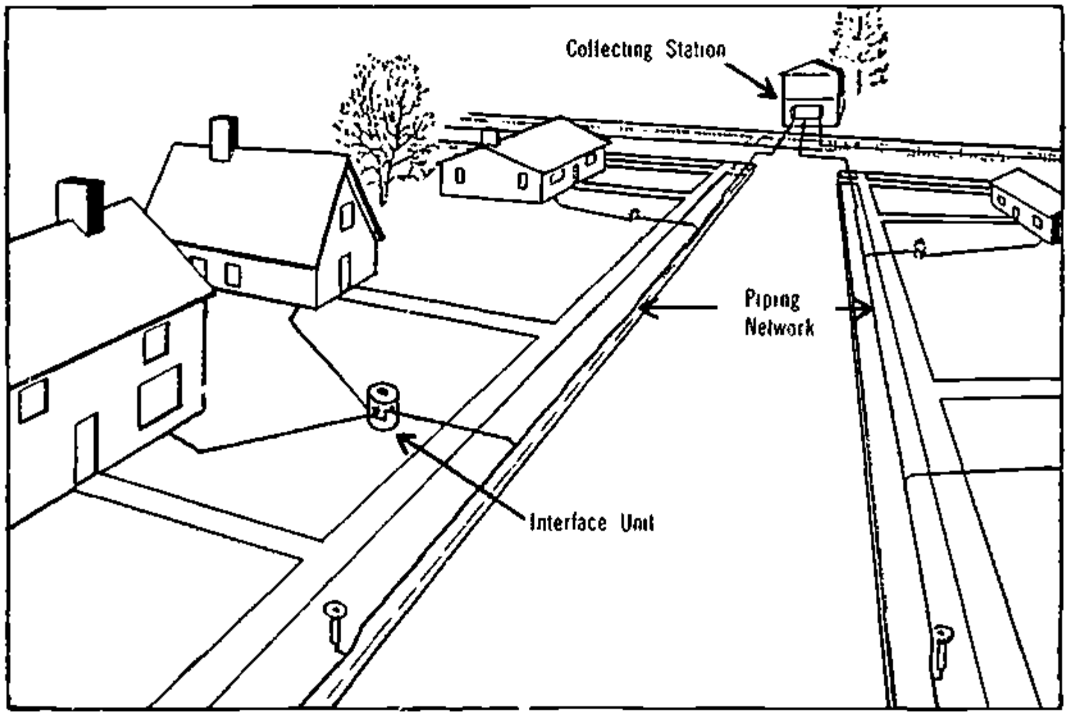


Figure 37-33. A Typical Vacusan On-Line System Layout

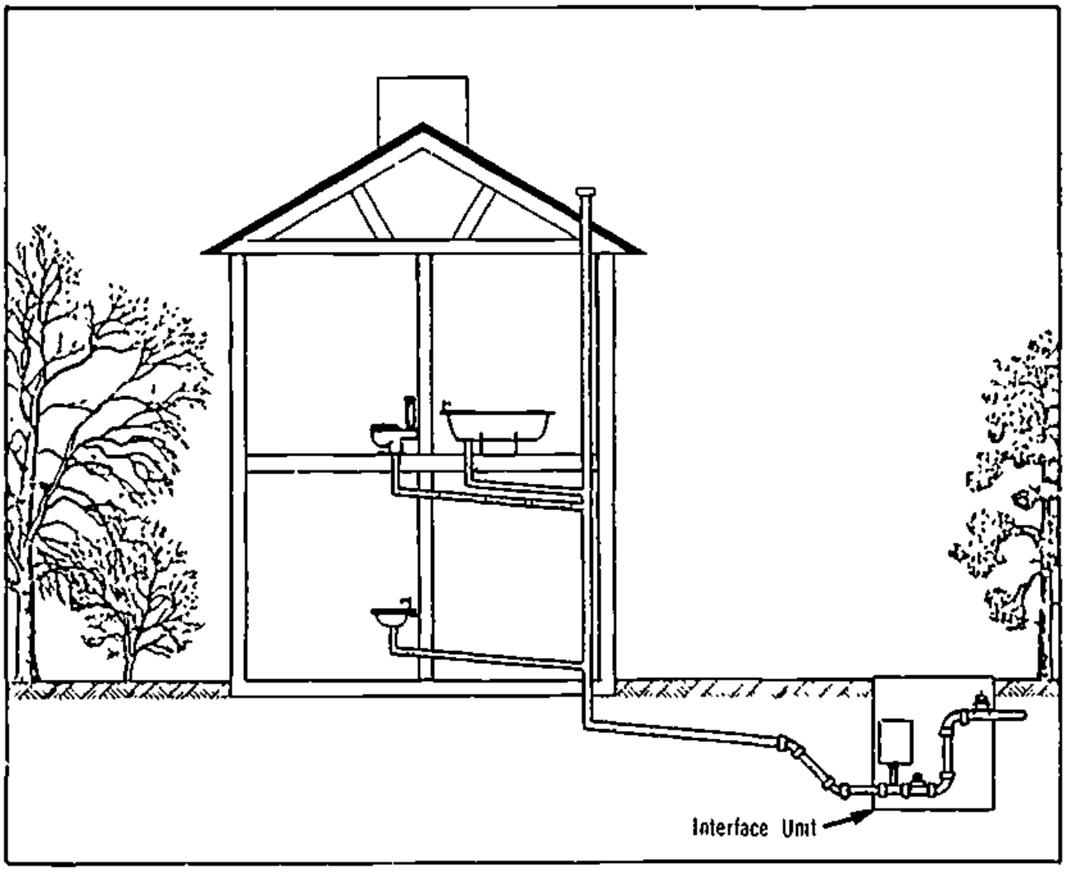


Figure 37-34. The Interface Unit

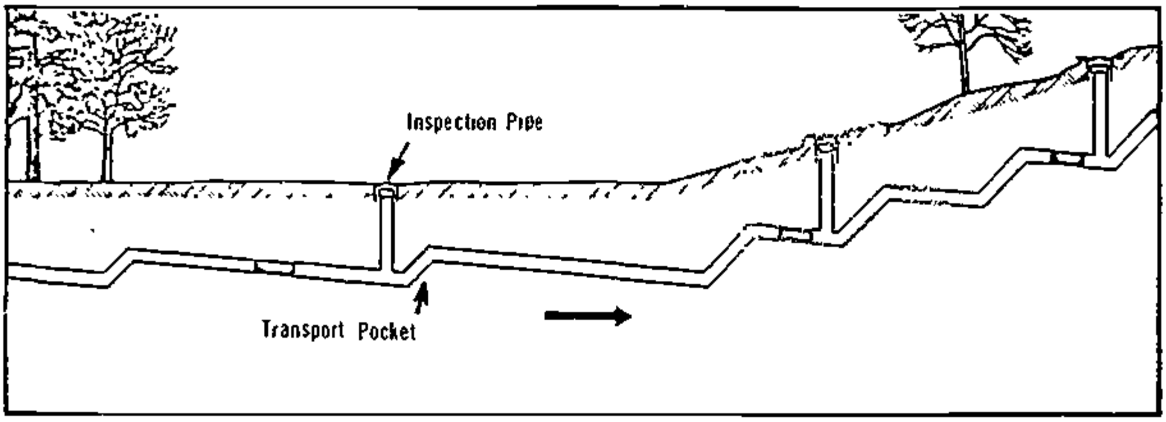


Figure 37-35. The Vacuum Piping Network

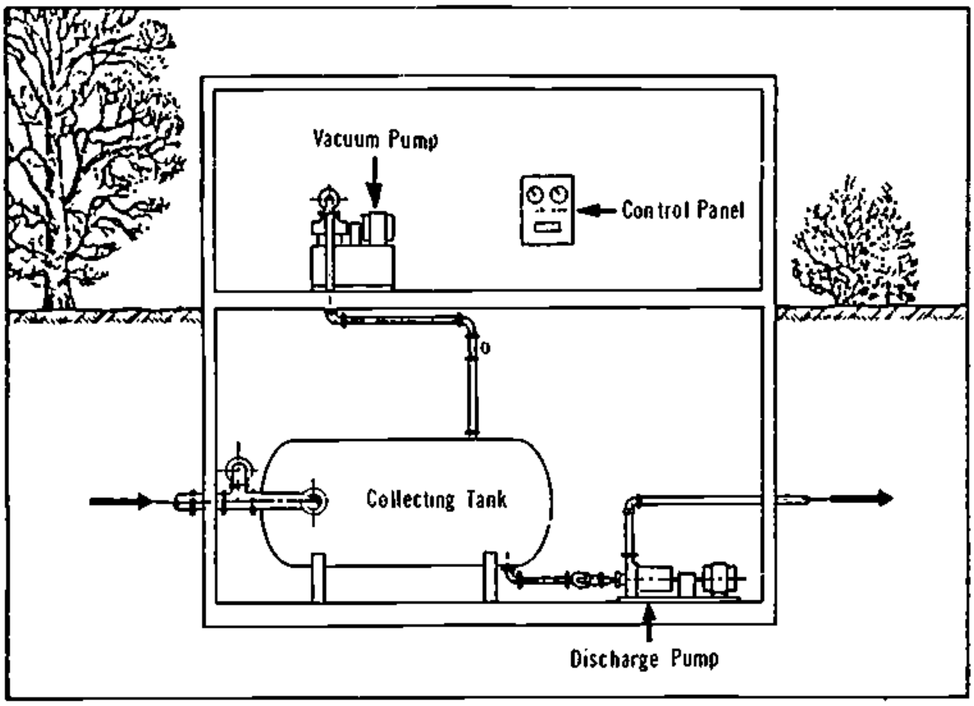


Figure 37-36. The Collecting Station

106. At each source of sewage entering the vacuum system, an interface unit is installed on-line between the gravity service connection and the vacuum piping network, allowing sewage into the vacuum main on demand. (See Figure 37-34.)

The interface unit has two main components — the activator and the discharge valve. Sewage is interfaced into the vacuum main in predetermined volumes, followed by air. The air ensures that the discharge valve closes on air and not on sewage, and helps to increase transport velocity and improve lift capacity in the piping network.

The completely automatic interface unit is self-powered, using vacuum available from the piping network without the need for any electrical supply.

107. The vacuum network transports sewage from various interface units to the central collecting station. (See Figure 37-36.)

