NONRESIDENT
TRAINING
COURSE

June 1998

Utilitiesman Basic Volume 1

NAVEDTRA 14265

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

Although the words "he," "him," and "his" are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.

PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

COURSE OVERVIEW: In completing this nonresident training course, you will demonstrate a knowledge of the subject matter by correctly answering questions on the following subjects:

Plans, Specifications, and Color Coding
Advanced Base Functional Components (ABFC)
Plumbing
Plumbing Valves and Accessories
Plumbing Fixtures and Plumbing Repairs
Prime Movers, Pumps, and Compressors
Water Treatment
Maintenance of Water Treatment Equipment

THE COURSE: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

THE QUESTIONS: The questions that appear in this course are designed to help you understand the material in the text.

VALUE: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

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Sailor’s Creed

“I am a United States Sailor.

I will support and defend the Constitution of the United States of America and I will obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

I proudly serve my country’s Navy combat team with honor, courage and commitment.

I am committed to excellence and the fair treatment of all.”

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Nonresident Training Course follows Index

SUMMARY OF UTILITIESMAN BASIC

VOLUME 1

Utilitiesman Basic, Volume 1, NAVEDTRA 14265, consists of chapters on Plans, Specifications, and Color Coding; Advanced Base Functional Components (ABFC); Plumbing; Plumbing Valves and Accessories; Plumbing Fixtures and Plumbing Repairs; Prime Movers, Pumps, and Compressors; Water Treatment; and Equipment Maintenance.

VOLUME 2

Utilitiesman Basic, Volume 2, NAVEDTRA 14279, consists of chapters on Boilers; Boiler Maintenance; Steam Distribution Systems; Heating Systems; Galley Equipment; Laundry Equipment; Air Conditioning; and Refrigeration.

INSTRUCTIONS FOR TAKING THE COURSE

ASSIGNMENTS

The text pages that you are to study are listed at the beginning of each assignment. Study these pages carefully before attempting to answer the questions. Pay close attention to tables and illustrations and read the learning objectives. The learning objectives state what you should be able to do after studying the material. Answering the questions correctly helps you accomplish the objectives.

SELECTING YOUR ANSWERS

Read each question carefully, then select the BEST answer. You may refer freely to the text. The answers must be the result of your own work and decisions. You are prohibited from referring to or copying the answers of others and from giving answers to anyone else taking the course.

SUBMITTING YOUR ASSIGNMENTS

To have your assignments graded, you must be enrolled in the course with the Nonresident Training Course Administration Branch at the Naval Education and Training Professional Development and Technology Center (NETPDTC). Following enrollment, there are two ways of having your assignments graded: (1) use the Internet to submit your assignments as you complete them, or (2) send all the assignments at one time by mail to NETPDTC.

Grading on the Internet: Advantages to Internet grading are:

- you may submit your answers as soon as you complete an assignment, and
- you get your results faster; usually by the next working day (approximately 24 hours).

In addition to receiving grade results for each assignment, you will receive course completion confirmation once you have completed all the assignments. To submit your assignment answers via the Internet, go to:

http://courses.cnet.navy.mil

Grading by Mail: When you submit answer sheets by mail, send all of your assignments at one time. Do NOT submit individual answer sheets for grading. Mail all of your assignments in an envelope, which you either provide yourself or obtain from your nearest Educational Services Officer (ESO). Submit answer sheets to:

COMMANDING OFFICER
NETPDTC N331
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

Answer Sheets: All courses include one "scannable" answer sheet for each assignment. These answer sheets are preprinted with your SSN, name, assignment number, and course number. Explanations for completing the answer sheets are on the answer sheet.

Do not use answer sheet reproductions: Use only the original answer sheets that we provide—reproductions will not work with our scanning equipment and cannot be processed.

Follow the instructions for marking your answers on the answer sheet. Be sure that blocks 1, 2, and 3 are filled in correctly. This information is necessary for your course to be properly processed and for you to receive credit for your work.

COMPLETION TIME

Courses must be completed within 12 months from the date of enrollment. This includes time required to resubmit failed assignments.

PASS/FAIL ASSIGNMENT PROCEDURES

If your overall course score is 3.2 or higher, you will pass the course and will not be required to resubmit assignments. Once your assignments have been graded you will receive course completion confirmation.

If you receive less than a 3.2 on any assignment and your overall course score is below 3.2, you will be given the opportunity to resubmit failed assignments. **You may resubmit failed assignments only once.** Internet students will receive notification when they have failed an assignment--they may then resubmit failed assignments on the web site. Internet students may view and print results for failed assignments from the web site. Students who submit by mail will receive a failing result letter and a new answer sheet for resubmission of each failed assignment.

COMPLETION CONFIRMATION

After successfully completing this course, you will receive a letter of completion.

ERRATA

Errata are used to correct minor errors or delete obsolete information in a course. Errata may also be used to provide instructions to the student. If a course has an errata, it will be included as the first page(s) after the front cover. Errata for all courses can be accessed and viewed/downloaded at:

http://www.advancement.cnet.navy.mil

STUDENT FEEDBACK QUESTIONS

We value your suggestions, questions, and criticisms on our courses. If you would like to communicate with us regarding this course, we encourage you, if possible, to use e-mail. If you write or fax, please use a copy of the Student Comment form that follows this page.

For subject matter questions:

E-mail: n314.products@cnet.navy.mil
Phone: Comm: (850) 452-1001, Ext. 1826
DSN: 922-1001, Ext. 1826
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC N314
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

For enrollment, shipping, grading, or completion letter questions

E-mail: fleetservices@cnet.navy.mil
Phone: Toll Free: 877-264-8583
Comm: (850) 452-1511/1181/1859
DSN: 922-1511/1181/1859
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
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NAVAL RESERVE RETIREMENT CREDIT

If you are a member of the Naval Reserve, you may earn retirement points for successfully completing this course, if authorized under current directives governing retirement of Naval Reserve personnel. For Naval Reserve retirement, this course is divided into two units evaluated at 14 points: 12 points upon satisfactory completion of unit 1, assignments 1 through 8; and 2 points upon satisfactory completion of unit 2, assignment 9. (Refer to *Administrative Procedures for Naval Reservists on Inactive Duty,* BUPERSINST 1001.39, for more information about retirement points.)

Student Comments

Course Title: *Utilitiesman Basic, Volume 1*

NAVEDTRA: 14265 **Date**: ____________

We need some information about you:

Rate/Rank and Name: ____________ SSN: ____________ Command/Unit ____________

Street Address: ____________ City: ____________ State/FPO: ________ Zip ________

Your comments, suggestions, etc.:

Privacy Act Statement: Under authority of Title 5, USC 301, information regarding your military status is requested in processing your comments and in preparing a reply. This information will not be divulged without written authorization to anyone other than those within DOD for official use in determining performance.

NETPDTC 1550/41 (Rev 4-00

CHAPTER 1

PLANS, SPECIFICATIONS, AND COLOR CODING

LEARNING OBJECTIVE: *Interpret basic plans, drawings, and specifications in construction operations. Recognize crew leader responsibilities* and *safety color-coding standards.*

In the day-to-day work as a Utilitiesman, you will be installing, assembling, inspecting, and troubleshooting many types of utility systems. To do these jobs properly, you must read and interpret plans and drawings. You may also have to read specifications that contain additional information on the details of construction and installation. Plans and specifications help you in doing the job correctly and safely.

After studying this topic, you should be able to read and interpret simple drawings and sketches as well as using the specifications to help you with more complex plans. Additionally, you should be able to draw simple shop drawings and specify the hazards associated with each color code for piping and compressed gas containers.

PLANS

LEARNING OBJECTIVE: *Identify the arrangement of a set of project blueprints and types of plans and drawings.*

You will be working with several types of plans and drawings. These may range from simple shop drawings and sketches, made perhaps by your immediate supervisor, to construction blueprints created by engineers. For the most part you will be working with plans created by architects and engineers. In Seabee construction, a complete set of plans for a project consists of civil, architectural, structural, electrical and mechanical plans, or drawings. You will be spending the majority of your time with mechanical drawings, but you will need all of these plans together to obtain a full picture of your part of that project and how to accomplish it.

CIVIL PLANS

Civil plans, or site plans, encompass a variety of drawings and. information. They furnish essential data, such as land contours, roads, utilities, trees, structures, site preparation and development, and significant physical features, on or near the construction site (fig. 1-1)

ARCHITECTURAL PLANS

Architectural plans show the architectural design and composition of a building. They include floor plans, exterior elevation plans, and door and window schedules (fig. 1-2).

STRUCTURAL PLANS

Structural plans show the support of the building or structure, including walls, columns, beams, foundation, roof, and deck slab. They also show their relationship to each other (figs. 1-3 and 1-4).

ELECTRICAL PLANS

Electrical plans contain the electrical distribution system plans, interior wiring drawings, and electrical component schedules for a building, or structure. They show wiring circuits, light switches, receptacles, light fixtures, and equipment (fig. 1-5).

MECHANICAL PLANS

Mechanical plans include layouts and details for systems of plumbing, heating, ventilating, air conditioning, and refrigeration (fig. 1-6). These systems vary, depending on whether they are for a permanent installation with the most modern fixtures and equipment or for a temporary installation where less complex equipment is used. Whatever the job, you

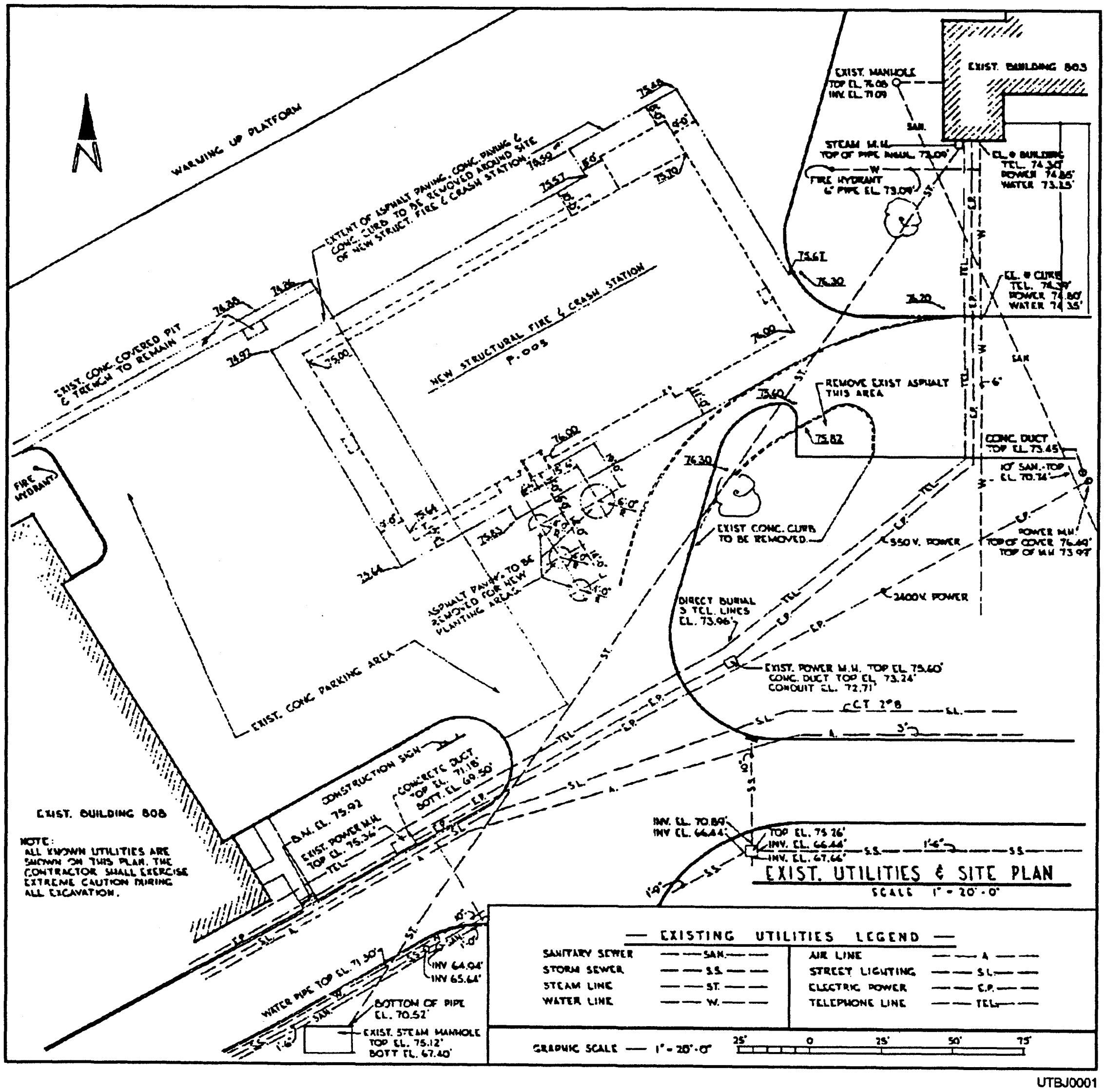


Figure 1-1.—Civil or site plan with existing utilities.

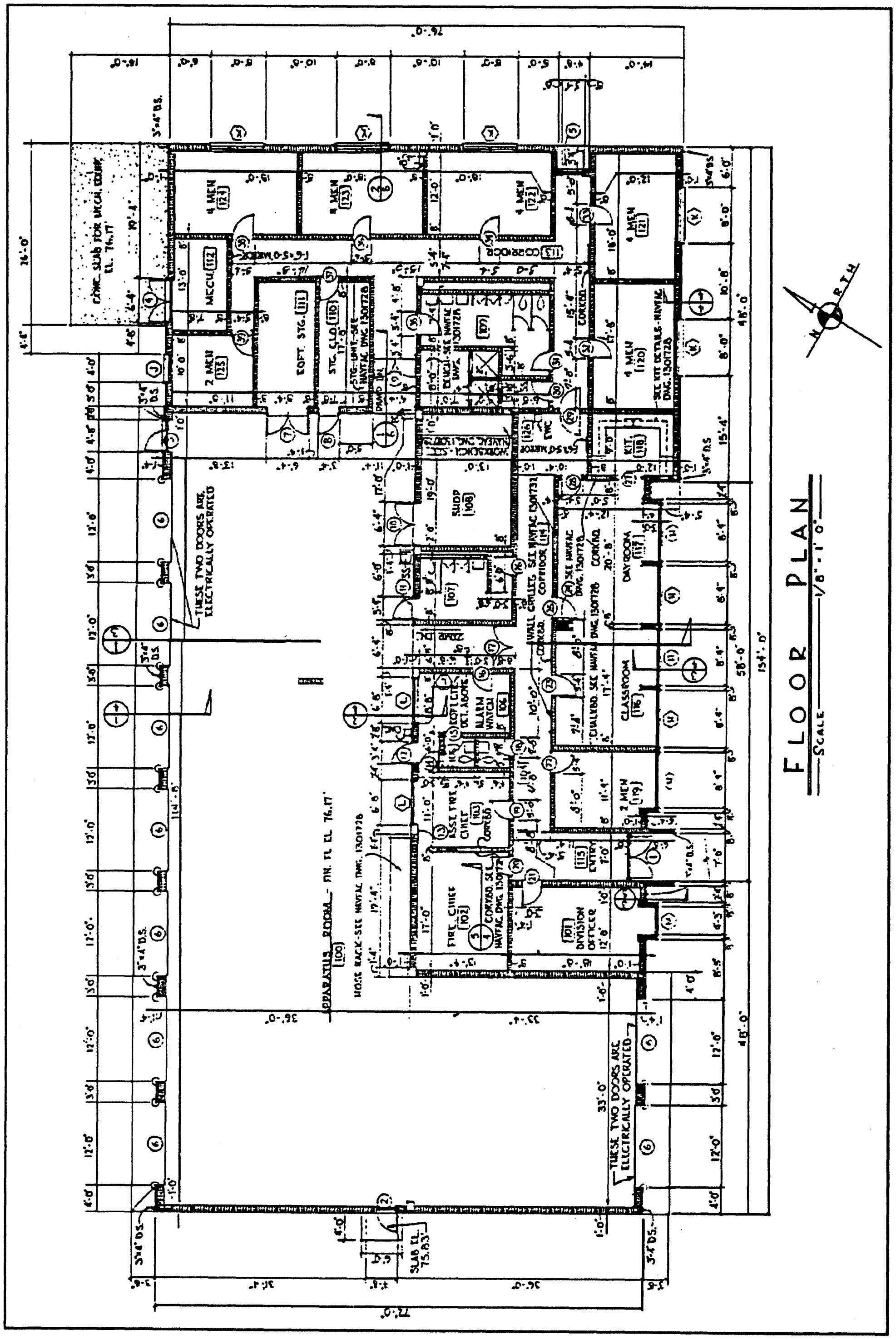


Figure 1-2.—Architectural or floor plan of concrete-masonry construction.

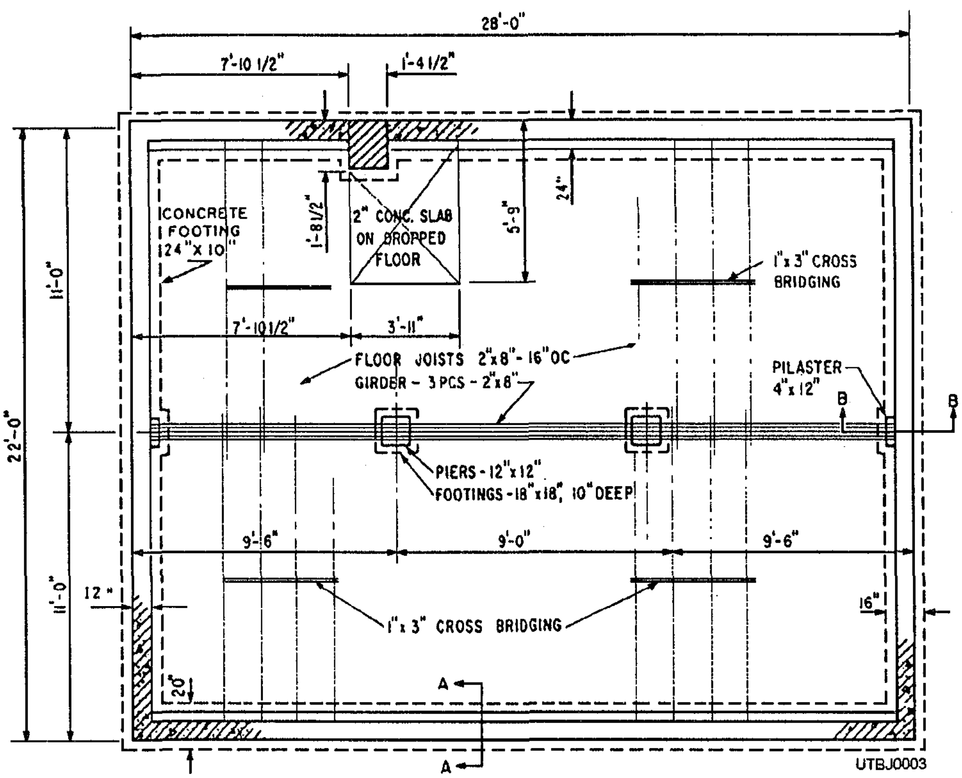


Figure 1-3.—Structural or foundation plan.

should work directly from the jobsite plans or working drawings, so the finished job is done properly and complies with the plans.

The chief parts of a mechanical plan are the views of the fixtures and equipment and the layout and details of the system. Plans also contain written information in the title block; the scales; the lines, symbols, and abbreviations; the print notes; the revision block; the drawing, reference, and zone numbers; and the bill of material. All of these areas are covered in detail in *Blueprint Reading and Sketching,* NAVEDTRA 12014.

Q1. In Seabee construction, a complete set of blueprints consists of how many plans?

Q2. The plans normally used by Seabees in construction are created by whom?

Q3. If you wanted to know the height of an exterior wall of a structure, to what section of the plans should you refer?

Q4. On the jobsite, you will work from what type of plans?

ISOMETRIC SKETCHING

LEARNING OBJECTIVE: *Recognize and develop isometric drawings.*

You may not be able to sketch or draw objects exactly as they should look or as a two-dimensional orthographic picture. However, with the aid of some basic rules and practice, you can learn to draw an isometric sketch.

PURPOSE OF THE ISOMETRIC DRAWING

The purpose of an isometric drawing is to show a three-dimensional picture in one drawing. It resembles a picture without the artistic details. Many Utilitiesmen have difficulty in visualizing a piping installation clearly when they are working from a floor plan to an elevation drawing and back again. The isometric drawing combines the floor plan and the elevation. It clearly shows the details and the relationship of the pipes in a piping installation.

Normally, isometric drawings are NOT drawn to scale on blueprints; however, when you sketch out an

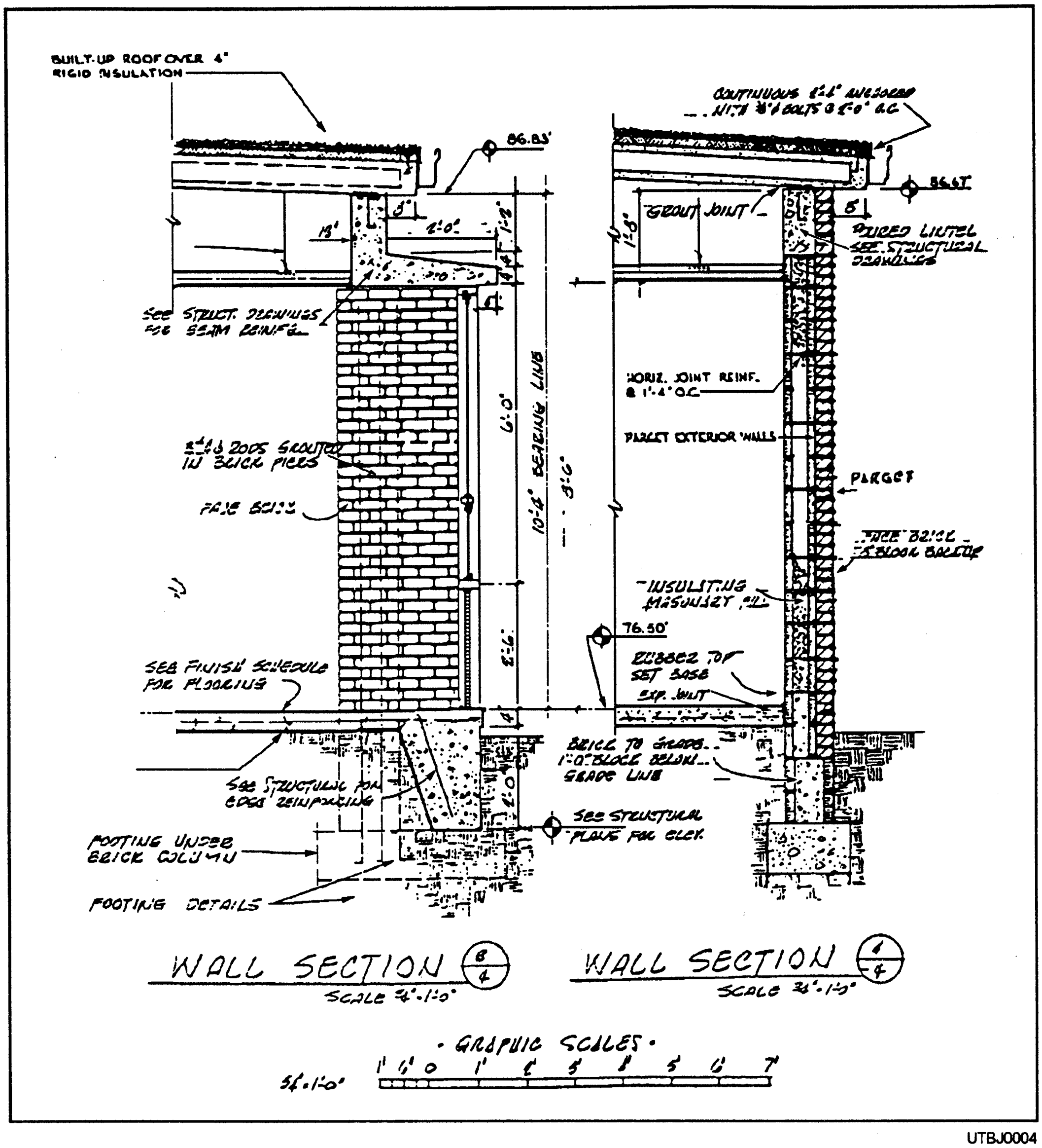


Figure 1-4.—Structural plan wall sections.

isometric drawing, you have the option of drawing it to scale.

The isometric drawing follows certain rules or conventions to show three dimensions on a flat surface. These rules are as follows:

1. Vertical lines in an orthographic elevation remain vertical in an isometric sketch.

2. Horizontal lines in an orthographic elevation are projected at an angle of 30 degrees and 60 degrees in an isometric drawing.

COMPARISON OF ISOMETRIC AND ORTHOGRAPHIC DRAWINGS

Compare the simple rectangular block shown in the orthographic representation in view A, figure 1-7, and the three-dimensional-view isometric representation in view B. Notice that the vertical lines of the orthographic drawing and isometric drawing (views A and B) remain vertical. The horizontal lines of the orthographic drawing are NOT horizontal in the isometric drawing but are projected at 30-degree and 60. degree angles, and the length of the lines remain the same in the isometric as they were in the orthographic.

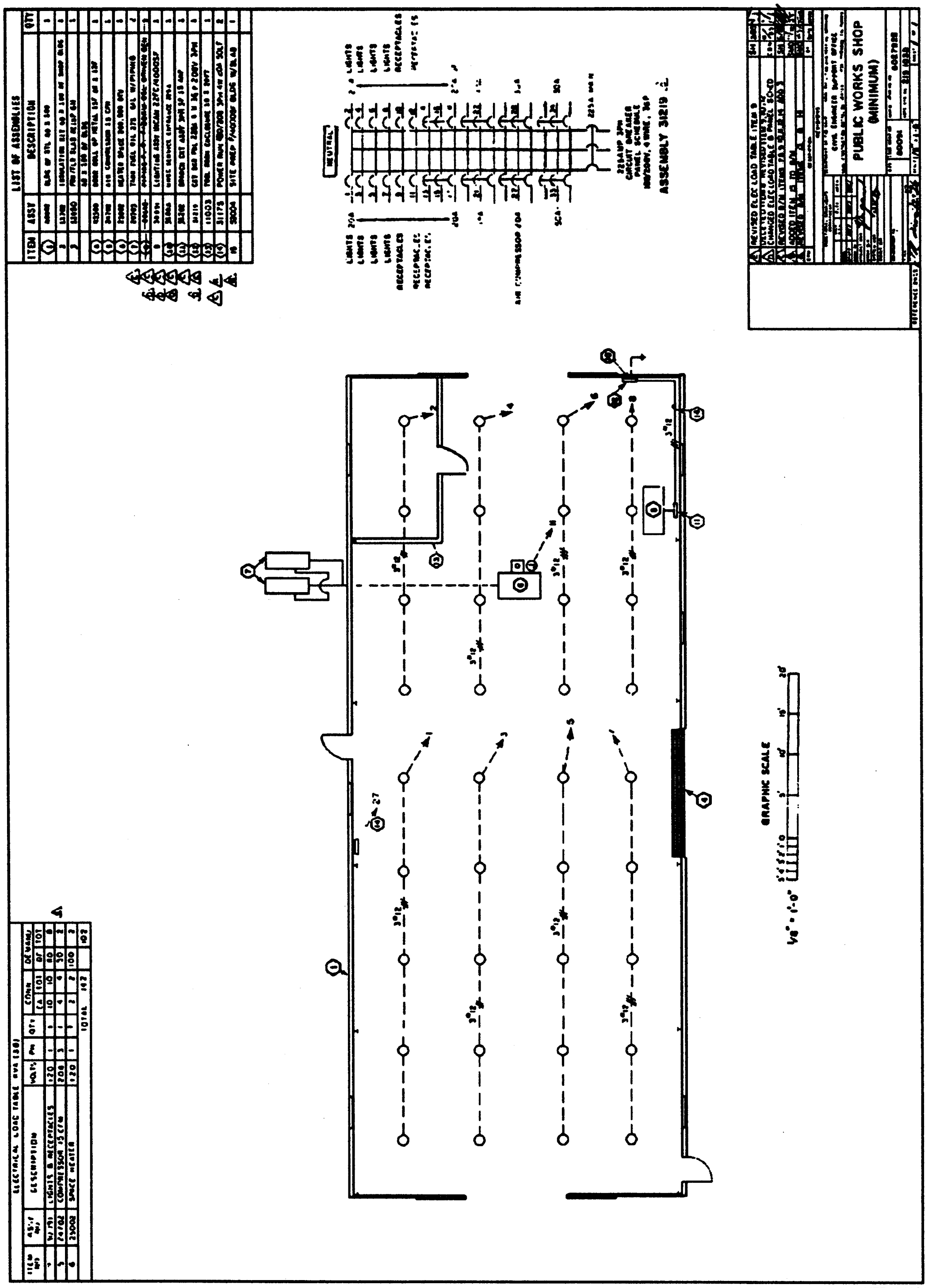


Figure 1-5.—Interior electrical plan.

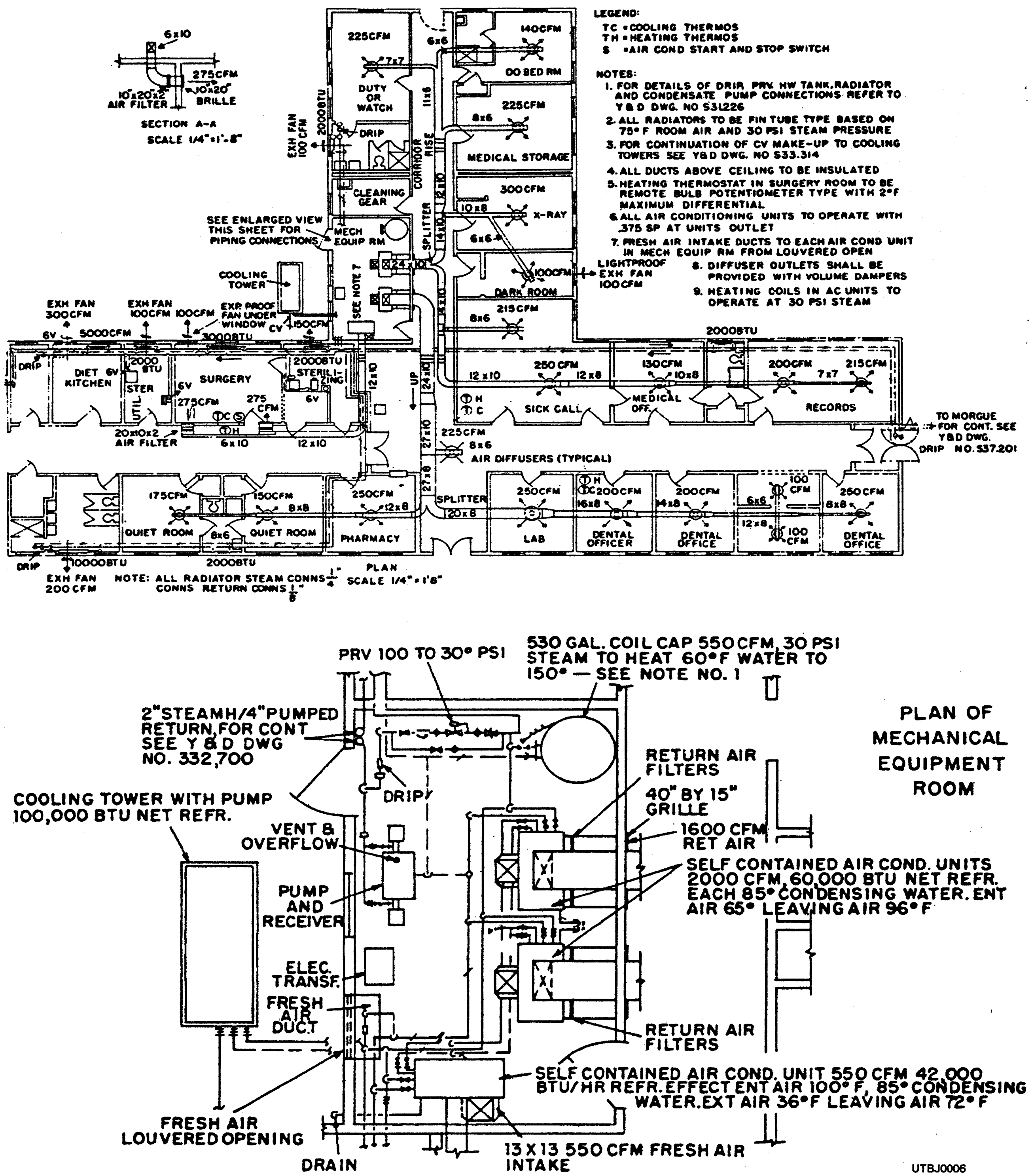


Figure 1-6.—Mechanical plan-air-conditioning system.

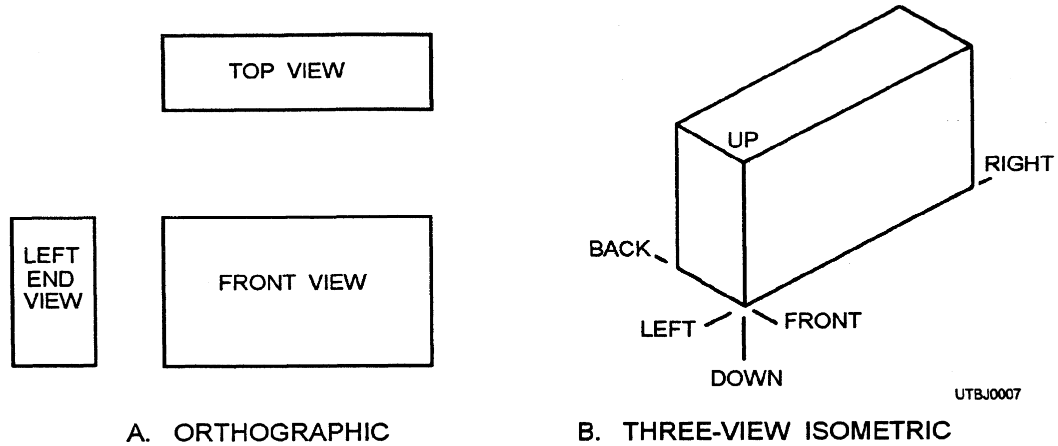


Figure 1-7.—Orthographic and isometric drawings.

Once you understand the drawing in figure 1-7, the same idea can be applied to the drawing of the shape of a room, as shown in figures 1-8 and 1-9.

DRAWING AN ISOMETRIC VIEW

To determine the pipe layout, you can draw the dimensions of a room in several ways. Some Engineering Aids suggest that the lines of the room be drawn with fine, light lines, and the pipe diagram with heavy, dark lines to give the effect of a transparent room you can see into, as shown in figure 1-10. This method requires drafting room equipment and is difficult in field sketching.

Another means of visualizing the pipe layout is to "section" or remove from the drawing those parts in front of what is important to show. The usual section in a plumbing pipe layout leaves the ceiling and two walls out of the drawing, as shown in view C of figure 1-10.

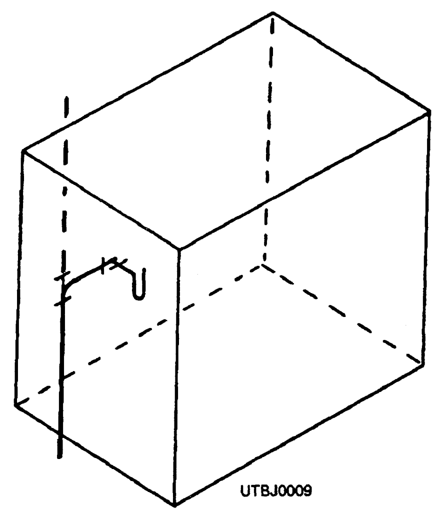


Figure 1-9.—Isometric drawing of a room and drainage pipe.

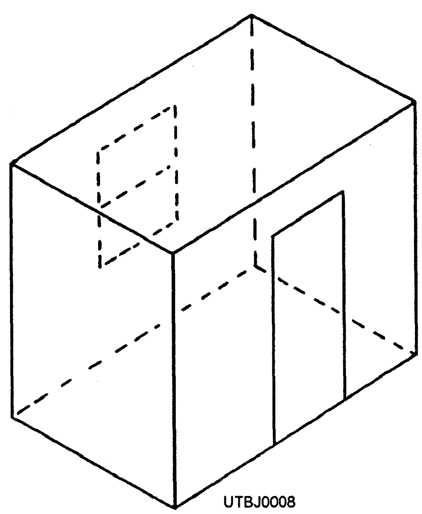


Figure 1-8.—Isometric drawing of a room.

A third method is simpler in that the room is shown only as a partial floor plan view, as shown in view D, figure 1-10. The walls are omitted from the drawing entirely. It is understood that the walls are to be there, but they are left out so the piping diagram is' shown without unnecessary details.

To lay out a 45-degree angle in an isometric drawing, draw a square and lay out the 45-degree angle, as shown in view A, figure 1-11. Now look at view B and you will see a block with a 45-degree chamfer. The chamfer is located by measuring equal distances from the corner that would ordinarily be there.

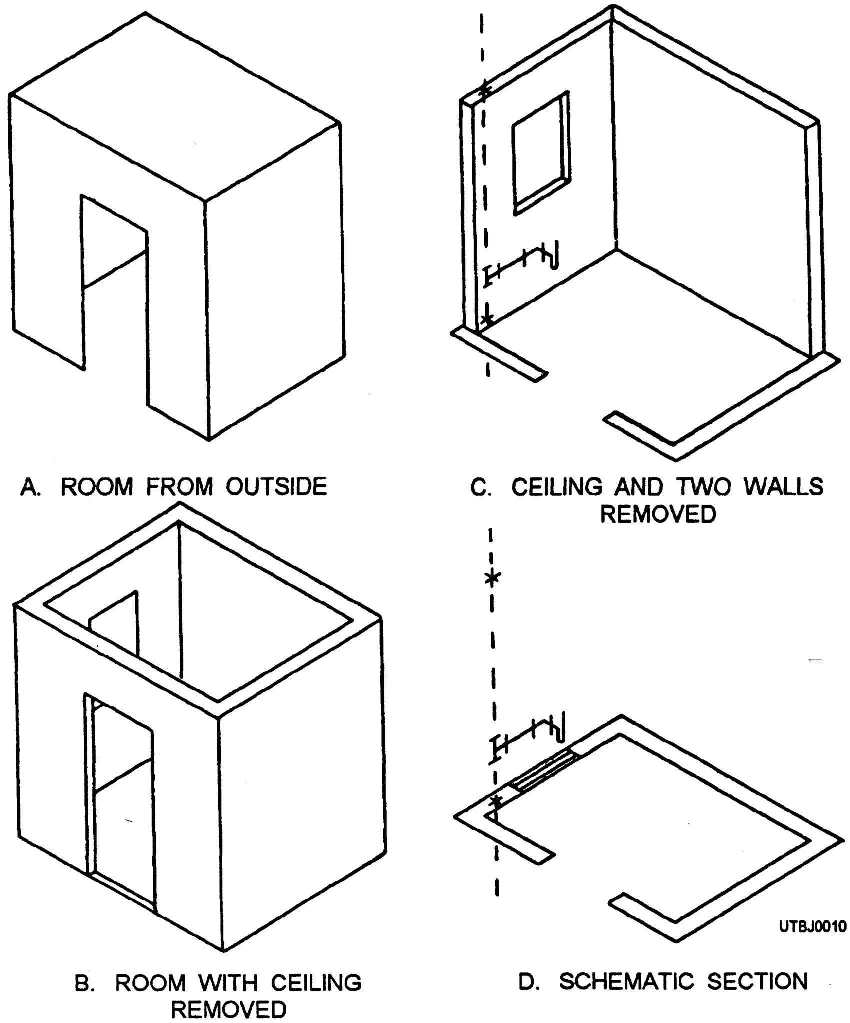


Figure 1-10.—Isometric plumbing pipe layout.

A piping diagram with a 45-degree angle, as shown in view C, would be very similar to the lines for part of the block, as shown in view B. To draw a 45-degree angle in an isometric drawing, begin with a 90-degree angle. Measure an equal distance from the intersection of the two legs connecting these points; then, establish two sides of a square. By connecting these points, you have established the diagonal, which is a 45-degree angle. In view C, point A would be the intersection of the two legs of a 90-degree angle, measured an equal distance along each leg; three fourths of an inch is used here. Now, locate points B and C. Connect points B and C, and you have established the 45-degree offset.

DIMENSIONING AN ISOMETRIC DRAWING

An isometric drawing, or sketch, is dimensioned with extension and dimension lines nearly like a two-dimensional drawing. The extension lines extend from the drawing, so the dimension lines are parallel to the object line and of equal length to it.

To dimension the isometric drawing is more difficult because there is only a single view, and less room is available than on three separate views. Figure 1-12 shows a dimensioned isometric drawing for part of a pipe hanger. In making the isometric pipe diagram, refer to the architect's plans and "rough in" sheets for accurate information.

Since pipe diagrams are measured from the center of one fitting to the center of the next fitting, it is possible to omit the extension and dimension lines by use of a notation, such as 13 inch c to c (center to center).

Pipe sizes must be added to the pipe diagram. The size of pipe is shown by a number near the line indicating the pipe, as shown in figure 1-13.

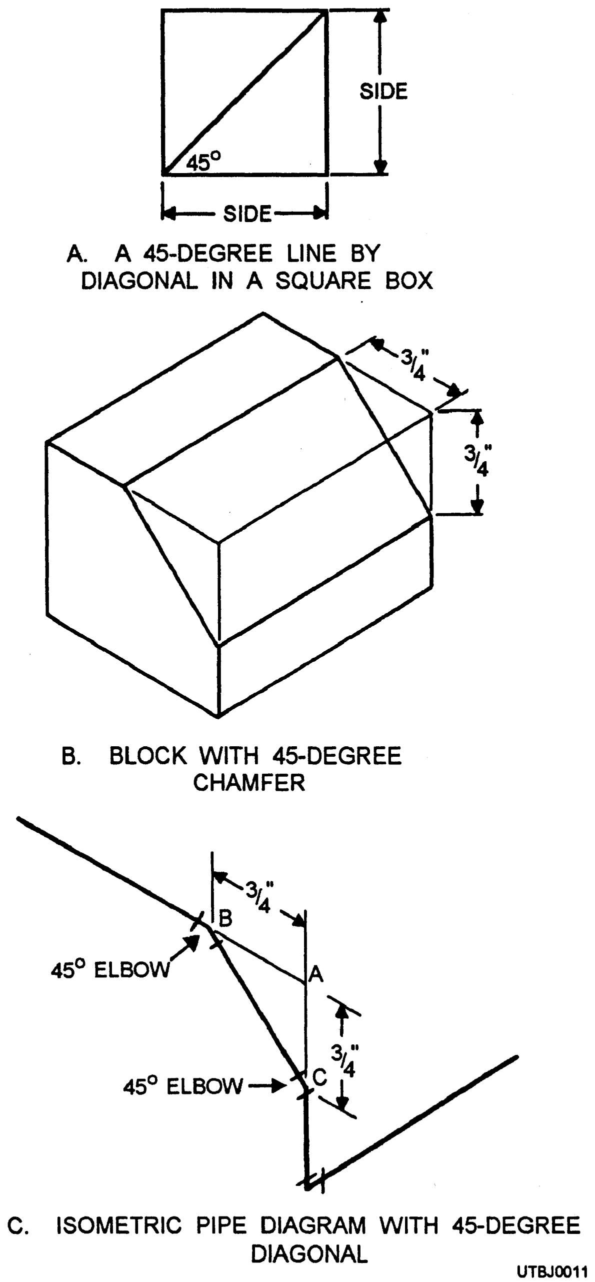


Figure 1-11.—Isometric 45-degree squares, chamfers, and diagonals.

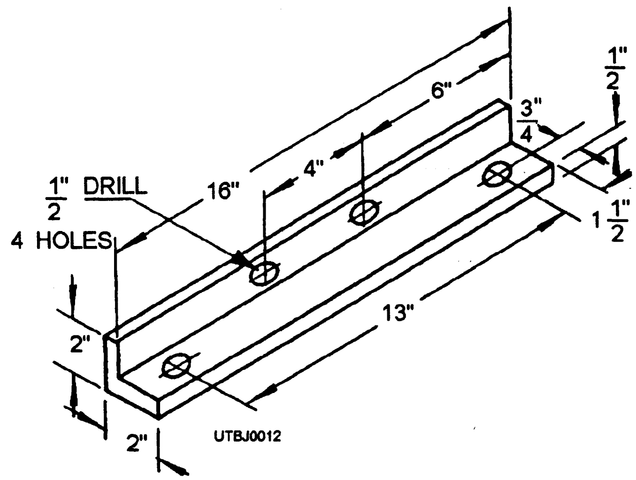


Figure 1-12.—Isometric drawing of a pipe hanger.

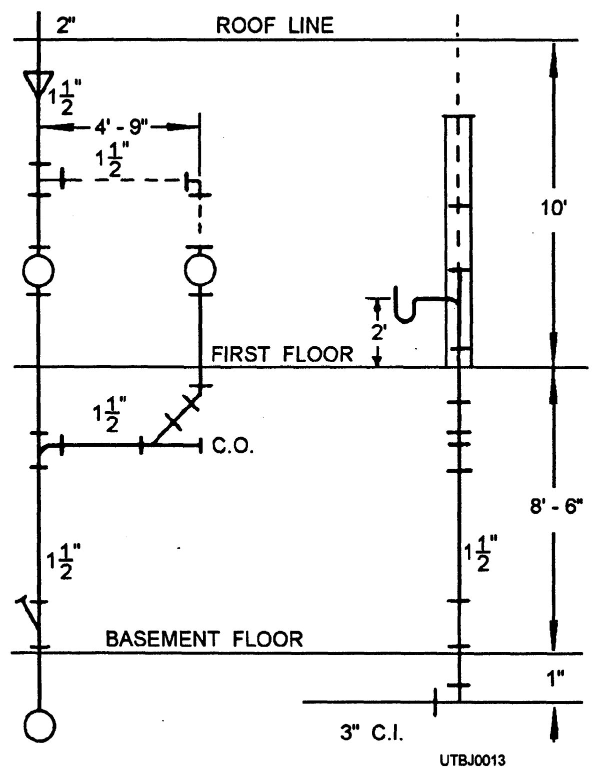


Figure 1-13.—Pipe layout.,

PLACING DIMENSIONS ON AN ISOMETRIC DRAWING

The purpose of an isometric pipe layout is best served by a simplified dimensioning system. Because few dimensions are shown, draw accurately to scale, so the layout can be measured.

Practice dimensioning by redrawing the pipe diagram of figure 1-13 as an isometric pipe layout. Ensure the lengths are to scale, and dimension the pipe size accordingly. Also, make a list of fittings and pipe required (MTO).

SKETCHING PRACTICE

So far, the principles of reading prints and drawing sketches have been discussed. To practice these rules, look at the three isometric drawings in figure 1-14 and sketch three, 3-view drawings, properly dimensioned

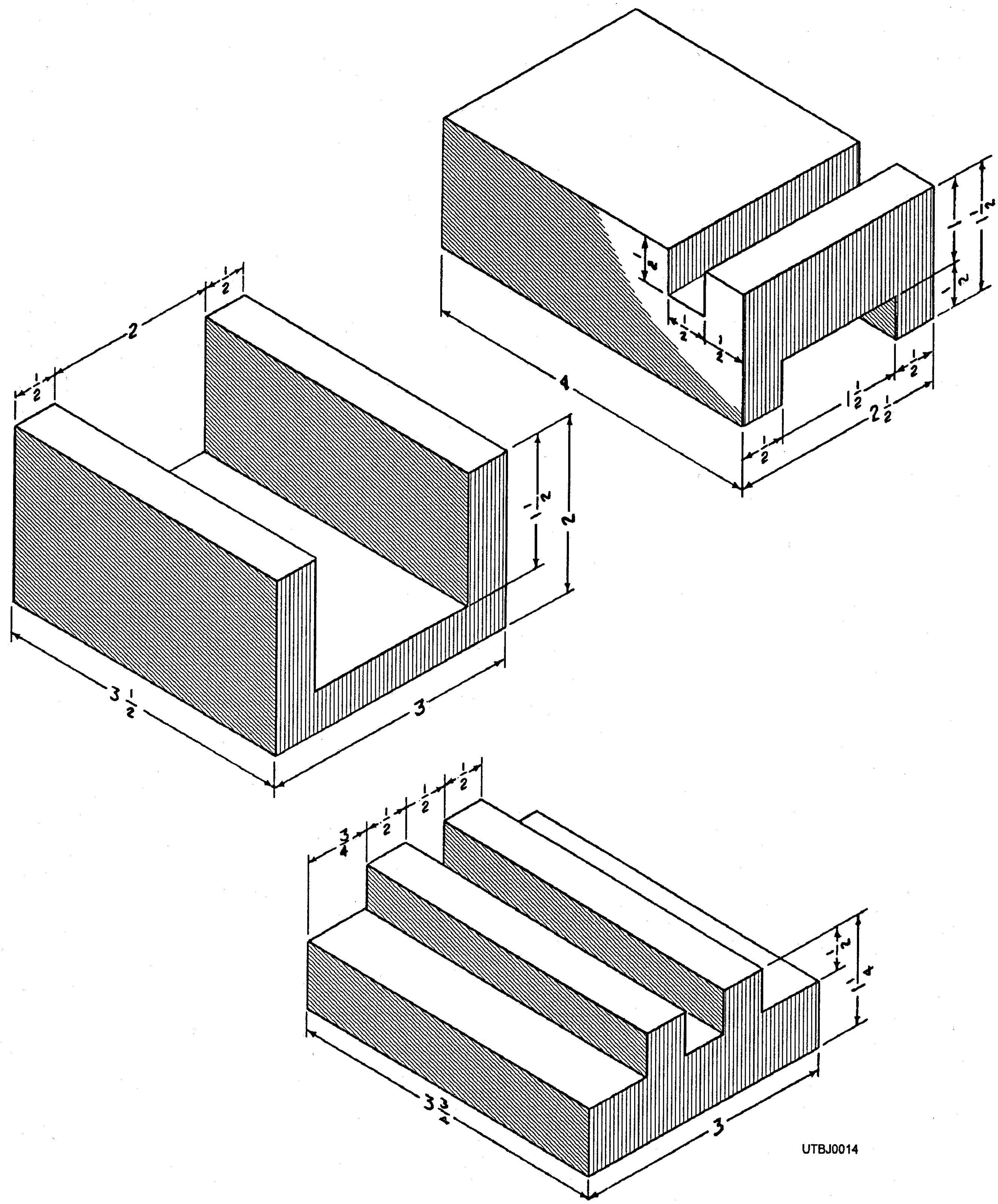


Figure 1-14.—Three isometric views to be drawn orthographically.

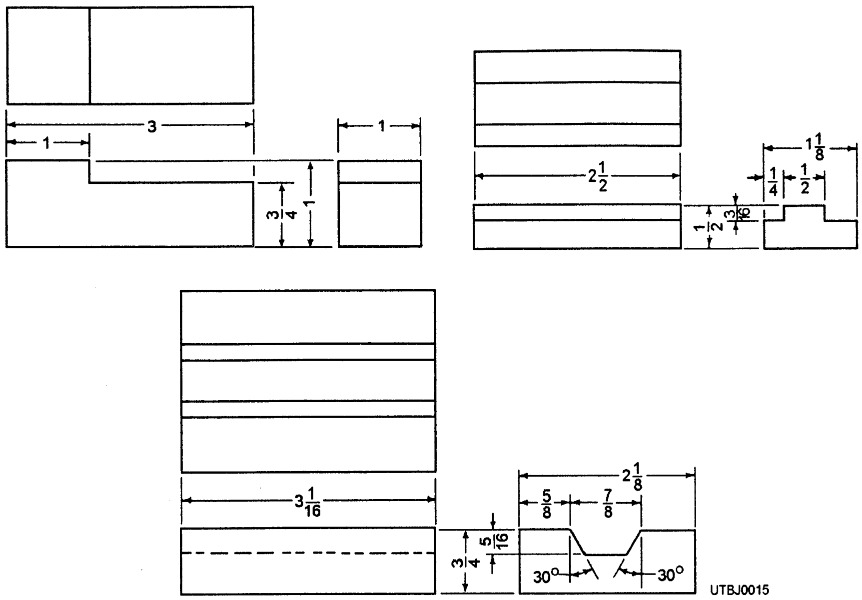


Figure 1-15.—Three orthographic views to be drawn isometrically.

(fig. 1-15). Now, make three isometric sketches properly dimensioned.

There is more information on drawing sketches in *Blueprint Reading and Sketching,* NAVEDTRA 12014.

Q5. An isometric drawing is designed to show what type of picture?

Q6. Horizontal lines on an isometric drawing are projected at what angles?

Q7. It is more difficult to dimension an isometric drawing than an orthographic drawingfor what reasons?

SPECIFICATIONS

LEARNING OBJECTIVE: *Relate to the arrangement and purpose of specifications and their relationship with plans and drawings.*

Although the plans you will be working from usually have sufficient detail, you will need additional information regarding materials and methods of installation. This information is located in the appropriate specifications. Plans and specifications go together to provide visual and written information about a project required by you, as the constructor, installer, or maintainer, to produce the best quality product.

There are several types of specifications **(SPECS),** but you will work primarily with project guide, federal, military, and NAVFAC specifications.

Project guide specifications usually begin with Division 1, the **GENERAL REQUIREMENTS** for the structure. They state the type of foundation, the character of load-bearing members (wood frame, steel frame, concrete), the type or types of doors and windows, the types of mechanical and electrical installations, and the principal function of the building. Next comes the **SPECIFIC CONDITIONS** that are carried out by the constructors. The conditions are grouped in divisions under headings applying to each major phase of construction as follows:

1. — **GENERAL REQUIREMENTS.**

2. — **SITE WORK.** Includes work performed on the site, such as grading, excavation, compaction, drainage, site utilities, and paving.

3. — **CONCRETE.** Includes precast and cast-in-place concrete, formwork, and concrete reinforcing.

4. — **MASONRY.** Includes concrete masonry units, brick, stone, and mortar.

5. — **METALS.** Includes such items as structural steel, open-web steel joists, metal stud and joist systems, ornamental metal work, grills, and louvers.

6. — **WOOD AND PLASTICS.** Includes wood and wood framing, rough and finish carpentry, foamed plastics, fiber-glass reinforced plastics, and laminated plastics.

7. — **THERMAL AND MOISTURE PROTECTION.** Includes such items as waterproofing, dampproofing, insulation, roofing materials, sheet metal and flashing, caulking, and sealants.

8. — **DOORS AND WINDOWS.** Includes doors, windows, finish hardware, glass and glazing, storefront systems, and similar items.

9. — **FINISHES.** Includes floor and wall coverings, painting, lathe, plaster, and tile.

10. — **SPECIALTIES.** Includes prefabricated products and devices, such as chalkboards, movable partitions, fire-fighting devices, flagpoles, signs, and similar items.

11. — **EQUIPMENT.** Includes such items as medical equipment, laboratory equipment, food service equipment, kitchen and bath cabinetwork, and counter tops.

12. — **FURNISHINGS.** Includes prefabricated cabinets, blinds, drapery, carpeting, furniture, and seating.

13. — **SPECIAL CONSTRUCTION.** Includes prefabricated structures, integrated ceiling systems, and swimming pools.

14. — **CONVEYING SYSTEMS.** Includes dumbwaiters, elevators, moving stairs, material-handling systems, and other similar conveying systems.

15. — **MECHANICAL.** Includes plumbing, heating, air conditioning, fire-protection systems, and refrigeration systems.

16. — **ELECTRICAL.** Includes electrical service and distribution systems, electrical power equipment, electric heating and cooling systems, lighting, telephone systems, and other electrical items.

17. — **EXPEDITIONARY STRUCTURES.** Include tension fabric structures, K-span buildings, and other similar items.

Not all of the specification divisions are required for every construction project. Divisions that are not required for a construction project are normally omitted. Sections under one of these general categories generally begin with **GENERAL REQUIREMENTS** for that category and continue with the **SPECIFIC REQUIREMENTS.** An example of a section of Division 15 **(MECHANICAL)** follows.

In studying the guide specifications for plumbing which follow, study the drawing shown in figure 1-16, keeping in mind that these specifications are for this project and are listed as samples.

DIVISION 15. **MECHANICAL**

Section 15. 1a- Plumbing

15. 1a-01. **GENERAL REQUIREMENTS.** The work consists of a complete plumbing system, including the sanitary soil, waste, and vent piping; cold- and hot-water supply piping, water meter (if required), plumbing fixtures, hot-water heater, and other appurtenances. The system must be inspected, tested, and approved by local governing plumbing codes before burying, concealing, or covering the various piping systems. Each system must be complete and ready for operation except as specified or indicated otherwise.

15. 1a-02. **SANITARY SEWER, BELOW-GROUND** level, must be of extra-heavy cast-iron soil piping and fittings of the bell-and-spigot type, extending 3 to 5 feet beyond the foundation wall and graded not less than 1/8 inch per foot. The joint will be made from a good grade of twisted oakum uniformly and well-tamped into the joint and with a l-inch depth of hot poured lead, made in one pouring, and caulked tight. All horizontal soil connections to the system must be accomplished by Y-fittings or combination Y and 1/8 bends. All changes in direction greater than a 1/8 bend must be of the long sweep pattern. Lines

should be well-supported to eliminate sagging. Backfilling will be well-tamped in (i-inch layers.

15. 1a-03. **SANITARY SEWER, ABOVE-GROUND** level, must be as specified for the belowground level, except waste lines and vent piping above the ground must be of zinc-coated, standard-weight, screwed-end steel pipe and cast iron, recessed, long radius, screwed drainage fittings, and graded not less than 1/8 inch per foot. The sanitary sewer vent will extend full size through the roof for a distance of not less than 12 inches, where it must be flashed with suitable corrosion-resistant metal before the roofing is installed. A 4-inch cleanout will be provided slightly above the ground elevation at the base of the soil stack. All male screw ends will be coated with a good grade pipe joint compound before entering into fittings. The bathtub trap must be provided with a 3/4-inch brass, screw dram plug; all lines must be properly supported from the floor joists with suitable hangers. A closet-bowl floor connection must have a cast-iron closet-bowl floor flange with provisions for anchoring the brass closet-bowl bolts and an approved type of horn gasket. The finished joint must be absolutely leakproof, and the bowl will sit squarely on the finished floor.

15. 1a-04. **WATER PIPING BURIED IN THE GROUND** must be jointless, type "K," soft copper tubing. No kinking of the tube will be allowed.

15. 1a-05 **WATER PIPING ABOVEGROUND** level must be type "L," hard copper tubing with solder-type fittings, except that vertical lines may be of type "L," soft copper tubing. All tubing lines will be properly anchored to the floor joists to eliminate pipe sag and vibration and pitched to the main shutoff valve for draining, when necessary. A hose bib will be provided at the rear of the building with a stop and waste located inside the foundation wall for winter cutoff and waste and arranged for complete drainage of the line from the hose bib. Slip-joint connections will not be permitted below the finished floor.

15. 1a-06. Fixtures must be of a reliable manufacturer and will be as follows:

(a) The **KITCHEN SINKS** will have a left-hand drainboard and be of cast iron with a smooth, white, acid-resisting porcelain enamel finish, 54 inches long by 25 inches wide by 35 inches high from floor to top of rim. The trim will be chromium plated, including combination mixing faucets with a soap dish, a large basket-type strainer with a 1 1/2-inch tailpiece, and a 1 1/2-inch wall-type P-trap. Hot- and cold-water supply lines in the sink cabinet will be provided with copper tubing valves. The cabinet will be of a heavy gauge steel with a baked-on, white enamel finish and have at least two sliding drawers.

(b) The **LAUNDRY TRAY** will be of the double compartment, cement type, 48 inches long by 20 inches wide by 32 inches high from floor to rim and be of a smooth cement mixture to withstand sudden temperature changes without cracking or leaking. Tubs will have a metal guard around the rim. The laundry tray will be complete with stand, combination mixing faucets with tray-mounting brackets, 1 1/2-inch tailpiece, and 1 1/2-inch wall-type P-trap. A copper tubing valve will be provided in each supply line.

(c) The **WATER CLOSET** will be of white, vitreous china, close-coupled tank and bowl, complete with white seat and seat cover, and have a chromium, 3/8-inch, screwed, brass floor supply line with a chromium I.P valve.

(d) The **LAVATORY** will be cast iron with a white porcelain enamel finish. The trim will be chromium plated and include combination mixing faucets with a 1 1/4-inch tailpiece, pop-up waste, 1 1/4-inch wall trap, and 3/8=inch, screwed, brass floor supply lines with I.P. valves.

(e) The **TUB** will be of the built-in type, cast iron, with a white porcelain enamel finish. The trim will be chromium plated and include a built-in wall-type faucet complete with shower attachments, a curtain rod and pins, and a 1 1/2=inch trip-lever waste. Copper tubing valves will be provided on each supply inside the wall access door.

15. 1a-07. **WATER HEATER** must be of the electrical storage type with a capacity of not less than 52 gallons. It must be of an approved manufacturer with the underwriter's label attached. It will be provided with two thermostatically operated heating elements: a 15-kilowatt element located near the top of the tank and l-kilowatt element located near the bottom of the tank. A 3/4-inch bronze drain valve will be provided at the extreme bottom of the tank with a 3/4-inch hose connection. A l/2-inch brass, combination temperature and pressure-relief valve with a discharge extending to the floor drain will be furnished. A copper tubing valve will be installed in

the cold-water supply. Electrical work must conform to the local governing electrical codes.

15. 1a-08. A main **SHUTOFF VALVE** will be installed as indicated or specified. The 1-inch main shutoff valve must be accessible to the stop-and-waste valve with solder-type ends, and the waste arranged for complete drainage of the entire water-supply system.

15. 1a-09. **WORKMANSHIP** will be performed in a fast-class manner, observing all standards of good installation practices.

15. 1a-10. **TESTS** must be conducted on all plumbing systems to provide tightness of all piping joints. If leaks occur, they will be repaired immediately and the tests repeated. The soil, waste, and vent systems will be completely filled with water to the highest point before checking for leaks. The hot- and cold-water piping must be tested with water at 1 1/2 times the working pressure. After all tests have proved satisfactory, all the necessary adjustments on the faucets, traps, valves, and other specialties will be checked, so the entire system can be placed in normal operation.

15. 1a-11. **INSULATION.** All the piping and fittings subjected to freezing temperatures must be adequately insulated with a suitable frostproof covering secured in place.

The project guide specifications, then, provide all the required information on the materials and methods of work to be used in completing a project that is not contained in the plans. There may be times when you will need to know more about the characteristics of materials listed in the bill of material. For example, if you cannot obtain a specified type of material or piece of equipment and want to substitute, you will need to know the characteristics of each in order to compare them before making the decision to substitute. This is where a knowledge of and access to federal, military, and NAVFAC specifications are important.

FEDERAL specifications are written technical descriptions of materials and supplies used by the Navy and other federal government agencies. They cover in detail the characteristics and compositions of these items and are listed, along with military specifications, in numerical and alphabetical indices generally available to you.

MILITARY specifications are similar to federal specifications but are developed for use by the Department of Defense. Formerly called JAN (Joint Army and Navy) specifications, they have been revised to MIL-SPECS, using the same serial number as before.

The last of the specifications that you will most likely use is the **NAVFAC** specifications. These are developed by the Naval Facilities Engineering Command and cover the Naval Facilities Engineering Command and other items normally used for construction. They are listed as "Type Specs" and Standard Specifications in the *Service Contracts Specifications,* NAVFAC MO-327.

Q8. Are all specification divisions required for every construction project?

Q9. You are installing a dental operatory chair on a project. To what division of the specifications should you refer?

Ql0. In the specifications sample "Division 15 Mechanical," what paragraph identifies the type of pipe for aboveground, vertical waterlines?

Qll. When is it necessary to know specific characteristics of a part or material?

ASSIGNMENT AS A CREW LEADER

LEARNING OBJECTIVE: *Identify the basic fundamentals of project planning, organization, and supervision.*

As you gain experience in utilities work, you will probably be called upon to serve as the leader of one or more crews. They may perform various types of work, such as measure, cut, and thread pipe; install pipe lagging and other insulation and protective materials on pipe; or other related utilities type work. Your duties, as a crew leader, may vary from one activity to another. Usually, these duties involve planning work assignments, supervising work teams, preparing requisitions, and keeping time cards.

PLANNING WORK ASSIGNMENTS

Planning is the process of determining requirements and devising and developing methods and schemes of action for construction of a project. Proper planning saves time and money for the Navy and makes the project easier for everyone concerned. Here are some pointers that are designed to help you plan day-to-day work assignments for your crew(s).

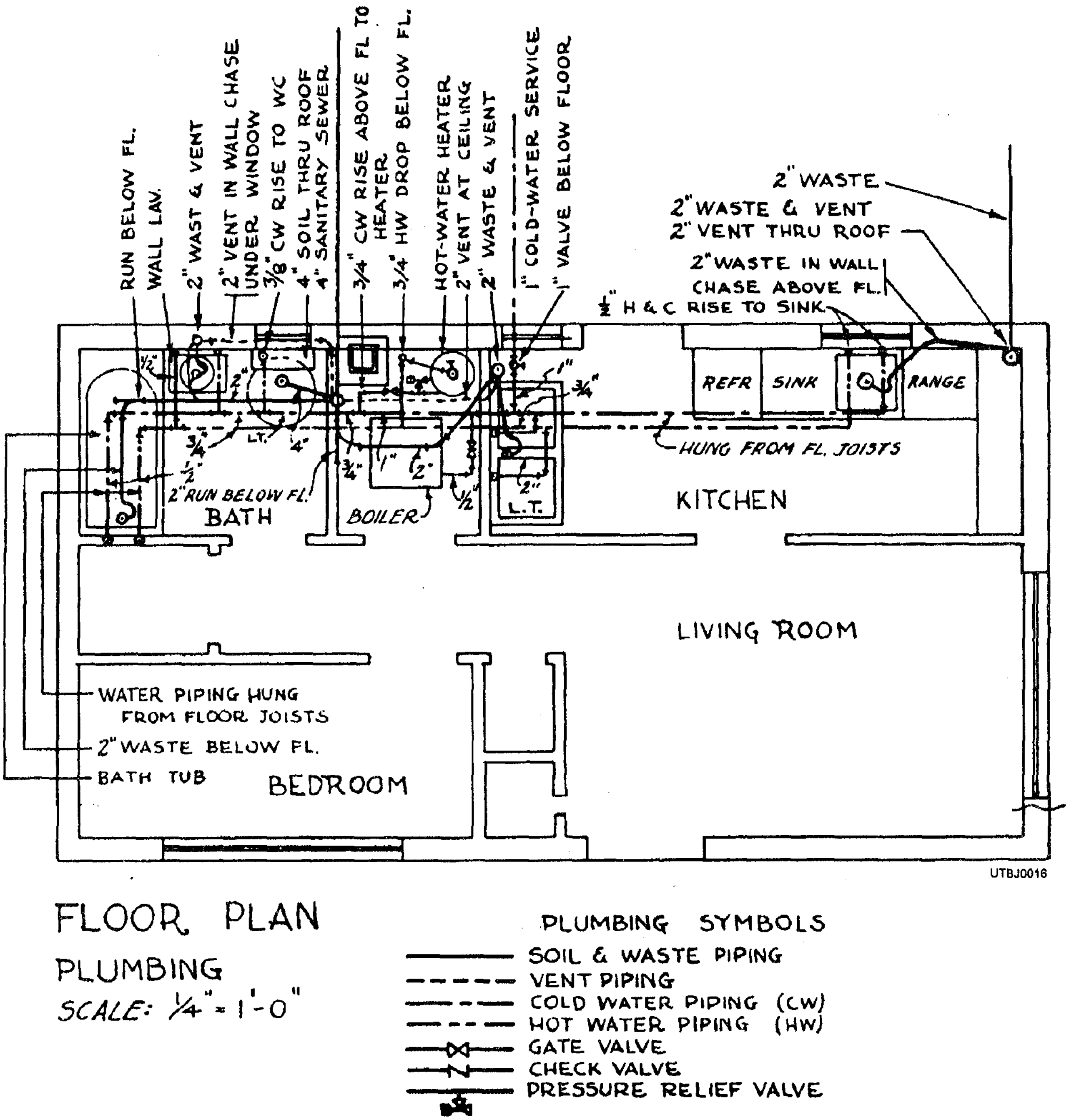


Figure 1-16.—Typical plumbing layout for a small house.

When you are assigned a job, whether in writing or orally, one of the first things to do is to make sure you understand clearly just what is to be done. Study plans and specifications where applicable. If you have any questions, find out the answers from those in a position to supply the information you need. Among other things, make sure you understand the priority of the project, time of completion, and any special instructions to be followed.

In planning for a small or a large project, you must consider the capability of the personnel available for assignment. Determine who is to do what and how long it should take to complete the job. Realizing that idleness may breed discontent, arrange to have another job ready for starting as soon as the first one is finished.

Establish goals for each workday and encourage your crew to work together as a team in accomplishing these goals. You want goals to be such that your crew is kept busy, but make sure they are **realistic.** During an emergency, most people will make a tremendous effort to meet a deadline. But people are not machines, and when there is no emergency, they cannot be expected to achieve an excessively high rate of production continually.

In planning, you must also allow for things that are not considered direct labor, such as safety training, disaster control training, leave, and liberty.

To help ensure that a job is done properly and on time, you should consider the method to use in doing the job. If there is more then one way, make sure the method you select is the best. After selecting a method, analyze it to see if it could be simplified and still save time and effort.

Plan material requirements so you will not have a lot of leftover materials. But do not make material estimates so low that you might run out of necessary items and cause the job to be delayed. At times, you may have to use more materials than anticipated, so it is better to have some leftover materials than to run short.

Consider the tools and equipment you need for the job and arrange to have them available at the place where the work is to be done and at the time the work is to get under way. Determine who is to use the tools, and make sure these individuals to whom they are assigned know how to use them properly and safely. Determine whether special permits are required to operate special tools. Plan to have the materials in an accessible place that will not pose a safety hazard.

SUPERVISING WORK TEAMS

After the job has been planned properly, it is necessary to supervise the job carefully to ensure it is completed properly and on time. Some pointers for supervising work teams are provided below.

Before starting a job, make sure your crew members know what is to be done. Give instructions clearly, and urge them to ask questions on any points that are unclear. If they do not understand the requirements, they will be unable to do their job properly. It is also important to ensure the crew members know all pertinent safety precautions and wear safety apparel as required. Check all tools and equipment before use to ensure they are in a safe condition. Ensure electrical tools are marked with the current safety color code. The color code for any given month will be uniform for a 30-day period or less, according to COMSECOND/COMTHIRDNCBINST 5100.1. Ensure all electrical power tools are protected by GROUND FAULT INTERRUPTER (GFI) before use. Do not permit dangerously defective tools and equipment to be used; see that they are turned in for repair immediately. A job can be done without a specific tool by substitution, but people are not as expendable.

During construction, check from time to time to ensure the work is progressing satisfactorily. Determine if the proper methods, materials, tools, and equipment are being used. If one of your crew members is doing a job incorrectly, stop and point out what is wrong. Then explain the correct procedure and check to see that it is done. In checking the work of your crew, make sure they know that the purpose of your inspection is to teach, guide, and direct, rather than to criticize and determine fault. Ask questions to show interest, and praise good, sound ideas and judgment.

When time permits, rotate the crew members on various jobs. Rotation gives them varied experience and helps to ensure that you will have a person who can do the work if someone is hospitalized, transferred, or goes on leave.

A good supervisor should be able to get others to work together in getting the job accomplished., The supervisor should maintain an approachable attitude toward the crew, making members feel free to come and seek advice when they are in doubt as to any phase of the project. Emotional balance is especially important; a supervisor cannot become panicky in front of the crew. A good supervisor should use tact and courtesy in dealing with members of the crew and not show partiality to certain members. The supervisor should keep crew members informed on matters that affect them personally or concern their work. The supervisor should also seek to maintain a high level of morale, keeping in mind that low morale can have a definite effect upon the quantity and quality of work being turned out by the crew.

The information above is only a brief treatment on the subject of supervision. As you advance in rate, you will be spending more and more of your time supervising others, so make a continuing effort to learn more about the subject of supervision. Study books on supervision, as well as leadership. Also, read articles on topics of concern to supervisors, such as safety, training, job planning, and so forth, that appear from time to time in trade journals and other publications. Additional planning and estimating can be located in *the NMCB Crew Leader's Handbook* and the *Seabee* *iPlanner's and Estimator's Handbook,* NAVFAC P-405. There is a big need in the Navy for petty officers who are skilled supervisors. Consider the role of supervisor as a big challenge and endeavor to become proficient in all areas of the supervisor's job.

Q12. What are the two benefits for the Navy when a project is planned properly?

Q13. As a supervisor, what is the first thing you should do once planning is complete?

COLORS FOR SAFETY

LEARNING OBJECTIVE: *Recognize piping, gas cylinders, and general safety color coding.*

Color warnings provide for marking physical hazards, for indicating the location of safety equipment, and for identifying fire and other protective equipment. As a Utilitiesman, you may often be concerned with uniform colors used for marking pipelines carrying hazardous materials, compressed gas cylinders, and fire- protection equipment.

CLASSES OF MATERIALS AND THEIR COLOR CODES

Five classes of materials have been selected to represent the general hazards for all dangerous materials, while a sixth class has been reserved for fire-protection materials. A standard color represents each of these classes, as shown in table 1-1.

In some instances, piping systems that do not require warning colors may be painted to match surroundings; in other instances, such systems may be painted aluminum, black, or remain unpainted.

MARKING PIPING SYSTEMS

In addition to color warnings, **WRITTEN TITLES** should be used to identify hazardous or dangerous materials conveyed in piping systems.

Table 1-1.—Warning Colors

Class	Standard Color	Class of Material
a	Yellow, number 13655	FLAMMABLE MATERIALS. All materials known ordinarily as flammables or combustibles. Of the chromatic colors, yellow has the highest coefficient of reflection under white light and can be recognized under the poorest conditions of illumination.
b	Brown, number 10080	TOXIC AND POISONOUS MATERIALS. All materials extremely hazardous to life or health under normal conditions as toxics or poisons.
c	Blue, number 15102	ANESTHETICS AND HARMFUL MATERIALS. All materials productive of anesthetic vapors and all liquid chemicals and compounds hazardous to life and property but not normally productive of dangerous quantities of fumes or vapors.
d	Green, No 14260	OXIDIZING MATERIALS. All materials which readily furnish oxygen for combustion and fire producers which react explosively or with the evolution of heat in contact with many other materials.
e	Gray, number 16187	PHYSICALLY DANGEROUS MATERIALS. All materials not dangerous in themselves, which are asphyxiating inconfined areas or which are generally handled in a dangerous physical state of pressure or temperature.
f	Red, No. 11105	FIRE PROTECTION MATERIALS. All materials provided inpiping systems or in compressed-gas cylinders exclusively for use in fire protection.

Titles should be stenciled or lettered on pipe (or covering) where the view is unobstructed, such as on the lower quarters. Lettering in this position is unlikely to be obscured by dust collection or mechanical damage. Titles should be in black or white ONLY and be clearly visible from operating positions, especially those next to control valves.

Use stencils with standard-size letters, as shown in table 1-2. For pipelines smaller than three quarters of an inch in diameter, use securely fastened metal tags with lettering etched or filled in with enamel. Apply titles with uppercase letters and Arabic numerals whenever applicable.

PRIMARY COLOR WARNINGS should be a single color, applied as a BAND (or BANDS), that completely encircle(s) the piping system. They are located on the piping system immediately next to all operating accessories, such as valves, regulators, strainers, and vents. The bands should be painted throughout the system at convenient intervals where branch lines join the system, where the system passes underground or through walls, and at any other conspicuous place where warnings are required. All piping and covering of an entire system, excluding straps, hangers, and supports, may be painted with the primary color warning. When this is done, DO NOT paint color bands of any kind on the system.

A colored ARROW should be used next to each primary color warning applied to a piping system to indicate the normal direction of flow of the material in the system. A double-headed arrow is used on lines subject to reverse flow. The color of arrows can be the same as the primary warning when bands are used—black or white. (Refer to fig. 1-17 for identification of piping systems.)

Table 1-2.—Size of Stencil Letters

Outside diameter of pipe or covering	Size of Stencil Letters
Inches	**Inches**
Under 1 ½	1/2
1 ½ to 3 ½	3/4
3 ½ to 6	1 1/4
6 to 9	2
9 to 13	3
Over 13	3 ½

MARKING COMPRESSED GAS CYLINDERS

Compressed gas cylinders used throughout the Department of Defense are of a standard color code. The material within is shown by a written title in two locations diametrically opposite and parallel to the longitudinal axis of the cylinder. Cylinders having a background color of yellow, orange, or buff have the title painted black. Cylinders having a background color of red, brown, black, blue, gray, or green have the title painted white.

A primary color warning relates to the primary hazard of the material. These colors appear as a circular band on piping systems and as main body, top, or band colors on compressed gas cylinders.

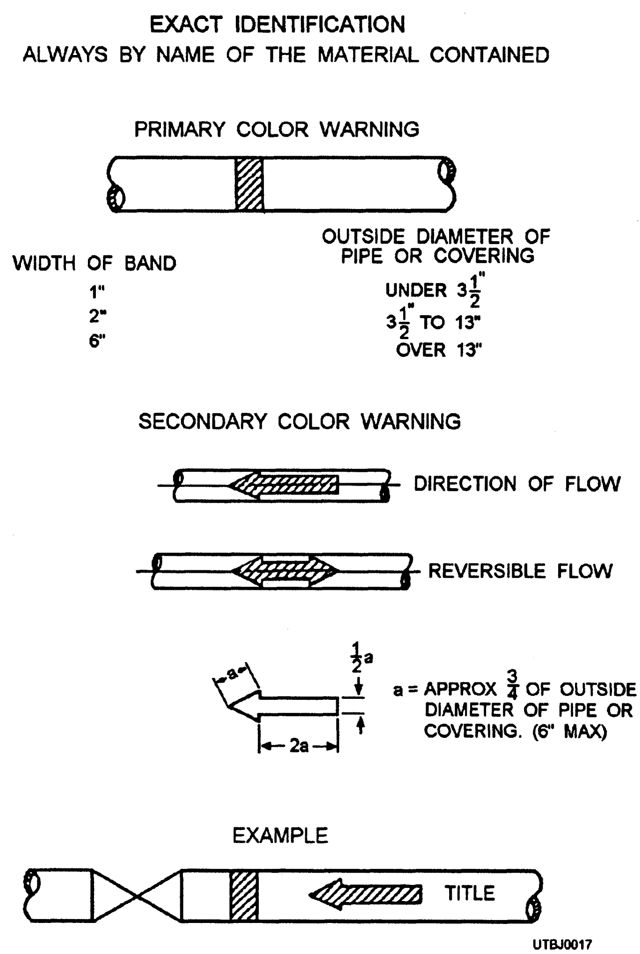


Figure 1-17.—Identification of piping system.

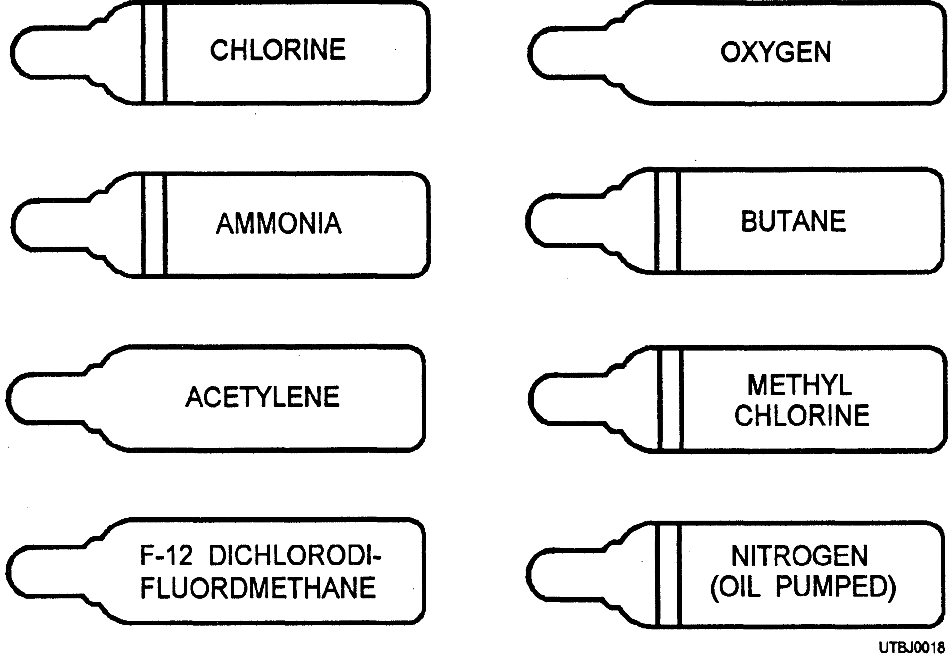


Figure 1-18.—Compressed gas cylinders commonly used by Utilitiesmen.

Table 1-3.—Cylinder Color Chart

Type Cylinders	Top Color	Band Color	Main Body Color
Chlorine	Entire	Cylinder	Brown
Ammonia	Brown	Yellow	Orange
Acetylene	Entire	Cylinder	Yellow
F-12 Dichlorodifluoromethane	Entire	Cylinder	Orange
Oxygen	Entire	Cylinder	Green
Butane	Yellow	Orange	Yellow
Methyl Chlorine	Yellow	Brown	Orange

A secondary color warning alerts you to the secondary hazard of a material. The second hazard differs from the primary hazard. These colors appear as arrows (or triangles) on piping systems and as main body, top, or band colors on compressed gas cylinders.

Two decalcomanias may be applied on the shoulder of each cylinder diametrically opposite at right angles to the titles. They should indicate the name of the gas, precautions for handling, and use. A background color corresponding to the primary color warning of the content should be used.

A shatterproof cylinder must be stenciled with the phrase "Non-Shat" longitudinally at 90 degrees from the title. Letters must be black or white and approximately 1 inch in size.

On cylinders owned by or procured for the Department of Defense, the bottom and the lower portion of the cylinder body opposite the valve end may be used for service ownership titles.

The appearance on the body, top, or as a band of any of the six colors listed in table 1-1 warns of danger from the hazards in handling the type of material contained in the cylinder.

Figure 1-18 shows compressed gas cylinders and table 1-3 shows cylinder colors most commonly found in a Naval Mobile Construction Battalion or in a Public Works Department where Seabee personnel will be working. For a complete listing of compressed gas cylinders, refer to MIL-STD-101B; but make sure you have a standard with the latest up-to-date changes inserted, as changes may occur in the manual as prescribed by the Department of Defense after this writing.

Q14. What class of material has a green warning color?

Q15. Other than warning colors, what else should be used to identify dangerous or hazardous materials?

Q16. The name or title of a gas should be painted in what color on the outside of the cylinder?

Q17. What does the secondary warning color of a material indicate?

Q18. What do arrows indicate on piping systems?

CHAPTER 2

ADVANCED BASED FUNCTIONAL COMPONENTS

LEARNING OBJECTIVE: *Explain the basic functions of the Advanced Base Functional Component (ABC) System, as outlined in the NAVFAC P-437, and identify the basic operation of various types of advanced base field support facilities.*

The Seabees are involved in many projects, ranging from building playgrounds in local communities to renovating buildings or building structures from scratch; however, the primary responsibility of the Seabees must not be forgotten-the construction of advanced bases. It is the Seabee's job to get in the middle of a contingency situation and construct the temporary facilities required to support U.S. military operations.

When these services are called upon, Seabees are expected to react expediently, and planning time is often limited. Planning is still required to organize personnel working schedules, material requirements, and tool/equipment usage. At one time, this planning was not done in advance.

The need for advanced planning was discovered when our forces were jumping from island to island during World War II. It was realized that many of the requirements of the advanced bases were the same and a new advanced base could benefit from the planning done on a previous base. Advanced base requirements were grouped together into components according to their desired functions, and the ADVANCED BASE FUNCTIONAL COMPONENT (ABFC) SYSTEM was born. The ABFC System revolves around a building block type of system. The largest type of block is a COMPONENT, which brings together all of the people, facilities, equipment, and supplies required to perform a particular function. A component is made up of a FACILITY or a number of facilities that best meet your requirements. A facility is composed of smaller building blocks known as ASSEMBLIES. One or more assemblies are grouped together as required to make up the facility. A single assembly can often be used in several different facilities.

ABFC SYSTEM

LEARNING OBJECTIVE: *Explain the different sections of the ABFC Facilities Planning Guide, NAVFAC P-437. Identify setup, operation, and maintenance procedures for Utilitiesman—specific advanced base field assemblies.*

To bring together all of the information of the ABFC System, the Naval Facilities Engineering Command published the *Facilities Planning Guide,* NAVFAC P-437, volumes 1 and 2. Volume 1 contains all of the reproducible drawings and is divided into three parts. Part 1 has applicable plot plans for the components. Facility drawings are located in Part 2. The assembly drawings, which are used as the working drawings, make up Part 3. Each of the three parts is arranged in numerical/alphabetical sequence by component, facility, or assembly number. 'A picture may be worth a thousand words, but sometimes it takes a thousand and one words to convey an idea. To provide us with that "extra word," NAVFAC published volume 2. The written information concerning a component, a facility, or an assembly can be located by referring to this information-packed publication. Like volume 1, volume 2 is divided into three parts. Part 1 contains component information. The facility information is in Part 2. Part 3 contains the assembly information..

The advanced base support facilities discussed in this chapter will be the PORTABLE BATH UNIT; PORTABLE SPACE HEATER; IMMERSION HEATER; FIELD RANGE BURNER UNIT; CESSPOOLS, SEPTIC TANKS, TILE FIELDS, and LATRINES; LAUNDRY UNIT; AND WATER PURIFICATION UNITS.

By the use of various components, facilities, and assemblies, a construction battalion is able to construct advanced bases. Advanced bases include administrative, medical, living, messing, and other essential facilities. When the ABFC shipment arrives at the site, the assemblies and facilities should be distributed in the storage areas, so they are available in the order of erection or installation.

The first procedure is to check all parts against the bills of material. This action helps to ensure that all the parts have been included in the assemblies. Visually inspect all the components for damage. Check for dents, cracks, broken parts, and loose or kinked connections. If an item is missing or damaged, you should report the discrepancy to your supervisor, so steps can be taken to remedy the situation.

PORTABLE BATH UNIT

The nine-shower head Portable bath unit is a liquid fuel-fired water-heating device that supplies warm water to each of the shower nozzles. The bath unit is equipped with the necessary water heater, water pump assembly, mixing unit, hoses, and shower stands to supply all of the warm water needed for operation. The water pump draws water through the suction strainer and the hose from the water source and forces it through the discharge hose to the water heater. The water heater raises the temperature of the incoming water and maintains it at the desired temperature. The heated water is then forced through one discharge hose to the mixing unit where it is mixed with cold water to provide water at the desired temperature to the shower heads.

The electrical power required to operate the bath unit should be supplied by a self-contained portable 3 kW, 60 Hz, 208 V, three-phase power generator source. All of the components of the bath unit that are operated electrically should be grounded through a fifth wire incorporated in the power cables.

A description of major components to the portable bath unit is listed below. The location of each component is shown in figure 2-1

A. A SHOWER STAND ASSEMBLY. Eachofthe three shower-stand assemblies come equipped with three shower heads. Each shower head has a valve to control the water flow. A curtain is supplied to enclose each shower.

B. WATER HOSE ASSEMBLY. There are five 1-inch inside diameter (ID) hoses, each measuring 7 1/2 feet in length. The hoses interconnect with the water pump assembly, the water heater assembly, the mixing valve assembly, and three shower-stand assemblies

C. MIXING VALVE ASSEMBLY. The mixing valve assembly mixes hot water from the water heater and cold water from the water pump and water source to provide heated water to the shower stands at temperatures of approximately 105°F.

D. WATER HEATER. The water heater is a self-contained, liquified fuel-fired boiler that heats water supplied by the water pump. The major subassemblies or components that make up the water heater are the water vessel, the burner assembly, the blower assembly, the control box assembly, the sight glass assembly, and the transformer and ignition cables.

E. DRUM FILL ADAPTER ASSEMBLY. The drum fill adapter assembly can be used with either a 55 gallon fuel drum or a 5-gallon gasoline can. The fuel level can be checked visually and refueled without disconnecting the fuel lines.

F. FUEL CONTAINER. The fuel container may be either a 55-gallon fuel drum or a 5-gallon gasoline can.

G. FUEL FEED AND RETURN HOSE ASSEMBLIES. Flexible hoses provide supply and return fuel between the fuel storage container and the fuel pump assembly on the water heater.

H. POWER CABLE ASSEMBLY. The power cable assembly consists of two cables that extend from the Power source to the bath unit. The short cable connects to a 208 V, three-phase Power source. The long cable connects to the short cable, the water heater, and the water pump.

I. WATER PUMP HEATER-HOSE ASSEMBLY. The assembly consists of one 1 1/24nch ID hose, measuring 6 feet in length that connects the water pump to the water heater.

J. WATER PUMP. The water pump draws water from the source through the intake hose and the in-line strainer then supplies it through a discharge line to the water heater.

K. SUCTION HOSE ASSEMBLY. The suction hose assembly has one l-inch ID hose, measuring 25 feet in length that connects the water supply to the water pump.

L. SUCTION STRAINER ASSEMBLY. The suction strainer assembly is connected to the suction hose assembly. It prevents leaves and debris from entering the water system.

Setting Up the Bath Unit

Locate the bath unit so drainage from the shower area is carried downstream or downhill from the suction hose strainer to prevent wastewater from being

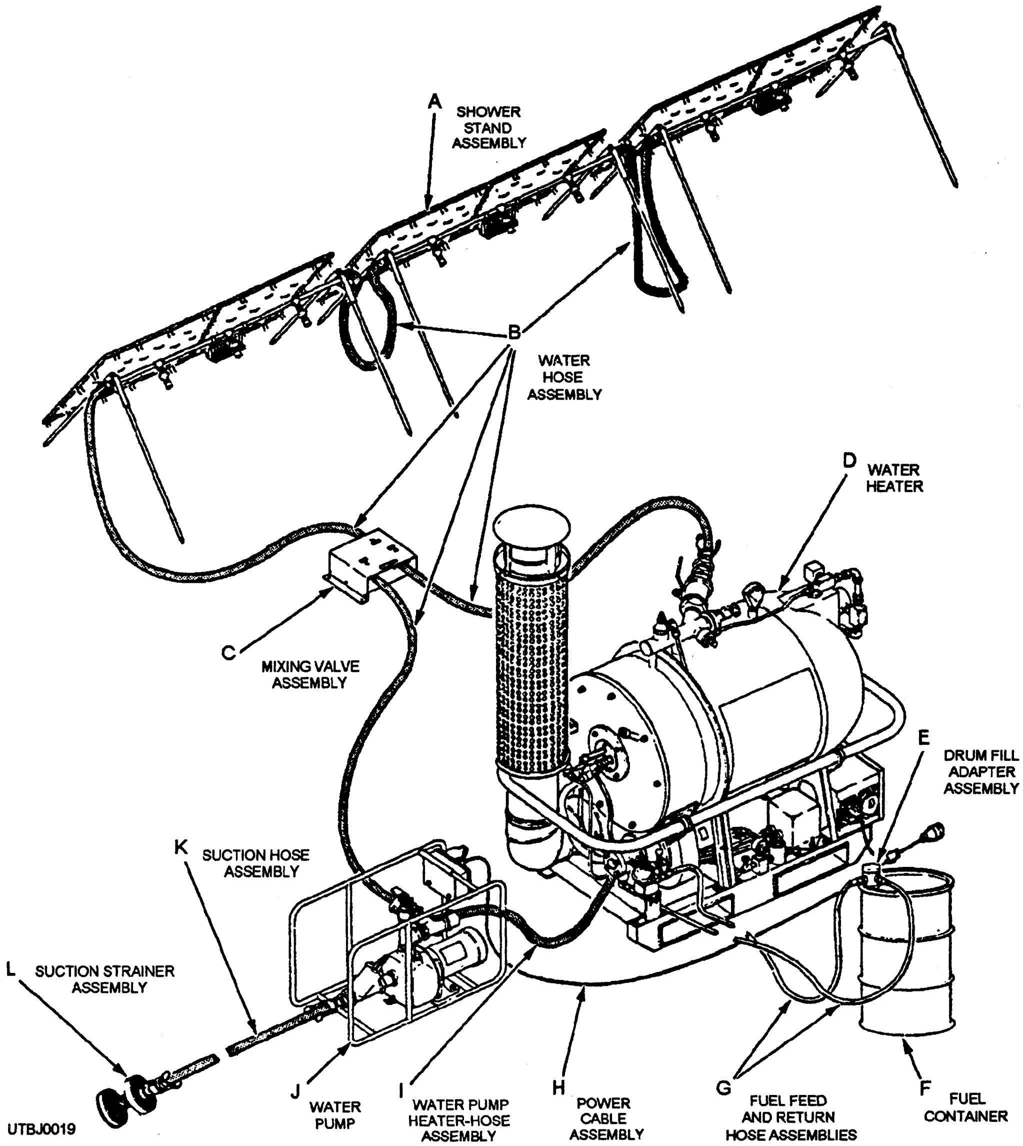


Figure 2-1.—Bath unit, portable, major components.

drawn back into the water source. If this arrangement is not possible, dig a ditch or build a dike around the shower stands to allow wastewater to drain away from the water source. When a pressurized water source is used, discharge the water into an open reservoir before it is drawninto the bath system. This prevents excessive strain on the water pump. Use the following procedures to set up the bath unit:

WARNING

Do not connect the heater to an untested water supply. Contaminated water can cause illness or death.

