Survey Instruments, Plumbing Valves and Other Accessories

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Credit: 3 PDH

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This course was adapted from the Naval Education and Training Professional Development and Technology Center "Piping System Layout and Plumbing Accessories" NAVEDTRA 14265A training course, Chapter 5, "Survey Instruments, Plumbing Valves and Other Accessories", which is in the public domain.

Chapter 5

Piping System Layout and Plumbing Accessories

Topics

Overview

Your job as an Utilitiesman (UT) is to prepare the construction site before laying wastewater and water distribution systems. Your work could begin with site surveys using specialized surveying equipment and methods.

This chapter introduces you to the concepts of site surveys, including construction surveys, leveling rods, bench marks, sewer stakeouts, and common errors and mistakes encountered.

In this chapter, you will be provided with information regarding the different types of valves and procedures for installing and repairing them, valve accessories, and pipe fittings. Also discussed are testing of systems, and laying out water distribution systems.

Objectives

When you have completed this chapter, you will be able to do the following:

1. Describe surveying operations.
2. Describe the operation and use of leveling rods.
3. Identify bench mark as associated with surveying.
4. Identify common errors and mistakes associated with surveying operations.
5. Describe the purpose and components of sewer stakeout.
6. Describe plumbing valves and accessories.
7. Describe the types, purpose, and correct method of reading water meters.
8. Describe water distribution system accessories.

Prerequisites

None.

This course map shows all of the chapters in Utilitiesman Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.

Utilities Equipment and Maintenance	↑	
Air Conditioning		
Refrigeration		
Heating Systems		U
Steam Distribution Systems		T
Boilers		
Sewage Disposal, Field Sanitation, and Water Treatment		B
Prime Movers, Pumps, and Compressors		A
Plumbing Fixtures		S
Piping System Layout and Plumbing Accessories		I
Structural Openings and Pipe Material		C
Fundamentals of Water Distribution		
Basic Math, Electrical, and Plumbing Operations		
Plans, Specifications, and Color Coding		

Features of this Manual

This manual has several features which make it easier to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with an italicized instruction telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for

review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 SURVEYING INSTRUMENTS

The engineer's level, often called the ***dumpy level***, is the instrument most commonly used to attain the level line of sight required for differential leveling. The dumpy level and the self-leveling level can be mounted for use on a tripod, usually with adjustable legs, shown in *Figure 5-1*.

Figure 5-1 - Tripod.

Mount the level by engaging the threads at the base of the instrument, called the footplate as shown in *Figure 5-2*, with the threaded head on the tripod. These levels are the ones most frequently used in ordinary leveling projects. For rough leveling, use the ***hand level***.

1.1.0 Dumpy Level

Figure 5-2 shows a dumpy level and its nomenclature. Notice that the telescope is rigidly fixed to the supporting frame.

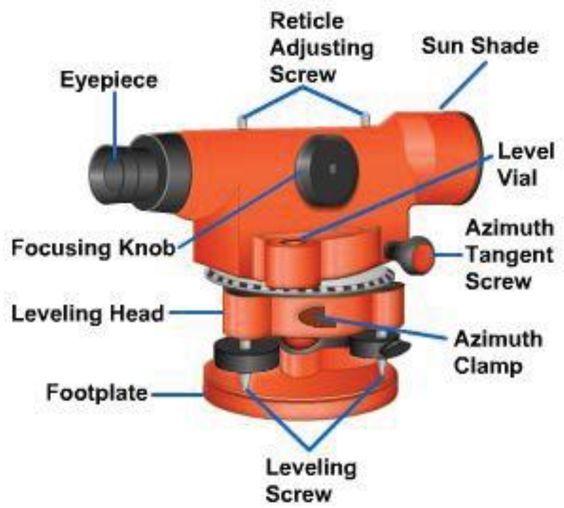


Figure 5-2 - Dumpy level.

Inside the telescope is a ring, or diaphragm, known as the reticle, which supports the cross hairs. The cross hairs are brought into exact focus by manipulating the knurled eyepiece focusing ring near the eyepiece, or the eyepiece itself on some models. If the cross hairs get out of horizontal adjustment, they can be made horizontal again by slackening the reticle adjusting screws and turning the screws in the appropriate direction. Only trained personnel, such as Engineering Aids (EA), should perform this adjustment.

The object to which you are sighting, regardless of shape, is called a target. Bring the target into clear focus by manipulating the focusing knob shown on top of the telescope. The telescope can be rotated only horizontally, but before it can be rotated, release the azimuth clamp. Bring the vertical cross hair into exact alignment on the target by rotating the azimuth tangent screw.

The level vial, leveling head, leveling screws, and footplate are all used to adjust the instrument to a perfectly level line of sight once it is mounted on the tripod.

1.2.0 Self-Leveling Level

The self-leveling, or automatic, level, shown in *Figure 5-3* is a precise, time-saving development in leveling instruments. It did away with the tubular spirit level, whose bubble takes time in centering as well as in resetting to its correct position from time to time during operation.

The self-leveling level is equipped with a small bull's-eye level and three leveling screws. The leveling screws, which are on a triangular foot plate, are used to center the bubble of the bull's-eye level approximately. The line of sight automatically becomes horizontal and remains horizontal as long as the bubble remains approximately centered. A prismatic device called a compensator makes this possible. The compensator is suspended on fine, nonmagnetic wires. The action of gravity on the compensator causes the optical system to swing into the position that defines a horizontal sight. The level maintains this horizontal line of sight despite a slight out of level of the telescope or even when a slight disturbance occurs on the instrument.

Figure 5-3 - Self-leveling level.

1.3.0 Hand Level

The hand level, like all surveying levels, combines a level vial and a sighting device. *Figure 5-4* shows the ***Locke level***, a type of hand level. A horizontal line, called an index line, is provided in the sight tube as a ***reference line***. The level vial is mounted atop a slot in the sighting tube in which a reflector is set at a 45° angle. This permits the observer sighting through the tube to see the object, the position of the level bubble in the vial, and the index line at the same time.

To get the correct sighting through the tube, stand straight, using the height of your eye, if known, above the ground to find the target. When your eye height is not known, you can find it by sighting the rod at eye height in front of your body. Since the distances over which you sight a hand level are rather short, no magnification is provided in the tube.

Figure 5-4 - Locke level.

1.4.0 Setting Up a Level

After you select the proper location for the level, your first step is to set up the tripod.

1. Spread two of the legs a convenient distance apart and then bring the third leg to a position that will bring the protector cap, which covers the tripod head threads, about level when the tripod stands on all three legs.
2. Unscrew the protector cap, exposing the threaded head, and place it in the carrying case where it will not get lost or dirty. The tripod protective cap should be in place when you are not using the tripod.
3. Lift the instrument out of the carrying case by the footplate, not by the telescope.

4. Set the instrument squarely and gently on the tripod head threads and engage the head nut threads under the footplate by rotating the footplate clockwise. If the threads will not engage smoothly, they may be cross threaded or dirty. Do not force them if you encounter resistance; instead, back off, and, after checking to see that they are clean, square up the instrument, and then try again gently.
5. Screw the head nut up firmly, but not too tightly. Screwing it too tightly causes eventual wearing of the threads and makes unthreading difficult.
6. After you have attached the instrument, thrust the leg tips into the ground far enough to ensure that each leg has stable support, taking care to maintain the footplate as nearly level as possible.
7. With the instrument mounted and the legs securely positioned in the soil, firmly tighten the thumbscrews at the top of each leg to prevent any possible movement.

Quite frequently, you must set up the instrument on a hard, smooth surface, such as a concrete pavement. When you do, you must take steps prevent the legs from spreading. *Figure 5-5* shows two good ways of doing this. In *View A*, the tips of the legs are inserted in joints in the pavement. In *View B*, the tips are held by a wooden floor triangle.

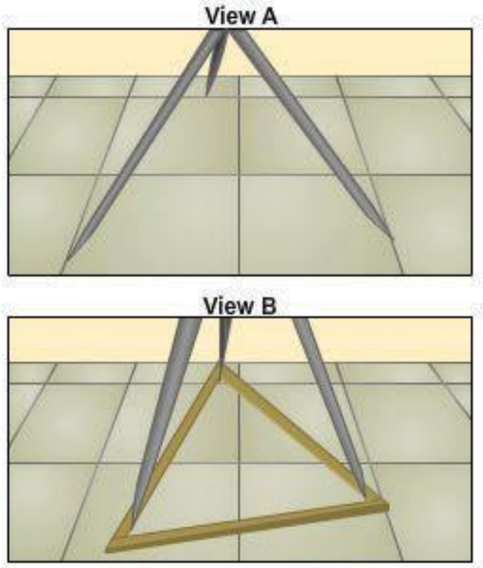


Figure 5-5 – Methods of preventing tripod legs from spreading.

1.5.0 Leveling a Level

To function accurately, the level must provide a perfectly horizontal line of sight in any direction you train the telescope. To ensure this, you must level the instrument as discussed in the next paragraphs or follow the manufacture's instructions.

When you first set up the tripod and instrument, make the footplate as nearly level as possible.

Train the telescope over a pair of diagonally opposite leveling screws, and clamp it in that position.

Manipulate the leveling thumbscrews, as shown in *Figure 5-6,* to bring the bubble in the level vial exactly into the marked center position. Manipulate the thumbscrews by simultaneously turning them in opposite directions. This shortens one spider leg, the threaded member running through the

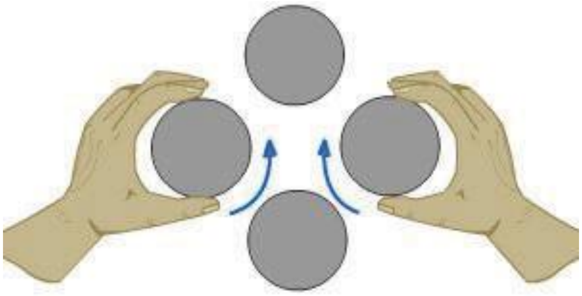


Figure 5-6 - Manipulating leveling thumbscrews.

thumbscrew, while it lengthens the other. It is helpful to remember that the level vial bubble will move in the same direction that your left thumb moves while you rotate the thumbscrews. In other words, when your left thumb pushes the thumbscrew clockwise, the bubble will move towards your left hand; when you turn the left thumbscrew counterclockwise, the bubble moves toward your right hand.

After leveling the telescope over one pair of screws, train it over the other pair and repeat the process. As a check, set the telescope in all four possible positions and be sure that the bubble centers exactly in each.

Various techniques for using the level will develop with experience.

1.6.0 Care of Levels

An engineer's level is a precision instrument containing many delicate and fragile parts. Handle it gently and very carefully at all times; never subject it to shock or jar. Movable parts, if not locked or clamped in place, should work easily and smoothly. If a movable part resists normal pressure, something is wrong. Forcing the part to move will probably damage the instrument. Tightening clamps and screws excessively will also cause wear or damage.

The only proper place to stow the instrument when it is detached from the tripod is in its own carrying box or case. The carrying case is designed to reduce the effect of jarring to a minimum. It is strongly made and well padded to protect the instrument from damage. Before stowing, slightly tighten the azimuth clamp and leveling screws to prevent movement of parts inside the box. When transporting it in a vehicle, place the case containing the instrument as nearly as possible midway between the front and rear wheels. This is the point where jarring of the wheels has the least effect on the chassis.

Never lift the instrument out of the case by grasping the telescope. Wrenching the telescope in this manner will damage a number of delicate parts. Lift it out by reaching down and grasping the footplate or the level bar.

When you attach the instrument to the tripod and carry it from one point to another, set up the azimuth clamp and level screws tightly enough to prevent part motion during the transport but loosely enough to allow give in case of an accidental bump against some object. When you are carrying the instrument over terrain that is free of possible contacts, such as across an open field, you may carry it over your shoulder like a rifle. When there are obstacles around, carry it with the telescope and base close into the front of your body. Carried in this manner, the instrument is always visible to you, and this makes it possible for you to avoid striking it against obstacles.

Test your Knowledge (Select the Correct Response)

1. By what part should you initially remove surveying equipment from the carrying case?

   A. Footplate
   B. Telescope
   C. Legs
   D. Leveling rods

2.0.0 LEVELING RODS

A leveling rod is a vertically supported tape used to measure vertical distance, which is the difference in elevation between a line of sight and a required point above or below it. Although there are several types of rods, the most popular and frequently used is the Philadelphia rod. *Figure 5-7* shows the face and back of this rod.

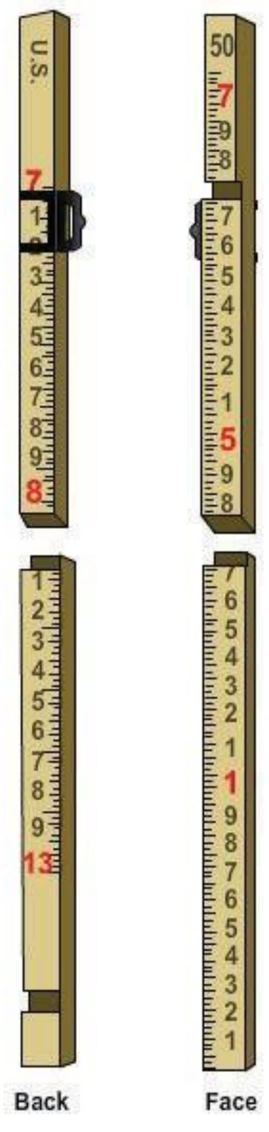


Figure 5-7 — Back and face of Philadelphia leveling rod.

The Philadelphia rod consists of two sliding sections, which can be fully extended to a total length of 13.10 feet. When the sections are entirely closed, the total length is 7.10 feet. For direct readings, or readings on the face of the rod, between 7.10 and 13.10 feet, the rod is used extended and read on the back by the rodman. If you are in the field and do not have a Philadelphia rod, you can use a 1 by 4 with a mark or a 6-foot wooden ruler attached to a 2 by 4.

In direct readings, the person at the instrument reads the graduation on the rod intercepted by the cross hair through the telescope. In target readings, the rodman reads the graduation on the face of the rod intercepted by a target. In *Figure 5-7* the target does not appear; it is shown in *Figure 5-8*. It is a sliding, circular device that can be moved up or down the rod and clamped in position. The rodman places it on signals from the instrumentman.