Vacuum sewage transport is essentially a plug transport, in which sewage in the form of a long plug or slug is propelled through the piping. Gravity, however, tends to break down the plug which has to be re-formed at certain low points, or transport pockets, installed at intervals. (See Figure 37-35.)

The pipe runs with a slight downslope toward the transport pocket, and a small lift is taken at that point to compensate for this downslope so that the pipe fundamentally remains horizontal under flat terrain conditions. Uphill transport is accomplished by increasing the lift to allow for the elevation of the ground contour, as well as for the downslope to the pocket.

An inspection pipe is normally installed at the transport pocket to permit detection of potential leaks. It also serves as a clean-out and major isolation point.

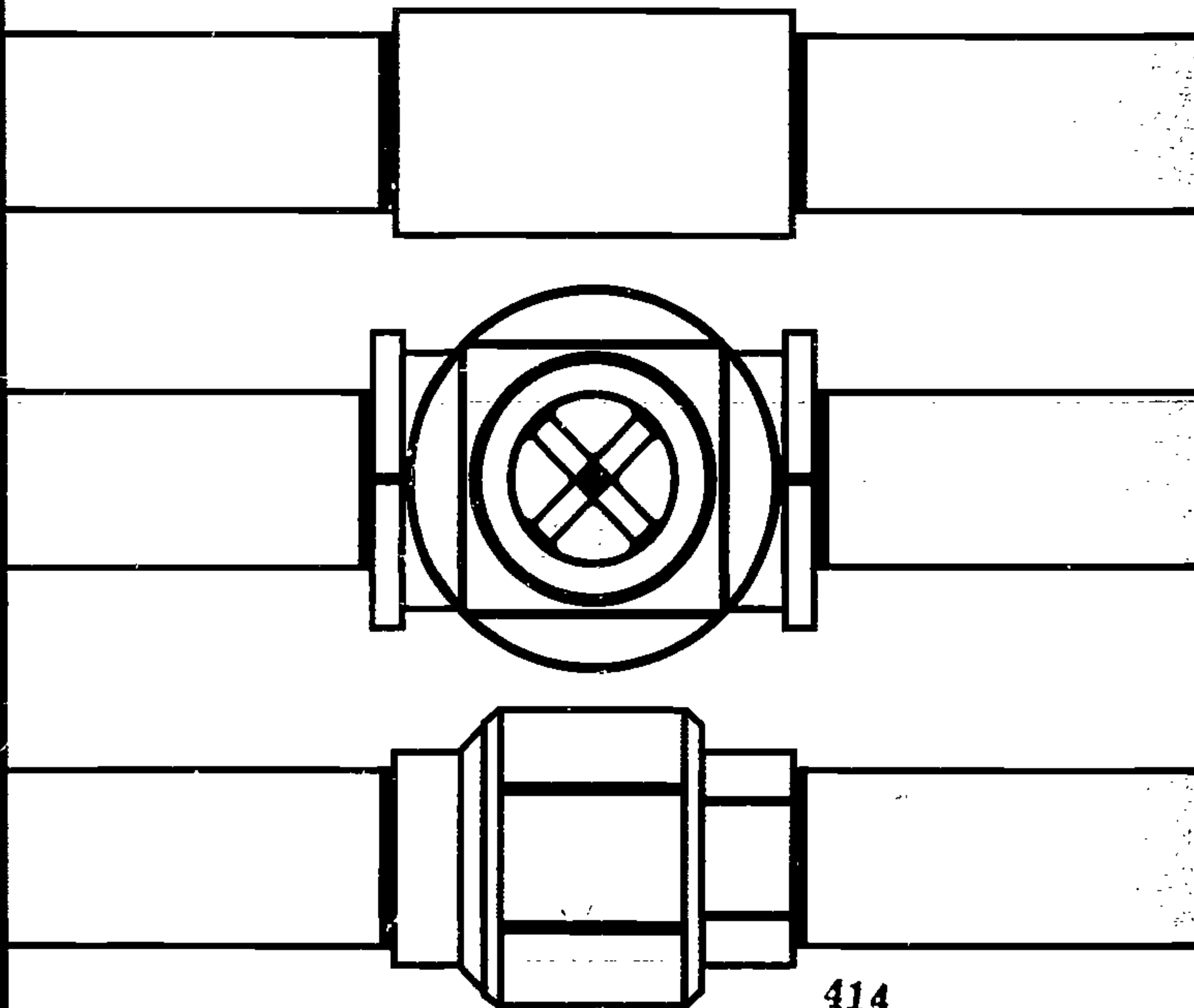
108. A central collecting station, which may serve an area of up to 8 km in diameter, houses a vacuum pump(s) to maintain vacuum, a collecting tank(s) to collect sewage from the vacuum piping network, and a discharge pump(s) to transfer sewage to a treatment plant, gravity sewer, or force main. (See Figure 37-36.)