CAUTION

To prevent equipment damage, be sure the hose couplings are free of dirt or foreign matter and the coupling gaskets are in place before you couple the hoses.

1. Connect the section hose strainer to the male end of a 25-foot long, l-inch ID hose.

2. Connect the female end of the water hose to the water pump suction port.

3. Place the water pump on a level surface approximately 20 feet from the water source. Be sure the suction line does not exceed 5 feet in length.

4. Place the suction hose assembly and strainer into the water source using one of two methods:

a. Place the strainer on a mound of stones or gravel and make a large pile of stones upstream from the strainer to divert debris from it.

b. Build a tripod using tree branches and suspend the strainer from the tripod. Build a barrier using tree branches upstream from the strainer to prevent leaves, weeds, or other debris from entering the strainer.

5. Place the water heater on level ground approximately 5 feet from the water pump. When it is possible, arrange a suitable shelter or windbreak for the water heater to conserve fuel.

6. Connect the male coupling of a 1 1/2-inch water hose to the water pump and connect the female end of the hose to the water heater intake.

7. Connect the female end of a 7 1/2-foot, 1-inch ID hose to the water heater and the male end of the hose to the HOT fitting on the mixing valve.

8. Connect the male end of a 7 1/2-foot, 1-inch ID hose to the water pump outlet and the female end of the hose to the COLD fitting of the mixing valve.

9. Erect the shower stand approximately 20 feet from the mixing valve. Connect sections of the shower stand assembly using a 7 1/2-foot, 1-inch ID hose. Install the cap on the shower stand end connector.

10. Connect the female end of a 25-foot, 1-inch ID hose to the MIXED fitting of the mixing valve. Connect the male end of the hose to the female fitting of the shower stand.

11. Install an elbow on the water heater with a slight turn to the right to seat the pin in the slot.

12. Insert a smokestack and guard assembly through the bracket onto the elbow.

13. Tighten the screw on the bracket to secure the smokestack and guard assembly.

14. Place the fuel container approximately 5 feet from the water heater.

WARNING

The fuel used with the bath unit is highly flammable and may be dangerous to human life if handled improperly. Tighten all fuel fittings firmly. Recheck all fittings when the water heater is operating to ensure there are no leaks with the system under pressure.

15. Screw the drum fill adapter into the fuel container.

16. Connect the fuel line from the pump filter to suction the fitting on the drum fill adapter assembly.

17. Connect the fuel line from the pump to the return fitting.

18. Connect the cable assembly to the water heater, the water pump, and the power source.

WARNING

Use only the fuel specified. Failure to do so may result in injury to personnel or equipment.

CAUTION

The lack of lubrication may cause pump damage when pure gasoline is used as fuel. To avoid failure, when Firing the fuel burner with gasoline, mix 1 quart of oil with each 5 gallons of gasoline. This mixture provides internal lubrication for the fuel pump. To ensure proper mixture, pour the gasoline into the oil.

19. Fill the fuel container with the approved fuel mixture.

Preventive Maintenance Checks and Services (PMCS)

To ensure that the equipment is ready for operation at all times, you must inspect it systematically before operation, during operation, and after operation, so defects may be discovered and corrected. The necessary preventive maintenance checks and services (PMCS) will be performed before operation. The defects discovered during operation of the unit will be noted, and corrections made as soon as operation has ceased. Stop the operation immediately if a deficiency is noted that could damage the equipment. After operation, the necessary PMCS must be performed. Report defects or unsatisfactory operating characteristics beyond your scope to your supervisor.

The PMCS procedures are contained in the operating manual provided with the field unit.

Preparation for Use

Before you start the bath unit, go to the "Operator's Preventive Maintenance Checks and Services (PMCS)" and do the "Before Operation" checks and then proceed as follows:

- Make certain the water heater load limit switch is turned to OFF.
- Make sure the manual fuel valve is closed.
- Press the reset button to ensure the flame safeguard control is not locked out.
- Open the blower shutter approximately halfway.
- Open the fuel pump primer plug and fill the fuel container with the fuel mixture. Replace the plug.

Make sure that one end of the hose is connected to the supply fitting of the fuel filter and to the fittings on the vent. Connect the return fuel line to the drum fill adapter.

NOTE
The operator must periodically monitor the level of the fuel supply. The fuel container should be kept as full as possible to reduce water condensation. The frequency of refueling depends on the size of the fuel container. Excessive water in the fuel supply decreases heater efficiency and corrodes both chamber and the burner.

WARNING
Exposed fuel and fuel vapor can ignite or explode, resulting in possible serious injury and even death. Observe proper safety precautions when servicing the fuel system. Ensure the water heater is cold before servicing the burner.

- Check to see that all water lines are connected.
- Be certain the water heater drain cock is closed.
- Check to be sure the smoke-pipe elbow, the two lengths of the smoke-pipe guard assembly, and the smoke pipe are securely installed.

Start-up Procedures

After having performed the recommended PMCS and the water heater is ready for use, you should proceed as follows:

- Turn off the limit switch and connect the power cable to the power source. Close the fuel valve by turning it to the right.
- Remove the plug and fill the coupling with water.
- Replace the plug.
- Open the fuel valve and turn the load limit switch and power source ON. The fuel pressure gauge should indicate 100 psi.
- View the ignition spark through the sight tube after the power is turned ON.
- Wait 7 seconds; then view the combustion through the sight tube.
- If combustion does not occur after an additional 12-second wait, the buzzer sounds and the ignition spark shuts down. Wait 2 minutes after the buzzer sounds and press the safety reset button. If combustion still does not occur, troubleshoot the unit according to table 2-1.
- After start-up, the exhaust gases from the exhaust stack should be transparent and smokeless. When smoke is present, open the air band on the blower assembly slowly until the exhaust gases are transparent and smokeless. The water heater is now in automatic operation.

Shutdown Procedures

Perform the following shutdown procedures after normal use or when the equipment will not be used for an extended period:

- Turn off the fuel valve.
- Turn off the load limit switch.
- Turn off the water pump.

If there is danger of the bath unit freezing, perform the following procedures:

Table 2-1.—Troubleshooting Procedures

Component	Malfunction	Corrective Check
Water Heater	Fails to start	1. Electrical power source 2. Load limit switch 3. Flame safeguard control 4. Blower motor reset 5. Water supply in tank 6. Low-water probe 7. Low-water relay
Burner	Flame failure during fire cycle	1. Fuel supply 2. Fuel hoses 3. Fuel nozzle 4. UV scanner 5. Flame safeguard control 6. Fuel pump strainer 7. Fuel pump drive coupling 8. Fuel pump 9. Fuel solenoid valve
Burner	Fails to ignite or is delayed	1. Fuel supply 2. Fuel hoses 3. Burner nozzle 4. Water in fuel 5. Electrodes 6. Ignition transformer 7. Burner to transformer connection
Fuel Pressure Gauge	Pressure too high	1. Fuel Gauge 2. Fuel Pump 3. Fuel nozzle 4. Fuel hose (return)
Fuel Pressure Gauge	Pulsating pressure	1. Suction hose 2. Fuel pump strainer 3. Fuel filter 4. Burner nozzle 5. Pressure Gauge
Fuel Pump	Noisy	1. Suction hose 2. Fuel pump strainer 3. Fuel filter 4. Fuel pump
Fuel Pump	Leaks	1. Strainer cover 2. Plugs 3. Shaft seals 4. Fuel pump for cracks

Table 2-1.—Troubleshooting Procedures—Continued

Fuel Pump	Fails to deliver fuel to burner	1. Fuel supply 2. Reversed pump rotation 3. Suction/discharge fuel hoses 4. Fuel pump strainer 5. Burner nozzle 7. Pump drive coupling 8. Fuel solenoid valve
Blower Motor	Continues to trip off	1. Fuel pump and motor
Smokestack	Gases are smoky	1. Electrode spark 2. Contaminated fuel 3. Burner nozzle 4. Blower operation 5. Power source - low- voltage output
Smokebox Cover	Escaping smoke	1. Boiler box gasket 2. Smokebox cover bolts
Water Temperature Gauge	Indicates overheating	1. Temperature control 2. Low-water probe
Water Pump	Fails to deliver water	1. Pump motor 2. Shaft seals
Shower Stand Nozzles	Not discharging enough water	1. Water flow control valves 2. Fittings

- Open the drain cock on the water pump by turning it to the left and tilt the water pump on end to let the water drain out.
- Reach under the water heater and open the drain cock by turning it to the left.

When the bath unit is not scheduled for use for 5 days or more, perform the following procedures:

- Remove the fuel feed hose from the fuel container.
- Place the end of the hose into a quart container.
- Fill the container with diesel fuel.
- Turn on the load limit switch and allow the unit to operate until the quart container is almost empty. Turn off the water heater fuel shutoff valve and let the system operate until the flame is extinguished.
- Turn off the load limit switch.

Troubleshooting Procedures

This section contains troubleshooting information for locating and correcting most of the operating troubles that may develop in your bath unit. The troubleshooting procedures are listed in table 2-1. The table lists the common malfunctions that you may find during operation or maintenance of the bath unit or its components. You should perform the tests/inspections and corrective actions in the order listed. Each malfunction for an individual component, unit, or system is followed by a list of tests or inspections to help you determine what corrective action(s) to take. This manual does not attempt to list all possible malfunctions and corrective actions or all the necessary tests and inspections. Remember, you should always notify your supervisor when something unusual occurs.

PORTABLE SPACE HEATER

Types I and II portable space heaters are designed to heat tents. The heater assembly consists of essentially a heater body (top and bottom), adapter ring, grate or liquid fuel burner assembly, and air conditioning-heating pipe sections. (See figs. 2-2 and 2-3.)

Type I heaters may be operated with wood or coal. Type II heaters operate with diesel oil, light fuel oil, or gasoline. The heat output is measured in British thermal units (Btu). The fuel consumption rates are as follows:

Type I (coal) 1/4 ton per week

Heat output (normal) 35,000 Btu per hour (maximum) 45,000 Btu per hour

Type II (gasoline or oil) 5 gallons for 10 to 30 hours

Before you place the heater in service, perform the following procedures:

- Inspect the entire heater assembly for signs of physical damage.
- Inspect the heater to be sure it is assembled properly, secure, clean, adjusted correctly, and mechanically operable.
- Correct deficiencies within the scope of organizational maintenance before placing the heater in service.
- Perform daily preventive maintenance services.

Setting Up the Heater

Place the heater base on the ground or floor of the tent. In tents with wooden floors, the base should be set in a sandbox or on sheeting that is designed to protect the floor from heat. In an emergency, a pile of stones or brickbats may be used. The sandbox must meet the following standards:

1. It must be no smaller than 40 inches long by 28 inches wide by 4 inches high. Use 2- by 4-inch lumber for the framework.

2. It must have a sheet metal bottom to act as an insulating shield.

3. The stove should be placed in the center of the box with a minimum of 3 1/2 inches of sand between the bottom of the stove and the metal insulation shield.

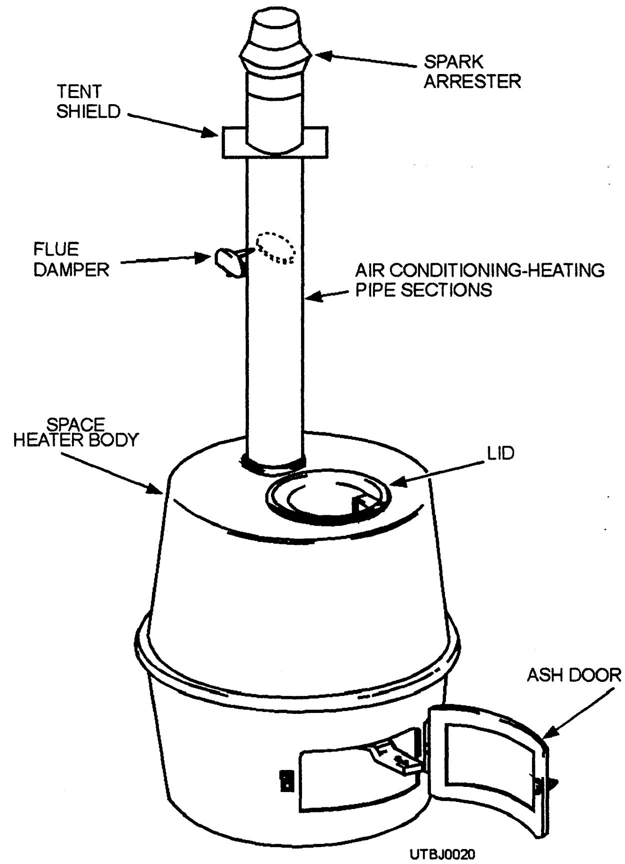


Figure 2-2.—Space heater (Type I).

4. Areas surrounding the stove should be void of combustibles at any point closer than 4 feet on a horizontal plane from the floor to the ceiling of the tent or building. Necessary material may be secured locally upon approval of the local commander.

To assemble and set up the Type I space heater components, refer to figure 2-4 and proceed as follows:

1. Assemble the grate.

2. Place the adapter ring on top of the base. Level the heater base by sight.

3. Insert the grate assembly in the adapter ring with the shaker catch facing the ash door and the draw grate on the bottom.

4. Place the top of the space heater on the adapter ring.

5. Assemble the air-conditioning smoke pipe as follows:

    a. Join the formed edges of a curved sheet of metal to form a cylindrical pipe.

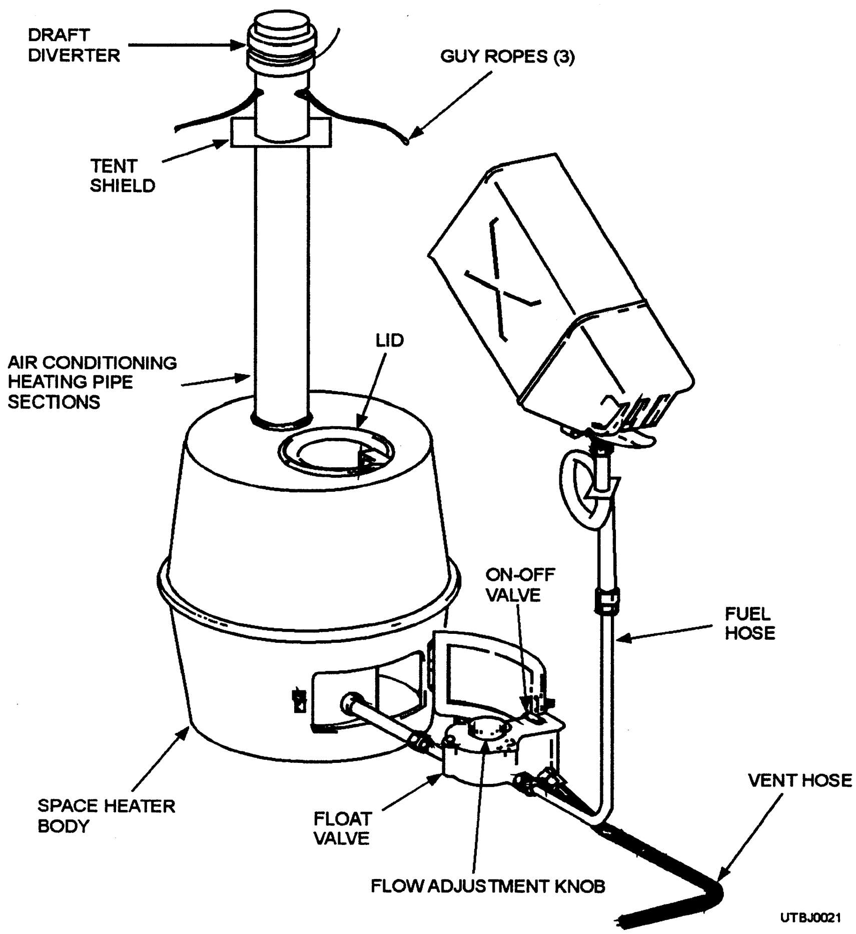


Figure 2-3.—Spate heater (Type II).

> **CAUTION**
>
> Hold the sheet metal securely while curling it to prevent it from slipping and causing severe cuts.

b. From the inside, insert a split rivet through each of the three holes in the smoke-pipe sections. Spread the tines of the rivet, and hammer them flat.

> **NOTE**
>
> The damper is not required in the smoke pipe when it is burning liquid fuel.

c. In one section of the smoke pipe, insert the damper. Punch a hole through the pipe at a position half the length of the pipe. Hold the damper in place inside the pipe, and thread the damper shaft through the holes locking the curved shank of the damper shaft into the center slot of the damper. When they are locked together properly, the damper and operating handle are parallel.

6. Assemble the smoke-pipe sections starting with the section of pipe having the damper installed. Place the smooth female end of the pipe over the steel collar on the heater top.

> **NOTE**
>
> When conditions permit, use six lengths of pipe extended straight up. Elbows and horizontal pipes reduce the draft and cut down the heat output.

7. Install the spark arrester on one pipe section above the heater or on top of the smoke pipe outside of the shelter.

To assemble and set up the Type II space heater, refer to figure 2-5 and proceed as follows:

1. Place the adapter ring on the heater base.

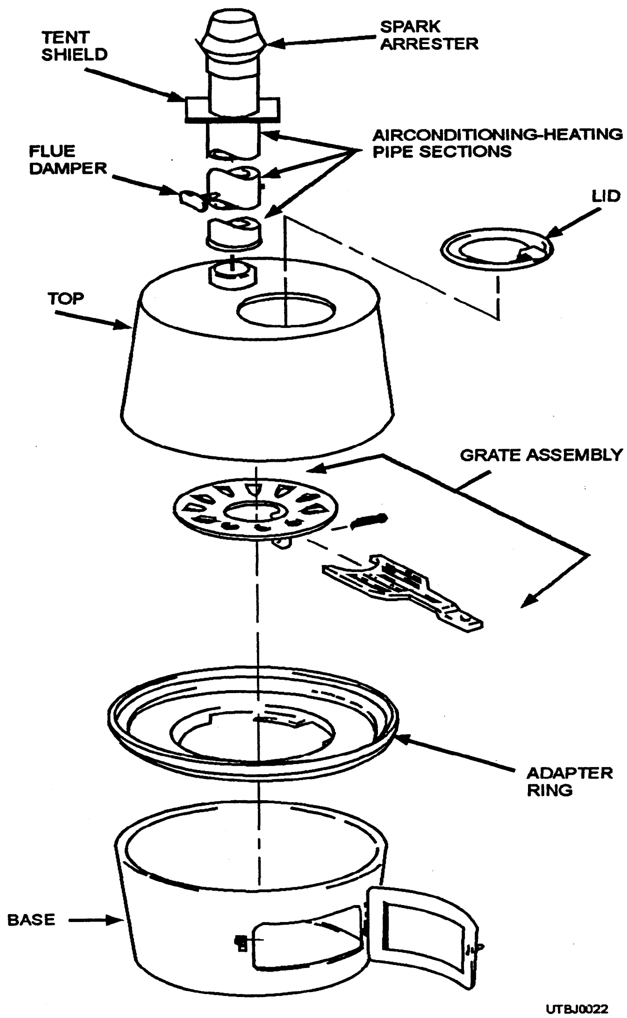


Figure 2-4.—Spare heater installation (Type I).

2. Set the oil-pot burner in the adapter ring, so the fuel inlet pipe faces the ash door opening.

3. Turn the adapter ring to the right until it engages the locking clips on the right side of the door opening.

4. Install the flame spreader in the center of the burner.

5. Attach the float valve nipple to the smaller end of the pipe reducer located on the oil-pot burner. Make sure the connection is tight enough to hold the valve in a level position and to prevent leaks.

6. Place the top of the space heater on the adapter ring.

7. Assemble the smoke pipe.

8. Install the draft diverter on top of the stack and anchor it with guy ropes.

CAUTION

Install the guy line radially to eliminate contact with the smoke pipe. Lines should be erected and anchored, so the movement of the tent does not adversely affect the stability of the smoke pipe.

Refer to figure 2-6, and assemble the fuel can adapter and insert it in the fuel can as follows:

CAUTION

When changing fuel cans, release the cam before removing the adapter from the empty can. The washer on the adapter may squeeze out of place when the adapter is screwed into place on the fuel can. Wipe excess fuel from the washer, the washer seat, and the lid of the fuel can.

1. Attach the male end of one fuel hose to the drip loop hose of the adapter, and attach the opposite female. end of the hose to the male fuel inlet fitting of the float valve.

2. Attach the other length of hose to the ovefflow fitting (under the center of the float valve) to carry off any possible overflow. This hose must drain downward and discharge into a safe outside location.

CAUTION

Be sure the fuel from the fuel can is connected to the male fitting marked “INLET” on the valve.

3. Make sure the inlet shutoff knob on the float valve is in the OFF position.

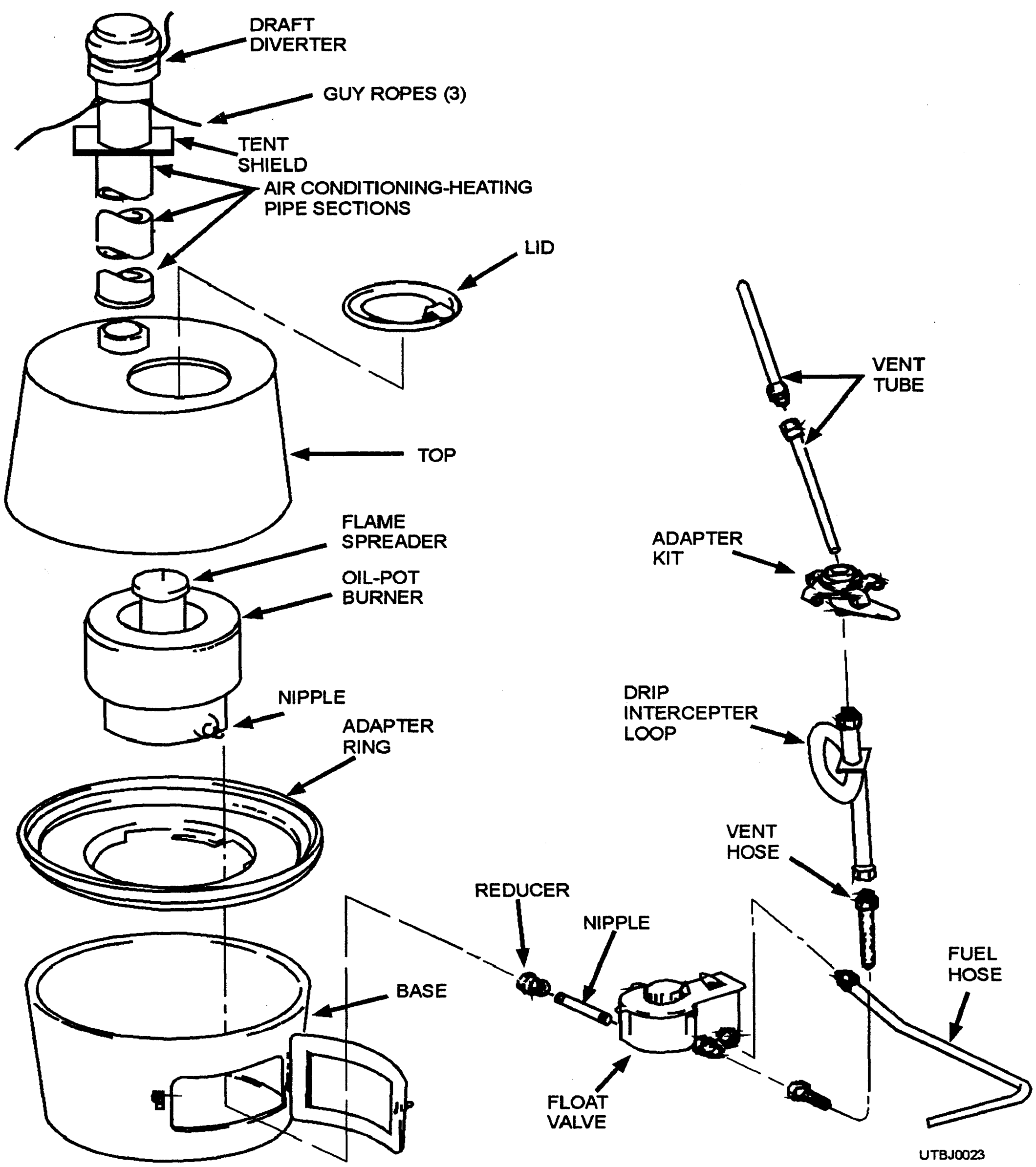


Figure 2-5.—Space heater installation (Type II).

4. Invert the fuel can on a support no less than 1 foot or more than 8 feet above the float valve.

Preventive Maintenance and Troubleshooting

To ensure the space heater is ready for operation at all times, you must inspect it systematically, so the defects may be discovered and corrected before they result in serious damage or failure. The preventive maintenance checks and troubleshooting procedures are listed in *Department of the Army Technical Manual,* TM 10-4500-200-13.

IMMERSION HEATER

The 32-gallon, immersion, liquid fired, water heater used by the Naval Construction Force (NCF) is shown in figure 2-7. The heater body is constructed of watertight sheet steel. The combustion chamber is doughnut-shaped, and the stack assembly is welded together. A vertical partition divides the stack into two sections: a burner compartment and a flue

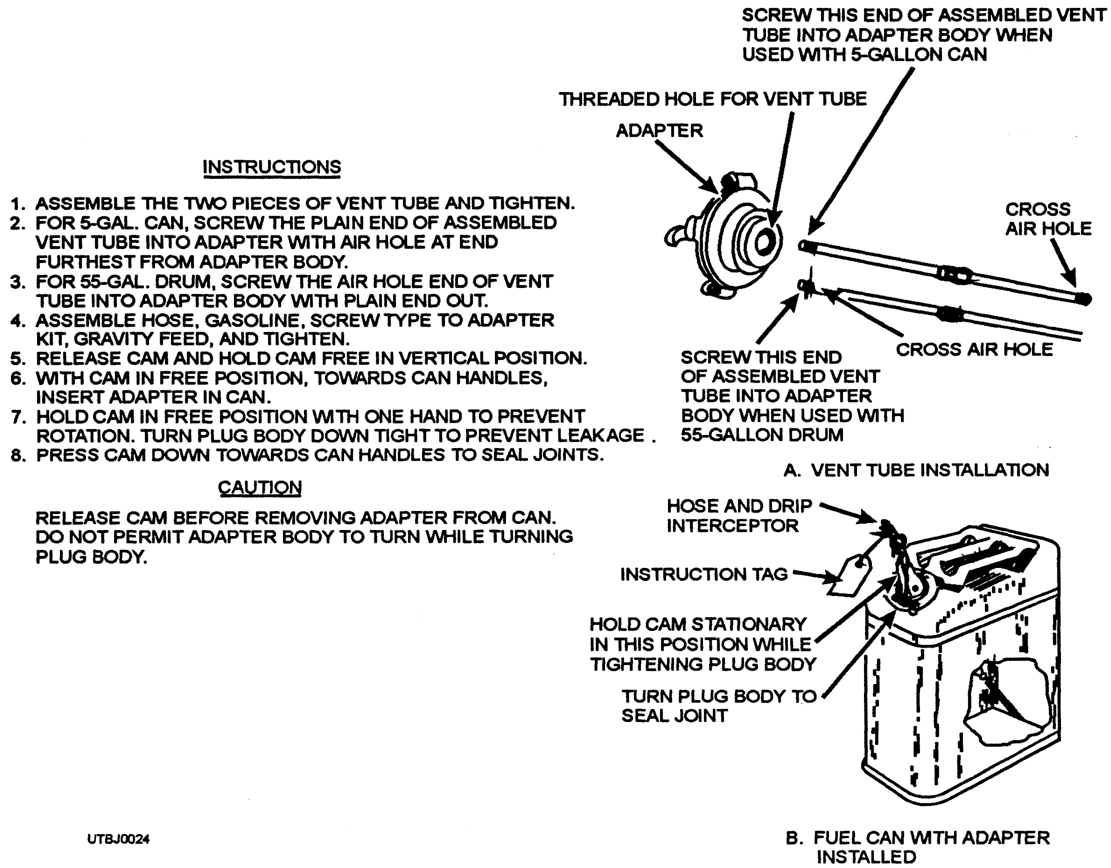


Figure 2-6.—Fuel can adapter installation.

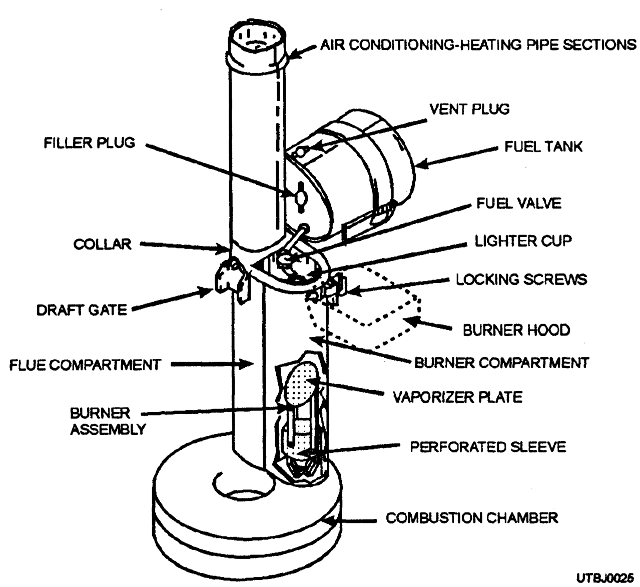


Figure 2-7.—Corrugated can, fuel fired, immersion heater.

compartment. Instructions for operation are located on the hinged hood that covers the top of the burner.

Use the following procedures when setting up the unit for use:

1. Place the immersion heater in a 32-gallon corrugated can and fill it until the water is 6 inches below the collar assembly of the heater.

2. Fill the fuel tank through the filler plug with unleaded or regular mogas and attach the fuel tank to the unit.

3. Assemble the four 2-foot sections of the flue and attach them to the unit.

The following steps are for operating the immersion heater:

1. Open the vent plug on the fuel tank and swing the lighter cup below the drip valve.

2. Open the drip valve until the lighter cup is 1/4 full of fuel.

3. Ignite the fuel in the lighter cup and return the cup into the flue. In approximately 1 minute, the flue will be preheated.

4. Swing the lighter cup so the edge of the cup is below the drip valve

5. Open the drip valve and the stream of fuel will ignite from the burning lighter cup.

6. Swing the lighter cup back into the flue and adjust the flow of fuel to just below smoke point.

> **WARNING**
> When the flow of fuel is excessive, an explosion may result. If dark smoke is coming out of the flue pipe, reduce the fuel flow.

FIELD RANGE BURNER UNIT

The portable field range used by the NCF has a self-contained burner unit that is portable. The burner unit can be used with a range unit or by itself. Figure 2-8 shows the M59 range unit and M2 burner unit.

When the M-59 range outfit is used for cooking or baking, the M-2 burner should be placed in the bottom position. When the cabinet is used for frying, the burner should be placed in the top position. The two burner positions are shown in figure 2-9.

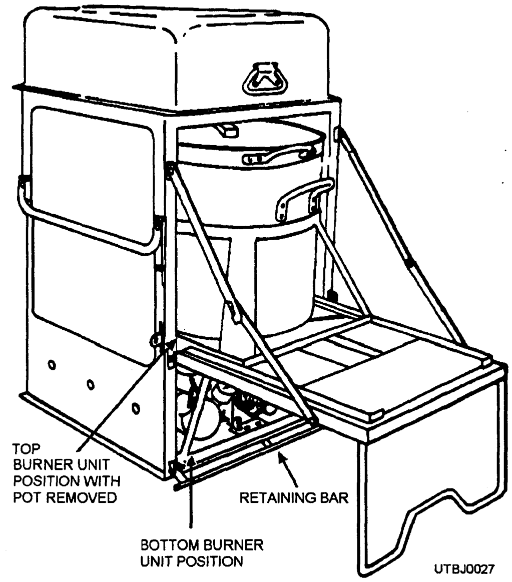


Figure 2-9.—Burner unit positions.

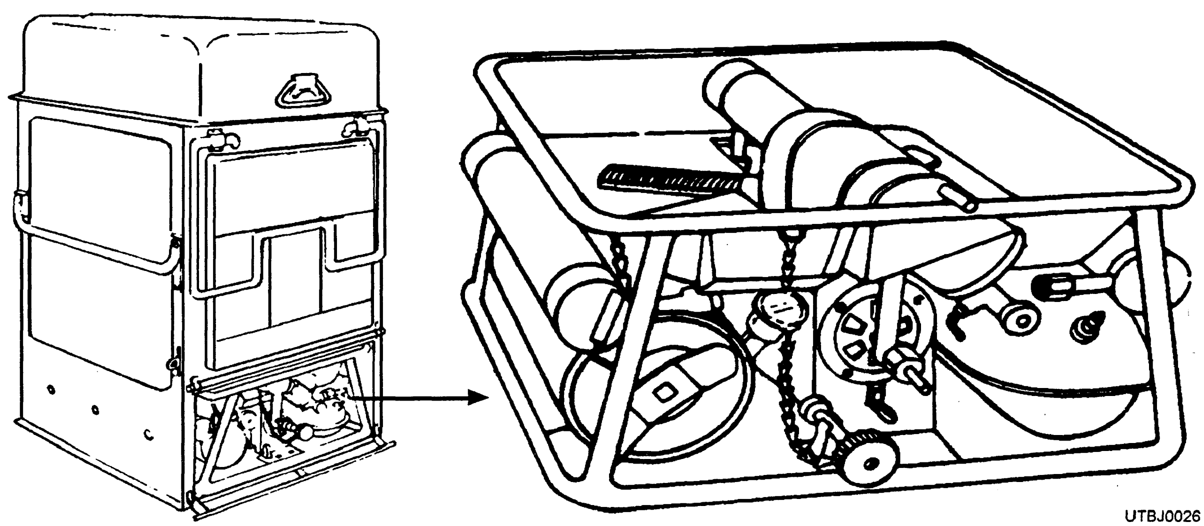
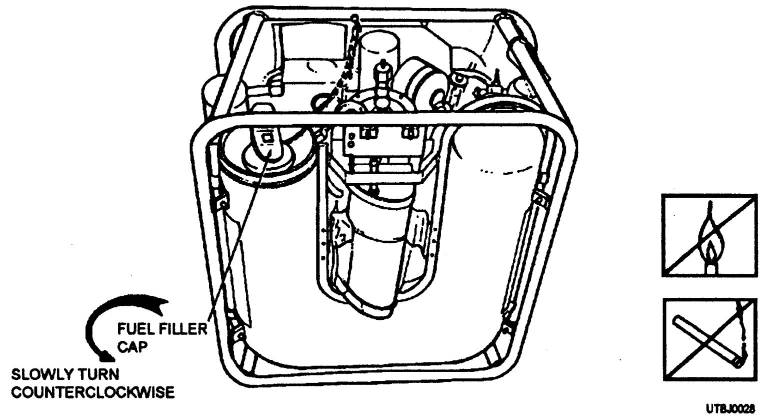
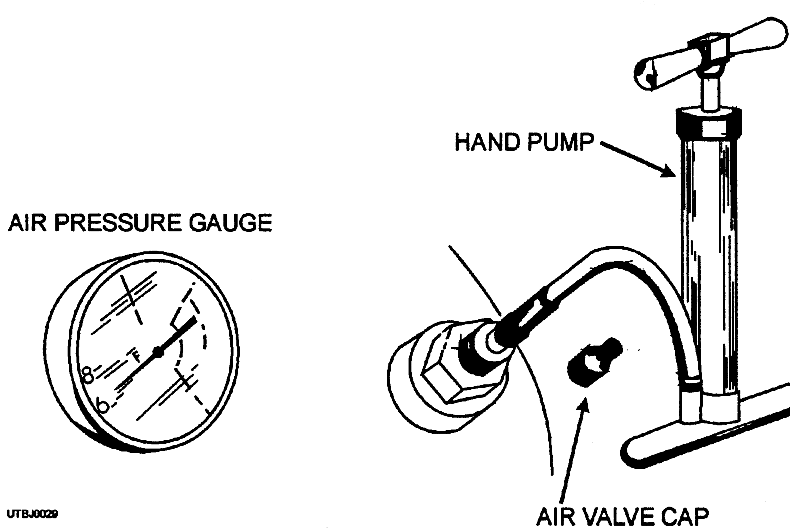
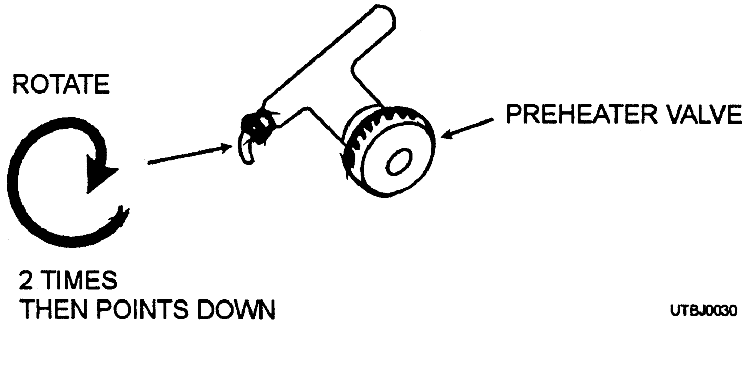


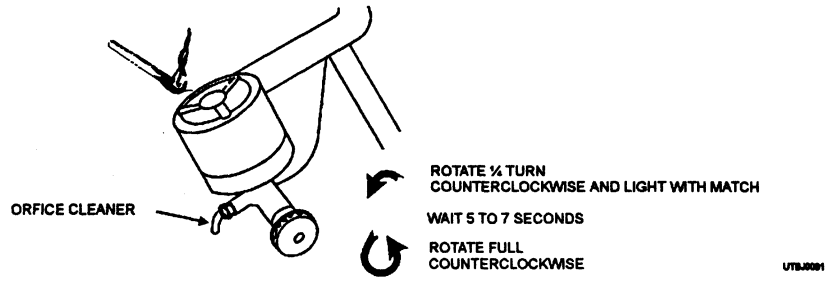
Figure 2-8.—M59 range outfit with M-2 burner.

The following inserts show the recommended way of setting up and operating the field range outfit.

Procedure	Insert
Take the burner unit to the fueling area at least 50 feet away from the lighting and cooking area. Place the burner in a vertical position and release the air pressure by turning the filler cap counterclockwise, then remove the filler cap. Fill with 8 quarts of mogas. Eight quarts will last approximately 4 hours.	
Take the burner unit 50 feet away from the fueling area and the cooking area. Place the unit in a horizontal position. Remove the air valve cap, place a hand pump on the valve, and pump until the pressure gauge reads 6-8 pounds. Remove the pump and replace the valve cap.	
Turn the orifice cleaning control completely around two or three times. When completed, the handle should point in the downward position.	

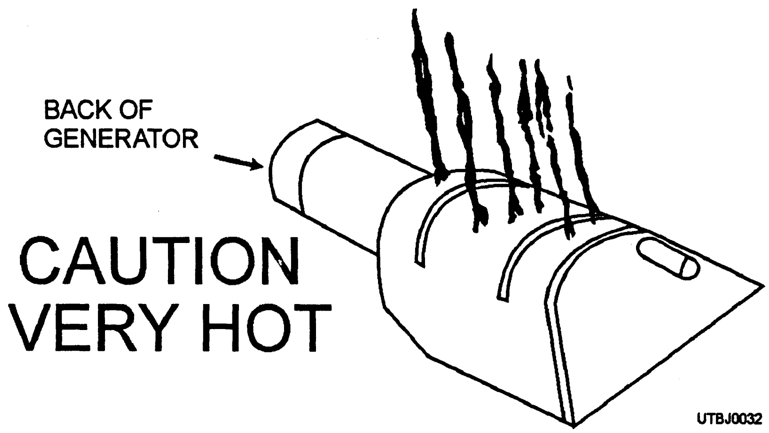
Procedure	Insert

Place a lighted match close to the preheater head and turn the preheater valve one-quarter turn counter clockwise and ignite. Allow the preheater to burn 5 to 7 seconds or until the flame burns evenly. Now turn the preheater valve filly counterclockwise and place the preheater shield over the preheater.

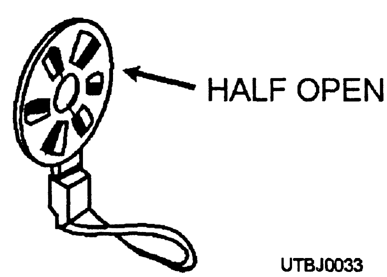


Allow the preheater to burn for 10 minutes or until the shield is hot to touch.

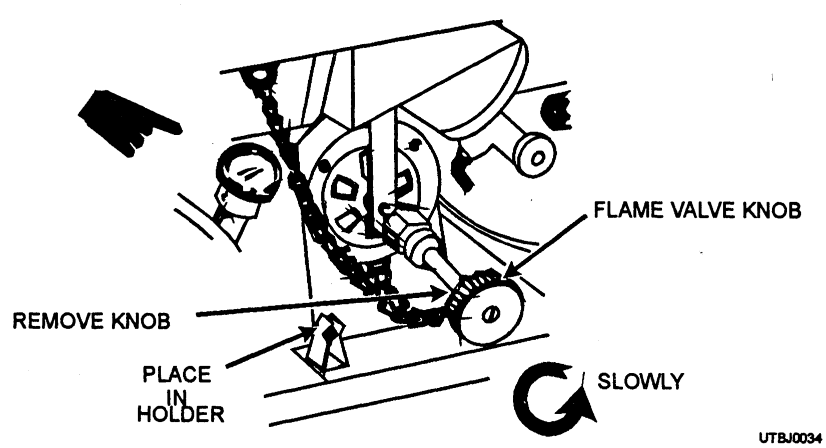
CAUTION: The preheater shield is very hot.



Open the air control shutter lever to half open.

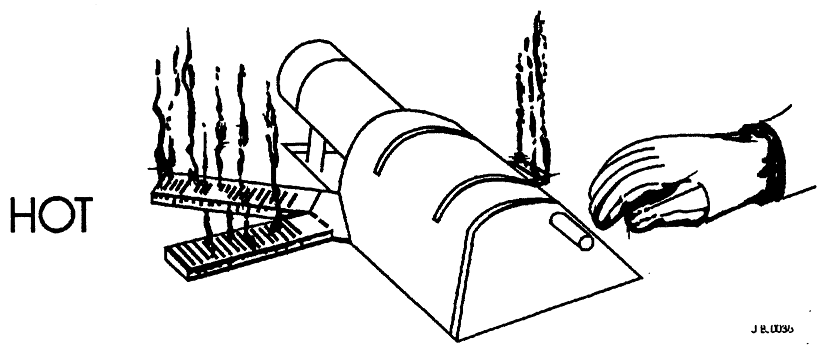


Remove the flame valve knob from the holder and place it on the valve. Slowly turn the knob counterclockwise to the fully open position.

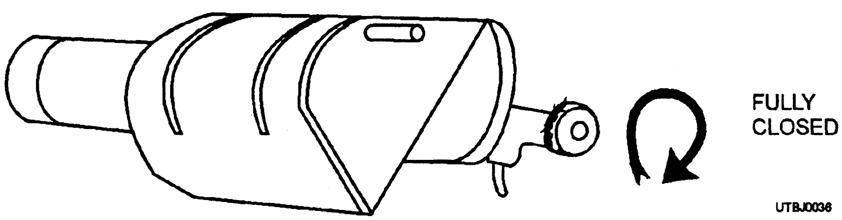


Procedure	Insert

The burner should ignite. When lit, remove the preheater shield. Be sure that you use a glove when handling the heater shield.



Shut the preheater valve by turning it fully clockwise. Now turn the flame valve clockwise until the flame lowers to the height of the generator. Adjust the air shutter until the flame is green in color. Place the flame valve knob back in the holder.



Carry the burner unit to the cooking area and place it in the cabinet.

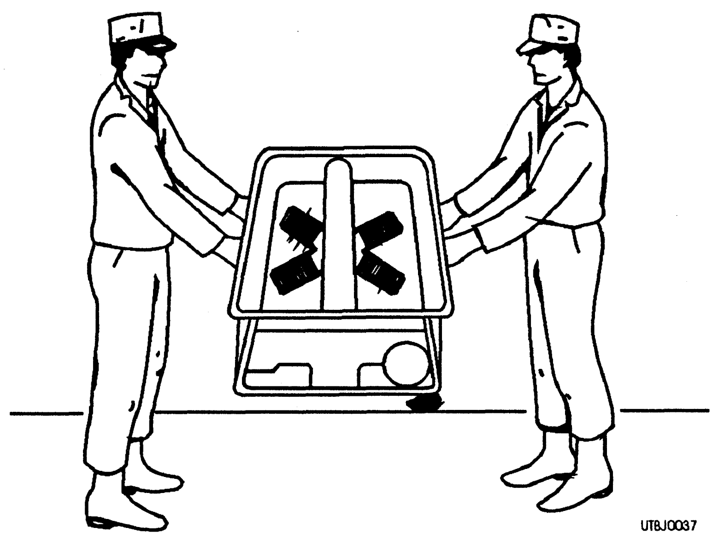
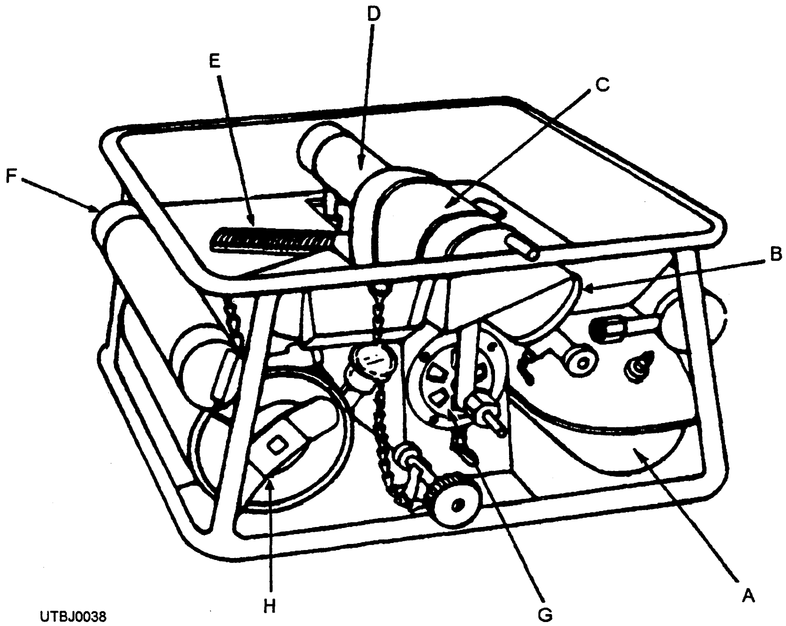


Figure 2-10 shows the location and describes the functionof the M-2 burner major components.

Figure 2-11 shows the operating controls of the M-2 burner.

CESSPOOLS, SEPTIC TANKS, TILE FIELDS, AND LATRINES

Various facilities are used for treatment and disposal of sewage at installations where common sewers are not available.



A. Fuel tank - Contains fuel to operate burner.

B. PREHEATER - Heats generator, which will then change fuel to gas vapor.

C. PREHEATER SHIELD - Helps generator heat up faster.

D. GENERATOR - Filters and converts liquid fuel into gas vapor.

E. BURNER - Spreads out the flame under cooking pots or pans.

F. SPARE GENERATOR - Replacement for defective generator.

G. AIR SHUTTER - Adjusts air input to burner.

H. FUEL FILLER - Provides an opening to place fuel in the unit.

Figure 2-10.—Location and description of burner major components.

These facilities include cesspools, septic tanks, tile fields, and field-type latrines. Information on each of these facilities is provided below.

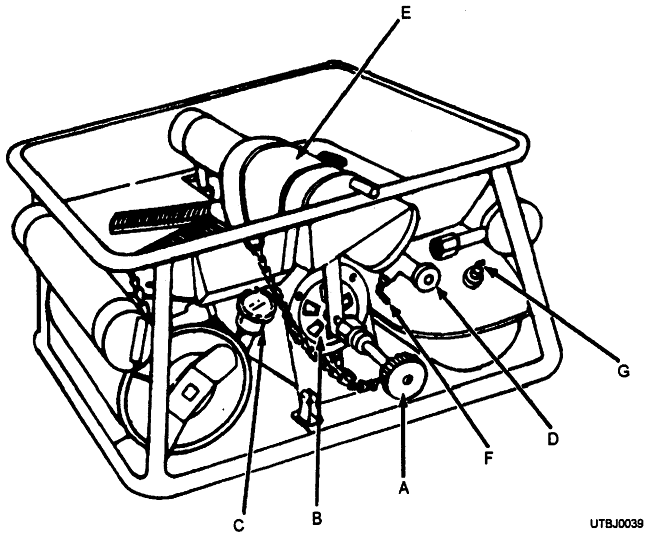
Cesspools

Leaching cesspools are usually dry-laid masonry or brick-lined wells without masonry at the bottom; the sewage flows into them and leaches out into the soil. Floating solids collect at the top and settling solids collect at the bottom of the well. The leaching capacity of the well is exhausted when the solids accumulate and clog the soil (fig. 2-12). The use of chemicals is not recommended for increasing the useful life of a cesspool.

When the first cesspool becomes filled, a second well may be constructed to take the overflow from the first. In such cases, the first cesspool should operate as a septic tank to collect the settling and floating solids and provide a trapped outlet on the connection leading to the next leaching cesspool. Septic tanks can be placed advantageously ahead of leaching cesspools in larger installations. Leaching cesspools should not be placed closer together than 20 feet by out-to-out measurement of the walls.

Leaching cesspools should be used only where the subsoil is porous to a depth of at least 8 or 10 feet and where the groundwater is below this elevation. When cesspools are located in fine sand, the leaching area can be increased by surrounding the walls with graded gravel.

The number and the size of cesspools required depend on the quantity of sewage and the leaching characteristics of the total exterior percolating area above the groundwater table, including bottoms and sidewalls below the maximum-flow lines. The allowable rate of sewage application per square foot per



A. GENERATOR KNOB, FLAME VALVE - Fuel adjustment to burner.

B. AIRCONTROL SHUTTER VALVE - Air input adjustment to burner.

C. AIR PRESSURE GAUGE - Air input adjustment to burner

D. PREHEATER VALVE - Inputs gas to preheater.

E. GENERATOR PREHEATER SHIELD - Contains heat while gas is vaporizing.

F. ORIFICE CLEANER - Cleans orifice in preheater.

G. AIR VALVE - Hand pump attachment used to pressurize fuel tank.

Figure 2-11.—Burner operating controls.

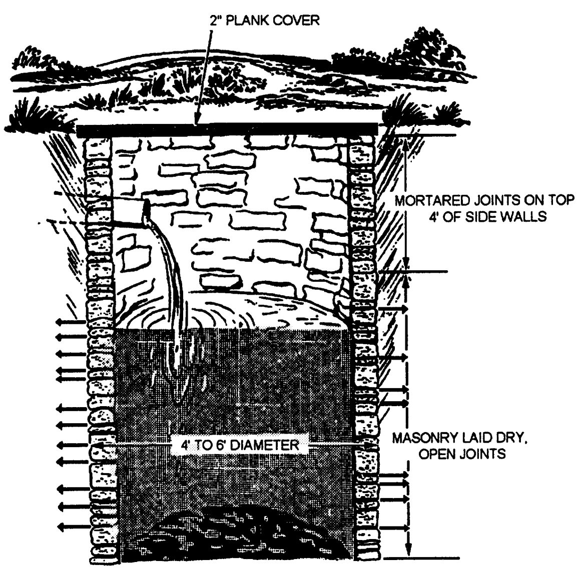


Figure 2-12.—Leaching cesspool.

day, based on the recommended leaching test, is provided below. Soils that require more than 30 minutes for a fall of 1 inch are unsatisfactory for leaching, and some other disposal method must be used.

Time for water to fall 1 inch (minutes)	Allowable rate of sewage applicable (gallons per square foot of percolating area per day)
1	5.3
2	4.3
5	3.2
10	2.3
30	1.1

The test for leaching should be made by digging a pit about one half of the proposed depth of the cesspool, making a test hole 1 foot square and 18 inches deep at the bottom. The test hole is filled with 6 inches of water that is allowed to drain off. Six inches of water is again added, and the downward rate of percolation is measured in minutes required for the water surface to lower 1 inch in the hole.

Septic Tanks

For emergency and temporary construction, septic tanks are made of wood or nonreinforced concrete with wood covers and baffles. Reinforced concrete construction is more suitable for permanent installations (fig. 2-13). The tank capacity should equal a full day's floss, plus an allowance of from 15 to 25 percent for sludge capacity. The minimum size of a tank required by code is 1,000 gallons.

In constructing a septic tank, be sure the length of the septic tank is not less than two, or more than three times the width. The liquid depth should not be less than 4 feet for the smaller tanks and 6 feet for the larger ones. Manholes should be provided over the inlet and outlet pipes and over the low points in the bottom of hopper bottom tanks. The roof of the tank may be covered with earth, but access openings should extend at least to the ground surface. Although ells or tees may be used at inlet and outlet connections, straight connections are better for rodding (cleaning out). Instead of ells, wooden baffles, located approximately 18 inches from the ends of the tank and extending 18 inches below and 12 inches above the flow line, are provided. Elevations should permit free flow into and out of the tank. The bottom of the inlet sewer should be at least 3 inches above the water level in the tank. The inlet and outlet connections should be sufficiently buried or otherwise protected to prevent damage by traffic or frost.

Although septic tanks that are designed properly require little operating attention, they must be inspected periodically; the frequency of inspection is determined by the size of the tank and the population load. The minimum frequency should be once every 2 months at periods of high flow. The inspection should be made to assure that the inlet and outlet are free from clogging, the depth of scum and sludge accumulationis not excessive, and the effluent passing to subsurface disposal is relatively free of suspended solids. A high concentration of suspended solids in the effluent clogs subsurface disposal facilities quickly. Sludge and scum accumulation should not exceed one fourth of the tank capacity. It should not be assumed septic tanks liquefy all solids, they never need cleaning, and the effluent is pure and free of germs. Perhaps 40 to 60 percent of the suspended solids is retained, and the rest is discharged in the effluent.

Separating sludge and scum from the liquid in septic tanks is difficult. In small tanks, these wastes are customarily mixed; the entire contents are removed when the tanks are cleaned. The material removed contains fresh or partially digested sewage solids that must be disposed of without endangering the health of personnel. Disposal through manholes in the nearest sewer system, as approved by local authorities, or burial in shallow furrows on open land is

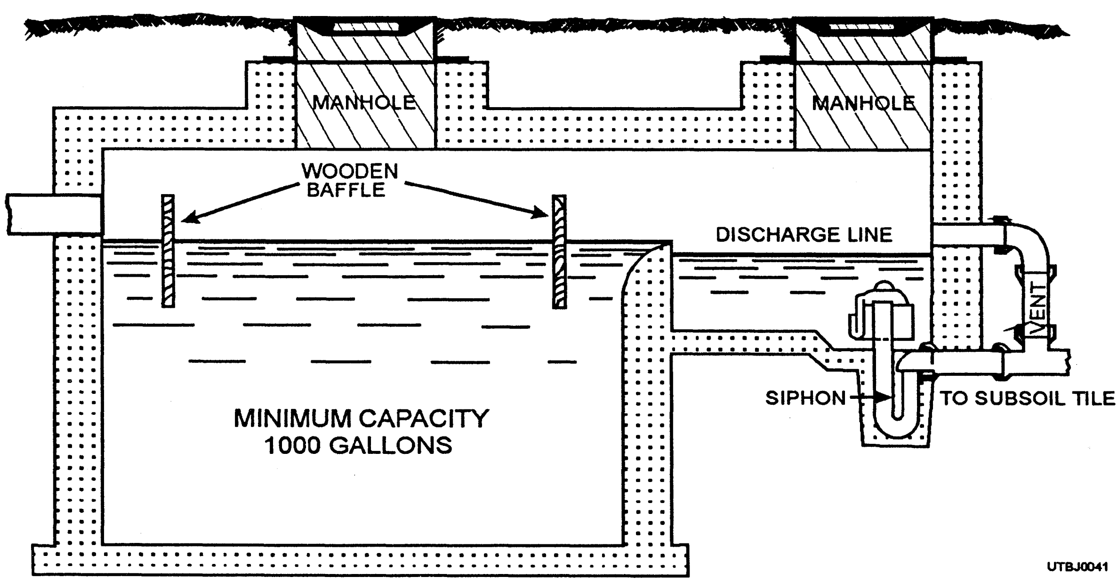


Figure 2-13.—Septic tank.

recommended. A diaphragm sludge pump is best suited for removing the tank contents that should be transported in a watertight, closed container. Trucks are made that specifically pump and carry the waste material to a place where it can be disposed of.

Tile Fields

Tile fields of lines made of concrete, clay, or PVC are laid in the ground with open joints or perforations to dispose of settled sewage into the ground. A fiber pipe (Orangeburg Alkacid) or plastic pipe with holes bored in the lower portion of the pipe to allow drainage may be used for these drain lines. This pipe is light in weight and is easily laid in the trench. It comes in sizes ranging from 2 inches to 8 inches in diameter and in lengths from 5 feet to 8 feet. Because of these long lengths, this type of pipe is particularly valuable in soil where other types of pipe may settle unevenly. Figure 2-14 shows a typical field layout.

PROPER FUNCTIONING.—The following conditions are important for proper functioning of tile fields:

- Groundwater well below the level of the field
- Soil of satisfactory leaching characteristics within a few feet of the surface, extending several feet below the tile
- Subsurface drainage away from the field
- Adequate area
- Freedom from possibility of polluting drinking water supplies, particularly from shallow dug or driven wells in the vicinity

TESTS.—The length of tile and details of the filter trench generally depends upon the character of the soil. Soil leaching tests should be made at the site, as described for leaching cesspools, except the test hole should extend only to the approximate depth at which the tile lines are to be laid. For extensive tile fields,

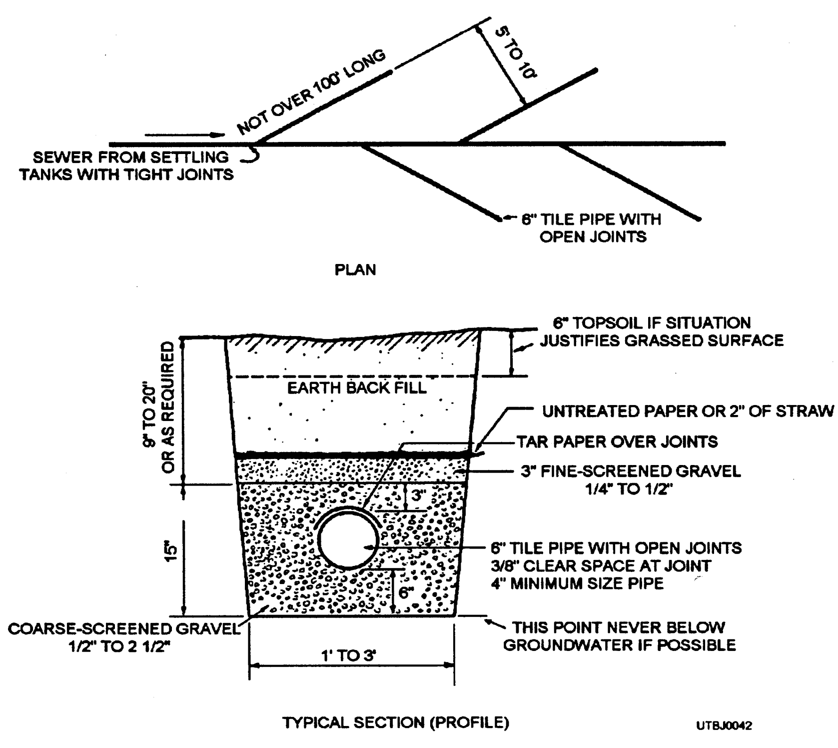


Figure 2-14.—Typical layout of a subsurface tile system.

several tests to determine the best location and average conditions should be made. From test results, the rate of sewage application to the total bottom area of the tiled trenches may be taken from the data below. Soil testing over 30 minutes is not suitable.

Time for water to fall 1 inch (minutes)	Allowable rate of sewage application in gallons per square foot per day, bottom of trench in tile field
1	4.0
2	3.2
5	2.4
10	1.7
30	0.8

TRENCH WIDTH.—The minimum width of a trench on the basis of the types of soil is as follows:

- Sand and sandy loam, 1 foot
- Loam and sand and clay mixture, 2 feet
- Clay with some gravel, 3 feet

FROST LINE.—Placing tile below the frost line to prevent freezing is not necessary. Tile placed 18 inches below the ground surface operated successfully in New England for many years. Subsurface tile should never be laid below groundwater level.

PIPE SIZE.—Design and construction should provide for handling and storage of some solid material, eliminating, as much as practical, the opportunity for clogging near pipe joints. Pipe 4 to 6 inches in diameter is recommended. The larger pipe gives greater storage capacity for solids and a larger area at the joint for solids to escape into the surrounding gravel.

LAYING THE PIPE.—To provide for free discharge of solids from the line to the filter trench, lay the pipe with 3/8-inch clear openings. The top of the space is covered with tar paper or similar material to prevent entry of gravel. Bell-and-spigot pipe is laid to true line and grade easily. Good practice calls for breaking away two thirds along the bottom of the bells at the joint and rising small wood-block spacers. The pipe is commonly laid at a slope of about 0.5 foot per 100 feet when taking the discharge directly from the septic tank and 0.3 foot per 100 feet when a dosing tank is used ahead of the field.

BEDS.—The tile is laid on a bed of coarse-screened gravel at 6 inches deep with 3 inches of coarse gravel around and over the pipe. Coarse-screened stone passing 2 1/2-inch mesh and retained on a 3/4-inch mesh is recommended. This gravel bed gives a relatively large percentage of voids into which the solids pass and collect before the effective leaching area becomes seriously clogged. The soil that fills the trench must not fill the voids in the coarse-screened gravel around the pipe. A 3-inch layer of medium-screened gravel over the coarse stone and 3 inches of either fine-screened gravel or suitable bank-run gravel over the medium stone is recommended.

LAYOUT.—The layout of the tile in the field should be designed carefully. Generally, the length of laterals should NOT exceed 100 feet. When tile is laid in sloping ground, distribute the flow so each lateral gets a fair portion. Flow must be prevented from discharging down the slope to the lowest point. Individual lines should be laid nearly parallel to land contours (fig. 2-14). Tile fields are laid out either in a herringbone pattern or with the laterals at right angles to the main distributor. The distance between laterals is three times the width of the trench. Distribution boxes to which the laterals are connected may be desirable. Trenches, 24 inches wide or more, are economical. When a trenching machine is practical on a large installation, base the design on the width of the trench excavated by the machine.

PROTECTING THE FIELD.—Once constructed, all traffic must be excluded by fencing or posting the tile field to prevent crushing of the tile. Planting shrubs or trees over the field is not good practice since the roots tend to clog the tile lines; grass over the lines aids in removing moisture and keeping the soil open.

Field-Type Latrines

Upon arrival at an advanced base, temporary facilities must be provided immediately for the disposal of human waste. A number of designs of field-type latrines are used for this purpose. A 16. by 32-foot wood-frame tent may be used to shelter the field-type latrine.

A prefabricated four-seat latrine box is shown in figure 2-15. This box can be collapsed for shipment, as shown in figure 2-16.

A plan view of an eight-seat field-type latrine is shown in figure 2-17. As shown, the eight-seat field-type latrine can be expanded to a 1 B-seat latrine. With this type of latrine, two 4-seat boxes are placed to straddle a 3- by 7-foot pit. After the pit is dug and before the boxes are placed, a 4-foot-wide margin around the pit is excavated to a depth of 6 inches, as shown in figure 2-18. A layer of oil-soaked burlap is laid in this excavation; then the excavated earth is soaked with oil, replaced, and tamped down to keep out surface water. Two 4-foot 6-inch trough-type urinals are furnished with the eight-seat latrine. Each urinal is mounted in a frame constructed as shown in figure 2-19. A 2-inch urinal drainpipe leads from the downpipe on each urinal to a 6- by 6-foot urinal SEEPAGE PIT, located as shown in figure 2-l 9. The seepage pit is constructed as shown in figure 2-20.

A four-hole burnout field-type latrine is used at most advanced or temporary bases. The burnout latrine is kept in an orderly condition (daily) by camp maintenance personnel or by the sanitation crew assigned. Two people can effectively and efficiently dispose of the excremental waste of 500 people. There are two easy ways of maintaining the burnout latrine. They are as follows: by spreading lime over the waste material or by using diesel fuel to burn the waste material. The burning pit for the waste material should be located so resulting smoke, fumes, odors, and blowing ashes do not interfere with operations or the health and general well-being of personnel.

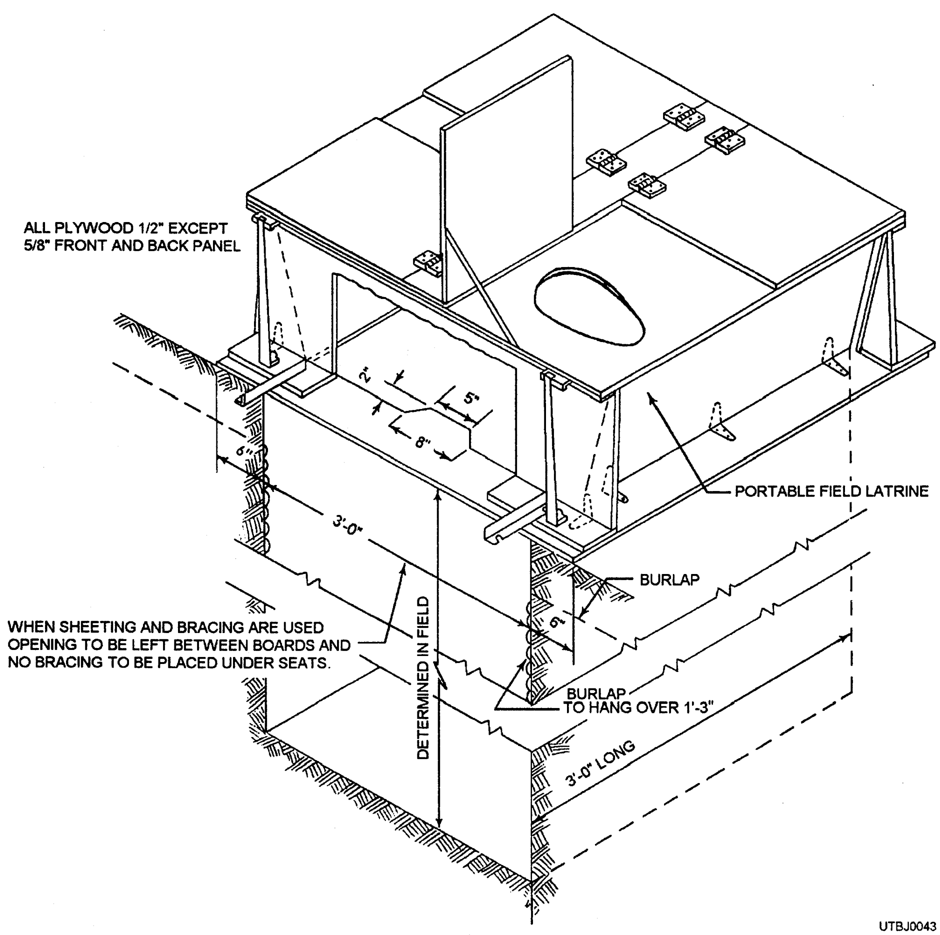


Figure 2-15.—Prefabricated four-seat latrine box.

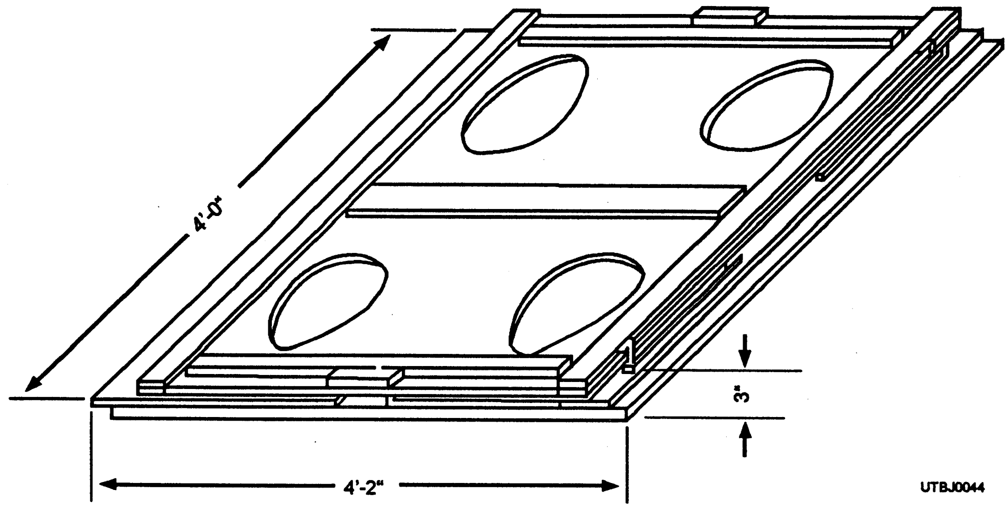


Figure 2-16.—Latrine box collapsed for shipment.

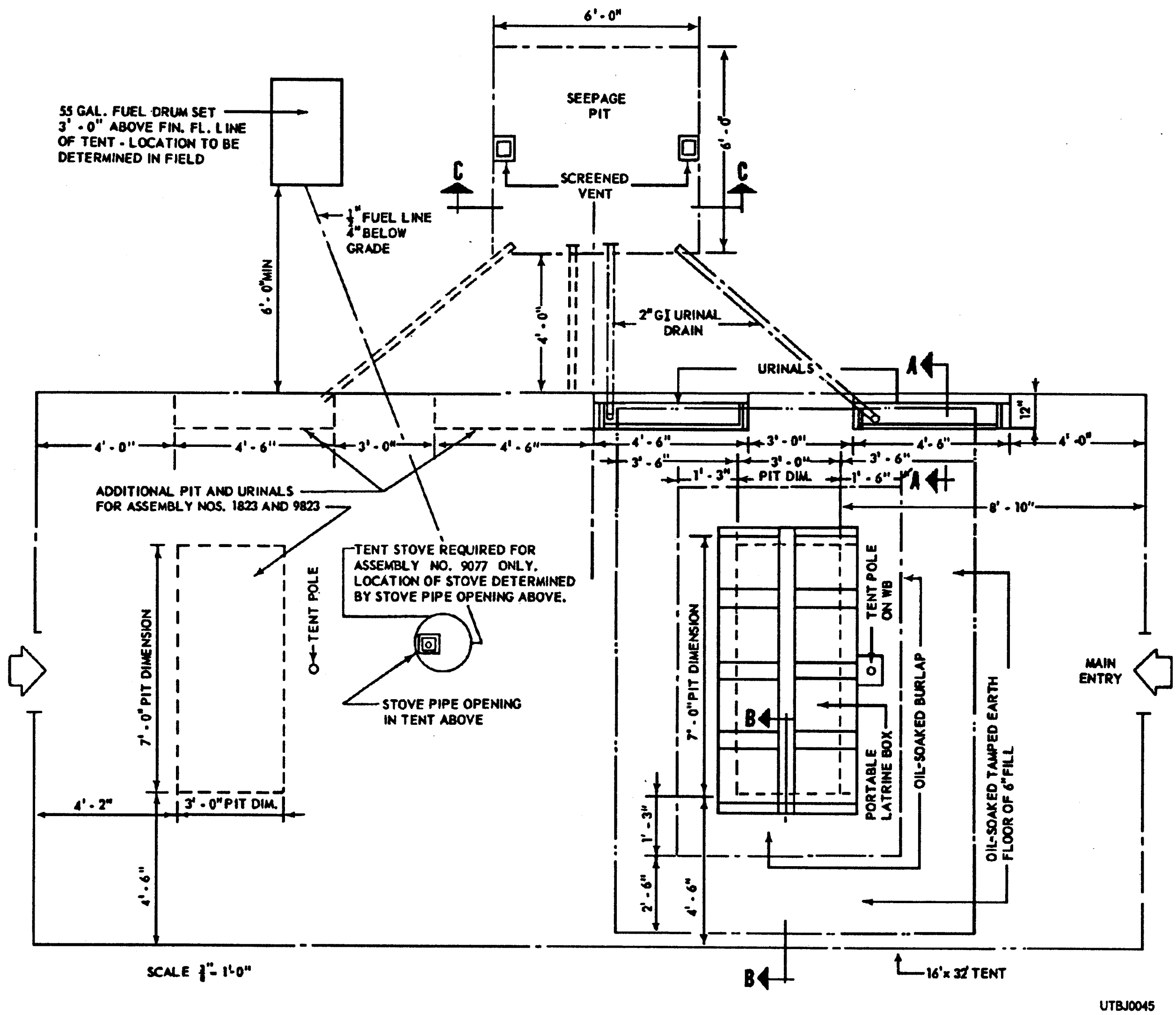


Figure 2-17.—Plan view of an eight-seat field-type latrine.

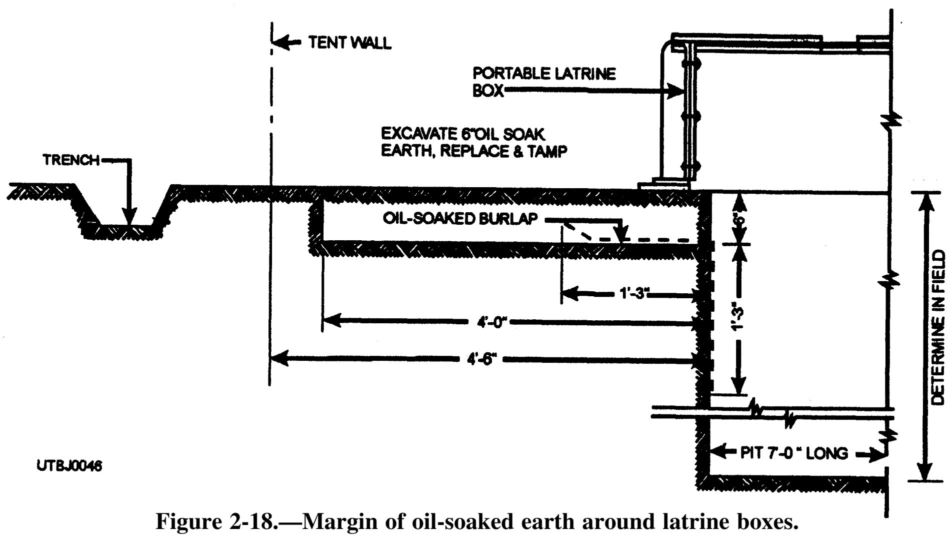


Figure 2-18.—Margin of oil-soaked earth around latrine boxes.

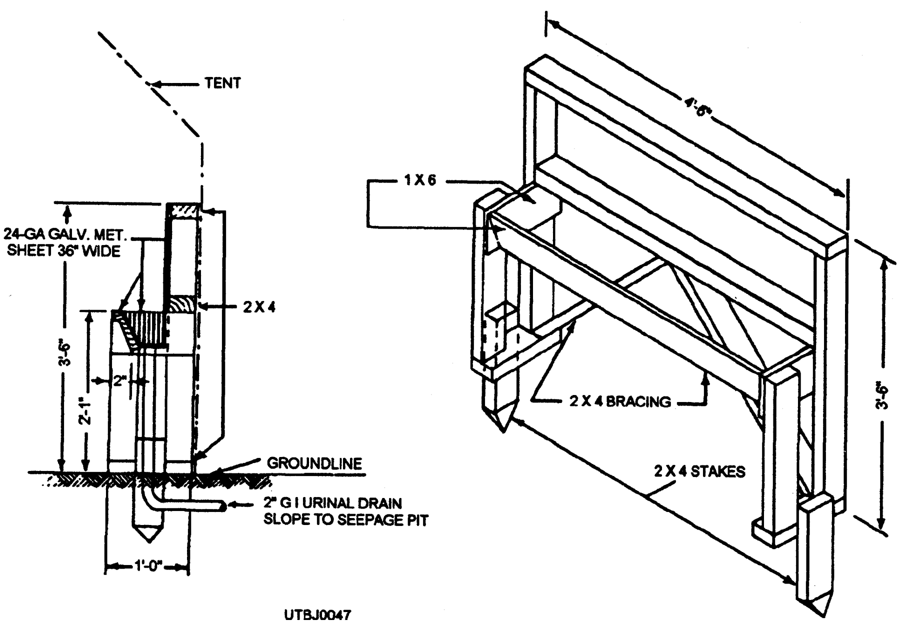


Figure 2-19.—Frame for urinal trough.

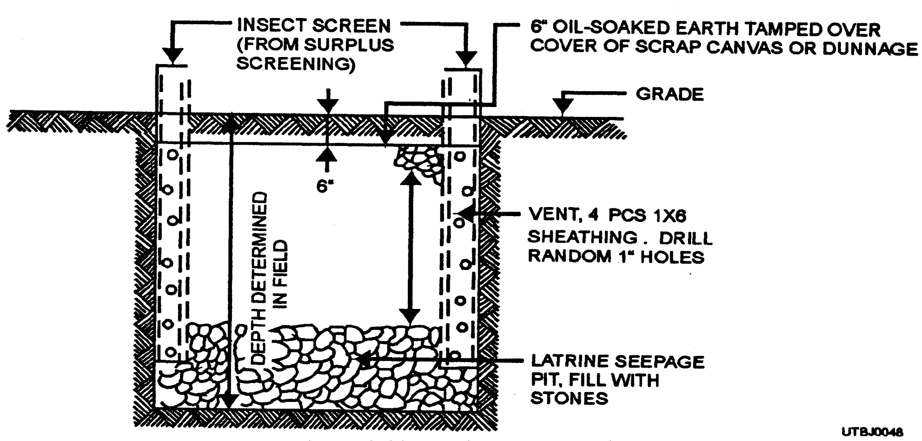


Figure 2-20.—Urinal seepage pit.

GALLEY WASTE

The wastewater in the galley sewer normally contains a large amount of grease; therefore, a grease trap must be installed in the sewer system to intercept and collect grease. A typical grease trap, which can be constructed in Bravo company shops, is shown in figure 2-21. This trap allows grease to enter the sewer system, to congeal, and to float to the top of the barrels. At a minimum, the grease must be removed once daily from the trap and disposed of, usually by burning. A properly constructed and maintained grease trap helps to ensure proper operation of the leach field that disposes of the wastewater.

LAUNDRY UNIT

Laundry units are installed after the advanced base has been established and essential support equipment is in place. You will encounter units similar to the one shown in views A, B and C of figure 2-22. The laundry unit shown in figure 2-22 is shown in a more permanent location This oil-fired, skid-mountedlaundryunit (fig. 2-22) is comprised of a washer, a dryer, a moisture extractor, a centrifugal water pump, and a water heater with a pressurized water storage tank.

A description of the major components of the skid-mounted laundry unit is listed below.

The Milnor washer is a fully automatic or manually operated unit with a 50-pound or 100-pound load capacity. It is supplied with a programmable cycle control and an automatic supply injector and uses 125 gallons of water per wash cycle.

The Cissell L36SMS30 model dryer or tumbler has a drying capacity of 50 pounds (dry weight) of laundry perhourandaheatingcapacityof 130,000 Btu per hour. It has a temperature-regulating thermostat, drying timer, cool-down timer, and a start/stop button.

The Bock 205 model moisture extractor extracts water from the clothes after rinsing by spinning the clothes at a high rate of speed, applying centrifugal. force, pushing the water to the outer surface, and discharging it through the basket. The extractor is equipped with a programmer that can be set for a 1- to 10-minute cycle.

The centrifugal water pump has a self-priming volute impeller. The only movable parts are the impeller, seal rotating elements, and shaft. The pump should pull a minimum vacuum of 20 inches of mercury.

The water heater is equipped with a fuel unit assembly, oil burner control relay, ignition transformer, fuel pump, and "drawer assembly," consisting of electrodes, insulators, nozzle adaptor, electrode support, and flame sensor, or "fire eye."

Different sizes of storage tanks with a capacity ranging from 6 to 85 gallons can be fitted to the skid when the unit is ordered. The storage tank has a maximum operating pressure of 100 psi.

In the paragraphs that follow, generic information is provided about installation, start-up, operation, and securing of this particular unit. This information is not all-inclusive nor intended for all types of units. As each laundry unit configuration is slightly different from the next, you should always refer to the instruction technical manual for the particular unit you are using.

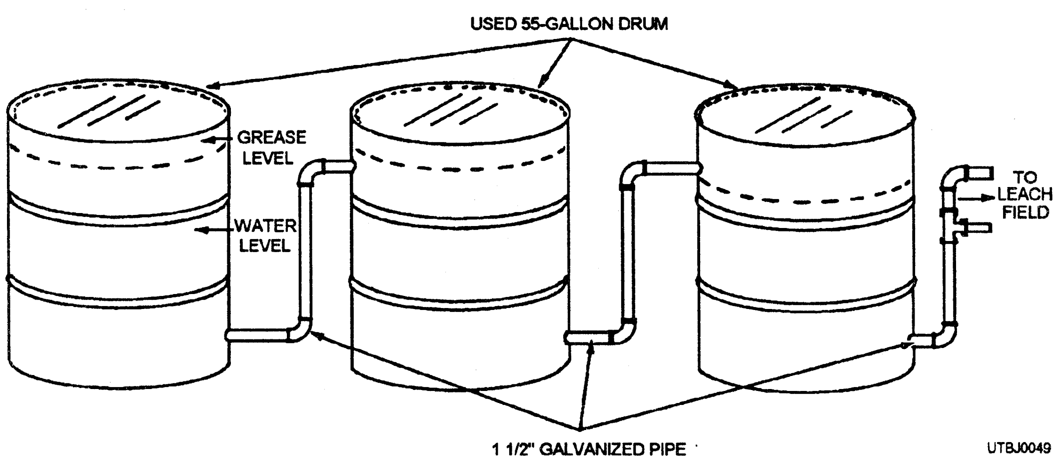


Figure 2-21.—Field galley grease trap.

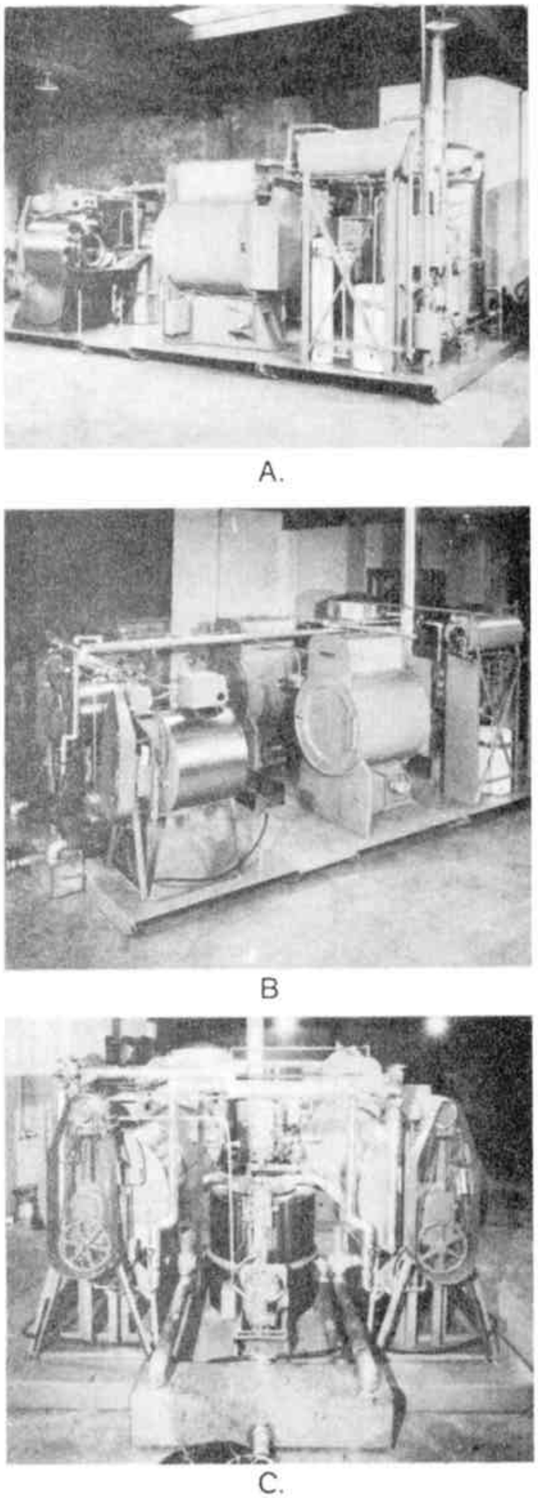


Figure 2-22.—Skid-mounted laundry unit.

Start-up

Place the unit on a level surface as close to the intended water and electrical source as practicable. Inspect the unit for damage due to transport or installation.

Check the mounting bolts to ensure they are secure. Component mounting bolts are factory-torqued. If bolts are loose, refer to the manufacturer's specifications and use a torque wrench to reset them.

Carefully perform all duties and prestart checks indicated in the manufacturer's operation manual.

Each time the unit is moved or disconnected, the following start-up procedures should be followed:

- Remove the rib holder assembly from the dryer drum before supplying power to the unit.
- Attach the line from the water source to the pump.
- Attach the drain hose to the drain and flex duct hose to the dryer exhaust. Both are supplied with the unit.
- Attach the fuel line supply and return from the source to the unit.
- Connect the power line to the power source.
- Open the water shutoff valve and then open the air-relief valve. Close the air-relief valve after all the air has been bled from the waterline.
- Switch the main breaker to ON.
- Switch the pump breaker to ON. Check the pump operation.
- Open the fuel valves on the unit.
- Switch the dryer breaker to ON. Be sure to bleed the fuel line. Read the dryer operating instructions carefully.
- Allow the water heater to fill before switching the breaker to ON. Be sure to bleed the fuel line. Read the water heater operating instructions.
- To ensure complete filling of the water heater, open the pressure-relief valve to permit trapped air to escape. When the water begins to run out of the pressure-relief valve, close the valve.
- Switch the washer and moisture extractor breakers to ON. The laundry unit is now ready for use.

Operation

The purpose of this laundry unit is to wash, extract water, and dry clothes and other suitable materials. The washing process is a series of baths during which soil is loosened from the materials, suspended in the water, and finally rinsed away. Several baths are usually necessary to remove the soil completely.

Operation is controlled by a timer and removable FORMULA CHART located in the washer, which regulates water temperature, wash rinse cycle, and adding of supplies. The chart carries the unit through a complete cycle according to the formula cut into the chart (up to 88 minutes). This chart can be changed at the discretion of the operator. The washer has an automatic supply injector unit that consists of five compartments that facilitates addition of starch, dry soap, and bleach before and during the washing cycle.

The extractor is simple in operation and is controlled by a moisture programmer located inside the control panel. The programmer is adjustable with a 1-minute to lo-minute time range. Once set, the extractor will run at the set time each time the start button is depressed.

The dryer, or tumbler, is operated by three different controls that are manually set by the operator. These controls are as follows:

- Temperature regulating thermostat sets the basket outlet temperature as determined by the material being dried.
- The drying timer sets the time duration for drying. It can be set from 0 minutes to a maximum of 60 minutes.
- The cool-down timer controls the allowed cool-down time for materials being dried. This control can be set from 0 to 15 minutes.

More specific operation, maintenance, and troubleshooting information is contained in the Utilitiesman Basic, Volume 2, Chapter 7, Laundry Equipment, NAVEDTRA 11020.

Securing the Unit

Before transporting or relocating the unit, you must secure it properly to prevent damage and extend the operational life of the unit. As each unit may be somewhat different, general securing procedures are as follows:

- Turn the unit OFF and empty all components.
- Switch all breakers to OFF.
- Open the drain valve on the pump assembly, and open the pressure-relief valve on the water heater.
- Replace the rib holder assembly in the dryer drum.
- Close the water and fuel valves. Disconnect the fuel and water sources.
- Disconnect and store the following components:

  a. Dryer'flex hose; store it in the tumbler.

  b. Power line; store it in the washer.

  c. Drain hose; store it in the washer.

- Remove the drain plug on the pump and let the water out. After draining is complete, replace the plug.
- When all the water has drained from the system, close the drain and pressure-relief valves.

WATER PURIFICATION UNITS

The remainder of this topic concerns the NCF water purification equipment. One of the most important jobs as a Utilitiesman is the purification of water.

Insufficient quantity or quality of water is not only debilitating to the individual but has a significant impact on unit readiness. Water that is not properly treated and disinfected can spread bacterial diseases, such as cholera, shigellosis, typhoid, and paratyphoid fever. Untreated water can also transmit viral hepatitis, gastroenteritis, and parasitic diseases, such as amoebic dysentery, giardiasis, and schistosomiasis.

The treatment process includes one or more of the following processes: coagulation, sedimentation, filtration, and disinfection.

The medical department advises the commanding officer on water quality issues. This entails assisting the Utilitiesman in selecting water sources, surveying the potable water system, conducting routine bacteriological examination of the potable water supplies, and testing the water for halogen levels. The medical representative also informs the Utilitiesman of water quality and type of treatment required, if any.

Lyster Bag

The lyster bag shown in figure 2-23 is primarily a dispensing unit for purified or distilled water. These bags are sturdy, watertight, and readily collapsible for packing. Water is withdrawn through small faucets at the bottom. When no other purification equipment is available, the lyster bag can be used to disinfect raw water. Chemical kits for purification are supplied with each lyster bag. When you must use a lyster bag for water treatment, follow the manufacturer's instructions.

Tank Trailers

Tank trailers (fig. 2-24), like lyster bags, are designed as dispensing units for purified or distilled water; however, tank trailers may be used to disinfect raw water. The water is treated as directed by local medical authorities.

The tank trailer, sometimes referred to as a "water buffalo," has a capacity of 400 gallons of water. The unit comes equipped with faucets for dispensing the water. When desirable, water can be transferred from the tank trailer into a lyster bag. The responsibility for cleaning and disinfecting the tank trailer before it is filled with water belongs to the Utilitiesman.