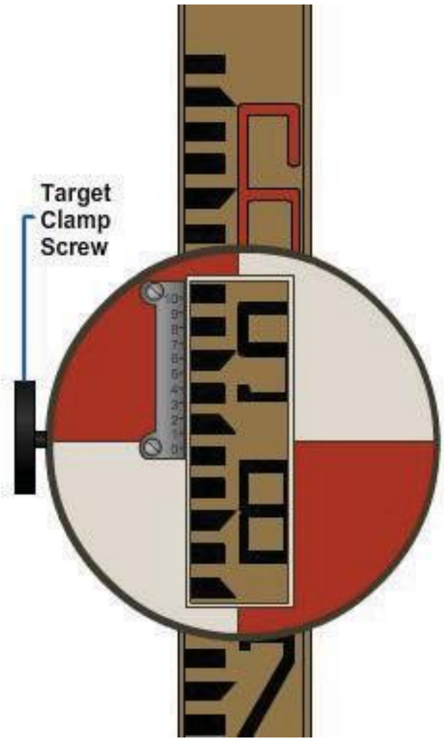


Figure 5-8 – Philadelphia rod set for target reading of less than 7000 feet.

The rod shown in the figures is graduated in feet and hundredths of a foot. Each even foot is marked with a large red numeral. Between each pair of adjacent red numerals, the intermediate tenths of a foot are marked with smaller black numerals. Each intermediate hundredth of a foot between each pair of adjacent tenths is indicated by the top or bottom of one of the short, black dash graduations.

2.1.0 Direct Readings

As the levelman, you can make direct readings on a self-reading rod held plumb on the point by the rodman. If you are working to tenths of a foot, it is relatively simple to read the footmark below the cross hair and the tenth mark that is closest to the cross hair. If greater precision is required, and you must work to hundredths, the reading is more complicated, as shown in *Figure 5-9*.

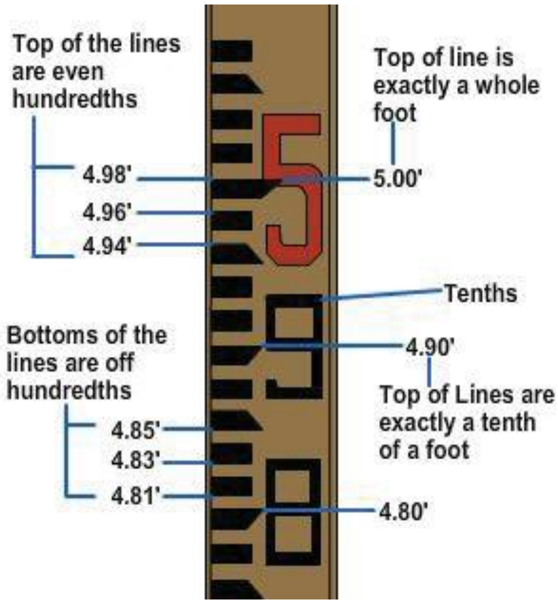


Figure 5-9 - Philadelphia rod marking.

For example, suppose you are making a direct reading that should come out to 5.67 feet. If you are using a Philadelphia rod, the interval between the top and the bottom of each black graduation and the interval between the black graduations each represent 0.01 foot.

This is shown in *Figure 5-10*, where each graduation represents 0.01 foot. For a reading of 5.76 feet, there are three black graduations between the 5.70 foot mark and the 5.76 foot mark. Since there are three graduations, a beginner may have a tendency to misread 5.76 feet as 5.73 feet.

Neither the 5 foot mark nor the 6 foot mark is shown in *Figure 5-10*. Sighting through the telescope, you might not be able to see the foot marks to which you must refer for the reading. When you cannot see the next lower foot mark through the telescope, it is a good idea to order the rodman to "raise the red**."** On the Philadelphia rod, whole feet numerals are in red. Upon hearing this order, the rodman slowly raises the rod until the next lower red figure comes into view.

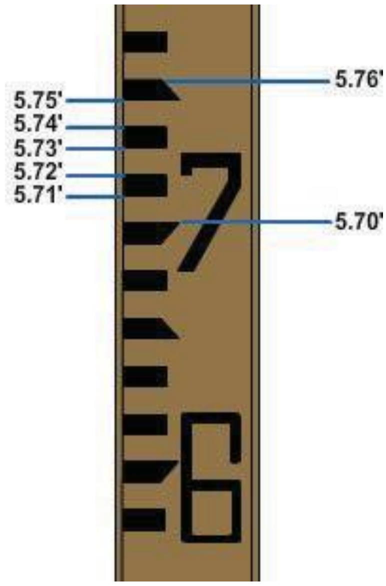


Figure 5-10 - Direct reading of 5.76 feet on a Philadelphia rod.

2.2.0 Target Readings

For more precise vertical measurements, level rods may be equipped with a rod target that can be set and clamped by the rodman at the direction of the instrumentman. When the engineer's level rod target and the vernier scale are being used, it is possible to make readings of one thousandth of a foot (0.001), which is slightly smaller than one sixty-fourth of an inch. Either the rodman or the instrumentman can read the indicated reading of the target. In *Figure 5-11*, you can see that the 0 on the vernier scale is in exact alignment with the 4 foot mark. If the position of the 0 on the target is not in exact alignment with a line on the rod, go up the vernier scale on the target to the line that is in exact alignment with the hundredths line on the rod, and the number located will be the reading in thousandths.

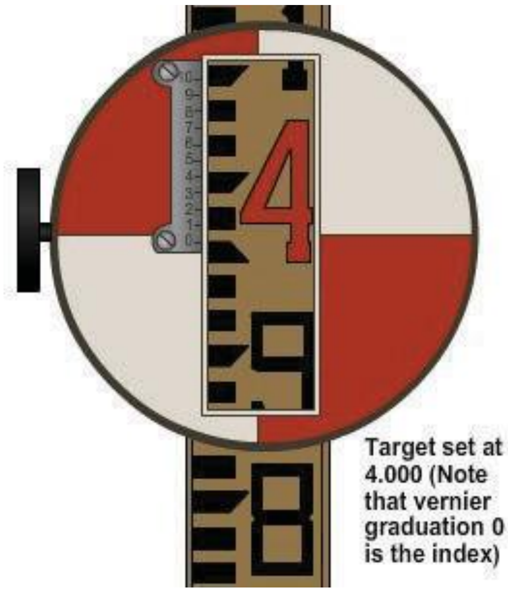


Figure 5-11 - Target.

There are three situations in which target reading, rather than direct reading, is done on the face of the rod:

- When the rod is too far from the level to be read directly through the telescope.
- When a reading to the nearest 0.001 foot, rather than to the nearest 0.01 foot, is desired. A vernier on the target or on the back of the rod makes this possible.
- When the instrumentman wants to ensure against the possibility of reading the wrong foot designation on the rod, indicated by a large red number.

For target readings up to 7.000 feet, the rod is used fully closed, and the rodman, on signals from the instrumentman, sets the target at the point where its horizontal axis is intercepted by the cross hair, as seen through the telescope. When the target is located, it is clamped in place with the target screw clamp, shown in *Figure 5-8*. When a reading to only the nearest 0.01 foot is desired, the graduation indicated by the target's horizontal axis is read; in *Figure 5-8*, this reading is 5.84 feet.

If reading to the nearest 0.001 foot is desired, the rodman reads the vernier, the small scale running from 0 to 10, on the target. The 0 on the vernier indicates that the reading lies between 5.840 feet and 5.850 feet. To determine how many thousandths of a foot over 5.840 feet, examine the graduations on the vernier to determine which one is most exactly in line with a graduation, the top or bottom of a black dash, on the rod. In *Figure 5-8*, this graduation on the vernier is the 3; so the reading to the nearest 0.001 foot is 5.843 feet.

For target readings of more than 7.000 feet, the procedure is a little different. If you look at the left-hand view of *Figure 5-7* showing the back of the rod, you will see that only the back of the upper section is graduated and that it is graduated downward from 7.000 feet at the top to 13.09 feet at the bottom. You can also see there is a rod vernier fixed to the top of the lower section of the rod. This vernier is read against the graduations on the back of the upper section.

For a target reading of more than 7.000 feet, the rodman first clamps the target at the upper section of the rod. Then, on signals from the instrumentman, the rodman extends the rod upward to the point where the horizontal axis of the target is intercepted by the cross hair. The rodman then clamps the rod, using the rod clamp screw shown in *Figure 5-12*, and reads the vernier on the back of the rod, also shown in that figure. In this case, the 0 on the vernier indicates a certain number of thousandths more than 7.100 feet. Remember that in this case, you read the rod and the vernier down from the top, not up from the bottom. To determine the thousandths, determine which vernier graduation lines up most exactly with a graduation on the rod. In this case, it is the 7, so the rod reading is 7.107 feet.

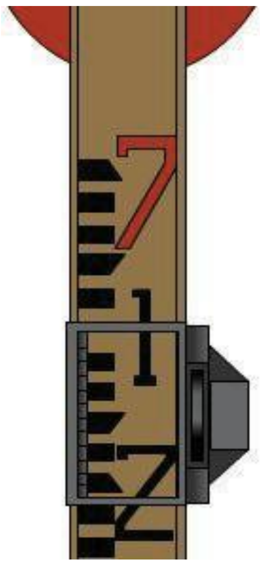


Figure 5-12 - Philadelphia rod target reading of more than 7000 feet.

2.3.0 Rod Levels

A rod reading is accurate only if the rod is perfectly plumb, or vertical, at the time of the reading. If the rod is out of plumb, the reading will be greater than the actual vertical distance between the height of instrument (HI) and the base of the rod. On a windy day, the rodman may have difficulty holding the rod plumb. In this case, the levelman can have the rodman wave the rod back and forth, allowing the levelman to read the lowest reading touched on the engineer's level cross hairs.

The use of a rod level ensures a vertical rod. A bull's-eye rod level is shown in *Figure 5-13*. When it is held as shown and the bubble is centered, the rod is plumb. Note that the rod is held on a part of the rod where readings are not being taken to avoid interference with the instrumentman's view of the scale.

A vial rod level has two spirit vials, each of which is mounted on the upper edge of one of a pair of hinged metal leaves. The vial level is used like the bull's-eye level, except that two bubbles must be watched instead of one.

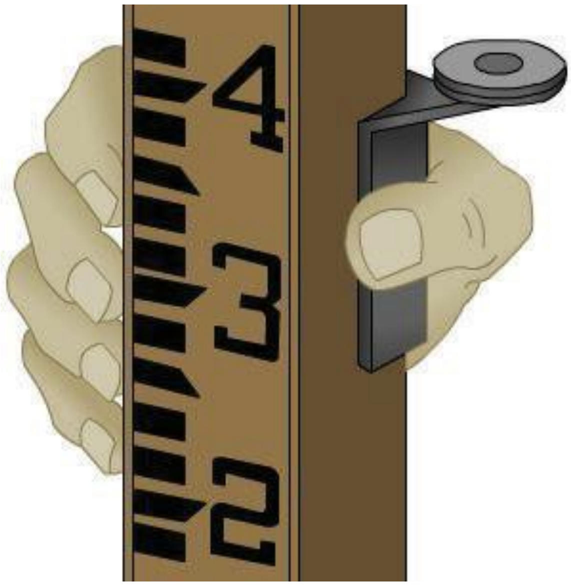


Figure 5-13 - Bull's-eye rod level.

2.4.0 Care of Leveling Rods

A leveling rod is a precision instrument and must be treated as such. Most rods are made of carefully selected, kiln-dried, well seasoned hardwood. Scale graduations and numerals on some are painted directly on the wood; on most rods they are painted on a metal strip attached to the wood. Unless a rod is handled at all times with great care, the painted scale will soon become scratched, dented, worn, or otherwise marked and obscured. Accurate readings on a damaged scale are difficult.

Allowing an extended sliding section rod to close on the run by permitting the upper section to drop may jar the vernier scale out of position or otherwise damage the rod. Always close an extended rod by easing the upper section down gradually.

A rod will read accurately only if it is perfectly straight. Anything that might bend or warp the rod must be avoided. Do not lay a rod down flat unless it is supported throughout, and never use a rod for a seat, lever, or pole vault. In short, never use a rod for any purpose except the one for which it is designed or intended.

Store a rod that is not in use in a dry place to avoid warping and swelling caused by dampness. Always wipe off a wet rod before putting it away. If there is dirt on the rod, rinse it off, but do not scrub it off. If you must use a soap solution, to remove grease, for example, use a very mild one. A strong soap solution will soon cause the paint on the rod to degenerate.

Protect a rod as much as possible against prolonged exposure to strong sunlight. Such exposure causes paint to chalk, to degenerate into a chalk-like substance that flakes from the surface.

2.5.0 Colors and Markings

The face of all rods are painted white with graduation marks painted black.

The black graduations on the rod are 0.01 or (one hundredth) of a foot wide and are spaced one hundredth of a foot apart. So each alternate black and white space is 0.01, or one hundredth, of a foot.

The large numbers painted in red represent whole feet, and the small black numbers indicate tenths of a foot.

From the face of the level rod you can determine feet, tenths, and hundredths.

Test your Knowledge (Select the Correct Response)

2. How many sliding portions does a Philadelphia rod have?

   A. 1
   B. 2
   C. 3
   D. 4

3.0.0 BENCH MARK (BM)

A Bench Mark (BM) is a relatively permanent object, natural or artificial, bearing a marked point whose elevation is known. BMs are established over an area to serve as (1) starting points for leveling operations so the topographic parties can determine other unknown elevation points, and (2) reference marks during later construction work. BMs are classified as Permanent or Temporary. Generally, BM indicates a permanent bench mark, and TBM a temporary bench mark. TBMs are established for a particular job and retained for the duration of that job. Throughout the United States, a series of BMs has been established by various government agencies. These identification markers are set in stone, iron pipe, or concrete, and are generally marked to show the elevation above sea level. When the elevation is not marked, you can find out what it is by contacting the government agency that originally set the BM. Be sure you give them the identification number on the marker.

Bench marks may be constructed in several ways. *Figure 5-14* shows brass shaft stocks in the tops of permanent horizontal control points, also known as monuments. Monuments of this type are sometimes also used for vertical control BMs. Original BMs may be constructed in the same manner. When regular BM disks are not available, brass, not steel, 50-caliber empty shell casings may be used. The shank of the empty shell casings should be drilled crosswise and a nail inserted to prevent its being pulled

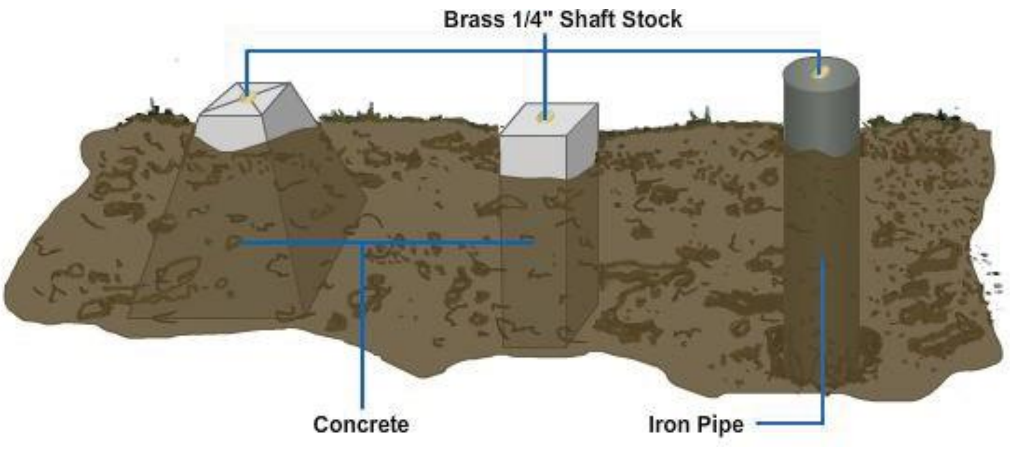


Figure 5-14 — Horizontal control points used also as bench marks.

out or forced out by either expansion or contraction.