The system is automatically operated by a simple control panel, which also provides for operation of the pumps and automatic standby equipment.

109. For further particulars of the Vacusan vacuum systems, in British Columbia, contact Vacusan Systems Limited, Unit 111, 2931 Olafson Ave., Richmond, B.C., V6X 2R4.

Symbols for Architectural Drawings

38



PART 38

SYMBOLS FOR ARCHITECTURAL DRAWINGS

1. Building Plans

a) The plumber requires a copy of the architect's plans and specifications in order to bid on the job and to later lay out the plumbing portion if awarded the contract.

b) Plans for plumbing installations generally contain the following four basic categories of symbols:

- Symbols for piping, which are represented as various types of lines.
- Symbols for fittings such as tees, couplings, elbows, and unions.
- Symbols for valves.
- Symbols for plumbing fixtures.

NOTE: Architectural symbols, like codes and regulations, may be subject to periodic revision. Therefore it is important that you always consult the most up-to-date references issued by the appropriate agencies.

2. Piping Symbols

Figure 38-1 illustrates symbols used to identify the various pipes in a system. The pipe sizes will be shown on the architect's drawings.

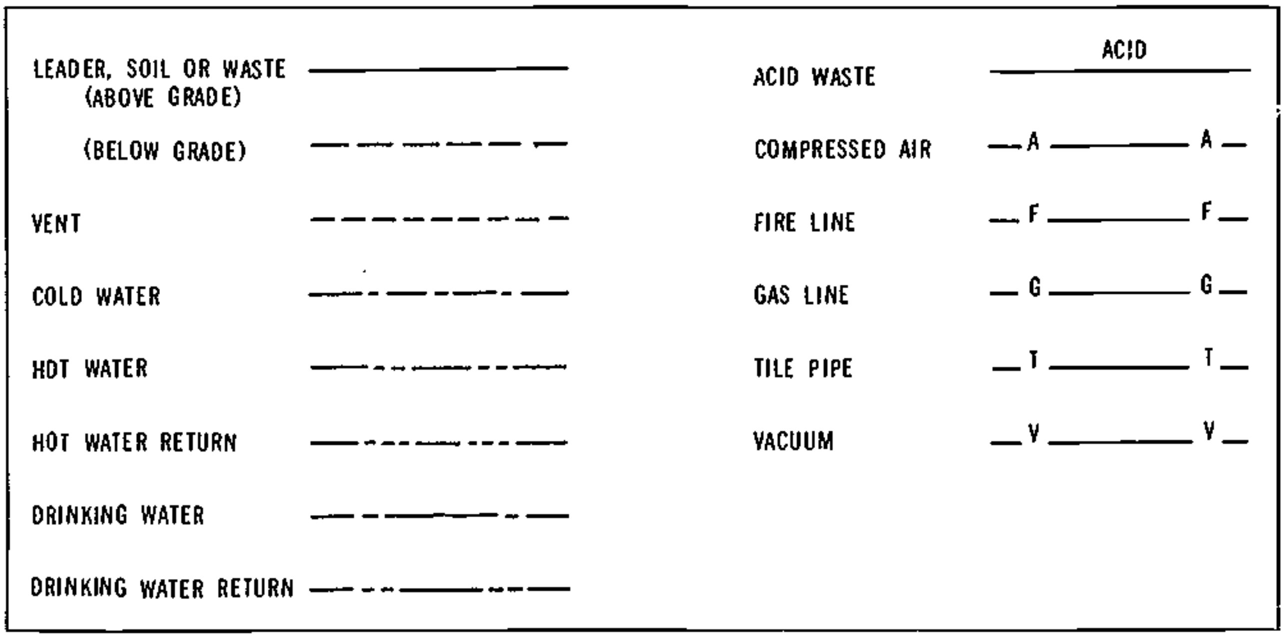


Figure 38-1. Identification of Various Pipes

3. Fitting Symbols

Figure 38-2 illustrates symbols used on plans to designate types of fittings and joints.

ITEM	SYMBOL	SAMPLE APPLICATION(S)	ILLUSTRATION
PIPE	SINGLE LINE IN SHAPE OF PIPE- USUALLY WITH NOMINAL SIZE NOTED		
JOINT FLANGED	DOUBLE LINE		
SCREWED	SINGLE LINE		
BELL AND SPIGOT	CURVED LINE		
OUTLET TURNED UP	CIRCLE AND DOT		
OUTLET TURNED DOWN	SEMICIRCLE		
REDUCING OR ENLARGING FITTING	NOMINAL PIPE SIZE NOTED AT JOINT		
REDUCER CONCENTRIC	TRIANGLE		
ECCENTRIC	TRIANGLE		
UNION SCREWED	LINE		
FLANGED	LINE		