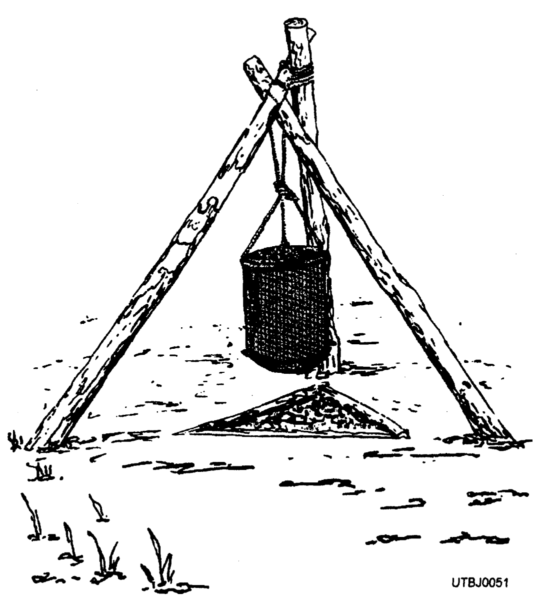


Figure 2-23.—Lyster bag.

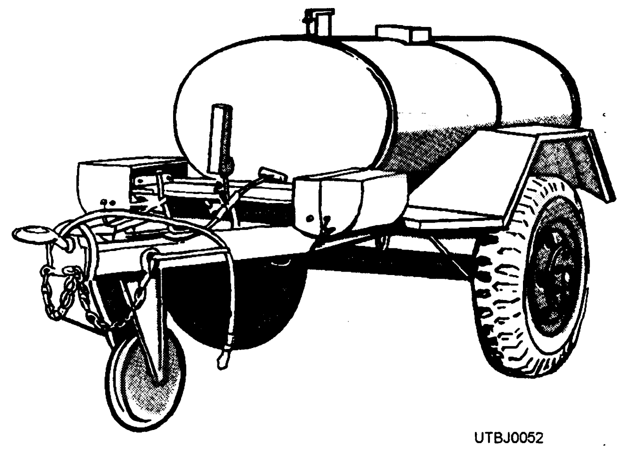


Figure 2-24.—Tank trailer.

Disinfection

Disinfection destroys harmful organisms (pathogenic viruses, bacteria, and protozoans) present in water by exposing them to specific concentrations of disinfecting agents or to heat. The Navy guidelines on disinfection are as follows.

The superchlorination process is used to disinfect water containers (lyster bags, tank trailers, etc.) and distribution systems initially- before they are used or when they have become contaminated. Superchlorination is accomplished by chlorinating the water in a container or distribution system to at least 100 ppm FAC and holding it in the container for 4 hours. During the 4-hour period, the FAC must not drop below 50 ppm. If the ppm falls below 50 ppm the process must be repeated. A sign "POISON DO NOT DRINK" must be displayed clearly on all sides of the container or at all water outlets during this process.

Using the three charts in table 2-2, choose the one that applies to the percentage of HTH material you intend to use. Let's say the chief gave you a bottle of 65% granular calcium hypochlorite. You should use the chart that has the title "For 65% to 70% Granular Calcium Hypochlorite." Now locate the amount of water you are going to treat. For our example here, let's say that we are going to treat a 400-gallon tank trailer. Look on the correct chart and locate the quantity in gallons. There is no 400-gallon figure, so use the larger capacity of 500 gallons. Now follow over on the chart and locate the corresponding number of ounces to add to receive a 100 ppm FAC. The answer is 10 ounces. We have determined that 10 ounces of 65% calcium

Table 2-2.—Chlorine Dosage Calculator

Instruction for use: Select desired parts per million. Determine strength of solution to be used. Compute number of gallons to be chlorinated. Read across to where lines intersect to obtain quantity of material to be used.

Desired PPM	1	1	1	1	5	5	5	5	25	25	25	25	50	50	50	50	100	100	100	100	200	200	200	200
Strength of chlorine solution	5%	25%	70%	100%	5%	25%	70%	100%	5%	25%	70%	100%	5%	25%	70%	100%	5%	25%	70%	100%	5%	25%	70%	100%
Gallons of water to be chlorinated 50,000	1 Gal	1 lb 11oz	10 oz	6.7 oz	5 Gal	8 lb 6 oz	3 lb	2 lb 2 oz	25 Gal	41 lb 12 oz	14 lb 15 oz	10 lb 7 oz	50 Gal	83 lb 7 oz	30 lb	20 lb 14 oz	100 Gal	166 lb 13 oz	59 lb 10 oz	41 lb 12 oz	200 Gal	333 lb 10 oz	119 lb 4 oz	83 lb 7 oz
25,000	2 Qt	134 oz	5 oz	3.34 oz	2.5 Gal	4 lb 3 oz	1 lb 8 oz	1 lb 1 oz	125 Gal	20 lb 14 oz	7 lb 8 oz	5 lb 4 oz	25 Gal	41 lb 12 oz	15 lb	10 lb 7 oz	50 Gal	83 lb 7 oz	29 lb 13 oz	20 lb 14 oz	100 Gal	166 lb 13 oz	59 lb 10 oz	41 lb 12 oz
10,000	25.6 oz	5.5 oz	2 oz	1.34 oz	1 Gal	1 lb 11 oz	9.6 oz	6.72 oz	5 Gal	8 lb 6 oz	3 lb	2 lb 2 oz	10 Gal	16 lb 11 oz	6 lb	4 lb 3 oz	20 Gal	33 lb 6 oz	12 lb	8 lb 6 oz	40 Gal	66 lb 12 oz	23 lb 14 oz	16 lb 11 oz
5,000	12.8 oz	2.8 oz	1 oz	.61 oz	2 Qt	14 oz	4.8 oz	3.36 oz	2.5 Gal	4 lb 3 oz	1 lb 8 oz	1 lb 1 oz	5 Gal	8 lb 6 oz	3 lb	2 lb 2 oz	10 Gal	16 lb 11 oz	6 lb	4 lb 3 oz	20 Gal	33 lb 6 oz	11 lb 12.4 oz	8 lb 6 oz
2,000	5.12 oz	1.1 oz	.4 oz	.26 oz	25.6 oz	6 oz	1.92 oz	1.35 oz	1 Gal	1 lb 11 oz	9.6 oz	6.68 oz	2 Gal	3 lb 6 oz	11 lb 4 oz	13.5 oz	4 Gal	6 lb 11 oz	2 lb 62 oz	1 lb 11 oz	8 Gal	13 lb 6 oz	4 lb 12.4 oz	3 lb 6 oz
1,000	2.56 oz	.55 oz	.2 oz	.14 oz	12.8 oz	3 oz	.96 oz	.68 oz	2 Qt	13.6 oz	4.8 oz	3.34 oz	1 Gal	1 lb 11 oz	9.6 oz	6.72 oz	2 Gal	3 lb 6 oz	1 lb 3.1 oz	13.5 oz	4 Gal	6 lb 11 oz	2 lb 6.2 oz	1 lb 11 oz
500	1.28 oz	.28 oz	.1 oz		6.4 oz	1.4 oz	.48 oz	.34 oz	1 Qt	6.72 oz	2.4 oz	1.67 oz	2 Qt	13.5 oz	4.8 oz	3.36 oz	1 Gal	1 lb 11 oz	9.54 oz	6.72 oz	2 Gal	3 lb 6 oz	1 lb 3.1 oz	134 oz
200	.512 oz	.11 oz			2.56 oz	.56 oz	.2 oz	.14 oz	12.8 oz	2.68 oz	.96 oz	.68 oz	25.6 oz	5.4 oz	1.92 oz	1.35 oz	51.2 oz	10.7 oz	3.82 oz	2.67 oz	102.4 oz	1 lb 6 oz	7.64 oz	5.34 oz
100	.256 oz				1.28 oz	.28 oz	.1 oz	.64 oz	.64 oz	1.35 oz	.48 oz	.34 oz	12.8 oz	2.7 oz	.96 oz	.68 oz	25.6 oz	5.4 oz	1.91 oz	1.35 oz	51.2 oz	10.7 oz	3.82 oz	2.67 oz
50	.13 oz				.64 oz	.14 oz			3.2 oz	.68 oz	.24 oz	.17 oz	6.4 oz	1.4 oz	.48 oz	.34 oz	12.8 oz	2.72 oz	.96 oz	.68 oz	25.5 oz	5.4 oz	1.91 oz	1.34 oz
25	.064 oz				.32 oz				1.6 oz	.34 oz	.12 oz		3.2 oz	.68 oz	.24 oz	.17 oz	6.4 oz	1.36 oz	.48 oz	.34 oz	12.8 oz	2.72 oz	.96 oz	.67 oz
10	.026 oz				.128 oz				.64 oz	.14 oz			1.28 oz	.3 oz	.1 oz		2.56 oz	.56 oz	.192 oz	.14 oz	5.12 oz	1.12 oz	.384 oz	.27 oz
5	.013 oz				.064 oz				.32 oz				.64 oz	.14 oz			1.28 oz	.28 oz	.1 oz		2.56 oz	.56 oz	.192 oz	.14 oz

* Materials used are as follows: 5%—Sodium hypochlorite (liquid) 25%—chlorinated lime (solid) 70%—calcium hypochlorite (solid) 100%—gaseous chlorine

hypochlorite should be used to disinfect the water in the tank trailer. The procedure for preparing and adding the solution to the tank trailer is as follows:

1. Fill the tank trailer half full of water.

2. Prepare a small amount of HTH concentrate by dissolving the required amount of HTH in a canteen cup or other container. In this case, place the 10 ounces of HTH in a l- or 2-gallon bucket of water.

3. Stir the mixture thoroughly. All of the granules will not dissolve. Allow undissolved granules to settle to the bottom of the bucket.

4. Add only the clear concentrate liquid to the tank trailer. By pouring the supematant into the tank trailer slowly, you can see that the settled granules will remain in the bucket.

5. Fill the remainder of the tank with the water to be treated

6. The water now must be agitated to distribute the HTH. In this example, you could simply attach the tank trailer to a vehicle and go for a short drive.

7. The final step is to take a FAC reading 30 minutes after adding the HTH. The reading must be at or above the required ppm. In this example, the FAC must read 100 ppm or higher. If the ppm is not high enough, add more HTH until the desired ppm is maintained.

NOTE

Remember that during superchlorination the FAC may not fall below 50 ppm wihin 4 hours or the whole procedure must be repeated.

After the 4-hour contact time and the tank trailer ppm has stayed above 50 ppm, the trailer is now disinfected. Rinse the tank thoroughly with potable water and then refill it for usage. An occasion may occur when you must use the water that you superchlorinated. If the chlorine ppm is too high, you may use sodium thiosulfate or sodium bisulfate to dechlorinate the water.

Table 2-3 shows water sources and the required chlorine residual.

For further information, see chapter 9 of the *Manual for Preventive Medicine,* NAVMEDP-50109.

Table 2-3.—Chlorine Residual Chart

WATER SOURCE	REQUIRED CHLORINE RESIDUAL
Public water supply system of questionable quality	5.0 ppm FAC after 30-minute contact time and maintain at a minimum of 2.0 ppm FAC throughout the distribution system
Engineering water points	5.0 ppm FAC at the standpipe or fill hose
Water tankers, trailers, bladders, and cans	Maintain between 5.0 ppm and 2.0 ppm FAC when filling from an approved water point. Maintain 5.0 ppm FAC when used as a source of distribution (piping system)
Distribution (piping) system	Maintain 5.0 ppm at the source and 2.0 ppm FAC at the spigot
Lyster bags and canteens	Maintain 2.0 ppm FAC when filling from an approved water source. Chlorinate to 5.0 ppm FAC initially and maintain at 2.0 ppm FAC when filling from an unapproved or raw water source

Diatomite Water Purification Unit (3000-D)

The 3000-D Water Purification System is portable and completely self-contained, as shown in figure 2-25. The unit purifies turbid and bacteria-polluted water. Particular attention was paid to design and packaging to increase efficiency, mobility, and cost effectiveness. It also provides a trouble-free method of producing potable water at the rate of 3,000 gallons per hour.

The system is constructed in separate modules, interconnected, and mounted in a common chassis. The chassis is not required for operation, but it greatly eases the transportability of the system. The system contains all of the functional apparatus and supplies necessary to process approximately 20,000 gallons of potable water. The user must have a water source and a

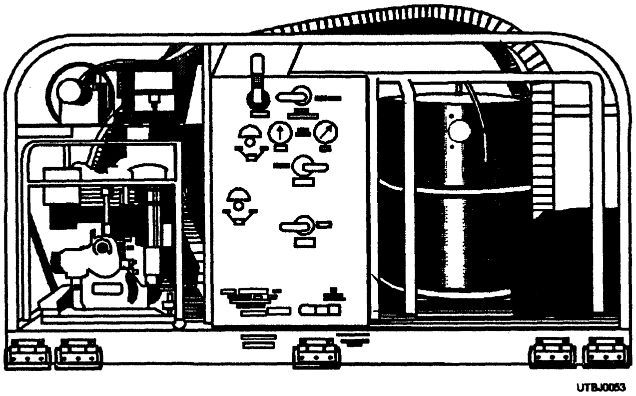


Figure 2-25.—3000-D water purification unit.

container to hold the processed water. Subsequent water processing requires only diatomaceous earth (DE), chlorine, and fuel.

The major components of the system are shown in figure 2-26. This mobile water purification unit contains a diesel-powered pumping module, a control and chlorination module, a filter module, supplies, and components mounted within a protective frame. It is supported on a pair of skids. Each module may be operated independently in or out of the frame because the interconnections and external connections use the same cam-locking devices. The unit may or may not be mounted on a trailer. The 3000-D can be set up and operated by one person, and it requires no support equipment.

The power for the system is supplied by an air-cooled diesel engine to take advantage of a greater fuel supply in the field.

A highly durable bronze pump, directly linked to the engine, provides both the suction to draw in the untreated water and to provide the water pressure to the unit. The 3000-D Water Purification System is designed to be transported to remote sites on its own optional trailer, on the back of a compact pickup truck, or air-lifted by helicopter with its own standard sling.

SETUP.-At the site, the system should be located on a level area located as close to the water source as possible to reduce suction lift to a minimum. For best results, the system should be located not more than 15 feet above the liquid supply. The suction line should be as short as possible and have few bends to keep friction losses low. The system is usually placed within 30 feet

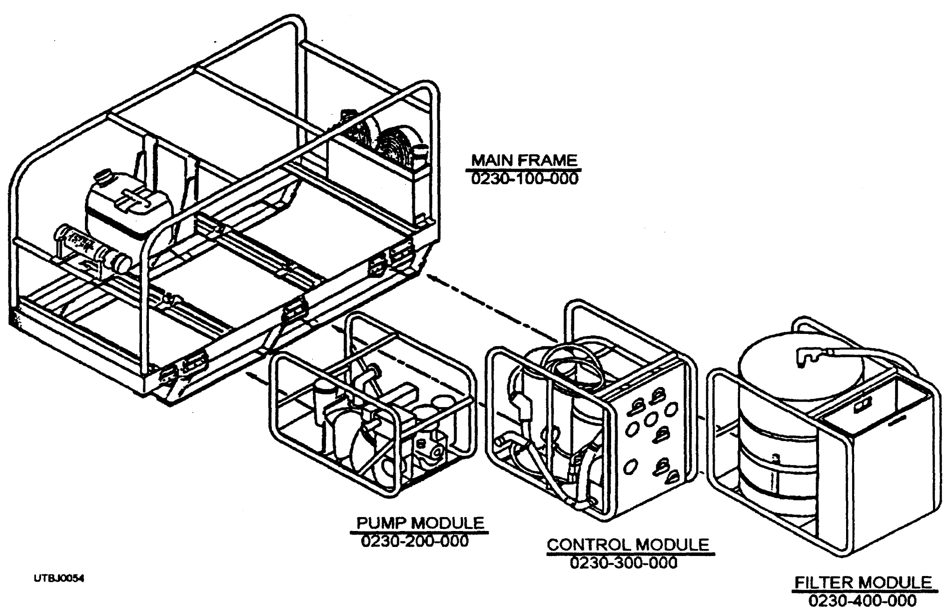


Figure 2-26.—Separate modules of the 3000-D unit.

of the water source. The semirigid suction hose segments are removed from the main frame mounting cam locks and fitted together with a suction strainer placed in the water source. The green freshwater hose is fitted to the freshwater discharge port on one end. The other end feeds the processed water to the potable water holding tank or dispersement center. One end of the blue wastewater hose is fitted to the wastewater discharge port. The other end is placed so runoff can take place without hampering or contaminating further operations.

START-UP.—Follow the steps listed below before starting the engine.

1. Fill the pump strainer with water to prime; close the cover tightly.

2. Set all control valves to START, as shown in figure 2-27.

3. Remove the DE storage container and set it aside.

4. Fill a 3-gallon bucket three-quarters full of water and add three 2000 ml measures of DE slowly, stirring the mixture as you add the DE. Do NOT add the DE to the DE tank at this time.

5. Fill a 3-gallon bucket three-quarters full of water and add 8 ounces of chlorine. After mixing the calcium hypochlorite solution, allow the solution to settle. When the mixture is settled, pour the solution into the hypochlorite tank.

The engine of the 3000-D is equipped with an automatic decompression device and an excess fuel-starting device that allows the engine to start easily and safely. The automatic decompression device has three positions:

1. Operation—the decompression is OFF, the engine has compression.

2. Neutral—for cold starting, compression is OFF.

3. Start position—cranking the engine causes the automatic decompression to operate. When the pin moves into the operating position, decompression ends and the engine fires.

WARNING

Never use the decompression device to stop the engine. This causes internal engine damage.

CAUTION

Wear hearing protection.

The procedures for a cold start are as follows:

1. Place the automatic decompression device in START and pull the excess fuel-starting device.

2. Insert the crank handle into the crank-handle guide. If you are not sure of the proper way to place your hand on the crank handle while cranking, then ask your supervisor for instructions.

3. Crank the engine slowly for four cranks and then turn the crank as quickly as you can. Once the engine starts, run the engine at half speed for about 1 minute.

4. Raise the engine to full speed.

Once you have precoated the filter, the unit is ready to perform the function of purifying water. Every 30 minutes, check the chlorine residual, the turbidity of the potable water, and the DE tank for slurry mixture.

Backwashing of the filter must be done when the pressure difference between the filter inlet and the outlet exceeds 20 psi.

SECURING THE UNIT.—Set the control valves as follows:

1. Outlet selector valves—WASTE

2. Waste outlet valve—OFF

3. Backwash valve—BACKWASH

4. Precoat valve—FILTER

5. Filter drain valve—DRAIN

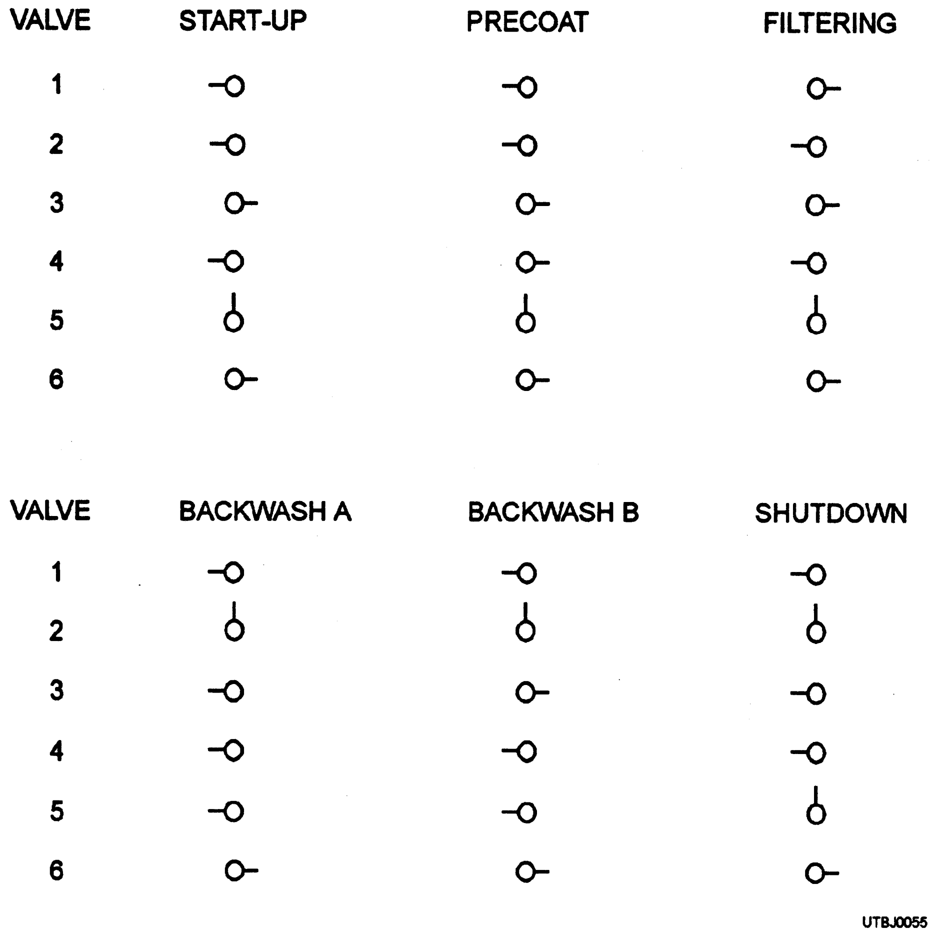


Figure 2-27.—Valve positions.

Let the engine idle for 5 minutes, and then place the speed- regulating lever to STOP until the engine stops. Pull the excess fuel-starting device, and place the speed-regulating lever to FULL LOAD.

Further information on operation, preventive maintenance, and troubleshooting of the 3000-D can be found in the *Technical Manual for the Model 3000-D (Diesel Powered) Modular, Field Portable Water Purification Unit, Goodman* Ball, Inc., 1989.

Reverse Osmosis Water Purification Unit (ROWPU)

Potable water is acritical element in the operational functioning of the Seabees. The 600 GPH Reverse Osmosis Water Purification Unit (ROWPU) purifies water by reducing the dissolved and suspended solids in water. The unit processes raw water, brackish water, and seawater into potable water. Additionally, the ROWPU can treat water contaminated with CBR agents. Two views of the 600 GPH ROWPU can be seen in figure 2-28.

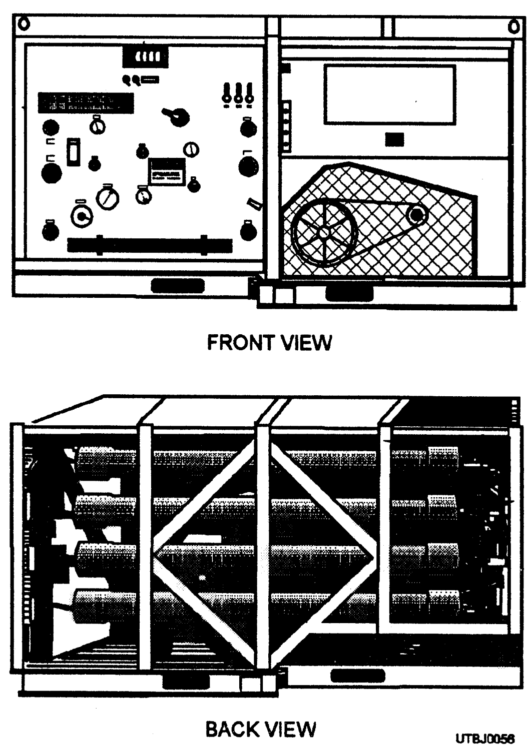


Figure 2-28.—Two views of the 600 gph ROWPU unit

The purification is done by filtering the water to remove the majority of suspended solids. Once the majority of the suspended solids are removed, high pressure forces the water through a semipermeable membrane. A maximum of 600 pounds psi is used for fresh and brackish water, and a maximum of 900 pounds psi is used for salt water. Chemicals are added to the product water to kill bacteria.

SUPPORT EQUIPMENT.—The self-contained skid-mounted ROWPU unit requires a portable generator capable of providing 30 kilowatts of power (fig. 2-29).

Other supportable equipment includes the following: portable onion skin bladders (3,000 gallons), as shown in figure 2-30, or collapsible water tanks (3,000 gallons); four frame-mounted, portable, electrical motor-driven water pumps with hoses and fittings; water test equipment (TDS meter, color comparator, etc.); and an operating supply of chemicals (chlorine, sodium hex, polymer, and citric acid).

WATERFLOW THROUGH THE ROWPU.—you read through the next 18 items listed, refer to the flow diagram in figure 2-31.

1. This is the water source that you are going to purify through the ROWPU.

2. The strainer is attached to the end of the intake hose to keep rocks, leaves, and any other foreign objects from entering the pumps and filters.

3. The first of the two pumps that draw water from the water source and pump the water to the ROWPU.

4. The second of the two pumps that draw water from the water source and punp the water to the ROWPU.

5. The polymer pump adds a polyelectrolyte solution to the raw water. The polymer causes coagulation of small floating particles. This enables the filters to remove the particles.

6. The sodium hex pump adds a solutionof sodium hexametaphosphate to prevent scaling of the filters.

7. The multimedia filter is the first actual filter that the raw water goes through.

8. After the water has been filtered, the booster pump draws the water and forces it through the cartridge filter.

9. As the water goes through the cartridge filter, tiny particles that were not filtered out by the multimedia filter are filtered out.

10. The reverse osmosis (RO) pump increases the filtered water pressure and forces the water through the RO elements (semipermeable membranes)

11. The pulse dampener is simply a ball-shaped device that reduces the shock caused by the piston action of the pump.

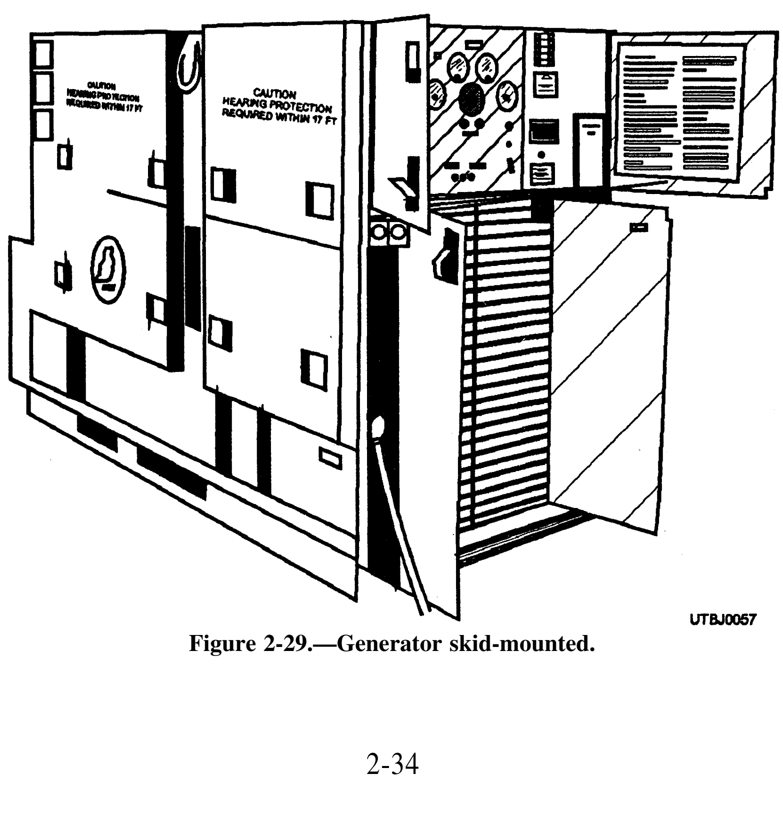


Figure 2-29.—Generator skid-mounted.

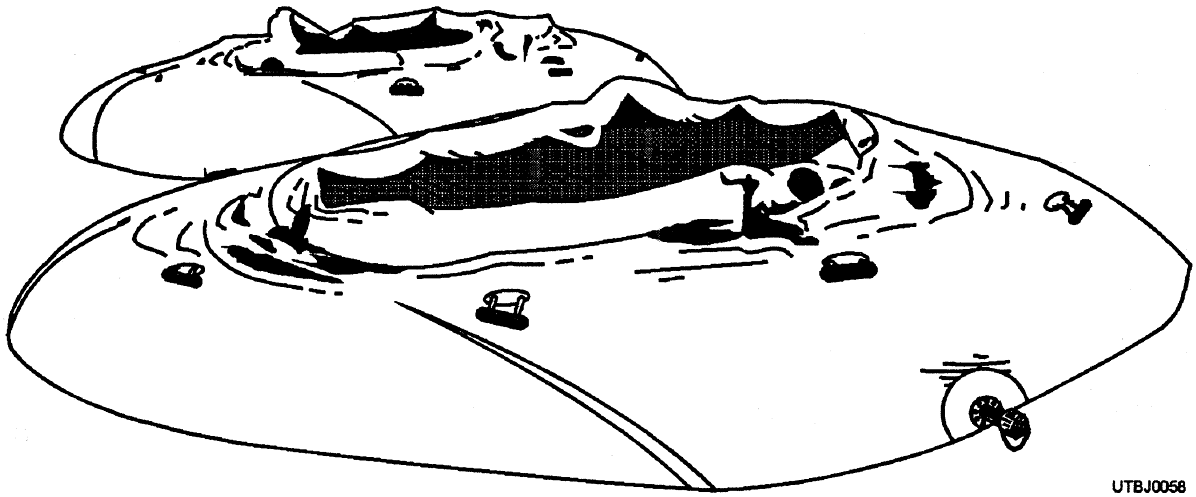


Figure 2-30.—Portable onion skin bladders, 3,000 gallon.

12. All of the dissolved solids are removed from the water in the membranes. The membranes consist of rolls of thin film that separate dissolved solids from the water.

13. Once the water comes out of the RO elements, the chlorine pump injects chlorine into the product water to kill bacteria that is present. If the chlorine pump is not in use, you must batch chlorinate the water in the bladder or storage container.

14. The product water tank is a storage device for holding product water (potable water). The tank may be a bladder, a container, or a collapsible tank.

15. The distribution pump is used to move the product water from the product-water tank into vehicles, tank trailers, and so forth.

16. A distribution nozzle is used to fill the end-users container.

17. Diluted citric acid cleans the RO elements. The citric acid lowers the pH of the water and improves the salt rejection of the elements.

18. A separate storage tank is used for the brine water. The brine is used to flush the multimedia filter. The backwash pump (19) forces the brine backwards (from bottom to top) through the filter media to flush out any unwanted accumulation in the filter.

19. The backwash pump provides pressure that pumps the brine through the multimedia filter for backwashing.

The ROWPU can purify 13.5 gallons per minute of product water from a fresh or brackish water source and 12 gallons per minute of potable water from a seawater source.

Temperature has a substantial effect on the quantity of product water the ROWPU can produce. The higher the temperature of the raw water, the more product water the ROWPU can produce. At 77°F the ROWPU can produce 600 gph from fresh or brackish water and 400 gph from seawater. Again, as the temperature of the water increases so does the flow of product water.

You can obtain more information about the ROWPU operation, setup, maintenance, and troubleshooting in the TM 5-4610-215-24, *Water Purification Unit, Reverse Osmosis 600 GPH Trailer Mounted.* Additionally, every NMCB is required to have eight UTs. This is accomplished by sending them to the SCBT 740.2, Water Treatment II course.

Q1. What is the primary responsibility of the Seabees?

Q2. What is the first procedure you should perform after receiving an ABFC assembly?

Q3. Where should the portable bath unit suction hose be located in relation to the wastewater drain?

Q4. Type I portable space heaters can be operated with what two types of fuel?

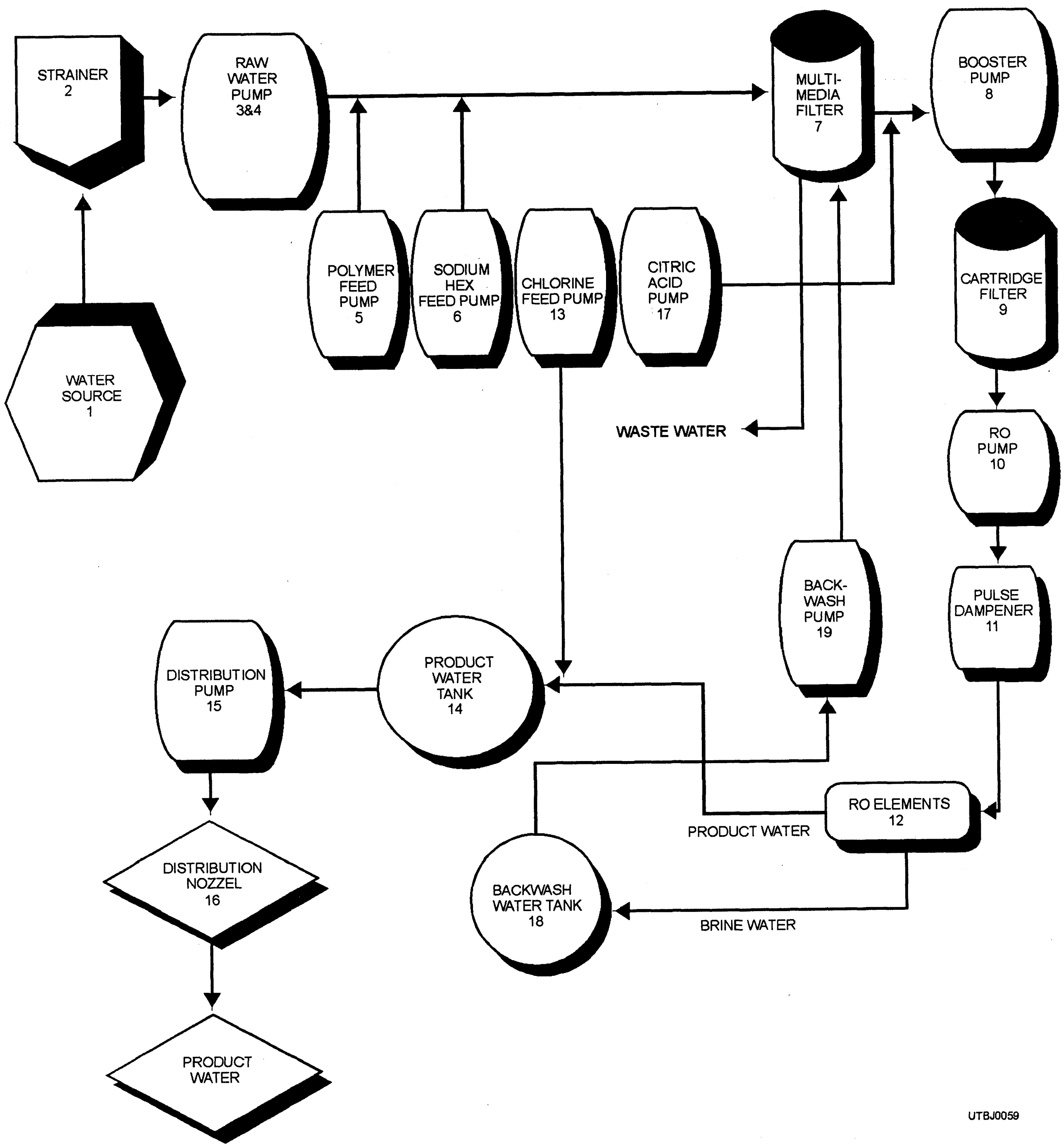


Figure 2-31.—Water flow through the ROWPU.

Q5. The stack of an immersion heater is divided into two sections. What are they?

Q6. Where are the operating instructions on an immersion heater located?

Q7. When the field range burner unit is used for frying, the burner should be placed in what position?

Q8. The number and size of cesspools depends on what two factors?

Q9. When a septic tank is being constructed, the length should be at least how many times larger than the width?

Q10. For a tile field in soil composed of clay and gravel, you should dig a trench of what minimum width?

Q11. An eight-seat field-type latrine can be expanded to how many additional seats?

Q12. What control runs the wash, the rinse, and the spin cycle of a skid-mounted laundry unit washer?

Q13. A lyster bag is primarily used for dispensing what types of water?

Q14. The 3000-D diatomite waterpurification unit should be locatedd what distance above the water supply?

Q15. What water purification unit purifies water by reducing dissolved and suspended solids?

CHAPTER 3

PLUMBING

LEARNING OBJECTIVE: *Recognize proper tool accountability and safety; recognize procedures for laying out wastewater systems, water distribution systems, and joining different types of piping; and recognize accessories used in their construction.*

Plumbing plays a major role in the construction of all types of residential, commercial, and industrial buildings. Of all the building trades, plumbing is most essential to the health and well-being of the community, in general, and to the occupants of the buildings in particular. It is an obligation and responsibility for each and every Utilitiesman to uphold the vital trust placed in him or her for proper installation of plumbing materials and equipment. Each plumbing installation is governed by the rules and regulations set forth in local plumbing codes that have been adopted from standards established at the local, state, and federal level. As you progress in rate as a Utilitiesman, it becomes your job to ensure that codes established for the job are carried out. You may soon be the supervisor or instructor responsible for training Utilitiesmen under you.

In this chapter you are introduced to the tools required for plumbing and to the different types of materials used in underground and aboveground piping. You will discover where, why, and when to use certain materials during installation and repair of these piping systems.

TOOLS

LEARNING OBJECTIVE: *Recognize the importance of tool accountability, types of tool kits, and methods of their use and safety.*

To install varioustypes of equipment, you will use many different hand tools and power tools. For the purpose of safety, you should understand the major importance of using the proper tools for the proper job. For a complete and thorough understanding of various tools, read the training manual, *Use and Care of Hand Tools and Measuring Tools,* NAVEDTRA 12085. The following tool kits are available to the Utilitiesman from the Naval Construction Force, Table of Allowance (TOA):

80001 Kit, Plumbers: This kit contains the basic equipment and hand tools required for field installation of various plumbing systems.

80002 Kit, Plumbers Shop: This kit contains the basic equipment and hand tools required for establishing a base maintenance plumbing shop.

80005 Kit, Service Refrigeration: This kit contains the basic equipment and hand tools required for routine maintenance, recharging, and repair of various types of refrigeration units.

80055 Kit, Cast-Iron Pipe Installation: This kit contains the basic equipment and hand tools required for installation of cast-iron piping.

80088 Kit, Power Threading: This kit contains a power threader and all of the attachments to place threads on pipe material.

TOOL ISSUE

You may be required to draw tools from the central toolroom (CTR) or the central storeroom (CSR). Procedures for issue and accounting of tools and replacement of broken or missing tools are established in the *Seabee Supply Manual,* COMTHIRDNCB/COMSECONDNCB 4400.3. You are responsible for the following:

- Maintaining the complete tool kit for which you signed
- Using and caring for tools assigned to you
- Preserving those tools in use and those not in use
- Securing assigned tools
- Accounting for tools

- Seeing that tools are returned to their proper place at the end of each day

A requirement to conduct a biweekly inventory/ inspection ensures that tools are maintained and ready for use. Whenever you have missing, broken, or worn-out tools, submit NAVSUP 1250-1, signed by your division/company commander or chief, for replacement. You may also be required to start action on a survey form (NAVSUP Form DD 200) for lost, destroyed, or damaged by other than normal wear. For help in filling out these forms, ask your crew leader, first-class supervisor, or chief.

TOOL USE

When using tools, use them the way they were designed to be used. Adjustable wrenches should not be used as hammers; screwdrivers should not be used as chisels, and so forth. Not only can you damage what you are working on, but you can injure yourself or someone else. Keep tools clean and free of grease, oil, and dirt. When you are through with a tool, put it back in its proper place. Tools requiring maintenance must be turned into CTR/CSR for immediate replacement. Do not take chances. For instance, a chisel with a mushroomed head where the mushroomed portion of the head has just the slightest split when struck with a hammer, a piece of the metal may become an airborne piece of shrapnel. Normally, preventive maintenance is performed on all power tools at least monthly. Be sure you comply with the maintenance inspections of your command. Plan ahead. Use the prepared preventive maintenance schedule you received to help in job production and save the time lost to inspection.

As mentioned before, you are responsible for all tools assigned to you. The tool user is also responsible for tool safety and accountability. If you borrow a tool, be sure to return it to its proper place. Report any problems you have with tools. Remember tools are expensive. It also takes time to replace lost or broken tools.

TOOL SAFETY

Protect your hands from injury as directed by the applicable safety instructions whenever you use tools. You may be working under a severe handicap without the full use of both hands. Make it a habit to FOLLOW ALL SAFETY RULES.

TEN RULES OF TOOL SAFETY

Several important aspects of safety should remain uppermost in your mind when you are on the job. The ten rules are as follows:

- LEARN the safe way of doing your job before you start.
- THINK safety, and ACT safely at all times.
- Obey safety rules and regulations; they are for your protection.
- WEAR proper clothing and protective equipment.
- CONDUCT yourself properly at all times; horseplay is prohibited.
- OPERATE only the equipment you are authorized to use.
- INSPECT tools and equipment for safe condition before starting work;
- ADVISE your superior of any unsafe conditions or practices promptly.
- REPORT an injury to your superior immediately.
- SUPPORT your safety program and take an active part in safety meetings.

Additionally, there are several good tool habits to help you perform your work more efficiently and safely.

TOOL HABITS

"A place for everything and everything in its place" is just common sense. You cannot do an efficient, fast repair job when you have to stop and look around for each tool you need. The following rules will make your job easier:

KEEP EACH TOOL IN ITS PROPER STORAGE PLACE. A tool is useless when you cannot find it. When you return each tool to its proper place, you know where it is the next time you need it.

KEEP YOUR TOOLS IN GOOD CONDITION. Protect them from rust, nicks, cracks, burrs, and breakage.

KEEP YOUR TOOL ALLOWANCE COMPLETE. When you are issued a toolbox, each tool should be placed in it when the tool is not in actual use. When possible, the too lbox should be locked and stored in a designated area.

NOTE

Never leave your toolbox or individual tools adrift where they could become a missile, fallen object, or tripping hazard and cause injury to personnel nearby. To keep track of your tools, the NCF tool kits contain inventory sheets. When you receive a kit that does not contain an inventory sheet, request a sheet from CTR. Figure 3-1 shows a partial inventory listing of a plumber's kit.

USE EACH TOOL ONLY ON THE JOB FOR WHICH IT WAS DESIGNED. When you use the wrong tool to make an adjustment, the end result will probably be unsatisfactory. For example, if you use a socket wrench that is a trifle too big, you will round off the corners of the wrench or nut. If this rounded wrench or nut is not replaced immediately, the safety of your equipment may be jeopardized in an emergency.

KEEP YOUR TOOLS WITHIN EASY REACH AND WHERE THEY CANNOT FALL ON THE FLOOR OR INTO MACHINERY. Avoid placing tools anywhere above machinery or electrical apparatus. Serious damage can result when a tool falls into the machinery after the equipment is energized.

NEVER USE DAMAGED TOOLS. A battered screwdriver may slip and spoil the screw slot, damage other parts, or cause painful injury. A gauge strained out of shape can result in inaccurate measurements.

Remember, the efficiency of a craftsman is determined to a great extent by the condition of his or her tools and the manner in which they are maintained. Anyone watching a skilled craftsman at work notices the care and precision with which tools of the trade are being used.

The care of hand tools should follow a pattern similar to personal articles; that is, always keep hand tools clean and free of dirt, grease, and other foreign matter. After use, return the tools promptly to their proper place in the toolbox. Improve your efficiency by organizing tools in such a way that those used most frequently can be reached easily without digging through the entire contents of the toolbox. Avoid accumulating unnecessary junk.

Q1. You should always use tools safely and in what manner?

Q2. Tool kits available in an NMCB are listed in what NCF inventory?

UNDERGROUND SANITARY PIPING

LEARNING OBJECTIVE: *Recognize the different types of piping and methods for measuring, cutting, and joining sanitary piping.*

The main purpose of a sanitary sewage collection system is to transfer sewage from the source to the sewage treatment plant. Raw sewage that is not transferred safely to a sewage treatment plant can harm human beings because it contains harmful bacteria.

The sanitary sewage collection system includes all house sewers, laterals, branches, interceptors, force mains, and so on. In this section of the chapter, we are primarily concerned with materials and operations required in the installation of sewer systems.

The installation of an underground sewer system for transferring domestic sewage from the source to the sewage treatment plant includes (1) trenching and grading, (2) measuring and cutting pipe, (3) laying pipe, (4) joining pipe, (5) testing, and (6) backfilling and tamping.

TRENCHING AND GRADING

Underground pipe requires excavation, either manually or with heavy equipment, depending primarily on the size of the job and the type of soil to be removed. On a large job where the soil is suitable for machine work, your project supervisor arranges to have Equipment Operators operate those pieces of equipment necessary to excavate or dig the trench. When it is impractical to use machines, you must do the job with a pick and shovel. Whichever method is used, the trench must be dug wide enough (2 feet minimum) to allow ample working room to join pipe sections. The bottom of the trench must also be sloped in the direction of flow, so sewage traveling through the pipeline laid in the trench is not restricted. On most jobs, an Engineering Aid is on hand to check elevations to ensure that the slope of the trench is close to the slope where the pipe is to be laid. On most jobs, Engineering Aids establish a system of batter boards and grade bars (explained later) for you to check the slope of the pipeline accurately, as it is being laid in the trench. Check the job specifications for the proper grade of the sewer line being installed. When specifications are not available, a rule of thumb is to

FACSO RPT SYM/NO. 0440/B3561R0 INVENTORY MANAGEMENTS SYSTEMS 92MAR02

PROJECT NO. N0293 KIT INVENTORY LIST TA13 NCFSU PAGE 22

SEQUENCE = KIT, SEQ. NO., ALPHA

80001 SEQ. NO. 2 (JULIAN DATE OF INVENTORY/ NAVSUP FORM 1250 DEPT NO., AND QUANTITY SHORT)

COG	STOCK NUMBER QTY UI NIT PRICE EXT.PRICE	(J/D) DEPT # (QTY)	(J/D) DEPT # (QTY)	(J/D) DEPT # (QTY)	(J/D) DEPT # (QTY)	(J/D) DEPT # (QTY)	(J/D) DEPT # (QTY)	(J/D) DEPT # (QTY)
9Q	5136-00-555-8912 1 EA 471.17 471.17 THREADER, PIPE, HAND, ADJUSTABLE SEG MENTAL DIE, 1 TO 2 NPT	( )	( )	( )	( )	( )	( )	( )
9G	3439-01-068-2003 1 EA 175.47 175.47 TOUCH AND HANDLE, HEATING, FOR USE W/ALL LP GASES (USE WITH NSN 3939-01-067-9299)	( )	( )	( )	( )	( )	( )	( )
9G	3439-01-067-9299 1 EA 86.68 86.68 TOURCH OUTFIT SOLDERING AND HEATING F/USE W/ALL LP GASES W/HOSE, REGULATOR, HANDLE AND TWO TIPS (SEE SKO FOR COMPONENT BREAKDOWN)	( )	( )	( )	( )	( )	( )	( )
9Q	5120-01-204-9844 1 EA 175.47 175.47 VISE ABD STAND PIPE 1/4n - 4n CHAIN 3 LEGS W/ PIPE BENDER 45-1/2LBS	( )	( )	( )	( )	( )	( )	( )
9Q	5110-00-837-0990 6 EA 1.97 11.82 WHEEL PIPE CUTTING .346N BORE DIA 3/4N L X .08N MAX W X 1-17/64N OD CUTING BLADE 5/8N OD HUB	( )	( )	( )	( )	( )	( )	( )
9Q	5120-00-277-9086 1 EA 48.15 48.15 WRENCH ADJ MONKEY 1-3/16N MAX 7-3/4N OAL NON-MAGNETIC NON-SPARKING	( )	( )	( )	( )	( )	( )	( )
9Q	5120-00-449-8083 2 EA 7.92 15.84 WRENCH ADJ OPEN END 1-1/8N MAX SGL HEAD RACK/WORM ADJ 12N OAL CHROME	( )	( )	( )	( )	( )	( )	( )
9Q	5120-00-264-3796 1 EA 10.71 10.71 WRENCH ADJ OPEN END 1-5/16N MAX SGL HEAD RACK/WORM ADJ 12N OAL CHROME	( )	( )	( )	( )	( )	( )	( )

Figure 3-1.—Plumber's kit inventory list.

slope the trench 1/4 inch per foot. This is the grade at which sewage flows freely through a pipe and provides proper scouring action to keep the sewage flowing.

When a pipeline is to be laid in stable soil, such as hard clay or shale, the trench should be excavated below the pipe grade. If bell-and-spigot pipe is to be used, excavation must be made for the bells. See that enough undisturbed earth remains at the bottom of the trench, so the pipe, both joints and hubs, rests on and is fully supported by undisturbed earth. In areas where the temperature drops below freezing, the trench must be excavated deep enough for the pipeline to be below the frost line. Pipes that cross under roads or areas of vehicular traffic must be buried in trenches at least 4 feet deep and may require some type of metallic sleeving. Refer to the specifications of the job for details on sleeving pipe.

The sides of excavations, 4 feet or more in depth or in which the soil is so unstable that it is not safe at greater depths, should be supported by substantial and adequate sheeting, sheetpiling, bracing, shoring, and so forth, or the sides should be sloped to the angle of repose. Surface areas adjacent to the sides should be well-drained. Trenches in partly saturated, filled, or unstable soils must be suitably braced.

SANITARY DRAINAGE PIPING

Among the pipe materials installed underground by Utilitiesmen are cast-iron soil pipe, vitrified clay pipe, concrete pipe, and plastic pipe.

Cast-Iron Soil Pipe (CISP)

Cast-iron soil pipe and fittings are composed of gray, cast iron that is made of compact, close-grained pig iron, scrap iron and steel, metallurgical coke, and limestone. Cast-iron soil pipe is used in and under buildings, protruding from 2 to 10 feet from the building. (The *National Standard Plumbing Code-Illustrated* recommends at least 3 feet.) Here it connects into a concrete, plastic, or clay house sewer line. Cast-iron soil pipe is also used under roads or other places of heavy traffic.

When the soil is unstable, it is better to use cast-iron soil pipe; however, cast-iron soil pipe should not be used in soil containing cinders or ashes; the reason is that the soil may contain sulfuric acids, which cause the pipe to corrode and to deteriorate rapidly.

NOTE

When the soil contains cinders and ashes, instead of using cast-iron soil pipe, use vitrified clay or plastic pipe.

The cast-iron soil pipe used in plumbing installations comes in 5-foot and 10-foot lengths. Sizes of cast-iron soil pipe are 2, 3, 4, 6, 8, 10, 12, and 15 inches nominal inside diameter. It is available as single hub or double hub in design, as shown in figure 3-2. Note that single-hub pipe has a hub at one end and a spigot at the other. The double-hub pipe has a hub at both ends. Hubs, or bells, of cast-iron soil pipe are enlarged sleeve-like fittings. They are cast as a part of the pipe and are used to make a water- and pressure-tight joint with oakum and lead. Cast-iron soil pipe is generally available in two weights: standard or service (SV) and extra heavy (XH). The extra heavy pipe is used where superior strength is required, for example, under roadways, where the pipe may vibrate or settle slightly, and tall stacks. Standard or service weight pipe is adequate for most Navy base construction.

MEASURING.—Cast-iron soil pipe sections are generally 5 and 10 feet in length, but strictly speaking, this is not true. The reference to a 5-foot length of pipe applies to the laying length, not the overall dimensions. For clarity, first note that cast-iron soil pipe in 2-, 3-, 4-, and 6-inch (inside) diameter sizes are in common use. The length of the bell for the 3-inch-diameter pipe is 2 3/4 inches; and for the 4- and 6-inch-diameter sizes, the length is 3 inches. Now note that while the laying length of a 4-inch-diameter

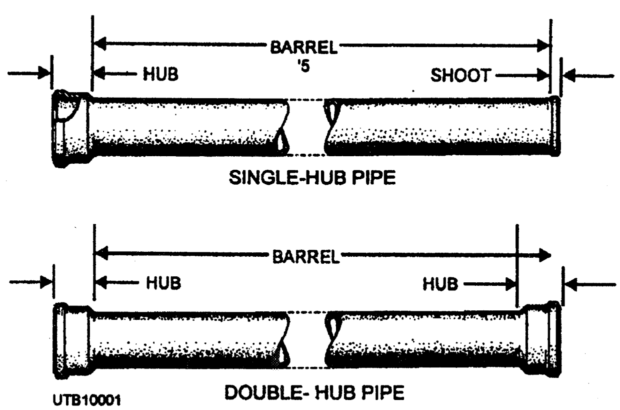


Figure 3-2.—Single-hub and double-hub cast-iron soil pipe.

cast-iron soil pipe is 5 feet, the overall length is 5 feet 3 inches.

The most common measurement of cast-iron soil pipe, for a shorter length than 5 feet, is the overall measurement. When making this measurement for 4-inch pipe, you should take the desired length of pipe for the installation and add 3 inches to it for the bell.

CUTTING.—Before joining cast-iron pipe, you often have to cut the pipe to provide the desired length. Cast-iron soil pipe can be cut with an abrasive cutter, a band saw, a hydraulic manual snap or ratchet cutter (fig. 3-3, views A and B), or a hammer and chisel. The hammer and chisel method is slow and used only when other cutting tools are not available. Here is a step-by-step procedure for cutting with a hammer and chisel.

- Mark or score the pipe with a triangular file or wrap your belt around the pipe and mark the cut line with soap stone.
- Lay the pipe over a board or mound of earth at the point to be cut to support the pipe (fig. 3-4) and allow it to turn easily.
- Score the pipe with a cold chisel (not too sharp). Move the chisel a little at a time along the mark, tapping lightly with a hammer until the pipe is evenly scored all around.

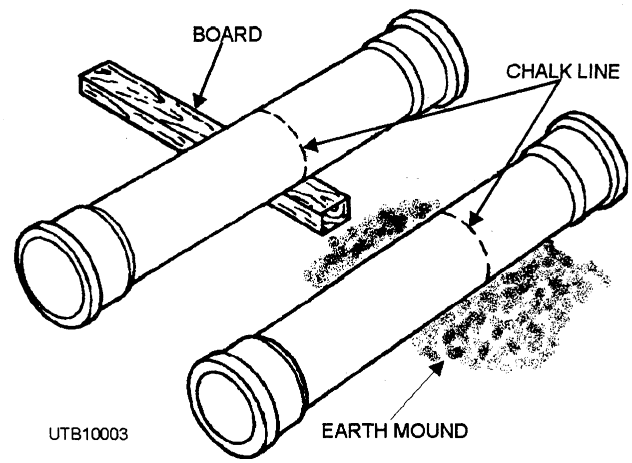


Figure 3-4.—Supporting soil pipe for cutting.

- Continue to turn the pipe and strike the chisel with increasingly heavier blows until the pipe breaks on the line evenly.

Another means of cutting a short piece, 1 or 2 inches, is with a hacksaw and an adjustable wrench. Cut a groove with the hacksaw around the pipe to a depth equal to one half of the wall thickness of the pipe. Break away the section of pipe with an adjustable wrench, used as a lever, as shown in figure 3-5.

A good point to remember is that if you must cut a short piece of CISP (cast-iron soil pipe), cut it from a piece of double-hub pipe (a hub on both ends instead

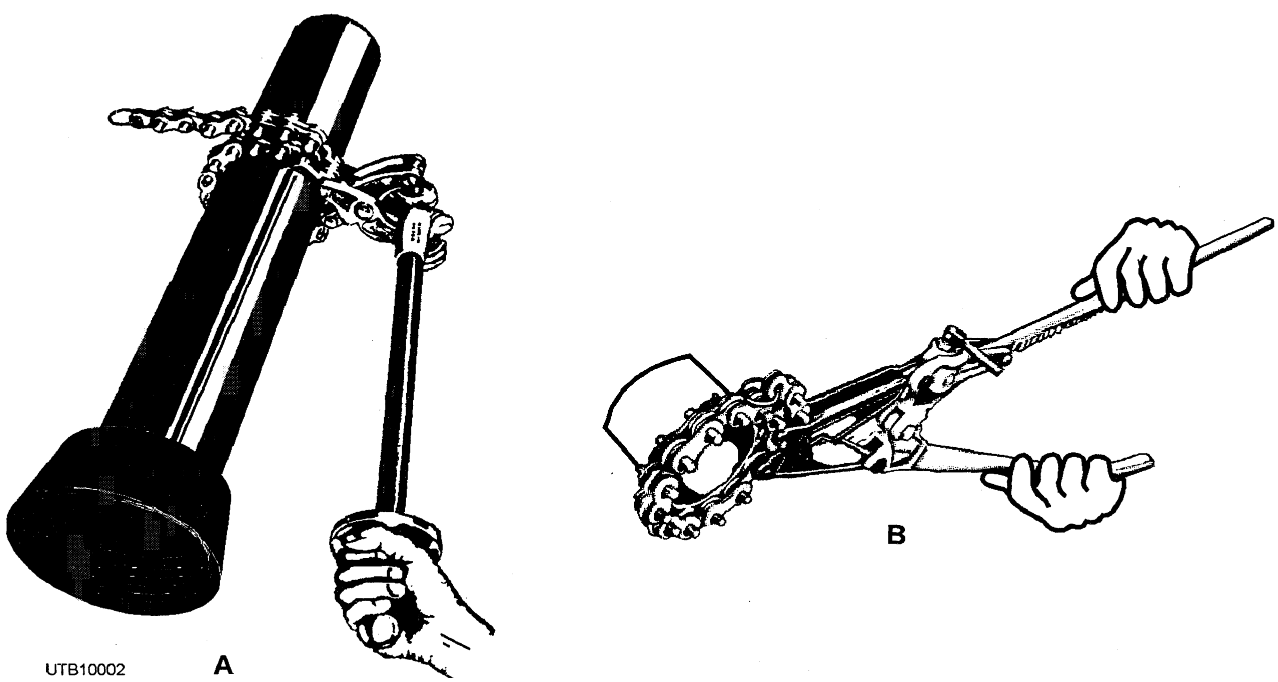


Figure 3-3.—Ratchet cutter and squeeze cutter.

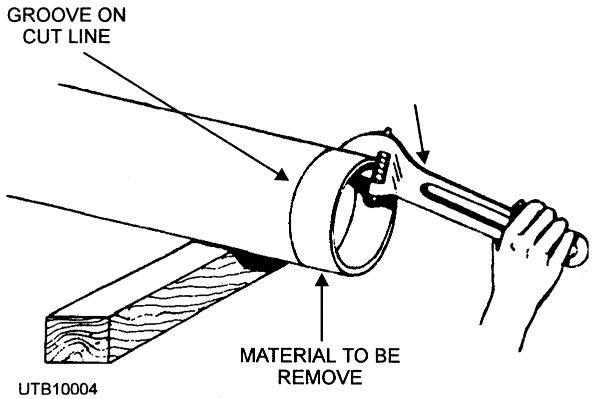


Figure 3-5.—Cutting cast-iron pipe with hacksaw and adjustable wrench.

of a hub and spigot). Thus the remaining pipe still has a hub, and it can be used.

FITTINGS.—Cast-iron soil pipe fittings are used for making branch connections or changes in the direction of a line. Both cast-iron soil pipe and fittings are brittle, so exercise care to avoid dropping them on a hard surface. Some of the cast-iron soil pipe fittings you may use in your work are described below.

A number of different types of bends are generally used on jobs involving cast-iron soil pipe. Some of the common types are the 1/16, 1/8, short sweep 1/4, long sweep 1/4, and reducing 1/4 bend. Look at figure 3-6 to get an idea of the shape and appearance of each of these types of bends.

The 1/16 bend is used to change the direction of a cast-iron soil pipeline 22 1/2 degrees. A 1/8 bend is used to change the direction of a cast-iron soil pipeline 45 degrees. The SHORT SWEEP 1/4 bend is a fitting used to change the direction of a cast-iron soil pipeline 90 degrees in a short space. The LONG SWEEP 1/4 bend is used to change the direction of a cast-iron soil pipeline 90 degrees, but more gradually than the short sweep 1/4 bend. The REDUCING 1/4 bend gradually changes the direction of the pipe 90 degrees, and in the sweep portion, it reduces nearly one size. A 4 by 3 reducing long sweep 1/4 bend has a 4-inch SPIGOT on one end, reducing 90 degrees to a 3 1/4-inch HUB on the other end. Note that for all CISP fittings, the spigot end is always listed first.

Tees connect branches to continuous lines. Learn to recognize the four designs of tees shown in figure 3-7. For connecting lines of different sizes, REDUCING tees are often suitable.

The TEST tee is used in stack and waste installations where the vertical stack joins the horizontal sanitary sewer (fig. 3-8). It is installed at this point, so the plumber can insert a test plug and fill the system with water in testing for tightness. The test tee is also used in multistory construction.

The TAPPED tee is frequently used in the venting system; it is called the main vent tee. The SANITARY tee is commonly used in a main stack to allow the takeoff of a cast-iron soil pipe branch.

Four types of cast-iron soil pipe 90-degree Y-branches are in general use, as shown in view A,

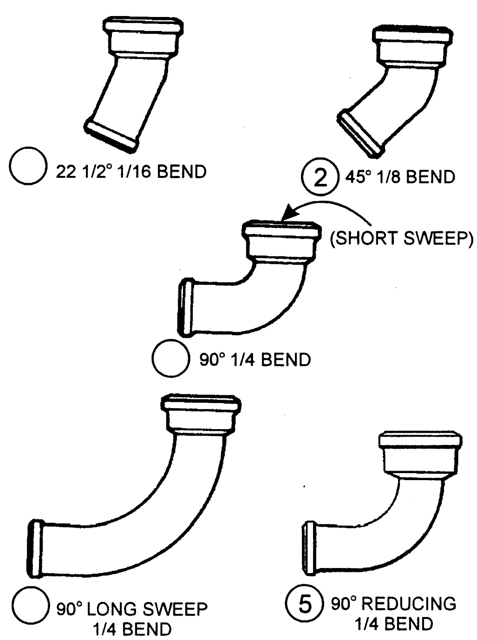


Figure 3-6.—Types of cast-iron soil pipe bends.

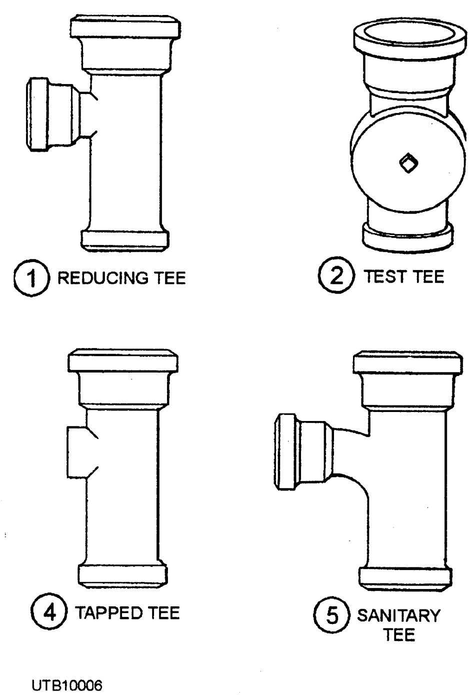


Figure 3-7.—Cast-iron soil pipe tees.

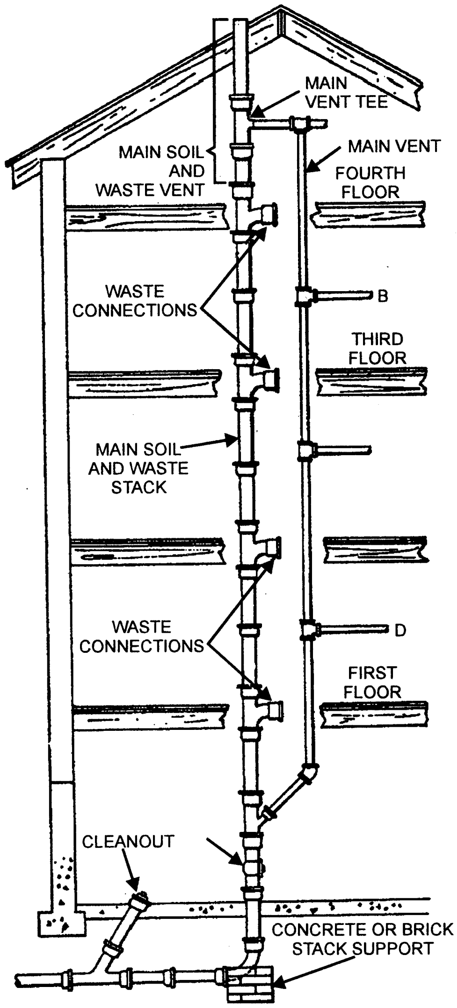


Figure 3-8.—Typical stack and vent installation.

figure 3-9. These are normally referred to as combination Y and 1/8 bends.

The STRAIGHT type of 90-degree Y-branch has one section that is straight through and a takeoff on one side. The side takeoff starts out as a 45-degree takeoff and bends into a 90-degree takeoff. This type of branch is used in sanitary sewer systems where a branch feeds into the main, and it is desirable for the incoming branch to feed into the main as nearly as possible in a line parallel to the main flow.

The REDUCING 90-degree Y-branch is similar to the straight type; however, as shown in view A, figure 3-9, the branch takeoff of the 90-degree Y-branch is smaller than the main straight-through portion. It is generally used the same as the straight type, except the branch coming into the main is a smaller pipe than the main.

The DOUBLE 90-degree Y-branch (or DOUBLE COMBINATION Y and 1/8 BEND) is easy to recognize since there is a 45-degree takeoff bending

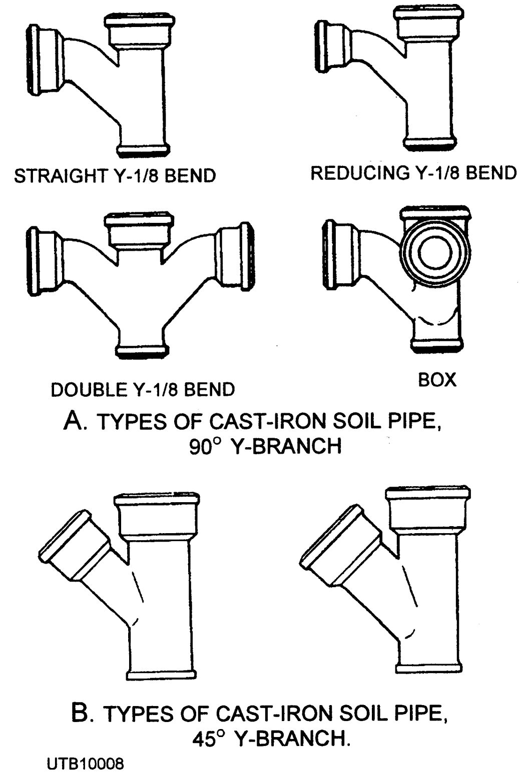


Figure 3-9.—Types of cast-iron soil pipe, 90- and 45-degree Y-branches.

into a 90-degree takeoff on both sides of the fitting, as shown in view A. It is very useful as an individual vent.

The BOX type of 90-degree Y-branch has two takeoffs. It is designed for each takeoff to form a 90-degree angle with the main pipe. The two takeoffs are spaced 90 degrees apart.

There are two types of cast-iron soil pipe 45-degree Y-branches. These are the reducing and the straight types; both are shown in view B, figure 3-9.

The REDUCING type is a straight section of pipe with a smaller size 45-degree takeoff branching to one side. There are different sizes of this fitting. As an example, a 4 by 4 by 3 reducing 45-degree Y-branch has a 4-inch-straight portion with a 3-inch 45-degree takeoff on one side.

The STRAIGHT type of 45-degree Y-branch, or true Y, is the same as the reducing type, except that both bells are the same size. It is used to join two sanitary sewer branches at a 45-degree angle.

Cleanout plugs are installed to permit removal of stoppages from waste lines. View A, figure 3-10, shows one type of cleanout plug. It consists of an iron ferrule caulked with the hub of a pipe or fitting. The top opening is taped and threaded, so a pipe plug can be screwed into it. Cleanouts should not be more than 50

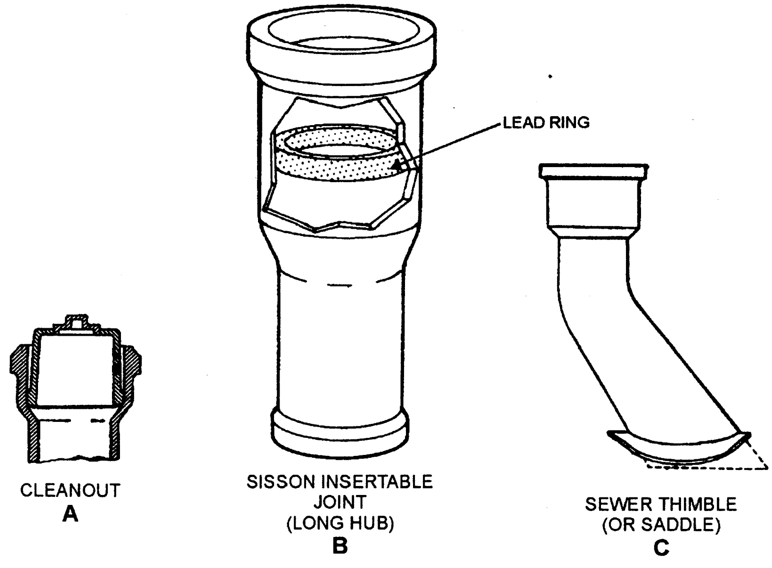


Figure 3-10.—Adapter-type cast-iron soil pipe fittings.

feet apart in horizontal 4-inch building drain lines in a straight run. When the change of direction is greater than 45 degrees (or a 1/8 bend), you must install a cleanout plug.

The long hub, or Sisson, type of cleanout (view B, fig. 3-10) is used as an insert to an existing line. The long hub allows you to push it up far enough to clear the other bell of the bottom pipe, and then to drop the fitting in place.

Another type of adapter is a sewer thimble (or saddle). This is a special fitting that is used to tie into an existing sewer line, as shown in view C, figure 3-10. It has a hub on one end, bending around to almost 45 degrees, with a flange near the opposite end. To install, cut a hole halfway between the top and the center line in the sewer line. The hole should be the same size as the outlet portion of the thimble beyond the flange. Slip the thimble into the opening until the flange seats on the sewer pipe. Using oakum and concrete, grout around the thimble to make a watertight joint.

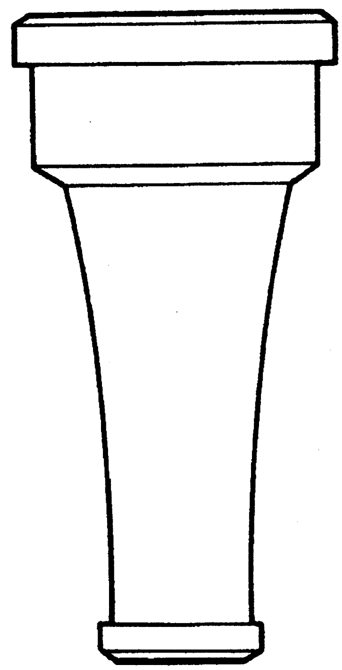


Figure 3-11.—Increaser.

The increaser (fig. 3-11) is used to increase the size (diameter) of a straight-through line. It is often used at the top of a main stack and vent.

A closet bend (fig. 3-12) is a special fitting inserted into a soil branch. This enables the soil branch to be fitted to the water closet. It may be untapped or have either one or two side taps for waste to vent use. Closet bends are made in different styles to fit different types of floor flanges (rims for attachment). One type (view A, fig. 3-12) has a spigot end for caulking into the branch line, and a scored end (marked with lines) to fit into the floor flange. The scoring makes it easier to cut the bend to the desired length for a given connection. Another type, shown in view B, figure 3-12, has a hub connected to the floor flange with a sleeve or short length of pipe. The end caulked into the soil line is scored for cutting to size. Still other types may be scored for cutting at both ends or may be of the regular hub-and-spigot pattern.

Regular offsets, view A, and 1/8 bend offset, view B, figure 3-13, are used to carry the soil or waste lines

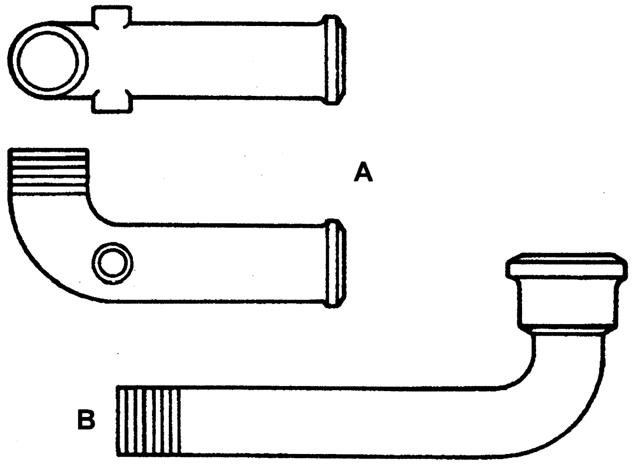


Figure 3-12.—Cast-iron soil pipe closet bends.

past an obstruction, such as a part of the building. The 1/8 bend offset gives a smoother transition than the regular one. Fittings for no-hub cast-iron pipe are identical to the others, except there are no hubs.

JOINING.—Various methods are used in joining pipe. This means that you must know the procedure to make various types of joints required for the kind of pipe to be joined. Lead and oakum joints, oakum and lead-wool joints, compression joints, and no-hub joints are means for connecting pipes. Figure 3-14 shows these types of joints; however, if oakum is not available, cotton braid or jute can be used as a substitute. Oakum is made of hemp or jute fibers, impregnated with a bituminous compound and loosely twisted or spun into rope or yarn.

In making caulked joints, you need various types of equipment. Because of the importance of this equipment, the common types of caulking equipment and safety procedures to be observed when making caulked joints are discussed.

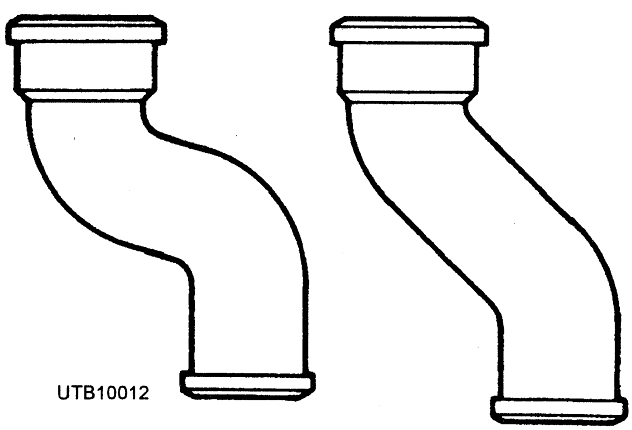


Figure 3-13.—Offsets.

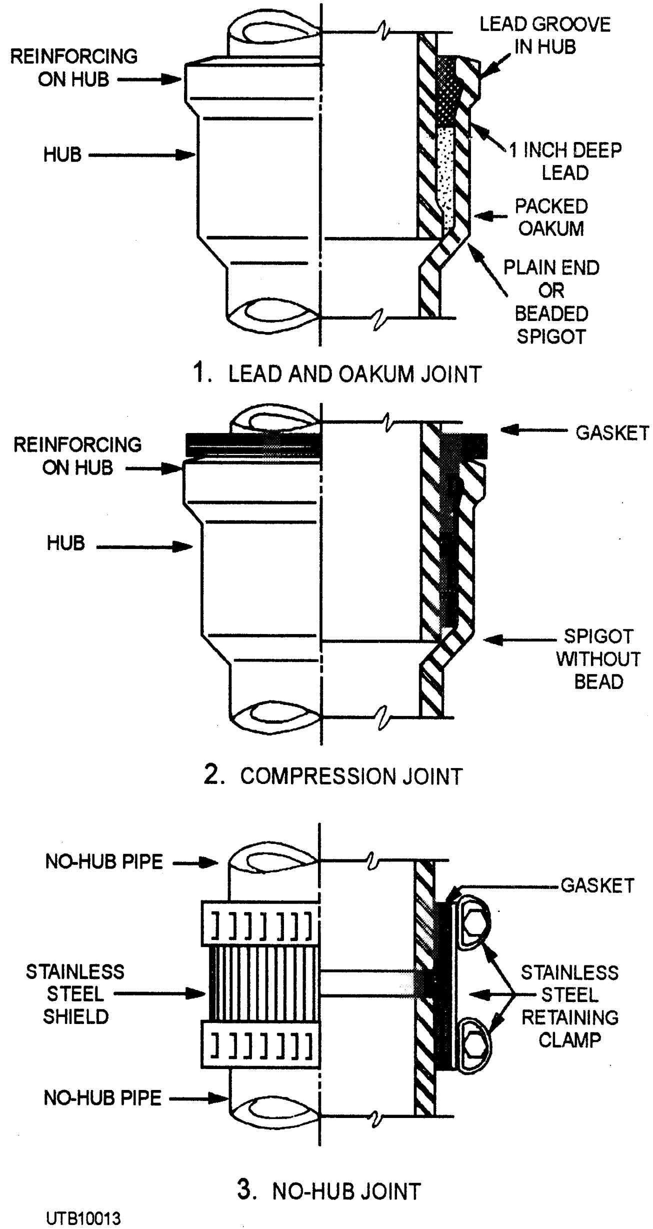


Figure 3-14.—Various joints used to connect CISP and fittings.

Equipment frequently used in making caulked joints in cast-iron soil pipe includes the melting furnace, melting pot, and plumber's ladle. These components are shown in figure 3-15. The melting furnace is a portable gas-burning furnace used to melt lead. The melting pot is made of cast iron and contains the lead while it is being melted on the furnace. The ladle, also made of cast iron, is used to spoon up the molten lead and carry it to the joint to be poured.

Several types of melting furnaces are available. Follow the manufacturer's instructions when you are operating a particular type. The general procedure below is for operating a MAPP-gas burning melting furnace.

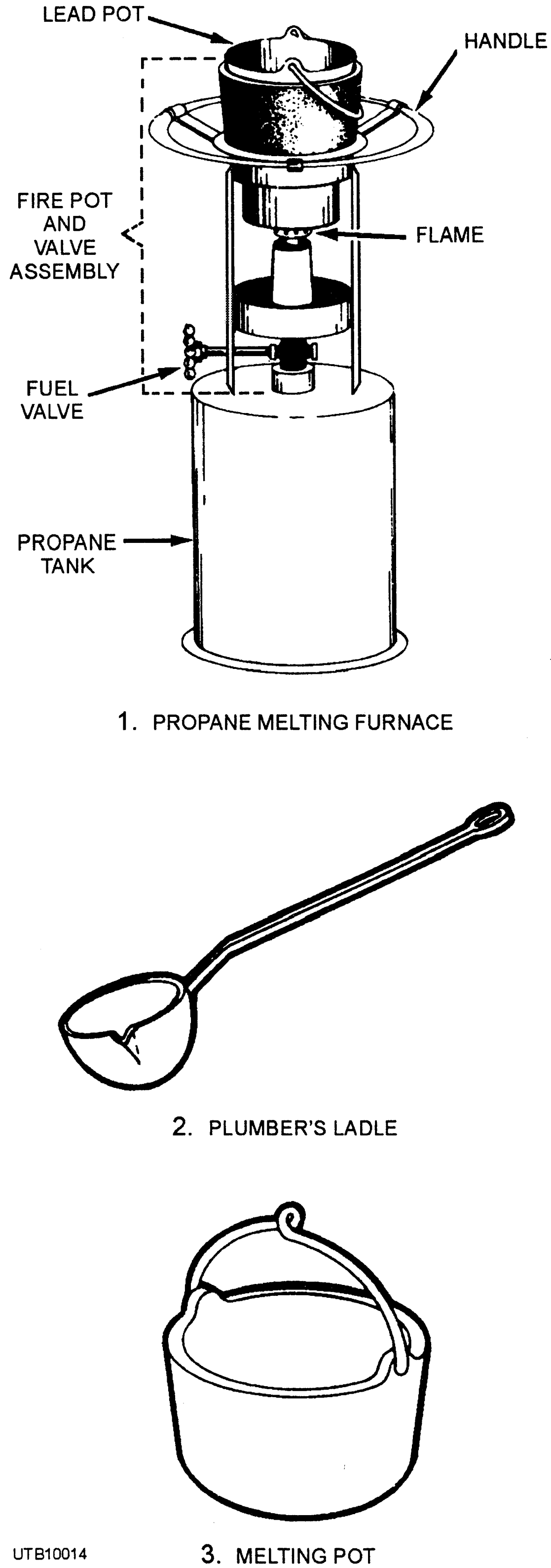


Figure 3-15.—Melting furnace, plumber's ladle, and melting pot.

This type of furnace consists of a fire pot and valve assembly that mounts directly on a portable propane gas tank. The tank is detachable and can be recharged with fuel. A propane furnace, as shown in figure 3-15, lights instantly and burns with a high-temperature blue flame.

Look for leaks before you light the furnace. There is always a danger of explosion from gas leakage around the connections and valves. To light the propane furnace, fold or twist a piece of paper and light it. Hold the flame up and under the burner orifice of the fire pot. Stand back as far as possible and open the fuel valve until the burner lights. When the valve is opened too much or too rapidly, the pressure of the escaping gas may extinguish the lighter flame. If this should happen, close the fuel valve immediately and then light the paper before you reopen the valve.

Molten lead is dangerous. Most accidents occur because the Utilitiesman ignored safety procedures. When molten lead is handled, be SAFETY MINDED. When moisture gets into the molten lead, the heat will cause the moisture to boil rapidly and splash hot lead out of the melting pot. If you suspect moisture in the lead, heat the lead with a torch until the moisture is driven off. Now, you can add the lead to the melting pot. Make sure the plumber's ladle is free of moisture too.

When lead is melted, certain products of oxidation, known as slag, form on top of the molten metal. The slag must be removed from the lead before it can be used for pouring a joint. Scoop it up in the plumber's ladle. Use care in disposing of the slag.

Always preheat the ladle before you dip it into the lead because a cold ladle chills and solidifies some metals. When the ladle is in steady use, keep it hot by hanging it over the edge of the pot. In loading the ladle, use the bottom of it to push back the dross (or scum) on top of the lead, exposing enough clean lead so that the ladle can be filled and withdrawn without dross. Do not disturb the molten lead more than is necessary.

Wear a face shield, gloves, and protective clothing when melting and pouring the lead. Keep out of range of flying lead even though the joint appears dry. Also, see that drops of perspiration do not drop into the pot of hot lead.

When making vertical caulked joints, you should wipe the hub-and-spigot ends of the pipes to remove moisture and foreign matter. WATER CAUSES MELTED LEAD TO SPATTER AND SERIOUS BURNS MAY RESULT. If the ends are wet, dry them with a torch. Slide the spigot end of one pipe into the hub of the other and align the joint, so the cut end is in

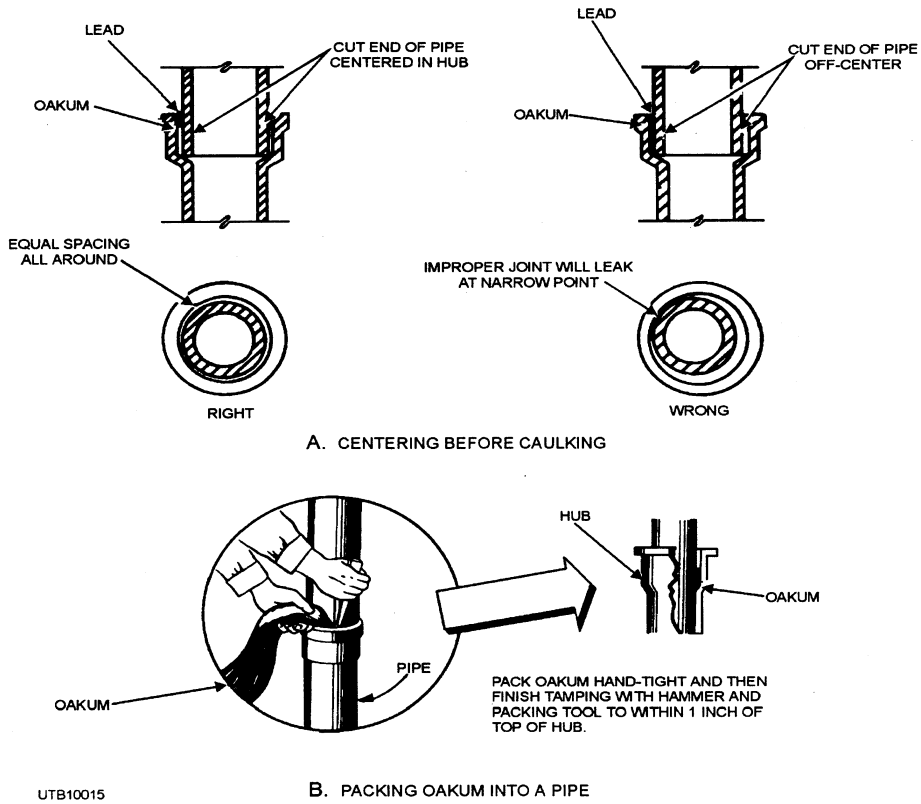


Figure 3-16.—Caulking cast-iron joints.

the center of the hub, as shown in view A, figure 3-16. As shown in view B, figure 3-16, use packing (yarning) irons (1 and 2, fig. 3-17), and pack a layer of spun or twisted oakum into the hub completely around the joint. Repeat with more layers until the hub is packed to about 1 inch from the top. Compress the oakum thoroughly to make a solid bed for the lead and to prevent leakage of the joint. With a plumber's ladle (2, fig. 3-15), pour melted lead carefully into the joint until it rises slightly above the top rim of the hub (fig. 3-18). Dip up enough lead with the ladle to make the joint in one pouring. Allow a minute or two for the lead to harden.

CAUTION

To avoid using a wet ladle to dip the hot lead, you must heat the ladle. Remember, moisture causes hot lead to spatter out of the melting pot. Always wear protective clothing, face shield, and gloves when working with hot lead.

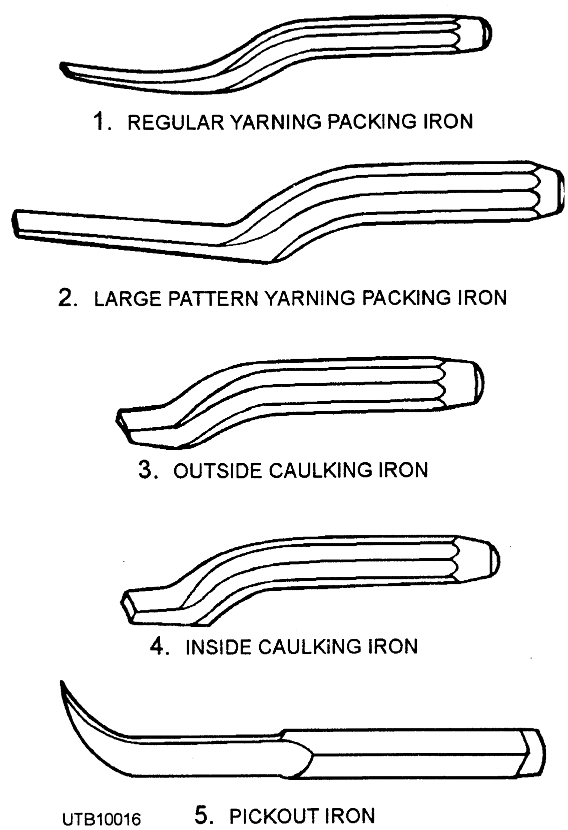


Figure 3-17.—Packing and caulking irons.

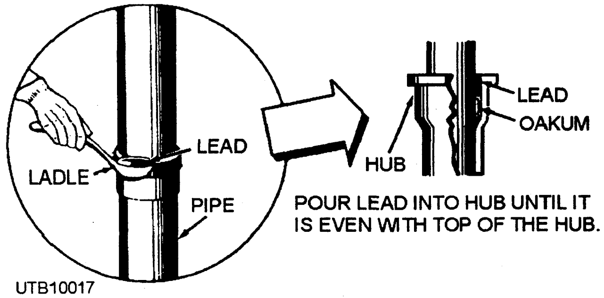


Figure 3-18—Pouring hot lead into a joint.

Perform caulking operations using an inside caulking iron first and then an outside caulking iron (views 4 and 3, fig. 3-17). Drive the lead down upon the oakum and into contact with the spigot surface on one edge and against the inner surface of the hub on the other. Strike the caulking iron gently but firmly with a hammer. Caulking the lead too tightly can crack the pipe. A cracked pipe or fitting must be replaced. A pickout iron (view 5, fig. 3-17) should be used when oakum and lead must be removed from a joint.

Sometimes a joint must be made in a vertical line with the hub upside down as in a vent stack. Prepare the ends of the pipes and pack the joint with oakum, as shown in view B, figure 3-16. Clamp a joint runner around the pipe. Raise the end of the joint runner, as shown in figure 3-19, and make a funnel in the raised end, using fine clay, putty, or plaster. The funnel must be at least as high as the inside height of the lead portion of the joint.

CAUTION

Be sure the funnel is dry before the lead is poured to prevent the hot lead from blowing out. Pour the lead and allow it to cool before removing the joint runner. Caulk the lead with a caulking iron to adjust it to the inside walls of the hubs.

When making a horizontal caulked joint, you must prepare the ends of the pipes by packing the joint with oakum, as shown in view A, figure 3-20. Clamp a joint runner around the pipe; place a small piece of oakum between the clamp and the pipe to seal the gap and prevent hot lead from running out of the joint; and then fill the joint with melted lead, as shown in view B, figure 3-20. After the lead hardens, remove the runner and the trim off of the surplus lead with a chisel. Caulk the lead in the same way as a vertical joint, as shown in view C, figure 3-20.

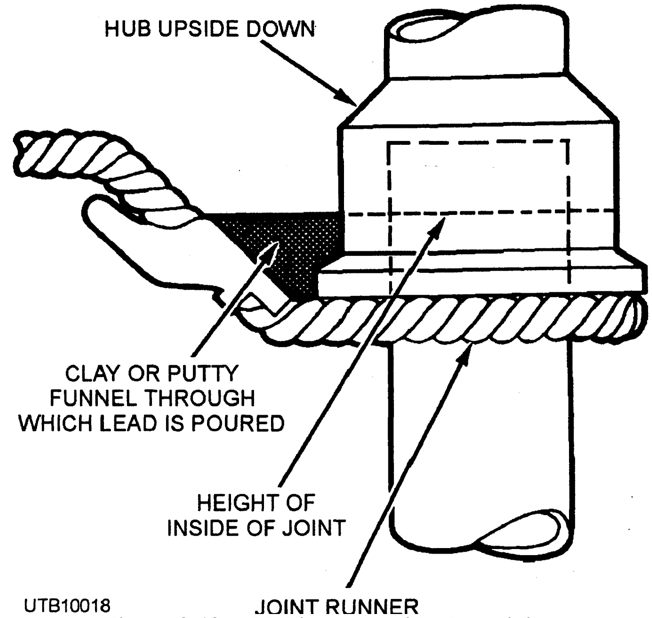


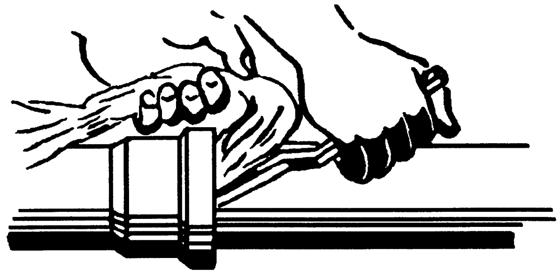
Figure 3-19.—Making an upside-down joint.

When making a lead-wool joint in cast-iron soil pipe, you need a yarning iron and a caulking iron. This is a cold-caulked joint and should be used where a line is underwater or in a wet place where molten lead cannot be used. Before starting the joint, place the spigot end of the pipe to be installed in the hub of the soil pipe. Make sure the pipe is blocked securely with braces to prevent shifting. The pipe must also be centered in the hub, so the thickness of the joint is uniform. With the pipe braced firmly and in proper position for joining, make the joint following the procedure provided below:

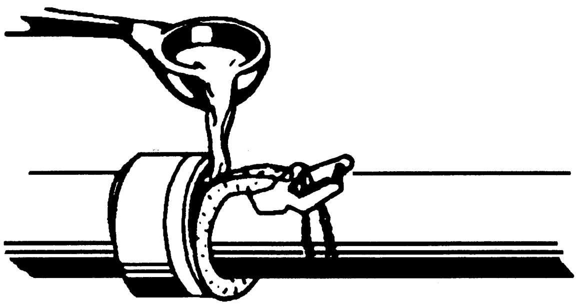
- Pack oakum in the joint to within 1 inch of the top of the hub. Use a ball peen hammer and a packing iron to tamp the oakum tightly in the joint.
- Pack two 1/2-inch layers of lead wool over the oakum.