For short lines and a level circuit of a limited area, any substantial object may be used for vertical control BMs. The remark in the field notes should bear the proper identification of the BMs used.

Figure 5-15 shows a mark like those commonly used on tops of concrete walls, foundations, and the like. Lines are chiseled out with a cold chisel or small star drill and then marked with paint or keel. The chiseled figures should be about the same size as the base area of the rod. They should be placed on some high spot on the surface of the concrete structure.

Figure 5-15 - Points on existing structures used as bench marks.

A spike may be driven into the root of a tree or placed higher up on the trunk of the tree when the limb clearance allows higher rod readings. *Figure 5-16* shows the recommended way to do this. Hold the rod on the highest edge of the spike, and mark the elevation on the blazed portion of the tree.

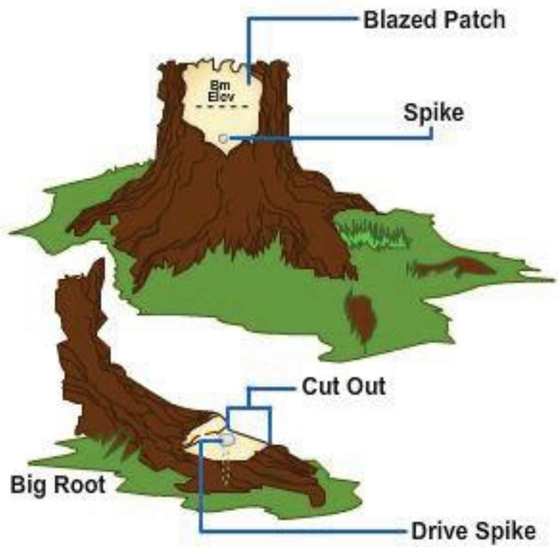


Figure 5-16 - Spikes used as bench marks on trees and roots.

Figure 5-17 shows a spike driven on a pole or post that also represents a BM. Drive the spike in horizontally on the face of the post in line with the direction of the level line. For the reading, hold the rod on the uppermost edge of the spike. After figuring the elevation, mark it on the pole or post for future reference.

Stakes driven into the ground can also be used as TBMs, especially if no frost is expected before they are needed. A detailed description of these points is just as important as one for a monument station.

In most permanent military installations, monument BMs are established in a grid system approximately one-half mile apart throughout the base to have a ready reference for elevations of later construction in the station. These BMs are generally fenced to mark their locations. The fence also serves to protect them from being accidentally disturbed.

BM systems, or level nets, consist of a series of BMs established within a prescribed order of accuracy along closed circuits and tied to a datum. These nets are adjusted by computations that minimize the effects of accidental errors and are identified as being of a specific order of accuracy.

In certain areas, Tidal Bench Marks must be established to obtain the starting datum plane or to check previously established elevations. Tidal bench marks are permanent BMs set on high ground and are tied to the tide station near the water surface.

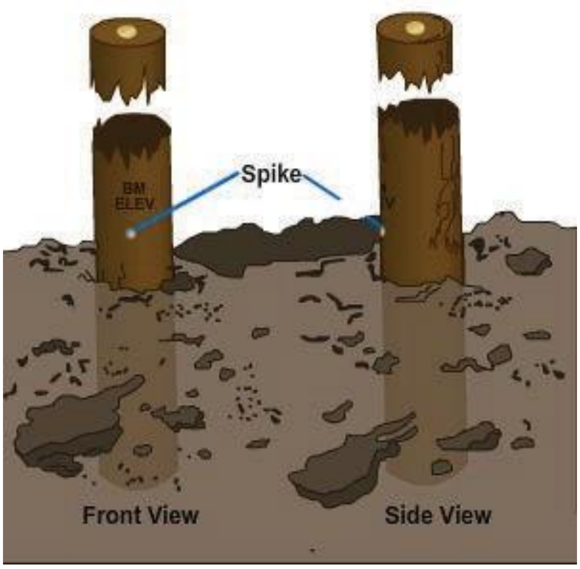


Figure 5-17 – Spikes used as bench marks on poles or posts.

Tide stations are classified as primary and secondary. Primary stations require observations for periods of nineteen years or more to derive basic tidal data for a locality. Secondary stations are operated over a limited period, usually less than one year, and for a specific purpose, such as checking elevations. The secondary station observations are always compared to, and computed from, data obtained by primary stations.

A tide station is set up, and observations are made for a period that is determined by a desired accuracy. These observations are compared with a primary tide station in the area, then furnished with a mean value of sea level in the area.

A closed loop of spirit levels is run from the tide station over the tidal BMs and is tied back to the tide station. The accuracy of this level line must be the same as or higher than the accuracy required for the BMs.

For permanency, tidal BMs usually are set in sets of three and away from the shoreline where natural activity or future construction will not disturb or destroy them.

4.0.0 COMMON ERRORS and MISTAKES

4.1.0 Instrument Out of Adjustment

Inaccurate adjustment of the instrument: The most common instrument error is caused by a level out of adjustment. The instrument must be adjusted so the line of sight is horizontal when the bubble is in the center of level vial.

4.2.0 Change in Position

Errors due to changes in the position of the instrument: When the instrument is not properly leveled, or if it is set up in an unstable position, errors will result. An unstable instrument setup makes the level bubble tremble slightly, even though it appears to be properly centered. Check the position of the bubble before and after each rod reading to make sure that the bubble has remained in the center of the level vial.

4.3.0 Faulty Handling

Faulty handling of the rod: The rod may not be properly plumbed. If the rod is not held plumb, such as if it leans toward or away from the instrument, the result will be an excessive reading.

Erroneous rod length: Check the length of the extended leveling rod with a steel tape.

Failure to clamp the rod at the proper place when using an extended leveling rod: This error could result in reading the wrong mark on the rod or reading the wrong cross hairs. Inspect the clamped positions before and after each sight to make sure that the extended rod has not slipped down.

4.4.0 Mistakes in Arithmetic

Always double check the addition and subtraction of every reading obtained.

5.0.0 SEWER STAKEOUT

5.1.0 Underground Utilities

For an underground utility, you will often need to determine both line and grade. For pressure lines, such as water lines, it is usually necessary to stake out only the line, since the only grade requirement is maintaining the prescribed depth of soil cover. However, staking elevations may be necessary for any pressure lines being installed in an area that (1) is to be graded downward or (2) is to have other, conflicting underground utilities.

Gravity flow lines, such as storm and Sewer Lines, require staking for grade to be sure the pipe is installed at the design elevation and at the gradient, or slope, the design requires for gravity flow through the pipe.

Grade for an underground sewer pipe is given in terms of the elevation of the invert. The invert of the pipe is the elevation of the lowest part of the inner surface of the pipe. *Figure 5-18* shows a common method of staking out an underground pipe.

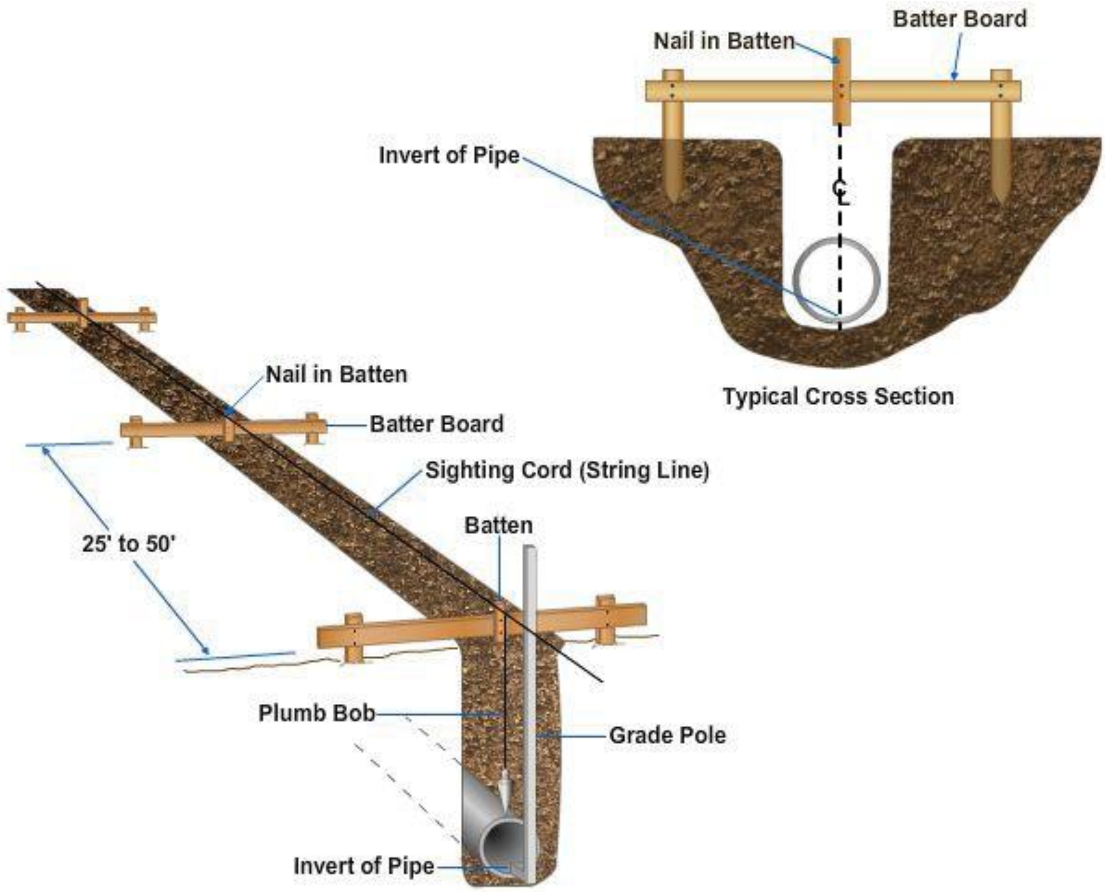


Figure 5-18 – Use of batter boards (with battens) for utility stakeout.

Notice that both alignment and elevation are facilitated by a line of batter boards and battens, or small pieces of wood, set at about 25 to 50 foot intervals. The battens, nailed to the batter boards, determine the horizontal alignment of the pipe when placed vertically on the same side of the batter boards and with the same edges directly over the center line of the pipe. As the work progresses, check the alignment of these battens frequently. A sighting cord, stretched parallel to the center line of the pipe at a uniform distance above the invert grade, is used to transfer line and grade into the trench. The center line of the pipe, therefore, will be directly below the cord, and the sewer invert grade will be at the selected distance below the cord. A measuring stick, also called a grade pole, is normally used to transfer the grade from the sighting cord to the pipe, as shown in *Figure 5-18*. The grade pole, with markings of feet and inches, is placed on the invert of the pipe and held plumb. The pipe is then lowered into the trench until the mark on the grade pole is on a horizontal line with the cord.

Figure 5-19 shows another method of staking out an underground sewer pipe without the use of battens. Drive nails directly into the tops of the batter boards so that a string stretched tightly between them will define the pipe center line. Keep the string or cord taut by wrapping it around the nails and hanging a weight on each end. Similarly, the string or cord gives both line and grade.

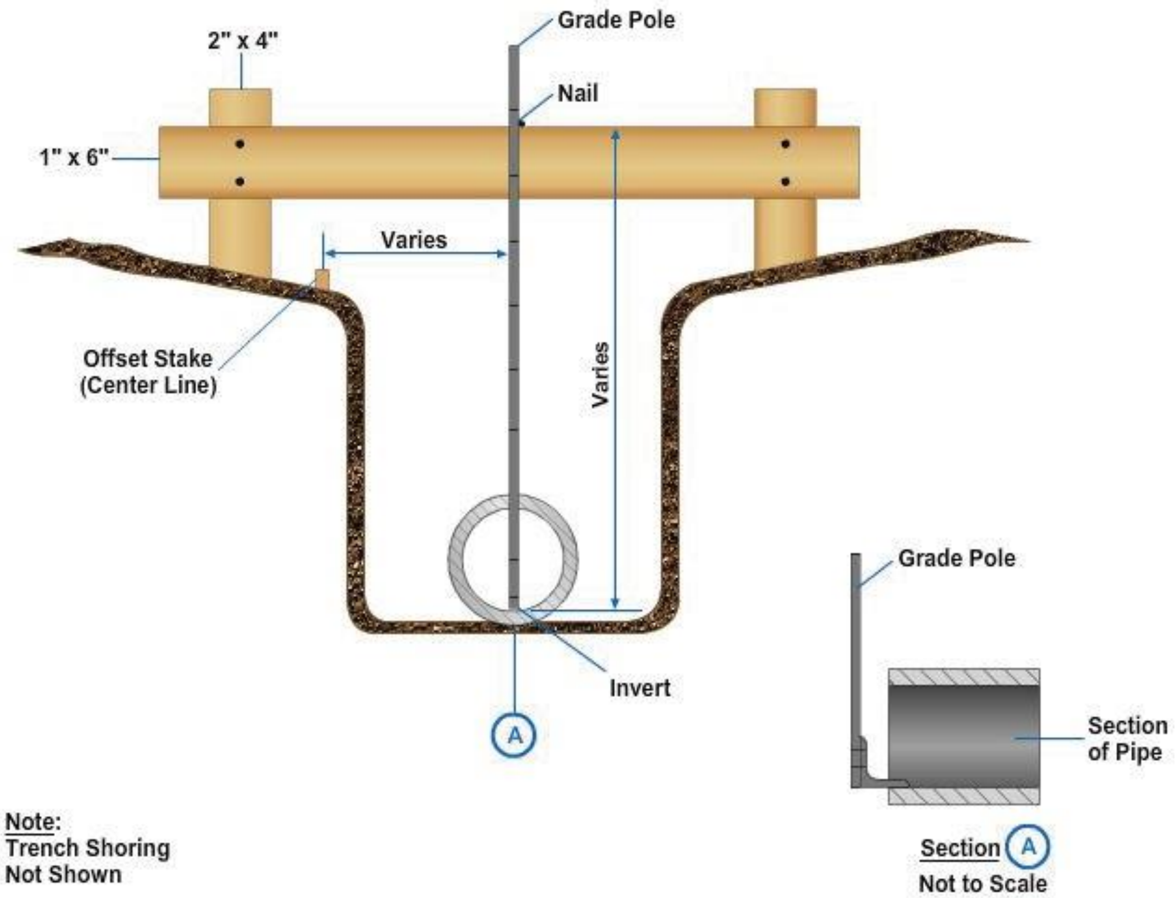


Figure 5-19 – Batter boards (without battens) for utility stakeout.