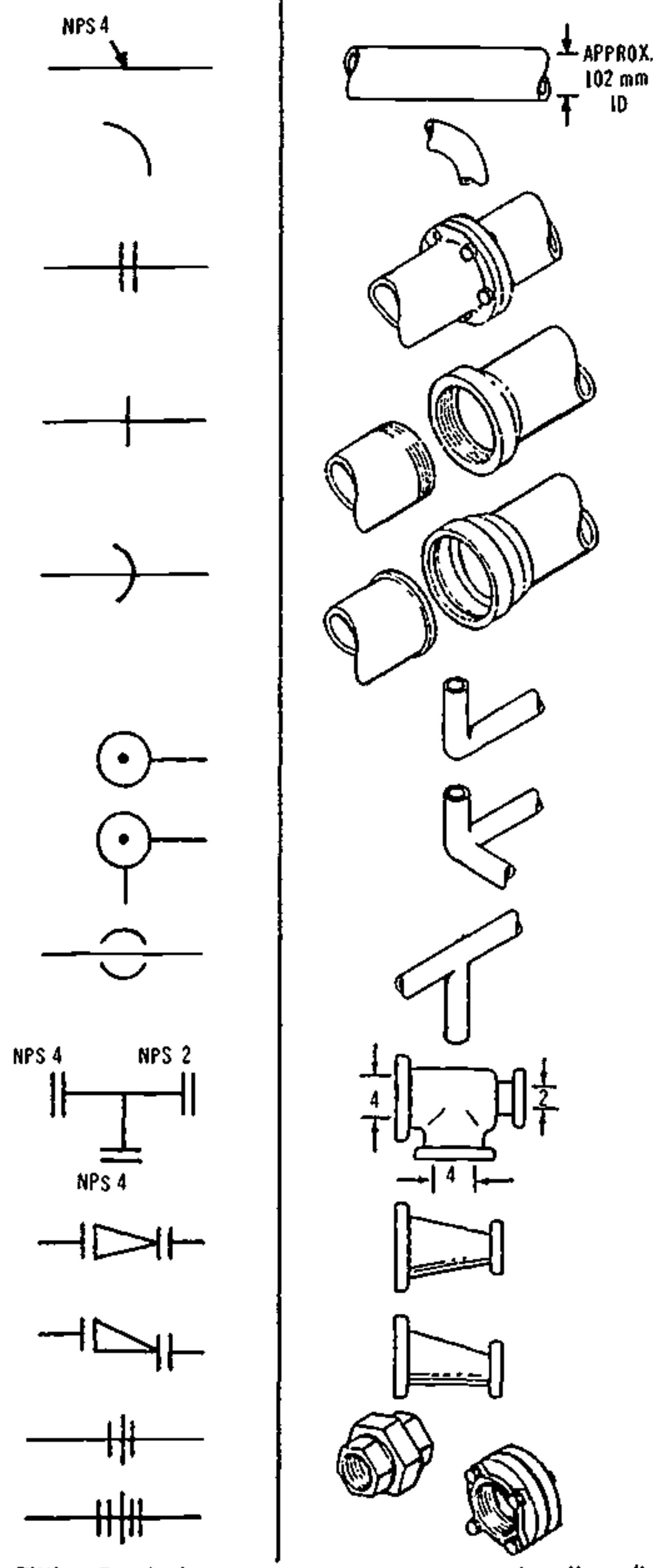
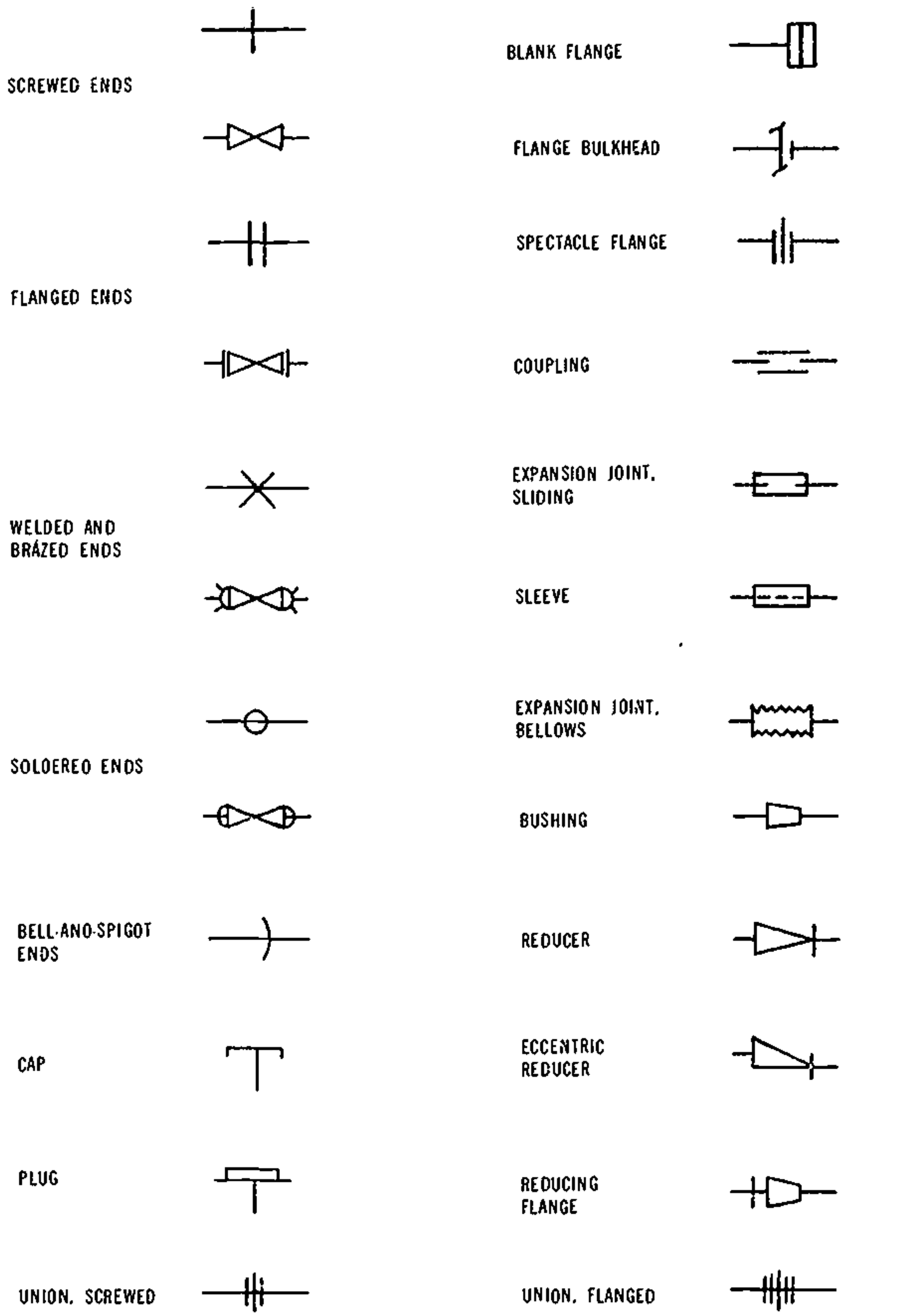


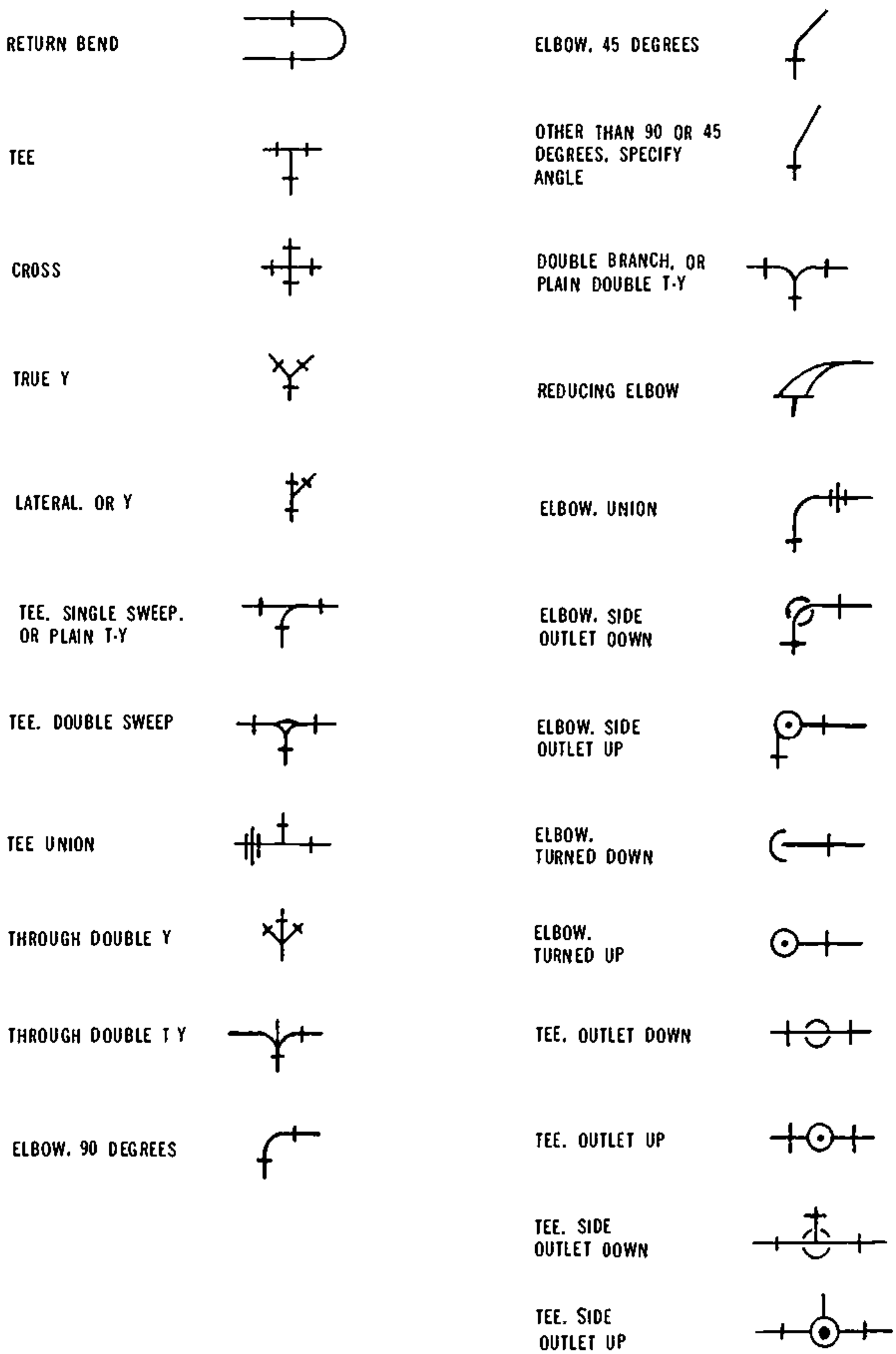
Figure 38-2. Fitting Symbols *(continued)*