Tamp the lead wool tightly into the joint, using the caulking irons and the ball peen hammer. (See fig. 3-21.)

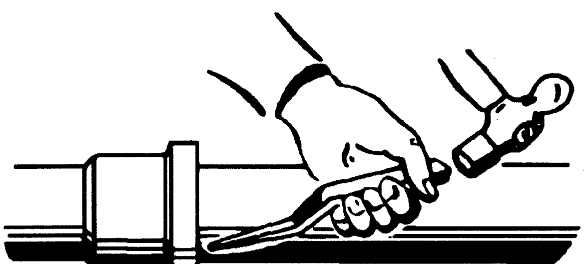
In making a compression joint, you should be sure to clean the internal surface of the hub and the external surface of the pipe and/or fitting to be joined. When using a cut pipe, you can remove the sharp edge by peening or by lightly filing the rough edge to permit the pipe to slide and NOT gouge into the gasket. Insert the gasket into the hub, and make sure the retaining flange or collar of the gasket is next to the face of the hub. Be sure to use the recommended lubricants available (normally a soap or an adhesive type). They are applied to the inside of the gasket. Align the spigot



A. PACK JOINT HALF FULL OF OAKUM.



B. CLAMP JOINT RUNNER AROUND PIPE AND POUR LEAD INTO JOINT. PLACE PUTTY OR CLAY ON BACKSIDE OF RUNNER TO PREVENT LEAD FROM RUNNING UNDER RUNNER CLAMP.



C. REMOVE JOINT RUNNER WHEN LEAD HAS COOLED AND CAULK JOINT.

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Figure 3-20.—Making a joint on horizontal piping.

and hub to be joined, keeping the spigot and hub in a straight line. The spigot end of the pipe or fitting can be forced into the gasket by using an assembly tool, as shown in figure 3-22.

When joining CISP as a no-hub joint, place a neoprene or an elastomeric gasket on the end of one pipe and the stainless steel shield and clamp assembly, as shown in figure 3-23, on the end of the other pipe. Firmly seat the pipe ends against the integrally molded shoulder inside the gasket. Slide the shield and clamps into position over the gasket and tighten the stainless steel clamps alternately and firmly to about 60 inch-pounds of torque. A torque wrench set at 60 inch-pounds is available in the NMCB cast-iron kit (assembly 80055).

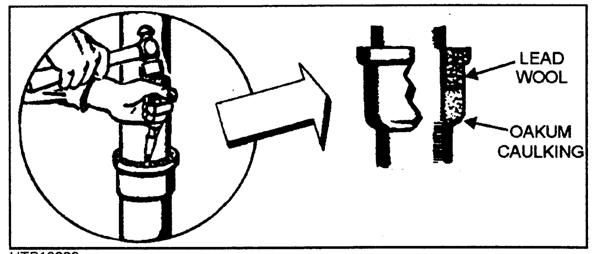

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Figure 3-21.—Tamping lead wool.

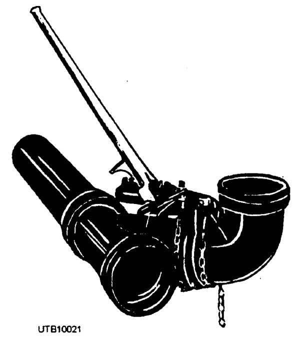

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Figure 3-22.—Compression joint assembly.

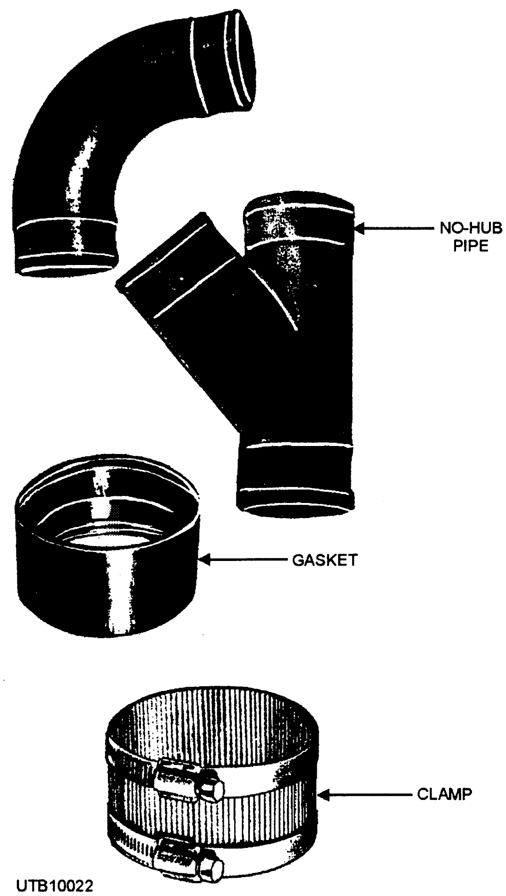

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Figure 3-23.—No-hub pipe and fittings.

Vitrified Clay and Concrete Pipe

Vitrified clay pipe is made of moistened powdered clay. It is available in laying lengths of 2, 2 1/2, and 3 feet and in diameters ranging from 4 to 42 inches. Like cast-iron soil pipe, it has a bell end and a spigot end to make joining easy.

After the pipe is taken from the casting, it is glazed and fired in large kilns to create a moistureproof baked finish. It is used for house sewer lines, sanitary sewer mains, and storm drains. The types of fittings for clay pipe are primarily bends, tees, and Y-branches.

You may have to use plain precast concrete pipe for sewers in the smaller sizes-less than 24 inches. This pipe is not reinforced with steel. This concrete pipe is similar to vitrified clay pipe in measuring, cutting, joining, and handling.

HANDLING AND STORAGE OF CLAY PIPE.—Be careful when you store and handle clay pipe because it is very fragile and cracks easily. Never drop clay pipe or roll it down an embankment without control. Do not drop heavy objects on clay pipe. When backfilling a trench, do not use fill with rocks or other heavy debris in it. Tamp by hand or by pneumatic tampers, bearing in mind the density of the backfill. Clay pipe should be laid in a trench and bedded evenly and firmly. The more perfect the bedding, the greater the load the pipe can sustain. Common sense can save a lot of time by eliminating rework.

CUTTING.—Vitrified clay and concrete pipe, both available in such short lengths, seldom need cutting except for manholes and inlets. If, after measurement, you have to cut vitrified clay or concrete pipe, score it with a chisel, deepening the cut gradually until the pipe breaks cleanly at the desired point. Vitrified clay and concrete pipes may be cut with CISP "snap-off" or "chain" cutters.

FITTINGS.—Figure 3-24 shows some common fittings used with vitrified clay and concrete pipes. Note that these types of pipes are used outside the building. This greatly reduces the number of different types of fittings required.

JOINING.—Joints on vitrified clay and concrete pipe may be made of cement or bituminous compounds. Cement joints may be made of grout, which is a mixture of cement, sand, and water. The following procedure may be used as a guide in joining pipe with grout. This procedure is very similar for joining pipe with bituminous compounds.

- Insert the spigot of one length of pipe into the bell of the other and align the two pieces to the desired position.

- Caulk a gasket of oakum about 3/4-inch thick into the bell to prevent the grout from running into the pipe.

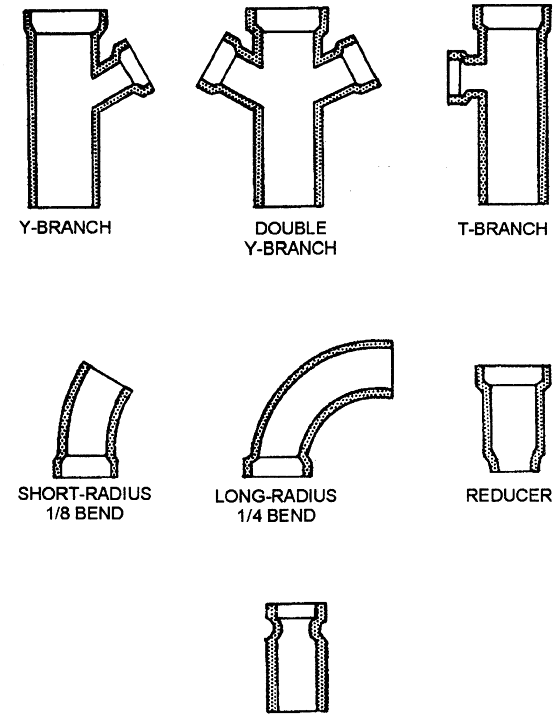


Figure 3-24.—Gross section of clay or concrete fittings.

- Mix grout, using 1 part portland cement, 2 parts clean, sharp, washed sand, and sufficient water to dampen thoroughly.

- Fill the joint with grout, using a packing iron.

- Recaulk the joint after 30 minutes with a packing iron. You have to close shrinkage cracks that occur after the initial set of the grout.

- Smooth and bevel the grout off with a trowel. In hot weather, cover the joint with a wet burlap sack.

- Remove excess mortar with either a swab or a scraper.

Note that a regular swab, with some additional rags tied to the end to compensate for larger size pipe, is ideal for dragging through each length to remove the excess mortar.

The use of "speed seal joints" (rubber rings) in joining vitrified clay pipe has become widespread. Speed seal joints eliminate the use of oakum and mortar joints for sewer mains. This speed seal is made a part of the vitrified pipe joint when manufactured. It is made of permanent polyvinyl chloride and called a "plastisol joint connection." This type of joint helps to ensure tight joints that are rootproof, flexible, and so forth.

The speed seal, or mechanical seal, joint can be installed quickly and easily by one person. To make the joint, first insert the spigot end into the bell or hub.

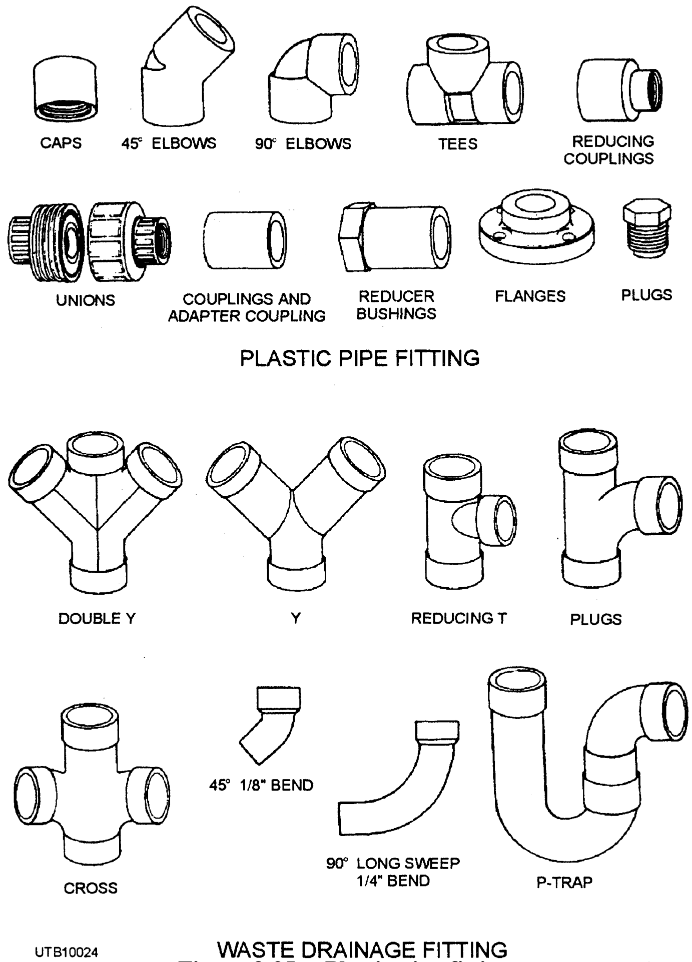


Figure 3-25.—Plastic pipe fittings.

Then give the pipe a strong push, so the spigot locks into the hub seal. A solution of liquid soap may be spread on the joint to help it slip into place easily. You will find that other types of mechanical seal joints are also available. They all use about the same method of installation. Special mechanical seal adapters are made to join vitrified clay pipe with CISP or CISP to vitrified clay pipe.

Plastic Pipe

At first, plastic was used for lawn sprinklers, farm water systems, and acid drainage from mines. Now plastic pipe is used for all kinds of applications, from shipboard installations to municipal water treatment and domestic water uses.

The advantages of plastic pipe (PVC—Polyvinylchloride) include resistance to nearly all acids, caustics, salt solutions, and other corrosive liquids. It does not scale, pit, corrode, or rust. Bacteria does not grow well, and it is also nontoxic. Plastic pipe has very low-friction resistance because of its smooth, inner surface. Being nonconductive, it is not subject to electrolytic corrosion. Plastic pipe can be used underground in acid, alkaline, wet, or dry soil without a protective coating. It is strong and can handle operating pressures in most moderate service processes within the temperature range of that particular material. Plastic pipe is light in comparison to metal. Finally, it can be easily joined in a wide variety of methods. Each method has a certain advantage.

HANDLING AND STORING OF PLASTIC PIPE.—When unloading plastic pipe, do not drop it on the ground. Remember, scratches and gouges from dragging it on rough surfaces tend to reduce the pressure-carrying capacity. Pipe should be stored on racks to prevent sagging. Burrs and sharp edges on storage racks should be removed before storing the pipe. Plastic pipe should be stored in a shaded area away from any source of heat that could cause damage to the pipe. During prolonged storage, it should not be stacked more than 2 feet high because the weight causes it to flatten or go out of round. Before installing plastic pipe, inspect all pipe and fittings for cuts, scratches, buckling, and kinks that should be cut out.

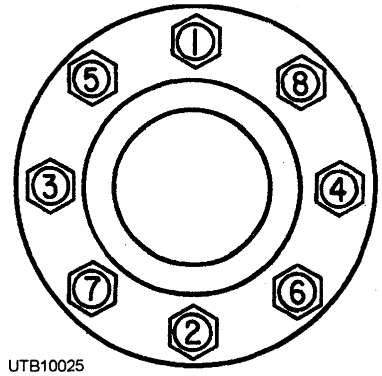


Figure 3-26.—Diametric order of tightening flange bolts.

CUTTING.-When cutting plastic pipe, use either a fine-toothed hacksaw, circular saw, band saw, or reciprocating saw with carbide-tipped blades. Pipe and tube cutters can be used when adapted with a deeper cutting blade made for cutting plastic pipe. DO NOT USE a tubing cutter. The cutting wheel will not cut deep enough, and the outside diameter (OD) of the pipe will become larger. Use a miter box or hold-down rig to help cut the pipe square. Remove all burrs and chips from both the inside diameter (ID) and outside diameter (OD) of the pipe. The end of the pipe should be beveled to approximately 1/16 inch to 3/32 inch at a 10-degree to 15-degree angle. This minimizes the wiping of solvent from the ID of the fitting, as the pipe is put into the socket. You can bevel the end of the pipe with a coarse file or special beveling tool.

FITTINGS.—Plastic flanges and flange fittings (fig. 3-25) are available in a full range of sizes and may be attached to the pipe. Soft rubber gaskets are preferred with plastic flanges. When tightening flange bolts, pull them down gradually to a uniform tightness and in a diametrical manner, as shown in figure 3-26.

JOINING.—There are four methods of joining plastic pipe: solvent welding, fusion welding, fillet welding, and threading. Before solvent welding PVC and CPVC plastic pipe, clean the pipe and fittings, as shown in view B, figure 3-27. Use a clean, dry cloth and wipe away all loose dirt and moisture from inside the fitting and from the outside of the plastic pipe. Ensure the fittings and the pipe are of the same temperature for at least an hour before welding; this will assure they are thermally balanced. With a bristle brush, apply a coating of primer to the outside of the pipe. This removes surface gloss and etches the pipe.

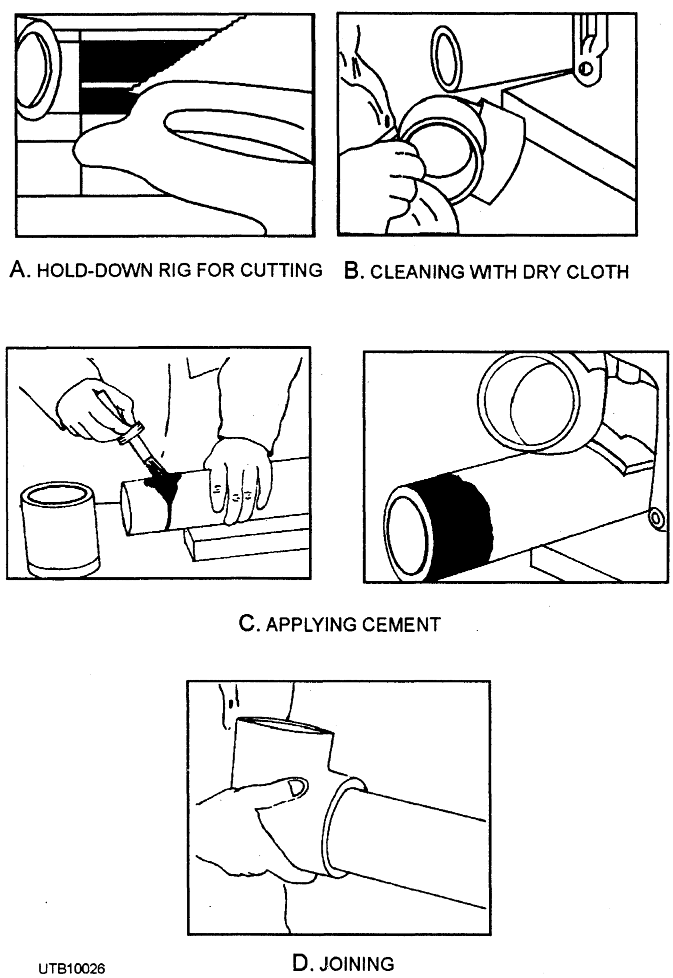
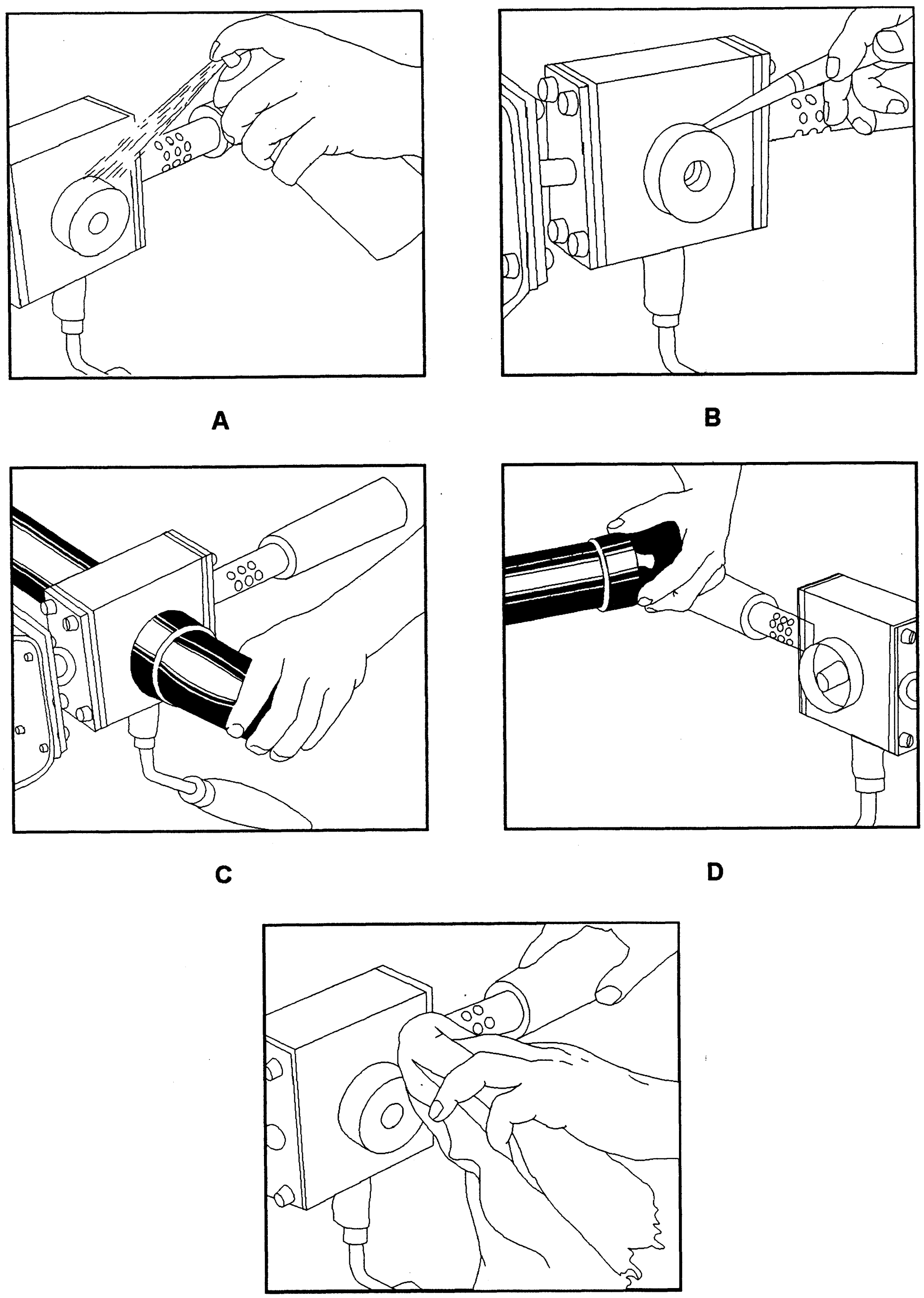


Figure 3-27.—Making cement solvent weld joints on plastic pipe.

Do the same to the inside of the fittings. If the pipe is so hot the primer evaporates or if the pipe is above 90°F, move it to a shaded area before priming the surfaces. Use notched boards to keep the pipe ends out of the dirt. Clean the pipe ends before cement application.

Dip a brush in cement and apply it to the entire active surface of the pipe to a width slightly more than the depth of the socket of the fitting, as shown in view C, figure 3-27. Then brush a light coating in the depth of the socket. (Avoid excess cement to eliminate the buildup inside the fitting when the pipe is socketed.) Apply the second coating of cement to the end of the pipe to ensure no voids exist. (There should be no problem of too much cement on the pipe because the



A B C D E

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Figure 3-28.—Fusion welding plastic pipe.

excess will bead out on the surface of the face of the fitting and can be easily wiped away.) Immediately, upon finishing the cement application, insert the pipe to full socket depth and rotate one fourth of a turn to ensure complete distribution of cement, as shown in view D, figure 3-27. Hold the pipe together for 10 to 15 seconds, so it does not move out of its socket. After joining, immediately wipe the excess cement from the pipe and fitting and gently set the pipe on a level surface. Do NOT move the pipe for about 2 minutes. (As the pipe size increases, it takes longer for the joint to set up.) The pipe SHOULD NOT be joined in temperatures below 40°F and above 90°F or when it is exposed to direct sunlight. The drying time should be at least 48 hours before the joint is moved or subjected to internal or external pressure. The drying time is shorter in hot weather and longer in colder weather. DO NOT ATTEMPT TO SPEED THE SETTING OR DRYING OF THE CEMENT BY APPLYING HEAT TO SOLVENT-WELDED JOINTS. Forced rapid drying by applying heat causes cement solvent to boil off', forming bubbles and blisters in the cement film. During cool weather, the setting of the cement can be speeded by prewarming the cement, the pipe, and the fitting, or by shielding the joint from the wind. CHECK THE SHELF LIFE OF THE CEMENT. Do NOT use cement that is lumpy or stringy. Do NOT try to thin it out with a thinner or primer. Always follow the instructions on the cement container; the above estimates should in no way be used in the place of application instructions.

Fusion welding requires either a gas- or an electric-heated welding tool, as shown in figure 3-28. As the tool warms up, spray its contact surfaces lightly with a silicone-releasing agent (view A, fig. 3-28). This prevents the pipe from sticking to the surface of the welding tool. Check the temperature of the tool. Ensure the tool reaches the proper temperature range (view B, fig. 3-28) before placing the pipe on the heating element. Be sure the pipe is squarely on the element. Hold onto the pipe, as shown in view C, figure 3-28, until a bead appears on the pipe at the entrance of the female tool piece. After the bead appears, remove the pipe and insert it into the fitting, squarely and completely, as shown in view D, figure 3-28. DO NOT ROTATE THE PIPE WHILE IT IS BEING JOINED WITH THE FITTING. After joining, clean the fusion welding tool, as shown in view E, figure 3-28.

In fillet welding plastic pipe, as shown in figure 3-29, maintain uniform heat and pressure on the rod while welding. Too much pressure on the rod stretches the bead and causes the weld to crack, as it cools. The rod should be held at a 90-degree angle to the joint. The rod bends in an arc when proper pressure is applied. When finishing a weld, make the bead overlap the top, NOT alongside itself, for at least 3/8 to 1/2 inch. Never overlap alongside when welds are being spliced.

Threaded plastic pipe should be used only as a temporary piping system. Threading reduces the wall thickness and results in lower pressure ratings. Only schedule 80 or heavier pipe should be used when plastic pipe is being threaded. Never use pipe wrenches to tighten threaded pipe; use a strap wrench, as shown in view A, figure 3-30. Be sure to use an insert within the vise jaws to prevent scoring of the pipe. Use a wood or aluminum plug while the pipe is being threaded to prevent distortion of the pipe and to avoid off-center threads, as shown in view B, figure 3-30. The dies should be sharp; and for best results with power tools, use a 5-degree negative front rake. When tightening threaded joints, avoid too much torque. One or two turns past hand-tight is sufficient. Teflon tape should be used as a pipe joint compound.

PLACING PLASTIC PIPE IN THE GROUND.—On hot days, after the plastic pipe has been cement solvent welded, it is a good idea to snake the pipe beside the ditch or if the ditch is wide enough, in the ditch during its required drying time. DO NOT APPLY STRESS or DISTURB A JOINT THAT IS DRYING. Snaking gives added length to the pipeline to compensate for thermal contraction, as the pipe cools. When the temperature change is less than 30°F, snaking is not necessary. When cement solvent welding on a hot, summer day during the late afternoon, be sure to snake the line. Since the pipe

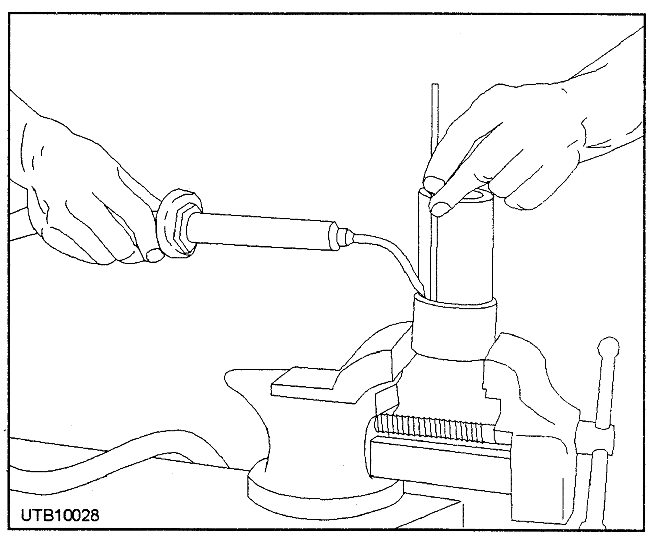
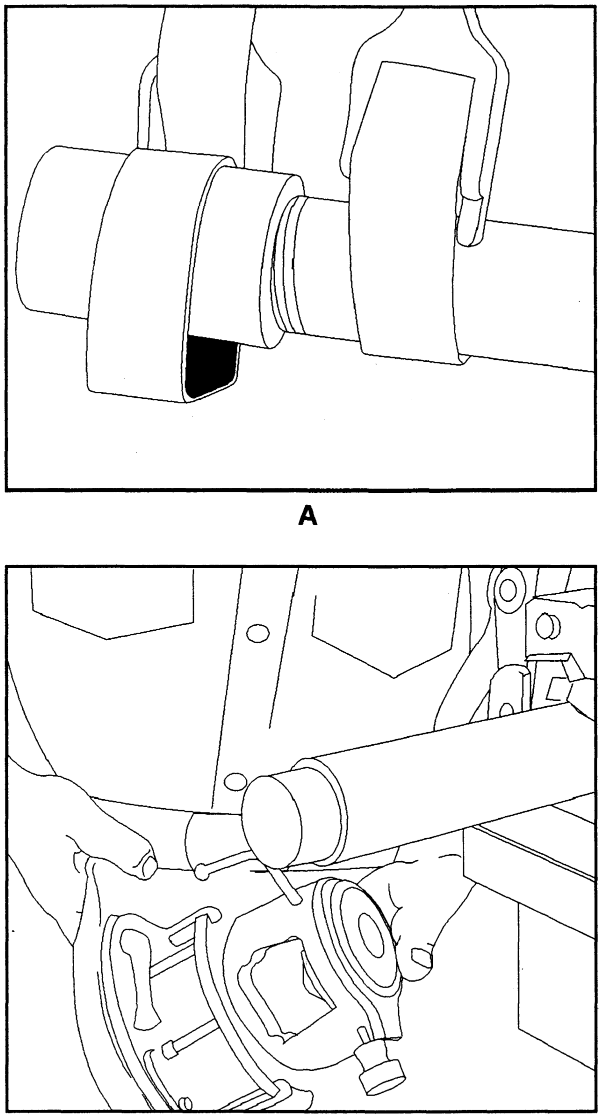


Figure 3-29.—Fillet welding plastic pipe.



A

B

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Figure 3-30.—Threading plastic pipe.

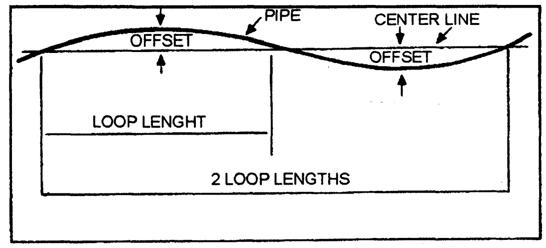
dries during the cool of the night, the thermal contraction of the pipe could stress the joint and pull the pipe apart due to the inadequate time to allow for the cement to cure. See table 3-1 for a general guideline on "loop" dimensions for various lengths of line and temperature ranges.

TESTING.—Testing should be done in two intervals:

1. The initial test should be a low-pressure hydrostatic test. (Air or gas is NOT recommended.) This test should never exceed 50 pounds per square inch gauge (psig). When testing with a gauge, allow the pipe to remain under pressure for a few hours; then check to see if there is a pressure drop. When the pressure drops, there is a leak. The pipeline should then be walked and closely inspected, checking each joint closely. After locating the leak, repair it, and pressurize it again using LOW pressure.

Table 3-1.—Pipe Snaking Loop Offset

PIPE SNAKING



LOOP OFFSET IN INCHES FOR CONTRACTION

	MAX. TEMPERATURE VARIATION, F, BETWEEN TIME OF SOLVENT WELDING AND FINAL USE				
LOOP LENGTH	10°	20°	30°	40°	50°
20 Feet	3"	4"	5"	5"	6"
50 Feet	7"	9"	11"	13"	14
100 Feet	13"	18"	22"	26"	29"
LOOP LENGTH	60°	70°	80°	90°	100°
20 Feet	6"	7"	7"	8"	8"
50 Feet	16"	17"	18"	19"	20"
100 Feet	32"	35"	37"	40"	42"

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2. After completion of the low-pressure test, place the pipeline in the trench (if not tested in the ditch) and backfill, leaving the joints exposed. The pipe should be uniformly and constantly supported its entire length. DO NOT SUPPORT WITH BLOCKS. The high-pressure test should be conducted at 1 1/2 times the working pressure and be held for at least 12 hours. Leaks found on the pipe itself should be cut out completely and replaced by using fittings (couplings). Backfill in the early morning during hot weather. The pipe should be covered 6 to 8 inches with backfill that is free of rocks and debris. It is advisable to maintain a pressure of 15 to 20 psig on the pipeline while backfilling to keep from damaging it. Anchors, valves, boxes, and so forth, should be supported separately to prevent additional stress or bending from the pipe. Piping, under roadways or railroads, should be done with sleeving (metal or concrete). The pipe should be isolated from direct contact with the concrete. When concrete anchors are being poured, wrap the pipe with rubber or other protective material. If the anchor is for axial movement, use the solvent welding process to weld a split collar to the pipe to provide the needed protection. When solvent welding collars on the pipe, allow 48 hours for drying time before pouring concrete.

Q3. What is the main purpose of a sanitary sewage collection system?

Q4. What six items are required for pipe installation?

Q5. A trench bottom should be sloped in what direction?

Q6. What person sets and checks the elevation of pipe that is layed in trenches?

Q7. What are the four types of sanitary drainage piping used in underground sanitary plumbing?

Q8. What is the laying length of cast-iron soil pipe?

Q9. Vitrified clay pipe can be cut with a chisel. It can also be cut with what otherpiece of equipment?

Q10. PVC is what type of pipe? What does the acronym "PVC" mean?

Q11. What is the difference between a fillet-welded joint and a fusion-welded joint for plastic (PVC) pipe?

SANITARY DRAINAGE INSTALLATION

LEARNING OBJECTIVE: *Recognize the methods of installing and testing sanitary drainage piping.*

Small pipes can be assembled and joined in sections on top of the ground and laid in the trench by hand. Large, heavy pipes are usually laid in the trench and then joined. These pipes may be lowered into the trench by rope, cable, or chain. Larger pipe may require the use of machinery operated by an Equipment Operator.

When assembling and joining pipes outside the trench, make sure you are a safe distance from the edge of the trench to prevent cave-ins. Also, do not leave tools or materials near the edge of a trench where they may be knocked off and injure someone working in the trench or cause a worker to loose his or her footing and fall into the trench.

Sewer pipes should be laid on a compacted bed of sand, gravel, or material taken from the trench excavation, if suitable, to provide a slightly yielding and uniform bearing. This step assures safe support for the pipe, the fill, and the surface loads. When pipes are laid on sand, gravel, or similar material, the weight of the pipe usually provides a suitable equalizing bed.

Pipelines should be embedded carefully, so they do not settle at any point. Settling causes suspended matter to collect in the lower portion of the pipe restricting the flow and reducing the handling capacity of the line.

TRENCHING AND GRADING

After you have laid the pipes, your next step is to check the grade and align the pipeline. This is very important in installing an underground sewer system. Remember, sewage does not flow uphill, unless of course you are using a pump, such as a lift station does. The pipe should be laid, so the flow of the sanitary waste in each length of pipe flows from the hub end to the spigot end or we could say the hub end is upstream. Each length of pipe should be placed starting at the lowest elevation and working up the grade; therefore, the spigot is inserted into the hub of the length laid previously. Each length should be checked as to its grade and alignment before the next length is placed.

When you are grading for the proper pitch per foot, the method shown in figure 3-31 may be used as a guide. This figure shows a ditch with batter boards used in transferring line and grade to trench; also, a stick for checking grade is shown in position.

An Engineering Aid (EA) is responsible for setting the batter boards at the proper level for the job at hand. Batter boards are placed across the trench at about 25. to 50-foot intervals. Elevations are run by an EA, and a mark is placed on the stakes at some even-foot distance above the invert (the lowest point on the inside of the pipe) of the sewer. A nail is then driven in the top of the batter boards, and a cord is stretched from board to board. The center line for the pipe is then transferred from the cord to the bottom of the trench by means of a plumb bob. Grade is transferred by means of a stick, marked in even-foot marks, having a short piece fastened at a right angle to its lower end. Grade is checked by placing the short piece on the invert of each length of sewer pipe and aligning the proper mark on the grade rod to the cord.

TESTING

After you complete the rough-in piping of a project, test and inspect all the piping for leaks. The purpose oftesting the pipeline is to make sure the joints are tight enough to withstand working pressure. Since a sewer line of this type flows by gravity drainage, the test procedures are different than those described later under the heading of "Water Service."

Before the pipe is covered with dirt, it must be tested for leakage. There are several methods of

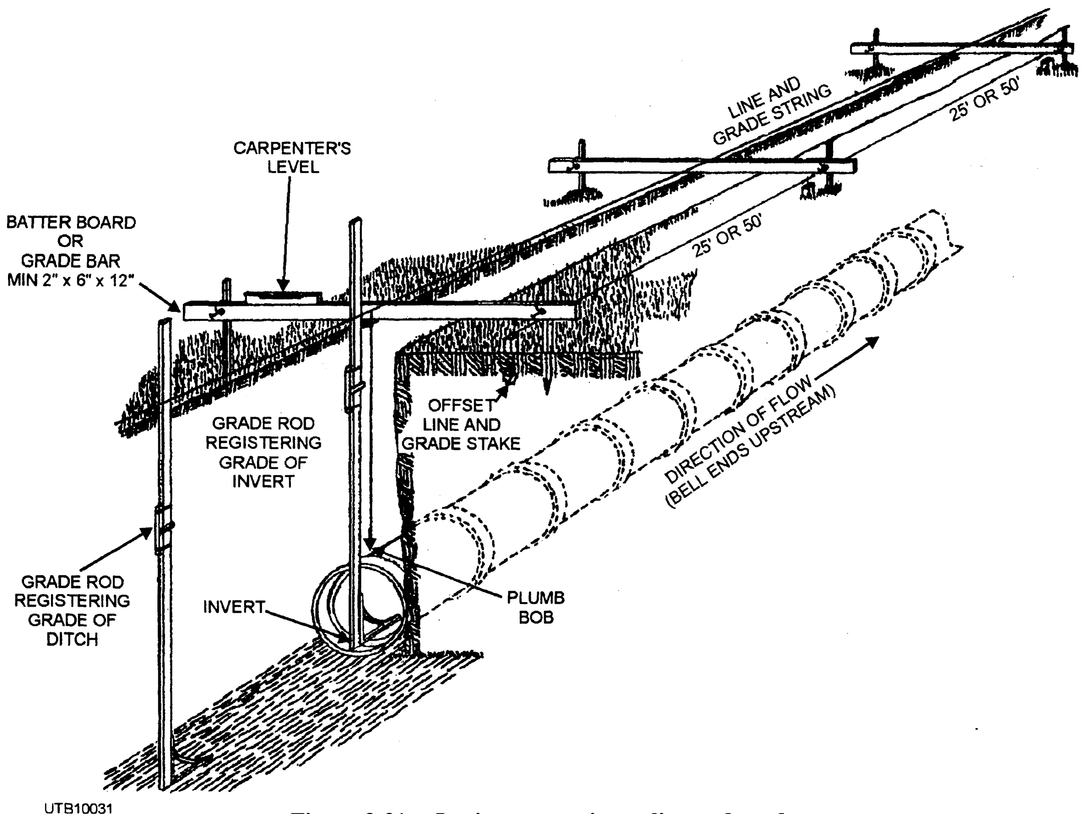

Figure 3-31.—Laying sewer pipe to line and grade.

effecting this test. The most widely used test is the water test, although an air test or odor test may be used.

Water Test

Here are the main steps in making a water test. At the lowest point of the section to be tested, insert a test plug in the open end of the pipe or a test tee, like those shown in figure 3-32, and plug other openings. Fill the pipe to its highest level with water; a IO-foot head is required. Leave the water in the pipe for at least 15 minutes before starting the test. This allows the oakum to soak up some water before you look for leaks. If necessary, refill the pipe to overflow and check each joint for leaks.

Air Test

Before making an air test, fill the system with water and allow it to stand until the oakum expands at the joints. Drain the water from the lines and reinsert the test plug. Close all openings and apply air pressure of at least 5 pounds per square inch (psi). In a satisfactory test, the line should hold 5 pounds psi for 15 minutes. If it does not, cover the joints with a soapy water solution and check for bubbles at the leak.

Odor Test

Before making an odor test, plug all openings in the sewer and the branches. After sealing the openings, pour 2 ounces of oil of peppermint in each line or stack. Then pour approximately 1 gallon of boiling water in the stack and seal it. The odor of peppermint at any point in the installation indicates a leak. The inspector, checking the installation for leaks, should not be near the oil of peppermint at any time before the inspection. Such exposure rapidly dulls his or her sensitivity to the odor of peppermint. The peppermint test is not as conclusive as the water and air tests described above, since no pressure is on the pipe.

NOTE

Repeat tests as necessary until all the leaks are located and repaired.

Where a system of pipelines has been installed using gaskets, test one floor at a time. Should there be more than one floor to be tested, be sure all bends, changes of direction, and ends of runs are restrained (limited).

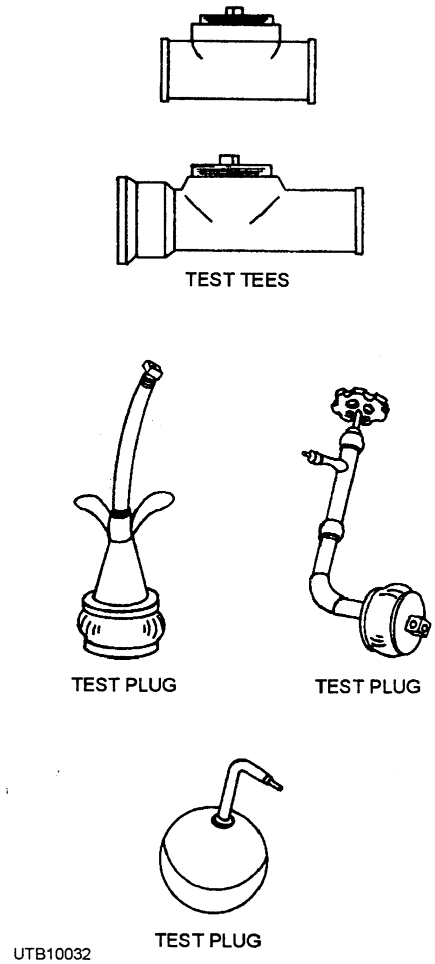

Figure 3-32.—Test plugs and test tees.

MANHOLES

Normally, it is not your responsibility as a Utilitiesman to construct manholes. They are made of concrete or brick; however, you may be working with the Builders in spotting the location for the manholes. Figure 3-33 shows a typical drop manhole.

Watertight manholes are made of brick or concrete, 4 feet in diameter at sewer level, and should be placed at junctions and bends in the line. They are spaced preferably 300 feet apart for 8-inch pipe, 400 feet apart for 10- to 15-inch pipe, 500 feet apart for 18- to 48-inch pipe, and 600 feet apart for larger sizes. Sewers should be laid straight to line and grade between manholes, and changes in the size of sewer lines must take place only at the manholes. The crown of the outlet pipe from a manhole should be on a line with or below the crown of the inlet pipe. When the invert of the inlet pipe is more than 2 feet above that of the outlet pipe, a drop manhole must be provided to conduct the sewage to a lower level with minimum turbulence.

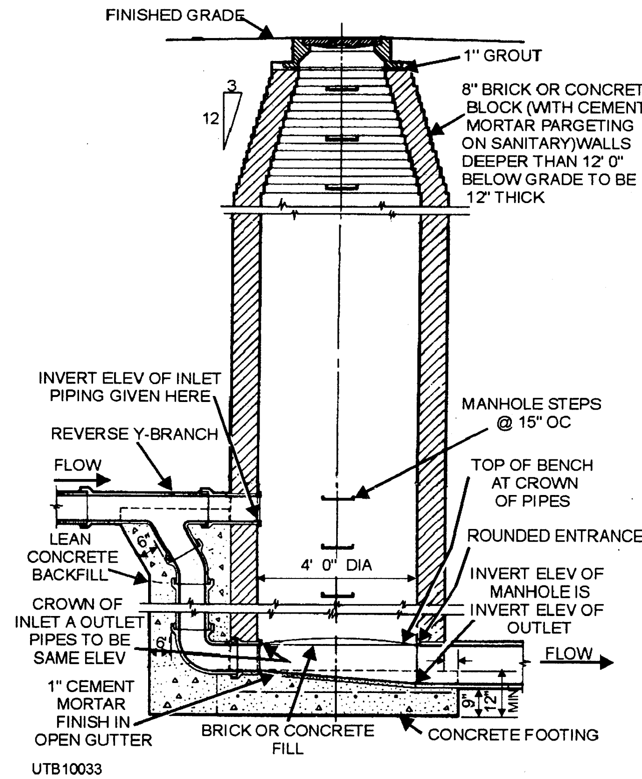

Figure 3-33.—Standard drop manhole for sanitary or storm drainage systems.

BACKFILLING AND TAMPING

After all pipelines have been laid and tested, they are ready to be covered; this process is known as backfilling and tamping. The method described below should work for sewer lines.

Fine material, free from stones and other debris, is tamped in uniform layers with a small hand- or air-operated tamper under, around, and over the pipe. Use a hand shovel to backfill the ditch until the pipe has a 2-foot covering. This fill should be placed in the ditch and tamped in 4-inch layers or less. It should proceed evenly on each side of the pipe, so injurious side pressure cannot occur. Make sure you do NOT walk on the pipe until you have at least 1 foot of soil tamped over the pipe. Until 2 feet of fill has been placed over the pipe, the filling should be done carefully with hand shovels; after that, machinery may be used for faster backfilling. However, do not let the machinery run over the line.

Puddling, or flooding, with water to consolidate the backfill should NOT be done for a sewer line. The sections of pipe are in short lengths and tend to settle very rapidly to form pockets or low spots in the line.

Q12. What is the required head height for a water test?

Q13. For an air test to be satisfactory, the system should hold 5 psi for what period of time?

Q14. What type of oil should be used for an odor test?

Ql5. A manhole should be what diameter at the sewer level?

Ql6. Earth fill should be placed in the trench over the pipe in layers of what thickness?

ABOVEGROUND SANITARY PIPING

LEARNING OBJECTIVE: *Identify pipe, traps, vents, and installation methods for aboveground sanitary drainage.*

After the underground piping is installed for a sewer system, the next phase is to install the aboveground piping. Information on materials applicable to the installation of aboveground sewage piping is provided in the following sections. Installation procedures are the same for aboveground and underground sewer pipe.

TYPES OF PIPE

A number of different types of pipes are used in the aboveground and interior parts of a plumbing system. Some of the common types of pipes are discussed briefly below.

While GALVANIZED WROUGHT-IRON PIPE is an excellent material for aboveground plumbing, it is costly. It is available in lengths from 18 to 22 feet. Galvanized wrought-iron pipe is constructed of wrought iron dipped in molten zinc to protect it from corrosion and provide high resistance to acid waste.

ACID-RESISTANT CAST-IRON PIPE is composed of an alloy of cast iron and silicon. It is used to serve chemical laboratories and other installations through which acid waste flows. In handling acid-resistant pipe, such as Durion™, be careful because it is very brittle and cracks easily. It is cast in 5-foot lengths and comes in single and double hubs.

BRASS PIPE consists of an alloy of zinc and copper. Brass pipe has a smooth interior and can resist most acids; however, it is expensive. It is available in 20-foot lengths; because it tends to bend, it must be supported at intervals of 8 to 10 feet.

LEAD or LEAD-LINED STEEL PIPE is sometimes used to carry distilled water for batteries; however, tin-lined, block tin, glass, or some types of plastic pipe must be used where no impurities are acceptable. Because it bends easily, lead pipe must be well-supported. It is available in three weights: (1) standard, (2) common, and (3) extra heavy. The standard weight is most commonly used.

COPPER PIPE. is suitable for use in waste, vent, and water installations. Remember that ammonia and water corrode copper and bronze lines. Also, when copper is used for waste pipe installations, always make sure it is rigid to overcome sagging. You can obtain the pipe in convenient lengths, then cut it to size for the job at hand.

PLASTIC PIPE is also suitable for use above-ground for sewage, venting, and water.

TRAPS

A number of different types of traps are available; however, the trap most commonly used with plumbing fixtures is the P-trap (fig. 3-34). Traps are required because they prevent sewer gases from entering a building and causing serious illness or death.

The term *trap seal* refers to the water being held in the bent portion of a fixture trap (fig. 3-34). True to its name, the trap seal forms a seal against the passage of sewer gases through the trap and into the building. The most frequently used seal trap has a depth of 2 inches between the overflow and the dip. The deep seal trap has a depth of 4 inches.

The P-trap gets its name because of its general shape-that of the letter *P*. It comes in sizes from 1 1/4 to 6 inches in diameter. Various types of P-traps are available, so designs may differ from one manufacturer to another. The P-trap is usually made

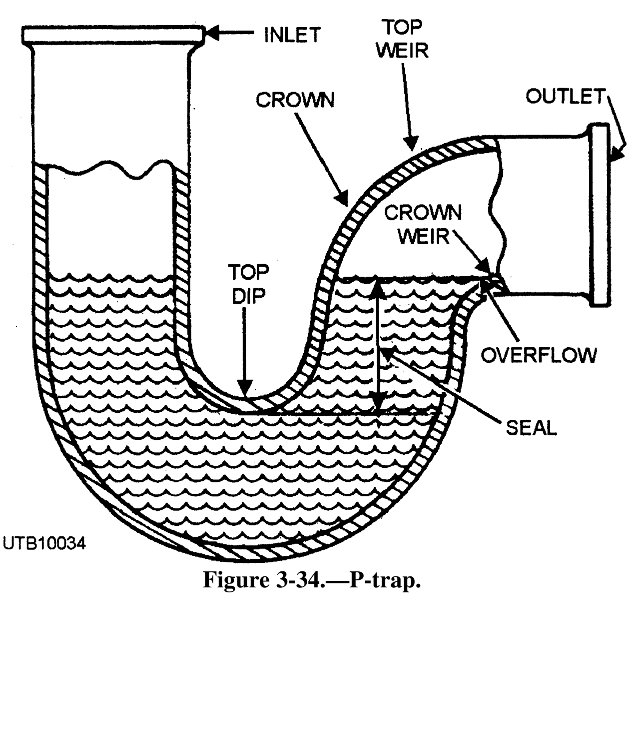

Figure 3-34.—P-trap.

of nickel or chrome-plated brass, malleable galvanized; cast iron, other metal alloys, and plastic.

The P-trap is used for fixtures suspended from the walls or supported on pedestals, for instance, lavatories, sinks, and urinals. At times the P-trap may also be suitable in showers, baths, and installations that do not waste large amounts of water.

When using a P-trap for fixtures suspended from the wall, you should install it as close to the fixture as possible. Be careful not to install a vertical leg that is too long between the trap and the fixture. It is also important for the horizontal leg connection to the waste system to be short for ventilation purposes.

VENTS

To prevent the siphonage of a trap seal in fixture traps and allow gravity flow of drainage, you must let atmospheric air from outside the building into the piping system to the outlet (or discharge) end of the trap. The air is supplied through pipes called VENTS. This air provides pressure on the outlet end of the seal equal to pressure on the inlet end.

Atmospheric pressure at sea level is about 14.7 pounds per square inch. This pressure remains virtually constant on the inlet end of the water seal. Obviously, a greater or lesser amount of pressure on the outlet end of the trap seal forces the water in the direction of least resistance. Since the air supplied by the vent to the outlet end provides a pressure equal to that at the inlet end of the trap, the trap seal cannot escape through siphonage.

All vent systems should be provided with a main vent or vent stack and a main soil and waste vent. A "main vent" may be defined as the principal artery of the venting system, and vent branches may be connected to the main vent and run undiminished in size as directly as possible from the building drain to the open air above the roof. The MAIN SOIL AND WASTE STACK, as shown in figure 3-8, is installed in a vertical position.

The term *main soil* and *waste vent,* or *soil stack vent,* refers to the portion of the stack extending above the highest fixture branch. In figure 3-8, this vent extends through the roof. Actually, it is an extension of the main soil and waste stack.

Common Types of Vents

Various types of vents are used in the ventilation of fixtures; even in the best of installations, you may find several different types of vents. The selection of a particular type of vent depends largely on the manner in which the plumbing fixtures are located and grouped. Some of the common types of vents you may use frequently in your work are mentioned briefly below. An INDIVIDUAL VENT, also known as a BACK VENT, is a vent that connects the main vent with the individual trap underneath or behind a fixture. This method of venting is shown in figure 3-35. When you install two or more fixtures on an individual vent basis, ensure the leg (see illustration) connecting individual vents to the main vent is large enough to carry the total load.

A COMMON VENT vents two traps to a single vent pipe, as shown in figure 3-36. The unit vent can be used when a pair of lavatories are installed side by side, as well as when they are hung back to back on

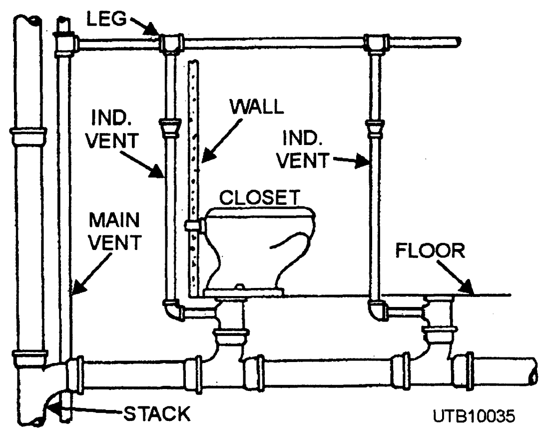

Figure 3-35.—Individual (or back) venting.

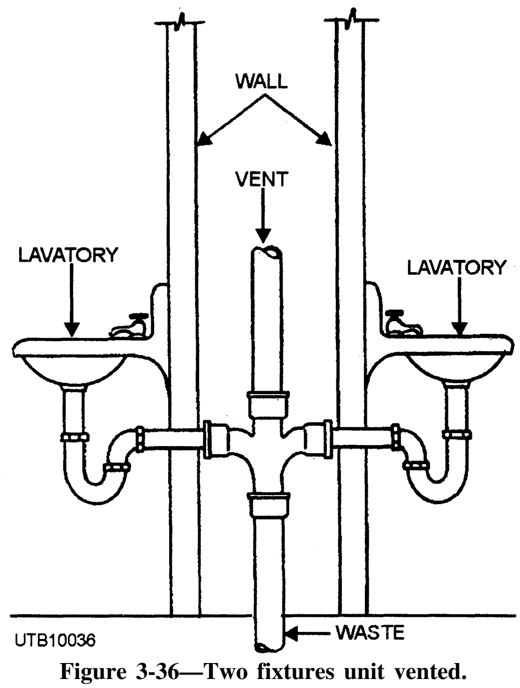

Figure 3-36—Two fixtures unit vented.

either side of a partition (as shown in the illustration). A point to note is that the waste from both fixtures discharges into a double sanitary tee.

A CIRCUIT VENT serves a group of fixtures. As shown in figure 3-37, a circuit vent extends from the main vent to a position on the horizontal branch between the last two fixture connections. Make sure that a maximum of eight fixtures are put on any one circuit. If you have more than eight fixtures to be circuit vented, use two circuits instead of one. In this type of vent, water and waste discharged by the last fixture tends to scour the vents of other fixtures on the line.

A vent pipe, in which liquid wastes flow through a portion of it, is known as a WET VENT. A LOOP VENT is the same, except it connects into the stack unit to form a loop. This type of vent may be used on a small group of bathroom fixtures, such as a lavatory, water closet, and shower, as shown in figure 3-38. The pipe for a wet vent installation should be sized to take care of the lavatory, the water closet, and the shower.

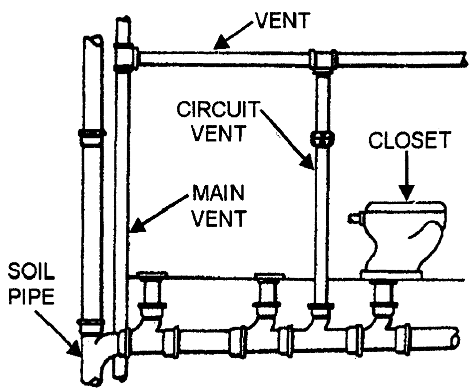

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Figure 3-37.—Water closets circuit vented.

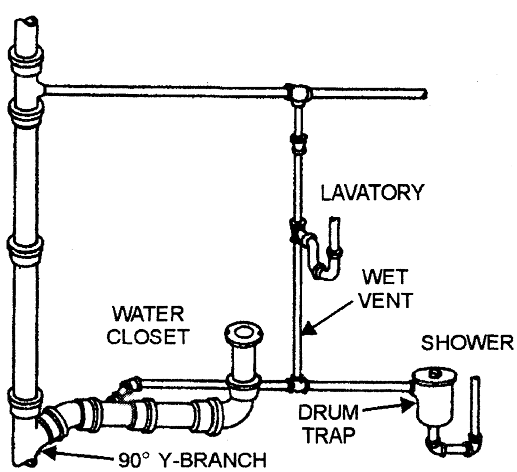

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Figure 3-38.—Wet vent.

> **NOTE**
>
> When you are draining more than four fixture units, the wet vent should never be under 2 inches in diameter. A water closet must not drain into a wet vent.

As shown in figure 3-38, the lavatory should be individually vented. This is necessary to prevent loss of the trap seal through indirect siphonage. Another point to note with the lavatory is that the relatively clean water discharged from it tends to scour the wet vent, preventing an excessive buildup of waste material in the vent.

Installation Pointers

A venting system must be installed properly with little repair and upkeep. This section points out your duties in installing vent systems.

Refer to figure 3-39. Notice that a MAIN VENT TEE forms a junction between the main vent and the main soil and waste vent. This is a tapped tee having a stack side outlet. It should be installed by caulking in the vertical stack, at least 6 inches above the overflow level of the highest fixture connected. After this has been done, the vertical stack should be extended, full size or larger, through the roof to form the vent terminal. The pipe must extend at least 6 inches above the roof. If the roof is used for other than weather protection, the vent terminal must be 7 feet above the roof. The opening in the roof through which the main soil and waste vent runs must be properly waterproofed. Roof flashing is used for this purpose Roof flashing is made of galvanized iron or copper. Flashing is available in different sizes. Normally, the size of flashing needed for a job is determined by the size of the main soil and waste vent.

When installing roof flashing on a shingled roof, extend it under two courses of shingles above the pipe. On a flat roof, place it between layers of the roofing material and have the finishing layer over the top of the flashing. To complete the installation on either type of roof, always apply a coat of roofing cement as added protection against leakage.

In a cold climate, you must think about ways to prevent closure of the main soil and waste vent at the roof outlet by freezing. The air discharged by the main stack and waste vent is humid and condenses. This

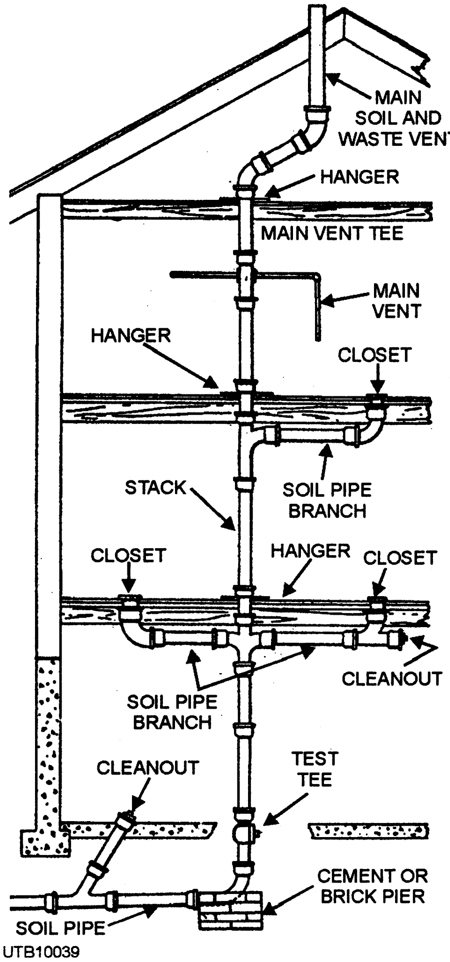

Figure 3-39.—Soil pipe branches.

condensation freezes when exposed to low temperatures.

One way to prevent freezing is to increase the pipe to a size or two larger than the vertical vent passing through the roof; or, install high-lead flashing to provide an insulating pocket of air between the flashing and the end of the main soil and waste vent above the roof. Being open to the heat of the building, the air pocket allows an intermediate warming area for gases leaving the main soil and waste vent.

Materials used in vent piping ordinarily include galvanized pipe, cast-iron soil pipe, and at times, brass, copper, and plastic pipe. Asbestos-cement pipe can also be used for venting both soil and waste pipe. A single length of this pipe is often sufficient for venting a stack. For such an installation, pipe is available with a machined end. This end is placed in the bell of the soil or waste pipe, and the connection is made by yarning, leading, and caulking.

In all phases of the venting system, do your best to use proper-sized piping. Remember, the diameter of the vent stack or main vent must not be less than 2 inches. The actual diameter depends on the developed length of the vent stack and on the number of fixture units installed on the soil or waste stack. The diameter of a stack vent should be at least as large as that of the soil or waste stack.

Both soil and waste pipe BRANCHES are horizontal branch takeoffs that connect various fixtures and the vertical stack (fig. 3-39). One method of installing a branch takeoff from the vertical stack is to use a Y-branch with a 1/8 bend caulked into it. Another method is to use a sanitary tee, which is an extra short pattern 90-degree Y-branch. Of these two methods, the sanitary tee is better because you eliminate one fitting and an extra caulked joint; both are required for the 1/8 bend takeoff. Some local codes allow you to connect more fixture units to a given size of stack when a combination Y and 1/8 bend is used. The combination Y and 1/8 bend may be more desirable than the sanitary tee. Once either fitting is caulked into place, the horizontal branch can be extended as necessary with lengths of soil pipe. They, too, are joined by caulking.

Pipes carrying waste should be graded downward to ensure complete drainage. Horizontal vents should be slightly pitched to facilitate drainage of condensation.

In this chapter, only the basic types of vents and the locations where they are used have been covered; however, there are many forms of ventilation that can be applied to a plumbing installation. The types of vents used on a project are determined largely by the manner in which the plumbing fixtures are to be installed and where they are located.

As plumbers know, the subject of vents is the science of plumbing. Anyone can try to install piping for a plumbing system; however, if the system cannot carry waste away, the would-be plumber and the system are useless. For more information on venting, consult the *National Standard Plumbing Code-Illustrated.*

Q17. Acid-resistant cast-iron pipe is an alloy composed of what two elements?

Q18. What is a trap seal?

Ql9. To prevent siphonage of seal traps in a plumbing system, what plumbing method should you use?

WATER SERVICE

LEARNING OBJECTIVE: *Identify types of pipe and methods for measuring, cutting, joining, and installing water service systems.*

The water-supply system for a building consists of the service pipe, the distributing pipes, and the connecting pipes, as well as fittings and control valves. Water carried by the system must meet accepted standards of purity. Two major functions of a water distribution system are (1) to carry potable water for domestic use and (2) to provide a high rate of flow for fire fighting.

TRENCHING

The method of trenching for waterlines is similar to that described earlier for sewer lines. In trenching for waterlines, it is not necessary to set batter boards since great care is not required in laying water pipes to grade because the water is under pressure. The pipes in a waterline may follow the contour of the earth's surface in a trench that is a minimum of 2 feet deep. Minimum depth of the ditch depends upon the depth of the frost line in the area. The trench should be wide enough to permit ease of working around the pipes and to allow earth to be placed during backfilling. Usually, the trench is not deep enough to require bracing or shoring.

Locate the trench at least 4 feet from a previously dug ditch, or trench, to help prevent cave-ins. Water pipes should be laid 1 foot above and 10 feet away from nearby sewers. This helps prevent the water distribution system from becoming contaminated by leaks. Sometimes the water main and sewer lines may cross each other. In such cases, the water pipe must cross over the top of the sewer line, so be careful to make all joints tight; however, check the local specifications before installing them in this manner.

The distribution system must be kept free from contamination caused by leaks, back siphonage from faulty plumbing, and cross-connections. The greatest hazard in a distribution system is cross-connection. This is one physical connection to another that is an unsafe or doubtful source of water or a connection or condition that will permit wastewater to enter the potable public supply.

PLACING WATER PIPE

An important phase in the installation of a water system is laying the underground water service pipes. Information to aid you in laying these pipes is provided below.

Regardless of the pipe material used, sharp bends and dead ends should be anchored by rodding or concrete anchors. Where the pipe is setting in saddles, metal straps may be used. Even though the pipe is installed within a ditch, the straps help support and hold the pipe in place. Pipe should be founded on solid trench bottoms. Automatic air-release and vacuum valves should be installed at prominent peaks on long supply mains to permit escape of air while the pipe is being filled and entrance of air when it is being drained. Elsewhere in the distribution system, air normally can be released and taken in through service lines.

Flow in water pipes may be achieved by gravity with an elevated tank or by a pumping system. When pipe must be placed in a sloping trench, the slope should be as even as possible to keep the pipe from bending and breaking. After the trench is dug, lay the pipe and fittings alongside it. Before you start placing the pipe; shut off the water in the main supply line. The placing should start at the main supply tee.

BACKFILLING

When you are ready to backfill a ditch, tamp the soil around the pipe by hand or use water. In backfilling, keep the pipe straight and minimize settlement. Soil used to backfill around the pipe should be as free as possible from rocks and debris. When you throw fill material directly on the exposed pipe, you could damage the pipe or move it out of alignment. DROP THE FILL MATERIAL ON BOTH SIDES OF THE PIPE AT THE SAME TIME. When you have water available, use it instead of the tamper, especially when you have a short run to backfill. Fill the ditch completely with loose soil. Attach a piece of pipe to a water hose and push it through the loosely replaced soil until it touches the water main. Turn on the water and let it run until the water appears on the surface. This method allows all the earth to be replaced except the volume equal to that of the pipe.

WATER-SUPPLY PIPING

Piping materials used in water-supply systems include cast-iron pressure pipe, copper pipe, galvanized pipe, cement-asbestos pipe, ductile iron pipe, concrete pipe, and PV-class water pipe. Some of the main characteristics of pipe made from these materials and the equipment used are presented below.

Cast-Iron Pressure Pipe (For Water Mains)

The cast-iron pipe used for a water distribution system is somewhat different from that used for waste systems. Some of the major differences are in the length of the pipe, the joints, and the lining. Cast-iron soil pipe for waste, as you know, comes in 5-foot and 10-foot lengths. Cast-iron pressure pipe for water mains comes in 20-foot lengths with either bell-and-spigot or mechanical (gland-type) joints. This pipe may be coated with coal-tar pitch or be cement-lined; however, uncoated pipe is available if needed for other purposes.

MEASURING AND CUTTING.—Cast-iron pressure pipe is measured by the inside diameter; a ruler or tape is frequently used for measuring. With a cement lining, the lining goes beyond the inside diameter of the pipe, so you have to allow for this reduced inside dimensioning.

To cut cast-iron water pipe to the desired length, use either a hand-operated chain cutter or a power hacksaw. Because of the construction of this pipe, it does not need reaming after cutting; but, you can use a file to dress down the cut when necessary.

FITTINGS.—Three major types of fittings for joining cast-iron pipes in water service are tees, elbows, and couplings. Since these fittings look like those used for sewer lines, a detailed description need not be provided here.

JOINING.—In water service lines, bell-and-spigot cast-iron pipe is joined with lead, lead wool, or sometimes a sulfur compound. Specially prepared treated paper may also be used.

Before making a joint, you should first check each length of pipe for cracks or splits. After eyeing the pipe for defects, rap it with a hammer. With a little experience, you will know the difference between a good pipe and a bad pipe (cracked or split).

Next, wrap the yarn around the spigot end, place it in the bell of the previously laid length, then straighten and adjust it with a yarning iron. Use enough yam to fill the joint within approximately 2 inches of the face of the bell. Then clamp a joint runner in place around the joint, so it fits tightly against the outer edge of the bell. The lead should then be poured into the V-shaped opening left at the top by the clamped joint runner. This lead fills the space between the yam and the runner. This joint must be made in one pouring for best results. After the lead has hardened (about 10 seconds), the runner is removed, and the lead, which shrinks while cooling, is expanded by caulking until it makes a tight fit. Caulking requires skill; hammer blows that are too heavy could split the bell, or blows that are too light could leave a loose joint.

Lead wool is lead in shredded form that does not require melting. Lead wool is sometimes used when water is encountered in a trench. In this process, more yarn is used; the joint is filled to about 1 inch of the face of the bell. Lead wool requires more time in caulking than poured lead.

A sulfur compound is melted on the job, like lead, but at a lower temperature. It is then poured into a joint prepared for a cast-lead joint. The fact that it is light in weight is its primary advantage. It requires no caulking and provides a strong joint that is unlikely to blow out. Initially, joints of sulfur compounds leak or sweat slightly, but they tighten up in a short time. Since the joints are rigid, they should not be used to connect a newly laid line to an old one, as the settlement of a new line can cause a crack. A lead joint should be used at the connection.

Mechanical joints are made with rubber sealing rings held in place by metal follower rings bolted to the pipe. This type of joint is designed to permit expansion and contraction of the pipe without injury to the joints.

Copper Pipe

Copper pipe and tubing with soldered joints or flared-tube connectors are used for water service. Copper is highly regarded because of its corrosion-resistant properties, flexibility, ease of installation, and low resistance to flow throughout its useful life.

Three types of copper, designated as Types K, L, and M, are commonly used. Type K is used for underground service and general plumbing; Type L for general plumbing; and Type M with soldered fittings only. Types K and L copper come in either straight 20-foot lengths of hard temper or in coils of 50 to 100 feet, soft temper. Type M comes in straight 20-foot lengths, hard drawn only.

Another type of copper, Type DWV (drain, waste, and vent), is used only in aboveground soil, waste, and vent lines. It is furnished in hard temper only and in sizes from 1 1/4 to 8 inches. It is available in 12-foot lengths as well as the standard 20-foot lengths.

The process used to soften copper is called "annealing." The word *anneal* means to soften thoroughly and render less brittle. Copper is unlike steel in many respects. If copper is bent often, it could break when you try to bend it again. Should the pressure on a copper tube increase or decrease too much, the tube could break. Vibration also makes copper tubing break.

To soften steel, heat it to a cherry red and cool it very slowly. The slower it is cooled, the softer the steel becomes. With copper, the opposite is true. Copper is heated uniformly to a dull red and then quenched (dipped) in water (for water service). The faster it is cooled, the softer the copper becomes.

BENDING.—Copper, properly annealed, can be bent by hand when sharp bends are not desired. Copper partially collapses during the bending process if a tubing bender is not used or if the copper is not filled with some kind of easily removable material, such as sand. Simple bends can also be made by wrapping the outside of the copper tightly with soft wire and bending the copper by hand; however, if a line must make a 45- or 90-degree bend, you should use a tubing bender. Hand-tubing benders are available for each size of copper. These benders assist you in making neat, accurate bends easily, quickly, and without marring the copper or restricting the flow through the copper. It is easy to make a bend but difficult to get the bend in the correct location on the copper and to the correct degree. Be certain that you have the correct size bender for the copper you intend to bend. A bender that is either too small or too large for the copper will make a faulty bend. Figure 3-40 shows one type of tubing bender. Figure 3-41 shows a typical one-story copper DWV system.

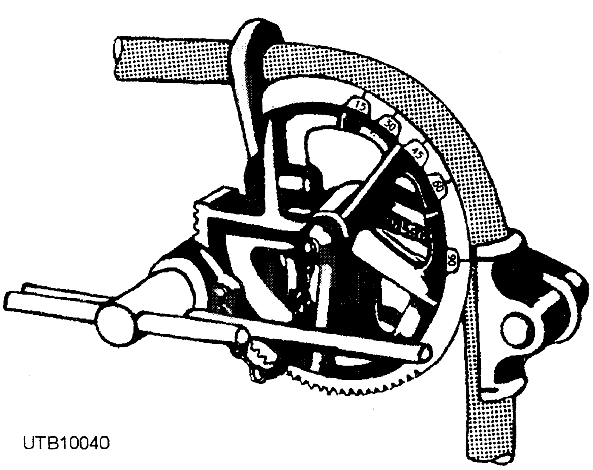

Figure 3-40.—Portable copper pipe and tubing bender.

MEASURING.—Seven methods are used in measuring pipe or tubing. They are (1) end to end, (2) center to center, (3) end to center, (4) end to back, (5) center to back, (6) back to back, and (7) face to face. These measurements are also used in measuring threaded galvanized or black iron pipe.

The measurements are generally made with a ruler. Each of the seven methods mentioned above is explained below, and each one is shown in figure 3-42.

END TO END indicates a pipe threaded on both ends. The measurement is from one end of the pipe to the other end, including both threads.

CENTER TO CENTER means there is a fitting on each end of the pipe. The measurement is made from the center of the fitting on one end to the center of the fitting on the other end.

END TO CENTER method applies to pipe having a fitting on one end. The measurement is made from the end of the pipe to the center of the fitting.

END TO BACK also refers to pipe with a fitting on one end. The measurement is from the back of the fitting to the other end of the pipe.

CENTER TO BACK indicates a pipe with a fitting on each end. The measurement is taken from the center of one fitting to the back of the other fitting.

BACK TO BACK measurement refers to pipe with a fitting on each end. Here the measurement is from the back of one fitting to the back of the other fitting.

FACE TO FACE measurement refers to a pipe with a fitting on each end that has an opening directly across from the pipe it is connected to on both ends. Measure from the face of the opening to the face of the other fitting.

CUTTING AND REAMING.—Copper should be cut with a tubing cutter, when available. Mark the copper where it is to be cut and install the cutter so the cutter wheel is over the mark, and you can see the cutting wheel from the top view of the pipe, as shown in figure 3-43. Now turn the adjustment wheel or handle clockwise to force the cutter wheel against the copper. Continue revolving the cutter, turning the adjustment wheel slightly after each revolution until the copper is cut through and it separates.

Copper may be cut with a hacksaw, although a tubing cutter is preferable; however, be careful to cut the copper square if it is to be flared. Be sure to use a fine-toothed hacksaw blade, 32 teeth per inch, when cutting copper.

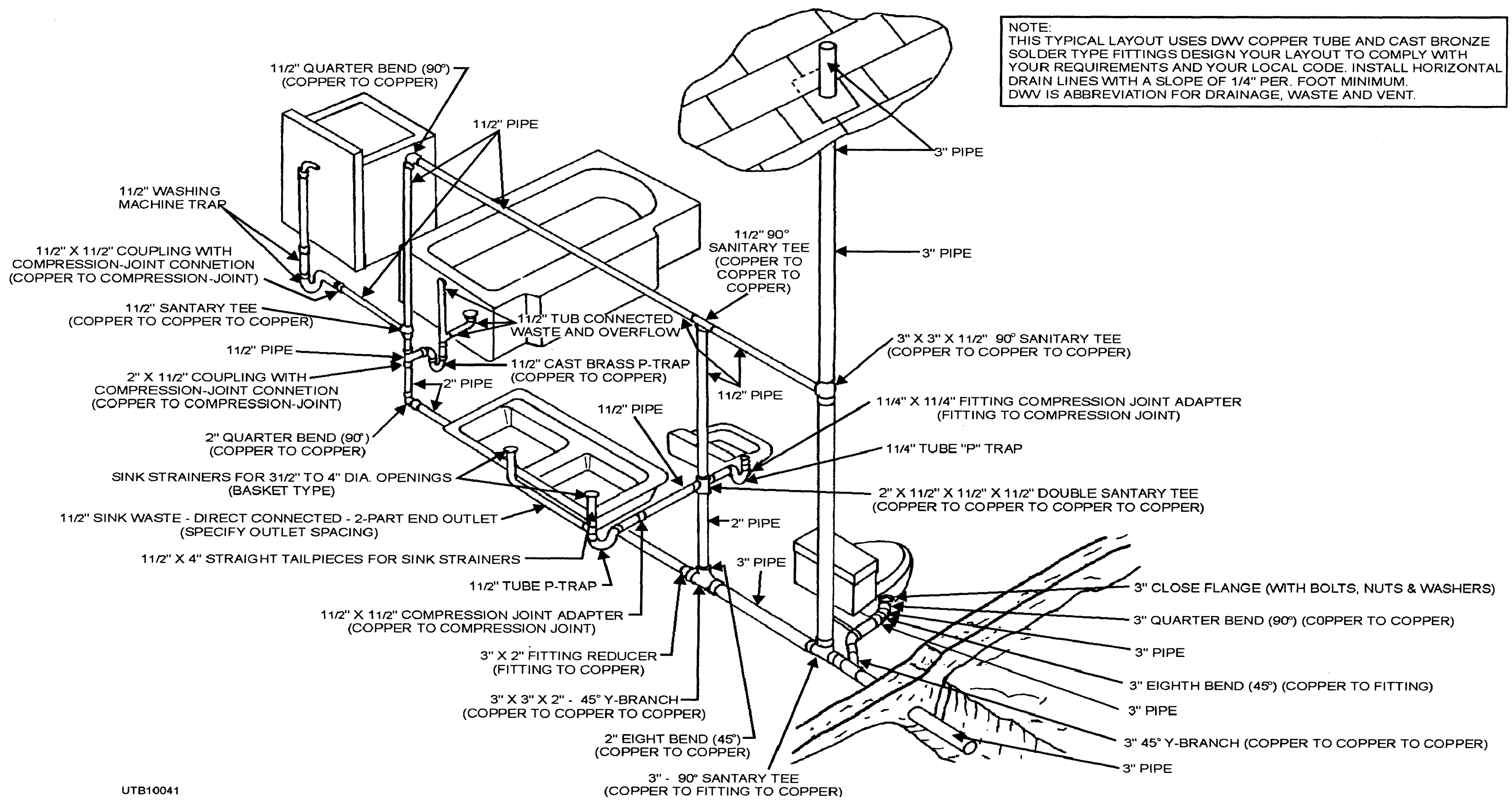

Figure 3-41.—Typical one-story copper DWV system.

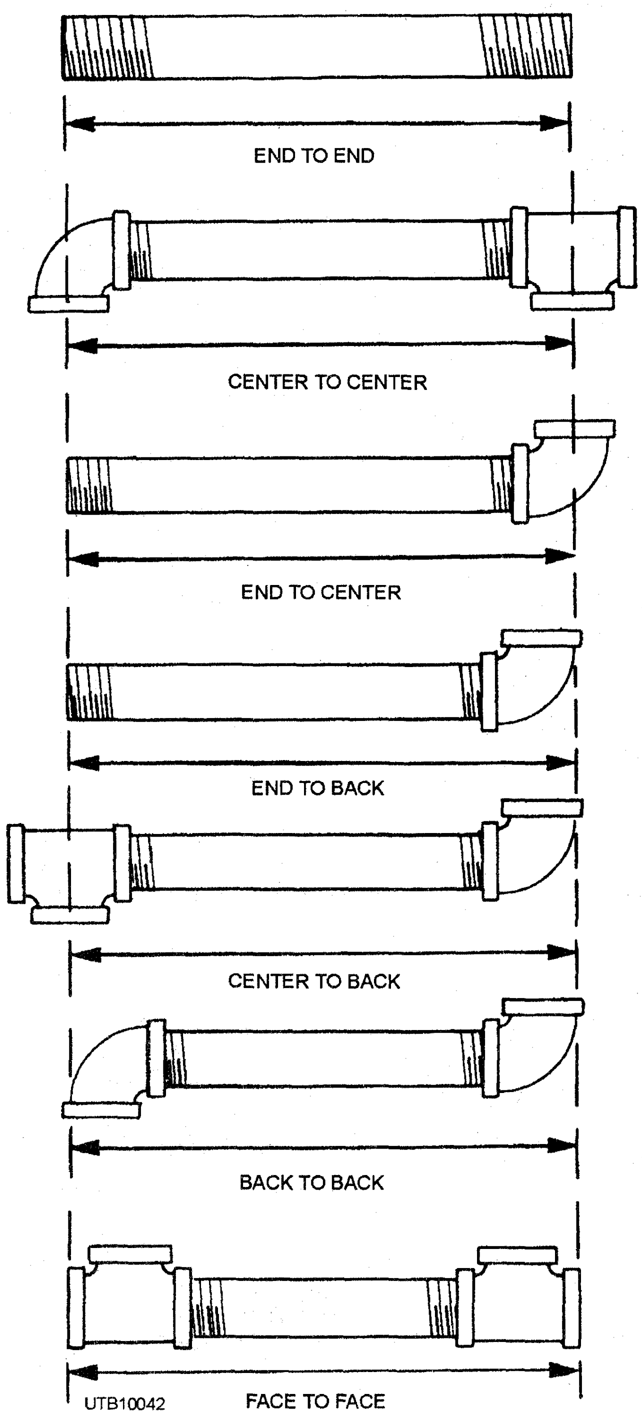

Figure 3-42.—Methods of measuring pipe and tubing.

After cutting the copper, remove the burr inside the cut with the reamer on the tubing cutter. Place the reamer in the end of the copper, and revolve the tubing cutter clockwise until the burr is removed.

JOINING.—When working with copper, you use both flared and sweated joints. "Flaring" is a method of forming the end of the copper into a funnel shape, so

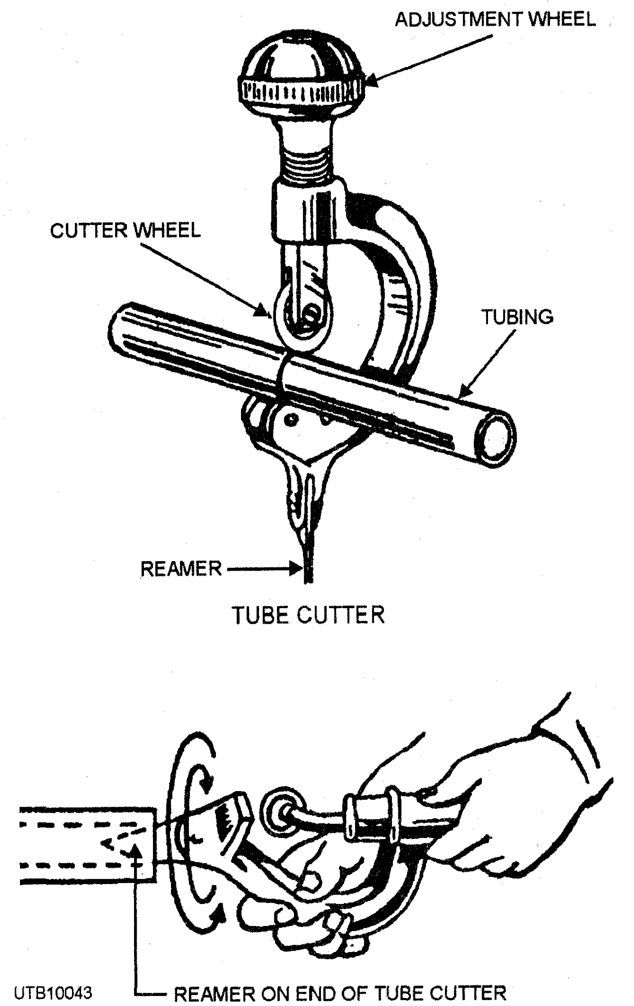

Figure 3-43.—Cutting and reaming copper tubing.

it can be held in a threaded fitting when a line joint is being made. Before a flare is made, slip a flare nut on the copper. A common error is forgetting to put the nut on before making the flare. For additional information on making flared connections, refer to *Use and Care of Hand Tools and Measuring Tools,* NAVEDTRA 12085. Figure 3-44 shows a few typical copper fittings.

A sweated joint is made with solder instead of threads or flares. When making a soldered joint with a sweat fitting, clean an inch or more of the end of the copper tubing with steel wool or 000 sandpaper until new metal appears. Clean the inside of the fitting in the same manner. Spread a thin film of paste flux on the tube end with a clean brush or applicator. Do not apply paste with your finger or an oily applicator.

Carefully insert the copper into the fitting to make them fit together very closely. Capillary action must spread the solder evenly and completely over the surfaces; however, the process is not effective with loose fits because of excess clearance. If the fit is loose, you may have to tin the end of the copper tube.

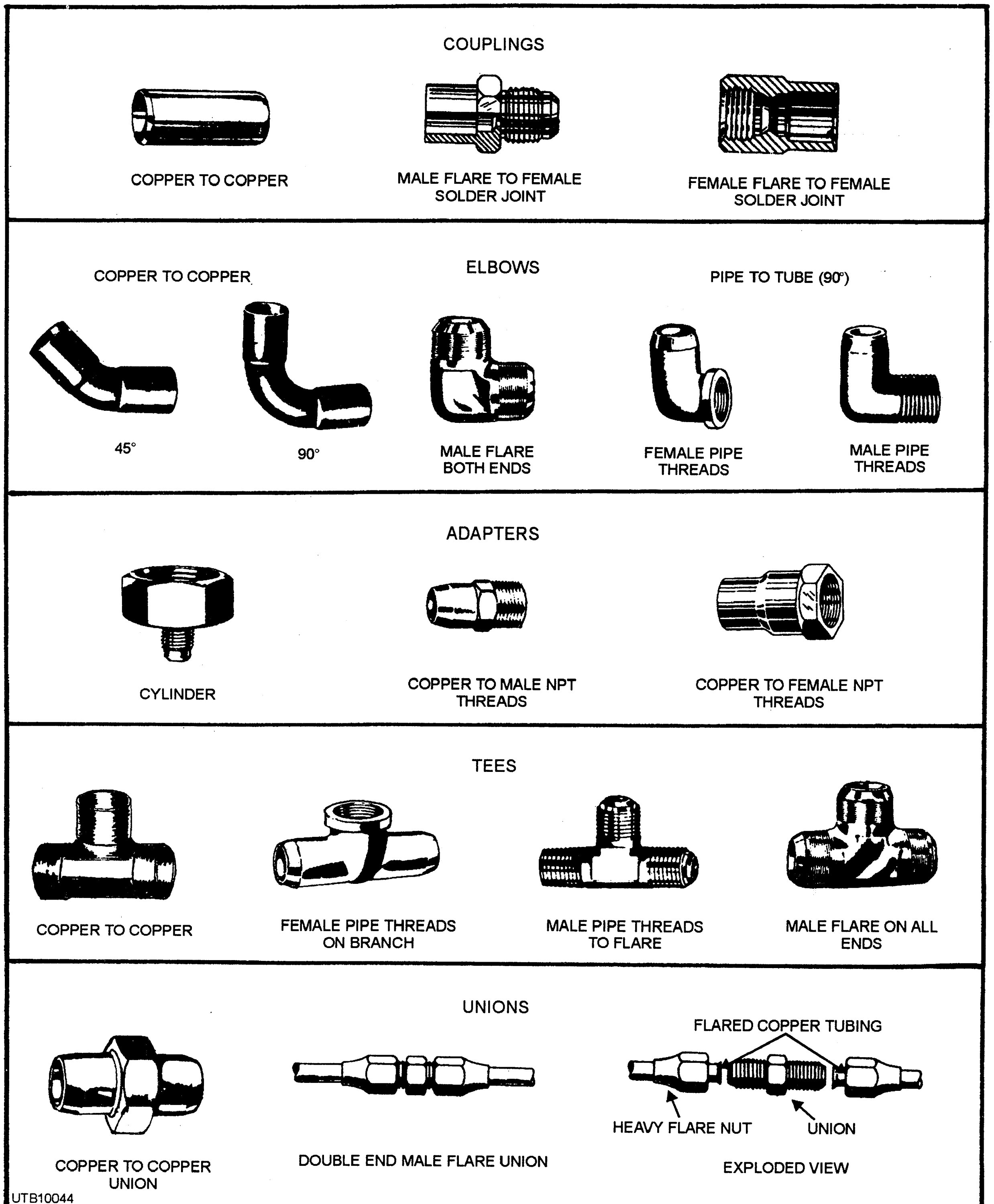

Figure 3-44.—Typical copper fittings.

"Tinning" is the process of applying a small amount of solder to the end of the copper before it is inserted into the sweat fitting.

In soft soldering, heat is applied directly to the metal with a flame. Various types of heat-generating equipment are available. In your work, however, you generally use methylacetylene propadiene (MAPP) cutting/welding equipment or a Presto-lite heating unit.

The Presto-lite torch is ideal for SOFT SOLDERING because it delivers a small controllable flame. The Presto-lite unit consists of a small MAPP-gas cylinder, regulator, rubber hose, torch, and two or more removable tips. This unit burns MAPP gas as a fuel in the presence of oxygen. Figure 3-45 gives you an idea of what the Presto-lite unit looks like.

When heating, apply heat to the fitting or thickest part until it reaches the melting temperature of the solder. Feed the solder at the edge of the fitting. When a continuous ring of solder appears at the end of the fitting, you have completed the joint.

After soldering is complete, clean the joints with a wire brush, soap and water, or emery cloth. Exercise caution to remove all flux from the joint after it is soldered. Any flux left on a joint causes corrosion.

In plumbing, you may occasionally be called upon to join copper pipe or tubing by silver brazing. You may also use silver brazing in making repairs to air-conditioning and refrigeration equipment, water systems, galley equipment, and so on.

In SILVER BRAZING, also called SILVER SOLDERING or HARD SOLDERING, joint members are fused by heating with a gas flame and silver alloy filler metal with a melting point above 800°F, but below the melting point of the base metal. The filler metal is distributed in the joint by capillary attraction.

Since capillary attraction is important in the silver brazing process, it may help you to understand what this term means. Perhaps the best way to understand capillary attraction is to consider some everyday examples of the process. If you put one end of a strip of cloth in a glass of water and allow the other end to hang over the edge of the glass, the end of the cloth that is not in the water becomes wet. Water rises in the cloth by capillary attraction. The wick on an oil lamp can be lit because the oil rises in the wick by capillary attraction. In both examples, we have a LIQUID (water, oil) that moves into an opening in a SOLID (cloth, wick) by a process called "capillary attraction." The basic rule of capillary attraction is that the distance the liquid is drawn into the opening in the joint depends on the size of the opening in the joint-the smaller the opening, the farther the liquid is drawn in.

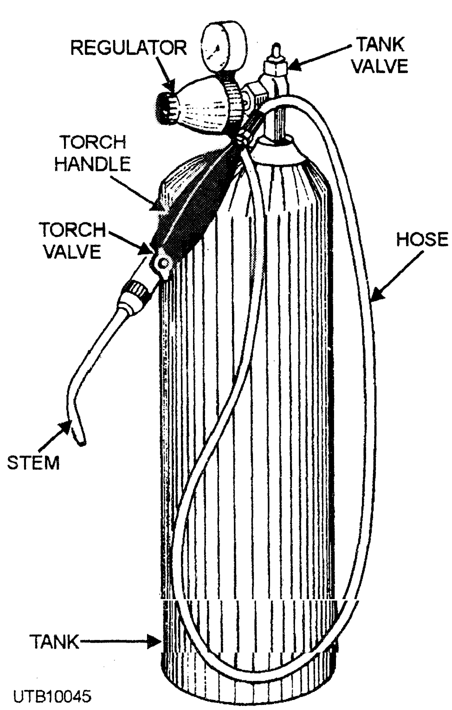

Figure 3-45.—Presto-lite heating unit.

In just the same way, capillary attraction causes the melted filler metal used in silver brazing to be drawn into the narrow clearance between the joining members. Capillary attraction does not work unless the filler metal is melted and unless the size of the opening is quite small; therefore, the application of heat and the use of a very small clearance between joining members are essential to silver brazing. The heat is necessary to melt the filler metal and to keep it molten; the small clearance is necessary to allow capillary attraction to draw the molten metal into the space between the joint members.

Silver-base alloys are commonly used as filler metal for brazing. Although filler metals other than silver-base alloys are often used, the technique for making a brazed joint is basically the same. The main difference is the amount of heat necessary to melt the filler metal. In all instances, this temperature is below the melting point of the base metals. Silver-brazed joints have high strength on ferrous and nonferrous metals. The strength of a joint that is made properly exceeds that of the metals joined. On stainless steel, it is possible to develop a joint tensile strength of approximately 130,000 pounds per square inch (psi). Since brazing with silver-based alloys is typical of brazing in general, it is especially interesting at this point to note the use of these materials as filler metal. This information applies equally to brazing with other filler metals that are distributed by capillary attraction.

Two methods are used to make joints between tubes and fittings in piping systems with silver-base brazing filler metal: the INSERT method and the FEED-IN method. With either method, the parts must be adequately supported during heating. The work must be held firmly in position until the brazing filler metal has completely solidified.

When using the insert method, insert a strip of the silver-base filler metal in the joint before assembly. Before brazing the parts, clean them with emery cloth, steel wool, or an acceptable cleaning solvent. Apply flux with a brush. Next, fit the two parts together and align them. Then light the torch and direct the heat on the tube or thinner portion, as shown in figure 3-46. The lines drawn on the tube indicate the path of the torch while heating the tube.