5.2.0 Sewer Stakeout Procedure

Refer to *Figure 5-20* for an example of a plan and profile sheet.

1. Obtain data from a plan and profile which will show the following:
   - Horizontal line located in each system
   - Horizontal location and character of each fitting or equipment
   - Invert elevation at each fitting or piece of equipment
   - Gradient of each line

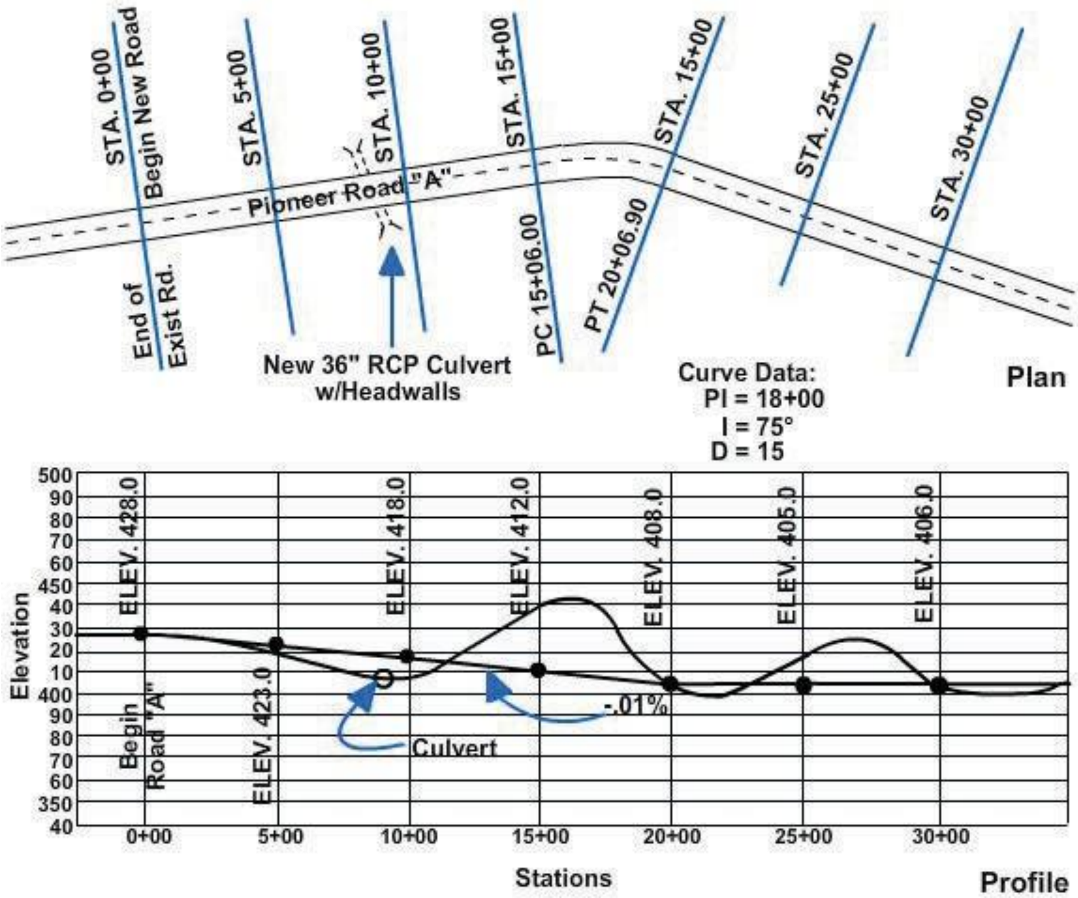


Figure 5-20 – Plan and profile sheet.

2. Stakeout consists of setting hubs and stakes to mark the alignment and indicate the depth of the sewer.

NOTE

Each hub should have a visible guard stake.

- Alignment may be marked by a row of offset hubs and stakes,
- Alignment could also be indicated by both offsets hubs and a row of centerline stakes,

3. Cuts
   - Cuts may be shown on a cut sheet or be marked on the centerline stakes, or both,

- The required grade is always established at the centerline of the project. The amount of change in the elevation, if any, is written on the back of the centerline stake with the symbol known as a crowfoot. The crowfoot is the reference point of the vertical measure or grade.
- On a centerline stake, guide the backhoe operator.
  - o Cuts are usually shown in tenths.
  - o Generally, represent the cut from the surface of the existing ground to the bottom of the trench taking into account the following: depth of invert, barrel (pipe) thickness, and depth of any sand or gravel bed.
- Cut marks on stakes next to the hubs:
  - o Generally are shown to hundredths,
  - o Represent the distance from the top of the hub to the invert,
  - o Guide the pipe crew,
- The distance between stakes and hubs are generally set at 25-foot intervals.

NOTE

50-foot and 100-foot intervals will suffice if necessary.

4. Sewer hubs are usually offset to 8 feet from the centerline.
   - Before you enter the field, compute from the profile the invert elevation at every station where you will set a hub.
   - The invert elevations at the fittings or pieces of equipment are given on the profile.
   - The gradient (percentage of drop) is also given on the profile.
   - To determine the invert at each station:
     - o The distance between each station times the percentage of the gradient
     - o To determine elevation of the top of the hub, first find the difference between the invert elevation of the station and the top of the hub; then write the difference on the guard stake for this hub.

6.0.0 PLUMBING VALVES and ACCESSORIES

In this section, you are provided with information regarding types of valves and procedures for installing and repairing them, valve accessories, and pipe fittings.

6.1.0 Valves

Flexibility in the operation of a water-supply system requires the proper valves for the condition that is to be controlled. Valves are used to stop, throttle, or control the flow of water in a pipeline. Other uses include pressure and level control and proportioning flow. A number of different valve designs are used by a Utilitiesman (UT). In this section, different types of valves, their purpose, and maintenance and repair of valves are presented.

6.1.1 Gate Valve

The gate valve (*Figure 5-21*) is used in systems where a straight flow with the least amount of restriction is needed. These valves are commonly used in steam lines, waterlines, fuel oil lines, and fire-main cutouts.

The part of a gate valve that opens or closes the valve flow is known as the GATE. The gate is normally wedge-shaped; however, some are uniform in thickness throughout. When the gate is wide open, the opening through the valve is equal to the size of the piping in which the valve is installed; therefore, there is little resistance in the flow of the liquid. Since regulating the flow of liquid is difficult and could cause extensive damage to the valve, the gate valve should NOT be used as a throttling valve. The gate valve should be left in one of two positions: completely open or closed.

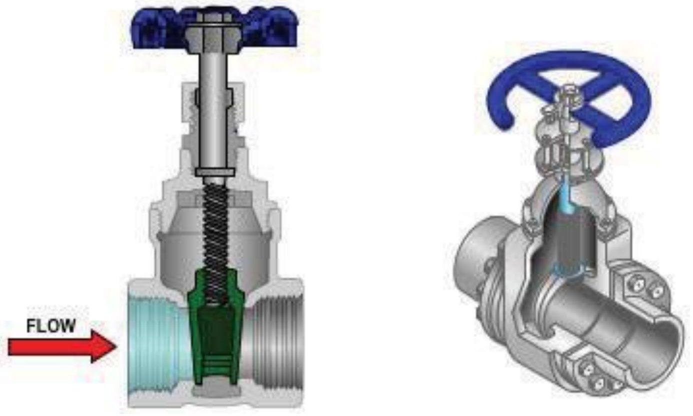


Figure 5-21- Gate valve.

Figure 5-21 shows a cross-sectional view of a gate valve. The gate is connected to the valve stem. Turning of the handwheel raises or lowers the valve gate. Some gate valves have NONRISING STEMS. On these, the stem is threaded on the lower end, and the gate is threaded on the inside; therefore, the gate travels up the stem when the valve is being opened. This type of valve usually has a pointer or a gauge to indicate whether the valve is in the OPEN or in the CLOSED position. Some gauge valves have RISING STEMS. In these valves, both the gate and the stem move upward when the valve is opened. In some rising stem valves, the stem projects above the handwheel when the valve is opened. The purpose of the rising stem is to allow the operator to see whether the valve is opened or closed.

6.1.2 Globe Valve

The name is derived from the globular shape of the valves; however, other types of valves may also have globe-shaped bodies, so do not jump to the conclusion that a valve with a globe-shaped body is actually a globe valve. The internal structure of a valve, not the external shape, is what distinguishes one type of valve from another.

In a globe type of stop valve, the disk is attached to the valve stem. The disk seats against a seating ring or a seating surface that shuts off the flow of fluid. When the disk is removed from the seating surface, fluid can pass through the valve in either direction. Globe valves may be used partially open as well as fully open or fully closed.

The fluid flow is proportionate to the number of turns of the wheel in opening or closing the globe valve. The purpose of the globe valve is for throttling.

Globe valve inlet and outlet openings are arranged in several ways to satisfy different requirements of flow.

Figure 5-22 shows three common types of globe valve bodies. In the straight type, the fluid inlet and outlet openings are in line with each other. In the angle type, the inlet and outlet openings are at an angle to each other. An angle type of globe valve (which is also the UT rate insignia) is commonly used where a stop valve is needed at a 90-degree turn in a line. The cross type of globe valve has three openings, rather than two; it is frequently used in connection with bypass lines.

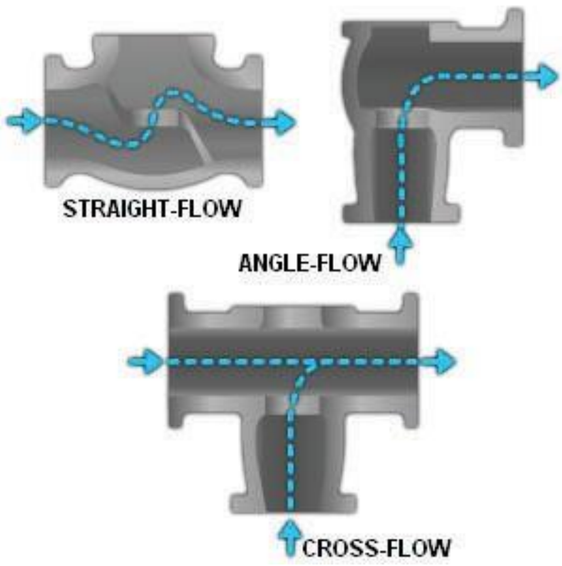


Figure 5-22 - Types of globe valve bodies.

Globe valves are commonly used in steam, air, oil, and water lines. Globe valves are also used as stop valves on the suction side of many fire room pumps as recirculating valves in the fuel oil system and as throttle valves on most fire room auxiliary machinery. A cross-sectional view of a globe valve is shown in *Figure 5-23*.

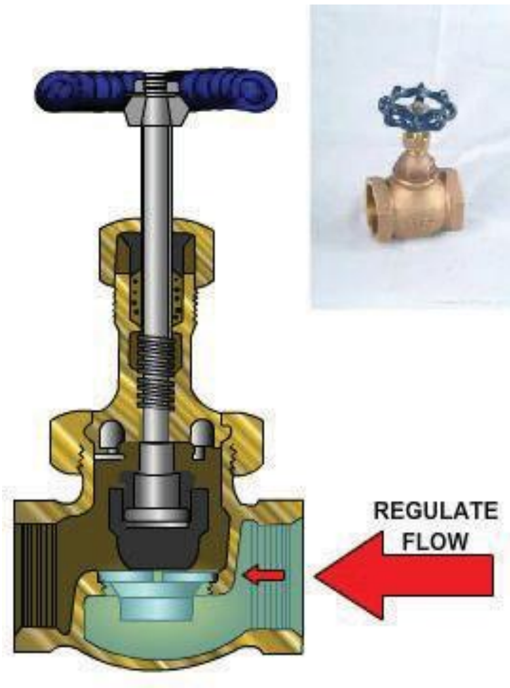


Figure 5-23- Globe valve.

6.1.3 Butterfly Valve

The butterfly valve (*Figure 5-24*) in certain applications has some advantages over gate and globe valves. The butterfly valve is light in weight, takes up less space than a globe valve or gate valve, is easy to overhaul, and can be opened or closed quickly.

The design and construction of butterfly valves may vary, but a butterfly type of disk and some means of sealing are common to all butterfly valves.

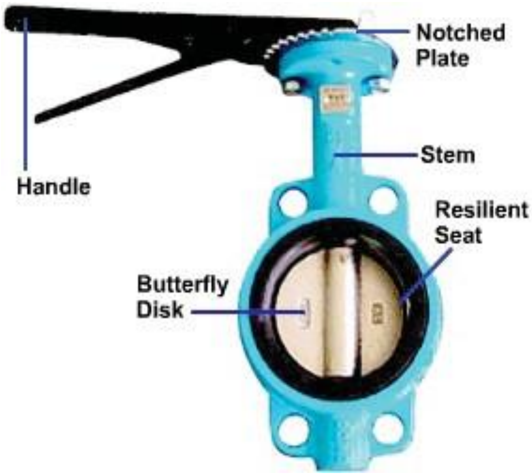


Figure 5-24 - Butterfly valve.

The butterfly valve shown in *Figure 5-24* consists of a body, a resilient seat, a butterfly type of disk, a stem, packing, and a notched positioning plate and handle. The resilient seat is under compression when it is mounted in the valve body. The compression causes a seal to form around the edge of the disk and both upper and lower points where the stem passes through the seat. Packing is provided to form a positive seal around the stem if the seal formed by the seat is damaged.

To close the valve, turn the handle a quarter of a turn to rotate the disk 90 degrees. The resilient seat exerts positive pressure against the disk, which assures a tight shutoff.

Butterfly valves are easy to maintain. The resilient seat is held in place by mechanical means; therefore, neither bonding nor cementing is necessary. Since the resilient seat is replaceable, the valve seat does not require any lapping, grinding, or machine work.

Butterfly valves serve a variety of requirements. These valves are now being used in salt water, fresh water, JP-5 fuel, naval distillate fuel oil, diesel oil, lubricating oil systems, air ventilation systems, and set for specific flow.

6.1.4 Altitude Valve

Altitude valves are used primarily on supply lines to elevated storage tanks. These valves are designed to (1) regulate the water level in the water storage tanks to prevent them from overflowing or running dry, and (2) maintain a constant water level as long as water pressure in the distribution system is adequate. *Figure 5-25* illustrates the altitude valve in relation to an elevated storage tank.