Figure 38-2. Fitting Symbols (continued)



(continued)

Figure 39-2. Fitting Symbols (continued)



4. Valve Symbols

Many types of valves are used in plumbing systems. Some control the direction of water flow in the pipe, and others regulate the amount of flow or shut off the supply. Figure 38-3 shows the symbols for the various types of valves.

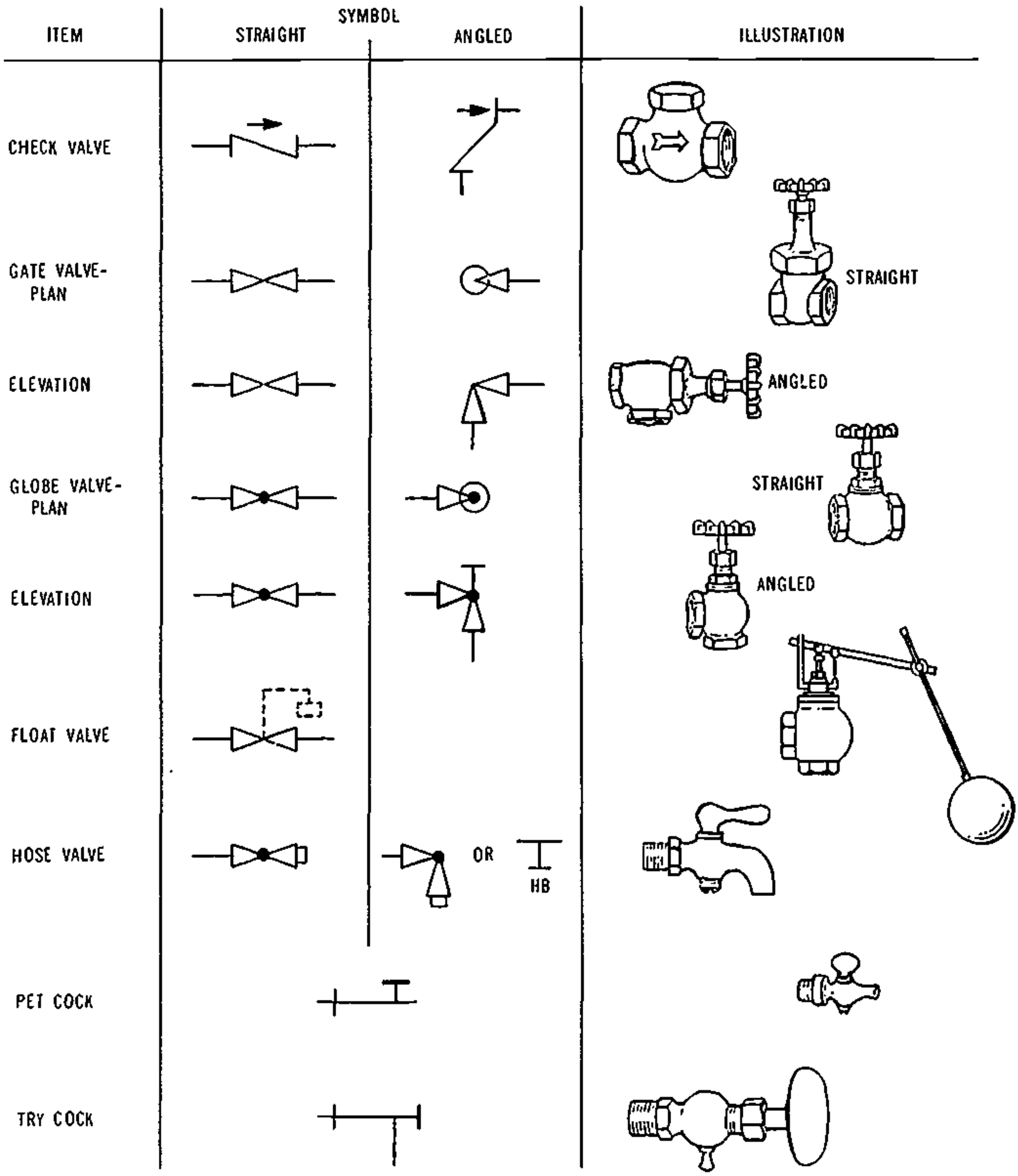
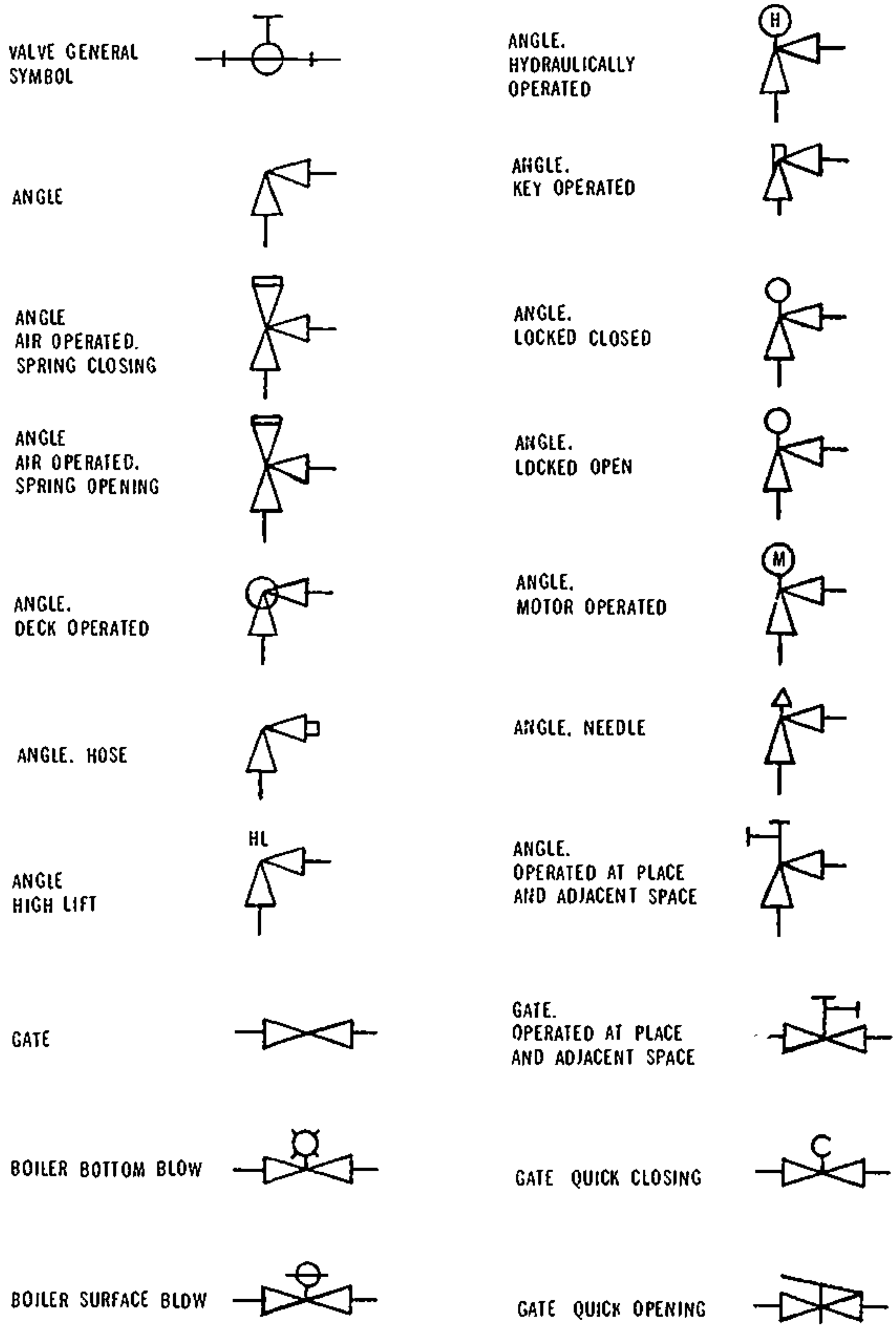