Heat applied to the tubing causes it to swell and bring the surface of the tube into contact with the inside surface of the fitting. This closes the clearance area, forcing the flux from either end of the joint. Be sure to heat the entire circumference of the tube until flux begins to flow. Flux flow tells you that the tube has expanded sufficiently. This is the signal to proceed to the second phase of heating. As soon as the flux flows freely, about 6 seconds after you see the fluid, direct the flame to that portion of the fitting hub farthest from the junction of the tube and the fitting. Rotate the flame over the joint segment until brazing filler metal appears at the junction of the pipe and fitting. At that moment, flick the torch away so the flame wipes toward the pipe. This completes one segment of the joint. This procedure is repeated until all segments are completed. A satisfactory joint has a continuous ring of filler metal at the end of the fitting. The ring must also be smooth and concave.

With the feed-in method, the parts are heated to the correct temperature. Watching the behavior of the flux is the best way to determine the temperature of the joint as the heating progresses. First, the flux dries out as the moisture (water) boils off. Then the flux turns milky and starts to bubble at about 600°F. Finally, it turns into a clear liquid at about 1100°F. This last temperature is just short of the brazing temperature. The clear appearance of the flux indicates the time to start adding the filler metal (silver solder). If the temperature and alignment are proper, the filler metal spreads over the metal surface and into the joint by capillary attraction. Make sure the filler metal penetrates the complete thickness of the metal for good bonding. Stop heating as soon as the filler metal has completely covered the surface of the joint. Then allow the joint to cool before moving, so the filler metal solidifies.

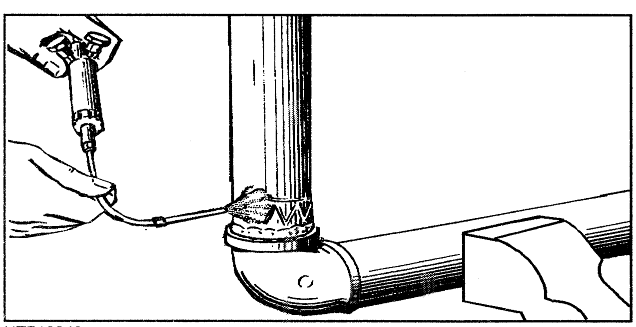
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Figure 3-46.—Applying heat for brazing a tube and fitting.

Gas-Welding Equipment

A number of different types of equipment are used in silver brazing. In your work, silver brazing can be accomplished by the use of methylacetylene propadiene (MAPP) cutting/welding equipment.

A commonly used oxygas welding outfit (fig. 3-47) consists of a cylinder of acetylene or MAPP gas or a cylinder of oxygen, two regulators, two lengths of hose with fittings, and a welding handle with tips. An oxygas outfit also is called a "welding rig."

In addition to the basic equipment mentioned above, numerous types of auxiliary equipment are used in oxygas welding. A very important item is the spark igniter that is used to light the torch (view A, fig. 3-48). Another item you will use a lot is an apparatus wrench, the same or similar in design to that shown in view B, figure 3-48. The apparatus wrench is sometimes called a "gang wrench" because it fits all the connections on the welding rig. Note that the wrench shown has a raised opening in the handle that serves as an acetylene tank key. Other common accessories include tip cleaners, cylinder tracks, clamps, and holding jigs. Safety apparel, such as goggles, face shields, gloves, leather aprons, sleeves and leggings, also is essential and should be worn as required for the job at hand.

Oxygas welding equipment may be stationary or portable. A portable oxygas outfit, such as that shown in figure 3-49, is advantageous where the equipment must be moved around from one job to another.

To carry out your welding duties, you should understand the purpose and function of the basic pieces of equipment that make up the welding outfit. Before discussing the apparatus, look at the gases used in gas welding, particularly MAPP gas and oxygen.

MAPP GAS.—MAPP gas is an all-purpose industrial fuel that has the high-flame temperature of acetylene and the handling characteristics of propane.

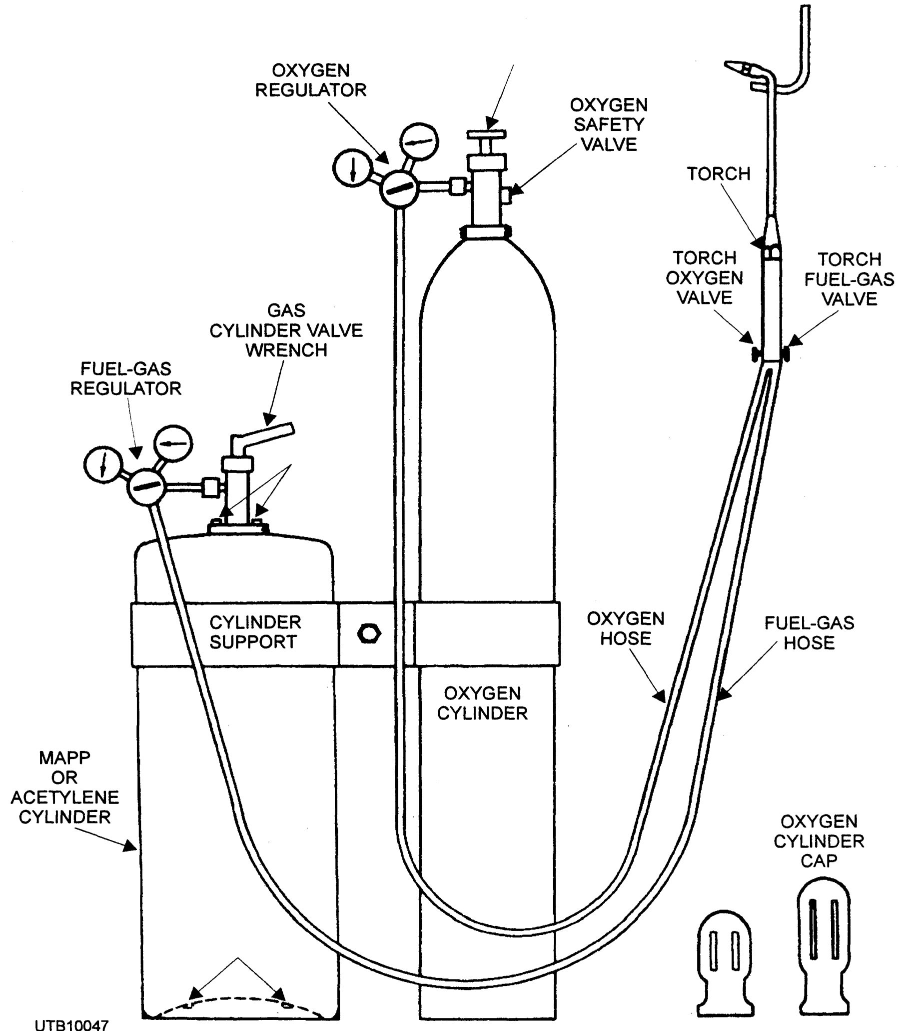


Figure 3-47.—An oxygas welding outfit.

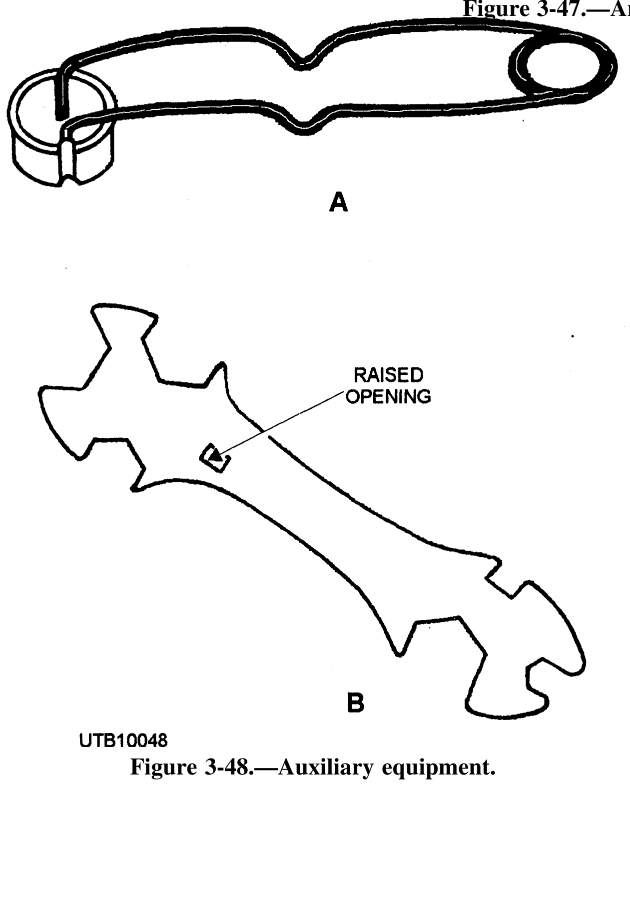
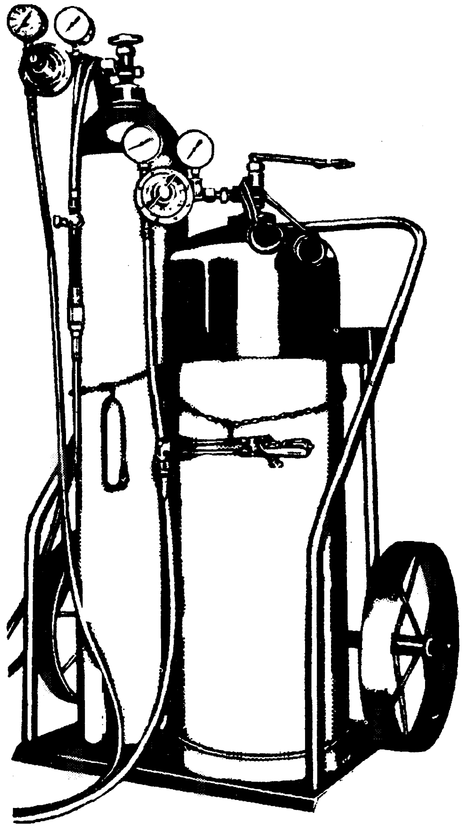


Figure 3-48.—Auxiliary equipment.

Being a liquid, MAPP is obtained by the pound, rather than by the cubic foot, as with acetylene. One 70-pound cylinder of MAPP gas does the work of more than six and one-half 225-cubic-foot acetylene cylinders. This is a ratio of 70 pounds of MAPP gas to about 1,450 cubic feet of acetylene.

Total weight for the 70-pound MAPP cylinder, which is the same physical size of a 225-cubic-foot acetylene cylinder, is 120 pounds when full.

MAPP cylinders contain only liquid fuel. There is no cylinder packing of acetone to impair fuel withdrawal. For heavy-use situations, a MAPP cylinder delivers more than twice as much gas as an acetylene cylinder for longer periods of time. The entire contents of a MAPP cylinder can be used, since there is no acetone that could be drawn into the regulators or the torch. As the gas burns with oxygen, it produces a flame temperature of 5300°F (2927°C) and equals or exceeds the performance of acetylene for



UTB10049

Figure 3-49.—Portable oxygas welding and cutting outfit.

cutting, heating, and brazing because of its superior heat transfer characteristics.

Acetylene regulators, hoses, torches, and welding tips may be used without any significant disparity. Very often the same-size tip can be used for welding with MAPP gas as with acetylene. However, it is recommended that a tip one or two sizes larger be used with MAPP gas for optimum results. Table 3-2 is a good guide to follow when you are using acetylene tips for MAPP-gas welding.

MAPP is not sensitive to shock, and it is nonflammable in the absence of oxygen. There is no chance of an explosion if a cylinder is bumped, jarred, or dropped. The cylinders can be stored for transporting in any position without danger of an explosive air pocket being formed. The characteristic odor, while harmless, gives warnings of fuel leaks in the equipment long before danger.

MAPP gas is not restricted to a maximum working pressure of 15 psig as is acetylene. In jobs requiring higher pressure and gas flow, MAPP at the full-cylinder pressure of 95 psig at 70°F (21°C) can be used safely.

WELDING AND BRAZING.—With MAPP gas, this requires some differences in equipment and technique.

Prepare steel to be welded with MAPP the same as for welding with acetylene. For metals thinner than 1/8 inch (3.1 mm), clean the metal to be welded well, either with a wire brush or a grinding wheel. When metal is thicker than 1/8 inch, bevel it first and clean it thoroughly.

Position the steel with a root opening equal to the material thickness when the work is thinner than 1/8 inch. If the metal is thicker than 1/8 inch, leave a gap equal to the diameter of the welding rod to be used.

Set the gauge pressure with the torch valves closed; if the metal to be welded is 3/16 inch (4.2 mm) or less, set the gas (MAPP) pressure at 2-3 psig and the oxygen pressure at 10-15 psig. When working with 1/4

Table 3-2.—Substituting Acetylene Tips for MAPP Gas Use

DRILL	INNER FLAME LENGTH	REGULATOR PRESSURE RANGE		MAPP GAS USE	METAL WIDTH
SIZE OF TIP	INCHES	MAPP GAS	OXYGEN	CFH	INCHES
72-70	1/4	1-2	5-6	1-3	1/32
65-60	7/16	1-3	5-6	2-4	1/32-1/16
59-54	5/8	1-5	6-8	3-8	1/16-1/8
49-48	1	2-8	8-10	5-18	1/8-3/16
43-40	1 1/8	3-9	10-12	6-30	3/16-1/4
36	1 1/4	5-10	10-15	6-35	1/4 -3/8

inch (6.2 mm) or thicker steel, set MAPP-gas pressure at 4-5 psig and oxygen pressure at 15-20 psig.

When indoors or in an enclosed area, you should light the torch by slightly cracking the gas valve on the torch. Light it with an approved friction lighter and then open the oxygen valve to obtain a neutral flame (very blue). This is best for welding outdoors or where there is a draft or when a smokeless flame is desired. Crack the oxygen and gas valves slightly, light the torch, and adjust it to a neutral flame.

Check the cone length and make sure the flame is neutral (fig. 3-50). REMEMBER THE NEUTRAL MAPP-GAS FLAME IS LONGER THAN THE ACETYLENE FLAME.

Flame adjustment is the most important step of successful welding with MAPP gas. As with all other fuel gases, there are three basic types of gas flames: carburizing, neutral, and oxidizing (fig. 3-50).

A carburizing flame looks much the same with MAPP as with acetylene. It has a yellow feather on the end of the primary cone. Slightly carburizing or reducing flames are used when you are welding alloys that oxidize easily, such as aluminum.

As the oxygen is increased or the fuel gas decreased, the carburizing feather pulls off and disappears, and the inner flame becomes a deep blue. This neutral flame (fig. 3-50) is ideal for welding. Increasing the oxygen flow produces a lighter blue flame, a longer inner cone, and a louder burning sound to give you an oxidizing MAPP-gas flame.

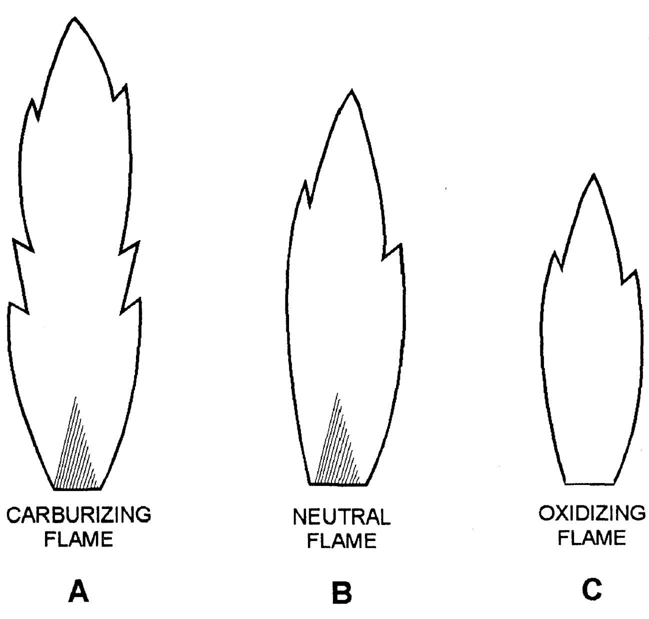


Figure 3-50.—MAPP-gas flames.

Occasionally a harsh, bushy flame may be required for a job; in such cases, counterboring is needed to provide a harsh, yet stable, flame with MAPP gas.

Bulk MAPP-gas facilities, similar to liquid oxygen stations, are installed at some activities where large supplies of gas are used. In a bulk installation, MAPP gas is delivered through a piping system direct to the points where it is used. Maximum pressure is controlled centrally for efficiency and economy.

Cylinder filling facilities are also available from bulk installations that allow users to fill their cylinders on site. Filling a 70-pound MAPP cylinder takes one person approximately 1 minute and is essentially like pumping water from a large tank to a smaller one.

MAPP-GAS SAFETY.—Liquified MAPP gas is insensitive to shock. A MAPP-gas cylinder does not detonate when dented, dropped, hammered, or even incinerated. It may also be used safely up to full-cylinder pressure. The gas vapors up to 419°F and 285 psig do not decompose when subjected to an energy source in the absence of oxygen. The vapor is also stable up to 600°F and 1,100 psig when exposed to an 825°F probe. The explosive limits of MAPP gas range from 3.4 percent to 10.8 percent in air or 1.5 percent to 60 percent in oxygen. These limits are very narrow in comparison with acetylene (fig. 3-51).

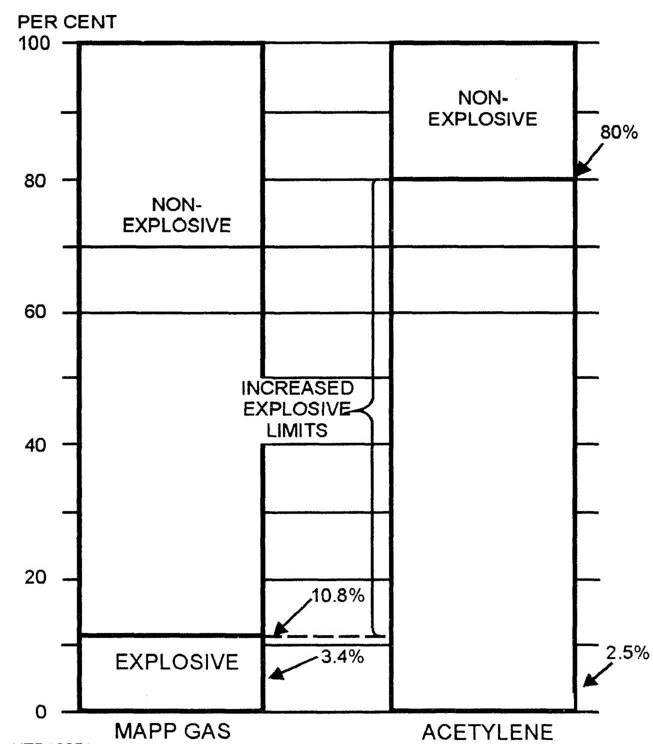


Figure 3-51.—Explosive limits of MAPP gas and acetylene in air.

MAPP gas has a detectable odor at 100 ppm or at a concentration 1/340 of its lower explosive limit.

Small fuel-gas systems may leak 1 or 1 1/2 pounds of fuel or more in an S-hour shift; bulk systems leak even more. Fuel-gas leaks are often difficult to find and oftentimes go unnoticed; however, a MAPP-gas leak is easy to detect and can be repaired before it becomes dangerous.

MAPP toxicity is rated very slight, but high concentrations (5,000 ppm) may have an anesthetic effect. Local eye or skin contact with MAPP-gas vapor causes no adverse effect. The LIQUID FUEL MAY CAUSE DANGEROUS FROSTLIKE BURNS because of the temperature at which MAPP gas must be stored.

OXYGEN.-Oxygen is a colorless, tasteless, and odorless gas slightly heavier than air. It is not flammable but supports combustion with other elements. In its free state, oxygen is one of the most common elements. Rusting of ferrous (containing iron) metals, discoloration of copper, and corrosion of aluminum are all due to the action of atmospheric oxygen. This action is called “oxidation.”

When oxygen is supplied for use in oxyacetylene welding, oxygen is contained in seamless steel cylinders. A typical oxygen cylinder is shown in figure 3-52. Oxygen cylinders are made in several sizes; however, you will find the size most often used in welding and cutting is the 200-cubic-foot capacity cylinder. It is 9 1/8 inches in diameter and weighs about 145 pounds. This cylinder is charged to a pressure of 2,000 psi at a room temperature of 63°F (17.2°C).

You can tell the amount of oxygen in a compressed-gas cylinder by reading the volume scale on the high-pressure gauge attached to the regulator.

REGULATORS.—The gas pressure in a cylinder must be reduced to a suitable working pressure before it can be used. This pressure is reduced by a regulator or reducing valve. Regulators that control the flow of gas from the cylinder are either single stage or double stage. Single-stage regulators reduce the pressure of the gas in one step, while two-stage regulators perform the same work in two steps or stages. Generally, less adjustment is necessary when two-stage regulators are used.

Figure 3-53 shows two SINGLE-STAGE regulators: one for acetylene and one for oxygen. The

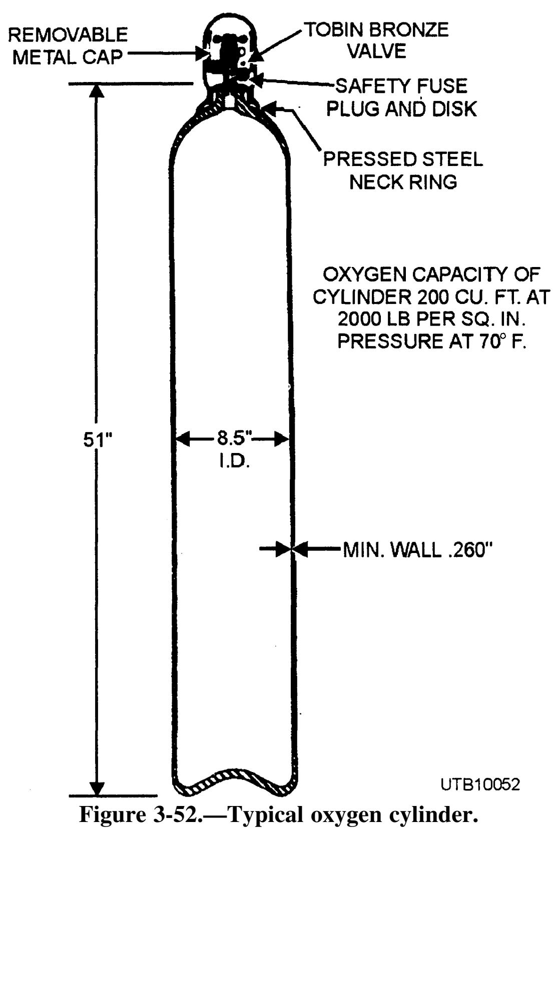


Figure 3-52.—Typical oxygen cylinder.

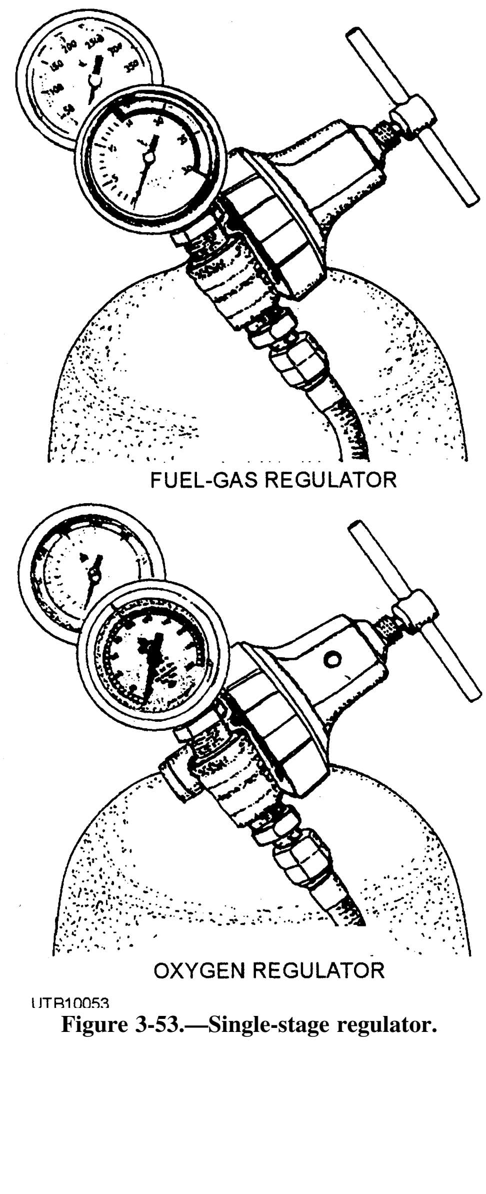


Figure 3-53.—Single-stage regulator.

regulator mechanism consists of a nozzle through which the high-pressure gases pass, a valve seat to close off the nozzle, a diaphragm, and balancing springs. These items are all enclosed in a suitable housing. Pressure gauges indicate the pressure in the cylinder or pipeline (inlet), as well as the working pressure (outlet). The inlet pressure gauge, used to record cylinder pressures, is a high-pressure gauge. The outlet pressure gauge, used to record working pressure, is a low-pressure gauge. Acetylene regulators and oxygen regulators are of the same general type, although those designed for acetylene are not made to withstand as high a pressure as those designed for use with oxygen cylinders.

In the oxygen regulator, the oxygen enters the regulator through the high-pressure inlet connection and passes through a glass wool filter that removes dust and dirt. Turning the adjusting screw IN (to the right) allows the oxygen to pass from the high-pressure chamber to the low-pressure chamber of the regulator, through the regulator outlet, and through the hose to the torch. Turning the adjusting screw to the right INCREASES the working pressure; turning it to the left DECREASES the working pressure. The high-pressure gauge is graduated in pounds per square inch from 0 to 3,000 and in cubic feet from 0 to 220. The gauge can be read to determine cylinder pressure and cubic content. Gauges are graduated to read correctly at 70°F (21°C). The working-pressure gauge is graduated in pounds per square inch from 0 to 150 or less, from 0 to 200, or from 0 to 400, depending upon the purpose of the regulator. For example, on regulators designed for heavy cutting, the working-pressure gauge is graduated in pounds per square inch from 0 to 400.

The TWO-STAGE regulator is similar in principle to the single-stage regulator. The main difference is that the total pressure drop takes place in two steps instead of one. In the high-pressure stage, the cylinder pressure is reduced to an intermediate pressure. In the low-pressure stage, the pressure is reduced from the intermediate pressure to a working pressure. A typical two-stage regulator is shown in figure 3-54.

WELDING TORCHES.—The oxygas welding torch mixes oxygen and MAPP gas in the proper proportion and controls the amount of the mixture. at the welding tip. Torches have two needle valves: one for adjusting the flow of oxygen and the other for adjusting the flow of MAPP gas. Other basic parts include a handle, two tubes (one for oxygen and another for MAPP gas), a mixing head, and a tip. Welding tips are made from copper and are available in different sizes to handle a wide range of plate thicknesses.

There are two general types of welding torches: a low-pressure type and a medium-pressure type. In the low-pressure torch, also known as an injector-type torch, MAPP-gas pressure per square inch is kept at about 1 pound. The oxygen pressure ranges from about 10 to 40 pounds, according to the size of the torch tip. A jet of relatively high-pressure oxygen produces the suction necessary to draw the MAPP gas into the mixing head. The welding tips may have separate injectors in the tip. A typical mixing head for the

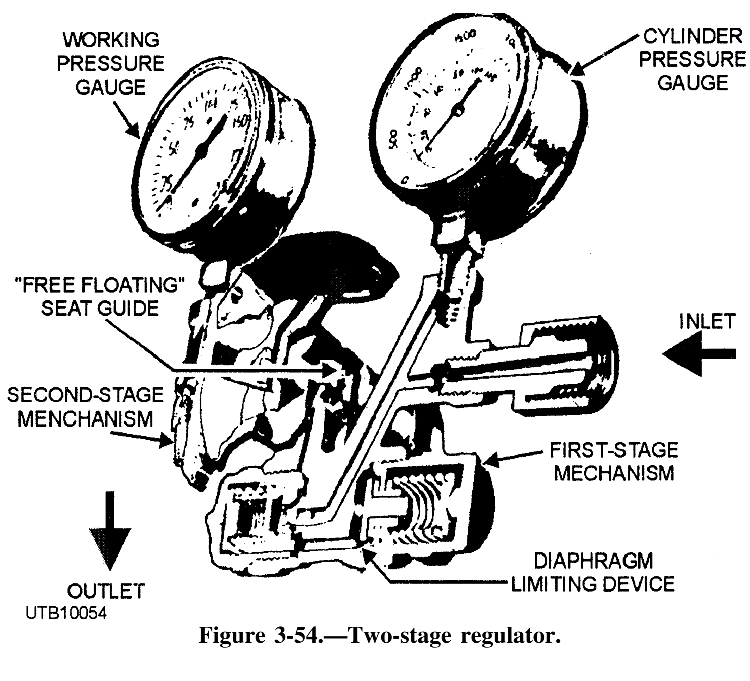


Figure 3-54.—Two-stage regulator.

low-pressure (or injector-type) torch is shown in figure 3-55.

Medium-pressure torches are sometimes called balanced-pressure or equal-pressure types, since the acetylene and the oxygen pressure are kept equal. Pressure per square inch may be from 1 to 6 or 8 pounds; **ACETYLENE PRESSURE MUST NEVER BE ALLOWED TO EXCEED 15 PSI.** A typical equal-pressure general-purpose torch is shown in figure 3-56. The medium-pressure torch is easier to adjust than the low-pressure torch and, since equal gas pressures are used for the medium-pressure torch, you are less likely to get a flashback; the flame is less likely to catch in or behind the mixing chamber. More details on flashback are provided later in this chapter.

Welding TIPS and MIXERS are designed in several ways, depending on the manufacturer. Some makes of torches have a separate mixing head or mixer for each size of tip. Other makes have only one mixer for several tip sizes. Tips come in various types. Some are one-piece, hard copper tips. Others are two-piece tips and include an extension tube to make connection

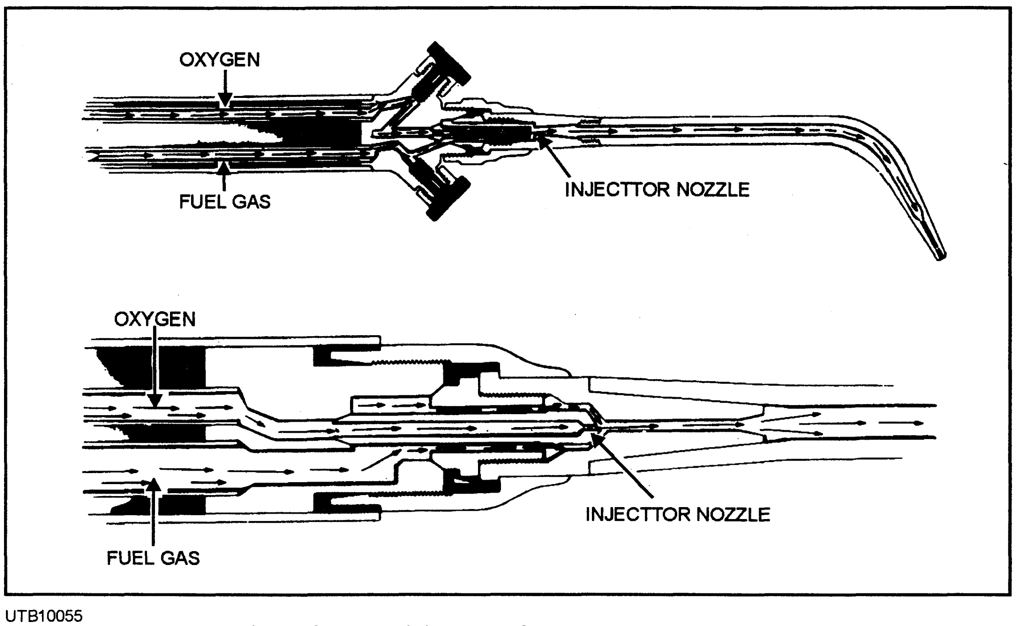


Figure 3-55.—Mixing head for a low-pressure torch.

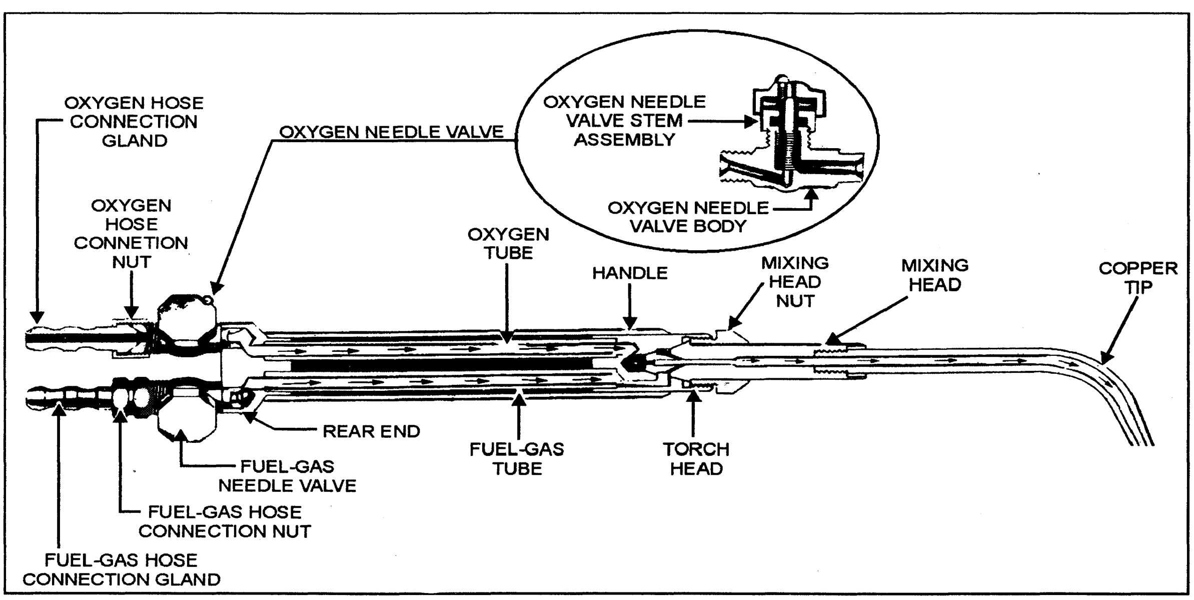


Figure 3-56.—Equal-pressure welding torch.

between the tip and the mixing head. When the removable tips are used with an extension tube, they are made of hard copper, brass, or bronze.

Tip sizes are designated by numbers, and each manufacturer has an arrangement for classifying them. Tip sizes differ in the diameter of the hole to obtain the correct volume of heat for the work to be done.

HOSE.—Hose used to make the connection between a torch and a regulator is strong, nonporous, and sufficiently flexible and light to make torch movements easy. It is made to withstand high-internal pressures. The rubber used in its manufacture is specially treated to remove sulfur to avoid the danger of spontaneous combustion. Welding hose comes in various sizes, depending upon the size of work for which it is intended. Hose used for light work is 3/16- or l/4-inch-inside diameter, and it has one or two plies of fabric. For heavy-duty welding and cutting operations, hose with a 5/16-inch-inside diameter and three to five plies of fabric should be used. Single hose comes in lengths of 12 l/2 feet to 25 feet. Some manufacturers make a double hose that conforms to the same general specifications. The hoses used for acetylene and oxygen are the same in grade, but they differ in color. Oxygen hose is GREEN; MAPP-gas hose is RED.

CAUTION

Use no oil, grease, or other lubricant on welding (or cutting) apparatus. Oil or grease in the presence of oxygen under pressure ignites violently!

FILLER RODS is the term that refers to a filler metal, in wire or rod form, for use in gas welding and brazing processes and certain electric welding processes when the filler metal is not a part of the electric circuit. A filler rod serves only one purpose; it supplies filler metal to the joint.

Filler rods for steel are often coated with copper to protect them from corrosion during storage. Most rods are furnished in 36-inch lengths and a wide variety of diameters, ranging from l/32 to 3/8 inch. Rods for welding cast iron vary from 12 to 24 inches in length and are frequently square, rather than round, in cross section. The rod diameter selected for a given job is governed by the thickness of the metals being joined. Except for the rod diameter, the filler rod selected is determined by military (MIL) specification on the basis of the metals being joined.

Many different types of rods are manufactured for welding ferrous and nonferrous metals. In general, welding shops stock only a few basic types that are suitable in all welding positions. These basic types are known as general-purpose rods.

SELECTION OF TORCH TIP.—Welding torch tip size is designated by a number stamped on the tip. The tip size is determined by the size of the orifice. There is no standard system of numbering welding torch tip sizes; each manufacturer has a numbering system. In this manual, tip size instructions are provided in orifice "Numbers drill" size. Number drills consist of a series of 80 drills, Numbers 1 through 80. Once you know a manufacturer's torches and numbering. system, you rarely have to refer to orifice number drill sizes.

Since the orifice size determines the amount of acetylene and oxygen fed to the flame, the orifice determines the amount of heat produced by the torch. The larger the orifice, the greater the amount of heat generated. For practical purposes with a balanced, pressure-type torch, use table 3-3.

If the torch tip orifice is too small, not enough heat is available to bring the metal to its melting and flowing temperature. If the torch tip is too large, poor welds result because the weld has to be made too fast. the welding rod melting is hard to control,

Table 3-3.—Welding Rod Sizes and Tip Sizes Used to Weld Various Thicknesses to Metal

Metal Thickness	Diameter Welding Rod*	Tip Drill Size
l/16	l/16	60-69
1/8	3/32	54-57
1/4	3/32-l/8	44-52
3/8	5/32	40-50
	3/16	
	3/16-l/4	

*Sizes listed in this table are approximate and provide satisfactory results. The size of the piece being welded will govern the tip choice. When welding small pieces, use a smaller tip and welding rod. When welding larger pieces, use a larger size tip and welding rod.

and the appearance and quality of the weld are unsatisfactory.

SECURING OXYGAS WELDING EQUIPMENT.—To extinguish the oxygas flame and to secure equipment after completing a job, or to interrupt work temporarily, take the following steps:

1. Close the MAPP-gas needle valve first, then close the oxygen needle valve to extinguish the flame.

2. Close both the oxygen and the MAPP-gas cylinder valves. Leave the oxygen and MAPP-gas regulators open temporarily.

3. Open the MAPP-gas needle valve on the torch and allow gas in the hose to escape (5-15 seconds) to the outside atmosphere. Do not allow gas to escape into a small or closed compartment. Close the MAPP-gas needle valve.

4. Open the oxygen valve on the torch and allow gas in the hose to escape (5-15 seconds). Close the valve.

5. Close both oxygen and MAPP-gas cylinder regulators by backing out the adjusting screws until they are loose.

Follow the above procedures whenever your work is interrupted for an indefinite period. When work is to stop for only a few minutes, you do not have to secure the cylinder valves nor drain the hose; however, for any indefinite work stoppage, follow the entire extinguishing and securing procedures. For overnight work stoppage in areas other than the shop, it is safer to remove the pressure regulators and the torch from the system. Double-check the cylinder valves to make sure they are closed securely.

Maintenance of Gas-Welding Equipment

Welding equipment must be kept up if it is to work well for a long time. You do not have to make repairs to welding equipment; but when repairs are needed, see that the equipment is removed from service and turned in for repair. You are responsible for various duties in the maintenance and care of oxygas welding equipment. This section identifies some of the common types of maintenance duties that you can expect to perform.

Ensure welding torches are kept away from oil and grease. At times, the needle valve may fail to shut off when hand-tightened in the usual manner. If so, do not use a wrench to tighten the seat in the valve stem. When foreign matter cannot be blown off the seat, remove the stem assembly and wipe the seat clean before reassembling. Be sure and keep the mixer seat free of dust, dirt, and other foreign matter.

Before a new torch is used for the first time, check the packing nut on the valves to make sure it is tight. Some manufacturers ship torches with these nuts loose.

Welding tips get rough treatment at times. So keep the orifice smooth and clean if you want the tip to work well. When cleaning a welding tip, do not enlarge or scar it. Remove carbon deposits and slag regularly.

Avoid dropping a tip because the seat that seals the joint may be damaged. The flame end of the tip may receive mechanical damage if you let it contact the welding work, the bench, or the firebricks. This damage can roughen the end of the tip and cause the flame to burn with a "fishtail."

Special welding tip cleaners have been developed to perform this service satisfactorily. The cleaner consists of a series of broachlike wires that correspond in diameter to the diameter of the tip orifices. These wires are packaged in a holder that makes their use safe and convenient. Some welders prefer to use a number drill that is the size of the tip orifice to clean welding tip orifices. A number drill must be used carefully, so the orifice is not enlarged, bell-mouthed, reamed out of round, or otherwise deformed.

The flame end of the tip must be clean and smooth. Its surface must be at right angles to the center line of the tip orifice for a flame that is shaped correctly. A 4-inch mill file is used to recondition this surface.

Should the end of the torch tip become rough and pitted and the orifice become bell-mouthed, recondition the tip. Place a piece of emery cloth, grit side up, on a flat surface; hold the tip perpendicular to the emery cloth; then rub it back and forth just enough to true the surface and to bring the orifice back to its original diameter.

If there is leakage around the TORCH VALVE STEM, tighten the packing nut, and repack it if necessary. For repacking, make sure you use only packing recommended by the manufacturer of the torch. DO NOT USE ANY OIL. If the valve stem happens to be bent or badly worn, replace it with a new stem.

A symptom of LEAKY VALVES is a continuous flow of gases after the valves are closed. Leaky valves are often caused by a dirty or damaged seat. To clean the seat, remove the valve assembly and wipe the seating portions of both the valve stem and the valve body with a clean rag. If the leak continues, try closing the valve tightly several times. When these measures fail to stop the leak, you may have to replace parts, or the valve body may have to be reseated. These repairs should be made only by qualified personnel.

Leaks in the MIXING-HEAD SEAT of the torch cause oxygen and MAPP-gas leaks between the inlet orifices leading to the mixing head. This defect can cause improper mixing of the gases and result in flashbacks. This defect can be corrected by reaming out the seat in the torch head and by truing the mixing-head seat. You may have to send the equipment to the manufacturer for these repairs, since special reamers are required for truing seats.

With regulators, gas leakage between the REGULATOR SEAT and NOZZLE is a common type of trouble. This defect can be detected by a gradual rise in pressure on the working-pressure gauge when the adjusting screw is fully released or is in position after adjustment. Frequently, this trouble, known as CREEPING REGULATOR, is caused by worn or cracked seats. It can also be brought on by foreign matter lodged between the seat and the nozzle. Regulators with leaks across the seats must be repaired at once; otherwise, damage to other parts of the regulator or apparatus may result. Leaks are particularly dangerous in acetylene regulators because acetylene, at very high pressure in the hose, becomes an explosive hazard. To ensure the safety of personnel and equipment, see that regulators with such leaks are removed from service and turned in for repair.

Another important aspect of welding safety is protecting your eyes and the vision of helpers, chippers, or inspectors where someone is soldering or silver brazing. Ensure you are aware of hazards, such as stray flashes, reflected glare, flying sparks, and bits of molten metal. Ensure that you are using the proper eye protective lenses. If you are not sure, ask your crew leader or project supervisor.

For hand protection, you may have to use either gauntlet gloves or mitts. Some of the important safety precautions in working with acetylene and oxygen cylinders are provided below. Quite a number of precautions apply to cylinders, so the following precautions are NOT a complete listing.

Store all cylinders carefully under prescribed storage procedures. Cylinders should be, stored in dry, well-ventilated, well-protected places, away from heat, and away from combustible materials: Do NOT store oxygen cylinders in the same compartment where acetylene or other fuel-gas cylinders are stored. All cylinders should be stored upright, rather than horizontally. If acetylene cylinders are not stored upright (valves at top), they must not be used until they have been allowed to stand upright for at least 12 hours to prevent acetone discharge. This tendency to discharge acetone depends largely upon the type of porous filler; however, 12 hours is ample time, regardless of the condition of the filler.

When the cylinder is empty, the letter *E* should be written on the cylinder with a piece of soapstone, keel, or crayon. Store empty cylinders separately from charged ones. Storage spaces must have adequate ventilation and must not be exposed to fire hazards, extremes of weather, continuous dampness, or accumulations of snow or ice.

Galvanized Pipe

The term *galvanized* means that wrought-iron and steel pipe are protected to resist corrosion. Wrought-iron and steel pipe are made in the same manner. Wrought iron is about twice the cost of galvanized steel, and it is used more for waste systems than for water service. Almost all steel and wrought-iron pipe are galvanized on the outside and on the inside at the factory.

Black iron pipe (not galvanized) is cheaper than galvanized pipe. Black iron pipe is suitable for heating (both steam and hot water) and compressed air systems. It is also used for gas and oil pipelines exclusively. Black iron pipe is NOT suitable for use, either in a water-supply system or a drainage system. This is because black iron pipe rusts and causes stoppages or leaks within a short time.

Galvanized wrought iron and steel pipes are cut, measured, and threaded in the same manner. Both types of pipe come in lengths from 18 to 22 feet. The 20-foot length is about average. These pipes are classified into weights, such as standard, heavy, and extra heavy and refer to the wall thickness of the pipe. The wall thickness is a factor that bears directly on the amount of pressure the pipe can withstand.

FITTINGS.—The fittings used on either wrought-iron or steel pipe are generally made of malleable iron or cast iron. There are two types of iron pipe fittings: the pressure type and the recessed type. To compare these two types of fittings, study figure 3-57.

The pressure type of fitting is the standard fitting used on water pipe. The recessed type of fitting, also known as a cast-iron drainage or Durham fitting, is generally required on all drainage lines. The recessed type is most suitable for a smooth joint; it reduces the probability of grease or foreign material remaining in the joint and causing a stoppage in the line. Recessed fittings are designed so horizontal lines entering them have a slope of 1/4 inch per foot.

Types of iron pipe fittings include elbows, crosses, tees, and unions The four types of elbows are 90-degree, 45-degree, street, and reducing elbows. The 90-degree elbow changes the direction of an iron pipe 90 degrees, and a 45.degree elbow changes the direction by 45 degrees.

STREET elbows change the direction of an iron pipeline in a closed space where it is impractical to use an elbow and nipple. Both 45- and 90-degree street elbows are available. Street elbows have one female and one male thread, rather than two female threads.

The REDUCING elbow is similar to the regular 90-degree elbow, except that one opening is smaller than the other. For instance, a 3/4-inch pipe can be screwed into one opening of this fitting and a 1/2-inch pipe into the other opening.

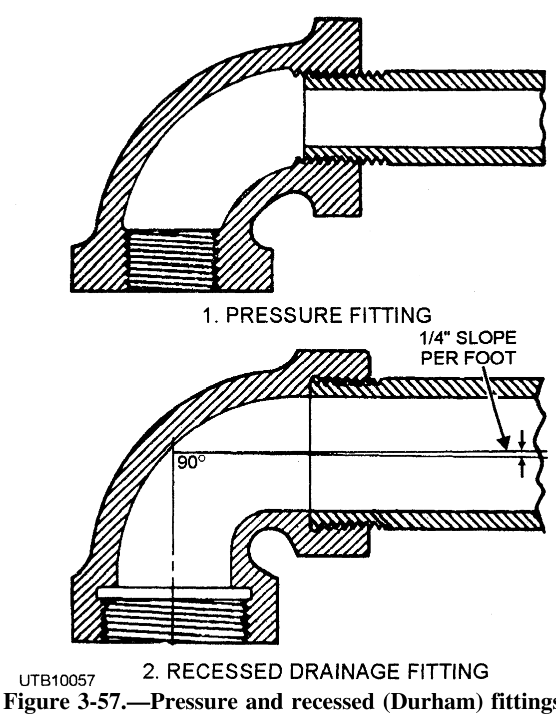


Figure 3-57.—Pressure and recessed (Durham) fittings.

An iron pipe CROSS is made of malleable iron in straight and reducing patterns and has female threads at all four branch points.

A common type of iron pipe tee is the STRAIGHT tee which has a portion that is straight through and a 90-degree takeoff on one side. All three openings of the straight tee are of the same size. Another common type is the REDUCING tee, similar to the straight tee just described, except that one of the threaded openings is of a different size than the others.

There are two types of iron pipe unions. They are the ground joint union and the flange union. The GROUND JOINT union consists of three pieces, and the FLANGE union is made in two parts. Both types are used for joining two pipes together and are designed so they can be disconnected easily.

Other types of iron pipe fittings include couplings, nipples, pipe plugs, pipe caps, and pipe bushings. Each fitting is discussed briefly.

Three common types of couplings are straight coupling, reducer, and eccentric reducer (fig. 3-58). The STRAIGHT COUPLING is for joining two lengths of pipe in a straight run that do not require additional fittings. A REDUCER joins two pipes of different sizes. The ECCENTRIC REDUCER has two female threads of different sizes with different centers so, when joined, the two pieces of pipe are not in line with each other. It is installed to provide optimum drainage of the line.

A NIPPLE is a short length of pipe (12 inches or less) with a male thread on each end. It is used as an extension for a fitting. In plumbing work, nipples are often used. Nipples are available in many precut sizes. Figure 3-58 shows several common types of nipples.

Pipe PLUGS are fittings with male (outside) threads. They are screwed into other fittings to close openings. Pipe plugs have various types of heads, such as square, slotted, and hexagon sockets (fig. 3-58).

A pipe CAP (fig. 3-58) is a fitting with female (inside) threads. It is used like a plug. It screws on the male thread of a piece of pipe.

A pipe BUSHING is a special fitting with a male thread on the outside and a female thread on the inside (fig. 3-58). Bushings reduce the size of openings of fittings and valves to a smaller diameter.

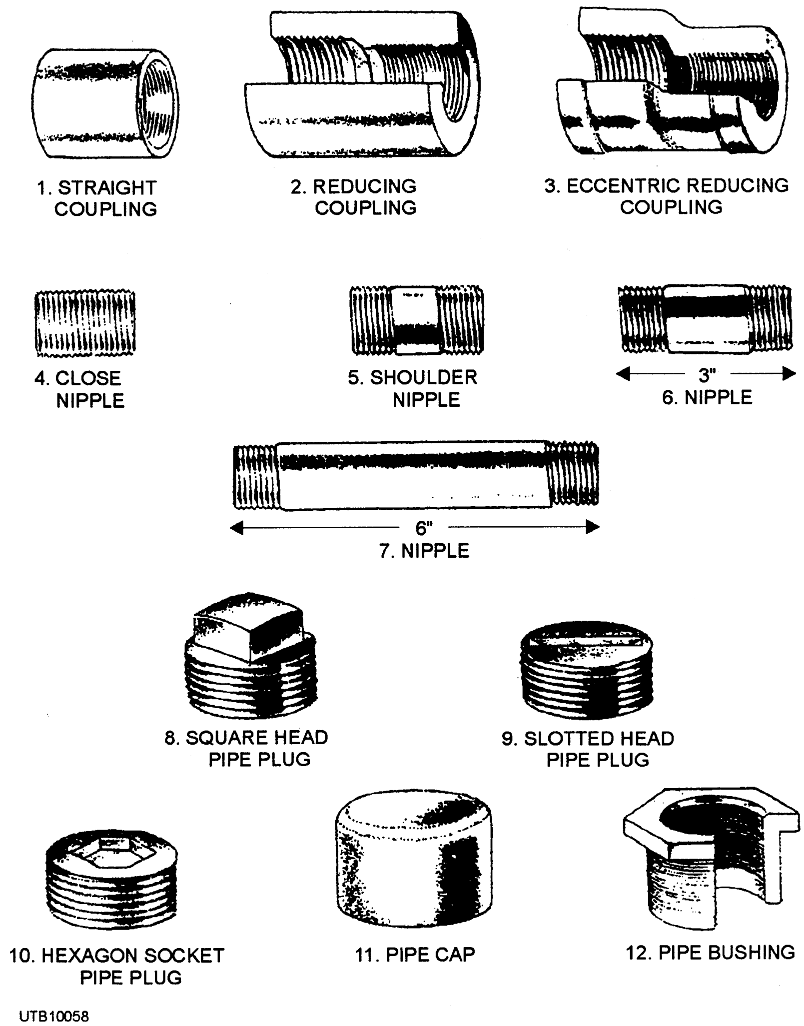


Figure 3-58.—Types of iron pipe couplings, nipples, plugs, caps, and bushings.

At times, you may use the DIELECTRIC or INSULATING type of fitting. These fittings connect underground tanks or water heater tanks. They are also used when pipes of dissimilar metals are joined. The purpose of dielectric fittings is to curtail galvanic or electrolytic action. The most common dielectric fittings are the union, the coupling, and the bushing.

READING THE SIZE OF FITTINGS.—To help you read the designations of fittings, you should know that each opening of the fitting is identified with a letter that indicates the sequence in reading the size of the fitting. As shown in figure 3-59, a cross with one end of run and one outlet reduced is designated as 2 1/2(A) × 1 1/2(B) × 2 1/2(C) × 1 1/2(D). This is done simply by naming the largest opening first and then naming the other openings in the order indicated.

Elbows and crosses are always identified by designating the size of the largest opening first, following with the size of the other openings in proper order. Tees, 45-degree Y-branches, and double-branch elbows are identified by designating the size of the largest opening on the run first, the opposite opening of the run second, and the size of the outlet last; for example, a 3 × 2 × 1 1/2 size tee is one that has openings 3(A) × 2(B) × 1 1/2(C). In designating the outlets of side outlet reducing fittings, the size of the side outlet is named last. Refer to figure 3-59. The rules for reading screwed fittings also apply to reading other reduced fittings.

MEASURING.—Galvanized steel, galvanized wrought-iron, and black iron pipe are measured for size by the INSIDE diameter of the pipe. The outside diameter of the pipe remains constant for the different weights; whereas the inside diameter of the pipe varies because of the wall thickness of the pipe. The outside diameter is held constant because the pipe is normally joined by threaded joints, and one die can be used to thread any weight of one size. Also, fittings of a uniform size on the inside fit all the different weights

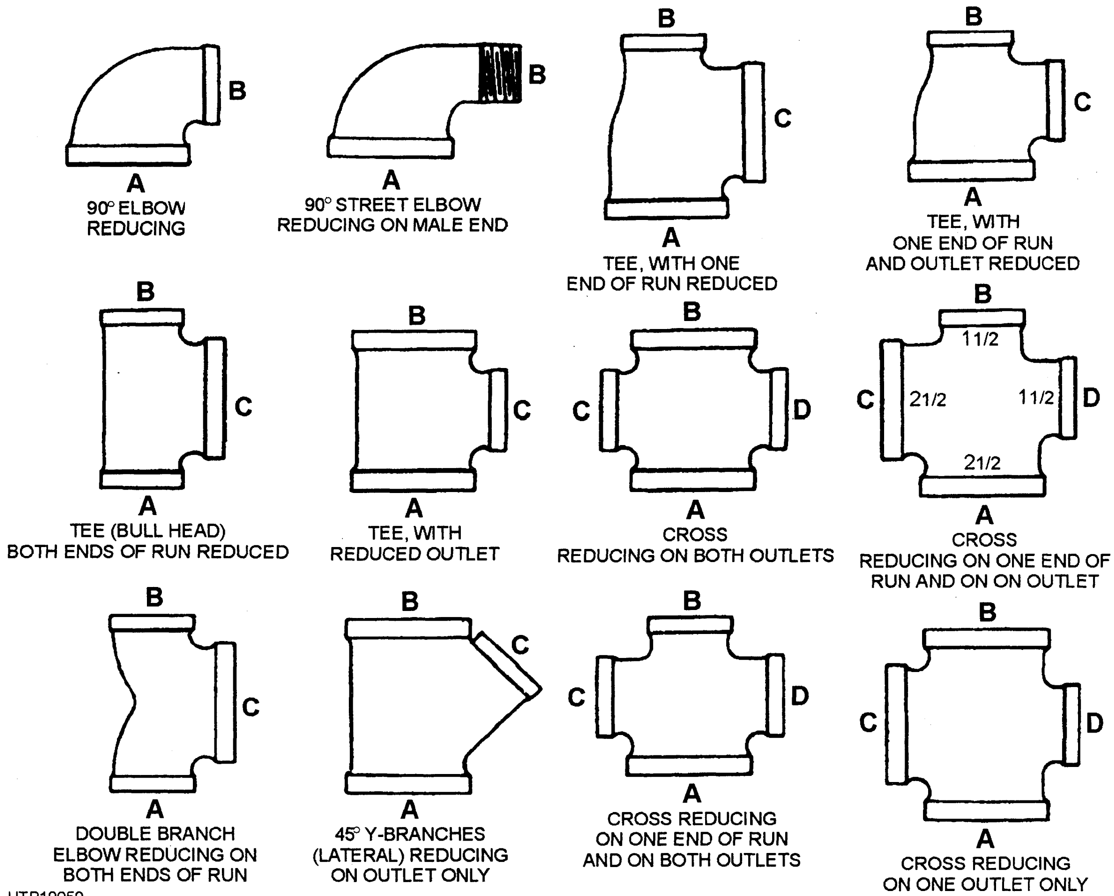


Figure 3-59.—How to read measurements of fittings.

of pipe. Threaded galvanized or black iron pipe is measured like copper pipe and tubing, as shown in figure 3-42.

CUTTING, REAMING, AND THREADING.—Galvanized pipe can be cut, reamed, and threaded by hand or with a power-operated machine. This discussion is limited to cutting, reaming, and threading pipe with a power-operated machine. A power-operated machine saves time, especially when a large volume of material has to be cut. A typical electrically operated pipe machine (drive) is shown in figure 3-60.

In cutting galvanized pipe with the machine shown in the figure, insert the pipe into the machine. Then

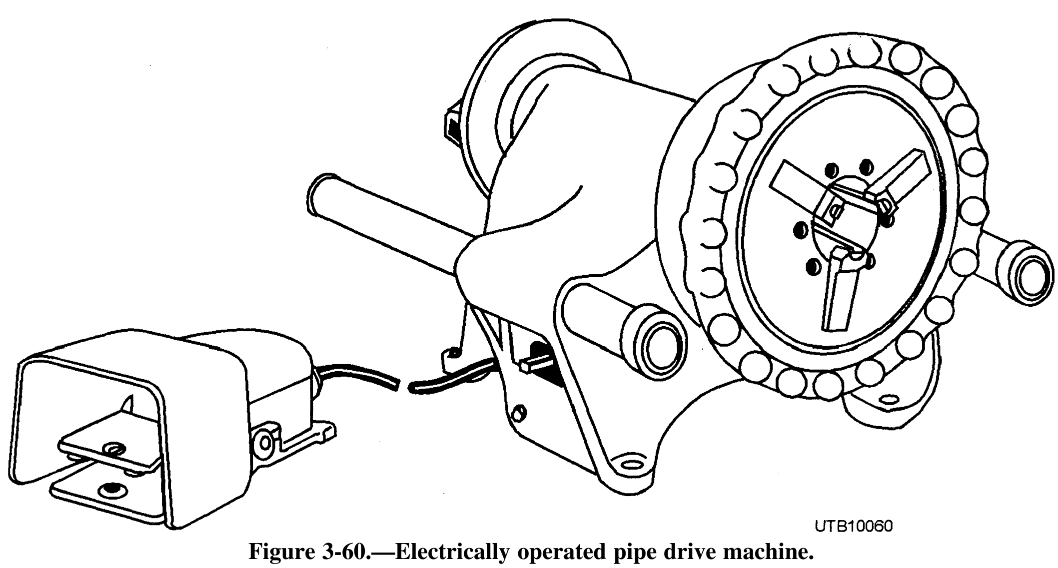


Figure 3-60.—Electrically operated pipe drive machine.

tighten the chuck jaws and rear centering jaws. Put the tool support bar in a position to support the cutter handle. Next, apply the cutter to the pipe as though you were cutting it manually. Let the cutter handle rest on the tool support bar. Ensure the cutter wheel is exactly on the mark where the pipe is to be cut. Now, tighten the cutter blade so it contacts the pipe. The next step is to turn the power switch to the FORWARD position. Continue turning the cutter blade into the pipe until the cut is completed.

After the pipe has been cut, it can be reamed with the same machine. To ream the pipe, place the reamer in the pipe end. Let the handle of the reamer rest against the tool support bar. Turn on the motor. Press the reamer into the pipe as needed to remove the burr.

The machine can also be used for threading pipe. First, insert the pipe into the front or the rear of the machine. Let the pipe extend out of the speed chuck far enough so the threader clears the chuck during threading. Next, center the pipe in the speed chuck and close the jaws with a snap spin of the handwheel. If the pipe extends out the back of the machine, close the rear centering jaws. Then place the threader on the pipe in the usual way. Pull out the tool support bar to the desired position and allow the threader handle to rest on the tool support bar on the switch side. Hook the safety latch over the handle. Now turn on the switch and proceed to thread the pipe. During the threading operation, remember to use plenty of cutting oil. In addition to the machine shown in figure 3-60, figures 3-61 and 3-62 show other types of power pipe machines and their accessories.

JOINING.—THREADED PIPE JOINTS are used on galvanized steel, galvanized wrought-iron, and black iron pipe. This method of pipe joining involves connecting threaded male and female ends.

To obtain a tight-threaded joint, be sure the threads are clean and in good condition. If the pipe has been exposed to the weather or banged around, check the threads carefully. When necessary, run a die over the threads to straighten the damage.

After securing the pipe in a vise, you must clean both ends with a wire brush. Then apply a good thread lubricant on the male pipe threads. You should always use a Navy-approved nontoxic compound for water pipes or antisiezing tape and mixed powdered graphite and oil for steam pipes. Do not apply pipe dope inside the pipe fitting, or you will foul the system.

Start the joint by hand and turn it up as far as you feel it will go. Now, slowly screw the remaining section of the pipe into the joint and tighten it with a pipe wrench. Do not use a hickey, or oversized wrench, or too much pull. Not all of the male threads should be screwed into the joint. If all the threads are used, the

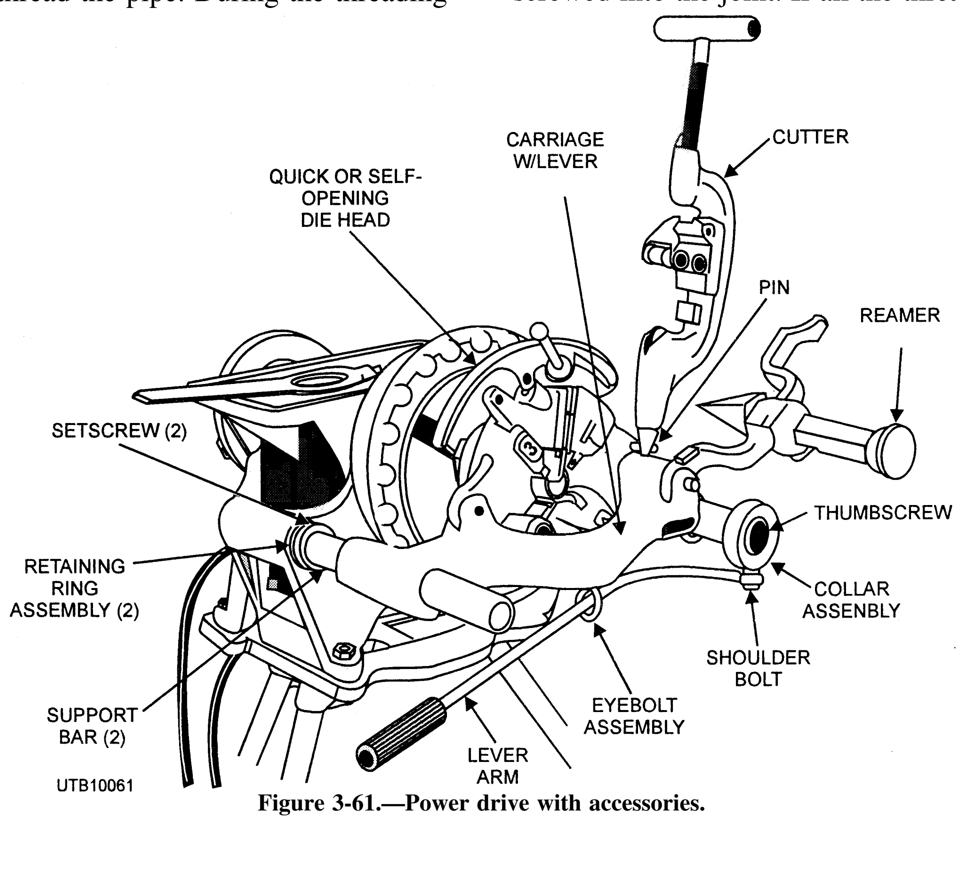


Figure 3-61.—Power drive with accessories.

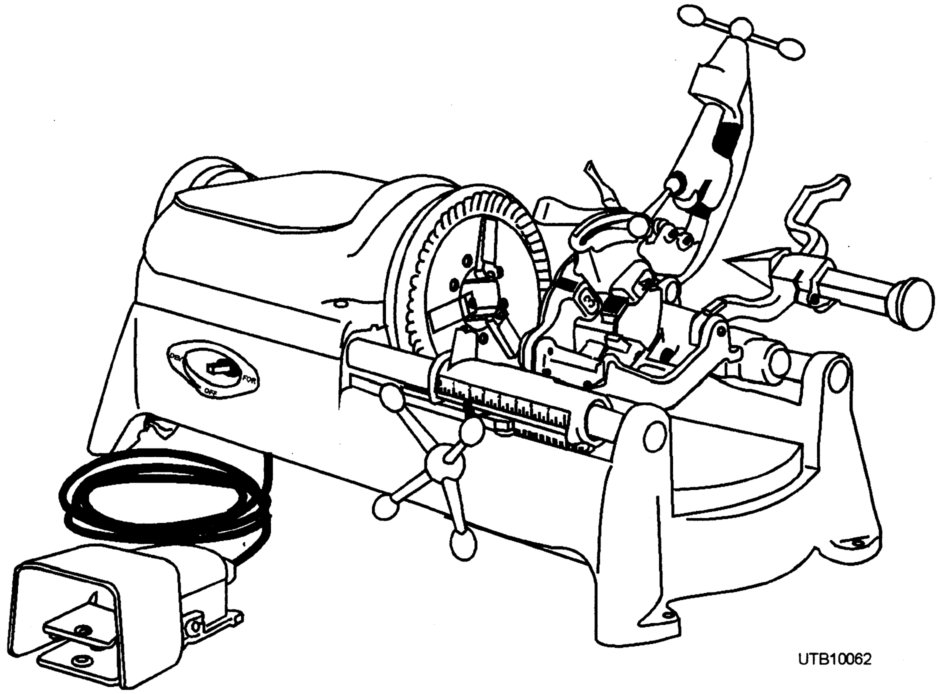


Figure 3-62.—Pipe- and bolt-threading machine.

wedging action of the tapered thread may cause the fittings to split. Usually there are two or three unused threads on a pipe that is threaded properly. If you follow the above steps and the threads are made properly, the joints will be tight for pressures several times the 150-psi working pressure of the fittings.

Cement-Asbestos Pipe

Cement-asbestos pipe is corrosion-resistant and does not rust or rot. It has a smooth interior surface that is a favorable friction factor. This pipe comes in sizes from 3 to 36 inches in diameter for pressures of 50 to 200 psi and in lengths of 5, 10, and 13 feet. Light in weight, cement-asbestos pipe is easy to handle. It is made with beveled ends, and adapters are available for connecting to pipe made of other materials.

FITTINGS.—In the absence of cement-asbestos fittings, you can use double-bell, cast-iron fittings and make them up as you would with cast-iron pipe, using sulfur compounds or lead.

CUTTING.—Cement-asbestos pipe can be cut to any length or angle with a carpenter's saw or a transite pipe cutter. Or, it can be tapped for threaded service connections by using a water main self-tapping machine. With this machine, the pipe can be tapped, threaded, and a corporation stop installed while the pipe is under water pressure.

Because of the health and environmental hazards associated with cement-asbestos pipe, special cutting and handling kits have been procured by the Navy and are available through the naval supply system. Whenever cement-asbestos pipe is encountered, the base or unit environmental officer should be contacted. Also, the newest and most up-to-date instructions should be obtained and followed. Since safety procedures governing asbestos-related equipment change, an attempt to outline all the pertinent procedures for working with asbestos are not included in this manual; however, there are two important factors you should keep in mind. First, always wear a breathing filter or mask. Second, use water while cutting to keep the dust from becoming airborne, or use a vacuum to pull dust from the area of the cutting tool.

JOINING.—Joints in cement-asbestos pipe are made with a special coupling with three rubber sealing rings. Three rings are fixed in grooves at the factory, ready for assembly.

Figure 3-63 shows a cutaway view of a completed joint with the three rings in proper position. As each pipe moves into position during assembly, the rubber

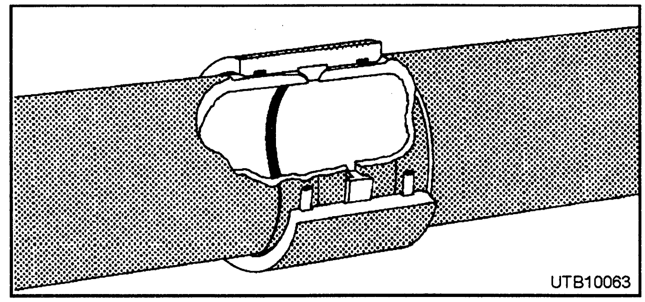


Figure 3-63.—Cutaway view of a cement-asbestos pipe joint.

rings in the two outer grooves of the coupling are compressed to seal the joint tightly. The T-shaped center ring forms a seal between the pipe ends to eliminate jogs and pockets and to provide for uninterrupted flow. In this type of joint, you have a tight and flexible connection.

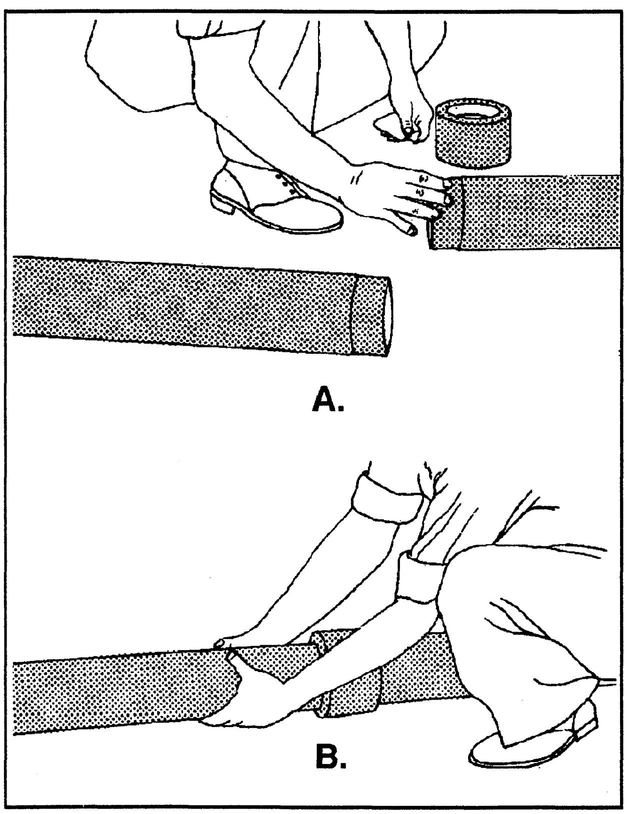
A joint like the one shown in the figure can be assembled entirely by hand. After making sure the rings in the grooves of the coupling are in correct position, use the following two-step procedure, shown in figure 3-64, to make the connection.

1. Apply a thorough coating of lubricant to the male end of the pipe, all the way around (view A, fig. 3-64). If a special lubricant supplied by the manufacturer is not available, prepare a jellylike soap solution instead.

2. Pull or push the pipe together, as shown in view B of figure 3-64, and the joint is complete.

Ductile Iron Pipe

Ductile iron is cast iron in which the carbon is reformed by magnesium inoculation. This results in exceptional strength characteristics without otherwise changing the basic nature of the cast iron. Because of this treatment, ductile iron has exceptional strength with good machinability, high impact, corrosion resistance, and great beam strength. For these reasons, ductile iron pipe is ideal for transportation of water.



UTB10064

Figure 3-64.—Steps in assembling a cement-asbestos pipe joint.

When laying this pipe, you should ensure that both the bell and plain ends are clean. This is to prevent leaking joints. Sand, dirt, excess coating, ice, and other foreign material should be removed carefully from the plain end and the interior of the bell. This ensures proper seating of the gasket and correct entry of the plain end into the bell socket. The direction of the bells is not related to the direction of water flow within the pipe.

The mechanical joint for ductile iron pipe has four parts: a flange cast integrally with the bell of the pipe; a rubber gasket fitting a recess in the socket; a gland, or follower ring, to compress the gasket; and bolts and nuts for tightening the joint. The assembly of the joint is simple and requires only a wrench to tighten the nuts.

If the pipe must be cut, it may be cut with an abrasive wheel, a rotary wheel cutter, a guillotine pipe saw, a milling wheel saw, or an oxyacetylene torch. Of these cutting tools, the abrasive wheel saw is used most often for out-of-trench cuts; while the oxyacetylene torch method is used in trench cuts. Cut ends and rough edges should be ground smooth. For push-on type connections, the cut end should be beveled slightly.

Because of the high-impact strength of ductile iron, you only need to remove rocks and boulders 8 inches or greater in diameter from the material to be used as backfill.

Concrete Pipe

An extremely dry mix of cement, sand, gravel, and water with or without additives is used and cast in steel forms to manufacture concrete pipe. Concrete pipe can be reinforced with welded wire fabric or rebar. It is normally a flared bell-and-spigot-type pipe, similar to cast-iron soil pipe, but in larger sizes, 10 inches and above. The bell and spigot have a smooth configuration.

FITTINGS.—The fittings are the same as cast-iron and vitrified clay pipe, using a flared bell-and-spigot joint, or a smooth bell and spigot. This joint is called the "slip joint."

CUTTING.—A portable concrete saw is used to cut concrete pipe reinforced with steel. When cutting with a concrete saw, ensure the pipe is on a solid base when cutting to avoid binding the saw. Also, use plenty of water to keep the blade cool. Never attempt to cut concrete pipe without proper personal safety equipment. Smaller sizes without reinforcement can be scored with a chisel, or "snap cut" like vitrified clay pipe. On larger sizes of pipe, 10 inches and above, cutting of the pipe is not practicable. Larger pipe is used in applications where cutting is not required.

JOINING.—Eight different types of joints for concrete pipe are available. The most common joint is the "slip joint". This kind of concrete pipe joint is similar to the cement-asbestos pipe connection, except a coupling is not used. There is a groove on the spigot end where a rubber gasket ring is placed. This gasket is compressed into the groove by the bell of the connecting pipe as they are pushed together, forming a watertight seal. On pipe 10 inches in diameter and greater, cement mortar is placed in the spaces between the ends of the pipe on the outside; also inside, if the pipe diameter is large enough for access.

PVC-Class Water Pipe

PVC-class water pipe is used for construction projects around the world. It is lightweight compared to iron pipe, and it can also be cut easily and beveled with cement-asbestos tools. Most importantly, PVC-class water pipe can be joined together easily.

When installing this type of pipe, ensure the bell end, the plain end, and the gasket are free of dirt and debris. Usually, the company supplying the pipe also supplies a lubricant to facilitate the sliding of pipes together. When backfilling, ensure there are no rocks or other hard debris in the backfill material, as they could, over a period of time, puncture the pipe.

One of the best reasons for using PVC pipe in a water main is the ease with which it can be tapped. A variety of adapters and valves are also readily available in the naval supply system.

Q20. For water service applications, cast-iron soil pipe comes in what lengths?

Q21. Water pipes should be layed a minimum of how many feet above and away from sewer lines?

Q22. In water service, what type of copperpipe should be used for aboveground general applications?

Q23. What type of copper pipe comes in only 20-foot hand-drawn lengths?

Q24. There is a total of how many different methods of measuring pipe?

Q25. What is the end-to-center method of measuring pipe?

Q26. It is important to clean all the flux from a soldered copper pipe joint for which of the following reasons?

Q27. Black iron pipe should be used for what type of piping systems?

Q28. Because of the strength of ductile iron, you only have to remove rocks and boulders of what size from backfill material?

Q29. Joining of concrete pipe is similar to joining of what other type of pipe?

CHAPTER 4

PLUMBING VALVES AND ACCESSORIES

LEARNING OBJECTIVE: *Recognize types of valves, accessories and their use, methods of installation, maintenance, and repair.*

In this chapter, you are provided information regarding types of valves and procedures for installing and repairing them, valve accessories, and pipe fittings. Also discussed are testing of systems, erecting shoring and scaffolding, and laying out wastewater systems, and water distribution systems.

VALVES

LEARNING OBJECTIVE: *Recognize types of valves and methods of valve repair.*

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. In this section, different types of valves, their purpose, and maintenance and repair of valves are presented.

GATE VALVE

The gate valve (fig. 4-1) is used in systems where a straight flow with the least amount of restriction is needed. These valves are 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.

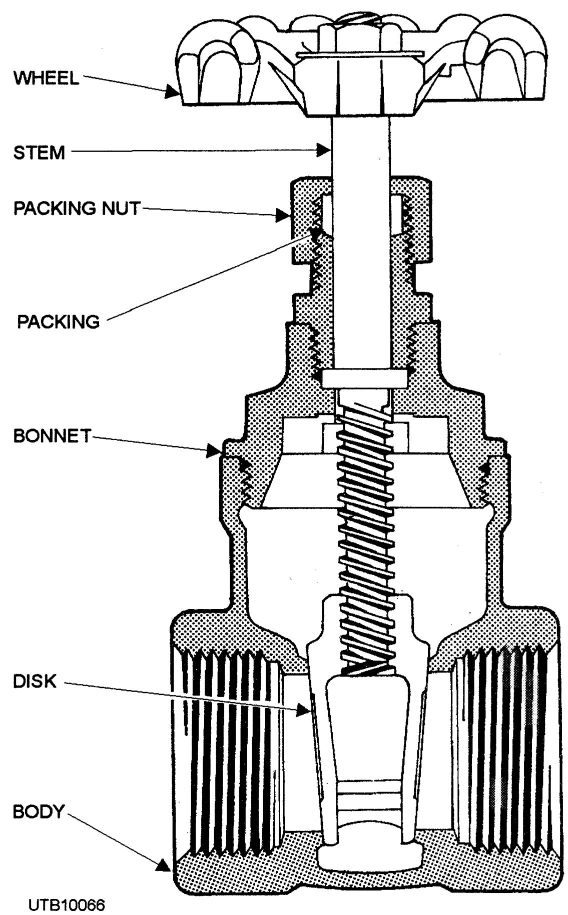


Figure 4-1.—Gate valve.

Figure 4-1 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.

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 globe valve is ideal for service that requires frequent valve settings (throttling).

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

Figure 4-2 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 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.

Globe valves are commonly used in steam, air, oil, and waterlines. In many boiler plants, there are surface blow valves, bottom blow valves, boiler stops, feed stop valves, and many guarding valves and line cutout valves. Globe valves are also used as stop valves on the suction side of many fireroom pumps as recirculating valves in the fuel oil system and as throttle valves on most fireroom auxiliary machinery. A cross-sectional view of a globe valve is shown in figure 4-3.

BUTTERFLY VALVE

The butterfly valve (fig. 4-4) 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.

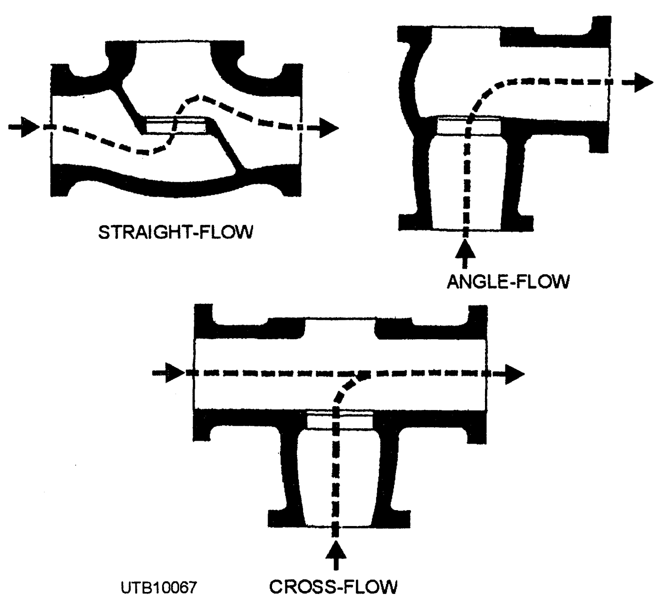


Figure 4-2.—Types of globe valve bodies.

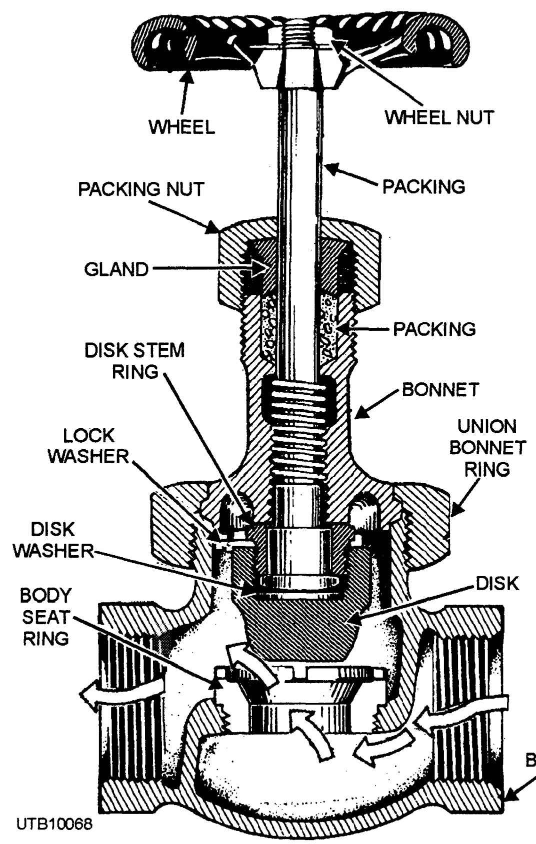


Figure 4-3.—Globe valve.

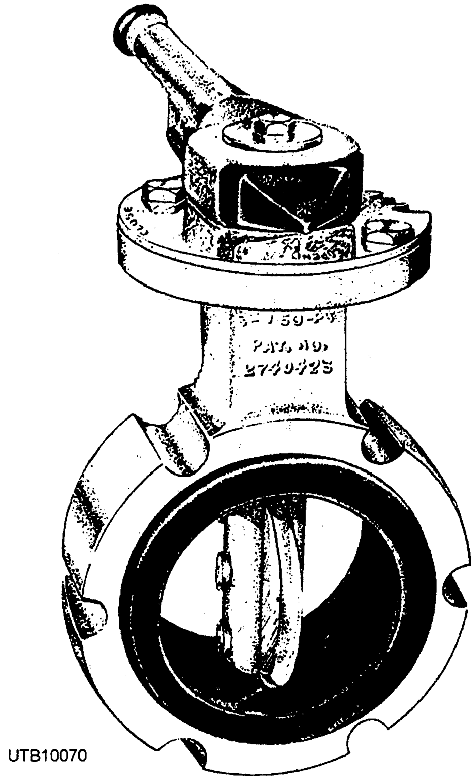


Figure 4-4.—Butterfly valve.

The butterfly valve shown in figure 4-4 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. The larger size butterfly valves have electrical or mechanical gear-driven mechanisms to open or close the valve.

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, and air ventilation systems.

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 (fig. 4-5) 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 (fig. 4-6) 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.

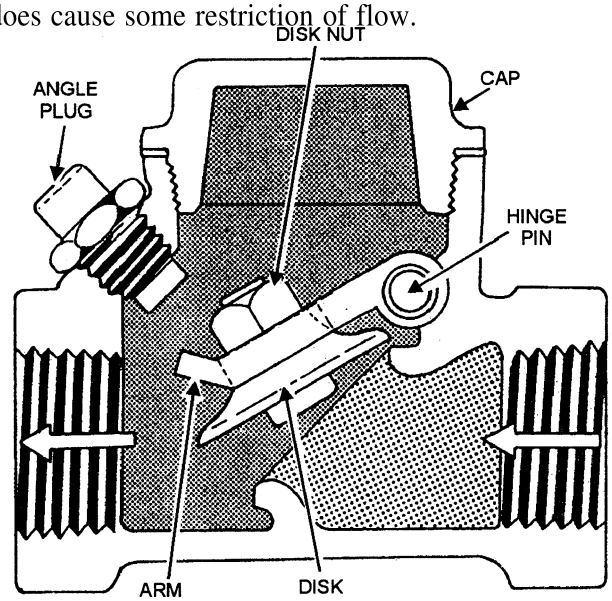


Figure 4-5.—Swing-check valve.

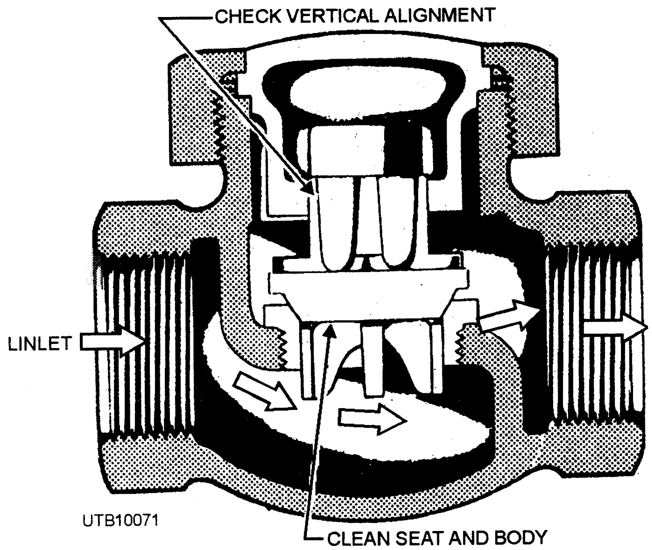


Figure 4-6.—Lift-check valve.

Ball-check valves handle viscous fluids and are very efficient in lines that contain scale and other debris. Because the ball-check valve operates quietly, it is recommended for use in lines that contain fluids where pressure changes rapidly.

STOP-CHECK VALVE

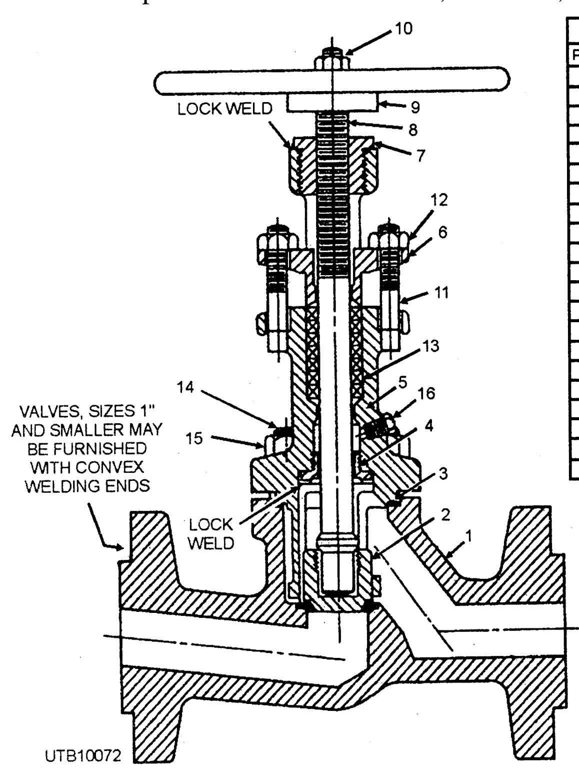
As we have seen so far, most valves are classified as either stop valves or check valves; however, some valves function either as a stop valve or as a check valve, depending upon the position of the valve stem. These valves are known as STOP-CHECK VALVES.

The cross section of two stop-check valves is shown in figure 4-7. 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.

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 4-8. Water passing through this valve



LIST OF PARTS

PART NO.	NAME OF PART
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 SETSRCEW
21	JAMB NUT

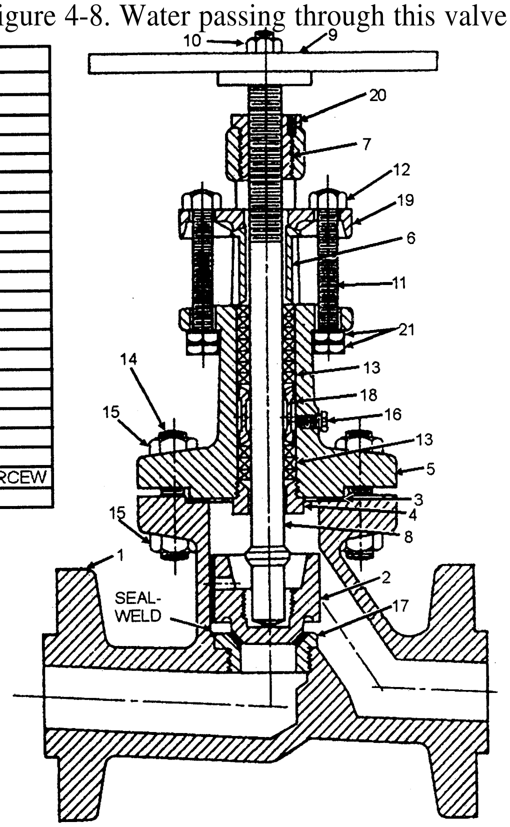


Figure 4-7.—Step-check valve.

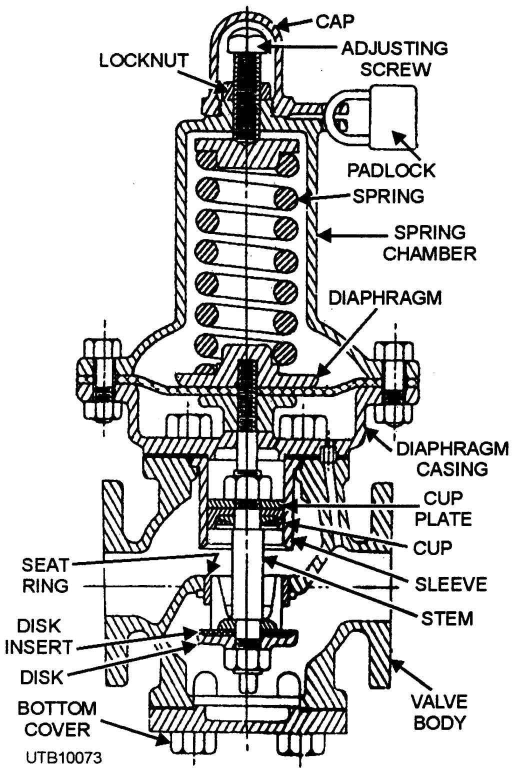


Figure 4-8.—Spring-loaded diaphragm type of pressure-reducing valve.

is controlled by means of a pressure difference on both sides of the diaphragm. The diaphragm is secured to the stem. Reduced water pressure 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 4-9 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.

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

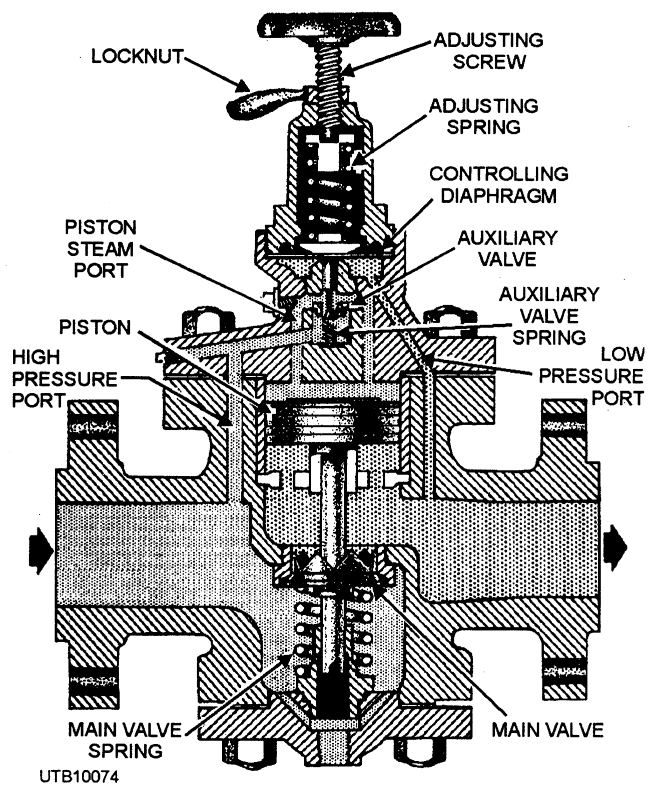


Figure 4-9.—Spring-loaded pressure-reducing valve.

pressure has reached 20 percent above the set pressure, 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.