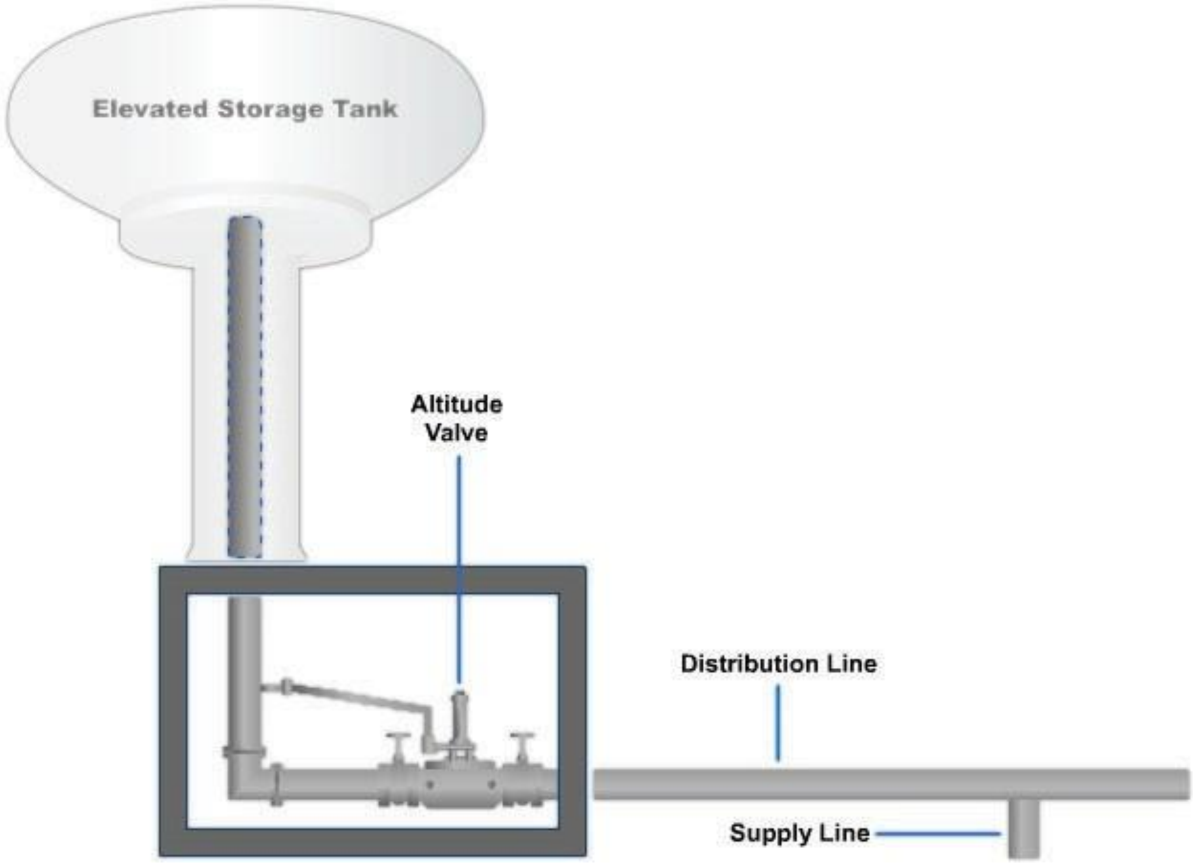


Figure 5-25 — Altitude valve with elevated storage tank.

As stated earlier, altitude valves are used primarily on supply lines to elevated storage tanks. When used on elevated storage tanks, the altitude valve automatically opens when the pressure in the distribution system drops below normal working pressure. Altitude valves will automatically close or shut off the flow into an elevated tank when the water level in the tank reaches a pre-determined level.

6.1.5 Ball Valve

A ball valve is a quick opening/closing device with a low-pressure drop. Ball valves, like gate valves, are used to start or stop the flow of water through plumbing components or piping systems. They are used on water or other types of supply lines in place of gate valves. Ball valves are not designed for throttling service.

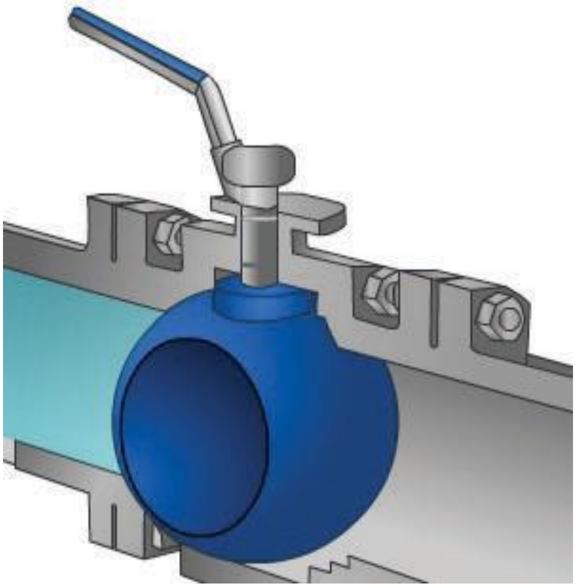


Figure 5-26 - Ball valve.

The basic components of the ball valve are the handle, a stem, a disc (ball), and a seat, which are machined into the valve body. *Figure 5-26* illustrates a ball valve. A quarter turn of the handle opens or closes the valve. When the handle is in line with (parallel to) existing piping, the valve is fully open. When the handle is across (perpendicular) to the piping, the valve is fully closed. The disk in a ball valve is a ball with a hole drilled through it. In the open position, the port (opening) in the ball is aligned with the inlet and outlet ports in the valve body.

Before installing a ball valve, you must consider the type of fluid the valve will be servicing. The steel (carbon, forged and stainless) ball valve is used for steam and high-pressure applications. Brass ball valves are used on water services. Finally, you can also use the plastic ball valves on water services, but they are not well adapted for use when a high resistance to acids is required. The type of ball valve and piping will dictate what type of joint that is used to install the valve. The common joints used to install ball valves include the threaded, soldered, mechanical, and solvent- glued. Finally, ball valves can be installed in the vertical or horizontal positions, but again, remember to make certain that the handle is accessible.

6.1.6 Check Valve

Check valves permit liquids to flow through a line in one direction only; for example, they are used in drain lines where it is important that there is no backflow. Considerable care must be taken to see that valves are installed properly. Most of them have an arrow, or the word "inlet," cast on the valve body to indicate direction of flow. If not, you must check closely to make sure the flow of the liquid in the system operates the valve in the proper manner.

The port in a check valve may be closed by a disk, a ball, or a plunger. The valve opens automatically when the pressure on the inlet side is greater than that on the outlet side. They are made with threaded, flanged, or union faces, with screwed or bolted caps, and for specific pressure ranges.

The disk of a SWING-CHECK valve (*Figure 5-27*) is raised as soon as the pressure in the line below the disk is of sufficient force. While the disk is raised, continuous flow takes place. If for any reason the flow is reversed or if back pressure builds up, this opposing pressure forces the disk to seat, which, in turn, stops the flow. Swing-check valves are used in horizontal lines and have a small amount of resistance to flow.

The operation of a LIFT-CHECK valve (*Figure 5-28*) is basically the same as that of the swing-check valve. The difference is the valve disk moves in an up and down direction instead of through an arc. Lift-check valves are used in lines where reversal of flow and pressures are changing frequently. This valve does not chatter or slam as the swing-check valve does, but it does cause some restriction of flow.

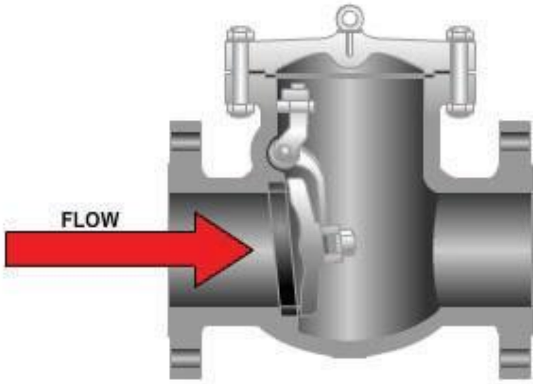


Figure 5-27 - Swing check valve.

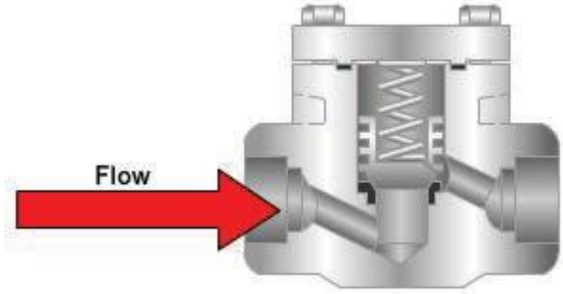
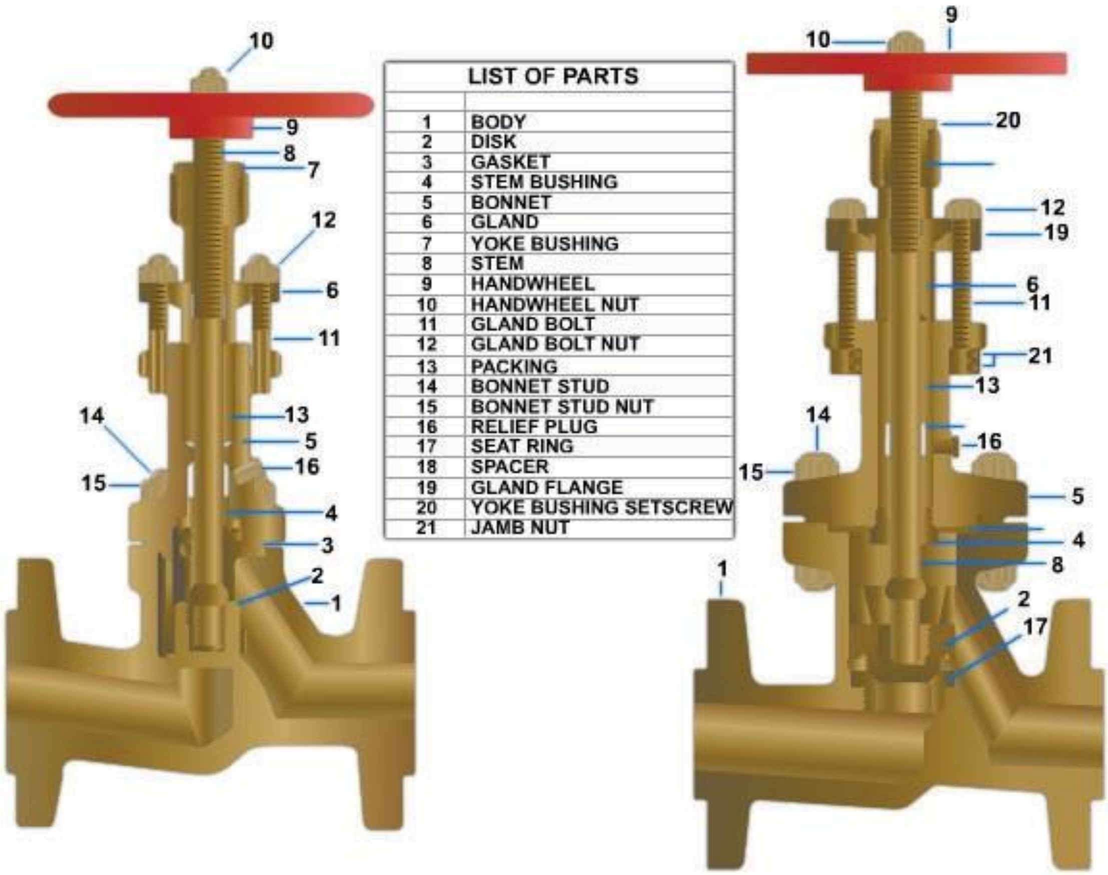


Figure 5-28 - Lift check valve.

6.1.7 Stop Check Valve

As we have seen so far, most valves are classified as either stop valves or check valves; however, some valves function either as a stop valve or as a check valve, depending upon the position of the valve stem. These valves are known as STOP-CHECK VALVES.

The cross section of two stop-check valves is shown in *Figure 5-29*. As you can see, this type of valve looks much like a lift-check valve. The valve stem is long enough so when it is screwed all the way down, it holds the disk firmly against the seat, thereby preventing the flow of any fluid. In this position, the valve acts as a stop valve. When the stem is raised, the disk can then be opened by pressure on the inlet side. In this position, the valve acts as a check valve and allows the flow of fluid in one direction only. The amount of fluid allowed to pass through is regulated by the opening. The opening is adjusted by the stem.



LIST OF PARTS	
1	BODY
2	DISK
3	GASKET
4	STEM BUSHING
5	BONNET
6	GLAND
7	YOKE BUSHING
8	STEM
9	HANDWHEEL
10	HANDWHEEL NUT
11	GLAND BOLT
12	GLAND BOLT NUT
13	PACKING
14	BONNET STUD
15	BONNET STUD NUT
16	RELIEF PLUG
17	SEAT RING
18	SPACER
19	GLAND FLANGE
20	YOKE BUSHING SETSCREW
21	JAMB NUT

Figure 5-29 —Stop check valve.

6.1.8 Pressure-Reducing Valve

Pressure-reducing valves are automatic valves used to provide a steady pressure lower than that of the supply pressure. Pressure-reducing valves can be set for any desired discharge pressure that is within the limits of the design.

Several types of reducing valves are used in the Navy; however, you will be working mostly with those in the water service system. These are normally single-seated, direct-acting, and spring-loaded, as shown in *Figure 5-30*. Water passing through this valve is controlled by means of a pressure difference on both sides of the diaphragm. The diaphragm is secured to the stem. Reduced water pressure

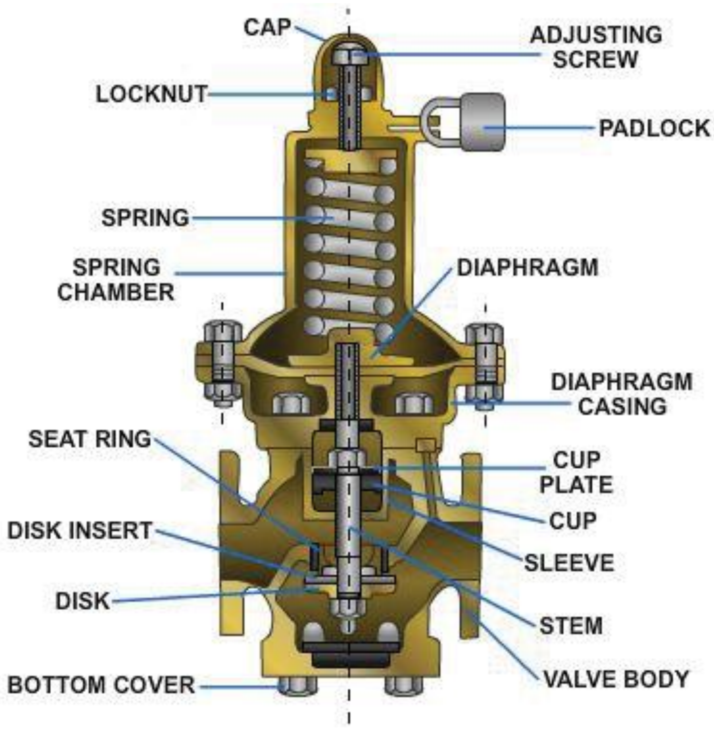


Figure 5-30- Spring-loaded diaphragm type of pressure-reducing valve.

from the valve outlet is then led through an internal passage to a diaphragm chamber located below the diaphragm. An adjusting spring acts on the upper side of the diaphragm. A leather cup washer or a neoprene O ring makes the water seal between the valve inlet and the diaphragm chamber. This seal is located halfway down the valve stem.