Figure 38-3. Symbols Identifying Various Types of Valves

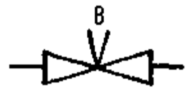
(continued)

Identification of Valves (continued)



(continued)

Identification of Valves (continued)

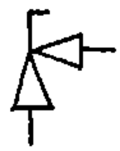
BUTTERFLY


CHRONOMETER


CROSS


GATE DECK OPERATED


GATE HOSE


GATE ANGLE


GATE LOCKED CLOSED


GATE LOCKED OPEN


GATE MOTOR OPERATED


GLOBE, AIR OPERATED, SPRING CLOSING


GLOBE, AIR OPERATED SPRING OPENING

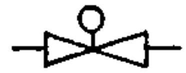

GLOBE MOTOR OPERATED

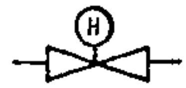

GLOBE KEY OPERATED


GATE, SLUICE


GLOBE


GLOBE, DECK OPERATED


GLOBE, LOCKED OPEN


GLOBE HYDRAULICALLY OPERATED


GLOBE, OPERATED AT PLACE AND ADJACENT SPACE


MICROMETER


NEEDLE


PISTON ACTUATED VALVE (SUITABLE FOR ADDITION OF CONTROL PIPING)


GLOBE, HOSE


ANGLE, STOP CHECK, DECK OPERATED


ANGLE, STOP CHECK HOSE

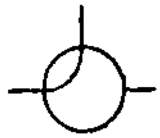

ANGLE, STOP CHECK, HYDRAULICALLY OPERATED


(continued)

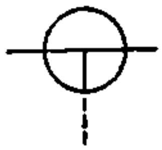
Identification of Valves (continued)

GLOBE LOCKED CLOSED

STOP COCK
PLUG OR CYLINDER
VALVE 3 WAY 2 PORT

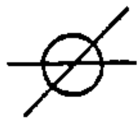


STOP COCK.
PLUG OR CYLINDER
VALVE 3 WAY. 3 PORT



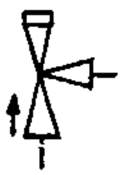
STOP COCK
PLUG OR CYLINDER
VALVE 4 WAY 4 PORT

GENERAL SYMBOL

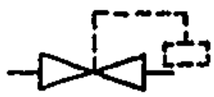


ANGLE STOP CHECK

ANGLE. STOP CHECK.
AIR OPERATED.
SPRING CLOSING



FLOAT OPERATED

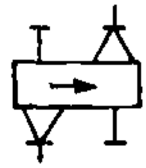


GLOBE. STOP CHECK

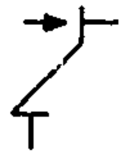
GLOBE. STOP CHECK.
AIR OPERATED.
SPRING CLOSING

ANGLE. STOP LIFT
CHECK

BOILER FEED. STOP
AND CHECK COMBINED



CHECK. ANGLE

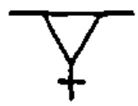


CHECK. BALL

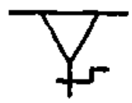
BACK PRESSURE

CROSS FEED

DRAIN

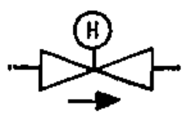


DUMP



GLOBE. STOP CHECK.
DECK OPERATED

GLOBE. STOP CHECK.
HYDRAULICALLY
OPERATED



5. Fixture Symbols

Figure 38-4 shows some of the pictorial and block symbols generally used on plans to show the locations of fixtures, including floor and roof drains.