HYDRAULIC CONTROL VALVE

Hydraulic control valves are used in many sprinkler systems. On some stations, they are installed in the sections of 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.

The hydraulic control valve shown in figure 4-10 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 4-10 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.

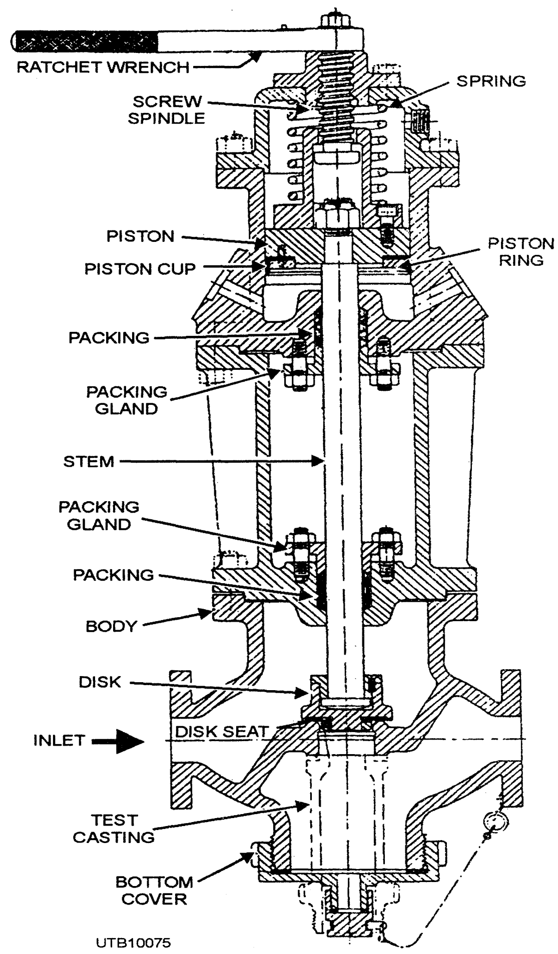


Figure 4-10.—Hydraulic control valve.

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.

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 4-11 shows what correct and imperfect seals look like when they are spotted-in.

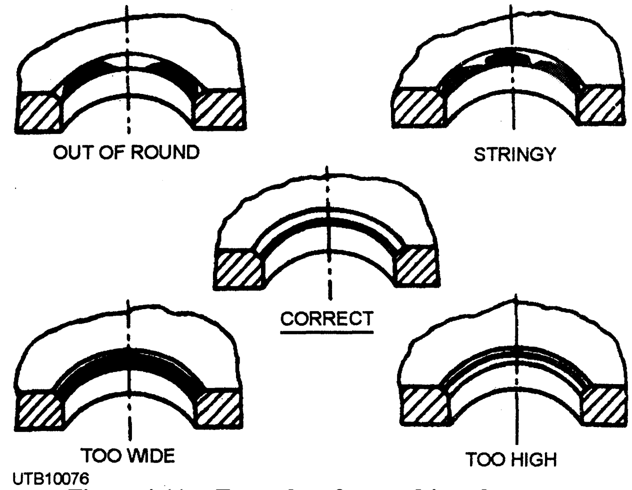


Figure 4-11.—Examples of spotted-in valve seats.

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.

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 overgrind a seat or disk. Overgrinding tends to produce a groove in the seating surface of the disk. It may also round off the straight, angular surface of the disk. Overgrinding must be corrected by machining.

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 (LAP) of exactly the same size and shape as the disk is used to rule the seat surface. Two lapping tools are shown in figure 4-12.

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 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.

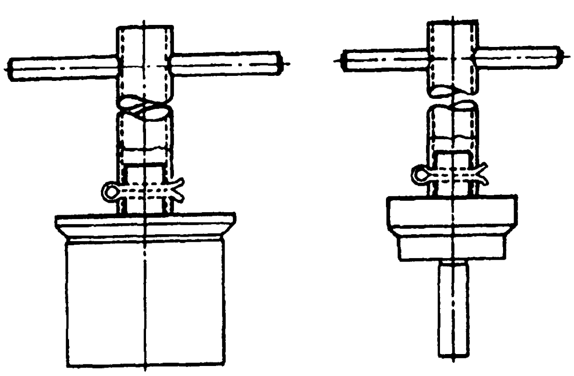


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Figure 4-12.—Lapping tools.

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.

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 (fig. 4-13) attach the correct 45-degree facing cutter to a

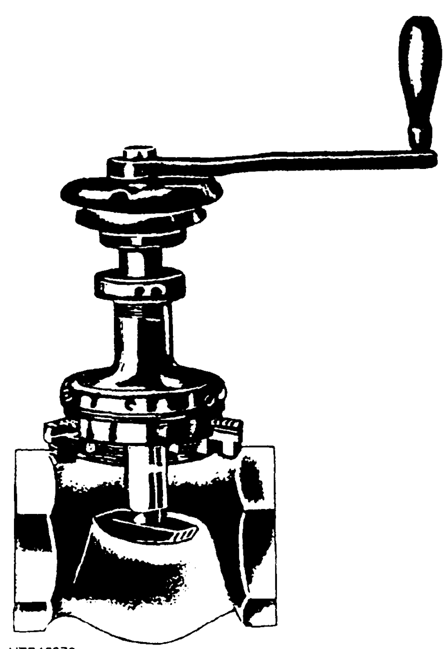

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Figure 4-13.—Valve reseating machine.

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.

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:

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

Repacking Valve Stuffing Boxes

When the stem of a globe 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 requi red. 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.

Gate, globe, angle, and stop-check valves are made to back seat the stem against the valve bonnet when the valve is fully opened. Back seating of these 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.

Q1. What structure of a valve distinguishes one type of valve from another?

Q2. Direction of flow is indicated on the exterior of a check valve in what manner?

Q3. Hydraulic control valves are used in what type of plumbing system?

Q4. To reface valves, you can use the valve reseating machine only when what condition exists?

VALVE ACCESSORIES

LEARNING OBJECTIVE: *Recognize the different types of valve accessories and the methods used to maintain them.*

Accessories that aid in the control of valves include valve boxes, floor stands, and post indicators. Each of these supporting materials is discussed briefly below.

Street valves must be accessible for turning them off and on; and, with large valves, the entire valve should be accessible for servicing. Since valves are placed at various depths, valve boxes are made in two or more pieces and telescope to provide adjustable lengths.

Valve controls may be mounted on floor stands for operating valves below a floor. They are operated manually by turning the handwheel or by automatic controls. Some floor stands are equipped with indicators to show when the valves are open or closed. Floor stands (fig. 4-14) are essentially an extension of the valve stem.

Post indicators (fig. 4-15) provide for operating nonrising-stem gate valves that are below the ground or floor level. They are used principally in fire-flow systems, and in this function must be fully approved by the Underwriters Laboratories and the Associated Factory Manual Fire Insurance Companies (indicated on the post by the letters UA and FM). The indicator post is operated by an attached vise when not in use. The valve is opened by turning the wrench to the left, unless otherwise indicated. The OPEN or CLOSED position of the valve is clearly indicated by the target places which show the words *Open* and *Shut* in glass protected openings on both sides of the post. Most post indicators are sealed open for safety. If the seal has been broken, the operator should report this condition to higher authority immediately.

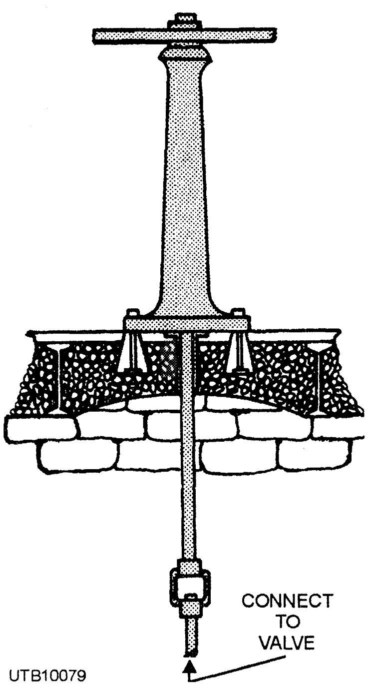

Figure 4-14.—Floor stand.

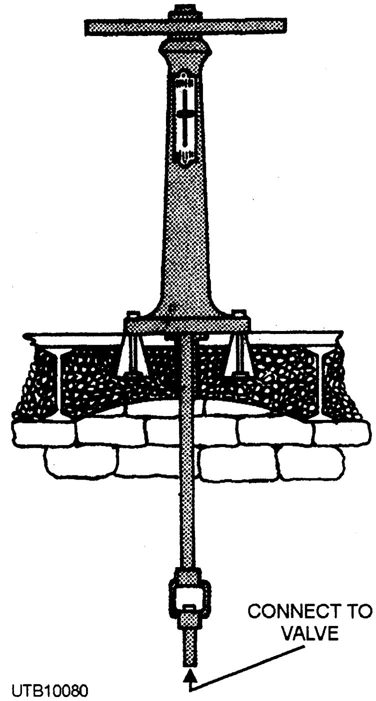

Figure 4-15.—Floor stand with post indicator.

GEARBOXES

Most large manually operated valves are operated through gears as are motor-operated valves. These gears are housed in gearboxes.

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

Semiannually, 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.

VALVE BOXES

All buried valves must have means for the valve key to reach the operating nut. This unit consists of a cast-iron pipe about 6 inches in diameter with a special yoke at the bottom to rest on the valve bonnet and a cover at the street level (or ground level, if not in the street). These valve boxes are adjustable in height; some have covers with locknuts to prevent unauthorized access.

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.

VALVE POSITION INDICATORS

Different types of valves have different types of valve position indicators. Nonrising-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.

Q5. Floor stands with post indicators are used for operating what type of valve in what condition?

Q6. A cast-iron pipe, approximately 6 inches in diameter, has a yoke at the bottom to rest on the valve bonnet and a cover at street level. This is what type of valve accessory?

WATER METERS

LEARNING OBJECTIVE: *Identify types of water meters and methods of obtaining readings.*

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 1/2 inches in diameter, although water meters are made in sizes up to 6 inches.

Figure 4-16 shows the nutating disk volume meter. This type of meter is mainly used for individual service

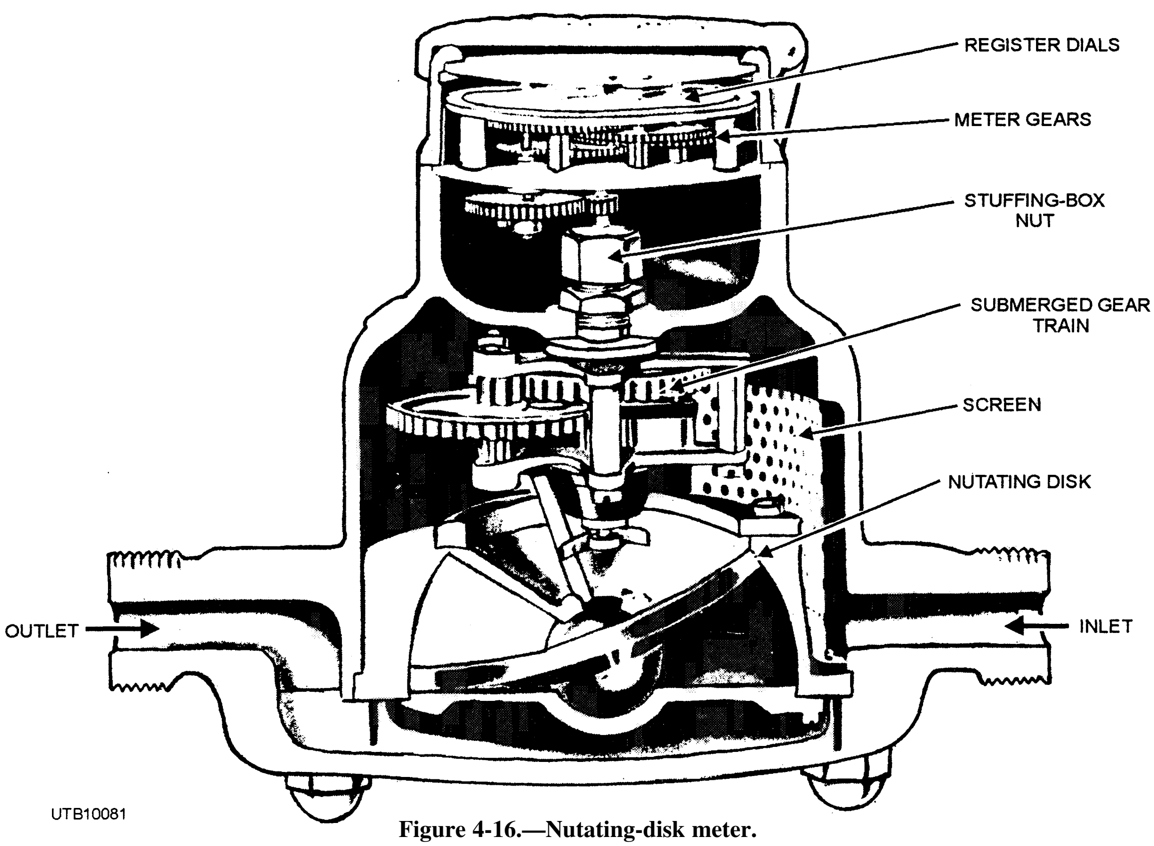

Figure 4-16.—Nutating-disk meter.

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:

Unit	Equivalent
Cubic feet per second (cfs)	6448.83 gpm
cfs	46,315 gallons per day (gpd)
gpm	1,440 gpd
Million gallons per day (mgd)	1.547 cfs
mgd	694.4 gpm
cu ft	7.48 gal

NOTE: IN READING A METER, YOU SHOULD FIRST DETERMINE WHETHER IT IS MEASURING THE WATER FLOW IN CUBIC FEET OR IN GALLONS.

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 4-17 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

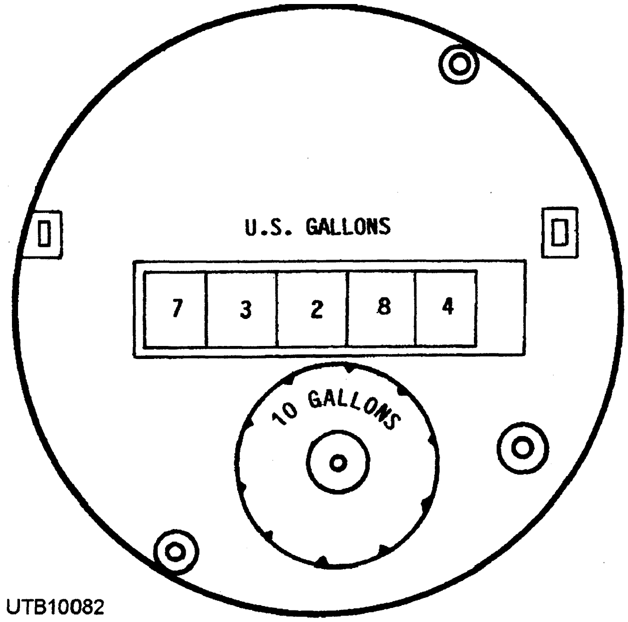

Figure 4-17.—Straight-reading meter dial.

which the hand lies; otherwise, read the next lower number. The procedure for reading the circular-reading dial, shown in gallons in figure 4-18, 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.

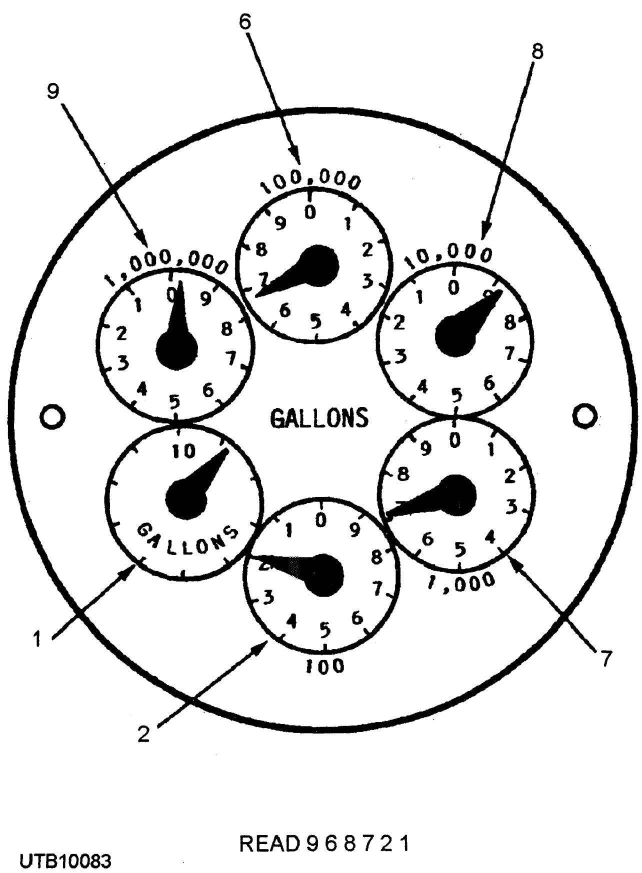

Figure 4-18.—Reading the circular-reading meter dial in gallons.

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.

Q7. What is the purpose of a water meter?

Q8. What should you determine about flow in a water meter before reading it?

Q9. For a circular meter, you should read the meter in what direction?

FIRE HYDRANTS

LEARNING OBJECTIVE: *Recognize types of fire hydrants and methods for inspection, flushing, and testing.*

The fire department (or safety office) is responsible for the selection and use of fire-fighting equipment, including fire hydrants. It is the responsibility of a Utilitiesman to ensure that water is available to the hydrant and that control valves operate properly.

MAINTENANCE

Most fire hydrants consist of a cast-iron barrel with a bell or flange fitting at the bottom to connect it to a branch from the main; a valve, of the gate or compression type, has a long stem terminating in a nut above the barrel and one or more outlets. There are many designs of fire hydrants, two of which are the DRY-BARREL HYDRANT and the WET-BARREL HYDRANT.

In cold climates, where freezing occurs, dry-barrel hydrants are used (fig. 4-19). With this type of hydrant, the drain valve or weep hole must be kept open in systems where the groundwater level is below the hydrant foot, so the barrel can drain and not freeze in cold weather. A box placed over a hydrant affords some protection against freezing and leaves the top of the hydrant free of snow and ice. The hydrant is equipped with two 2 1/2-inch hose outlets and a 4 1/2-inch pumper outlet whose threads conform exactly to the standards specified in *Screw Threads and Gaskets for Fire Hose Connections,* NFPA, 1963.

Where freezing temperatures do not occur, use wet-barrel (or California) hydrants (fig. 4-20). With this type of hydrant, all the packing glands must be kept in good condition to prevent leakage as well as to allow free operation of the stem controlling each outlet. Valve seats for wet-barrel hydrants afford easy access for inspection.

Hydrants exposed to traffic hazards must be protected by appropriate guards. Most damage is caused by an accident or by improper or careless operation.

Much of this can be prevented when operating personnel are made to realize that a properly functioning fire hydrant is critical to the protection of life and property at the activity. Without much extra labor or effort, operating personnel can take several precautions to keep the hydrant structure in good condition. General precautions are listed below.

1. The operation of fire hydrants should be restricted to personnel trained in this and allied work, such as fire fighters, utility maintenance, and operating personnel ONLY.

2. For opening and closing the hydrant, use ONLY an approved hydrant wrench. The reason is that ordinary wrenches can ruin the operating nut.

3. Keep the hydrant drained when it is not in use. This is particularly important in cold climates where ice in the hydrant may make it inoperative.

4. Pipes should be connected only to draw off water for fire-fighting purposes except in an emergency. Any such connection must be removed immediately after an emergency. Connections made to provide a temporary supply for vehicle washing, irrigation, and so on, is not permitted.

5. The hydrant valve should be kept in either the wide **OPEN** or fully **CLOSED** position and never used to throttle the flow of water. When it is necessary to restrict the flow, separate globe valves should be attached to the hydrant discharge outlet.

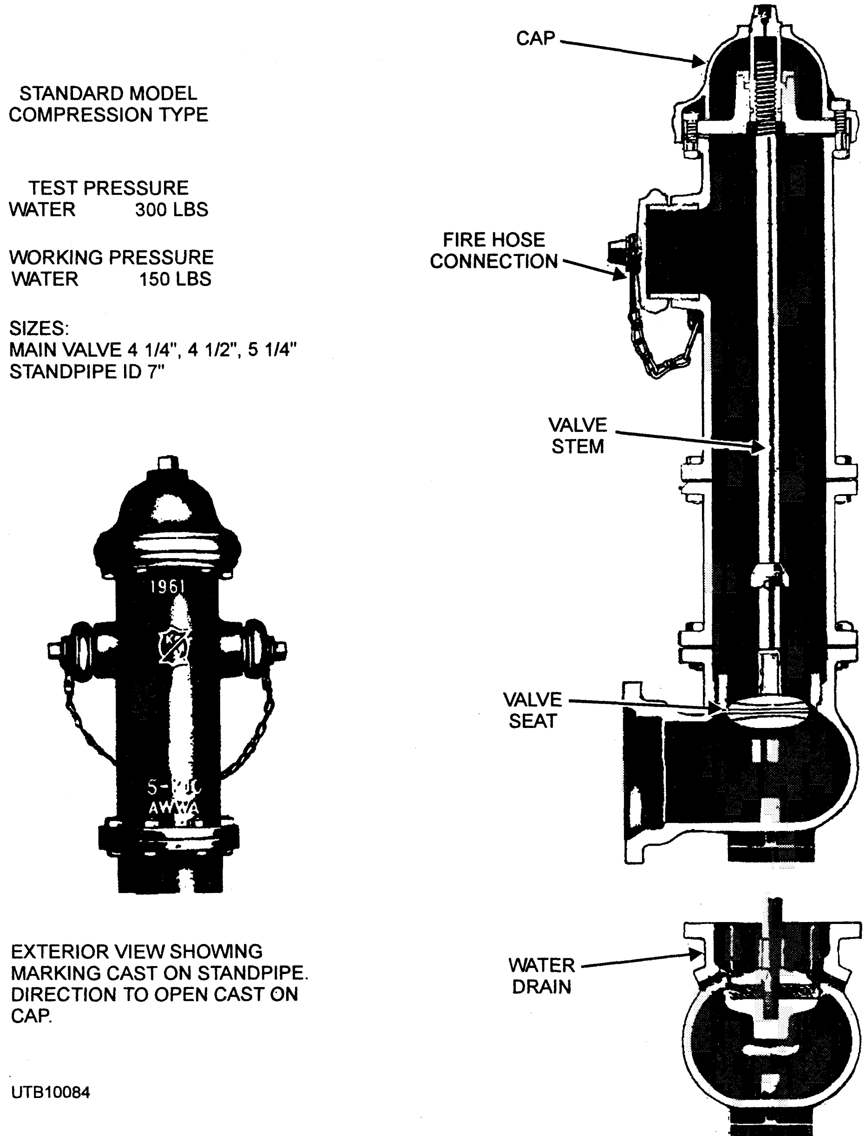

Figure 4-19.—Dry-barrel fire hydrant.

Figure 4-21 shows the proper method of installing and supporting fire hydrants.

FLUSHING AND TESTING

Of course, newly installed pipe must be tested for leaks by means of air or water. To make an AIR TEST, plug up all openings in the system, connect a source of compressed air to the system, and bring the pressure up slowly to the designed working pressure. Use a soapy water solution and cover each joint, then check for leaks. When a leak is present, you can detect the location by bubbles forming around the joint from the escaping air. When a leak is discovered, mark each spot with chalk or soapstone. DO NOT, AT THIS TIME, ATTEMPT TO REPAIR THE LEAK. After the line has been tested completely, relieve the pressure from within and repair the joint. Repeat the testing and repairing procedures until all the leaks have been located and repaired.

The procedure for making a WATER TEST is similar to that used for an air test. Water is used instead of air, and you do not use a soapy water solution to cover the joints. The pipe is filled with potable water, and pressure is applied and maintained by means of a hand pump. See that no air has been retained in the pipe being tested. Let it stand under operating pressure from 4 to 8 hours and inspect for leaks and maintenance of pressure during this period.

Q10. What department is responsible for selection of fire hydrants to be used in a system?

Q11. What are the two types of fire hydrants?

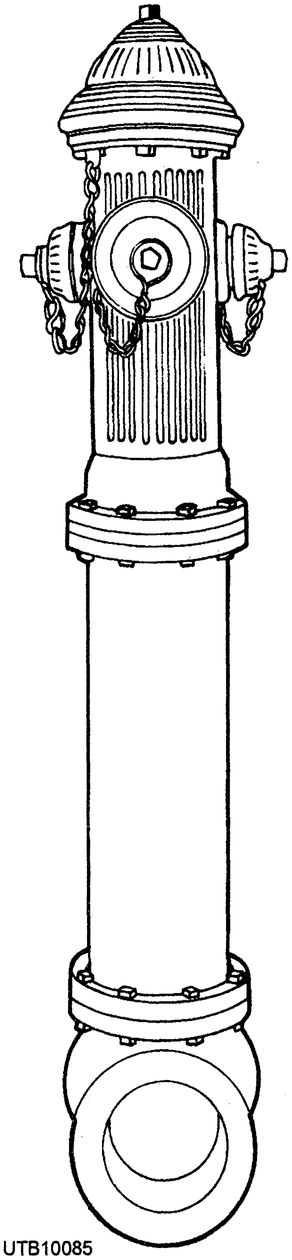

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Figure 4-20.—Wet-barrel, or California, fire hydrant.

DISINFECTION OF WATER-SUPPLY SYSTEM COMPONENTS

LEARNING OBJECTIVE: *Understand disinfection chemicals, methods, and emergencies and their applications. Understand the application of pipe supports and insulation in water-supply systems.*

Water mains, wells, filters, storage tanks, and other components of a water-supply system become contaminated during installation and repair. Flushing the system to remove dirt, waste, and surface water is the first step in disinfecting the water system, but it is not a sufficient safeguard. To ensure a safe water supply, you must thoroughly disinfect each unit of the system before it is placed in operation. The chemicals used in disinfecting a water-supply system are the same as those used in disinfecting water; for example, a hypochlorite solution or chlorine gas.

DOSAGE REQUIRED

The chlorine dosage required to disinfect a unit depends upon the contact time and the amount of jute, untarred hemp, and organic chlorine-consuming material present. Under average conditions, the following minimum dosages are recommended:

Unit	**Minimum dosage** (ppm)
Pipe	50
Storage tank	50
Filter	100
Well	150

The volume of water in the unit to be disinfected must be computed before the chlorine dosage can be estimated. Use the formula for finding the volume of a tank ($V = r^2h$) and divide the volume by 231 to determine the number of gallons (231 cubic inches = 1 gallon). The volume of water in different sizes of pipe is listed below.

Pipe diameter (inches)	**Volume per foot of pipe (gallons)**
6	61.47
8	82.61
10	104.08
12	125.88
16	1610.45
20	2016.32

APPLYING DISINFECTANT

The following methods of applying disinfectants should be observed:

- Liquid chlorine is applied by portable gas chlorinators. Chlorine cylinders should not be connected directly to mains because water may enter the cylinder and cause severe corrosion and hazardous leakage.

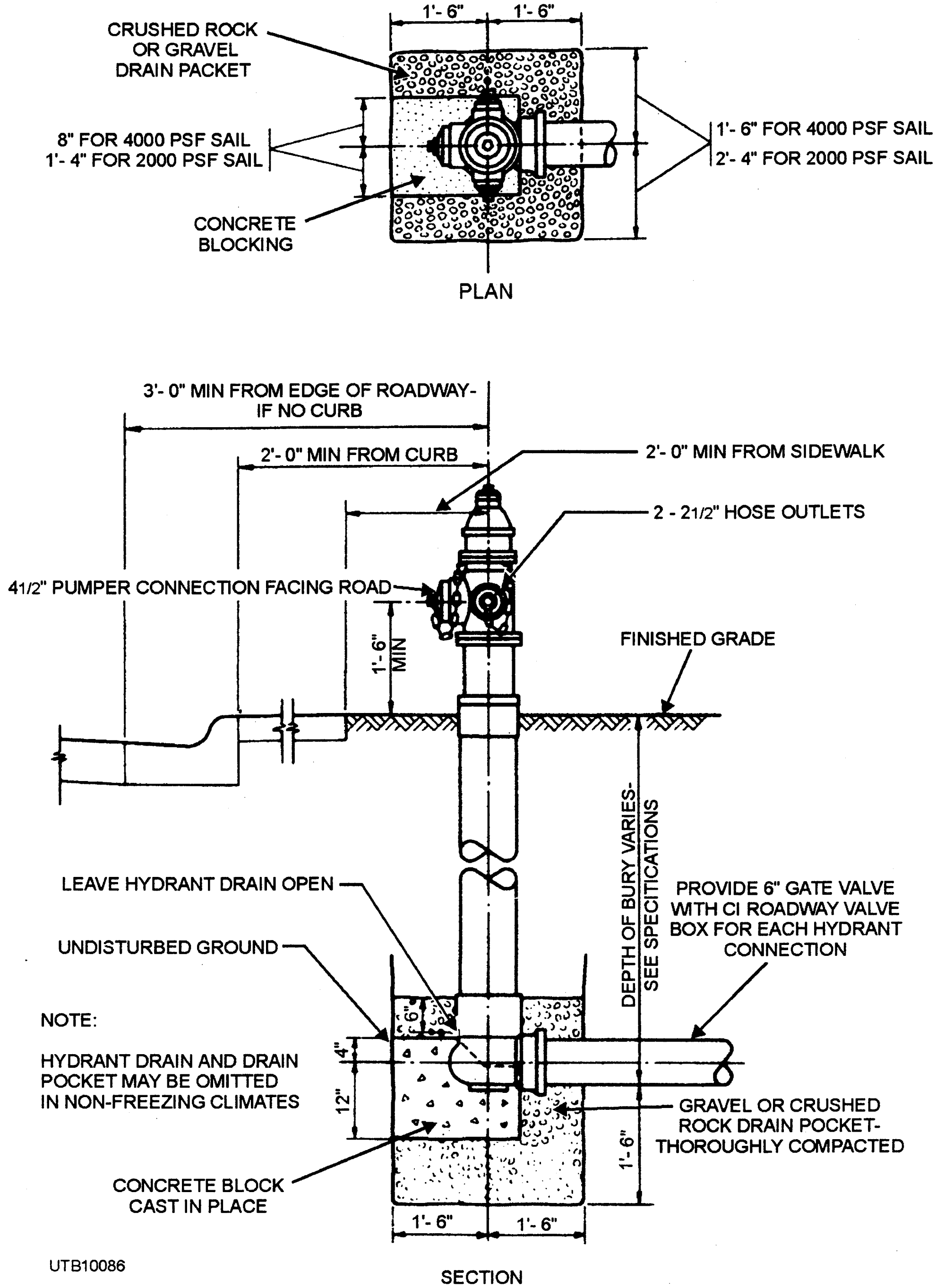


Figure 4-21.—Fire hydrant installation.

- Hypochlorite solution is usually applied by measuring pumps, gravity-feed mechanisms, or portable pipe disinfecting units.

When applying disinfectants, use the following procedures:

- Before adding disinfectant, flush the section thoroughly with water until dirt and mud are removed. A velocity of at least 3 feet per second is required for adequate scouring.

- Stop all branches and other openings with plugs or heads properly braced to prevent blowouts.

- Disinfect the water mains in sections and feed the disinfecting agent through a tap or hydrant at the end of each section. When a portable gas chlorinator or hypochlorinator is available, feed the discharge from the chlorinator into an auxiliary waterline leading to one of the hydrants or taps.

Bleed the air from the line at high points and crowns. Add the predetermined chlorine dosage as the main is filled slowly with water. Continue feeding until the water discharged at the other end of the section contains the desired residual chlorine. Let the chlorinated water remain in the contaminated unit or section for 24 to 48 hours. Then flush until the chlorine residual is only that amount normally in the supply. Make daily bacteriological analyses of water samples until the analyses show no further disinfection is required.

When a chlorinator is not available, feed a strong hypochlorite solution into the main from a pail through the highest hydrant top or valve with the bonnet removed. Add the hypochlorite and water until the main is full and the chlorine residual is about 50 ppm. Test the residual at the far end of the main. Bleed out air trapped in the line.

When the mains are to be disinfected under pressure by using supply or booster pumps, feed the chlorine into the main with chlorinators or hypochlorite feeders. Take care to ensure adequate and accurate distribution of the disinfecting agent when pumps are being used.

The use of dry calcium hypochlorite directly in mains is not uniformly effective because of unequal mixing with the water; therefore, when calcium hypochlorite is used, prepare a solution of this chemical beforehand.

EMERGENCIES

Natural contamination of water supplies can increase because of emergencies. Standby or portable chlorinators must be working to meet emergency disinfection requirements in water-supply components. This equipment should not be used to make drinking water safe after bombing, sabotage, or biological warfare has made water sources untreatable with chlorine for disinfection.

PIPE SUPPORTS

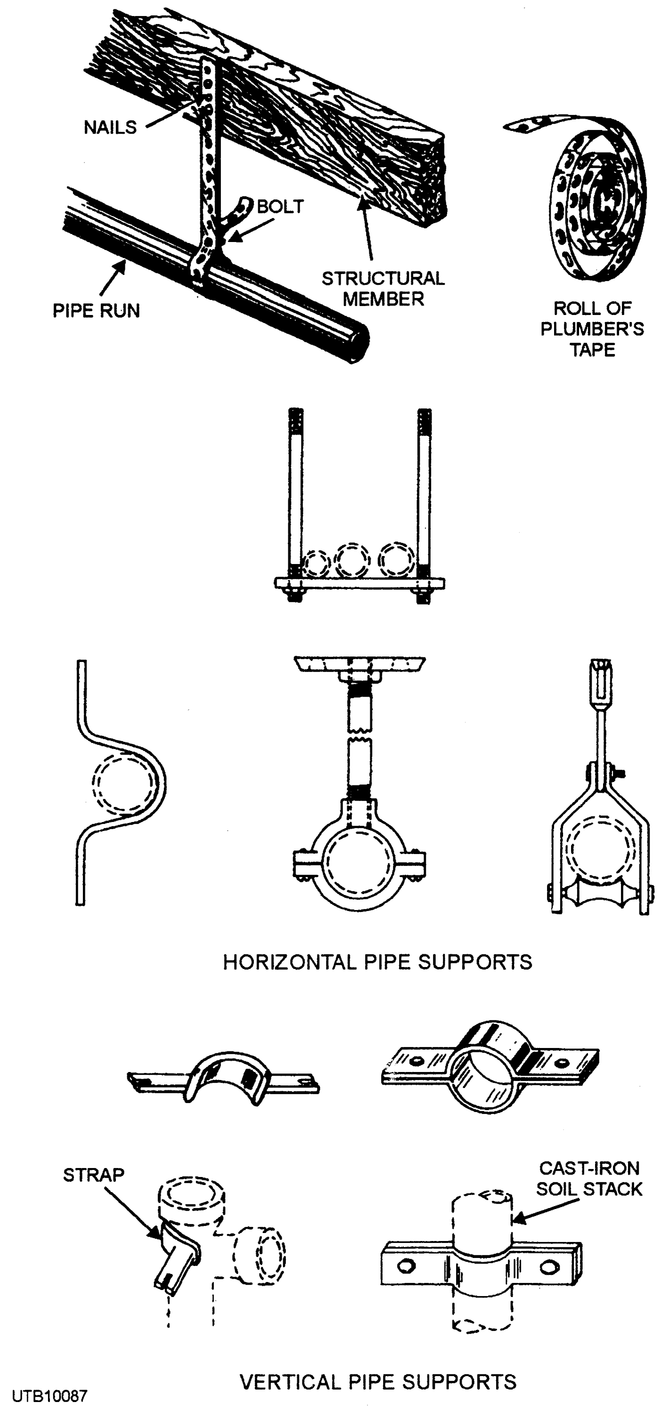


Figure 4-22.—Methods of supporting pipes.

Where pipes are exposed aboveground and in the interior of buildings supplying air, water, or steam, they must be supported adequately to prevent sagging. This is because the weight of the pipes, plus the fluid in them, can cause breaks, strain joints, and cause leaks in valves.

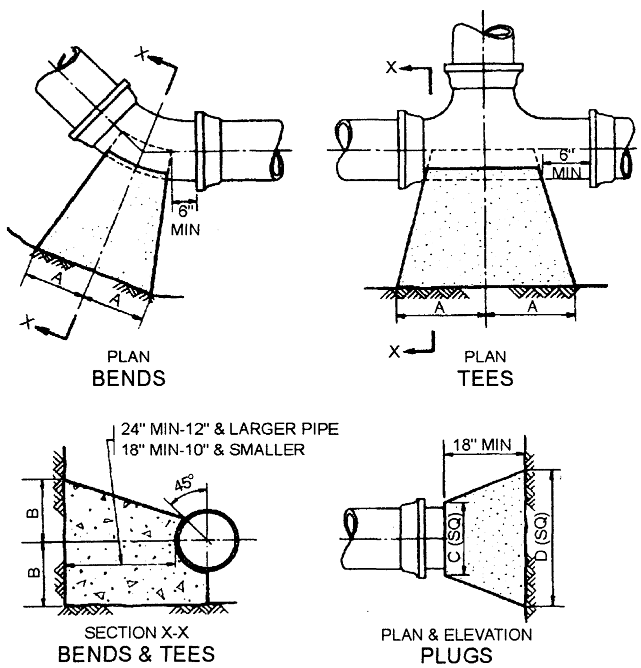
The main supply pipe (vertical or horizontal) must be adequately supported to take its weight off the fitting and to prevent future leaks. Refer to figure 4-22 for some methods of supporting cast-iron soil pipe and galvanized pipe. Fixture supply risers are pipes taken off of the supply pipes to furnish air, water, or steam to the fixtures being installed. These risers may be in the wall or exposed. They must be made tight and tested before being closed up in a wall. All vertical fixture risers should be supported at each floor level or in a change of direction. They should never be supported by the horizontal fixture supply branches.

As shown in figure 4-23, thrust blocks should be installed on water mains at all changes of direction to prevent pipe from separating from water pressure. Consult the chart at the bottom of the figure for dimensions of the thrust block according to the pipe size and compaction rating of the soil.

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 consists 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.



TYPE	SIZE	1/4 BENDS A	1/4 BENDS B	1/8 BENDS A	1/8 BENDS B	1/16 BENDS A	1/16 BENDS B	TEES A	TEES B	PLUGS C	PLUGS D
TYPE I 4000 PSF SOIL	6"	8"	10"	6"	8"	3"	8"	8"	8"	10"	15"
	8"	12"	12"	8"	10"	5"	9"	9"	12"	12"	20"
	10"	16"	14"	10"	12"	6"	10"	11"	14"	14"	25"
	12"	19"	16"	12"	14"	8"	11"	14"	16"	16"	30"
	14"	23"	18"	14"	16"	10"	12"	16"	18"	18"	34"
	16"	26"	20"	16"	18"	11"	13"	18"	20"	20"	38"
TYPE II 2000 PSF SOIL	6"	16"	10"	9"	10"	6"	8"	10"	12"	10"	21"
	8"	22"	13"	12"	13"	8"	10"	13"	16"	12"	29"
	10"	26"	17"	14"	17"	10"	13"	16"	20"	14"	36"
	12"	29"	21"	16"	21"	11"	16"	18"	24"	16"	41"
	14"	35"	24"	19"	24"	12"	20"	22"	27"	18"	48"
	16"	38"	27"	21"	27"	12"	24"	24"	30"	20"	54"

NOTE: BASE IN 100 PSI STATIC PRESSURE PLUS A.W.W.A. WATER HAMMER
ALL BEARING SURFACES TO BE CARRIED TO UNDISTURBED GROUND

STANDARD THRUST BLOCKS
FOR WATER MAINS
UTB10088

Figure 4-23.—Thrust block pipe supports.

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 to protect 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 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.

Piping

Some of the insulating materials on the market today for insulating pipe are sponge felt paper, cork pipe covering, wool felt, flex rubber, fiber glass, magnesia, and types called antisweat and frostproof.

Sponge felt paper is composed of asbestos paper with a maximum amount of sponge evenly distributed within it, as shown in view A, figure 4-24. Sponge felt paper is manufactured to fit most pipe sizes. It comes in 3-foot lengths and from 1 to 3 inches in thickness.

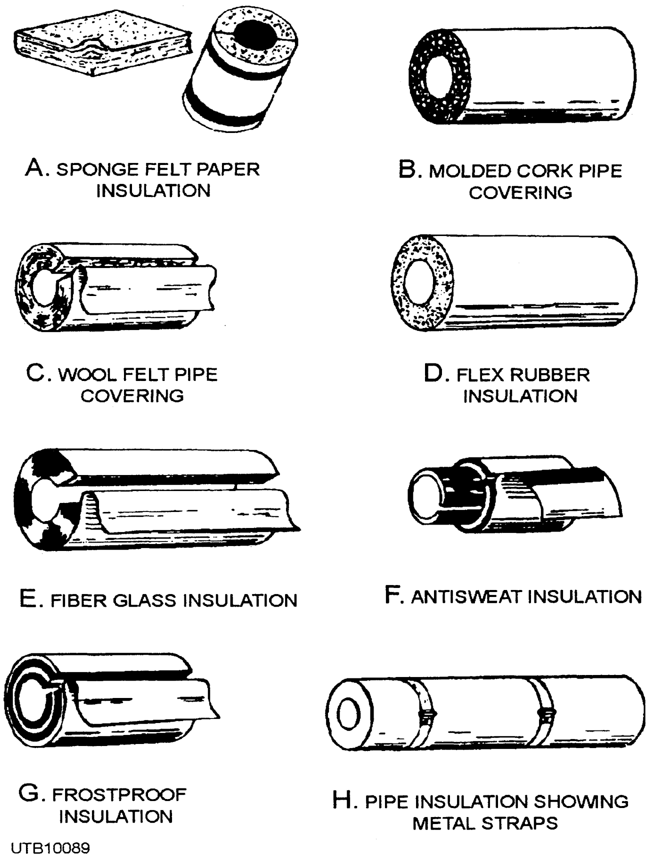


Figure 4-24.—Types of pipe insulation.

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 view B, figure 4-24, 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 l/2 to 1 inch, with a canvas jacket, as shown in view C, figure 4-24. It is manufactured in 3-foot lengths for straight runs of pipe.

Flex rubber insulation, shown in view D, figure 4-24, 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.

Fiber glass pipe insulation, shown in view E, figure 4-24, 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. Fiber glass insulation has a long life; it will not shrink, swell, rot, or burn. It is easily applied, light in weight, saves space, and has excellent insulating qualities.

Antisweat insulation, shown in view F, figure 4-24, 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.

Frostproof insulation, shown in view G, figure 4-24, is manufactured for use on (1) cold-water service lines that pass through unheated areas and (2) those lines exposed to outside weather conditions.

Frostproof 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. Frostproof insulation is 1 1/4 inches thick and comes in 3-foot lengths with a canvas cover.

The pipe coverings shown in this section are some of the types of coverings that 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 view H, figure 4-24.

Valves and Fittings

Cover 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 with 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.

Boilers and Storage Tanks

If the boilers and storage tanks are unjacketed, cover them with an approved insulation. Use only insulation approved by the 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 1/2-inch wire mesh.

Q12. What minimum dosage of chlorine is required to disinfect a well under normal conditions?

Q13. An 8-inch pipe contains how many gallons of water per foot of pipe?

Q14. What velocity of water through a pipe is required for proper scouring action?

Q15. What is the purpose of a thrust block?

SHORING AND SCAFFOLDING

LEARNING OBJECTIVE: *Recognize safety and construction requirements of shoring and scaffolding.*

As a Utilitiesman, it is part of your job to see whether there is a need for shoring or scaffolding on the job. Most of the time, job problems and accidents are a direct result of inadequate planning. As you plan each job, ensure that you have provided the equipment necessary to do the job safely. In this section, safety and health requirements are addressed. For more information, *see* the *Safety and Health Requirements Manual,* EM 385-1-1, U.S. Army Corps of Engineers.

SHORING

The need to protect personnel who work in trenches is important. Following the ground investigation, you should make a decision as to how the sides of the trenches are to be protected. All necessary materials must be obtained and delivered to the site (figs. 4-25 through 4-28 and table 4-1). All trenches deeper than 5 feet must have their sides supported or protected by sloping or battering. Trenches can sometimes be made in the case of hard rock, when it becomes clear to experienced engineers on the site (as the trench proceeds) that the rock is solid and has no dangerous cleavage planes that could cause the side of the trench to collapse. The requirements are listed below.

1. Banks more than 5 feet high should be shored, laid back to a stable slope, or provided with other equivalent protection whenever workers must move around or are exposed to a cave-in. Trenches less than 5 feet in depth must be protected when examination of the ground indicates that hazardous ground movement may be expected. The safe angle of repose for soil conditions and bracing systems should be determined by a qualified person.

Table 4-1.—Trench Shoring-Minimum Requirements

Depth of trench	Kind of condition of earth	Size and spacing of members										
		Uprights		Stringers		Cross braces						
						Width of trench					Maximum spacing	
		Minimum dimension	Maximum spacing	Minimum dimension	Maximum spacing	Up to 3 feet	3 to 6 feet	6 to 9 feet	9 to 12 feet	12 to 15 feet	Vertical	Horizontal
Feet		Inches	Feet	Inches	Feet	Inches	Inches	Inches	Inches	Inches	Feet	Feet
5 to 10	Hard, compact	3 × 4 or 2 × 6	6			2 × 6	4 × 4	4 × 6	6 × 6	6 × 8	4	6
	Likely to crack	3 × 4 or 2 × 6	3	4 × 6	4	2 × 6	4 × 4	4 × 6	6 × 6	6 × 8	4	6
	Soft, sandy, filled........	3 × 4 or 2 × 6	Close sheeting	4 × 6	4	4 × 4	4 × 6	6 × 6	6 × 8	8 × 8	4	6
	Hydrostatic pressure......	3 × 4 or 2 × 6	Close sheeting	6 × 8	4	4 × 4	4 × 6	6 × 6	6 × 8	8 × 8	4	6
10 to 15	Hard	3 × 4 or 2 × 6	4	4 × 6	4	4 × 4	4 × 6	6 × 6	6 × 8	8 × 8	4	6
	Likely to crack	3 × 4 or 2 × 6	2	4 × 6	4	4 × 4	4 × 6	6 × 6	6 × 8	8 × 8		6
	Soft, sandy, filled........	3 × 4 or 2 × 6	Close sheeting	4 × 6	4	4 × 6	6 × 6	6 × 8	8 × 8	8 × 10	4	6
	Hydrostatic pressure......	3 × 6	Close sheeting	8 × 10	4	4 × 6	6 × 6	6 × 8	8 × 8	8 × 10	4	6
15 to 20	All kinds or conditions ...	3 × 6	Close sheeting	4 × 12	4	4 × 12	6 × 8	8 × 8	8 × 10	10 × 10	4	6
Over 20	All kinds or conditions ...	3 × 6	Close sheeting	6 × 8	4	4 × 12	8 × 8	8 × 10	10 × 10	10 × 12	4	6

Trench jacks may be used in lieu of, or in combination with, cross braces. Shoring is not required in solid rock, hard shale, or hard slag. Where desirable, steel sheetpiling and bracing of equal strength may be substituted for wood.
Dimensions are based on nominal sizes of Douglas fir or equivalent. The greater dimensions of the stringers should be straight angle to the sheeting.

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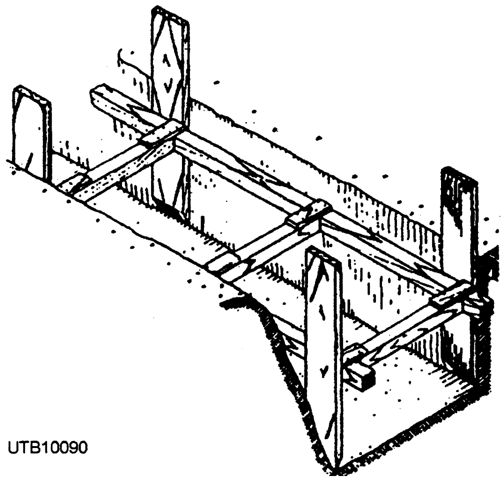


Figure 4-25.—Position of walers before placing sheetpiling for shoring trenches.

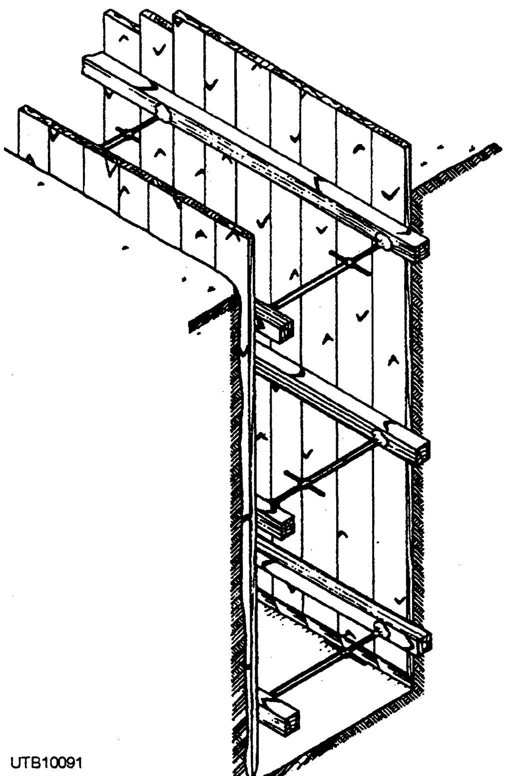


Figure 4-26.—Trench shoring with trench jacks for cross braces.

2. Bracing or shoring of trenches should be carried along with the excavation.

3. Cross braces or trench jacks should be placed in a true horizontal position, secured to revent sliding, falling, or kickouts.

4. Portable trench boxes, sliding trench boxes, or shields should be designed, constructed, and maintained

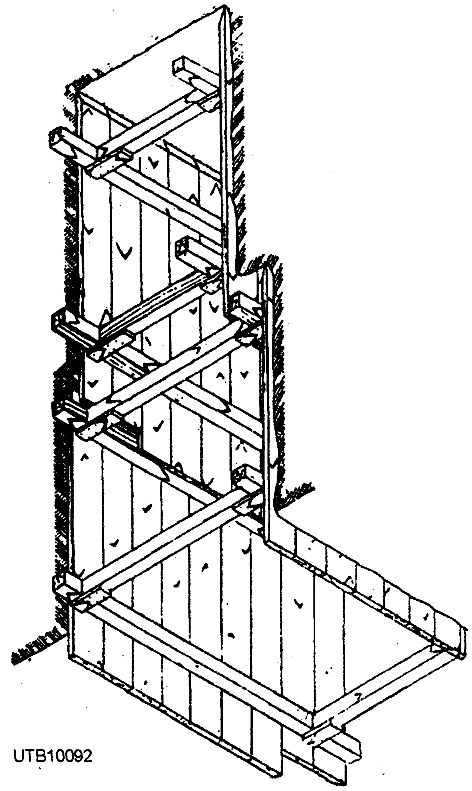


Figure 4-27.—Method of bracing when two lengths of sheetpiling are used.

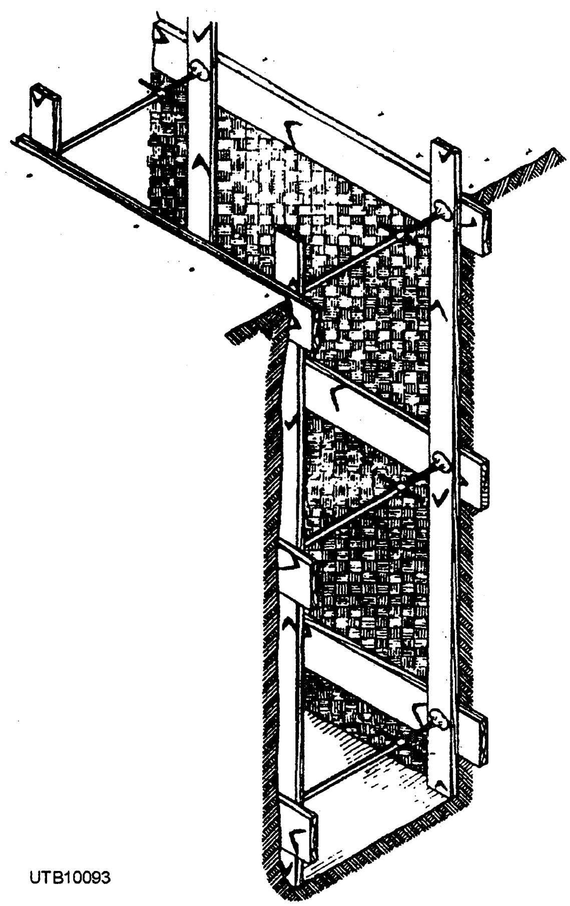


Figure 4-28.—Bracing with jack screws in hard soil.

in a manner to provide protection equal to or greater than the sheathing and shoring required for the situation.

5. Ladders used as access ways should extend from the bottom of the trench to not less than 3 feet above the surface. Lateral travel to an exit ladder should not exceed 25 feet.

6. Backfilling and removal of trench supports should progress together from the bottom of the trench. Jacks or braces should be released slowly and, in unstable soil, ropes should be used to pull out the jacks or braces from above after all personnel have cleared the trench.

7. Minimum size and spacing of timbers for shoring of trenches should be maintained according to set standards (table 4-1).

8. Aluminum hydraulic shoring should be installed according to the manufacturer's recommendations.

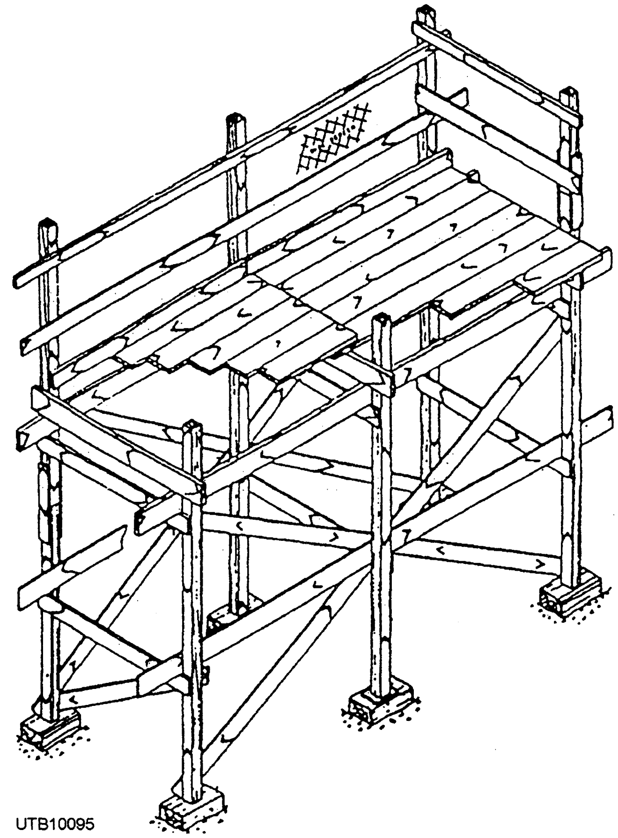


Figure 4-29.—Wood scaffold.

SCAFFOLDING

A scaffold is an elevated working platform for supporting both men and materials. It is usually temporary; its main use being in construction work. Scaffolds should be designed to support at least four times the anticipated weight of both men and materials that will use them.

Scaffolding is a structure made of wood (fig. 4-29) or of metal (fig. 4-30) to support a working platform. Built-up and suspended scaffolds may be made of wooden structural members, but steel tubing should be the first choice. This type of scaffold affords a firm, solid work platform for use by one or more men. Their lightness, mobility, and ease of erection make them most suitable for light-duty to heavy-duty work, particularly when the equipment must be erected and dismantled frequently.

Most scaffolds are in one of three primary categories: tubular, suspended, or rolling. They are also classified according to their intended use: light duty (working load must not exceed 25 pounds per square foot of platform surface), medium duty (50 pounds per square foot), and heavy duty (75 pounds per square foot).

A tabular scaffold is constructed of tubing that fits into various positions to form posts, bearers, braces, ties, and runners. A base assembly supports the posts and special couplers that serve to connect the uprights and to join the various members (fig. 4-30).

A suspended scaffold carries a working platform on beams and ropes that is secured to structural members or to thrust outs from the structure.

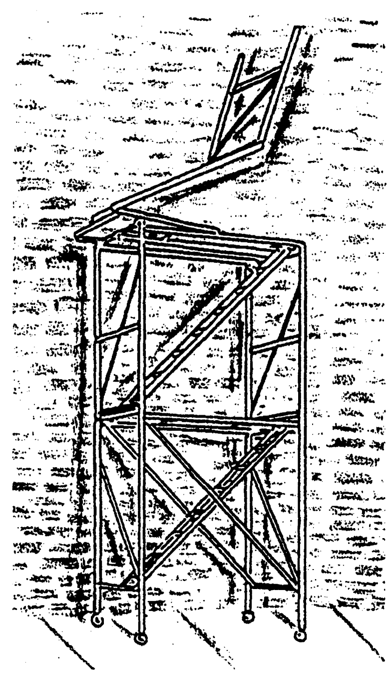


Figure 4-30.—Folding sections with fixed platforms, guard rails, and built-in stairs.

A mobile (rolling) scaffold is mounted on casters. It is constructed of a tubular-metal section of scaffolding or is made of components. designed specifically for a particular purpose (fig. 4-31).

The following are safety rules that pertain to scaffolding:

- Inspect all equipment before use.
- Inspect erected scaffolds regularly to ensure they are being maintained in a safe condition.
- Provide adequate sills for scaffold posts and use baseplates.
- Plumb and level scaffolds as erection proceeds, so the branches fit without having to be forced.
- Fasten all braces securely.
- Use and install scaffolding accessories according to the procedure recommended by the manufacturer. Do not alter accessories in the field.
- Do not ride on rolling scaffolds.
- Remove all types of material and items of equipment from the platform before attempting to move a scaffold.

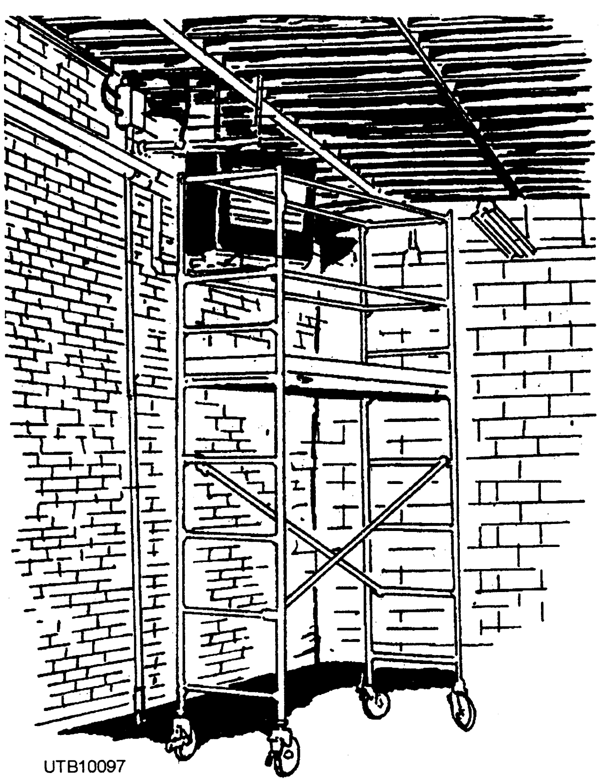


Figure 4-31.—Aluminum ladder scaffold.

Q16. Banks or sides of a trench of what height must be shored or sloped?

WASTEWATER SYSTEMS

LEARNING OBJECTIVE: *Understand wastewater component application and wastewater system installation.*

A wastewater system is a group of sewer pipes and pumps designed to convey domestic and industrial wastes and to transport them to a wastewater treatment plant (fig. 4-32). The wastewater system starts in a house or building that conveys wastewater, known as a house sewer, into a "lateral" sewer pipe. The sewer main receives wastes from two or more laterals. The trunk sewer is a large pipe that receives the flow from laterals and mains. When gravity flow is no longer practical or possible, a lift station is used to pump wastewater to a higher level. A forced main (pressure main) carries the discharge from the lift station to the main or trunk sewer. From here, the wastewater flows by gravity to an interceptor sewer, connecting into the wastewater treatment plant. An outfall sewer is a pipe that carries the treatment plant effluent to the point of final discharge.

A wastewater system safeguards the public health by preventing communicable diseases from getting into groundwater or drinking water systems. The wastewater system carries the raw wastewater to the treatment plant quickly for treatment. The wastewater system should only be carrying domestic and industrial wastes. Infiltration (leakage or seepage of water from a storm or groundwater into a sewer) should be controlled to the lowest practical limit. Good monitoring and maintenance are required to control infiltration. Too much infiltration overloads both the wastewater system and the treatment plant. The end result is not enough detention time and a washout of wastewater solids.

MATERIALS

As a Utilitiesman, you may be involved in construction of a wastewater system and in maintenance, repair, or minor replacement of sewers. The joints and seals used for each type and size of pipe are important. Leaks and breaks often occur at the joints; therefore, with fewer joints and proper seals, leaks can be reduced. The pipe chosen for the wastewater system should be based on the type of waste, the kind of soil, the estimated flow, and the weight of the backfill.

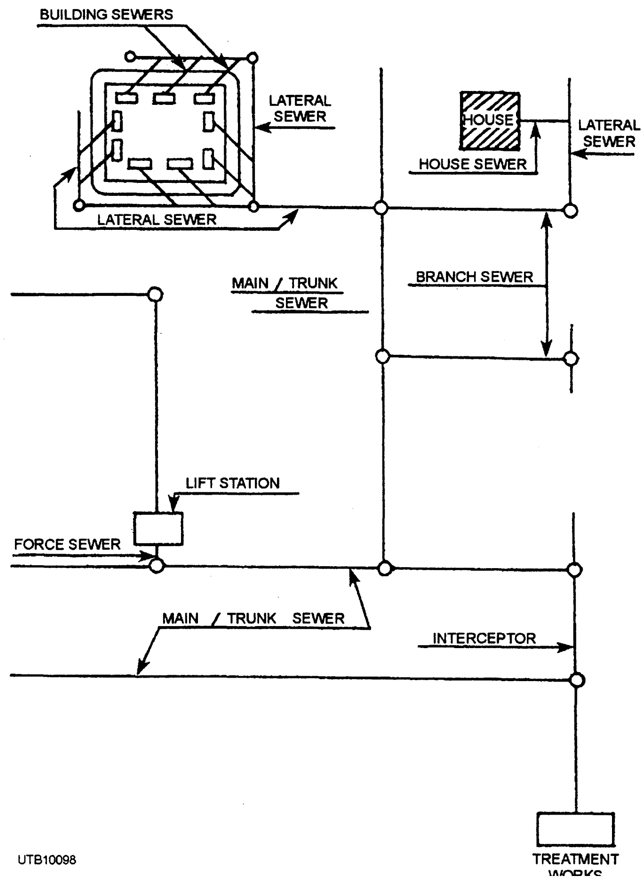


Figure 4-32.—A wastewater collection system.

Table 4-2.—Minimum Grades to Lay Sewer Lines to Maintain a Minimum Velocity of 2 Feet/Second

Pipe Size		Slope		Capacity	
Inches	CM	Inches/l00 Ft.	Cm/30.5m	Gal/Day	M^3/Day
6	15.24	7.2	18.29	260,000	984.1
8	20.32	4.8	12.19	460,000	1,741.1
10	25.4	3.4	8.63	700,000	2,649.5
12	30.48	2.6	6.60	1,000,000	3,785.0
15	38.10	1.8	4.57	1,600,000	6,056.0
18	45.72	1.4	3.56	2,300,000	8,705.5

FLOW

Wastewater systems use gravity flow to move the wastewater. Sewers should be designed to let the wastewater move at not less than 2 feet per second. Solids in the wastewater may begin to settle, and this can cause the pipe to clog and cause the wastewater to become septic. Speed of more than 8 feet per second may cause scouring and damage to the pipe. Table 4-2 shows the minimum grades to be used in laying sewer lines to provide a speed of at least 2 feet per second.

Inverted Siphon

If a part of the sewer dips below grade to avoid a railway cut, a subway, a stream, or some other object, an inverted siphon should be built in the pipe (fig. 4-33). A speed of at least 3 feet per second is needed to keep the pipe clear of settleable solids. The inverted siphon may have one, two, or more pipes. The amount of flow the siphon can handle should equal the amount of flow of the upstream system. A manhole should be placed at both ends of an inverted siphon, so it is easier to maintain the siphon.

Piers

Pipes can cross a small, shallow dip in the earth when they are supported by concrete piers. Piers require less maintenance than an inverted siphon and are less likely to make the wastewater become septic or cause other problems.

DESIGN

Knowledge of the design of a wastewater system can be of great help to you in constructing and maintaining the system. The amount of wastewater that can be carried depends on the size and slope of the pipe. Whether the system can carry certain types of industrial waste satisfactorily depends on the type of pipe being used. Sewer-use regulations should be enforced to keep toxic and corrosive wastes from getting into the system. The regulations may require grease traps in places where large amounts of grease will be wasted, sand traps where washracks and floor drains are built in, and pretreatment of some wastes. All sewer lines must be separated from potable water-supply lines. A cross-connection between the sewer and a potable waterline must never be allowed.

MANHOLES

Manholes let you inspect and clean sewer lines. Figure 4-34 shows the needed parts and sizes for a manhole. Manholes are required at points where the pipe changes direction and every 300 to 400 feet of piping. On large mains of 60 inches or more in diameter, the manholes are often spaced from 300 to 600 feet apart. The manhole should be built to keep the wastewater moving at about 2 feet per second, so the wastewater solids cannot settle in the pipe. A flow channel with a depth of three fourths of the diameter of the sewer pipe should be built in the manhole. The floor should slope toward the channel. The sewer lines and manhole must be well-aligned. If either the manhole or sewer line shifts, the pipe may break. A lid should fit tightly over the manhole. It must be strong enough to support traffic and heavy enough to keep someone other than maintenance workers from tampering with it. The lid should not be high enough to obstruct traffic nor low enough to let water build up over the lid.

LAYING PIPE

Knowledge of pipe laying can assist you in layout, performing maintenance, and making repairs. If the pipe is not installed properly, it can leak, break, or clog. The first step in installing a sewer pipe is digging the trench. The trench should be wide enough to permit proper installation of the pipe. Where shoring is required, ample allowance should be made in the width of the trench for proper working conditions. Where trenches are excavated to such a depth that the bottom of the trench forms a bed for the pipe, care should be exercised to provide solid and continuous bearing between joints, and bell holes should be provided at points where the pipe is joined. When excavated to such a depth that the bottom of the trench does not form a bed for the pipe, the trench should be backfilled to pipe grade. The bottom of the trench must also be sloped in the direction of flow, so sewage traveling through the pipeline laid in the trench is not restricted.

Trench Safety

Safety of the workers is a must when sewer lines are being laid. Signs, barricades, and lights should be installed and maintained in the area. The dirt from the trench should be piled at least 2 feet from the edge of the trench to keep it from falling back into the trench

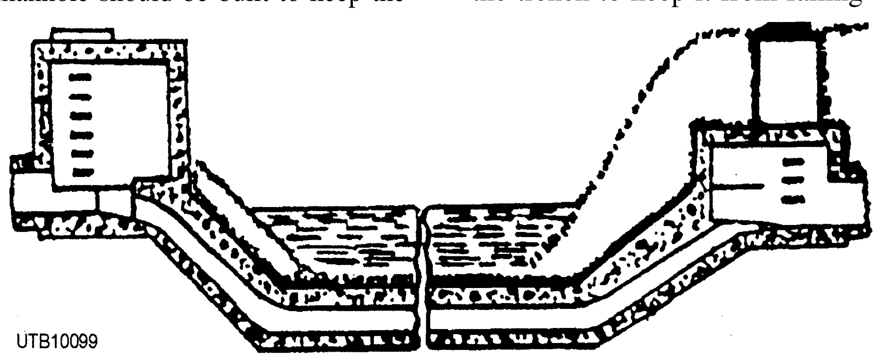


Figure 4-33.—An inverted siphon.

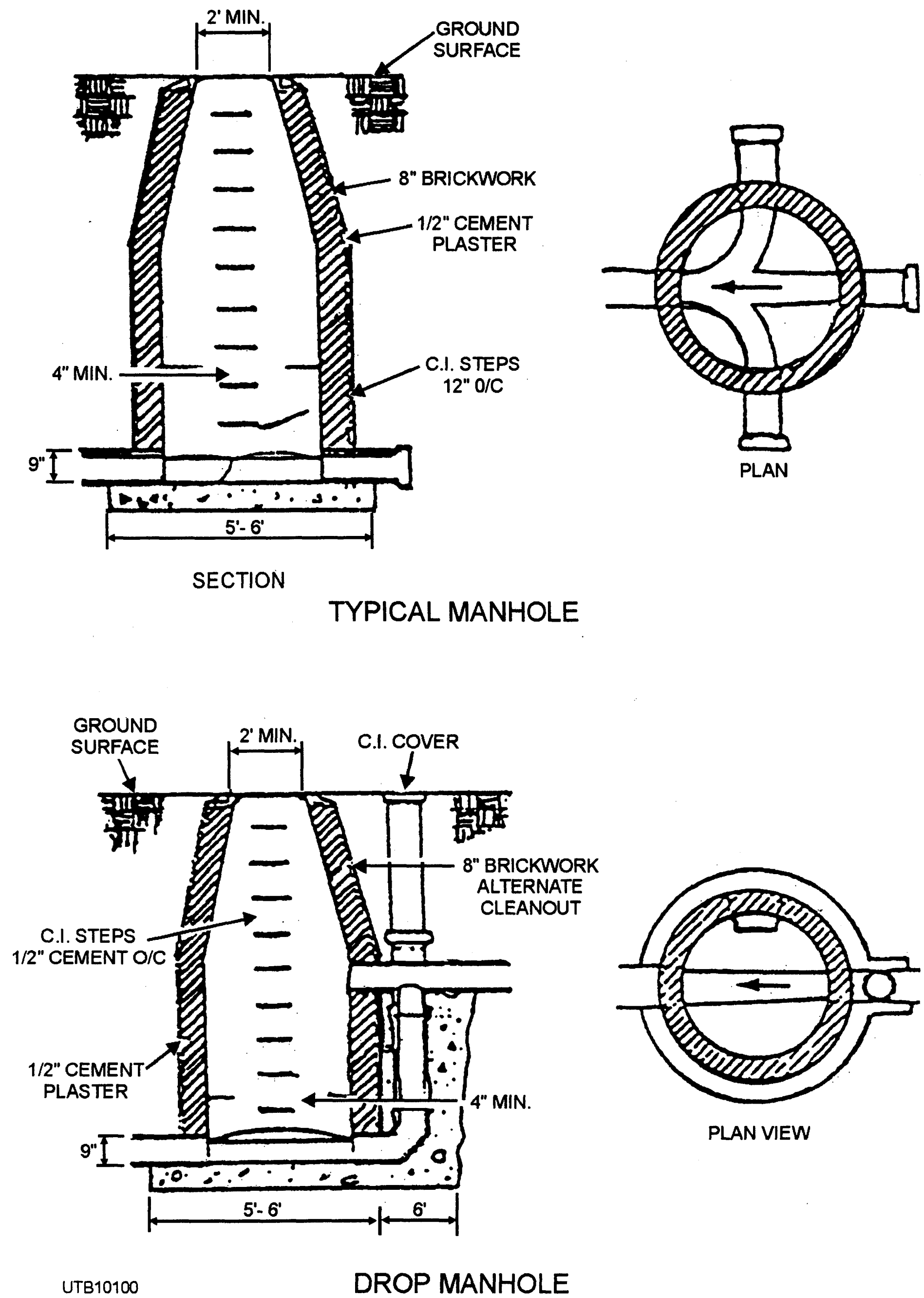


Figure 4-34.—Types of manholes.

and to allow access to the trench. If the trench is dug in unstable ground or is deeper than 5 feet, place shoring in the trench to protect workers from a cave-in.

Preparing the Trench

The pipe must be set on a well-prepared bed. The pipe should be laid with the bell ends on the upstream grade for a good joint. A small notch should be made for each bell, so the pipe will lie flat on the bed. Where rock is encountered, it should be removed to a point at least 3 inches below the grade line of the trench, and the trench should be backfilled with sand tamped in place to provide a uniform bearing for the pipe between joints. Care should be exercised, so the pipe does not rest on rock at any point including the joints. If materials of inadequate bearing are found at the bottom of the trench, stabilization should be achieved by overexcavating to solid bearing and bringing up to pipe grade by the use of sand, crushed stone, or a concrete foundation. Such a foundation should be bedded with sand tamped in place to provide a uniform bearing for the pipe between joints. The trench should be backfilled in layers of 6 inches. Until the crown of the pipe is covered by at least 2 feet of tamped earth, considerable care should be exercised in backfilling trenches. Loose earth free of rocks, broken concrete, frozen chunks, and other rubble should be placed in the trench carefully in 6-inch layers and tamped in place. Care should be taken to compact the backfill under and beside the pipe to be sure the pipe is supported properly. Backfill should be placed evenly on both sides of the pipe and tamped to retain proper alignment. The rest of the trench can be filled using heavy equipment.

SERVICE CONNECTIONS

Service connections, or house sewers (the lines from the house to the street lateral), are often built with concrete, cast iron, or plastic pipe. They should not be smaller than 4 inches in diameter. If a Y or a T branch is not built in at the point where a connection needs to be made, the Y or T saddles can be used. When you are tapping a sewer, extreme care should be taken to prevent breaking the pipe. Ensure the saddle fits well and is cemented firmly to the main line to prevent infiltration. This also helps to keep out roots from trees and other plants. Service connections must not be made by breaking into the pipe. This makeshift method is not watertight and often causes severe damage to the pipe.

Q17. To maintain a 2-foot slope, you must ensure that a 10-inch-diameter pipe has a minimum drop of how many inches per foot?

Q18. Manholes are required every 300 to 400 feet and at what other point on a main sewer line?

WATER DISTRIBUTION SYSTEM

LEARNING OBJECTIVE: *Identify water distribution system elements and installation.*

The last section of this chapter explains the procedures to be followed for providing a water source. The water-supply system for a building starts from a single source: the water main. In this section, tapping a water main to install a corporation stop and the elements that go into a water distribution system are discussed.

After the trench is dug to the main water line, a corporation stop (view A, fig. 4-35) can be installed while the main is under pressure by using the water main self-tapping machine shown in view B, figure 4-35. A 1-inch tap is the largest opening that can be made while the main is under pressure. Ninety pounds is the maximum pressure that can be tapped against it with a water-tapping machine. You must understand the operation of the machine before attempting to tap a main under pressure. The tap should be located as near to the top of the water main as possible. Clean the rust and dirt from the main at the point where the tap is to be made. Place the machine gasket on the main and mount the tapping machine over the gasket by wrapping the tie chain around the main.

NOTE

Ensure the saddle and the chain are of the correct size. If you attempt to use the incorrect size, the main will cock and the tap will cross thread.

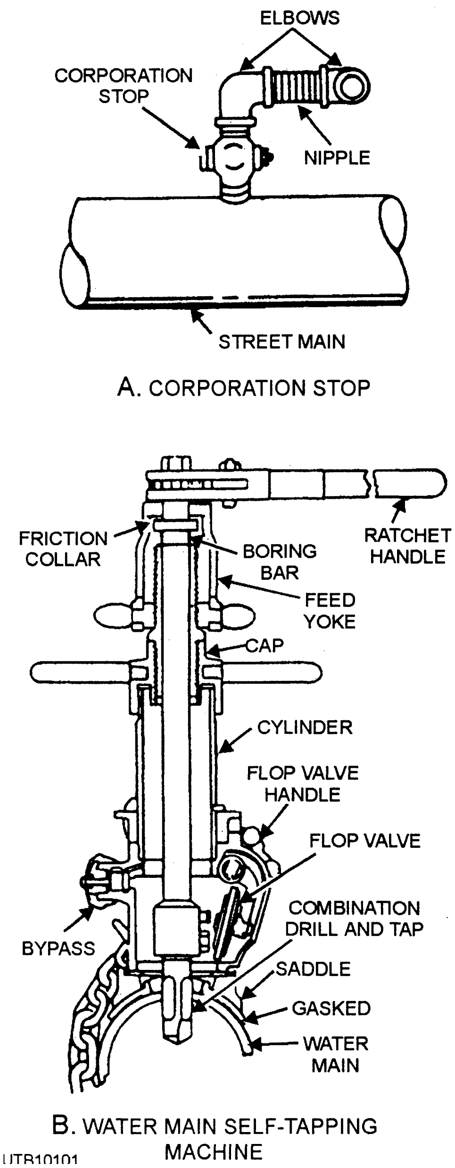


Figure 4-35.—Corporation stop and self-tapping machine.

Tighten the chain mounting bolts until a solid, watertight connection is formed between the main and the base of the machine. Check the depth adjustment on the boring bar, and insert the proper size drill and tap into the holder. Assemble the machine by inserting the boring bar through the cylinder and tightening the cap. Start drilling the hole by applying pressure at the feed yoke while operating the ratchet handle. After the drill penetrates the main, the boring bar turns easily until the tap starts cutting threads. When the tap starts threading the hole, back off of the feed yoke to prevent the threads in the main from stripping. Continue to turn the boring bar until the depth adjustment hits the stop. You have hit the stop when the ratchet handle tightens and it can no longer be tightened without undue force. To remove the tap from the hole, reverse the ratchet and back the boring bar out by turning it counterclockwise. When the boring bar is raised high enough to clear the bottom of the cylinder, close the flop valve. Check to see that the bypass valve is closed. This prevents water from entering the cylinder. The water under pressure from the main is now trapped in the base of the machine, and the boring bar can be removed by unscrewing the machine cap. Remove the drill and tap tool and install a corporation stop of the proper size in the end of the boring bar. Be sure the handle of the corporation stop is in the CLOSED position. Reinstall the boring bar in the cylinder and tighten the cap. Open the bypass valve to allow the water-main pressure into the cylinder, so the flop valve can be opened again. The corporation stop can now be screwed into the main by turning the boring bar. Since the corporation stop was closed before being installed, the only noticeable water leak from the operation is from the water trapped in the cylinder of the machine. Release the water pressure from the cylinder by opening the bypass valve and removing the boring bar. Disengage the chain from the main and remove the machine. Check for leakage around the corporation stop. If the corporation stop leaks, tighten it with an adjustable jaw wrench.

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, or it may serve a portion of the system that is at a higher elevation.
- 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.

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 (fig. 4-36). 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

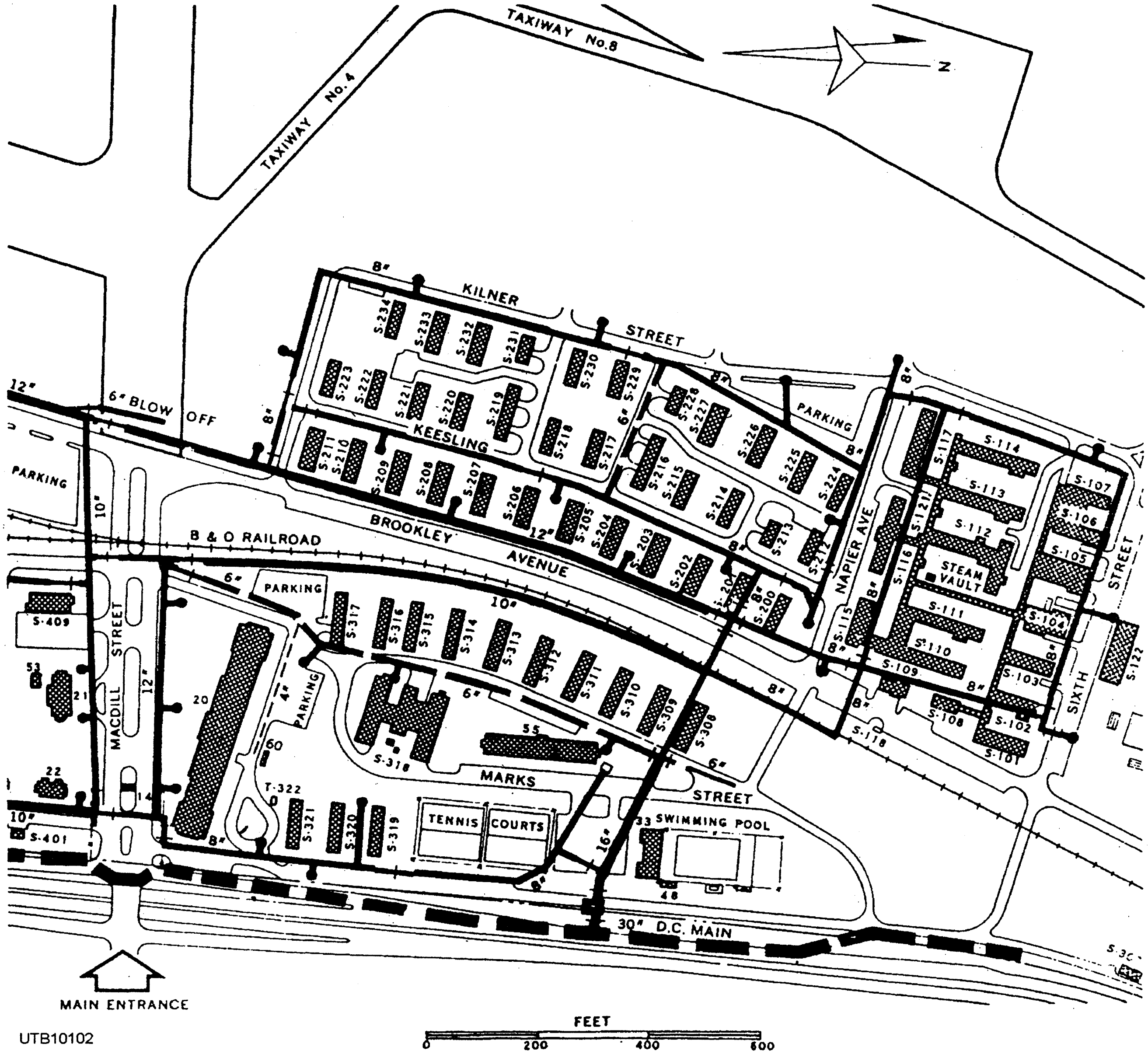


Figure 4-36.—Distribution system layout.

water remains for long periods of time, causing undesirable tastes and odors in nearby service lines.

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.

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 not greater than

5,000 feet in long supply lines and 1,200 feet in main distribution loops or feeders. 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.

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.

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. 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. In some circumstances, it may not be practical to meet this criteria. Then try not to exceed 16 feet (two sectons of hose) to the pumper.

Hydrants should not be placed closer than 3 feet to any obstruction nor in front of any entranceway. The center of the lower outlet should 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 must not be 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.

SAFETY PROCEDURES

Here are 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

Q19. Hydrants should be located what distance from buildings?

Q20. The top of a hydrant must not be higher than how many inches above the ground?

CHAPTER 5

PLUMBING FIXTURES AND PLUMBING REPAIRS

LEARNING OBJECTIVE: *Identify different plumbing fixtures; recognize procedures for rough-in measurements and methods of identifying problems; explain repair, maintenance, and troubleshooting of plumbing fixtures and accessories.*

"Roughing-in," as applied to plumbing and pipe fitting, is a term used for the installation of concealed piping and fittings at the time a building is being constructed or remodeled. As the building nears completion, the final connection of the plumbing fixtures is made. Once construction is complete, continuous maintenance and repair will be necessary on the entire water and sewer systems. In this chapter, you will be introduced to various procedures and methods to install, maintain, and repair water and sewage systems. Use the information given here as a foundation on which to build a wider and broader knowledge of the Utilitiesman rating.

PLUMBING FIXTURES

LEARNING OBJECTIVE: *Recognize rough-in measurements and types of fixtures and accessories.*

Plumbing fixtures are the receptacles into which body wastes are placed before being discharged into the sanitary sewer. There are many types and styles of fixtures, some are general, while others have been adapted to meet special applications, such as for hospitals, prisons, and similar institutions. Many plumbing fixtures are constructed solely of vitreous China, iron, or porcelain-covered steel. Always be careful when handling, installing, or repairing fixtures. Military installations usually are planned to house large numbers of personnel, and the plumbing fixtures ordinarily are installed in batteries. The actual installation of a fixture is a hard-and-fast rule; either the manufacturer states how it is to be done or specifications state the so called "roughing-in" measurements of the fixture in question. Sometimes you may have to design and lay out a fixture or battery of fixtures. You must know what water supplies and stack sizes are needed and work these into your design.

Standard plumbing fixtures are individually tested and the amount of liquid waste that can be discharged through their outlet orifices in a given interval is measured. When we learned that the washbasin, one of the smaller fixtures, discharges 1 cubic foot of water per minute, we had the basis for the fixture unit system. One fixture unit of a known liquid discharges 1 cubic meter of water per minute or about 7 1/2 gallons. Even though 7 1/2 gallons is not shown in table 5-1, we chose that value to come up with an even meter. Try this one. How many flushings of a urinal equal five flushings of a water closet or toilet? Five or six? The fixture unit value for different plumbing fixtures is shown in table 5-1.

Each fixture is equipped, of course, with a waste pipe of sufficient capacity to carry off 'quickly and quietly all water supplied to it. A plumbing fixture must also be furnished with water at a rate of flow that will fill it within a reasonable time.

Table 5-1.—Plumbing Fixture Unit Values

Fixture	Units
Lavatory or washbasin	1
Kitchen sink	2
Bathtub	2
Laundry tub	2
Combination fixture	3
Urinal	5
Shower bath	2
Floor drain	1
Slop sink	3
Water closet	6
180 square feet of roof drained	1

Table 5-2.—Minimum Size Fixture Supply

Fixture	Supply Pipe diameter min. size
Water closet (tank type)	1/2
Water closet	1
Flushometer urinal with flushing valve	3/4
Laundry tubs	1/2
Kitchen sink	1/2
Lavatory	1/2
Slop sink	1/2
Drinking fountain	1/2
Shower	1/2

As per the *National Standard Plumbing Code,* table 5-2 shows the minimum supply pipe diameters.

ROUGH-IN MEASUREMENTS

Figures 5-1 through 5-6 show single-line drawings of general rough-in measurements for various fixtures. The figures show general measurements and will vary depending on type of fixture and manufacturer. It is your responsibility to identify the fixtures you will be using, so you can obtain the proper rough-in measurements.

Service connections for steam radiators depend upon the sizes to be installed and location of each. The same holds true for water tanks used for storing or heating.

After roughing-in, you can easily install the plumbing fixtures and trim work. Instructions are given here for the installation of various fixtures and accessories. We cannot include every type of fixture you will install; but if you learn to install the fixtures covered in figures 5-1 through 5-6, you should not have any problems with other types.

WATER CLOSETS

Water closets come in various shapes, designs, and colors. The device is designed to receive human waste and dispose of the waste properly in a sanitary sewer system. Most water closets mount on the floor, but there are models that are wall hung. Modem water closets have various design features which create different flushing actions. To read more on the various designs and flushing action principles, see the publication titled *Plumbing Installation and Design* by L. V. Ripka.

Installation

To install a water closet (fig. 5-7), follow these procedures as a general guide.

1. Slip the water closet flange over the closet bend and slide it down until it is level with the finish floor.

2. Prepare the joint for a lead-caulked joint; pour and caulk the water closet flange to the closet bend.

3. With hammer and cold chisel, break off the portion of the closet bend that projects above the water closet flange. Do not break the closet bend below the flange.

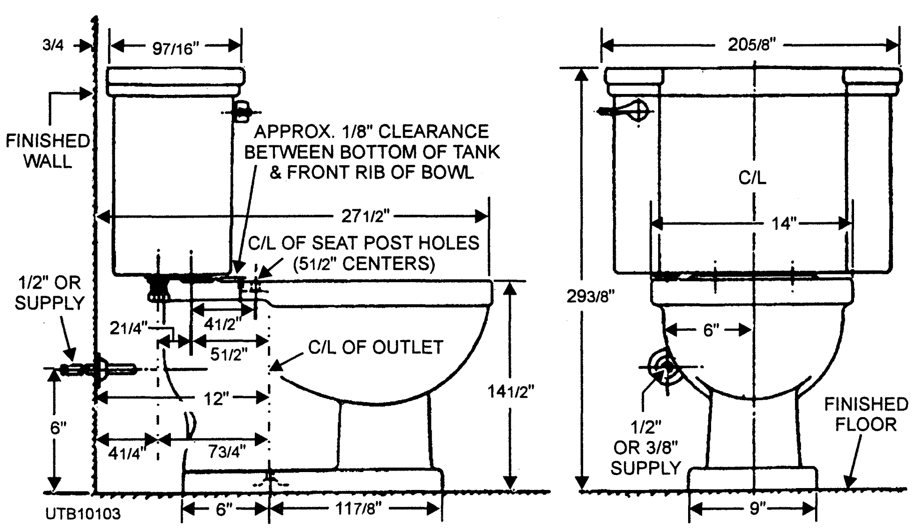


Figure 5-1.—Tank-type water closet.

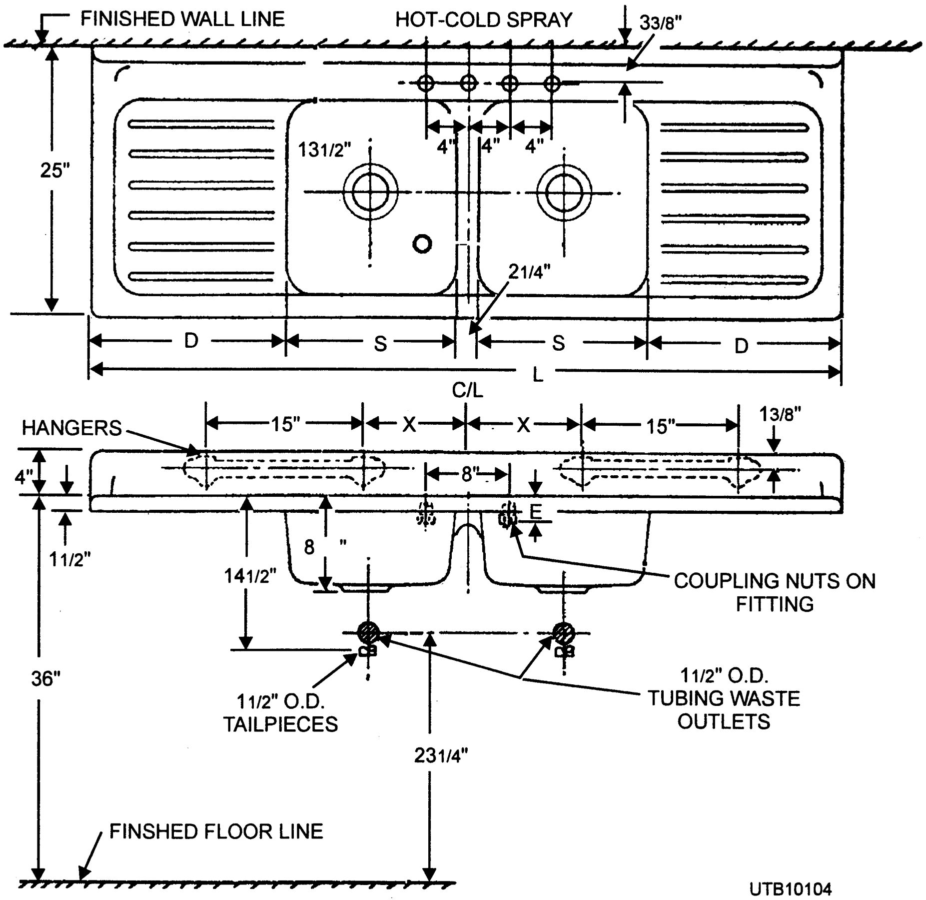


Figure 5-2.—Sink.