The amount of water pressure applied to the underside of the diaphragm varies according to the discharge pressure. When the discharge pressure is greater than the spring pressure, the diaphragm is forced up. Since this is an upward-seating valve, the upward movement of the stem tends to close the valve or at least to decrease the amount of discharge. When the discharge pressure is less than that of the spring pressure, the diaphragm and the valve stem are forced down, opening the valve wider and increasing the amount of discharge. When the discharge pressure is equal to the spring pressure, the valve stem remains stationary and the flow of water through the valve is not changed.

The amount of pressure applied by the spring to the top of the diaphragm can be adjusted by turning an adjusting screw. Turning the adjusting screw CLOCKWISE increases the pressure applied by the spring to the top of the diaphragm, which, in turn, opens the valve. Turning the adjusting screw COUNTERCLOCKWISE decreases the amount of spring pressure on top of the diaphragm, which, in turn, decreases the amount of discharge. Opening and closing of the valve continues as long as the discharge pressure fluctuates.

Figure 5-31 shows a different type of spring-loaded pressure-reducing valve. In this valve, water enters on the inlet side and acts against the main valve disk, tending to close the main valve; however, water pressure is also led through ports to the auxiliary valve, which controls the admission of water pressure to the top of the main valve piston. This piston has a larger surface than the main disk; therefore, a relatively small amount of pressure acting on the top of the main valve piston tends to open the main valve and also allow water at reduced pressure to flow out the discharge side.

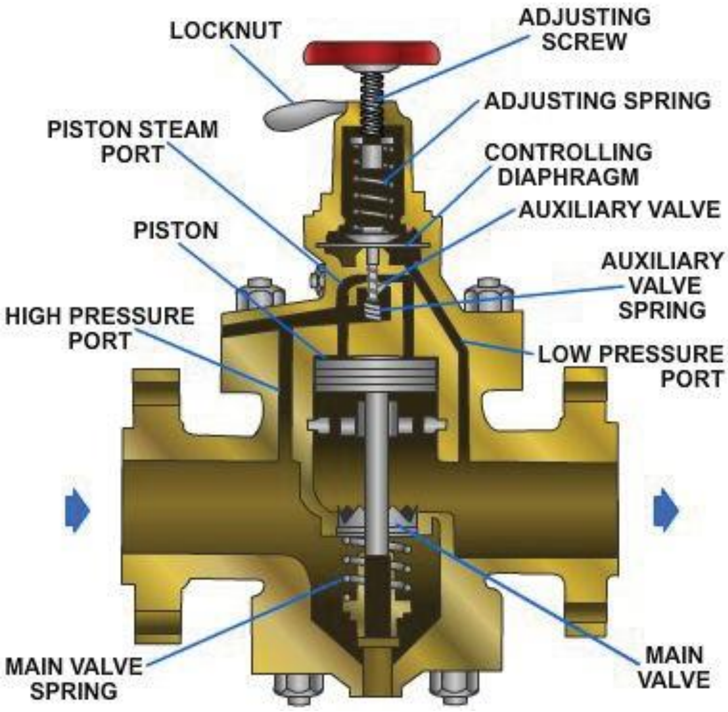


Figure 5-31- Spring-loaded pressure-reducing valve.

6.1.9 Pressure Relief Valve

This type of valve discharges water from pipes or systems when the maximum desired pressure is exceeded. Normally, the valve starts to open at the set pressure and continues to open gradually until the pressure has reached 20 percent above the set pressure, and then the valve opens completely. Pressure relief valves are installed on low-pressure systems fed through pressure-reducing valves from high-pressure supplies to ensure against damage if the pressure reducing valves fail to operate.

Pressure relief valves are also used on pump headers, discharging into large supply mains to relieve the high-surge pressure that builds up between the time a pump is started and the time required for water in the main to reach full velocity. Relief valves are essentially pressure-reducing valves in which the control mechanism responds to pressure on the inlet, rather than the outlet end.

6.1.10 Hydraulic Control Valve

Hydraulic control valves are used in many sprinkler systems. On some stations, they are installed in the sections of the fire main that supply water to the magazine sprinkling system. This type of valve may be operated from one or more remote control stations by a hydraulic control system.

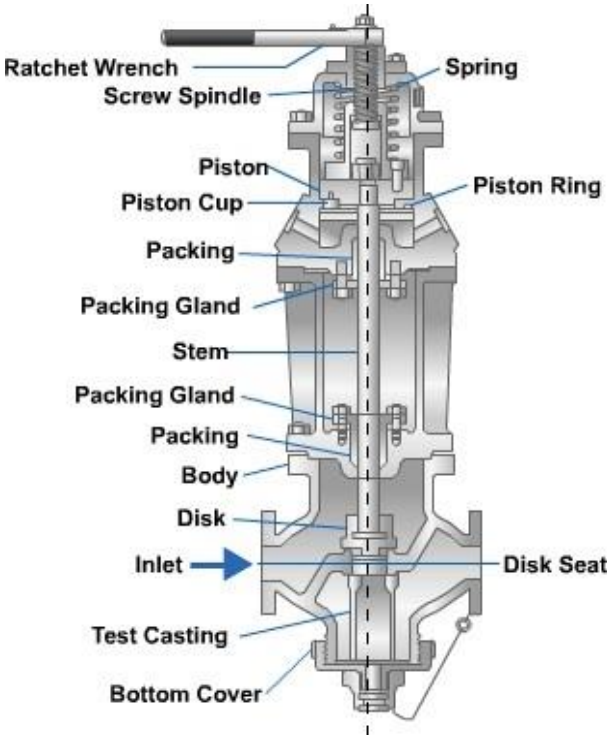


Figure 5-32 — Hydraulic control valve.

The hydraulic control valve shown in *Figure 5-32* is a piston-operated globe valve. It is normally held in the CLOSED position by both a spring force and by the fire-main pressure acting against the disk. When hydraulic pressure is admitted to the underside of the piston, a force is created that overcomes both the spring tension and the fire-main pressure, thereby causing the valve to open.

When hydraulic pressure is released from under the piston, the spring acts to force the hydraulic fluid out of the cylinder and back to the remote control station, thus closing the valve.

A ratchet lever is fitted to the valve so in an emergency, the valve can be opened by hand. After the valve has been opened by hand, you should first restore the stem to its normal CLOSED position with the ratchet lever. Then, line up the hydraulic system from a remote control station, so the hydraulic fluid in the valve cylinder can return to the storage tank at the control station. The full force of the closing spring acts to seat the disk, thereby closing the valve.

The valve shown in *Figure 5-32* is equipped with a test casting in the body of the valve. The bottom cover can be removed so you can check the valve for leakage.

6.1.11 Valve Boxes

Underground valves must have a means of access whereby you can use your hand or a valve key to reach the operating nut or handle. Valve boxes can be made of cast iron, cement, or plastic. Some have covers with lock nuts to prevent unauthorized access. They also protect the valve and piping against mechanical damage (pedestrian and vehicular traffic), and adverse weather if located outside.

Take care when installing the valve box over the pipe. Never allow the weight of the valve box to rest on the pipe; instead, let the soil around the pipe support the valve box. Clean debris out of the valve box periodically and ensure elevation and alignment are correct. A valve box that is full of debris or is not aligned properly does not allow proper alignment of the valve key on the operating nut or easy access to the handle. Debris also causes corrosion of valve handles, making it hard to turn off the valve.

Maintenance of valve boxes should be done twice a year, like the valve maintenance schedule for operation.

Maintenance consists of cleaning out debris in the box, checking for corrosion, checking the elevation of the top, and checking alignment of the box, so the valve key can be inserted readily. When the valve box has corroded and is no longer serviceable, remove it and replace it with a new unit. When changes in street or ground level have left the valve box too high or too low, adjust the height so the cover is at street or ground level.

6.1.12 Gear Boxes

Most large manually operated valves are operated through gears, as are motor-operated valves. These gears are housed in gear boxes.

Monthly or quarterly, lubricate the gearing under the manufacturer's instructions. Semi-

annually, check gear operation through a complete cycle of opening and closing. Listen for undue noise and observe smoothness of operation of the valve opening, and check for lubricant leakage from the flanges. Upon finding any evidence of improper operation, the operator should open the gearbox, inspect the gears, and make necessary repairs.

Annually, inspect the housing for corrosion; clean and paint it as necessary.

6.1.13 Valve Position Indicators

Different types of valves have different types of valve position indicators. Non-rising-stem gate valves may have indicators on the floor stand. Filter plant valves may have indicators on the filter operating table, and butterfly valves, or other valves used for flow control or throttling, may have indicator units that are controlled electrically and look like an ammeter. The care required depends on the design of the indicator unit; for example, post indicators require lubrication quarterly, and position indicators that are controlled electrically should be checked for contact, wiring, and so on, yearly.

6.2.0 Valve Repair

Periodic maintenance is the best way to extend the service life of valves and fittings. As soon as you see a leak, check to see what is causing it; then apply the proper remedy. This remedy may be as simple as tightening a packing gland nut. A leaking flange joint may need only to have the bolts tightened or to have a new gasket inserted. Dirt and scale, if allowed to collect, can cause leakage. Loose hangers permit sections of a line to sag. The weight of the pipe and the fluid in these sagging sections may strain joints to the point of leakage.

Whenever you intend to install a valve, make sure you know its function. In other words, is it supposed to prevent backflow, start flow, stop flow, regulate flow, or regulate pressure? Look for the information stamped on the valve body by the manufacturer: type of system (oil, water, gas), operating pressure, direction of flow, and other information.

You should also know the operating characteristics of the valve, the type of metal it is made of, and the type of end connection it has. Operating characteristics and material affect the length and type of service a valve can provide. End connections indicate whether or not a particular valve is suited for installation in the system.

Valves should be installed in accessible places and with enough headroom to allow for full operation. Install valves with stems pointing upward whenever possible. A stem position between straight up and horizontal is acceptable, but avoid the inverted position (stem pointing downward). When the valve is installed in the latter position, sediment collects in the bonnet and scores the stem. When a line is subject to freezing temperatures, liquid trapped in the valve bonnet may freeze and rupture it.

Globe valves may be installed with pressure either above or below the disk. It depends upon what method is best for the operation, protection, maintenance, and repair of the machinery. You should ask what would happen if the disk became detached from the stem. This is a major consideration in determining whether pressure should be above the disk or below it. Check the blueprints for the system to see which way the valve should be installed. Pressure on the wrong side of the disk can also cause serious damage.

Valves that have been in constant service over a long period of time eventually require gland tightening, replacing, or a complete overhaul. When a valve is not doing the job, it should be dismantled and all parts inspected. For proper operation, parts must be repaired or replaced.

6.2.1 Spotting-In Valves

Spotting-in is the method used to determine visually whether or not the seat and the disk make good contact with each other. To spot-in a valve seat, first apply a thin coating of Prussian blue evenly over the entire machined face surface of the disk. Then insert the disk into the valve and rotate it a quarter turn, using light downward pressure. The Prussian blue adheres to the valve seat at those points where the disk makes contact. *Figure 5-33* shows what correct and imperfect seals look like when they are spotted-in.

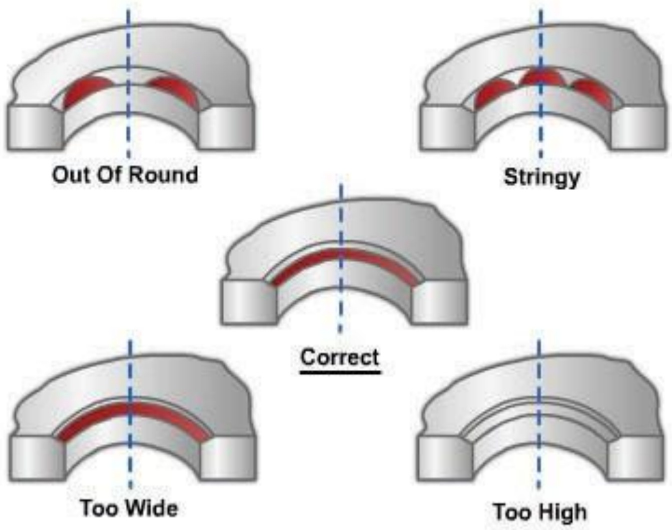


Figure 5-33 – Examples of spotted-in valve seats.

After you have examined the seat surface, wipe all the Prussian blue off the disk face surface. Apply a thin, even coat of blue to the contact face of the seat. Again, place the disk on the seat and rotate the disk a quarter of a turn. Examine the blue ring that appears on the disk. It should be unbroken and of uniform width. If the blue ring is broken in any way, the disk does not fit properly.

6.2.2 Grinding-In Valves

Grinding-in is a manual process used to remove small irregularities by grinding together the contact surfaces of the seat and disk. Grinding-in should not be confused with refacing processes in which lathes, valve reseating machines, or power grinders are used to recondition the seating surfaces.

To grind-in a valve, first apply a small amount of grinding compound to the face of the disk. Then insert the disk into the valve and rotate the disk back and forth about a quarter of a turn. Shift the disk-seat relationship from time to time, so the disk is moved gradually, in increments, through several rotations. During the grinding-in process, the grinding compound is gradually displaced from between the seat and disk surfaces; therefore, it is necessary to stop every minute or so to replenish the compound. When you do this, wipe both the seat and the disk clean before applying the new compound to the disk face.

When it appears that the irregularities have been removed, check your work by spotting-in the disk to the seat in the manner described previously.

Grinding-in is also used to follow up all machine work on valve seats or disks. When the seat and disk are first spotted-in after they have been machined, the seat contact is very narrow and located close to the bore. The grinding-in, using finer and finer compounds as the work progresses, causes the seat contact to become broader. The contact area should be a perfect ring covering approximately one third of the seating surface.

Be careful that you do not over-grind a seat or disk. Over-grinding tends to produce a groove in the seating surface of the disk. It may also round off the straight, angular surface of the disk. Over-grinding must be corrected by machining.