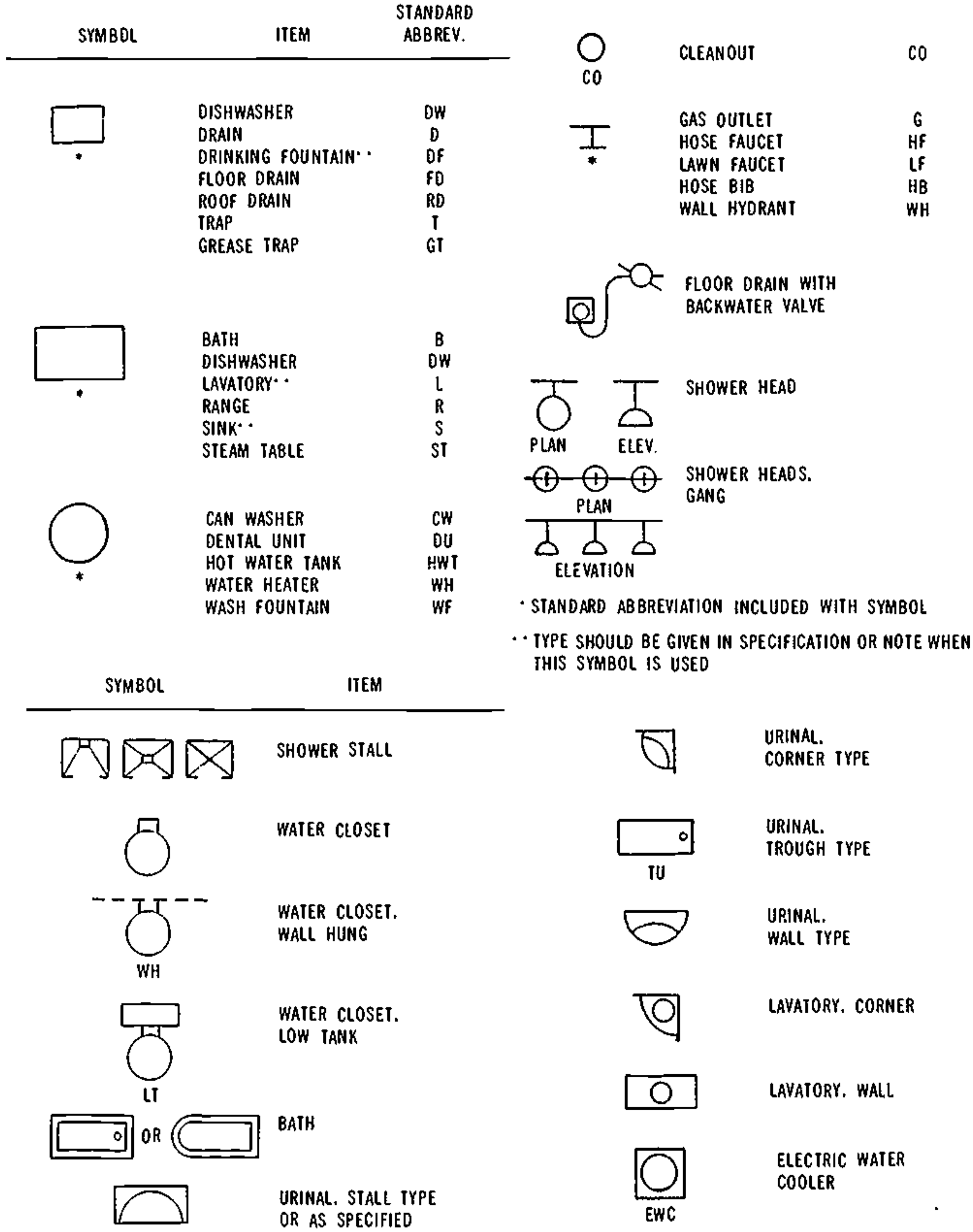
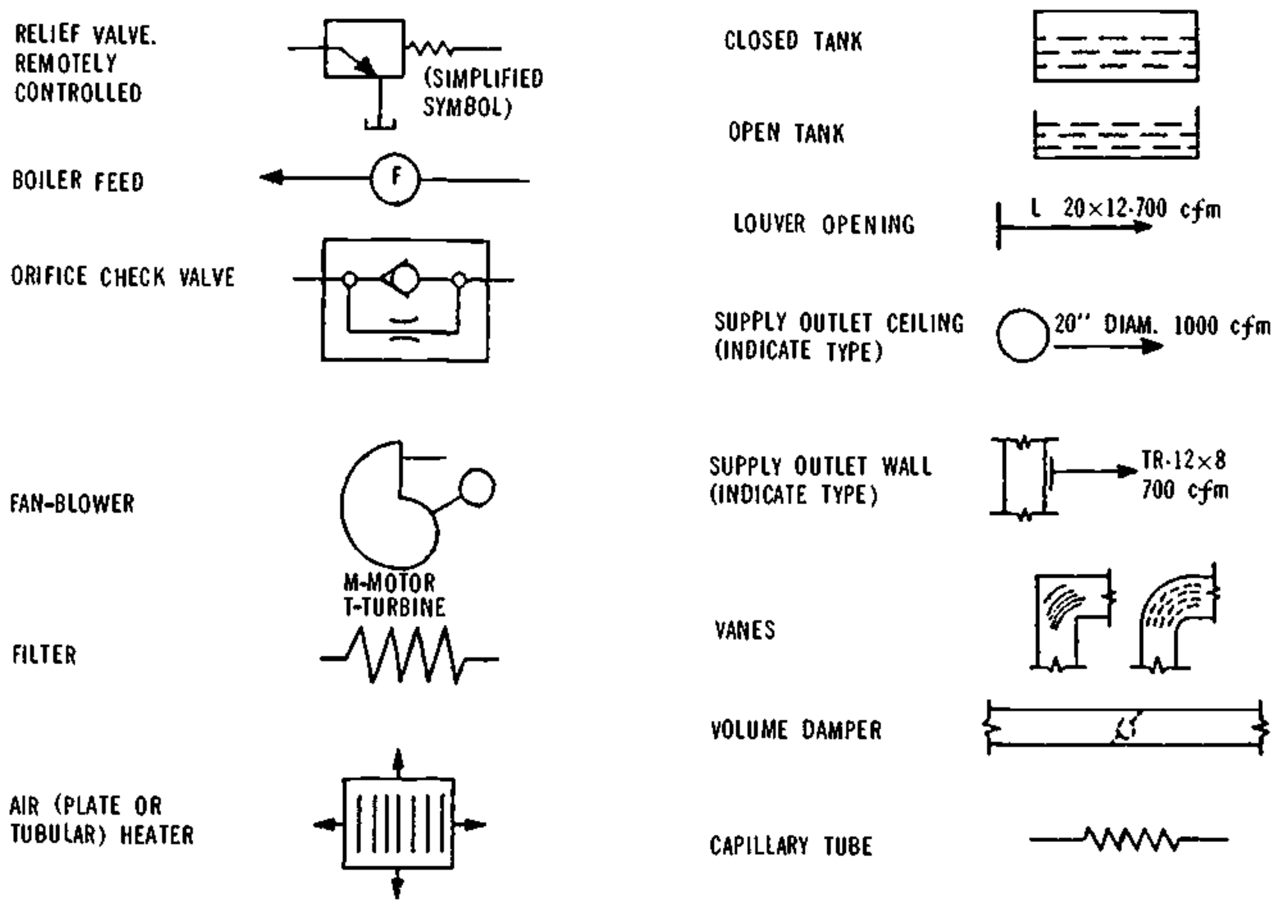