4. Place the two brass closet hold-down bolt heads in the slots of the flange.

5. On the bottom of the water closet, as shown in view A, figure 5-8, slip the preformed sealing ring over the horn to form a sealing gasket for the water closet against the face of the flange. Do not use putty as it will dry out and leave a possible sewer gas leak.

6. Turn the water closet bowl right side up and set it on the flange with the horn projecting down into the flange. In setting the bowl on the flange, as shown in view B, figure 5-8, guide the two hold-down bolts up through the bolt holes on either side of the base of the water closet. Using your full weight, press down and twist slightly to settle the bowl and the wax ring into position. The bowl should be perfectly level when settled. Check for level. If off level, use a wedge.

7. Install nuts on the hold-down bolts and tighten them alternately. Do not overtighten them as this may crack the base of the water closet.

8. A wall-mounted water closet, as shown in view A, figure 5-9, is attached to the wall by a chair carrier, similar to the one shown in view B, figure 5-9. The chair carrier is positioned and bolted to the floor. The foot carries the weight of the entire closet independent of the walls and drainage connections. A standard fitting is used to connect between the drain and the closet bowl after the chair carrier is bolted down. The fittings are for 4-inch iron, lead, or soil pipe. The bolt holes in the chair carrier are slotted to facilitate installation of the closet bowl.

When mounting a close-coupled tank on a closet bowl, note that two bolts hold the tank on the bowl. Figure 5-10 shows how. The water supply pipe is between the bolts and drops the water directly into the bowl. A specially designed gasket is installed between the tank and bowl to make the connection waterproof. The bolts are tightened from underneath the closet bowl. Do not apply too much pressure when you tighten these bolts, because you may crack the bottom of the tank or the back of the bowl.

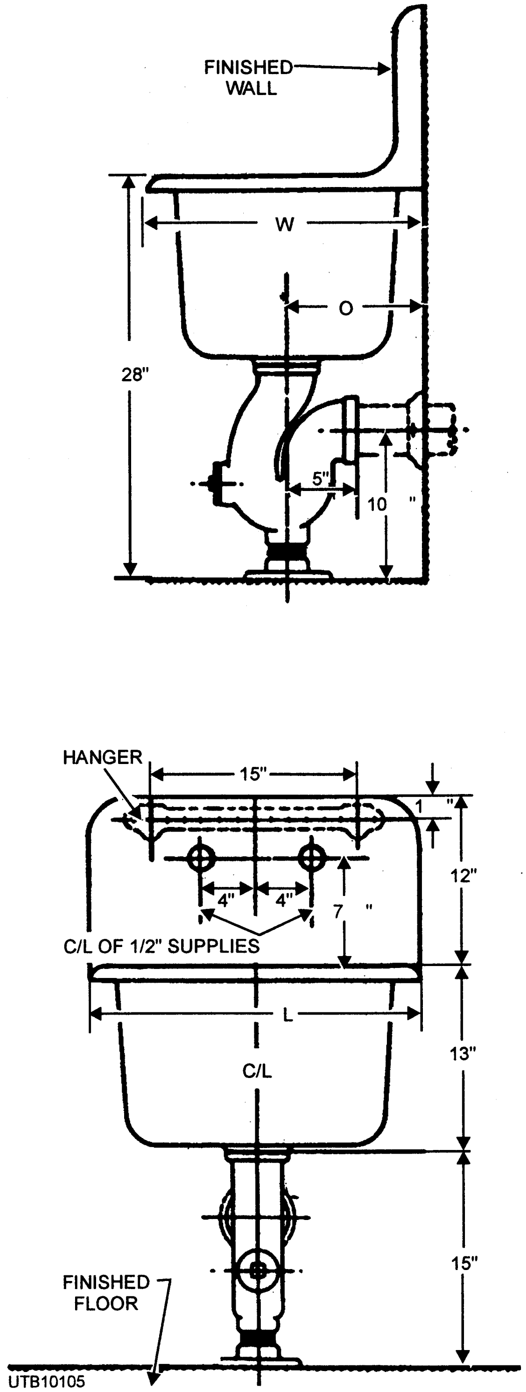


Figure 5-3.—Service sink (slop sink).

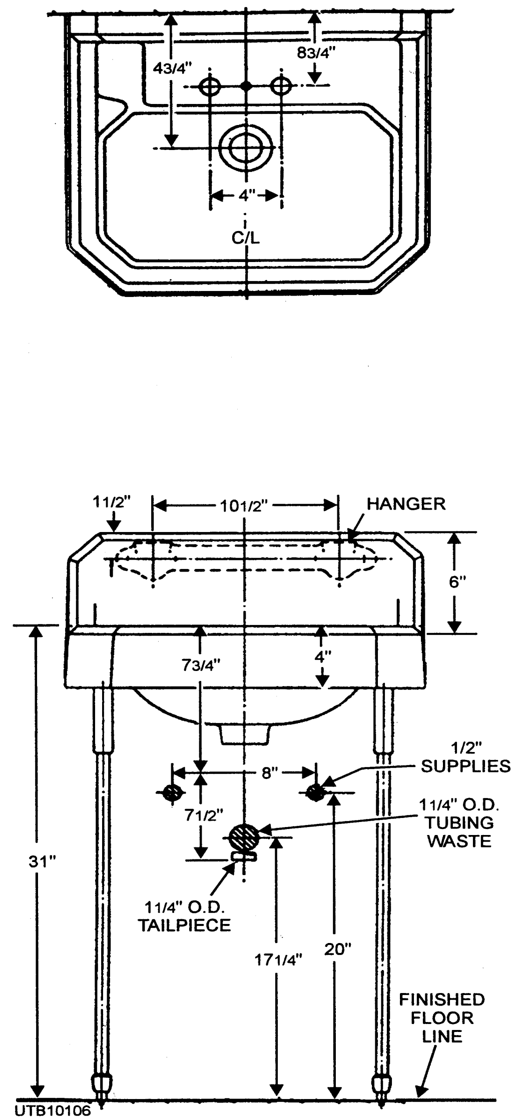


Figure 5-4.—Lavatory.

After the tank is firmly attached to the bowl, connect the water supply pipe to the tank inlet with a riser tube, as shown in figure 5-11. The jiffy connector used here is the same as the connector used to connect the water supply to the faucets of a lavatory.

Flushometer Valves

Flushometer valves are used in place of a tank-type valve in some applications. When a flush valve is used, no tank to hold the flushing mechanism or water is required. Flush valves operate by diaphragm or piston action.

Flush valves require less water volume per flush than a tank-type valve, provide quicker multiple flushing capability, and lower maintenance costs in commercial applications; however, they are noisier than tank-type valves, initially cost more than a tank-type valve, and require a higher operating pressure than tank-type valves. Basically, the flush valve is suited more for the commercial or industrial application, and the flush tank is used in small buildings or single family dwellings.

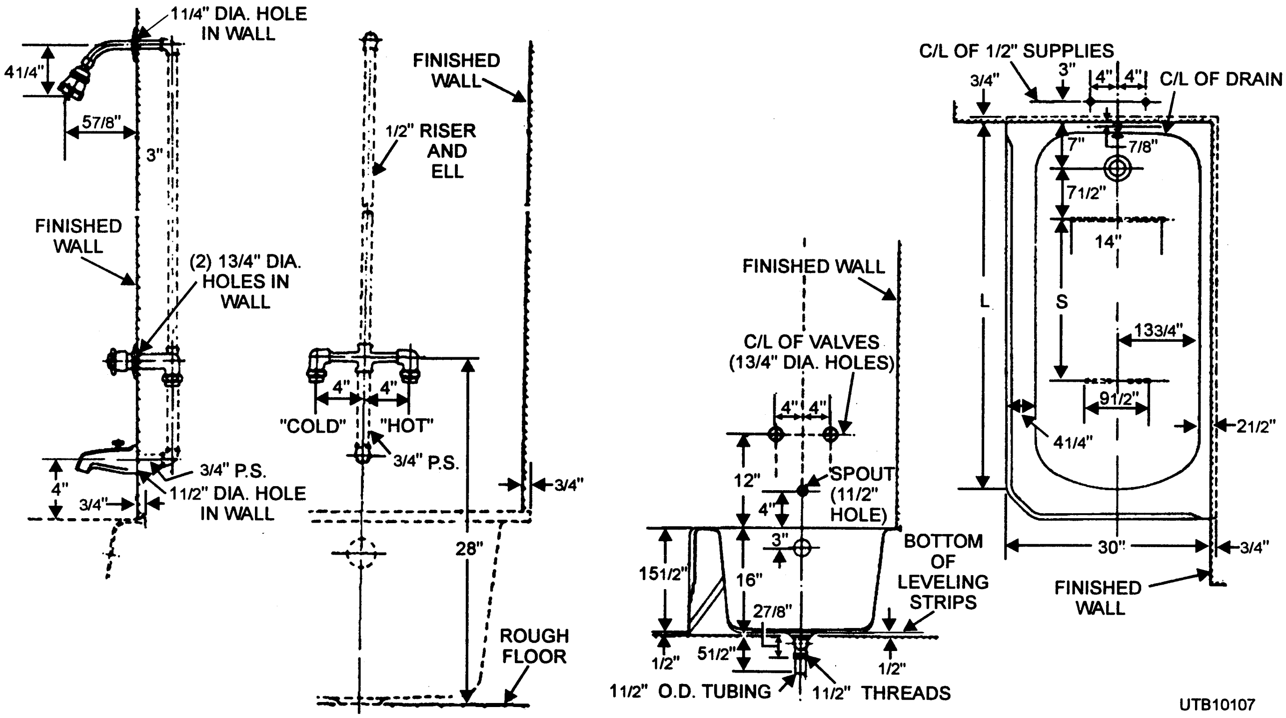


Figure 5-5.—Tub-and-shower combination.

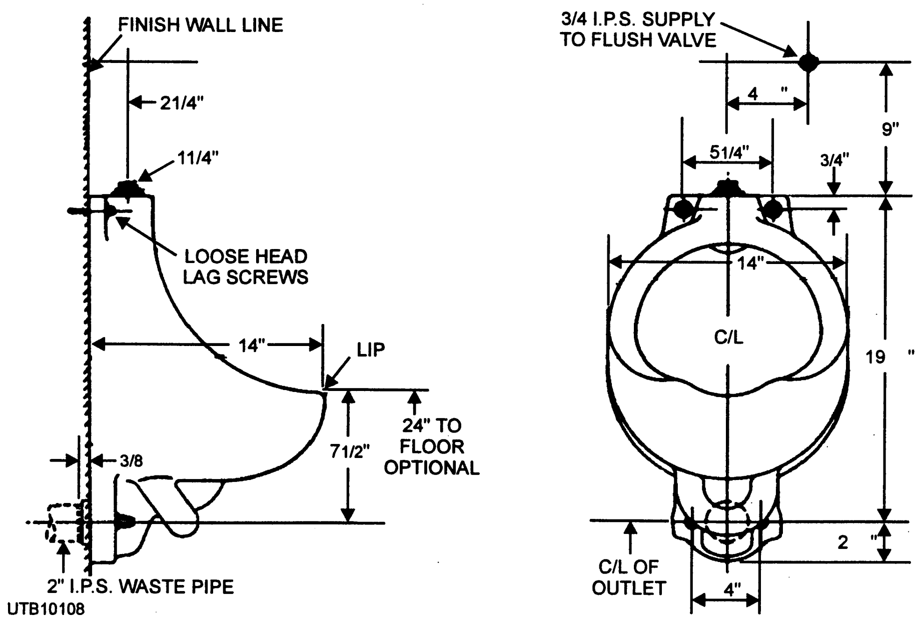


Figure 5-6.—Wall-hung urinal.

A backflow preventer, such as the type shown in figure 5-12, should be installed on the discharge side of a flushometer. A backflow preventer should be installed on the supply line of a float valve in a water closet tank if the tank outlet is below the flood level rim of the closet bowl.

A detail of a diaphragm type of flushing valve is shown in figure 5-13. The diaphragm type of valve consists of an upper and lower chamber. These chambers are separated by the diaphragm and relief valve. The lower chamber is connected directly to the incoming water supply. This incoming water is the flushing water and also the water shuts the valve off after the flushing period. The valve is flushed by the diaphragm and the water pressure in the upper chamber. Water is forced into the upper chamber through a small orifice (hole) in the diaphragm. Water

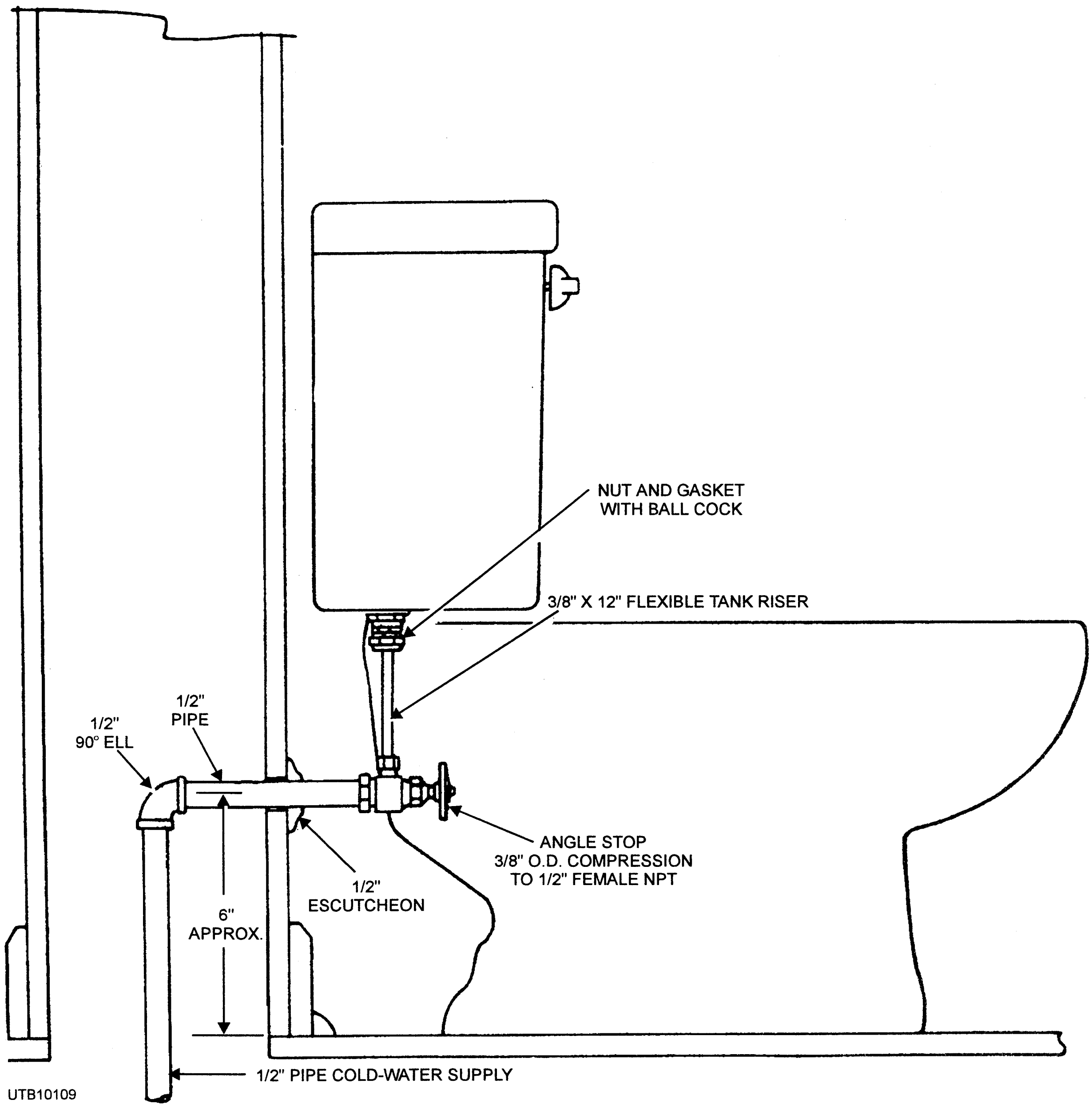


Figure 5-7.—Water closet (tank type).

pressure, passing through this orifice into the upper chamber, creates the pressure required to force the diaphragm down and shuts off the flushing water. By moving the flushing handle, the relief valve tilts open. Then pressure decreases in the upper chamber to less than that of the incoming and flushing water. The action allows the flushing water pressure to raise the diaphragm off the flushing seat and recycle.

Figure 5-14 shows a piston type of valve. With this type of flush valve, the piston is drawn up when the flushing begins, then to its closed position by the filling of the upper chamber through the expeller orifice tube.

Flush valve assemblies on urinals and water closets may be protected from unnecessary damage and wear by installing a grip handle or guard firmly over the handle housing. This grip handle increases the operating life of flush valves and thereby reduces service calls on the repair of flush valve assemblies and plumbing fixtures.

URINALS

Two major types of urinals in use are the floor-mounted and wall-mounted urinals. With spacing being limited, we will only consider some of the main items relating to installation of the wall-hung urinal

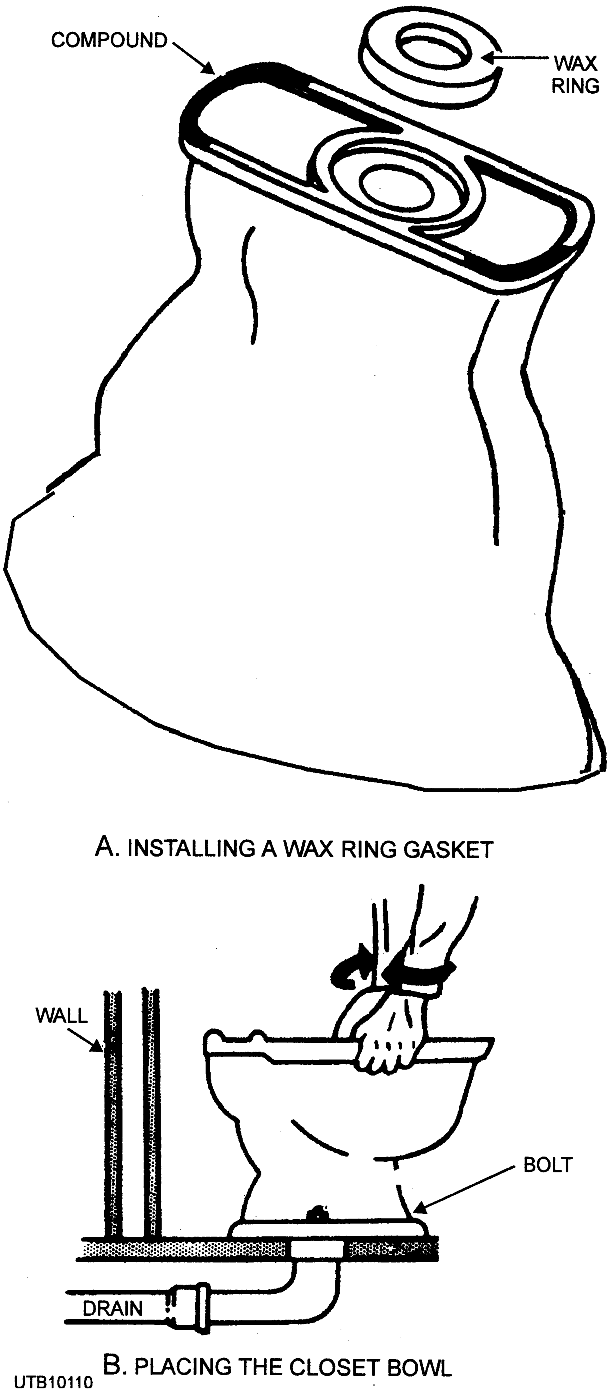


Figure 5-8.—Setting a closet bowl.

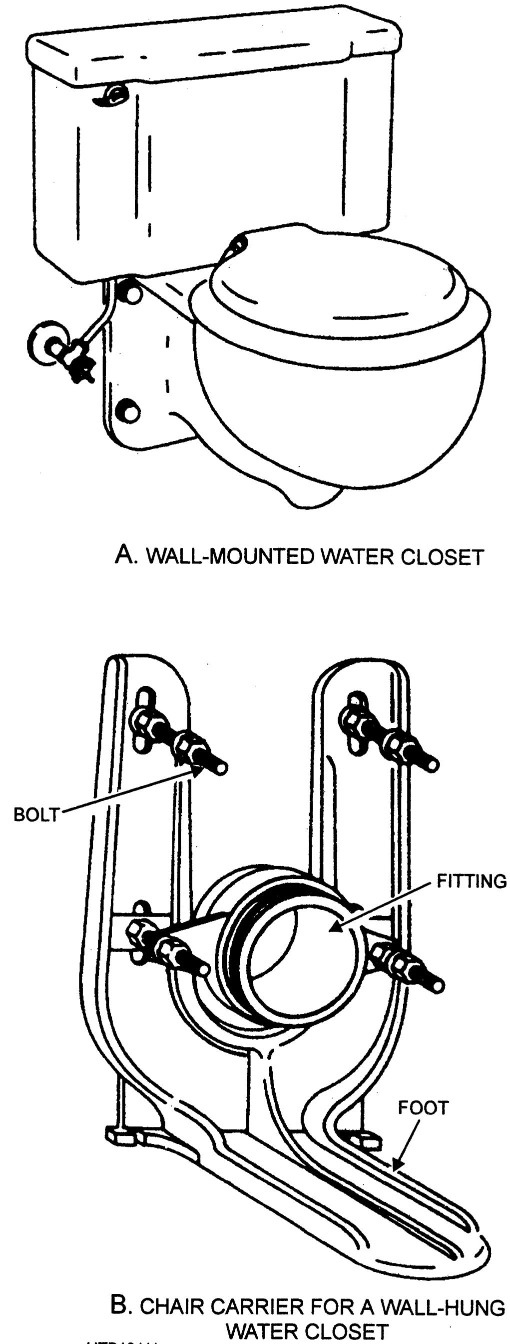


Figure 5-9.—Wall-mounted water closet.

(fig. 5-15). If you learn to install this type, you should have little trouble installing floor-mounted urinals.

In setting the wall-mounted urinal, see that the rough-in of the waste pipe is at the correct height so after installation the urinal is within reach of the user. The lip of the urinal should be from 20 to 25 inches from the floor. If the rough-in already installed in the building places the height of the urinal above or below these general measurements, the rough-in should be removed and the waste pipe brought in at the proper height. Since the wall-hung urinal sometimes has an

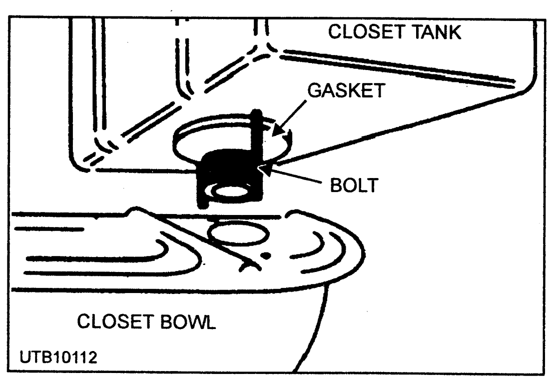


Figure 5-10.—Mounting of a close-coupled tank on a closet bowl.

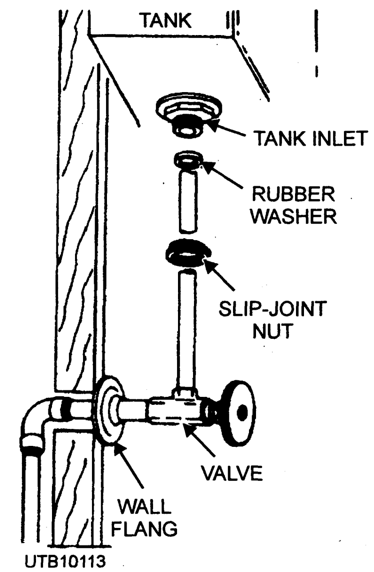


Figure 5-11.—Closet tank water-supply line.

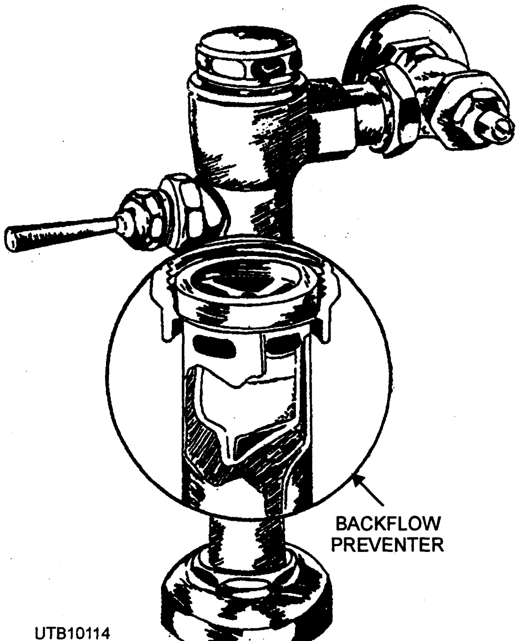


Figure 5-12.—Flushometer valve showing enlarged flow of backflow preventer.

integral trap (trap contained in fixture), it is not always necessary to provide the waste pipe with a separate chrome or iron trap. Integral trap urinals have a back spud fitting that connects the waste pipe and urinal together with a rubber seal in between. Install a mounting board on the wall where a urinal is to hang. This board will provide firm support for the urinal. The last step in the installation of the wall-hung urinal is the connection of a flushing mechanism, such as the diaphragm type of flushing valve.

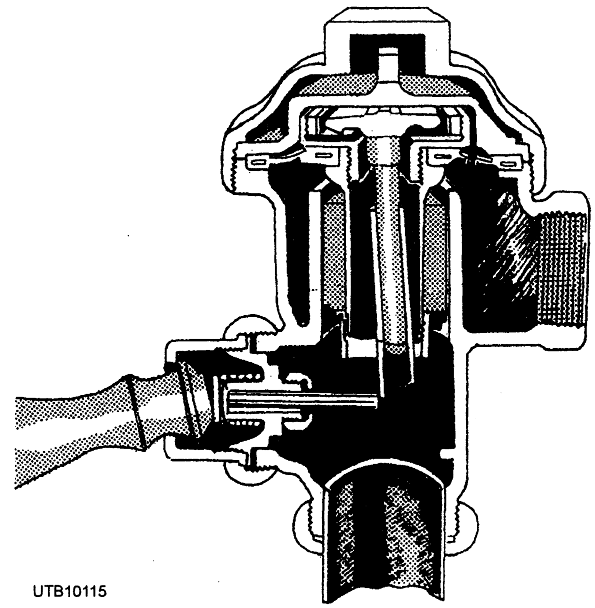


Figure 5-13.—Diaphragm type of flushing valve.

BIDETS

A bidet is equipped with running cold and hot water and is used for bathing external genitals and posterior parts of the body. The bidet is installed mainly overseas; however, the bidet is becoming very popular in the United States.

The water is controlled by faucets the same as a lavatory. The flow of water may rise from the center of the bowl or around the rim. The bowl contains a stopper which holds water in the bowl if desired.

SINKS

Sinks are made in different patterns, each intended to serve specific purposes. Two common types of sinks are the kitchen sink and the service sink (slop sink).

Kitchen Sink

The KITCHEN sink is available in different sizes and may have either a single bowl or a double bowl. It is made of either enameled steel or enameled cast iron.

In the installation of a kitchen sink, it is important that the sink be built into a cabinet or hung from a bracket that is screwed to a mounting board (fig. 5-2). The bracket should be screwed into the mounting board in a position where the sink, when mounted, is at a convenient height for use. As a rule of thumb, the distance between the top of the drainboard and finished floor should not be less than 36 inches.

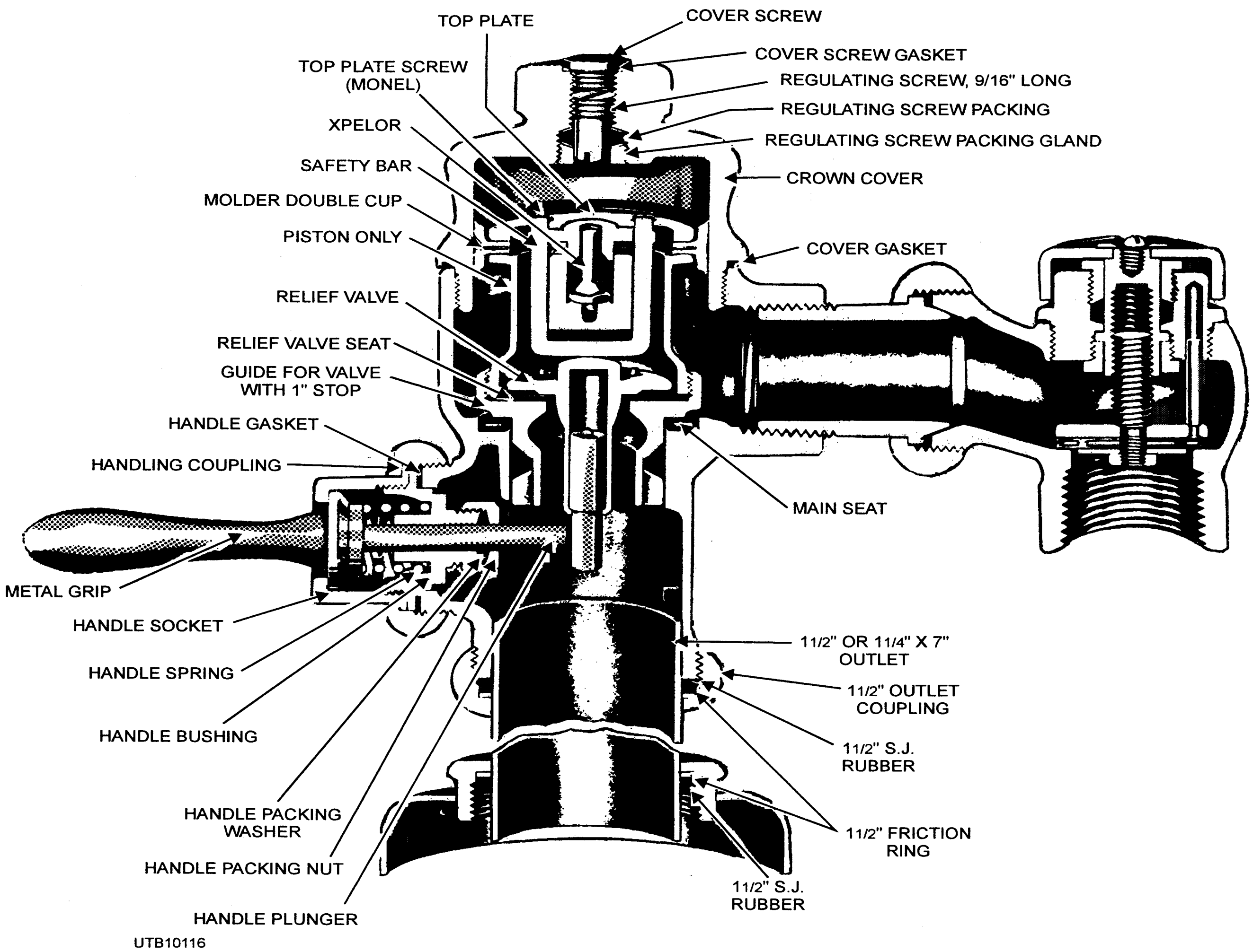


Figure 5-14.—Piston type of flushing valve.

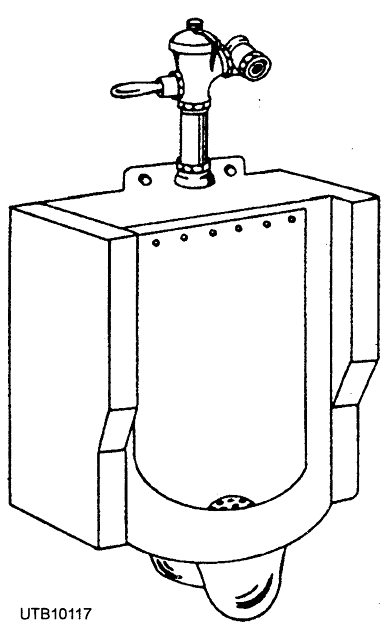


Figure 5-15.—Wall-mounted urinal.

After screwing the bracket into place, lower the sink into position on the bracket, so the lugs, cast into the back of the sink, fit down into the corresponding notches in the bracket. Screw the strainer and tailpiece into the sink bowl and connect the trap to the rough-in waste. To complete the installation, select a suitable faucet. Install the faucet on the sink and connect the water supply to it, as shown in figure 5-16. Then install and connect the waste lines to the sink, as shown in figure 5-17.

Service Sink

A SLOP sink, also referred to as a SERVICE sink, is especially useful for filling a bucket or washing out a swab. It has a deep bowl and generally is constructed of cast iron and finished in enamel.

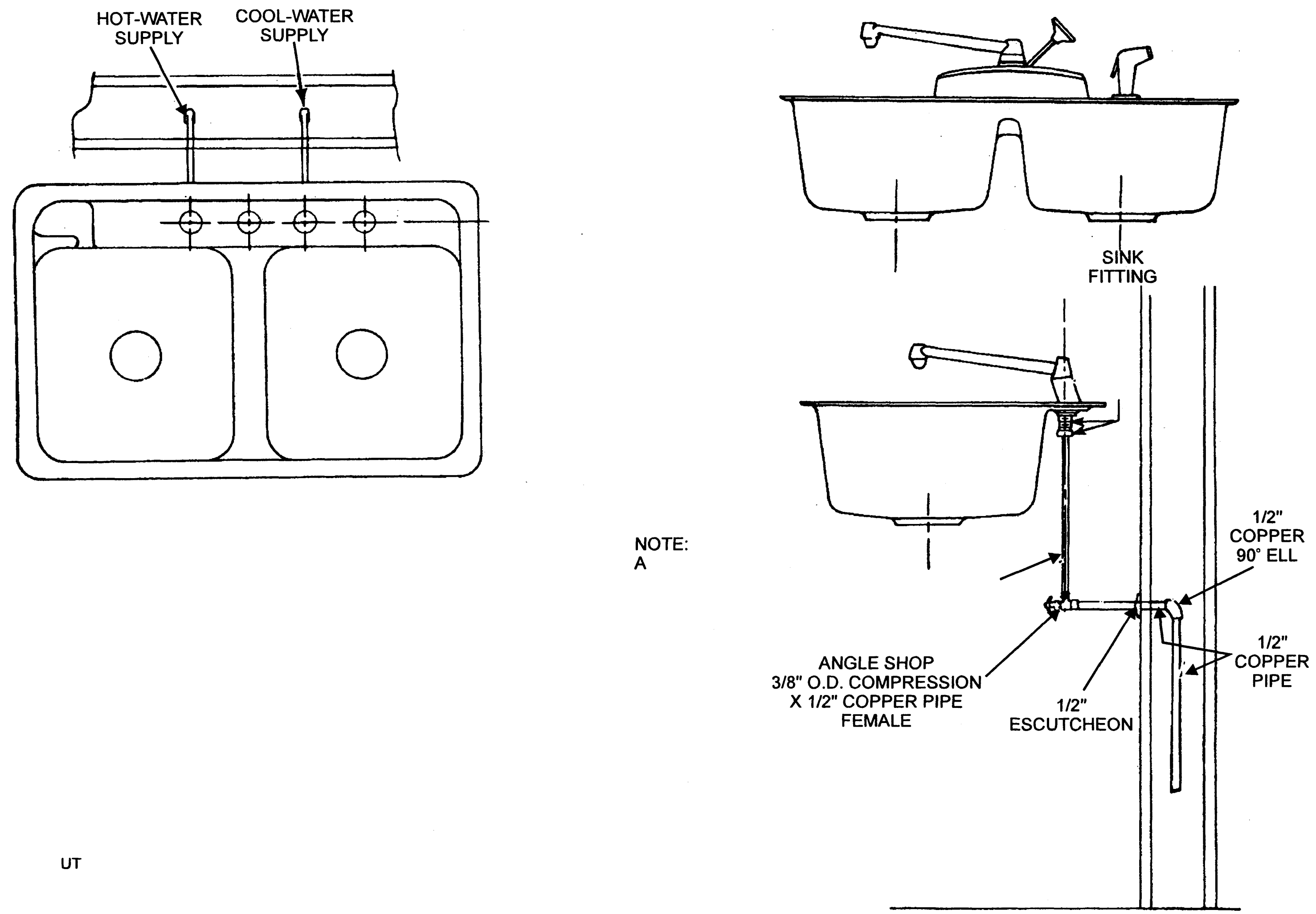


Figure 5-16.—Kitchen sink water-supply hookup.

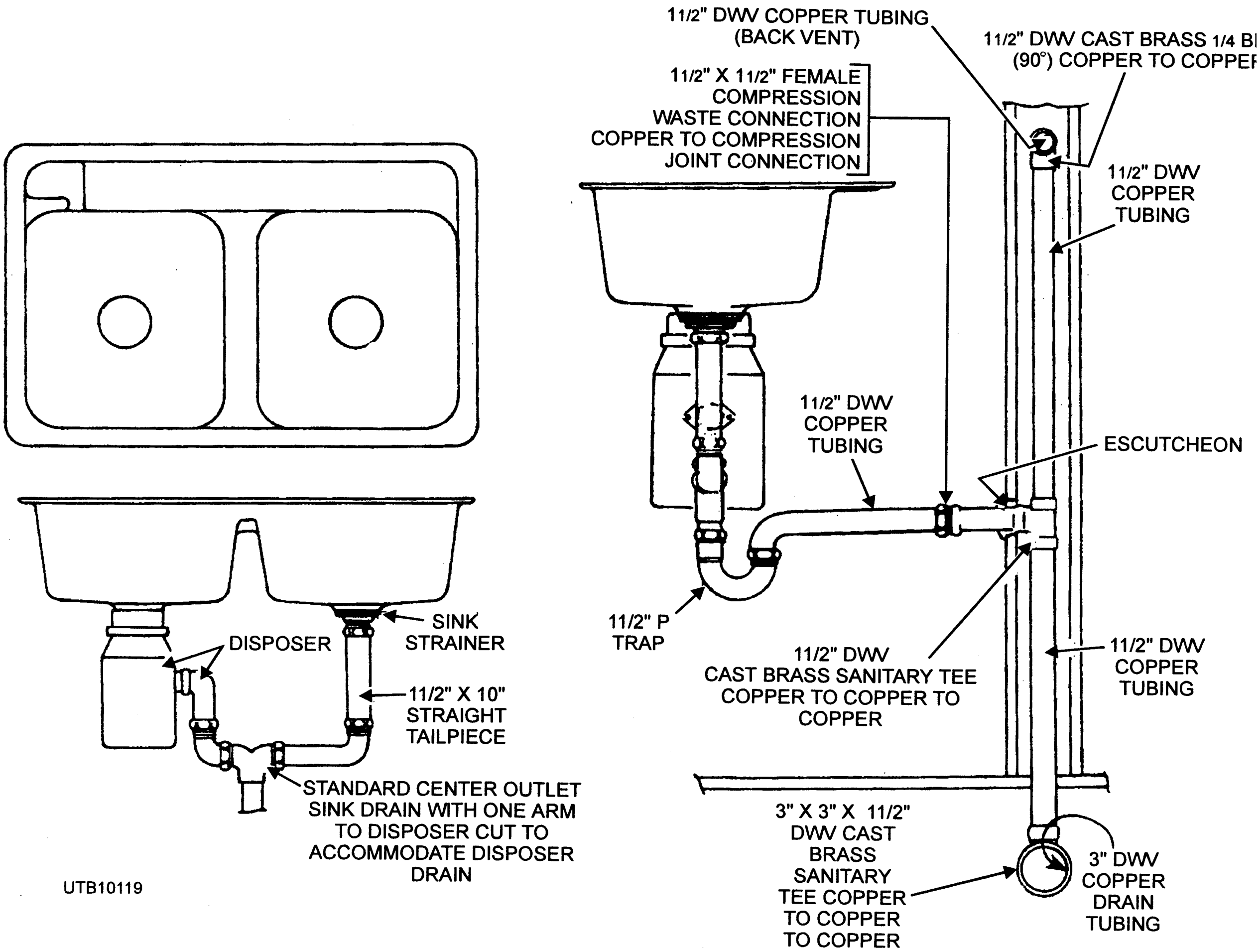


Figure 5-17.—Kitchen sink waste hookup.

The slop sink installation is similar to the kitchen sink installation. The slop sink is also mounted on a bracket and mounting board (fig. 5-3). In addition to the hanger, the slop sink has a built-in adjustable stand trap that bolts to the floor and provides a pedestal support (fig. 5-18). The stand trap should be adjusted to take most of the weight off the hanger and prevent the unit from sagging. After the fixture has been set in place and the waste supply has been connected, suitable faucets are installed and connected to the water supply, and the unit is ready for use.

Lavatories

The wall-hung lavatory, the most common type in use, is suspended from a bracket screwed to the wall. It may or may not be supported (additionally) by legs. Figure 5-4 shows a view of a wall-hung lavatory. To install this fixture, follow the steps below in the order given.

1. Mark the wall at the correct height for a lavatory and secure a hanger to the wall.

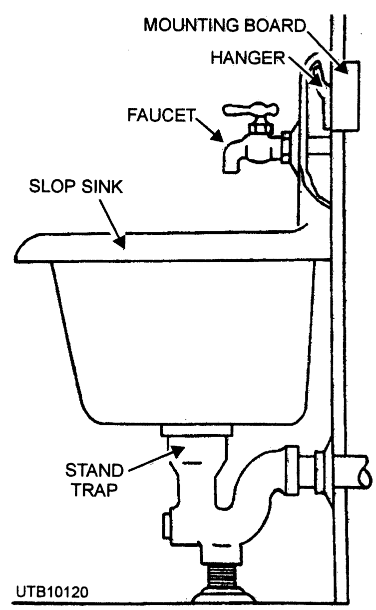


Figure 5-18.—Detail of a service (slop) sink.

2. Position the lavatory on the hanger.

3. Install the lavatory faucets using a basin wrench.

4. Install the permanent opening (P.O.) plug drain, as shown in view A, figure 5-19, or the pop-up type of drain, as shown in view B, figure 5-19.

5. Connect the water-supply lines, as shown in figure 5-20, to the faucets.

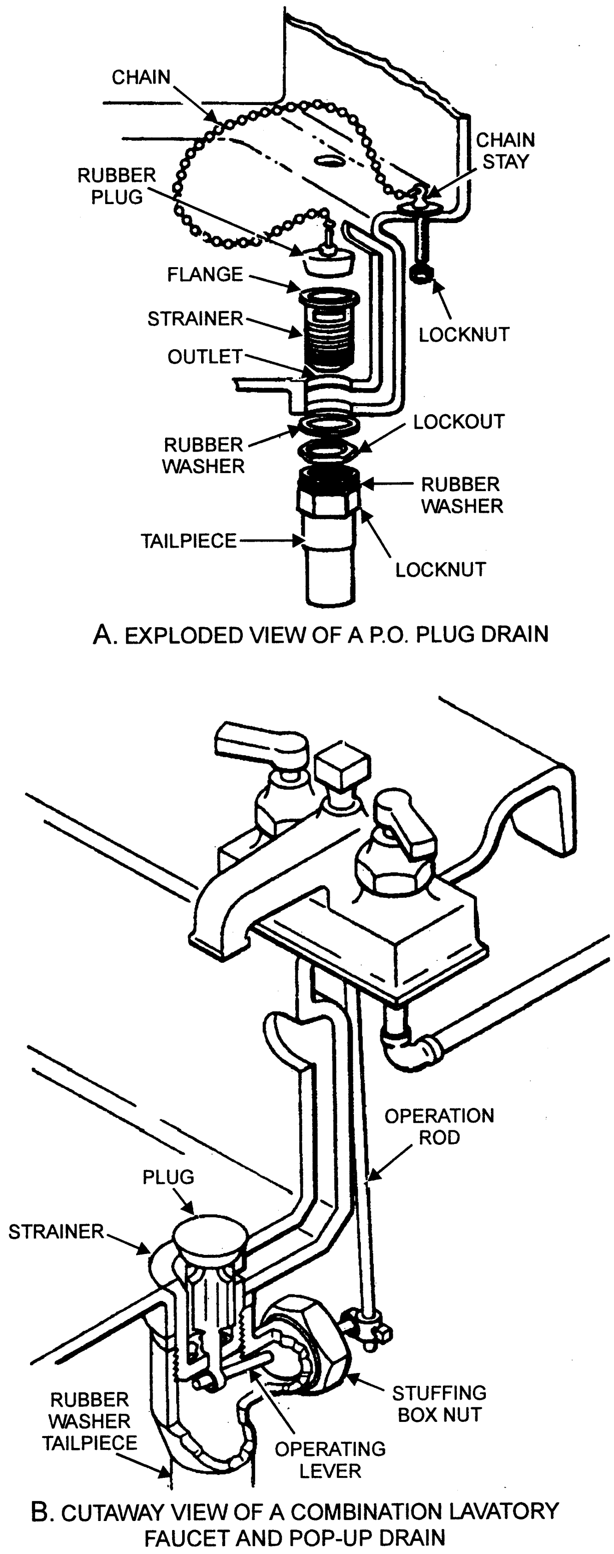


Figure 5-19.—Lavatory drains.

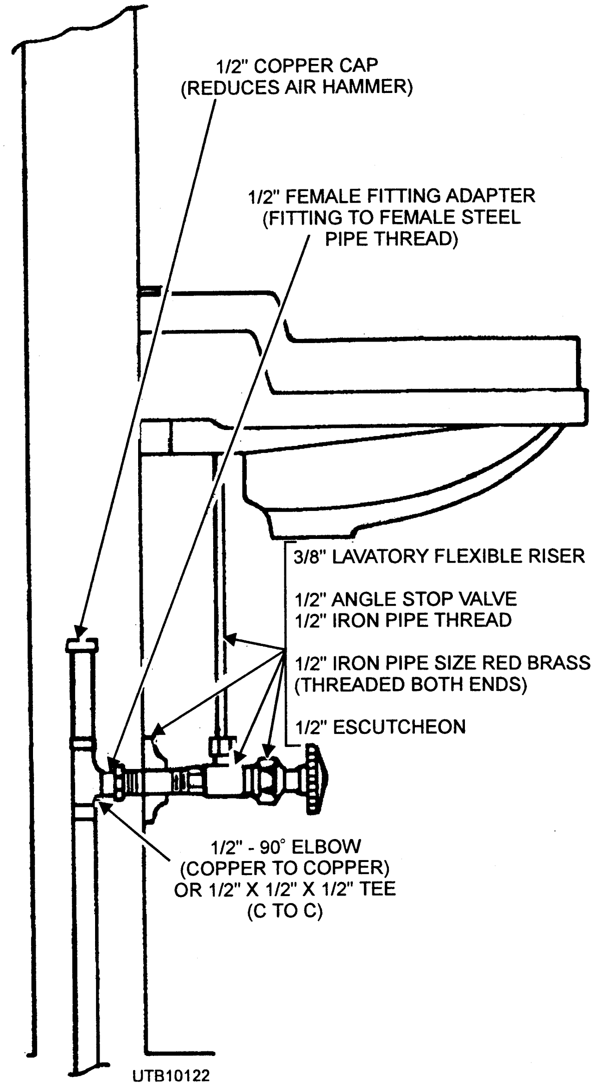


Figure 5-20.—Lavatory water-supply-lines hookup.

6. Connect the waste-supply lines, as shown in figure 5-21, to the lavatory.

Faucets

As a Utilitiesman, you may often be called upon to install or make repairs to faucets. There are many types of faucets in general use, such as the bib, lavatory, bath, and kitchen combinations.

The hose bib faucet, as shown in view A, figure 5-22, is used where outside hose connections are needed.

You probably recognize the combination faucets, as shown in views B, C, and D of the figure. This faucet generally is used to combine the flow from hot-and-cold water pipes. A main feature of these faucets enables the water to be tempered as it is discharged

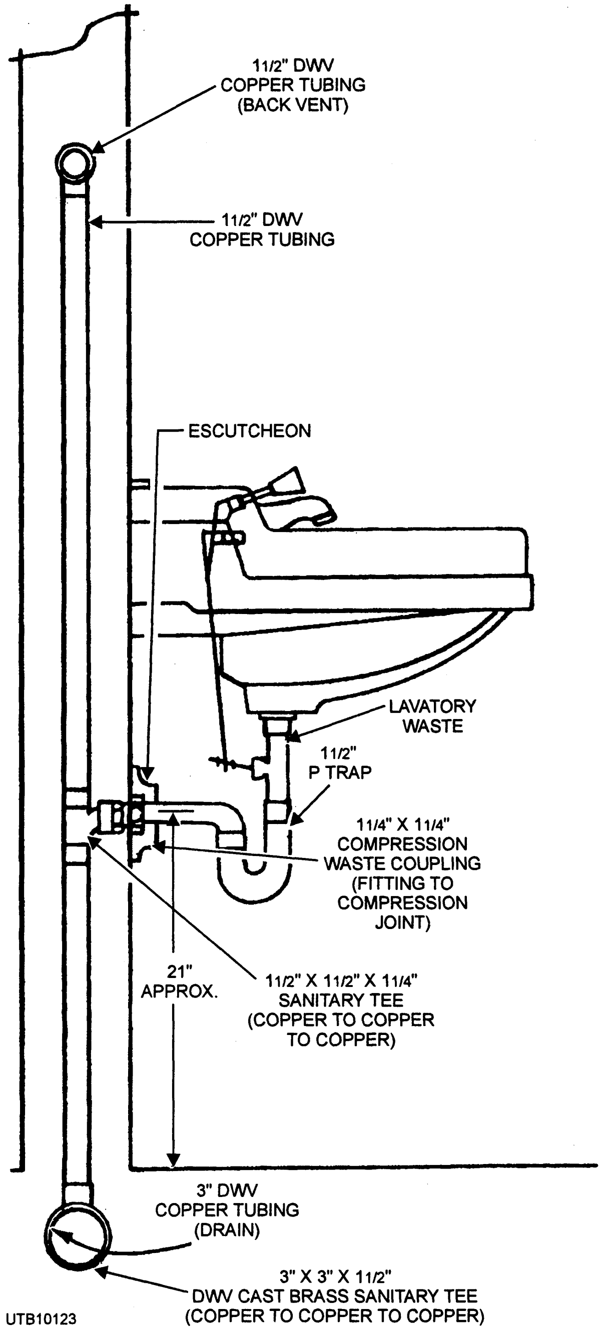


Figure 5-21.—Lavatory waste hookup.

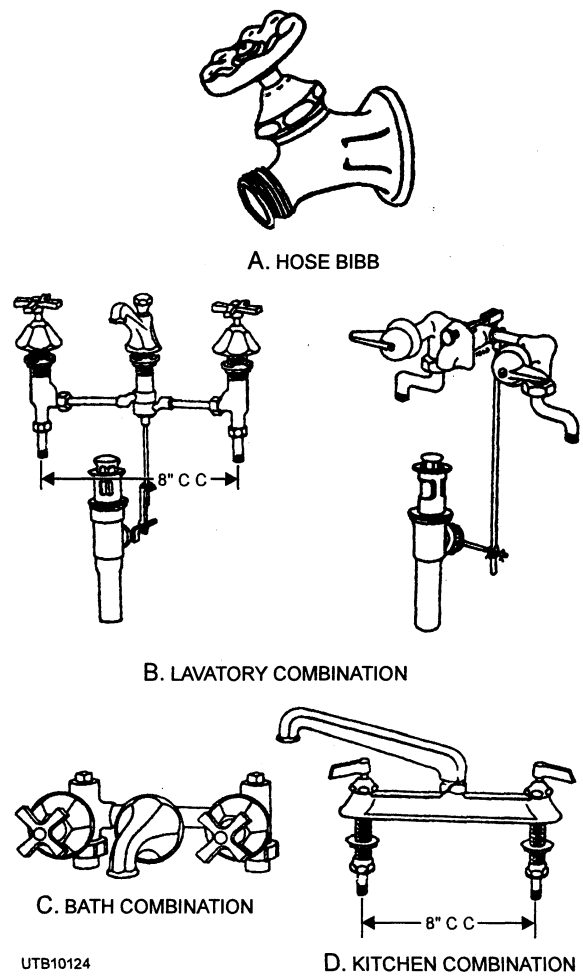


Figure 5-22.—Types of faucets.

through a single spout. They are commonly used on lavatories, baths, or kitchens.

SHOWER-AND-TUB COMBINATION

Several types of bathtubs are on the market today. Some of them are the recessed, the corner recessed, the sunken, and the leg type. Most tubs are made in several sizes, ranging from 4 to 6 feet in length and are designed as right- or left-hand tubs, depending on the location of the drain. When you face the tub, if the drain is on the right end, it is a right-hand tub; if on the left end, a left-hand tub. Most bathtubs today are made of enameled cast iron, enameled pressed steel, or the fiber glass design which is the most commonly used for the built-in type.

The installation of both the bathtub and shower is simple. Tubs and showers come in many different applications: tubs, showers, tub-and-shower combination, and gang showers (large room with no privacy partitions or dividers).

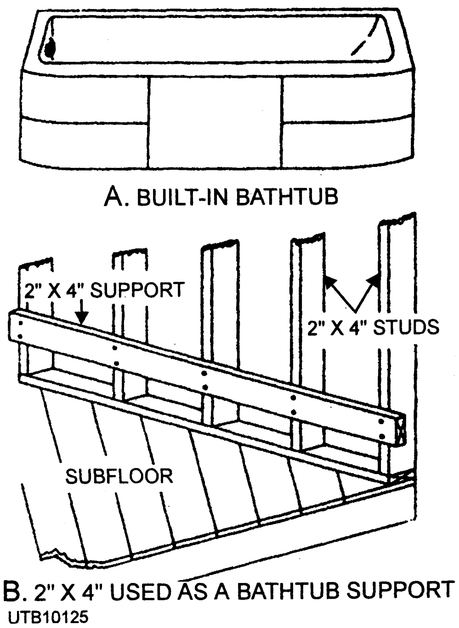


Figure 5-23.—Bathtub and support.

To install a tub, like the type shown in view A, figure 5-23, place the rim of the tub on the 2- by 4-inch support nailed to the 2- by 4-inch studs, as shown in view B, figure 5-23. Check to be sure the tub is level.

Once the tub is in place, hook up the water-supply lines, as shown in figure 5-24. Now you have a bathtub and shower combination. Water is furnished by a faucet and spray nozzle. Two valves usually control the flow of water to these units. Ordinarily, when the valves are opened, the water runs into the bathtub from the bathtub faucet. However, for water to run through the shower head, the valves are opened as for filling the bathtub; the diverter which is located in the bathtub faucet must be raised. This combination gives the bather two means of taking a bath.

A tub drain and overflow are usually similar to that shown in figure 5-25. The drain assembly is installed in the space provided by the studs at the end of the tub. The overflow and waste drains are made of chrome. The hidden parts are of rough brass and brass tubing. The fittings are 1 1/2 inches in diameter and come with a pop-up waste or a rubber stopper fastened to the overflow by a chrome chain. This drain and overflow combination is connected to the P trap with slip-joint nuts and rubber washers to seal off the leaks. The drain in the bottom of the tub is sealed against leaks with plumber's putty and rubber rings.

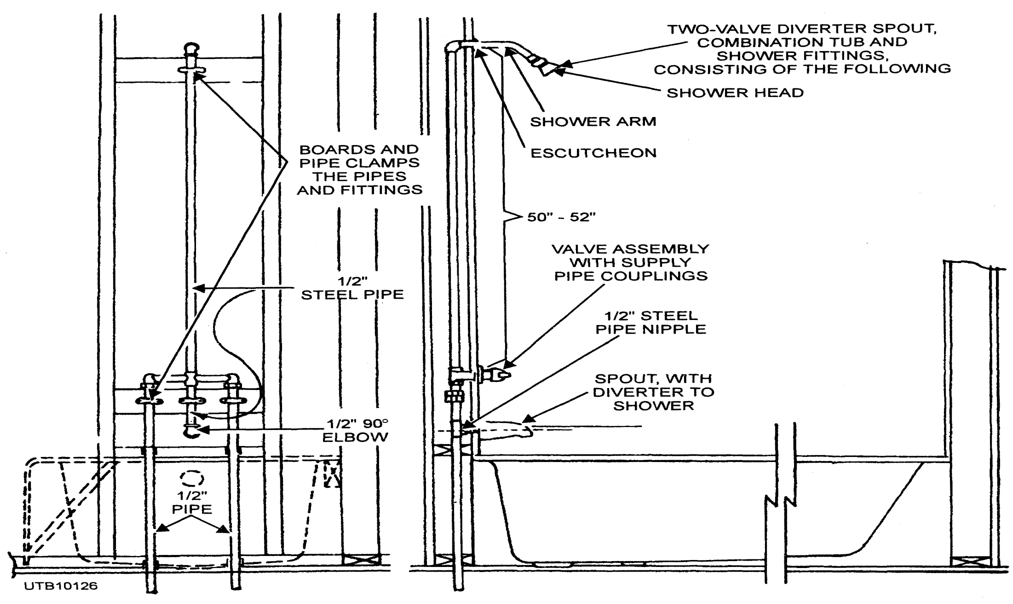


Figure 5-24.—Bathtub and shower piping combination.

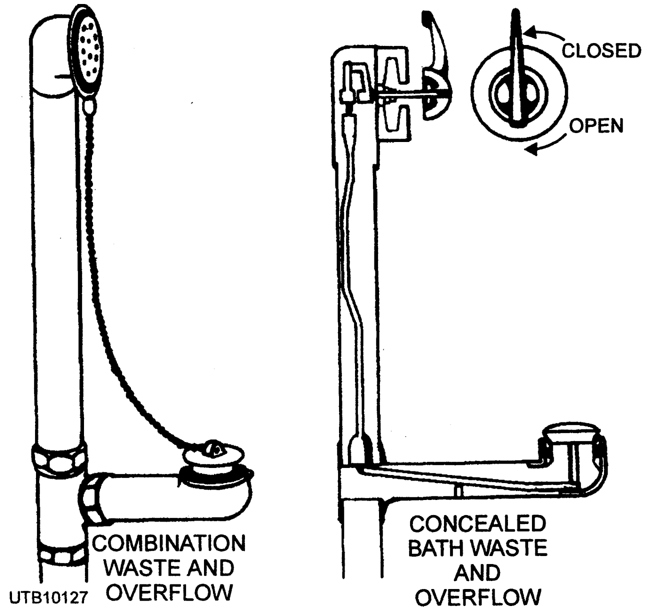


Figure 5-25.—Bathtub combination waste and overflow.

The wastewater supply lines, as shown in figure 5-26, are then connected to the tub.

The faucet and shower combination for a bathtub and shower is connected to the hot and cold waterlines that were installed when the piping was roughed-in. The manufacturer's specifications should be used to determine the height of the riser. The height, however, may be specified by the user. The shower and bathtub piping and fittings installed within the wall are made of rough brass; those that extend through the finished wall have a chrome finish. A typical bathtub and shower piping arrangement is shown in figure 5-27. When you make this type of bathtub and shower installation, be sure to locate the bathtub spout from 2 to 4 inches above the rim of the tub. Spacing the spout above the rim of the tub prevents siphoning of the water from the tub in case the valve is left open and the water drops at the same time. This installation prevents cross-connection between potable and nonpotable water.

The mixing valves in the shower system supply a uniform temperature of water for the shower or tub. The temperature of the water may be regulated between the limits of the temperature of the cold-water supply and the hot-water supply. The equipment used to control the temperature of the water are the manual, the pressure, and the thermostatic mixing valves.

The manually controlled mixing valves consist of two hand-operated valves in one body with an outlet for both valves that feed the shower head. The valves are turned by hand to control the temperature of the water. Manually controlled valves require a piping arrangement similar to the one shown in figure 5-28. This water tempering setup does not protect against

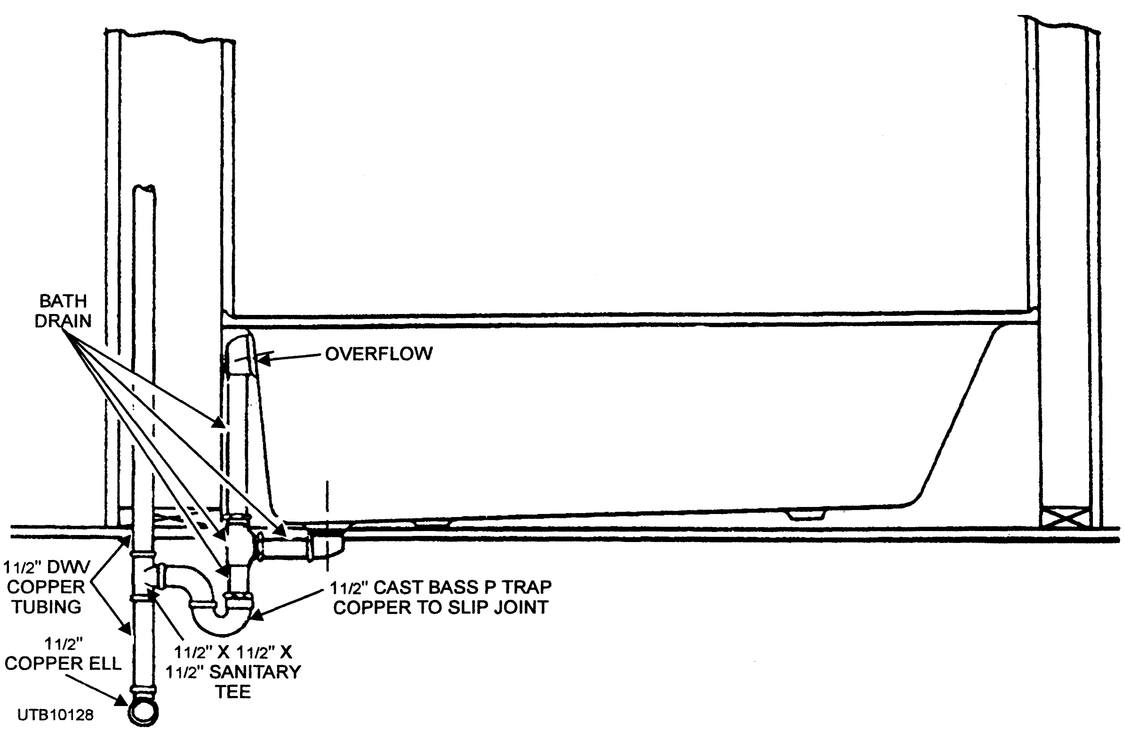


Figure 5-26.—Tub waste hookup.

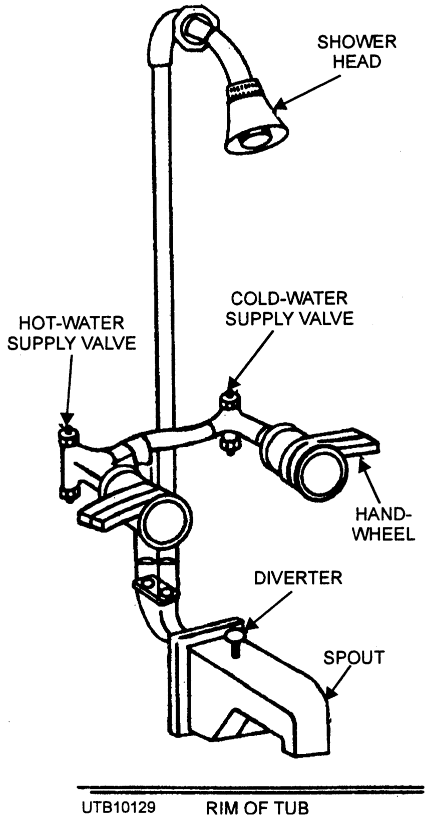


Figure 5-27.—Bathtub and shower piping arrangement.

sudden changes of temperatures due to slugs of hot or cold water from varying pressures or water temperatures in the supply lines.

The pressure-controlled mixing valve, like the one shown in view A, figure 5-28, consists of a brass mixing chamber that contains a sliding piston. The piston has jets to allow hot and cold water to pass through them and mix when the handle of the valve is operated. The setting of the handle controls the water temperature by establishing the mixing ratio. A change in pressure on one side of the piston causes the piston to move and increases the flow from the low-pressure supply to maintain a nearly constant pressure.

The thermostatically controlled mixing valve, similar to the one shown in view B, figure 5-28, is sensitive to changes in both temperature and pressure. The temperature of the water delivered by the valve remains constant regardless of the temperature and pressure changes in the hot and cold waterlines. The thermostatic mixing valve is used for showers only.

The shower head is attached to a 45-degree fitting mounted on a chrome pipe. There are two general types of shower heads: circular and economy. The circular spray head shown in figure 5-29 has notches or

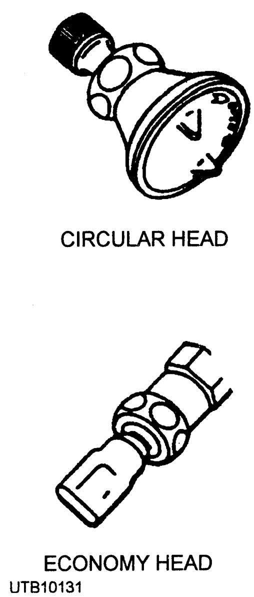


Figure 5-29.—Types of shower heads.

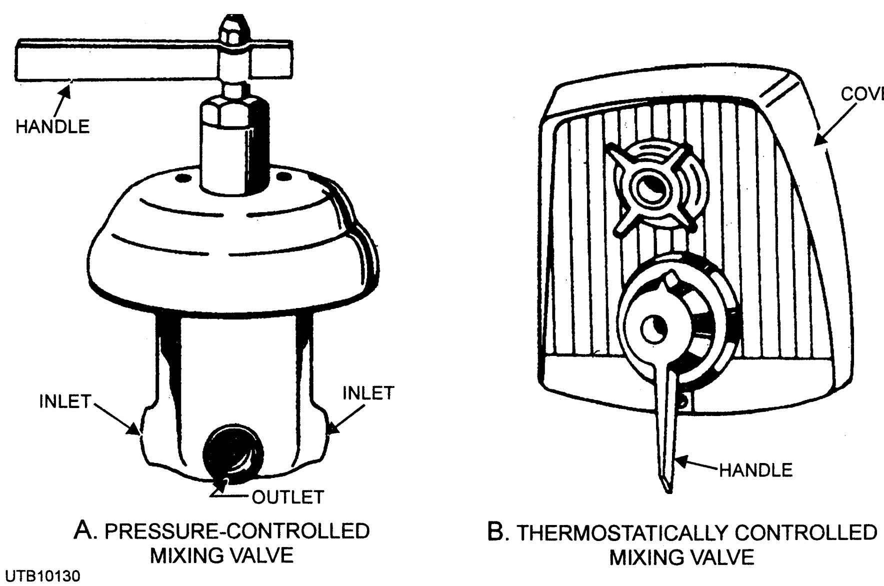


Figure 5-28.—Shower mixing valves.

grooves around the outer edge of its face. The spray in this type of head can be regulated. The economy head, also shown in figure 5-29, has a restricted nozzle that provides a finer spray and uses less water. Both shower heads have a ball-and-socket joint for adjusting the direction of the spray.

Shower heads are usually made of chrome- or nickel-plated brass. Newer types of shower heads are made of noncorrosive plastic. Deposits tend to form on the shower head because of the chemical content of the water; therefore, occasional maintenance is required to keep them functioning properly.

The most important requirement in a shower installation is the absolute waterproofing of walls and floors. Walls are less of a problem than floors since they are subject only to splashing of water and do not have water standing or collecting on them. Careful installation of tile or other impervious material with waterproof cement generally suffices to provide a waterproof wall installation. In the installation of the floor, an impervious waterproof subbase must be put under the shower floor, or water standing on the floor will gradually seep through and cause leaks.

Concrete shower pans, used with prefabricated steel shower stalls, are relatively easy to install. In many cases, steel shower stalls are set up after the original construction. In this case, the cement base is usually not recessed into the floor but is laid directly on top of the floor.

Generally, steel fabricated shower stalls are being replaced with fiber glass and plastics. All of the units are installed in the same manner. The dimension for the finished interior of a shower stall should be at least 30 inches. The shower head should be a minimum of 68 inches above the level of the drain on the shower pan (fig. 5-30). Figure 5-31 shows a cutaway view of a shower pan. All seams should be caulked to prevent leaking, and all pipe openings in the wall of the stall should be sealed. Be sure to follow the manufacturer's instructions that accompany the fixtures and trim. In

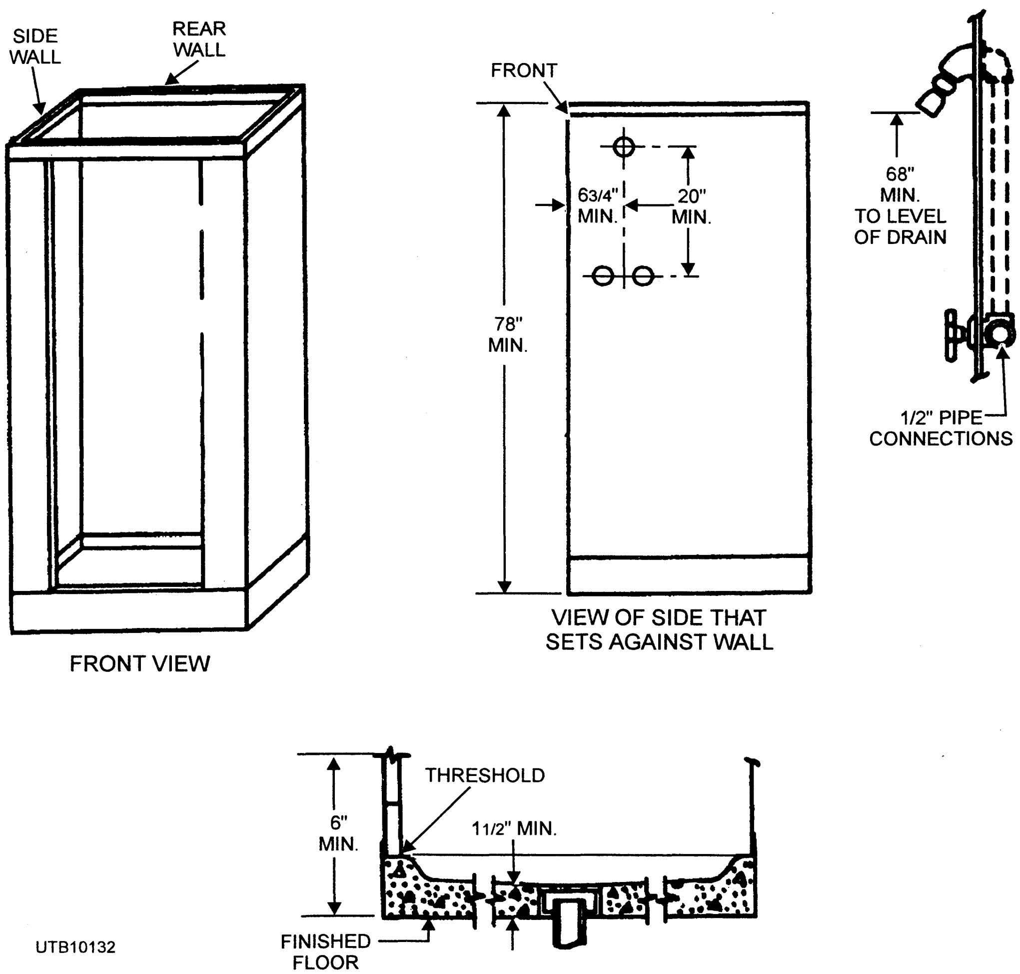


Figure 5-30.—Shower stalls and sections.

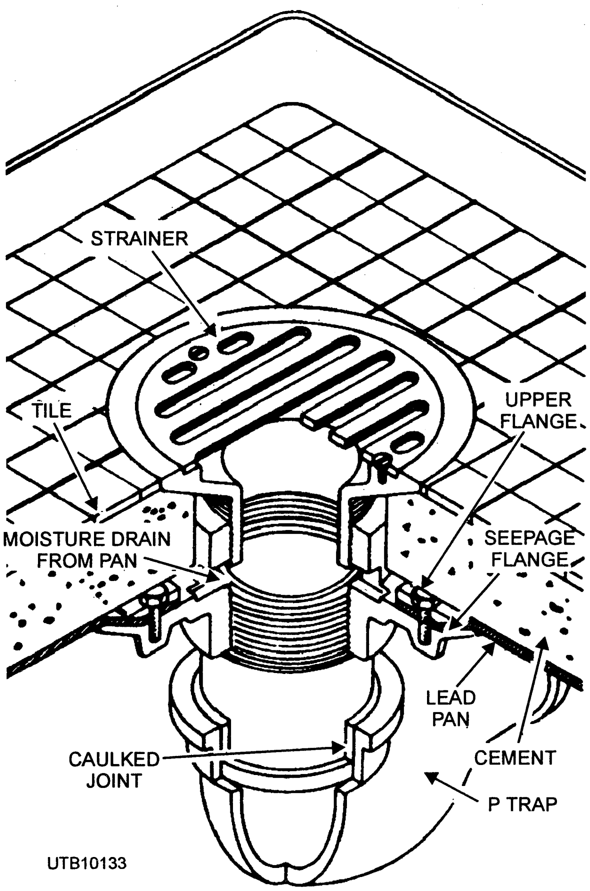


Figure 5-31.—Cutaway view of a shower pan drain.

connecting, the shower pan is connected to a P trap following the manufacturer's instructions that accompany the shower pan.

DRINKING FOUNTAINS

All types of drinking fountains should be installed with the orifice located from 30 to 40 inches above the floor, depending upon the general height of the users. One type of wall-hung drinking fountain is shown in figure 5-32. The mounting of the fixture should be sturdy and strong enough to hold more weight than that of the fixture itself. Most drinking fountains must be installed with a 1 1/4-inch P trap underneath the waste, but a few are available with integral traps. The electrically cooled drinking fountain requires an electrical outlet nearby for power. Because of the many variations in style of drinking fountains, the manufacturer's installation procedures and specifications should be followed in each case.

FLOOR DRAINS

Floor drains are used to carry contaminated water to the sanitary or storm sewer. Sanitary sewage very rarely passes through a floor drain, unless other

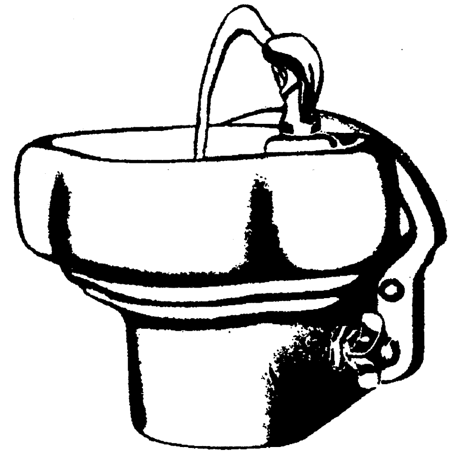


Figure 5-32.—Wall-mounted drinking fountain.

fixtures in a system overflow and sewage backs up into the floor drains.

Floor drains are divided up into two groups: those that are designed with a water seal and those that are not. Floor drains, used in connection with a sanitary sewer, by code, must have a water seal (fig. 5-33,

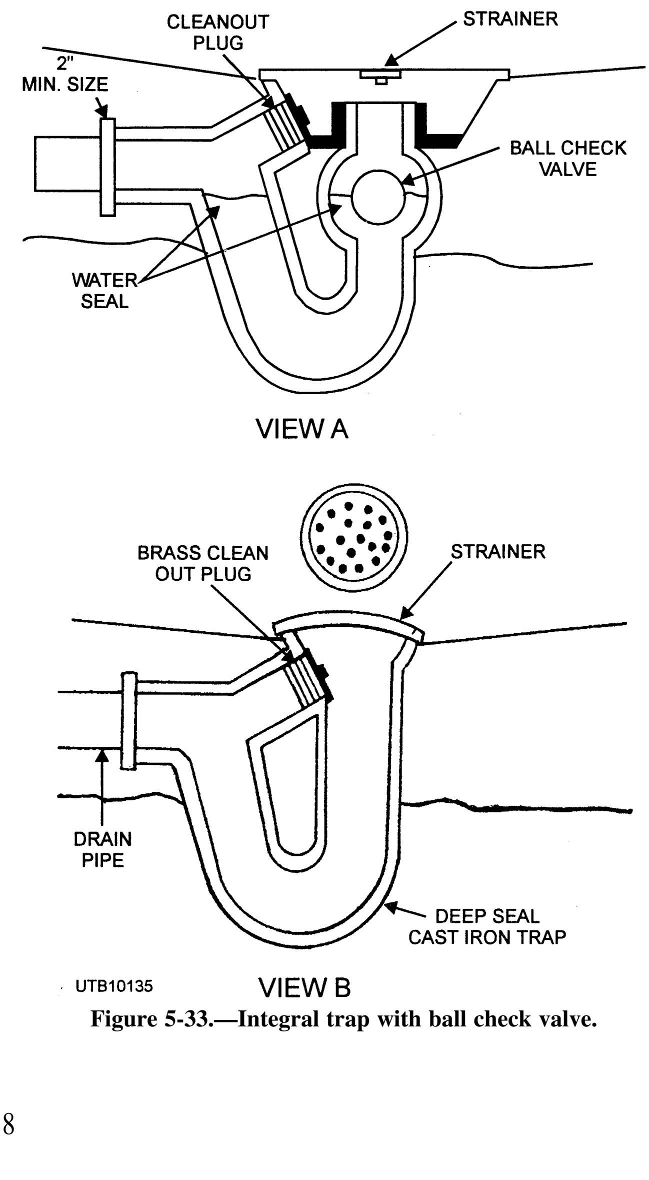


Figure 5-33.—Integral trap with ball check valve.

views A and B). The water seal prevents gases and odors from the sewer from coming into the building or structure containing the floor drain. Drains without a water seal (fig. 5-34) may be used when the floor drains are connected in a system that feeds into a storm sewer system.

A floor drain that is 2 inches is rated at two drainage fixture units. A floor drain that is 3 inches is rated at three drainage fixture units. The load of fixture units for floor drains is added to the sanitary system, not the vent system. Most code requirements do not require floor drains to be vented if they are installed within 25 feet of a vented drainage pipe line.

WATER HEATERS

Clean, hot water is required in many installations for domestic and industrial use. Since boiler water cannot be used for this purpose, because of the chemicals added, it is necessary to heat additional water. The water may be heated in tanks equipped with coiled piping through which the boiler water or steam circulates. Or it may be heated in independent units that heat by electricity, gas, solar, or oil.

Domestic water heaters are built in various sizes from 20, to 50-gallon capacities. Industrial type of water heaters are designed to heat thousands of gallons of water, depending upon the amount and use.

Modern water heaters are self-contained and require very little attention, since they are fully automatic. These units are cylindrical in shape, and they have diameters ranging from about 12 to 30, 40,

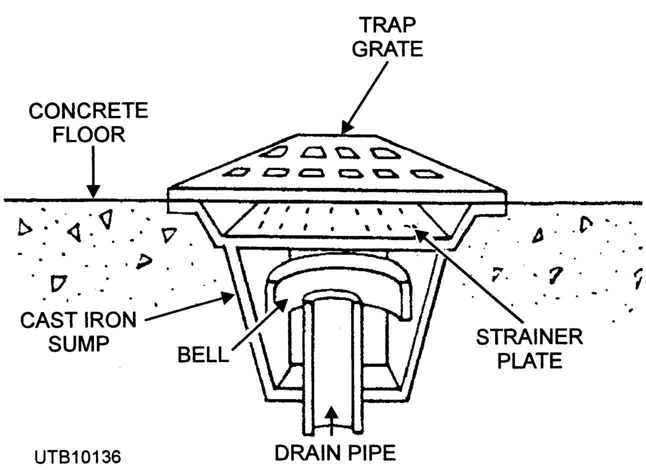


Figure 5-34.—Drain without a water seal.

and 50 inches, depending upon their capacity. The tank is constructed of galvanized sheet metal, which may be lined with a composition of glass to resist corrosion of the tank lining and prevent contamination of the water. The combustion chamber is in the lower section, which is vented by a baffled flue that extends through and ends at the top of the tank. The entire tank is insulated to prevent the escape of heat. It is also equipped with a thermostat which can be adjusted to maintain a certain water temperature. Safety features which make the hot-water heater automatic are also in the unit.

Both the cold-water inlet and the warm-water outlet are at the top of the tank. These tappings are usually marked “INLET” and “OUTLET.” However, if there is a question in your mind as to which is the inlet and which is the outlet, just remember that the cold-water inlet pipe extends over halfway into the tank, but the outlet pipe does not. There is usually a drain valve at the bottom of the tank.

You must ensure the dip tube is installed on the cold-water side or inlet to allow the cold water to go to the bottom of the heater and not cool the water at the top.

Gas water heaters must be installed with a relief valve normally located in the top of the shell. The relief valve is set to open on a temperature or a pressure rise of an unsafe limit. Relief valves differ from a safety valve in that a relief valve opens gradually at a set point. Normally the valve opens at 210 degrees or at 125 psi at a minimum. The pipe that carries the relieved water or steam from the tank must extend to within 18 inches of the deck to prevent a hazardous condition.

Always remember that water in a closed vessel, when heated, will expand and cause the pressure to rise. If, for some reason, a control fails to turn the heat source off, the pressure will be relieved by the relief valve. The water that comes out of the outlet of a relief valve will flash off due to the pressure change, and you will experience a hot steam discharge along with very hot water.

Q1. What term is used to refer to measurements used to set water supply and sewer drainage piping?

Q2. One fixture unit is equal to how many cubic meters of water per minute?

Q3. Using table 5-1, how many fixture units will be used to install two bathtubs, three water closets, and a slop sink?

Q4. Does a water closet, equipped with a flushometer valve, require more or less water per flush than one equipped with a flush tank?

Q5. What are the two types of urinals most commonly used by Utilitiesman?

Q6. A service sink is referred to by a more common name. What is it?

Q7. What type of faucet is used for exterior connections?

Q8. What instruction should be used to determine riser height if the user does not indicate a preference?

PLUMBING REPAIRS

LEARNING OBJECTIVE: *Recognize procedures for making plumbing repairs and testing; recognize methods of operation for fixture hardware and safety.*

This portion of the chapter will deal with some of the more common plumbing repairs that will be necessary from time to time to keep plumbing systems operating properly. Proper repairs and maintenance techniques save money by extending the life of plumbing systems. For example, one water faucet that is leaking one drop of water each second wastes about 2,300 gallons of water per year.

WATER BREAKS

Water distribution piping at one time or another will require repair on a leak or a break in the line. The following are problems you may have during a waterline break:

- The water supply for fire protection is reduced or does not exist.

- Escaping water under pressure undermines structures, damages foundations, destroys landscaping, or causes a serious erosion problem.

- A broken pipe causes a health hazard because the distribution system can become contaminated by external sources.

- The water supply for normal domestic or industrial use can be completely cut off.

To ensure proper repair of a water break, keep red line prints on hand that show the water distribution lines, existing conditions, and locations. Ensure to red line your set of prints every time you make a repair or line change. Additionally, notify engineering of your line repair or line change, and they will update the master set of base prints.

At some activities, electronic devices are available for subsurface survey and pipe location work. Sometimes you may have to find points of interconnection, pipe diameters, and the condition of exterior surfaces or coatings. For future use, make notes on the maintenance prints to show the general condition of the system. Use a symbol that stands out to show the approximate age of the installation or its parts. Prints should be complete and up-to-date. In maintenance or repair, these prints help in planning maintenance. Many times, they offer clues to the most probable location and probable cause of trouble. Now and then, the system should be flushed through hydrants and blowoffs to remove scale and accumulation in pipes and fittings. When performing this operation, start at the hydrants or blowoffs nearest the source of supply to conserve water and to stir up less of the distribution system. Each point should be flushed until the water comes out reasonably clear. All valves should be in their normal operating positions before you go on to the next point. Flushing dead ends is vital. When flushing does not induce enough velocity to scour the mains clean, night flush them with a large discharge. Night operation lessens work disruption caused by water shutoff or decreased water pressure.

WATER MAINS

Since water main breaks must be repaired as fast as possible, personnel must be trained and repair plans made in advance. The following procedures are essential:

1. Post the telephone numbers of the fire department and key personnel and have alternate personnel available in case members of the regular repair crew cannot be reached at the time of a break. Notify the public works officer at the time the break is reported.

2. Always keep the following items readily available: valve keys, hand tools, digging tools, pavement breakers, trench shoring, a portable centrifugal or diaphragm pump, floodlights, an emergency chlorinator, and calcium hypochlorite powder.

3. Maintain enough pipe repair materials and supplies. As a temporary measure, wooden plugs can be

used to stop small holes in a main. These plugs can be replaced later with metal plugs, or repairs may be made by other means. Wooden plugs can also be used temporarily to plug the ends of a pipe up to 8 inches in diameter, but such plugs must be braced to withstand existing main pressure. After repairs are completed, the main must be disinfected. Disinfection was discussed earlier in chapter 1 of this training module.

THAWING FROZEN PIPES

In cold weather, a water-supply system can freeze. Because of the lack of protection against freezing, and, sometimes regardless of it, pipes frequently freeze in Temperate Zones. When this happens, the pipes must be thawed. Breaks must be found, if possible, before natural thawing to prevent damage to material and property. Alert personnel to watch for the signs of a broken line. The prevention of freezing pipes can sometimes be accomplished by using heat tapes and cables.

Before starting to thaw a frozen pipe, open faucets affected by the freeze. Frozen pipes can be thawed by applying heat at the lowest open end of the frozen section. (Do NOT start in the middle of a frozen section because a pocket of steam could develop and an explosion or damage to the pipe can occur.) Where there is no danger of fire, simply heat the pipe with a blowtorch, applying the flame on the outside of the pipe.

When thawing frozen water pipes or heating pipes inside of buildings, use hot water. Do NOT use an open flame. A safe method is to wrap the frozen section of pipe with cloth and pour hot water on it until the ice gives way. Remember to protect the floor by catching the water in buckets or by covering the floor with material to absorb the water.

A good method of thawing water pipes that are underground or otherwise hard to get to is shown in figure 5-35. When using this method, remove the fittings (see illustration) and insert one end of the small pipe or tube into the frozen pipe. Now add an elbow and a piece of vertical pipe to the outer end of the thaw pipe. Place a bucket under the opening to the frozen pipe and insert a funnel in the open end of the vertical pipe. With that done, start pouring boiling water through the funnel into the pipe. As the ice melts, push the thawed pipe forward. Where necessary, add pipe at the outer end until a passage is made through the ice.

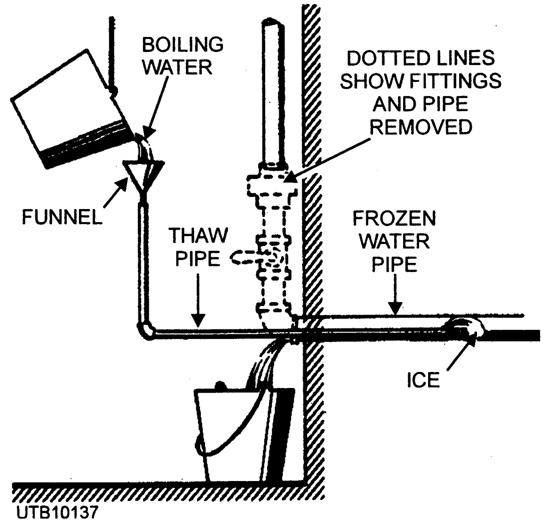


Figure 5-35.—Thawing an underground or otherwise inaccessible pipe.

Withdraw the thaw pipe quickly after the flow starts and do not stop the flow until the thaw pipe is fully removed and the pipe cleared of ice.

Instead of a funnel, a small force pump can be used. This pump is useful for thawing a long piece of pipe. When available, you can use steam in place of hot water. The above method can also be used without the elbow and piece of vertical pipe shown in figure 5-35. Simply connect the funnel to the outer end of the thaw pipe with rubber tubing. Have the tubing long enough so you can hold the funnel above the level of the frozen pipe. In this way, you give the hot water a head, forcing the cooled water back to the opening where it runs out into the pail. Hence the advantage of the elbow and vertical pipe is that they increase the head of the water and make the use of the funnel easier.

Electrical Thawing

Electrical thawing of frozen service lines is quick and cheap. The electrical current for the thawing operation consists of a source of current (a dc generator, such as a welding outfit, or a transformer connected to an ac outlet) and two insulated wires connecting the current source and the pipe (fig. 5-36). Only qualified personnel should use power lines as a source of current. As current flows through the pipe, heat is generated, and the ice within the pipe begins to melt. As the water starts to flow, the rest of the ice is melted by contact with the flowing water. The wires from the current source may be connected to nearby hydrants, valves, or exposed points at the ends of

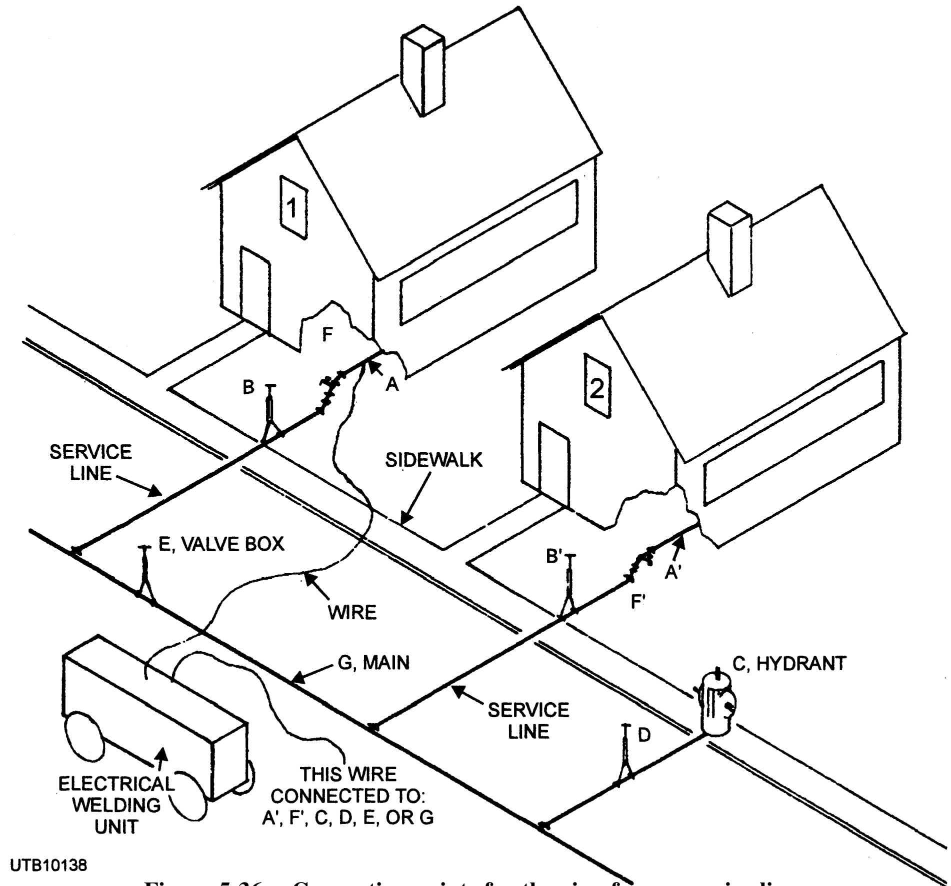


Figure 5-36.—Connection points for thawing frozen service lines.

Table 5-3.—Relation of Current and Voltage Required for Thawing

Type of pipe	Pipe Size (in.)	Pipe length (ft.)	Approximate,	Approximate (amps)
Wrought Iron	3/4	600	60	250
	1	600	60	300
	1	600	60	350
	1/2	500	55	400
	2	400	40	450
	3	400	50	500
Cast Iron	4	400	50	600
	6	300	40	600
	8			

the frozen sections. Some data on current and voltage required for electrical thawing of various sizes of wrought-iron and cast-iron pipes are presented in table 5-3.