6.2.3 Lapping Valves

When a valve seat contains irregularities that are too large to be removed by grinding-in, you can remove them by lapping. A cast-iron tool, also known as a LAP tool, of exactly the same size and shape as the disk is used to rule the seat surface. Two lapping tools are shown in *Figure 5-34*.

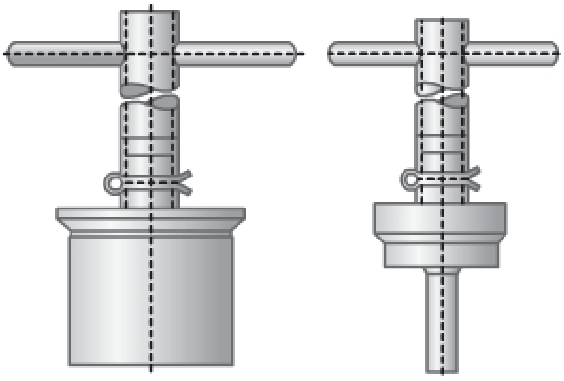


Figure 5-34 - Lapping tools.

Here are the most important points to remember while using the lapping tool.

1. Do not bear heavily on the handle of the lap.
2. Do not bear sideways on the handle of the lap.
3. Change the relationship between the lap and the seat so the lap gradually and slowly rotates around the entire seat circle.
4. Keep a check on the working surface of the lap. If a groove develops, have the lap refaced.
5. Always use a clean compound for lapping.
6. Replace the compound often.
7. Spread the compound evenly and lightly.
8. Do not lap more than is necessary to produce a smooth, even seat.
9. Always use a fine grinding compound to finish the lapping job.
10. When you complete the lapping job, spot-in and grind-in the disk to the seat.

Use only approved abrasive compounds to recondition seats and disks. Compounds for lapping and grinding disks and seats are supplied in various grades. Use a coarse grade compound when there is extensive corrosion or deep cuts and scratches on the disks and seats. Use a compound of medium grade to follow up the coarse grade. It may also be used to start the reconditioning process on valves that are not severely damaged. Use a fine grade compound when the reconditioning process nears completion. Use a microscopic fine grade for finish lapping and for all grinding-in.

6.2.4 Refacing Valves

Badly scored valve seats must be refaced in a lathe with a power grinder or with a valve reseating machine. Use the lathe, rather than the reseating machine, to reface disks and hard-surfaced seats. Work that must be done on a lathe or with a power grinder should be turned over to machine shop personnel. This discussion applies only to refacing seats with a reseating machine.

To reface a seat with a reseating machine (*Figure 5-35*) attach the correct 45-degree facing cutter to a reseating machine. With a fine file, remove all high spots on the surface of the flange upon which the chuck jaws must fit. Note that a valve reseating machine can be used ONLY with a valve in which the inside of the bonnet flange is bored true with the valve seat. If this condition does not exist, the valve must be reseated in a lathe and the inside flange bored true.

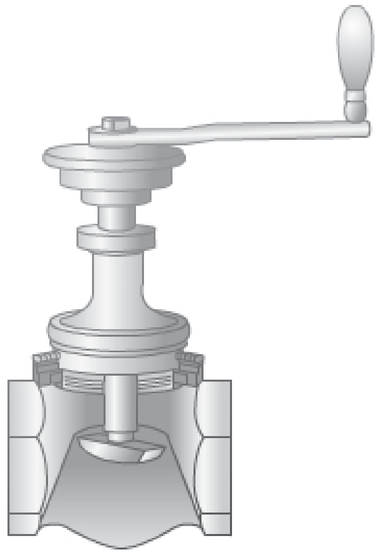


Figure 5-35 - Valve reseating machine.

Before placing the chuck in the valve opening, open the jaws of the chuck wide enough to rest on the flange of the opening. Tighten the jaws lightly so the chuck grips the sides of the valve opening securely. Tap the chuck down with a wooden mallet until the jaws rest on the flange firmly and squarely. Then tighten the jaws further.

Adjust and lock the machine spindle in the cutting position and begin cutting by turning the crank slowly. Feed the cutter slowly so very light shavings are taken. After some experience, you can tell whether or not the tool is cutting evenly all around. Remove the chuck to see if enough metal has been removed.

Be sure the seat is perfect. Then remove the 45-degree cutter and face off the top part of the seat with a flat cutter. Dress the seat down to the proper dimensions as follows. Refer to *Table 5-1*.

Table 5-1 — Seat to Valve Size Chart.

Width of Seat	Size of Valve
1/16 inch	1/4 to 1 inch
3/32 inch	1 1/4 to 2 inches
1/8 inch	2 1/2 to 4 inches
3/16 inch	4 1/2 to 6 inches

After the refacing, grind-in the seat and disk. Spot-in as necessary to check the work. A rough method of spotting-in is to place pencil marks at intervals of about l/2 inch on the bearing surface of the seat or disk. Then place the disk on the seat and rotate the disk about a quarter of a turn. If the pencil marks in the seating area rub off, the seating is satisfactory.

6.2.5 Repacking Valve Stuffing Boxes

When the stem of a valve is in good condition, stuffing box leaks can usually be stopped by setting up on the gland. If this does not stop the leakage, repack the stuffing box. The gland must not be set up or packed so tightly that the stem binds. If the leak persists, a bent or scored valve stem may be the cause of the trouble.

Coils (string) and rings are the common forms of packing used in valves. The form to be used in a particular valve is determined, in part, by the size of the packing required. In general, rings are used in valves that require packing larger than 1/4 inch. When a smaller size is required, string packing is used.

When you repack a valve stuffing box, place successive turns of the packing material around the valve stem. When string packing is used, coil it around the valve stem. Bevel off the ends to make a smooth seating for the bottom of the gland. Then put on the gland and set it up by tightening the bonnet nut or the gland bolts and nuts. To prevent the string packing from folding back when the gland is tightened, wind the packing in the direction in which the gland nut is to be turned. Usually, where successive rings are used, the gaps in the different rings should be staggered.

Valves are made to back seat the stem against the valve bonnet when the valve is fully opened. Back seating of valves is a safety feature to eliminate the stem being forced out under pressure while the valve is fully opened. Back seating makes repacking of the stem stuffing box possible under pressure; however, you should attempt this only in emergencies and with extreme caution.

Test your Knowledge (Select the Correct Response)

3. Which of the following valves allows water flow in one direction only?

   A. Swing
   B. Check
   C. Pressure-reducing
   D. Globe

7.0.0 WATER METERS

Water meters measure the flow of water within a line to a point of distribution, such as laundries, housing areas, and so on. There are various types of water meters. One type is the disk type of volume meter. This water meter is used chiefly for services supplied through pipes less than 1 I/2 inches in diameter, although water meters are made in sizes up to 6 inches.

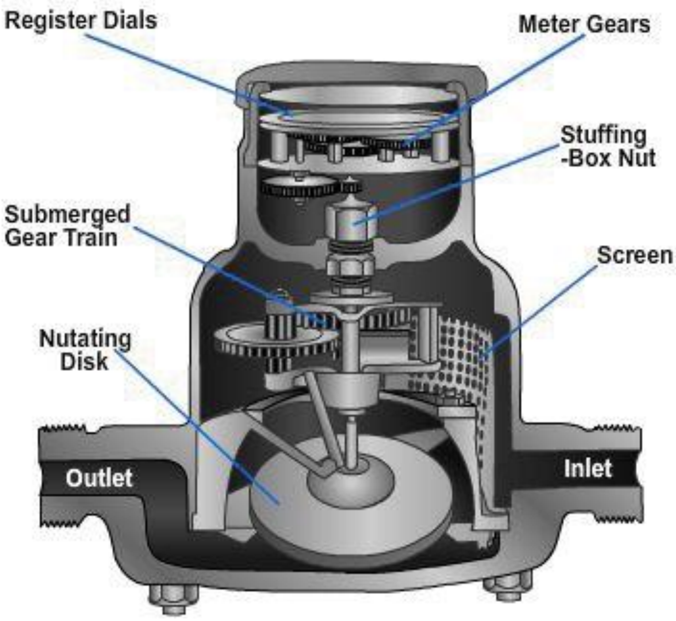


Figure 5-36 — Nutating disk meter.

Figure 5-36 shows the nutating disk volume meter. This type of meter is mainly used for individual service connections, as it is accurate for very low flow. A flow above normal causes rapid wear. The disk type of meter contains a measuring chamber of definite content in which a disk is actuated by the passage of water. Each cycle of motion of the disk marks the discharge of the contents of the measuring chamber. By means of gearing, the motion of the disk is translated into units of water volume on the register dial.

When installing a water meter, make sure it is horizontal and that it operates under back pressure. The meter should be located near the pressure-reducing valve at underground level; so in freezing temperatures, ensure the meter is protected from exposure.

Water is measured in terms of rate-of-flow (volume passing in a unit of time) or total volume. Units and equivalents usually are as follows. Refer to *Table 5-2*.

Table 5-2 — Unit to Equivalent Chart.

Unit	Equivalent
Cubic feet per second (cfs)	6448.83 Gallons per minute (gpm)
Cfs	46, 315 gallons per day (gpd)
Gpm	1,440 gpd
Million gallons per day (mgd)	1.547 cfs
mgd	694.4 gpm
Cubic feet (Cu ft)	7.48 gallons

NOTE

In reading a meter, you should first determine whether it is measuring the water flow in cubic feet or in gallons.

7.1.0 Meter Dials

Two general types of meter dials are used: the straight-reading type and the circular-reading type. Each type is discussed in the following paragraphs.

The STRAIGHT-READING DIAL shown in *Figure 5-37* may be read in the same way as mileage on an automobile. When the meter register has one or more fixed zeros, always be sure to read them in addition to the other numerals.

In the CIRCULAR-READING DIAL, when the hand on a scale is between two numbers, the lower number is read. If the hand seems exactly on the number, check the hand on the next lower scale. If that hand is on the "1" side of zero, read the number on which the hand lies; otherwise, read the next lower number. The procedure for reading the circular reading dial, shown in gallons in *Figure 5-38*, is to begin with the "1,000,000" circle and read clockwise to the "10" circle, the scales registering 9, 6, 8, 7, 2, and 1 respectively, making a total of 968,721 gallons.

Figure 5-37 —Straight-reading meter dial.

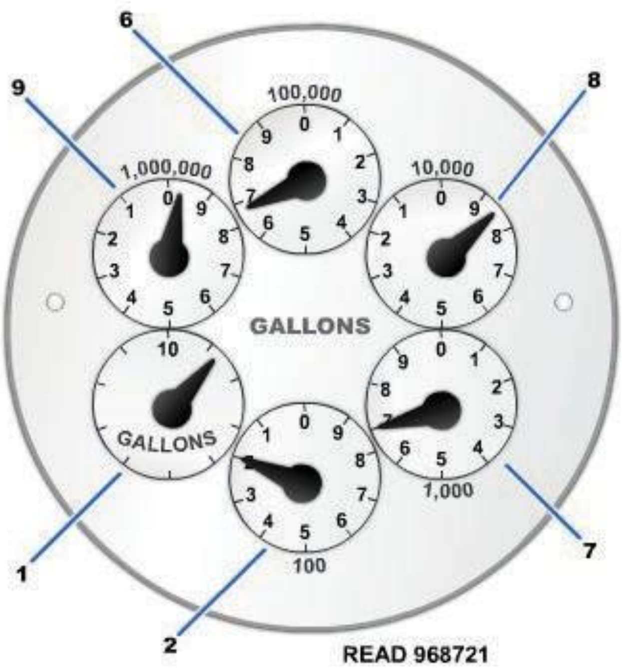


Figure 5-38 - Reading the circular-reading meter dial in gallons.

7.2.0 Obtaining Current Reading

Since the registers are never reset while the meters are in service, the amounts recorded for any period of time must be determined by subtraction. To obtain a current reading, subtract the last recorded reading from the current dial reading. Remember, the maximum amount that can be indicated on the usual line meter before it turns to zeros and begins all over again is 99,999 cubic feet, or 999,999 gallons. Thus, to obtain a current measurement when the reading is lower than the last previous one, add 100,000 to the present reading on a cubic foot meter, or 1,000,000 to the present reading on a gallon meter. The small denomination scale, giving fractions of one cubic foot or ten gallons, is disregarded in the regular reading. It is used for testing only.

8.0.0 INSULATION

The primary purpose of insulation is to prevent heat passage from steam or hot-water pipelines to the surrounding air or from the surrounding air to cold-water pipes. Thus hot-water lines are insulated to prevent loss of heat from the hot water, while drinking waterlines are insulated to prevent absorption of heat in drinking water.

Insulation keeps moisture from condensing on the outside of cold pipes. An example of condensation is the formation of droplets of moisture on the outside of a glass of ice water on a warm day. The same thing happens to the outside of a pipe containing cold water when the outside of the pipe is exposed to warm air. Insulation also prevents water from freezing in a pipe, especially when the pipe runs outside a building or in a building without heat.

Insulation is used on heating and air-conditioning ducts. The two kinds of duct insulation are (1) inside and (2) outside. The outside insulation is for the protection of heat loss, whereas the inside insulation is used for protection against noise and vibration from heating or air-conditioning equipment.

Insulation subdues noise made by the flow of water inside pipes, such as water closet discharges. Bathrooms directly above living rooms should be insulated. Insulation is vital in high buildings where water falls a long way, especially when the water falls in soil stacks and headers. Insulation also protects refrigerated and chilled waterlines that cool electrical and motor-driven equipment.

Insulation is made in two forms: (1) rigid preformed sections and (2) blankets. Rigid preformed sections are used on pipe runs and for the protection of other objects which they are designed to fit. Blanket-type insulation, manufactured in strips, sheets, and blocks, is wrapped around objects that are irregular in shape and in large, flat areas. Blanket-type insulation protects against heat loss and fire. This type of insulation is used on boilers, furnaces, tanks, drums, driers, ovens, flanges, and valves. It comes in wool-felt and hair-felt rolls, aluminum foil rolls, and in an irregular preformed covering.

Blanket insulation comes in different widths and thicknesses, depending upon the type of equipment to be insulated. It resists vermin, rodents, and acid. It is also fireproof.

8.1.0 Piping

Some of the insulating materials on the market today for insulating pipe are sponge felt paper, cork pipe covering, wool felt, flex rubber, fiberglass, magnesia, and types called antisweat and frost-proof.

Sponge felt paper is composed of asbestos paper with a maximum amount of sponge evenly distributed within it, as shown in *Figure 5-39, View A*. Sponge felt paper is manufactured to fit most pipe sizes. It comes in 3-foot lengths and from 1 to 3 inches in thickness.