Figure 38-4. Pictorial and Block Symbols Pictorial and Block Symbols

6. Heating Symbols

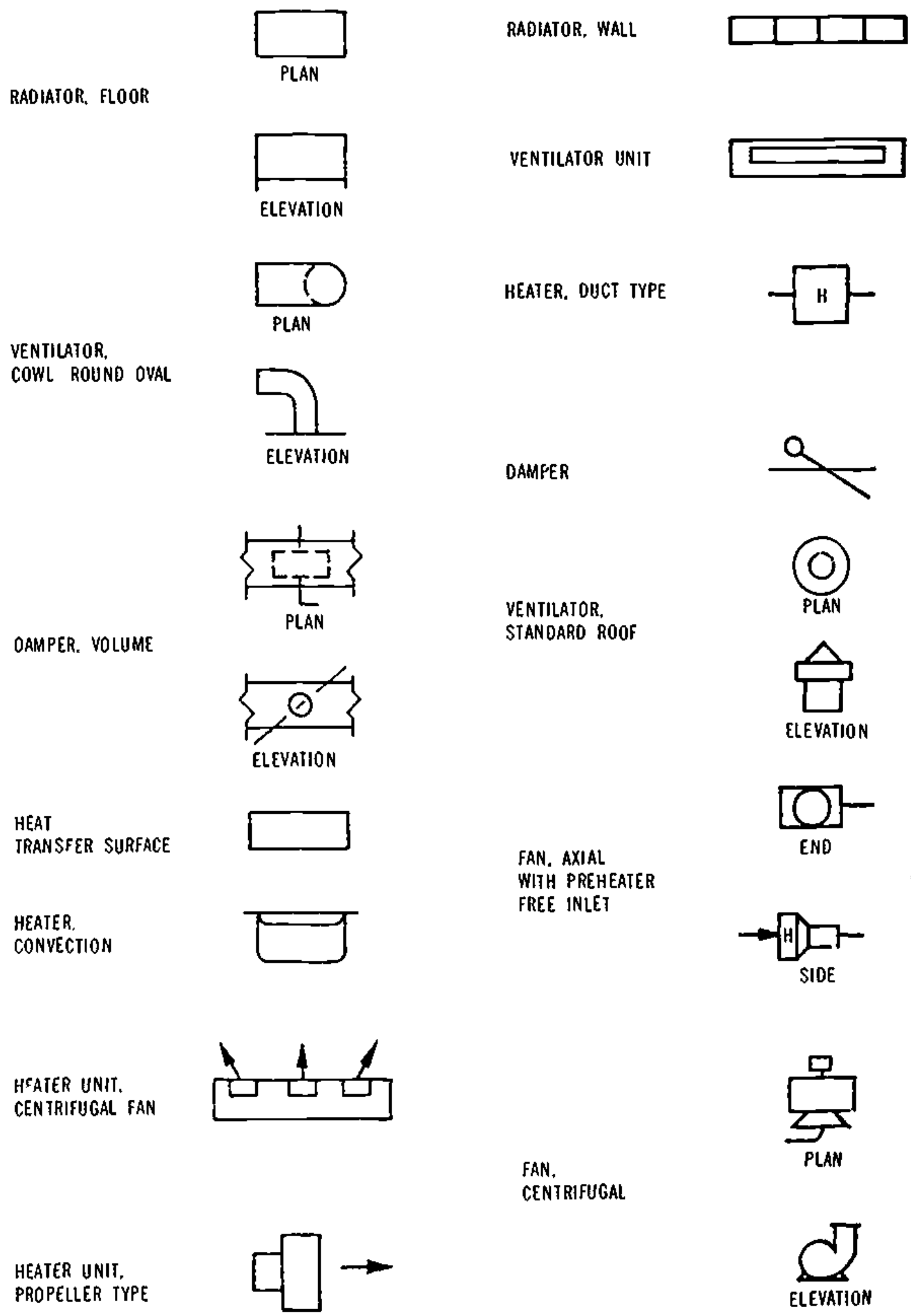
The heating symbols shown in Figure 38-5 are included in this manual only for general reference purposes.



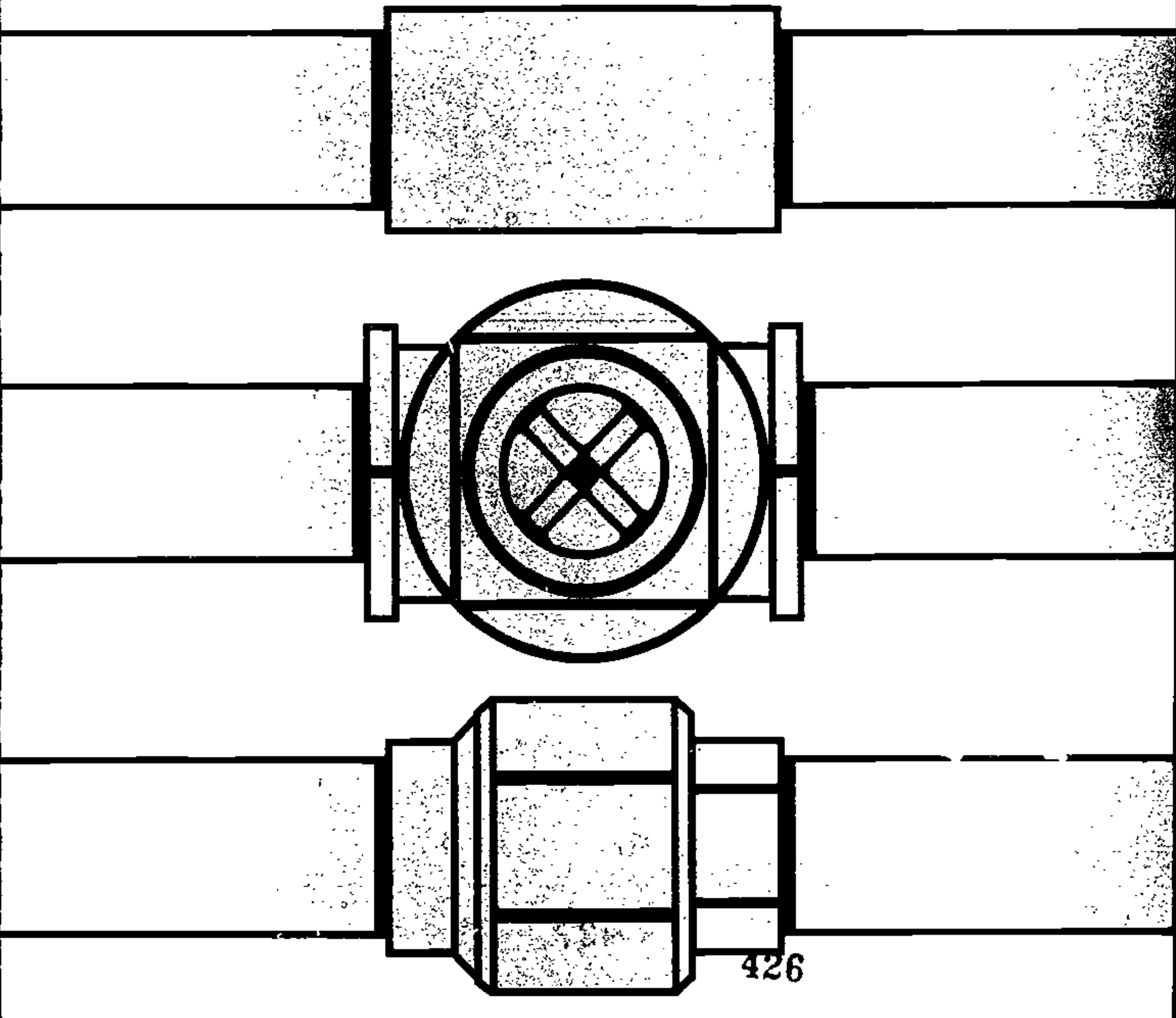
(continued)

Figure 38-5. Heating Symbols

Figure 38-5. Heating Symbols (continued)



Appendix: Sources of Data



SOURCES OF DATA

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Brass Craft Canada Ltd.

Canadian Copper & Brass Development Association
Canadian Forces School of Military Engineering, Chilliwack, B.C.
Canadian General Standards Board (formerly Canadian Government Specifications Board)
Canadian Johns-Manville Co. Limited
Canron Inc. Pipe Division
Cast Iron Soil Pipe Division (formerly Cast Iron Soil Pipe Association of Canada)
C-B Supplies Limited
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Crowle Fittings Limited
Cunningham and Hill Limited

Delta Faucet of Canada Ltd.

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ISE, Division of Emerson Electric Company

Jenkins Valve Company
Josam Manufacturing Canada

Kindred Industries Limited

MAC-Qest Products Limited
Milwaukee Electric Tool (Canada) Ltd.
Mueller Limited

National Association of Plumbing-Heating-Cooling Contractors, Washington, D.C.
National Standard Plumbing Code (U.S.A.)

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Reed Manufacturing Company
Ridge Tool Company
Rollco Pipe Supply Ltd.

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Vacusan Systems Limited
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Watts Regulator Company Ltd.
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