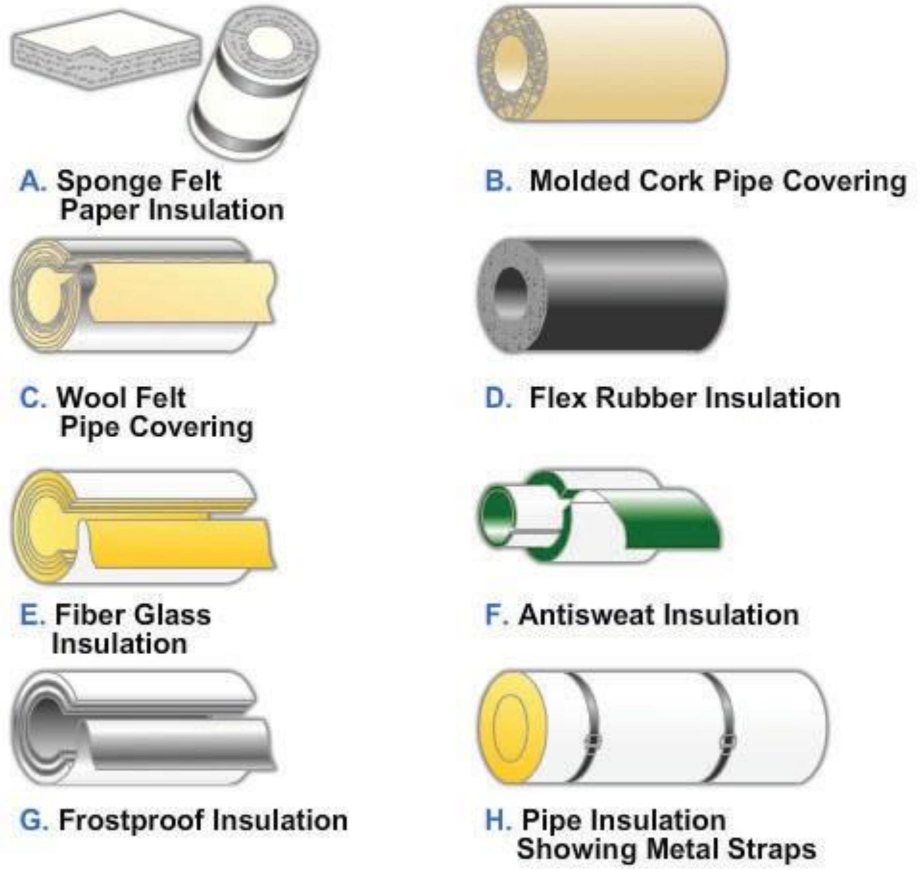


Figure 5-39 — Types of pipe insulation.

Sponge felt paper can be purchased in blocks of straight and preformed shapes for valves and fittings.

Cork pipe covering is a granulated material processed from the bark of cork trees. Granulated cork is compressed and molded to size and shape and finished with a coating of plastic asphalt. Cork pipe covering, as shown in *Figure 5-39, View B*, is an ideal covering for brine, ammonia, ice water, and all kinds of cold waterlines, and it insulates well over a wide low-temperature range. Cork pipe covering does not rot or support combustion. Clean, sanitary, and odor free, it is available in a wide variety of sizes and shapes to fit various sizes of pipes and fittings.

Wool felt is made of matted fibers of wool, wool and fur, or hair, worked into a compacted material by pressure rolling. It is used on cold-water service and hot-water return lines. Wool felt preformed pipe covering is manufactured in thicknesses of I/2 to 1 inch, with a canvas jacket, as shown in *Figure 5-39, View C.* It is manufactured in 3-foot lengths for straight runs of pipe.

Flex rubber insulation, shown in *Figure 5-39, View D*, is a tough, flexible rubber material constructed of millions of uniform closed cells. It has good insulating qualities, good cementing qualities, excellent weather-aging qualities, and it is ideal for the prevention of sweating cold-water lines. In addition, it is water and flame resistant. Flex rubber insulation is recommended for covering tubing used in refrigeration and cold-water lines in homes, as well as in industrial plants and commercial buildings. This rubber insulating material comes in random lengths, with a wall thickness size of 3/8 to 3/4 inch. It is made to fit pipe sizes up to 4 inches.

Flex rubber insulation can be installed on pipes and tubing by slipping the insulation over the pipe when it is being assembled or by slitting the rubber lengthwise and sealing it with cement. Before installing flex rubber insulation on iron or galvanized pipes, paint the pipes with an asphaltic base primer to prevent corrosion caused by condensation.

Fiberglass pipe insulation, shown in *Figure 5-39, View E*, is composed of very fine glass fibers, bound and formed together by an inactive resin type of mixture. It is formed into a flexible hollow cylinder and slit along its length for applying to pipes or tubing. It is furnished in 3-foot lengths with or without jackets. The insulation comes in thicknesses from l/2 to 2 inches and fits pipes from l/2 to 30 inches. Fiberglass insulation has a long life; it will not shrink, swell, rot, or burn. It is easily applied and light in weight, saves space, and has excellent insulating qualities.

Antisweat insulation, shown in *Figure 5-39, View F*, is designed for cold-water pipes. It keeps the water colder in the pipes than most types of insulation; and when installed properly, it prevents condensation, or sweating, of the pipes.

The outstanding feature of antisweat insulation is its construction. It is composed of an inner layer of asphalt-saturated asbestos paper, a 1/2-inch layer of wool felt, two layers of asphalt-saturated asbestos felt, another l/2-inch layer of pure wool felt, and an outer layer of deadening felts with asphalt-saturated felts. The outer layer has a flap about 3 inches long that extends beyond the joint to help make a perfect seal. A canvas jacket is placed around each 3-foot length to protect the outer felt covering.

Frost-proof insulation, shown in *Figure 5-39, View G*, is manufactured for use on (1) cold-water service lines that pass through unheated areas, and (2) those lines exposed to outside weather conditions.

Frost-proof insulation is generally constructed of five layers of felt. There are three layers of pure wool felt and two layers of asphalt-saturated asbestos felt. Frost-proof insulation is 1 l/4 inches thick and comes in 3-foot lengths with a canvas cover.

The pipe coverings shown in this section are installed easily, primarily because each section is split in half and has a canvas cover with a flap for quick sealing. Joint collars are furnished to cover joint seams on insulation exposed to outside conditions.

Cheesecloth is used on some types of insulation instead of canvas. To install the cheesecloth, use a paste to hold it in place. Allow enough cheesecloth to extend over the end of each 3-foot section to cover the joints.

After you have applied the cheesecloth and smoothed it out, install metal straps to hold the insulation firmly in place, as shown in *Figure 5-39, View H*.

8.2.0 Valves and Fittings

Cover valves and fittings with wool felt, magnesia cement, or mineral wool cement of the same thickness as the pipe covering. These materials are molded into shape to conform to the rest of the insulation. When magnesia or mineral wool cement insulation is used, cover the insulation with cheesecloth to help bind and hold it in place.

8.3.0 Boilers and Storage Tanks

If the boilers and storage tanks are unjacketed, cover them with an approved insulation. Use only insulation approved by the Military Standard (MIL-STD). Some of the approved types of insulation for boilers and tanks are magnesia, mineral wool, calcium silicate, cellular glass, or other approved mineral insulation at least 2 inches thick. Insulation may be of either the block or the blanket type and must be wired securely in place in an approved manner. When applying insulation to the outside of a boiler or storage tank, put it over 1 1/2-inch wire mesh. The mesh is held away from the metal surface by metal spacers that provide an air space of at least 1 inch. When you use blanket or block material, fill the joints in the insulation with magnesia, mineral wool, or other suitable cement. Cover the surface of the insulation with a thin layer of hard-finished cement, troweled smooth, and reinforced with 1 l/2-inch wire mesh.

Test your Knowledge (Select the Correct Response)

4. Which of the following types of pipe insulation has excellent weather-aging qualities?

   A. Antisweat
   B. Cheesecloth
   C. Fiberglass
   D. Flex rubber

9.0.0 WATER DISTRIBUTION SYSTEM ACCESSORIES

The last section of this chapter explains the procedures for providing a water source. The water-supply system for a building starts from a single source: the water main and continues through the distribution system.

9.1.0 Distribution System Elements

The elements of a distribution system include distribution mains, arterial mains, storage reservoirs, and system accessories (including booster stations, valves, hydrants, main-line meters, service connections, and backflow preventers).

Distribution mains are the pipelines that make up the distribution system. Their function is to carry water from the water source or treatment works to users.

Arterial mains are large-size distribution mains. They are interconnected with smaller distribution mains to form a complete gridiron system.

Storage reservoirs are structured to store water. They may serve to equalize the supply or pressure in the distribution system.

System accessories include the following:

- Booster stations that pump water from storage or a relatively low pressure main to the distribution system; they may serve a portion of the system that is at a higher elevation as well.
- Valves that serve to control the flow of water in the distribution system by isolating areas for repair or by regulating system flow or pressure.
- Hydrants that are designed to allow water from the distribution system to be used for fire fighting purposes.
- Main line meters that serve to record the flow of water in a part of the distribution system.

- Service connections that connect either an individual building or other plumbing system to the distribution system mains.
- Backflow preventers that protect the water source from contamination.

9.2.0 System Layout and Size

When distribution systems are carefully planned, the pipes are usually laid out in a grid or belt system. A network of large pipes divides the community or base into areas of several blocks each. The streets within each area are served by smaller pipes connected to the larger ones. When possible, the network is planned so the whole pipe system consists of loops, and no pipes come to a dead end. In this way, water can flow to any point in the system from two or more directions; hence, the water supply need not be cut off for maintenance work or a break in a pipe.

Older water systems frequently were expanded without planning and developed into a treelike system. This consists of a single main that decreases in size as it leaves the source and progresses through the area originally served. Smaller pipelines branch off the main and divide again, much like the trunk and branches of a tree. A treelike system is not desirable because the size of the old main limits the expansion of the system needed to meet increasing demands. Also, there are many dead ends in the system where water remains for long periods of time, causing undesirable tastes and odors in nearby service lines.

9.3.0 Main Location

Mains should be located along streets to provide short hydrant branches and service connections. Mains should not be located under paved or heavily traveled areas. They should be separated from other utilities to ensure the safety of potable water supplies so the maintenance of one utility causes a minimum of interference with other utilities.

9.4.0 Valve Location

The purpose of installing shutoff valves in water mains at various locations within the distribution system is to allow sections of the system to be taken out of service for repairs or maintenance without significantly curtailing service over large areas. Valves should be installed at intervals generally not greater than 5,000 feet in long supply lines and 1,200 feet in main distribution loops or feeders, refer to local and state codes for placement. All branch mains connecting to feeder mains or feeder loops should have valves installed as close to the feeders as practical, so branch mains can be taken out of service without interrupting the supply to other locations. In the areas of greatest water demand or when the dependability of the distribution system is particularly important, maximum valve spacing of 500 feet may be appropriate. At intersections of distribution mains, the number of valves required is normally one less than the number of radiating mains; the valve omitted from the line is usually the one that principally supplies flow to the intersection. Valves are not usually installed on branches serving fire hydrants on military installations. As far as practical, shutoff valves should be installed in standardized locations (that is, the northeast corner of an intersection or a certain distance from the center line of a street), so they can easily be found in emergencies. For large shutoff valves (approximately 30 inches in diameter and larger), it may be necessary to surround the valve operator or entire valve with a vault to allow for repair or replacement. In important installations and for deep pipe cover, pipe entrance access manholes should be provided so valve internal parts can be serviced. When valves, vaults, or access manholes are not provided, all buried valves, regardless of size, should be installed with special valve boxes over the operating nut to permit operation from ground level by the insertion of a special long wrench into the box.

9.5.0 Hydrant Location

Proper clearance should be maintained between hydrants and poles, buildings, or other obstructions so the hose lines can be readily attached and extended. Generally, hydrants are located at least 50 feet from a building and in no case are they located closer than 25 feet to a building, except where building walls are blank fire walls. Hydrants may be located adjacent to blank portions of substantial masonry walls where the chance of falling walls is remote, always check local and state codes for placement.

Street intersections are the preferred location for fire hydrants because fire hoses can then be laid along any of the radiating streets. However, the likelihood of vehicular damage to hydrants is greatest at intersections, so the hydrants must be carefully located to reduce the possibility of damage. Normally hydrants should not be located less than 6 feet nor more than 7 feet from the edge of a paved roadway surface. When hydrants exceed this distance, consider stabilizing or surfacing a portion of the wide shoulders adjacent to the hydrants to permit connection of the hydrant and pumper with a single 10-foot length of suction hose. If you cannot meet this criteria, you would normally not exceed 16 feet (two sections of hose) to the pumper.

Hydrants normally should not be placed closer than 3 feet to any obstruction nor in front of any entranceway. The center of the lower outlet is normally not be less than 18 inches above the surrounding grade, and the operating nut should not be more than 4 feet above the surrounding grade.

In aircraft fueling, mass parking, servicing, and maintenance areas, the tops of hydrants are normally not higher than 24 inches above the ground, with the center of the lowest outlet not less than 18 inches above the ground. The pump nozzle should face the nearest roadway.

9.6.0 Safety Procedures

Here are some rules for plumbing safety.

1. Keep the job clean.
2. Pick up scrap pieces of pipe.
3. Keep all tools and materials off the job when not in use.
4. Keep the shop floors dry and clean.
5. Keep the stockpiled materials carefully braced and blocked to prevent falling.
6. Lift with your legs, not your back.
7. Use pipe tongs for carrying heavy pipe sections.
8. Use proper tools for the job at hand.
9. Keep tools in good condition.
10. Use care in handling torches and hot lead.
11. Do not pour hot lead into a wet joint.
12. Use safety goggles when required.
13. After installing fixtures, test the pipes for leaks and proper drainage before leaving the job.

Summary

Proper surveying techniques and equipment are vital for the proper placement and distribution of water and drainage systems. This chapter covered the basics in equipment and technique, and common errors which may be encountered.

Knowing the correct valve for the job is essential for the uninterrupted flow of water to a building or structure. This chapter covered the most currently utilized valves. Your combination of knowledge and skill in valve repair may prevent a minor leak from becoming a major system shutdown. Included in this chapter were the types of water meters and the correct method of reading them, and also the different types of pipe insulation currently being used.

The responsibility of the proper material selection and location for the different distribution systems encountered begins with the UT. This chapter covered the basic requirements for installing water mains, valves, and hydrants.

Trade Terms Introduced in This Chapter

Dumpy level	A surveying instrument consisting of a telescope rigidly attached to a vertical spindle. Used to determine relative elevation.
Hand level	In surveying, a hand-held sighting level having limited capability.
Locke level	A hand level.
Reference line	A series of two or more points in line to serve as a reference for measurements.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

Basic Machines, NAVEDTRA 12199, Naval Education and Training Professional Development and Technology Center, Pensacola, FL, 1994.

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