The time for electrical thawing may vary from 5 minutes to over 2 hours, depending on pipe size and length, intensity of freezing, and other factors. The best practice is to apply current until the water flows freely.

Use the following procedures in electrical thawing:

1. DIRECT-CURRENT GENERATOR. To thaw pipes with a welding generator or similar direct-current source, set the generator to the correct amperage for the pipe to be thawed and connect the leads to the pipe.

2. ALTERNATING-CURRENT CIRCUIT. Transformers are required to adjust amperage of an

alternating-current circuit to the pipe being thawed. To reduce hazards, have a competent Construction Electrician set and connect transformers, make the connections, and assist in the thawing process. Where frequent thawing is necessary at different points, the transformers may be mounted on a trailer for ready use.

Some precautions in electrical thawing are given below.

- Avoid a higher current than listed in table 5-3. When in doubt, use low current for a longer period.
- Select contact points on the pipe as close as possible to the frozen section.
- Assure that contact points are free of rust, grease, or scale.
- Remove meters, electrical ground connections, and couplings to buildings with plumbing in the pipeline to be thawed.
- If there are gaskets or other insulation at pipe joints, thaw the pipe in sections between such joints, or use copper jumpers to close the circuit across insulated points.

Steam Thawing

Steam thawing of frozen systems is slower than electrical thawing and should be used only when insulating materials in pipes (plastic, transite, and wood), pipe joints, or couplings make the use of electricity impractical. In steam thawing, a hose connected to a boiler is inserted through a disconnected fitting and gradually advanced as the steam melts the ice.

Variation of Water Pressure

A change of water pressure can cause much discomfort to persons using the plumbing system. The mixture of hot and cold water from a shower can suddenly vary in temperature or rate of flow when water is turned on at another outlet. Failure to remedy this condition could injure somebody, especially if the temperature is scalding.

When a switch in pressure and water flow occurs often, look at the water pipes. Check the pipes to see if they are the proper size in diameter for their length and height as originally installed. Also look for liming and corrosion inside the pipes. Enough liming and corrosion can reduce the diameter of the pipe, causing low pressure and slow water flow.

Sometimes the trouble occurs after more fixtures have been installed in the system. When this happens, the piping is probably overloaded because of the extra fixtures. Pressure and water flow may also change when there is too much friction in the pipe, too many fittings, and the piping changes in direction.

If the pressure at showers changes only when other outlets are open, you can usually correct the trouble by installing automatic mixing valves. The only answer to an increase in the water flow from pipes that are too small is to replace them with larger pipes.

Q9. What is the most common repair performed on piping systems due to frozen pipes?

Q10. A 400-foot run of 4-inch cast-iron pipe requires approximately how many amperes of electricity for effective thawing if frozen??

PIPE LEAKS

LEARNING OBJECTIVE: Recognize *types of pipe and tank leaks and methods for repair.*

When a leak develops at a threaded joint of pipe, one of the most likely suspects is a fractured or ruptured pipe. Fractures often occur at the end of a length of pipe because of strain imposed by vibration of water hammer. It occurs at the end of the pipe because the wall thickness is decreased and weakened by threading. The risk of fracture becomes even greater when the threads are not cut true. In cold climates, freezing sometimes causes pipes to rupture, in which case replacement becomes necessary. A loose or cracked fitting can also cause leakage at the threaded joint of a pipe. These and other common failures resulting in pipe leakage make it important for you to determine the exact location and cause of failure before commencing any repairs to the piping.

LOCATING LEAKS

Find and repair leaks in the water piping system as quickly as possible to prevent serious damage to footings, walls, floors, plaster, and other parts of the structure, and to conserve water. Find leaks systematically by inspecting exposed piping and valves and by examining walls, floors, and ceilings around concealed piping. You should also check gauges, meters, and other water flow recording devices for evidence of abnormal flow, which might reveal loss through leakage.

In galvanized pipe installations, where the fittings on either side of the leak are not readily available, the leaking section may be cut out. In this operation, one person holds the pipe with a wrench to keep it from turning in the next fitting, and another person cuts a thread on it while it is in place using a hand type of pipe threader. The cutout section is then replaced with a coupling, a pipe section of the required length, and a union.

You may also have to repair leaks in copper piping. If a copper pipe leaks, cut out the damaged section and replace it with a new section, using either soldered or compression-type joints. When a piece of cast-iron pipe less than full length is needed for replacement, cut it from a double-hub pipe, so the remaining piece has a hub left for use in other work.

If you need a fitting for a short space or if existing work cannot be removed easily, use short spigot ends for sleeves. Closely observe figure 5-37. This figure shows how to install a fitting in a restricted space.

Replace a fitting or insert one into an existing line by following the four-step procedure shown in figure 5-38. When the job calls for adding connections to an outside vitrified clay sewer line, here is one step-by-step method.

1. Remove a section of the existing sewer pipe that is long enough to receive a new Y-fitting.

2. Break half of the hub rim of the new Y-fitting, as shown in view A, figure 5-39.

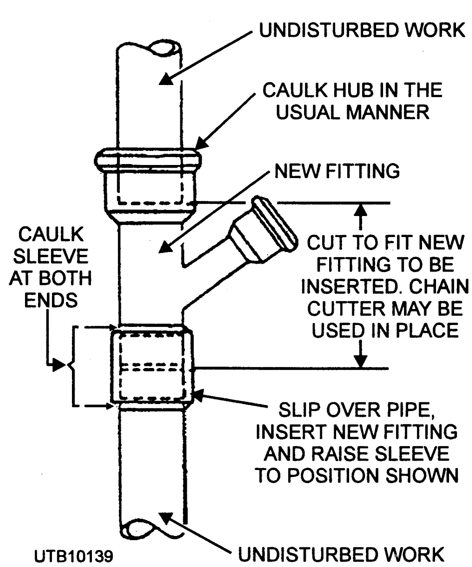


Figure 5-37.—Installing a fitting in a restricted space.

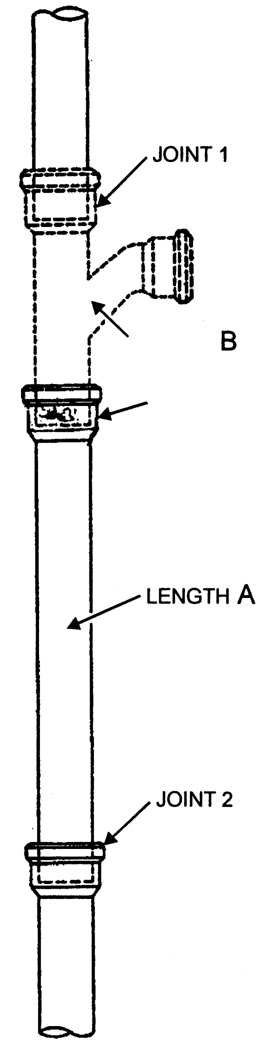


Figure 5-38.—Insert a fitting in an existing line.

3. Insert the spigot end of the Y-fitting into the hub of the existing pipe. At the same time, place the remaining half of the hub end of the Y-fitting over the cut end of the existing pipe with the Y-branch pointing away from the new inlet. (See the first position of view B, fig. 5-39.)

4. Rotate the Y-fitting, so the broken half of the hub is up and the Y-branch is in the correct position to receive the new inlet connection. (See the final position of view B, fig. 5-39.)

5. Pour the joint carefully; round over the broken half of the hub with plenty of concrete or mastic compound, as shown in view C, figure 5-39.

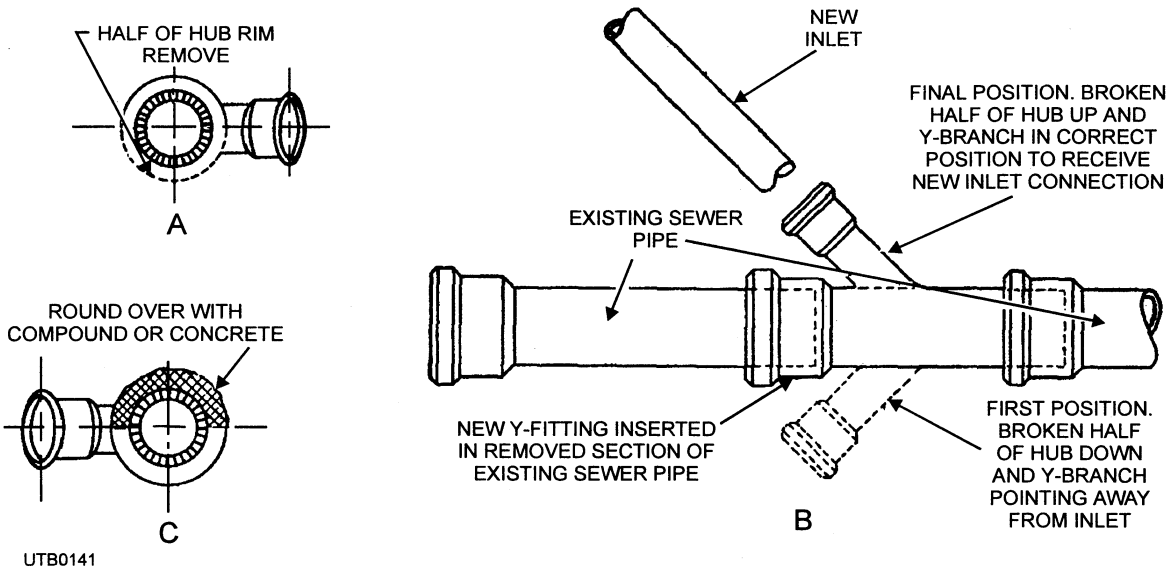


Figure 5-39.—Adding connections to an outside vitrified clay sewer pipe.

EMERGENCY TEMPORARY REPAIRS

At times, a pipe may start leaking and the materials needed to repair it permanently are not on hand. Here, you may have to use a temporary or emergency repair. Keep in mind that a permanent repair should always be made when the proper tools or materials are available.

One simple method of making a temporary repair of a leaky pipe is to use a length of rubber hose. After turning off the water supply, remove the defective section of the pipe by cutting it with a hacksaw. Then take a piece of rubber hose, slightly longer than the section of pipe you removed, and slip it over the ends where the cut was made (view A, fig. 5-40). Ensure the inside diameter of the hose matches the outside diameter of the pipe. Hose clamps hold the hose securely in place.

Another temporary method of repair for a leaky pipe is to wrap the leaky area with sheet rubber. Then place two sheet metal clamps, one on each side of the pipe, on the sheet rubber covering, as shown in view B, figure 5-40. Now, fasten the clamps with bolts and nuts. Sheet metal clamps for this type of repair can be made from scrap material from the sheet metal shop. You may want to make up a few of these clamps to keep on hand for an emergency repair job.

You can also secure the water supply, drain the water from the pipe, clean the pipe surfaces thoroughly, apply flux, and then wrap clean copper wire over the rupture and solder.

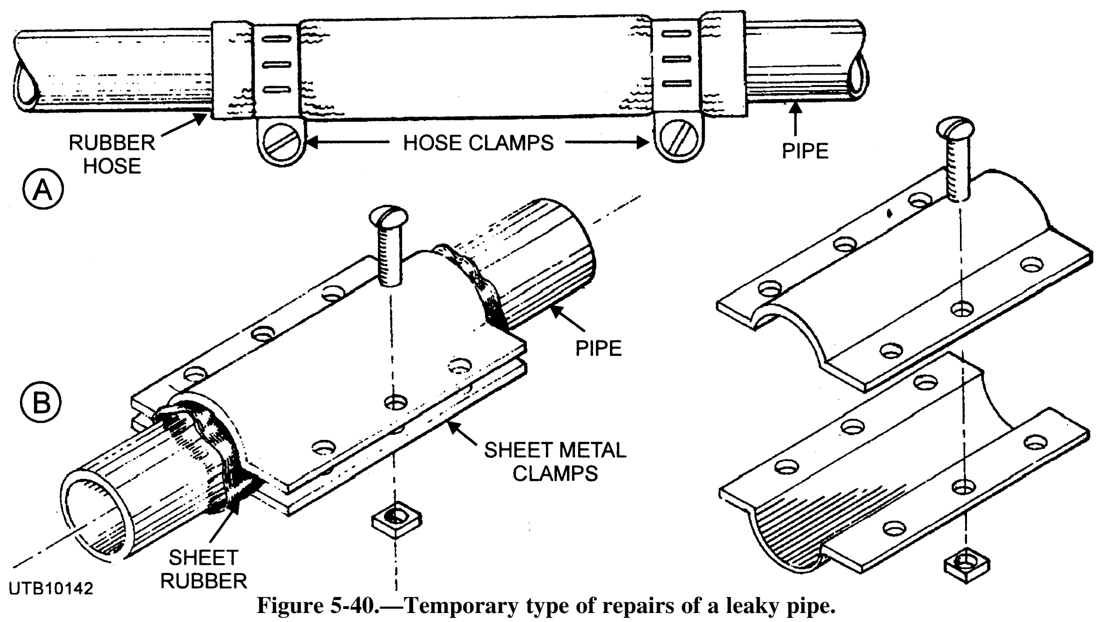


Figure 5-40.—Temporary type of repairs of a leaky pipe.

WATER TANK FAILURES

Where a plumbing system has been in use for some time, two failures in water tanks are (1) leaky seams and (2) corroded areas requiring welded patch plates. To repair a defective seam, first drain the water tank dry. Then clean the surfaces to be repaired until they are right. By welding or brazing, you can then make the leaky portions watertight.

As an effective tank patch for a large hole, you need both a temporary and a permanent patch. One temporary patch is a tapered softwood plug. Insert the plug in the hole, and tap it lightly with a hammer until the seal is watertight. Then saw off the top of the plug, so it is flush with the tank wall.

Next, the area around the plug to be covered by the permanent patch should be cleaned by wire brushing. Drain the tank; now you are ready to apply the permanent patch. One type of permanent patch includes a rubber gasket and a metal plate. Rubber sheeting, at least 6 inches by 6 inches and l/16 inch thick, may be used for the gasket, and it should be centered on the plug and cemented with adhesive. The patch plate of black steel or nonferrous (no iron) metal should be of the same material and thickness as the tank wall but a lot larger than the hole. Cover the hole with the metal plate, keeping an equal overlap around the edges, and braze or weld the plate to the tank, using a continuous seam.

Q11. What is the most common reason a threaded pipe joint will leak?

Q12. Water tank failures normally occur due to what two causes?

WATER CLOSETS

LEARNING OBJECTIVE: Understand operation, maintenance, and repair of water closet flush tanks.

Moisture on the floor at the base of a water closet bowl usually means the seal or gasket between the closet and its outlet has failed; however, it can result from condensation on the tank or piping or from leakage of the tank, flush valve, or piping. When the seal leaks, remove the water closet bowl and install a new seal to prevent damage to the building. This also prevents entry of sewer gas into the room.

In servicing plumbing fixtures, you have the job of clearing stoppages in water closets. Information on tools and chemicals used in clearing stoppages in water closets and other fixtures is given later in this chapter.

FLUSH TANK

Knowing the principles of operation of a flush tank will enable you to find the source of trouble when a flush-type water closet tank is not operating properly. For clarity, all of the parts of a flush tank have been labeled in figure 5-41. Keep in mind that in different types of flush tanks you may find some change in the method of operation.

Table 5-4 explains the principle operation of a water closet flush tank. Simple though it may seem, you must understand the operation to troubleshoot an inoperative flush tank.

FLUSH TANK REPAIRS

When water continues to run into the closet bowl after the flush tank is full, the trouble is in some part of the inlet valve assembly (ball cock assembly) or the stopper valve is not seated. The plunger has failed to close the inlet valve as it should, and thus the excess water that continues to flow in (after the tank has reached the proper level) is being discharged through the overflow pipe and into the bowl.

In checking for the source of trouble, several defects to look for are a leak in the float ball, a bent float arm, a worn washer on the bottom of the plunger,

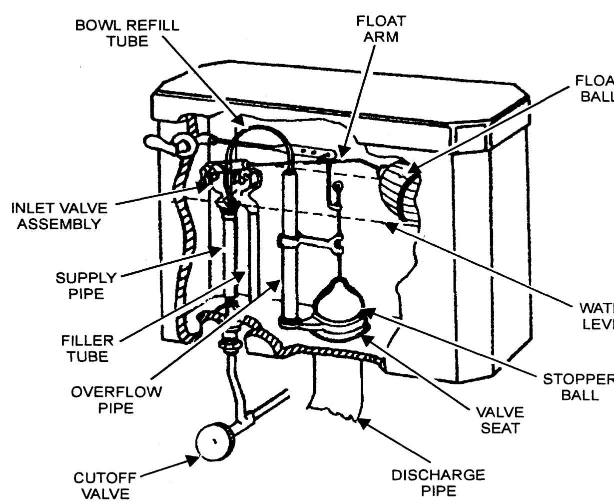


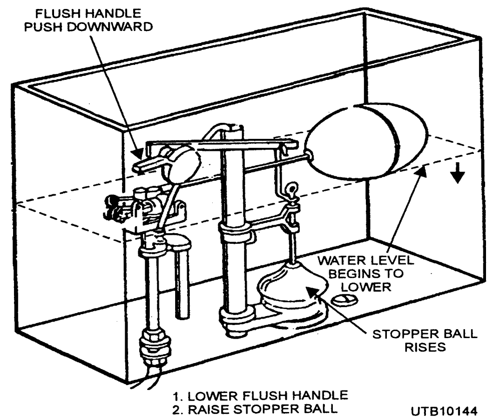
Figure 5-41.—Water closet flush tank.

Table 5-4.—Flush Tank Process

STAGE 1

When the flush handle is pushed downward, the rubber stopper ball is raised from the valve seat to allow the water from the tank to go into the discharge pipe.

When the flush handle is pushed downward, the rubber stopper ball is raised from the valve seat to ... water from the tank to go into the discharge

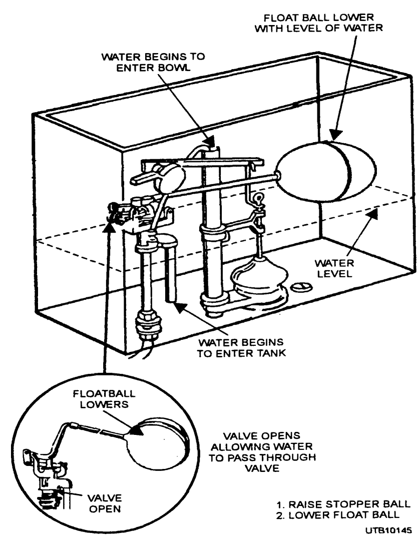


STAGE 2

STAGE 2

As the water lowers in the tank, the float ball lowers and the movement of the float arm opens the inlet valve, allowing water to start flowing into the tank slowly.

As the water lowers in the tank, the float ball lowers and the movement of the float arm opens the inlet valve, allowing water to start flowing into the tank slowly.



STAGE 3

STAGE 3

As the water flows from the tank to the discharge pipe, the stopper ball seats and incoming water holds the ball in place and the tank fills.

ball in place and the tank fills.

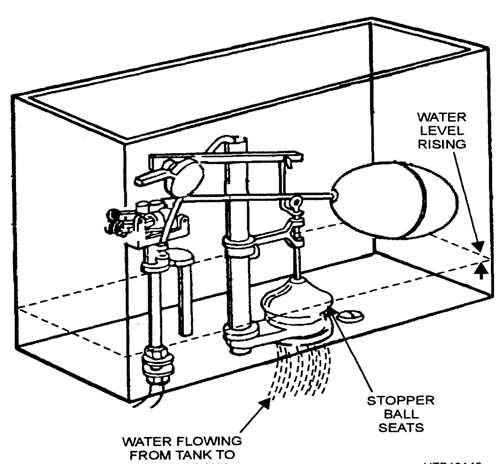


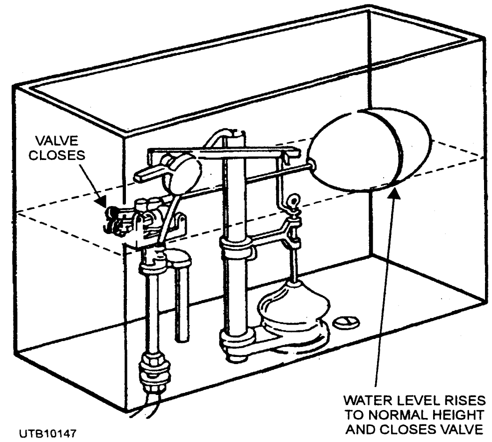
Table 5-4.—Flush Tank Process-Continued

STAGE 4

STAGE 4

As the water continues to fill the tank, the float ball rises until the float ball arm allows the valve to close.

rises until the float ball arm allows the valve to close.



or a worn valve seat. Start with the float ball, keeping in mind that a leaky, waterlogged float prevents the plunger from closing properly. A small leak in a copper float ball can be remedied by soldering. If it has a large leak, though, simply replace the float ball with a new one. A damaged float arm should also be replaced with a new one. Sometimes the float arm is bent or does not allow the valve to close. In this case, bend the float arm downward a bit to push the valve tighter into its seat. To replace the washer on the bottom of the plunger (view B, fig. 5-42), start by shutting off the water. Now, unscrew the two thumbscrews that pivot the float rod lever and the plunger lever (view A, fig. 5-42). Push the two levers to the left, drawing the plunger lever through the head of the plunger. Now, lift out the plunger, unscrew the cap on the bottom, insert the new washer, and reassemble the parts. If the cap is badly corroded, replace it with a new one. When replacing the washer, examine the seat for nicks and grit. The seat may need regrinding.

Suppose water continues to run into the closet bowl after flushing, yet the tank does not refill. Some part of the FLUSH VALVE assembly is at fault because the flush valve is not closing properly. To locate the trouble and get the tank back in order, proceed as follows:

First, stop the inflow to the tank by holding up the float ball or supporting it with a stick. Then drain the tank by raising the rubber stopper ball or the flapper. Now, examine the stopper ball to see if it is worn, out of shape, or has lost its elasticity. If either condition exists, unscrew the lower lift wire from the ball and replace the ball with a new one; or if it is a flapper valve, remove the flapper and replace it. There are no

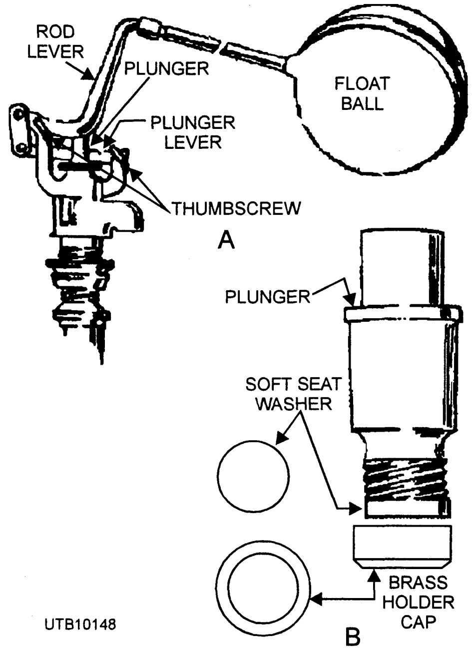


Figure 5-42.—A. Ball cock assembled; B. Plunger washer and cap.

lift wires or wire guides to adjust on the flapper valve type of flush valve. Ensure the lift wire is easily fitted over the center of the valve by means of the adjustable guide holder. By loosening the thumbscrew, you can raise, lower, or locate the holder over the overflow tube. The horizontal position of the guide is fixed exactly over the center of the valve by loosening the locknut and turning the guide screw.

The upper lift wire should loop into the lever arm hole directly above the center of the valve. The tank should empty within 10 seconds. Because of lengthening of the rubber ball and insufficient rise from its seat, the time needed to empty the tank may be longer than 10 seconds and the flush weak. In this case, shorten the loop in the upper lift wire. Also, a drop or two of lubricating oil on the lever mechanism makes it work more smoothly.

If you have a water closet tank that sweats and drops water on the deck, check the temperature of the water in the tank. If the temperature is very cold, this is the problem. The moisture that is in the air surrounding the tank is condensing on the tank. The solution to the problem is (1) place a terry cloth on the tank to catch the water, (2) place a styrofoam insert in the tank, or (3) install a water tempering valve, which places some warm water in the tank while the tank is filling.

Q13. *A water leak at the base of a water closet tank normally indicates what type of problem?*

Q14. *When water continues to run in the water closet bowl after the tank is fill, what most likely is the cause?*

FLUSHOMETERS

LEARNING OBJECTIVE: *Identify the types of flushometer valves, their operation, and methods of repair.*

Two major problems with flush valves are (1) the valve may run continuously, instead of shutting off at the right time, or (2) the valve may fail to deliver the desired amount of water (short flushing). Since flush valves are installed to avoid waste, they must be properly maintained. Once you understand the operation of a valve, you can keep a flushometer in good repair.

OPERATION OF DIAPHRAGM FLUSHOMETER

Table 5-5 shows the operation of a diaphragm-type flushometer. Read through the table and study the diagrams until you thoroughly understand the operation of the valve.

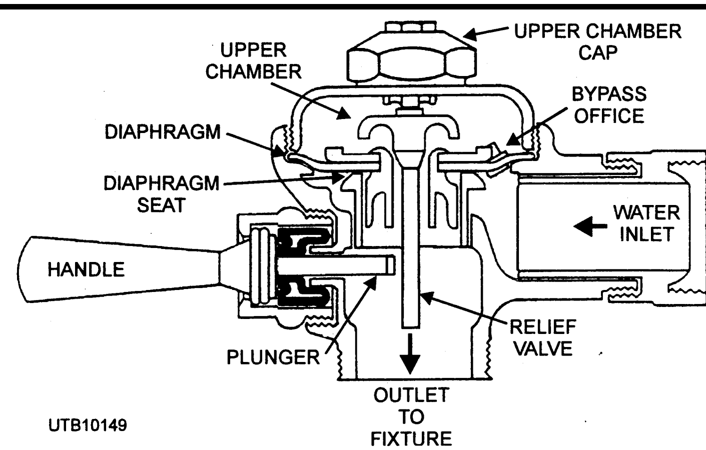
OPERATION OF A PISTON-TYPE FLUSHOMETER

The piston-type flushometer valve shown in figure 5-43 is opened by a lever which discharges the water from the dashpot chamber. The reduced water pressure in the dashpot chamber then forces the piston assembly upward, which allows the water to enter the fixture. The closing of the valve is automatically controlled with a bypass through which the water enters the

Table 5-5.—Operation of Diaphragm Flashometer

STAGE 1

The diaphragm valve is in the ready position with all of the parts labeled. In this position the upper and lower chambers contain the same amount of pressure. Therefore, the diaphragm remains seated on the seat.



STAGE 2

When the handle is moved in any direction, the plunger opens the relief valve, which allows the water from the upper chamber to flow into the lower chamber and causes the diaphragm to rise off of its seat. Water now continues to flow down the barrel and into the fixture.

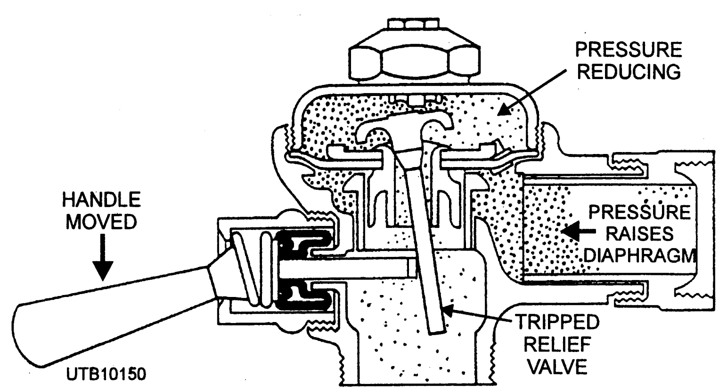
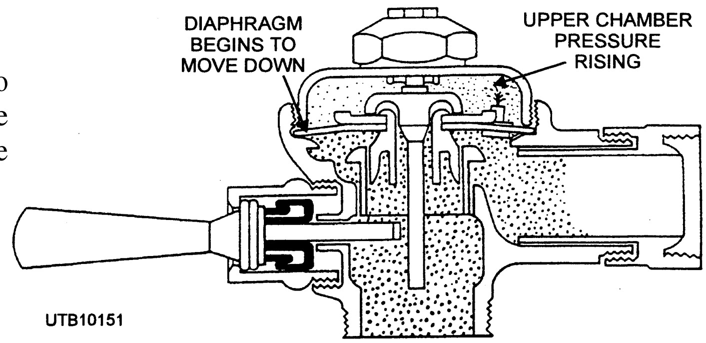


Table 5-5.—Operation of Diaphragm Flushometer—Continued

STAGE 3

As the valve lifts the diaphragm, water begins to flow slowly through the bypass orifice until the pressure rises enough to equalize the pressure in the upper and lower chambers, seating the valve.



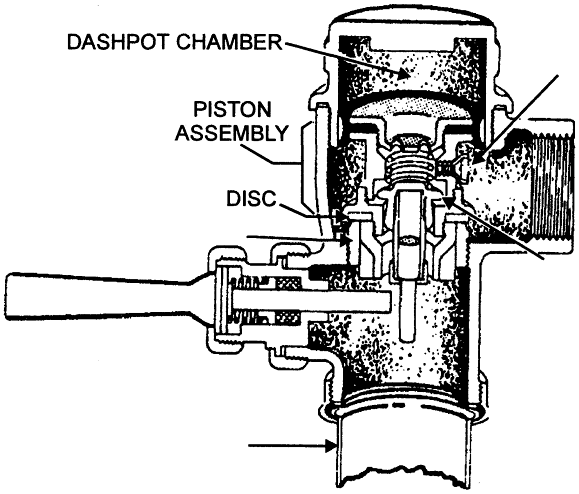


Figure 5-43.—Piston-type flushometer valve.

dashpot chamber. This forces the piston assembly down onto its seat and stops the water flow. The closing of the valve is regulated by a screw that controls the amount of time the valve stays open.

REPAIRS

Flush valves give years of adequate and trouble-free operation when they are properly installed and maintained. Continuous flow of water through a piston type of flush valve is almost always caused by failure of the relief valve to seat properly or by corrosion of the bypass valve. In both cases, there is not enough force on the piston to force it to seat. If the relief valve fails to seat as it should, the leakage may be enough to prevent the upper chamber of the valve from filling, and the piston remains in the OPEN position.

Inspect the relief valve seat for dirt or other foreign substances that may be causing the relief valve to tilt; disassemble the piston, wash the parts thoroughly, and reassemble. Replace washers that are worn, making sure that the surface upon which the washer sets is perfectly clean; scrape off old rubber if any sticks to the metal surface.

Corrosion of the bypass valve in the center of the top plate also causes continuous flow; the water cannot pass into the upper chamber of the valve, and no force is exerted on the piston to move it downward to its seat. Very dirty water passing through the system can clog the bypass and deprive the upper chamber of water. When pipelines in a new installation are not thoroughly flushed before they are placed in operation, the pipe dope or dirt in them can stop up the bypass valve.

Likewise, in a diaphragm valve, if chips or dirt carried by the water lodge between the relief valve and the valve seat, the relief valve cannot seat securely. The water leakage prevents the upper chamber of the valve from filling with water. The valve then remains in the OPEN position, since there is no pressure to force the diaphragm to its seat.

Short flushing can occur in a diaphragm type of valve. If the valve seat, diaphragm, and guide cover have not been tightly assembled, you should reassemble the valve to ensure proper operation. Sometimes you may find the bypass tube has been tampered with, enlarging it so the water passes rapidly into the upper chamber and closes the valve before the desired volume is delivered. Also, someone may have oiled or greased the valve parts to make the valve operate more easily. What actually happens is the oil or grease swells and ruins the rubber parts, interfering with the action of the valve.

Another commonly used unit is the pressure-valve-head flushometer (fig. 5-44). The most common problem with this type of flushometer is the rubber cap. To replace the rubber cap is a simple task; remove the retaining screws, lift out the plate, and remove and replace the cap.

Q15. What are the two types of flushometers used by Utilitiesman?

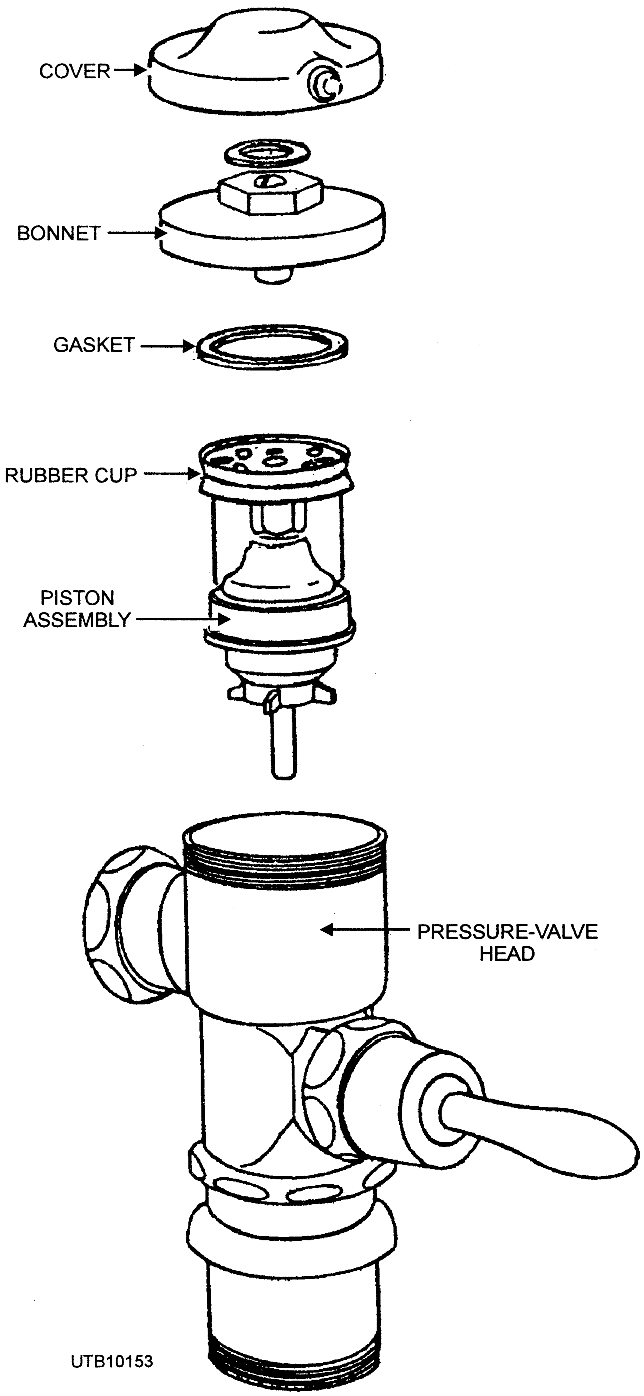


Figure 5-44.—Pressure-valve head flushometer.

Q16. What is the cause when water continuously flows through a piston-type flush valve?

Q17. What happens to a diaphragm flush valve if oil or grease is used on interior parts?

FAUCETS

LEARNING OBJECTIVE: *Recognize repair procedures and maintenance of faucets.*

There are many different types of faucets used in plumbing installations. If you can repair the compression washer faucet, you should have no trouble in repairing other types of faucets. A cutaway view of a compression faucet is shown in figure 5-45. This faucet, with a disc washer and a solid or removable seat, requires frequent attention to maintain tight closure against water pressure.

When a faucet is turned off, the washer on the end of the stem rubs against the seat. Frequent use wears down the washer and eventually causes the faucet to drip. A small, steady leak in a faucet wastes water. The remedy for a dripping faucet is simply to replace the washer. Be sure to replace flat or beveled washers with washers of the same design.

STANDARD FAUCETS

To repair a standard washer faucet, follow the steps below.

1. First, shut off the water supply to the faucet and open the faucet all the way.

2. Now, remove the faucet handle, bonnet, and stem.

3. Next, remove the brass screw holding the washer to the bottom of the spindle. Replace the washer with a new one which is flat on one side and slightly rounded on the other, so it can get both horizontal and vertical pressure and provide a firm seat. Use a good quality hard-compositionwasher because leather or soft

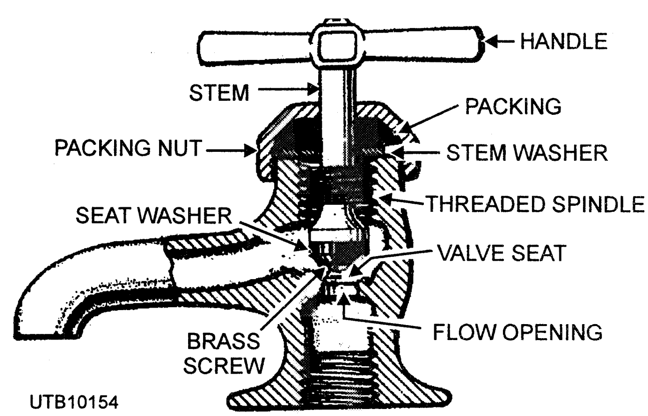


Figure 5-45.—Compression faucet.

washers do not give long service, particularly in hot-water lines.

4. If the brass screw is in poor condition, replace it with a new one (view A, fig. 5-46).

5. Examine the valve seat and repair or replace it with a new one (view B, fig. 5-46), if necessary, before replacing the spindle; otherwise, a new washer provides adequate service for only a short time.

6. Reface or ream solid seats (view C, fig. 5-46) with a standard reseating tool consisting of a cutter, a stem, and a handle. Rotate the tool with the cutter centered and held firmly on the worn or scored seat. Take care to prevent excessive reaming. Remove all grinding residue before reassembly. A solid seat can be replaced with a renewable seat by tapping a standard thread into the old solid seat and inserting a renewable seat.

7. Remove renewable seats with a regular seat-removing tool or Allen wrench. When the seat is frozen to the body, apply penetrating oil to loosen it. Faucet seats can usually be tapped, reseated, or replaced without removing the faucet from its fixture.

8. To stop leakage at the bonnet, replace the stem packing and the bib gasket.

Occasionally, you may find ball-bearing washer holders installed in faucets at some activities. The ball bearings between the stem and washer holder permit movement of the "washer" free of the movement of the stem. This allows the washer to stop its rotation on the slightest contact with the seat, thereby reducing the frictional wear of the washer.

SHOWER HEADS

Shower heads that supply an uneven or distorted stream can usually be repaired by removing the perforated faceplate and cleaning the mineral deposits from the back of the plate with fine sandpaper or steel wool. You can open clogged holes with a coarse needle or compressed air.

Q18. Which part of a faucet requires the most frequent maintenance and repair?

Q19. When a stem washer wears out, you replace it with what type of washer?

SEWER MAINTENANCE AND REPAIR

LEARNING OBJECTIVE: *Recognize methods for maintenance and repair of sewer systems.*

When you are working with sewers, most of your troubles are with stoppages and breaks. A common cause of a stoppage in a sewer system is tree roots.

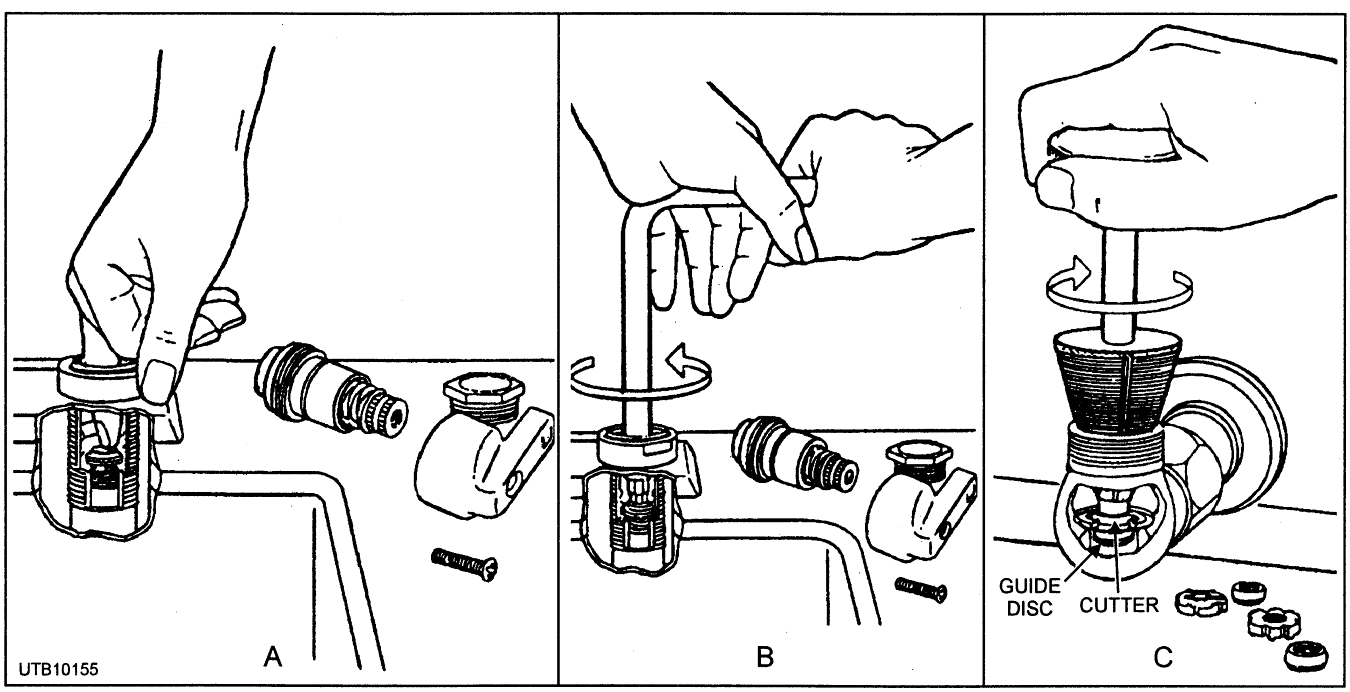


Figure 5-46.—Inspecting, removing, and refacing faucet seats.

Other causes include sand, gravel, and greasy or tar-related materials. A lot of sand, gravel, or just plain mud reveals a broken or loose sewer joint or pipe.

Explosions in sewers are not uncommon and should be guarded against. Check with your local safety office for the most current regulations and information. Systematic inspection and maintenance permit early correction of faults before major defects and failures develop. Trouble calls concerning stoppages or slow drainage are received occasionally.

The first step in correcting the trouble is to determine the cause. A sewer line can be inspected from manhole to manhole by using a flashlight or a reflecting mirror or both. One person acting as an observer can look up the sewer line toward the flashlight held by the second person in a preceding manhole. Thus the condition of the line can be noted to determine whether roots or other obstructions need cleaning out.

Before entering a manhole, ensure the air is safe. You are NOT permitted to enter a manhole until you have an entry permit, identifying all of the conditions that must be satisfied before the entry begins. Additionally, an attendant person shall be stationed outside the manhole at all times. The attendants sole responsibility will be for observation of the entrants into the manhole. The attendant shall have no other responsibilities or duties during the observation. For more information on entering confined spaces, refer to EM 385-1-1, *Safety and Health Requirements Manual.*

Purging or a fresh air pump may be required. Sewage gases are very toxic as well as explosive. Routine sewer maintenance includes flushing, cleaning, and immediate repair of defective sewers. Information pertaining to flushing, cleaning, and repairing sewers is given below.

FLUSHING

Flushing helps remove loose organic solids and sand or grit deposits from sewers. Flushing is not an efficient method of sewer cleaning unless a high velocity can be maintained between manholes on a short run; in other words, you depend on the high velocity for complete scouring action of the sewer. Flushing may be done by a number of methods, two of which are with a fire hose and with a pneumatic ball. When flushing with a fire hose, you need enough fire hose to reach between manholes. When using this method, string a rope or light cable through the sewer with sewer rods if a plain fire nozzle is used. Start at the upper end of the system and draw the flowing nozzle through the sewer. If a self-propelling turbine type of nozzle is used, the rope is not required. Try to use 2 1/2-inch fire hose discarded by the Fire Department. Paint the sewer-flushing hose at the ends with an identifying color (yellow, non-potable water) to prevent use for emergency potable water connections.

In pneumatic-ball flushing, inflate a light rubber ball, such as a beach ball or volleyball bladder, to fit snugly in the sewer, and place it in a small canvas or burlap bag with a light rope attached. Place the ball in the sewer, hold the line until the sewage backs up in the manhole, and allow the ball to move to the next manhole. When an obstruction is reached, the pressure pushes the ball against the crown of the sewer, causing a jet at the bottom (fig. 5-47). As much as 4 miles of sewer can be cleaned in 8 hours by this method, and it works for sewers up to 30 inches in diameter. A wooden ball with a diameter of 1 inch less than the sewer can also be used. Where sewage flow is low, the addition of water to the upper manhole may be required. In the sand cup method, a sand cup with an auger is attached to flexible steel sewer rods to run through the sewer (fig. 5-48). The rubber cup is perforated to provide flushing action.

WATER PRESSURE BAG (BLOW BAG)

Water pressure bags are made of various types of rubber and canvas material. The blow bag is very efficient and requires less time to operate than other types of drain cleaning equipment. Various sizes of the blow bags are available. To operate a blow bag, connect a water source to one end and insert the blow bag into the line to be cleared or flushed. Ensure that you are using a blow bag that is compressed when placed into the line. When the water pressure is turned on, the blow bag will expand in size, increasing the pressure and holding the blow bag in the line. Keep in

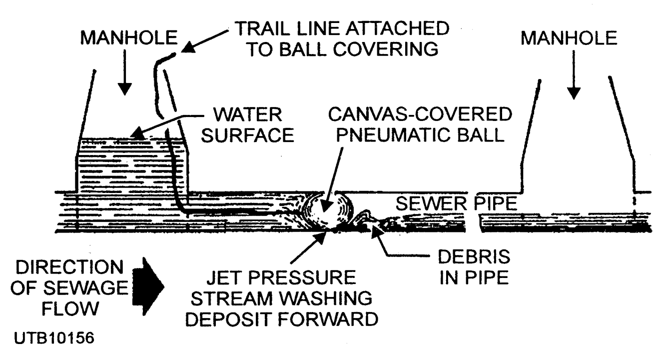


Figure 5-47.—Ball method of sewer flushing.

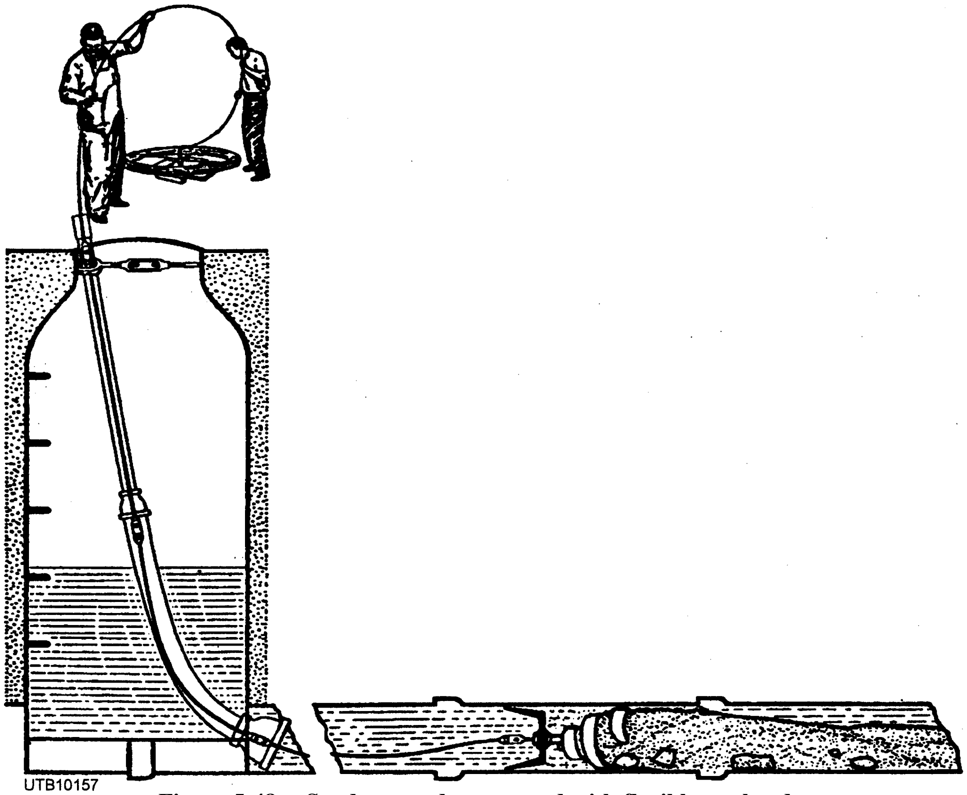


Figure 5-48.—Sand cup and auger used with flexible steel rods.

mind that once the water is turned on, any lines connected will receive high-pressure water. We do not want to turn water closets and lavatories into cool water geysers or bidets.

CLEANING

In routine sewer cleaning, the usual way is by putting a tool through the line to indicate a clean sewer, by removing partial obstructions, or by determining the necessity for a detailed job, such as grease removal, root cutting, or sand removal.

Sectional wooden sewer rods, to which a variety of end tools may be attached, have been used in sewer cleaning for many years. End tools for piercing an obstruction first, and cutters and scrapers for root and grease removal are available. Rods are pushed into the sewer from the bottom of a manhole. A device, as shown in figure 5-49, is useful for pushing the rods. Wooden rods are useful for stringing a cable through a partially obstructed sewer.

Another method of sewer cleaning is to use lightweight, spring-steel sectional rods coupled into a continuous line with several types of augers and sand cups as end tools (fig. 5-50). The tool and rod are fed into the sewer until the obstruction is reached; then the obstruction is removed by the following methods-by twisting the rod by hand, by using a small gasoline engine, or by an electric motor drive unit.

NOTE

When using power-driven equipment, ensure that it is maintained under the manufacturer's recommendations.

Flushing methods described in the previous section remove all but heavy sand deposits. Accumulated sand and grit dislocated by flushing should be removed from the sewer at a manhole. A sand trap, made from a stovepipe ell and sheet metal to

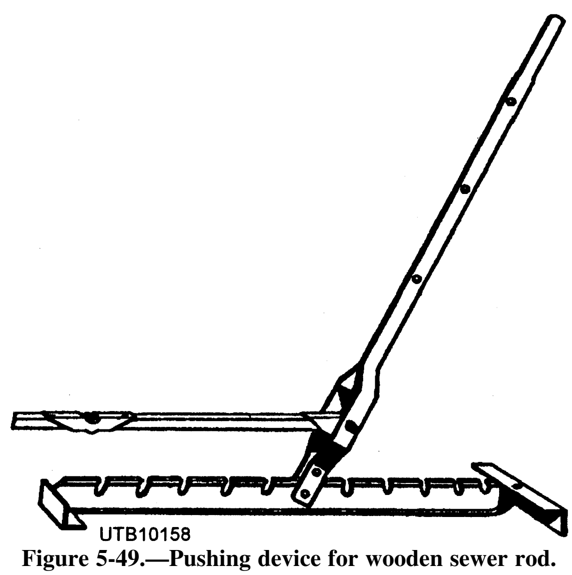


Figure 5-49.—Pushing device for wooden sewer rod.

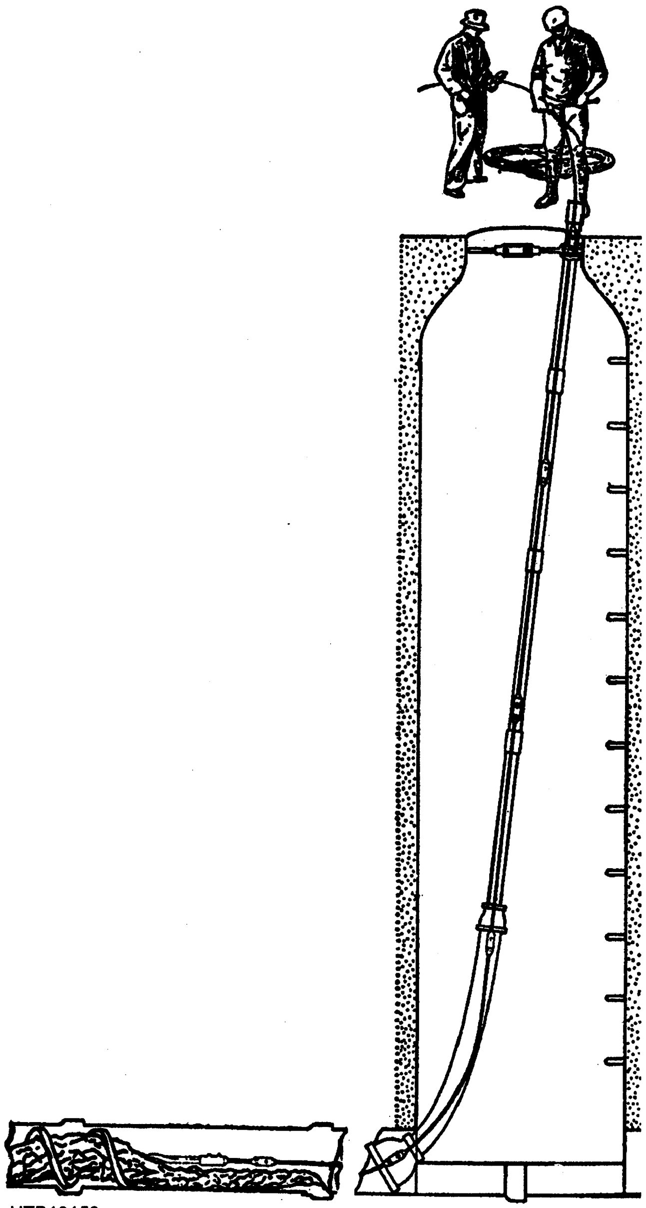


Figure 5-50.—Root removal by steel rod and auger, manual operation.

fit the sewer pipe, may be used, as shown in figure 5-51, to collect the sand. Commercial traps are available with adjustable slots to lower the water level below the top of the trap. Sand is removed by scoops or buckets.

For heavy sand deposits, a cable-drawn bucket is used, especially for storm sewers and larger sanitary sewers. The cable may be pulled by a hand winch, by a power winch, or by a truck with the cable through an anchored sheave. The sewer can be damaged if the bucket catches on misaligned joints, improper house connections, or other fixed obstructions, especially with power-driven buckets.

Turbine-driven tools (fig. 5-52) clean sewers with difficult obstructions and grease coatings. These tools are powered by water under pressure from a fire hose. The tool and hose are pulled through the sewer by a cable.

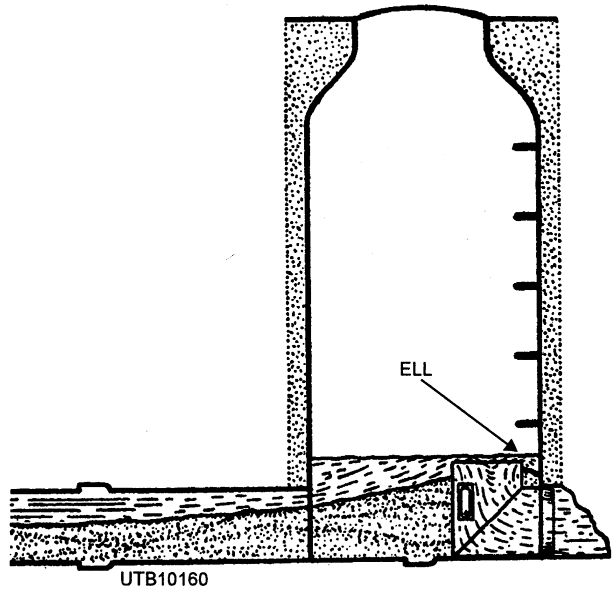


Figure 5-51.—Sand trap.

Various types of power-driven sewer-cleaning machines are available. These machines normally have a 3/4-horsepower electrically reversible motor and weigh about 90 pounds. They are especially designed for clearing sewer pipelines, ranging from 1 1/2 inches to 10 inches in diameter and up to 200 feet in length. Some have a cable counter indicator, so the operator knows the distance the tool is in the line. Others have a headlight to aid you in working the dark areas.

A major difficulty with sewer systems buried in the ground is tree ROOTS. These are hard to detect just by looking in the manholes. With trees growing rather close to a sewer line, you can expect roots to cause a break in the line. Such trees as poplars, willows, and elms are the most troublesome when it comes to root growth. When these trees are growing within 100 feet of a line, you can look for trouble from roots sooner or later. Take a close look at figure 5-53 which shows tree roots penetrating a line.

One method for removing roots in a sewer is to apply copper sulfate (blue vitriol). Another method is to use cable drawn scrappers; these may be homemade or equipment as shown in figure 5-50. Try copper sulfate first since this is the most economical.

When a sewer is completely stopped up, it is useless to apply copper sulfate. A partially blocked line that is flowing from 5 to 10 gallons per minute only

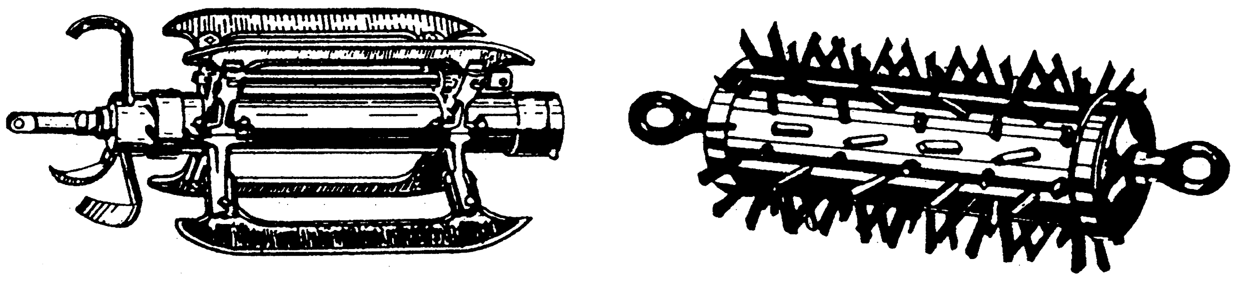


Figure 5-52.—Turbine-driven tools.

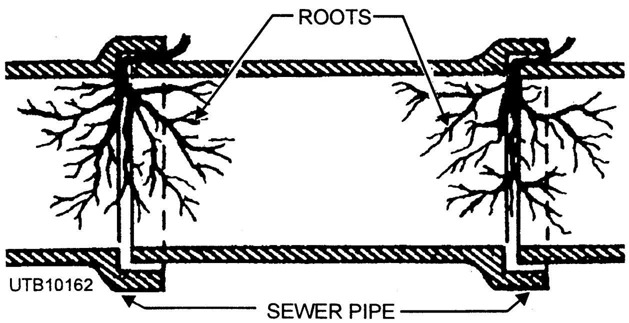


Figure 5-53.-Roots growing into sewer pipe.

requires a handful of copper sulfate crystals. If the flow is greater than 10 gallons per minute, apply more copper sulfate or treat the line with repeated applications. If the chemical fails to remove the roots, use power-driven equipment.

REPAIRING

Sewer breaks and obstructions must be repaired at once. Sewers under roadways, crushed by settling, must be encased in concrete or sleeved with steel piping. In difficult situations get technical assistance from higher authority.

Bypassing the sewage flow is usually required during repairs. The usual method is by blocking the upper manhole outlet with sand bags or an expandable rubber test plug, using portable pumps to discharge the sewage to a lower manhole through a fire hose or a temporary pipeline.

Excavations over 5 feet must be shored and ladders provided under safety requirements for excavation, building, and construction. Adequate guards and warning signs must be placed around the excavations in roadways. Details on the requirements mentioned are found in EM 385-1-1, *Safety and Health Requirements Manual.*

Q20. What is the first step to correct a problem in a sewer line?

Q21. You should use what size fire hose to do most sewer flushing jobs?

Q22. Accumulated sand and grit deposits should be removed at what point in the sewer system?

CLEARING STOPPAGES IN FIXTURES

LEARNING OBJECTIVE: *Recognize different types of equipment and methods for clearing fixture stoppages.*

Stoppages in fixtures are usually caused by materials lodged in the drain, trap, or waste line. Obstructions often can be removed by manually operated devices, chemicals, or both.

The method depends upon the seriousness and nature of the stoppage. The obstruction should be entirely removed and not merely moved from one place to another in the line. After the stoppage has been relieved, pour boiling water into the fixture to ensure complete clearance. Some of the methods used in clearing stoppages in fixtures are explained below.

When using a snake or sewer tape, keep track of the length of tape in the pipe, so you can determine the break or stoppage location. Also, with plastic pipe, exercise care not to use sharp ends to-avoid cutting through the wall of a pipe or fitting.

The FORCE CUP, or the PLUMBER'S FRIEND, is commonly used for clearing stoppages in service sinks, lavatories, bathtubs, and water closets. One type of force cup has a round, rubber suction cup, about 5 inches in diameter, fastened to a wooden handle, as shown in view A, figure 5-54. When using the force cup, partly fill the fixture with water. Now, place the force cup over the drain opening and work the handle up and down to provide alternate compression and suction. Take care not to raise the cup off of the drain opening. The downward pressure or upward suction often clears the stoppage.

Another type of force cup, shaped to fit the opening of a water closet drain, works more efficiently than the round type in clearing stoppages in water closets.

The CLOSET AUGER and PLUMBER'S SNAKE are used for opening clogged water closet traps, drains, and long sections of waste lines (views B, and C, fig. 5-54). The closet auger is a cane-shaped tube with a coiled spring or "snake" inside and has a handle for rotating the coiled hook on the end of the snake. To insert the closet auger into the trap of the water closet, retract the coiled spring all the way up into the cane line curve of the closet auger. Hook the cane end, with its projecting hook, into the trap. Then start turning the handle to rotate the coiled spring as it is pushed down into the trap of the water closet. Rotate the handle continuously until the snake reaches the obstruction in the drain. Turn the handle slowly until the obstruction is caught on the coiled hook of the closet auger. Continue rotating the handle and pull back at the same time to bring the obstruction up into the water closet where you can remove it.

NEVER assume that the water closet is clear after one object is brought up and removed. Insert the snake of the closet auger again and repeat the procedure until the closet auger passes down into the closet bend and branch. Withdraw the closet auger. Put four or five pieces of toilet paper in the water closet and flush them through the fixture to make sure that it is completely open.

TRAP AND DRAIN AUGERS, such as the one shown in view D of figure 5-54, are used in clearing obstructions in traps and waste pipes. Trap and drain augers, also known as SINK SNAKES, are made of coiled, tempered wire in various lengths and diameters. They are very flexible and easily follow bends in traps and waste lines when pushed into them. In clearing stoppages from lavatories, service sinks, and bathtubs, first use a plumber's force cup. If the obstruction is in the trap and is not cleared by the action of the plunger, clear the trap by inserting a wire or snake through the cleanout plug at the bottom of the trap. If the trap is not fitted with such a plug, remove the trap. Protect the finish of the packing nut with

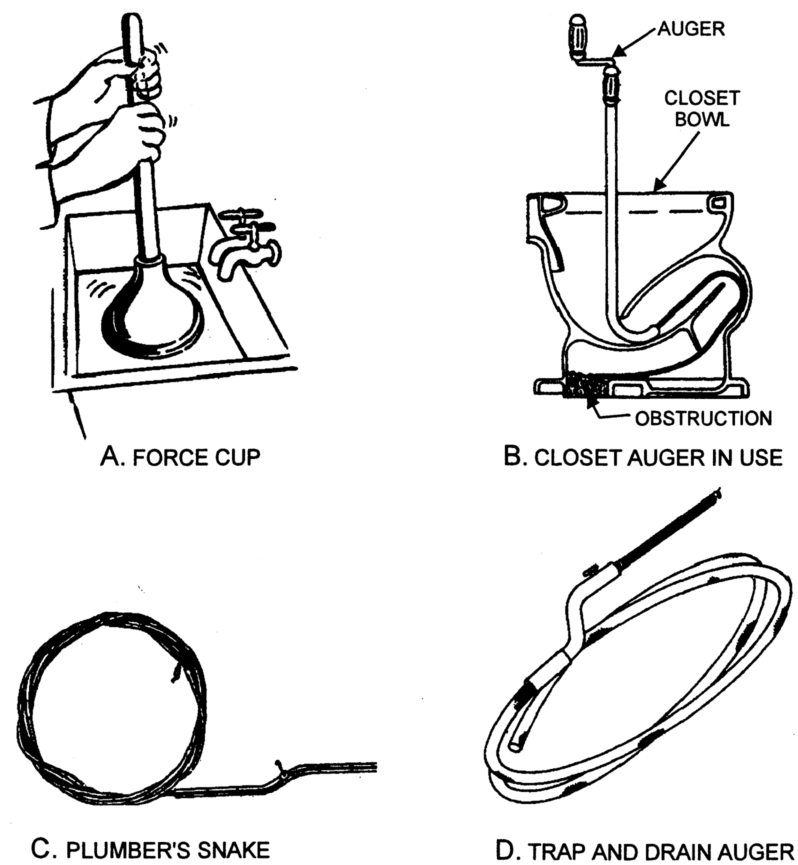


Figure 5-54.—Tools for clearing stoppages in plumbing fixtures.

adhesive tape or wrap a cloth around the jaws of the wrench.

Do not use a heavy steel-spring coil snake to clear traps under lavatories, sinks, or bathtubs. Use a flexible wire or spring snake that easily follows the bends in the trap. For example, a spring snake is used for clearing stoppages in floor drains. Remove the strainer or grate and work through the drain, or insert the snake through the cleanout plug opening nearest the obstruction. Stoppage clearance tools should be used with caution.

One reason why safety is so important is that a caustic chemical may have been poured into the stopped-up fixture in an effort to clear it. Caustic agents can cause serious injury if splashed into your face by a force cup. These caustic agents can also burn your hands while using a sink snake. When manually operated devices fail to clear stoppages, there are several types of chemicals that can be used to dissolve or burn them out. These chemicals are discussed briefly below.

CAUSTIC POTASH (POTASSIUM HYDROXIDE)

Stoppages can be burned out by pouring a strong solution of this chemical and hot water into the line through the fixture opening. Pour the mixture slowly into the pipe through a funnel. Since this solution can cause serious bums, personnel must wear goggles and rubber gloves. Potassium hydroxide (caustic potash) damages glazed earthenware, porcelain, and porcelain-enameled surfaces.

CAUSTIC SODA (SODIUM HYDROXIDE)

Kitchen and scullery sink stoppages are often tough problems because of grease, oil, or fat washed down along with coffee grounds and small bits of garbage into the drain. Grease congeals and acts as a binder for solid particles and can usually be cleared by successive applications of a chemical cleaner. Effective cleaners include caustic soda (sodium hydroxide) with bauxite (an aluminum compound or ore) and other ingredients to intensify their action or sodium hydroxide mixed with sodium nitrate and aluminum turnings. Adding water creates ammonia gas, which helps change grease to soap. This gas causes boiling and heating and helps dissolve the grease. When clearing a partially blocked drain, drop a small quantity of cleaner (from 2 to 8 ounces) into the open drain and follow with scalding hot water. Such cleaning agents cannot be satisfactorily used when the drain is completely plugged, since some flow is required to loosen the chemicals. A completely blocked drain must first be partially cleared with a plumber's snake before you can use the chemical cleaner effectively.

Q23. The seriousness and the nature of a stoppage determines the -type of equipment to be used. True or false?

Q24. You can use potassium hydroxide to remove a clog in PVC pipe. True or false?

SAFETY

LEARNING OBJECTIVE: *Identify procedures for safe work methods during handling, installation, and repairs of plumbing systems.*

As a Utilitiesman, treat safety as part of your job. Some of the main safety precautions in plumbing are given below. This training manual does not cover all you need to know about safety. Learn all you can about safety through further study and on-the-job experience.

PIPE WORK

When acids are used in working on piping, see that they are kept in only glass or lead containers. Keep out from under hot joints while they are being poured. Ensure that hot lead is not poured over water or wet caulking.

When floors are oily and cannot be kept dry, they should be covered with sand or an oil-absorbent compound. Any type of tee, valve, or other service connection used on piping maintenance or repair should be carefully checked to make sure it is designed to withstand maximum pressure.

SEWER WORK

Before beginning plumbing work on sewer jobs, pits, or tanks that require personnel to enter a confined space, the space must be inspected by a person qualified for Confined Space Entry. Environmental or Fire Department personnel normally conduct these inspections. They will check for toxic gases, explosive atmospheres, and oxygen deficient atmospheres. After the space has been inspected and evaluated, you should take the following two steps:

1. Ensure that that personnel doing the work are confined space qualified. Ensure that proper respiratory equipment, safety belts, lifelines, and blowers are on hand.

2. Ensure monitoring equipment is in place and personnel are properly protected prior to entry of personnel into these spaces.

Where such hazards exist, the area must be controlled, and workers must wear proper respiratory equipment before entering the structure. Workers must be qualified to enter the space and receive instruction on the type of respiratory equipment for use in an emergency, and how to assemble and use this equipment properly.

At least two people should be assigned to each sewer job where there may be a hazard of broken or leaking pipes. One person should always be in a relatively safe position and be prepared to help in an emergency. To help dissipate toxic or flammable gas in a sewer or underground sewage pumping plant, remove the manhole cover several minutes before a worker descends. (See EM 385-1-1, *Safety and Health Requirements Manual,* and the *Occupational Safety and Health Administration (OSHA) Regulations,* 29 CFR 1910, for more information.)

CLOTHING AND EQUIPMENT

Wear goggles, gloves, and other protective clothing in all pipe-fitting, pipe-handling, and plumbing work, particularly when you are handling hot metal or acid or flying material could injure your eyes. When using compressed air to clean out sand, dirt, or scale from pipes before installation, you should wear goggles.

Wear flameproof garments when using blow torches, welding torches, or similar tools. Plumbers should wear heavy coveralls and leggings that cover the in step to protect against hot lead; if unavailable, the regular working uniform may be acceptable.

When entering deep tanks, deep sewers, and other deep underground structures, you should wear a safety belt and a lifeline.

Use portable blowers for tank, pit, or manhole work where you suspect noxious gases, vapors, or a lack of oxygen. These blowers should have vapor-proof, totally enclosed motors or non-sparking gas engines. Place the blowers at least 6 feet away from the opening and on the leeward side protected from wind, so they do not ignite flammable gas.

TOOLS

The following precautions apply to tools in general. Since pipe wrenches are one of the plumber's most important tools, precautions for these tools are in the following section.

Keep tools and appliances in good condition. Replace worn tools. Check hammer handles frequently; do not use hammers with broken or cracked handles. Also, do not let tools or materials clutter up the floor and become stumbling hazards. Pick up pieces of scrap pipe promptly and dump them in the scrap bin or scrap tubs for the next pickup.

Vise jaws should be used to grip material securely. When threads are being cut and during backing off operations, hold the stock firmly. Protect freshly cut threads with caps or couplings whenever possible. Guard against sharp burrs or fins. When operating a pipe-threading machine, determine the clearance of the pipe before starting the machine.

You should NEVER drop a cold ladle or other cold material into a pot of molten lead. It will explode.

PIPE WRENCHES

Never use an extension on a pipe wrench. The wrench was not made to handle this strain. Be sure there is plenty of clearance if the wrench should slip. Ensure that an adjustable pipe wrench faces forward in the direction the handle is to turn. When you use it in that way, an adjustable wrench can withstand the greatest force, because the pulling force is applied to the stationary jaw side of the handle. Also, an adjustable wrench should always bite near the middle of the jaws, because there are teeth in front if the wrench slips. Do not overwork small wrenches, avoid side strain, and never use them as hammers.

PIPE HANDLING

Workers should wear leather or leather-faced gloves when handling pipe. They should also stand to one side when pipe is being unloaded from a truck. Pipe should be piled so the ends are even and do not project into walkways. Pipe should be stacked straight; that is, not crossed.

Pipe should not be piled directly on the bare ground; racks or dunnage should be provided.

Pipe should always be blocked to prevent it from rolling. Where practical, store pipe on specially designed racks.

When lifting heavy pieces of pipe, bend your knees, keep your back line as vertical as possible, and hold the load close to your body; straighten your knees and pull the load up directly over your feet. Lift with your legs, not with your back. Pipe should be carried with the forward end up to clear the heads of other people nearby. When pipe is transported on a vehicle, a red warning flag should be placed on the projecting ends.

When the crew is carrying a long and heavy pipe, each member should try to work as a team while observing the following precautions:

1. Each member of the crew should understand the signals for lifting and lowering.

2. Members should ensure that their feet are in the clear.

3. When needing to use either tongs or a carrying bar with a U-shape bend to fit the pipe. When the crew is carrying a length of pipe at shoulder or waist level, each member should carry it on the same side.

4. Take a firm grip on the lifting bar or tongs.

5. Lift the pipe when the supervisor or co-worker gives the signal. All members of the crew should lift and move together.

6. Carry the pipe without sudden starts or stops; move slowly and place your feet firmly.

7. Stop at the appointed place and wait for the supervisor's or co-worker's signal to lower the pipe.

8. Lower the pipe carefully, bending at the knees as in lifting, and lower slowly along with the other members of your crew.

Use caution in handling THREADED pipe. The threads are always sharp and cut flesh easily. Do NOT put your hands inside a pipe.

When removing pipe, work from the top end of the pile as much as possible. Pipe larger than 2 inches in diameter should be handled by means of a hardwood pipe stick. Use block and tackle, chain falls, or other lifting devices where appropriate, when handling heavy pipes and fittings.

EXCAVATIONS

Maintenance operations on distribution systems may often involve excavation. Some precautions in making excavations are as follows:

- Wear a protective hat when working in a trench.
- Keep a safe distance from other workers to avoid striking them with tools.
- Do not jump into a trench: but sit on the shoulder and slide in if the trench is shallow. Use ladders where required; for example, a trench that is 5 feet or more in depth. Before climbing out of a trench, look in all directions for traffic danger.
- Remove earth and other material to avoid overhanging banks. Do not go under an overhanging bank and, when working near one, exercise caution. To remove an overhanging bank, work from one side to the center, always facing the point of danger. Where necessary, shore trench walls.
- When undercutting, provide adequate bracing and restrict the public from braced areas.
- Where practical, place excavated material at least 2 feet away from the edge of the excavation; otherwise, provide bracing.
- Keep tools, working material, and loose objects away from the shoulder of the trench.

Q25. What must you do before going down into a manhole?

Q24. When threading or cutting pipe, you should always wear what personal protective equipment?

GAUGES

LEARNING OBJECTIVE: *Identify types of gauges and methods for adjusting, testing, and repairing gauges.*

Gauges are delicate instruments and require care and attention. They are most important in the safe operation of boilers, air-conditioning and refrigeration systems, or compressed-air systems; they tell you what you need to know about water, heat, and pressure conditions, and eliminate guesswork.

Proper care of gauges should include the following:

1. Keep the dials and face clean.

2. Have the gauges well lighted to make the correct reading easier to take.

3. Keep the covers tight, and replace broken glass promptly.

4. Protect the gauges as far as possible from vibration, excessive temperatures, corrosive liquids, and rapid changes in pressure.

TESTING

Whenever you believe that a gauge is not accurate, test it with a deadweight tester. Figure 5-55 shows such a tester. In this testing device, the gauge under test is subjected to pressure by applying weights to a plunger. The plunger is accurately fitted into a vertical cylinder that contains a water-base hydraulic fluid.

> **WARNING**
>
> Mineral oil or other petroleum products must **NEVER** be used in the deadweight pressure gauge tester.

Weights are applied to the plunger, and the pressure is transmitted to the fluid and then to the gauge by way of transmission piping and a control valve. The plunger itself exerts a known pressure of approximately 5 psi. Additional weights are provided in sizes that exert pressures equal to 5, 10, and 20 psi.

In figure 5-55, notice that there are two horizontal cylinders and a main vertical cylinder. The plunger in cylinder A pumps hydraulic fluid into the instrument when it is first filled. The plunger in cylinder B exerts enough force on the fluid so the testing plunger maintains the weight platform in position about 2 inches above the top of the vertical cylinder. At the beginning of the test, the plunger in cylinder B should be screwed out as far as it will go, so cylinder B (as well as the main cylinder) fills with fluid. If the weighted test plunger is pushed too far down at anytime during the test, the plunger in cylinder B should be screwed in as far as necessary to force the test plunger up so it will have freedom of movement.

To test a pressure gauge in the deadweight tester, connect the gauge to the apparatus and fill the tester with the proper water-base hydraulic fluid, if necessary. (Some testers of this type are designed to be kept full of fluid at all times, but others require filling before each use.) Then level the tester. Apply weights to the testing plunger, as required, and check the pressure gauge readings for accuracy. The plunger should be gently rotated, as each weight is added, to ensure its freedom of movement. If the gauge reading increases by the proper amount as each weight is added

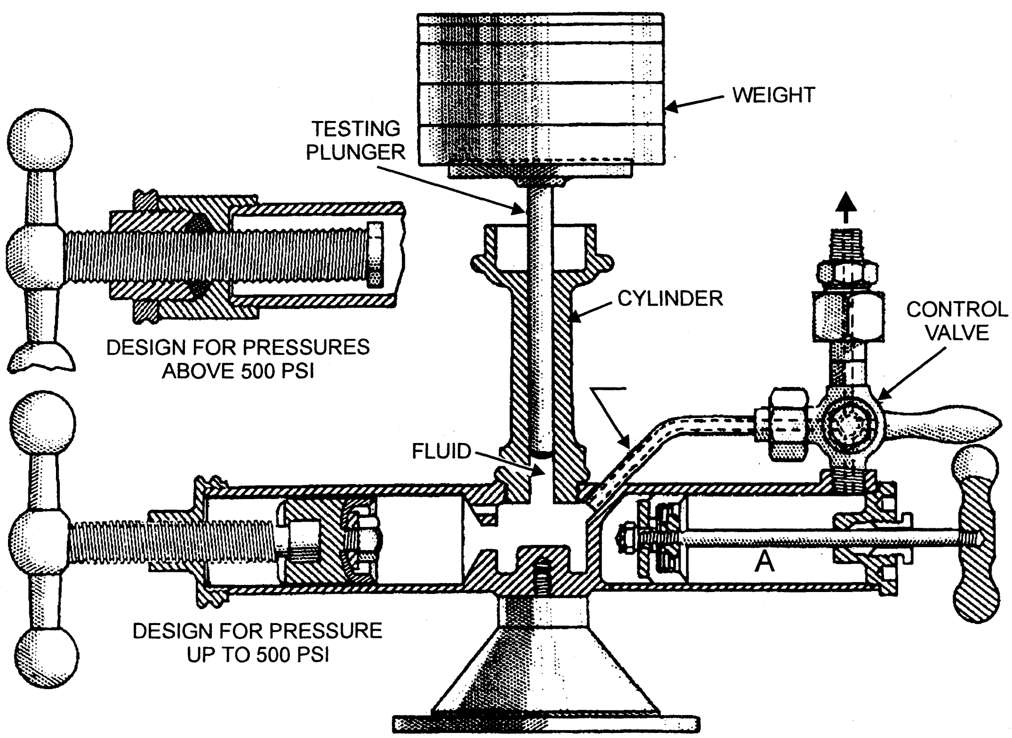


Figure 5-55.—Deadweight pressure gauge testing apparatus.

and if the gauge reading is equal to the pressure represented by the total weight added, the gauge is accurate. If the gauge is not accurate, it must be adjusted to read correctly.

ADJUSTING

When a Bourdon-tube pressure gauge is inaccurate, the following adjustments should be made:

1. If the pointer travels too far or not far enough as each weight is applied, change the ratio of movement between the Bourdon tube and the pointer. The movement of the sector gear meshes with a pinion on the pointer spindle. Lengthening the distance between the spindle and the link connection to the sector gear reduces the amount of travel to the pointer. Shortening this distance increases the amount of travel.

2. If the amount of travel is correct as each weight is added but the total reading is wrong, the pointer must be reset. Gauges of recent design have a countersunk split-head screw in the dial for setting the pointer. On some older types of gauges, the pointer must be pulled and reset. Pointer pullers are supplied with the gauge-testing apparatus.

3. If the gauge cannot be made to read correctly over the entire scale, it should be adjusted so the reading is correct at the working pressure. A table or curve should then be made that shows the corrections required for other readings.

From time to time, you may be required to adjust the diaphragm type of air pressure gauge, as shown in figure 5-56. The zero adjustment on these gauges should be checked frequently. Each gauge of this type has a three-way cock that can be turned to shut off the gauge without disconnecting the gauge piping. When the handle of the three-way cock is at right angles to the valve body, the gauge unit is open to the outside air pressure, and the reading on the scale should be zero. When the handle of the cock is parallel to the valve body, the gauge is open to the pressure in the line. A zero adjusting screw is provided either below the gauge or on one side of the gauge. Turn this screw in or out to bring the pointer to zero while the handle of the three-way cock is at right angles to the valve body. After making this zero adjustment, restore the gauge to service by turning the cock handle so it is again parallel with the valve body.

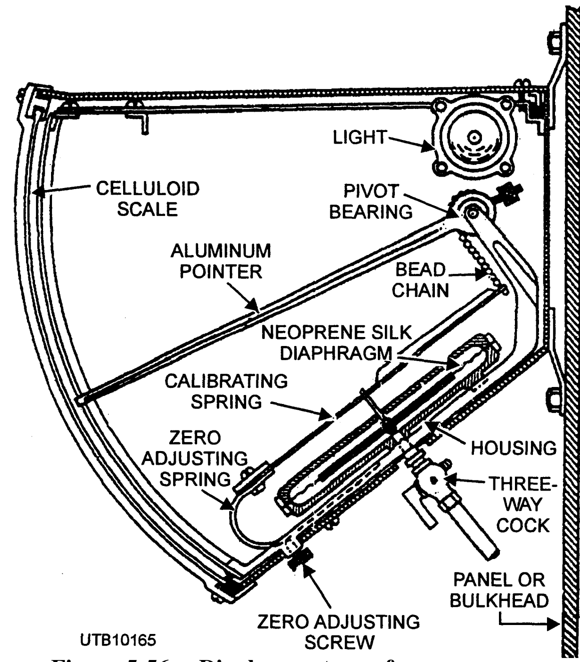


Figure 5-56.—Diaphragm type of pressure gauge.

REPAIRING

If you are required to replace any part of a pressure gauge, handle the mechanism carefully so none of the elements are bent or distorted.

You may occasionally have to replace the diaphragm in a diaphragm type of air pressure gauge (fig. 5-56). First, disconnect the pressure line below the unit. Remove the outside zero adjustment screw and the three-way cock (with its coupling), and remove the unit from its case.

Disassemble the unit by compressing the small spring on top of the calibrating spring to loosen the retaining pin. Remove the stem that holds the calibrating spring, and remove the screws (usually 10) around the edge of the diaphragm housing. The oil diaphragm can then be lifted out.

Clean both surfaces of the housing. Apply a small amount of gasket cement to the edge of the lower housing, and immediately place the new diaphragm-gasket assembly over the edge of the lower housing. Replace the top housing. Tighten the screws, being careful to draw them up uniformly. Replace the calibrating spring stem, compress the spring, and insert the retaining pin in the stem. Then replace the unit in the case. The gauge is ready for service.

Q27. On a deadweight tester, what is used to apply pressure to the gauge for testing?

Q28. What type of gauge has a zero adjusting screw?

CHAPTER 6

PRIME MOVERS, PUMPS, AND AIR COMPRESSORS

LEARNING OBJECTIVE: *Identify types and uses of prime movers, pumps, and air compressors; identify procedures required in preventive maintenance and maintenance on pumps and air compressors.*

Because of the many types of prime movers, pumps, and air compressors used by Navy units, the information presented on operating procedures and maintenance requirements in this chapter is brief and general. The emphasis is on fundamental operating principles, parts, and maintenance of prime movers, pumps, and air compressors, and operating problems you may experience.

Local commands develop specific operator maintenance schedules, logs, and reports. Each local command also maintains a file of manufacturer's instructions, parts lists, drawings, and diagrams for all equipment installed or used in that command. Taken together, these maintenance schedules, manufacturer's instructions, and so on, provide you with detailed information on operating procedures and maintenance requirements. Always get to know these guides before attempting to operate and maintain the equipment for which you are responsible.

There are several important Navy training publications of which you need to be aware. Although these books are described as basic texts, the information they contain can help you better understand the equipment covered in this chapter. To learn more about the operating principles and construction of electric motors, you should obtain a copy of each of the following TRAMANs:

- Module 5, *Introduction to Generators and Motors,* Navy Electricity and Electronics Training Series (NEETS), NAVEDTRA B72-05-00-96.
- *Basic Machines,* NAVEDTRA 12199, explains the operating principles and construction of internal combustion engines.
- *Fluid Power,* NAVEDTRA 12966, discusses fluid physics, construction, and operating principles of pumps and air compressors, valves, packing, pressure gauges, and fluid piping, tubing, and temperature.

PRIME MOVERS

LEARNING OBJECTIVE: *Identify the basic types, the operation, and the maintenance of prime movers.*

Prime movers are often called "driving equipment" because they are the primary source of mechanical energy or power. The mechanical energy produced by the prime mover is transmitted to another machine or mechanism, such as a pump or air compressor, to do some form of useful work. The mechanism, or linkage, that transmits the mechanical power developed by the prime mover is called the drive.

Electric motors and internal combustion engines are commonly used as prime movers. For this reason, this chapter briefly covers electric prime movers, gasoline-operated prime movers, and diesel-operated prime movers.

ELECTRIC MOTORS

As prime movers, electric motors receive electrical energy from some external source and transform it into the mechanical energy needed to produce work. Electric motors are either direct current (dc) or alternating current (ac). Because most of the electrical power generating systems that Seabees come in contact with produces alternating current, only the ac motor will be discussed.

Induction AC Motor

Of the various types of ac motors available, you will work primarily with the rotating-field INDUCTION ac motor. The popularity of this motor is due largely to its reliability and simplicity of construction. The basic induction motor has two main assemblies or components-a ROTOR and a STATOR, as shown in figure 6-1. The mechanical rotation of the rotor is produced through the principle of electromagnetic induction. Alternating current flows through the stator (a circular assembly of stationary coils or windings) which surrounds the rotor. The alternating current flow in the stator produces a constantly rotating magnetic field. This magnetic field induces a current flow in the conductors of the rotor (a cylindrical or drumlike assembly of copper bars mounted on a shaft). The induced current in the rotor then produces a magnetic field of its own. The magnetic field of the rotor is produced so it opposes the magnetic field of the stator; that is, the two fields repel each other. This continuous repulsion of the rotor field by the stator field results in a continuous rotation of the rotor assembly around its axis or shaft. Thus electrical rotation (in the stator) is transformed into mechanical rotation (in the rotor).

The rotational speed of the stator field remains constant unless the frequency of the electrical power source varies. The rotational speed of the rotor is also constant and is more or less independent of the workload imposed on it. This is not to say, however, that an induction motor cannot be overloaded. Under heavy or excessive loads, the motor tends to draw more current to maintain speed; this can result in overheating and burned-out windings.

Induction motors are usually named by the method used for starting the motor. Two fairly common types of induction motors, classified in this manner, are the SPLIT-PHASE MOTOR and the CAPACITOR-START MOTOR. Split-phase induction motors are designed to operate on single-phase current. Induction motors require two or more out-of-time-phase currents to produce the continuously rotating magnetic field in the stator. For this reason, induction motors that must run on a single-phase power supply are provided with split-phase windings that make two phases of the single-phase current. Split-phase motors can be used to drive a variety of equipment, such as washing machines, oil burners, small pumps, and blowers. The capacitor-start induction motor is a variation of the split-phase motor, but it has a high capacity, electrolytic capacitor. The primary function of this device is the storage of electricity to provide more power during the start.

There are a number of mechanical modifications to induction motors. The most important are as follows: (1) the splashproof motor; (2) the totally enclosed, fan-cooled motor; and (3) the explosionproof motor.

The splashproof motor is constructed so dripping or splashing liquids cannot enter the motor. The motor is self-ventilated; but, since moisture-saturated air may be circulated through the motor, the windings are made moisture-resistant. Motors of this type are most often used to drive pumps and other machinery where the moisture content of the air is high.

The totally enclosed, fan-cooled motor has totally enclosed windings and rotor. Cooling air is circulated over the enclosure to remove heat. This motor is used in locations where the surrounding air may contain a high proportion of dust, as in a carpenter shop.

The explosionproof motor is similar to the totally enclosed fan-cooled motor; but, it is constructed to prevent any explosion within the motor from igniting combustible gases or dust in the surrounding air. This

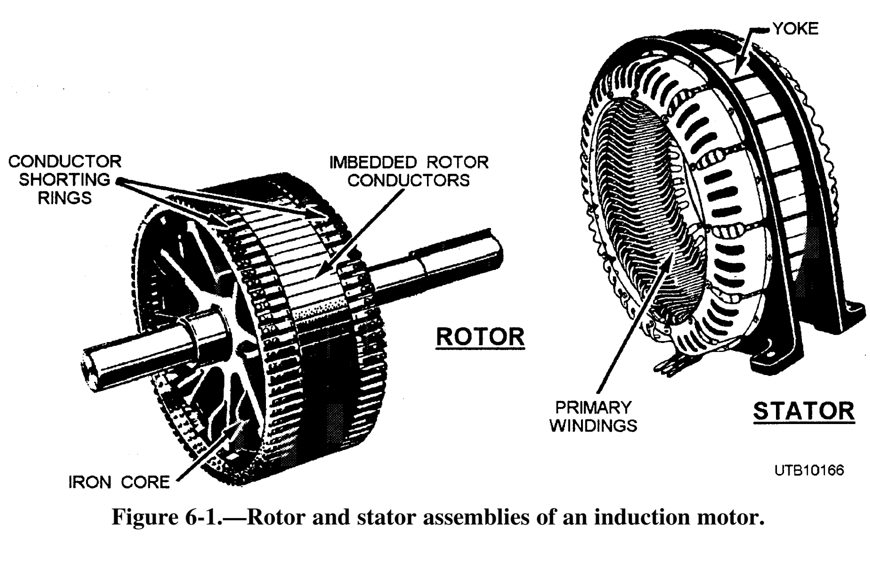


Figure 6-1.—Rotor and stator assemblies of an induction motor.

motor is extensively used in sewage treatment plants and at other locations to ensure safe operation.

The operation and operator maintenance of electric motors has four main aspects-(1) lubrication of moving or rotating parts, (2) proper alignment of drives, (3) safety, and (4) cleanliness of windings and rotors. Pay careful attention to each of these factors to ensure motor efficiency and, in many cases, to prevent motor breakdown.

LUBRICATION.—Electric motors are fitted with bearings which reduce friction. The types of bearings most often used are sleeve bearings, roller bearings, or ball bearings. For these bearings to remove the heat generated by friction, they must be properly lubricated. The lubricant used is usually either grease or oil.

Some motors are equipped with ball bearings permanently lubricated or packed with grease when the motor is assembled at the factory. These bearings are usually covered with a nameplate that reads-Do Not Lubricate. Most electric motor bearings, however, must be lubricated at frequent intervals. In such cases, the lubricant is fed to the bearings through a pressure fitting or grease nipple from a hand-operated grease gun. Or, the lubricant may be metered to the bearings from a grease or oil cup, which must be periodically turned or screwed down by hand to keep the bearings supplied with lubricant (fig. 6-2).

Some rotating shafts are fitted with sleeve bearings that usually are soft brass cylinders that fit around the machine-shaft journal like a sleeve. In some installations, the lubricating oil is circulated through the sleeve bearings under pressure. Some sleeve bearings, however, may be lubricated by means of an oil ring, or rings, as shown in figure 6-3. The weight of the ring hanging on the journal is enough to cause it to revolve, as the shaft revolves. As the oil ring rotates, it dips into an oil reservoir directly beneath the shaft journal. The oil picked up by the ring is then diffused along the shaft, between the shaft journal and sleeve bearing. Proper lubrication of ring-oiled sleeve bearings depends on maintaining a sufficient oil level in the reservoir. For this reason, most sleeve bearings have oil filler gauges or overflow fittings installed to aid the operator in maintaining the oil at a proper level.

When the electric motor is in operation, the operator is required to make frequent checks and inspections for proper lubrication of bearings and for overheated bearings. Check for heat radiated to your hand or check with a thermometer. Note that one of the most frequent conditions that cause bearings to overheat is excessive lubrication. This is a very

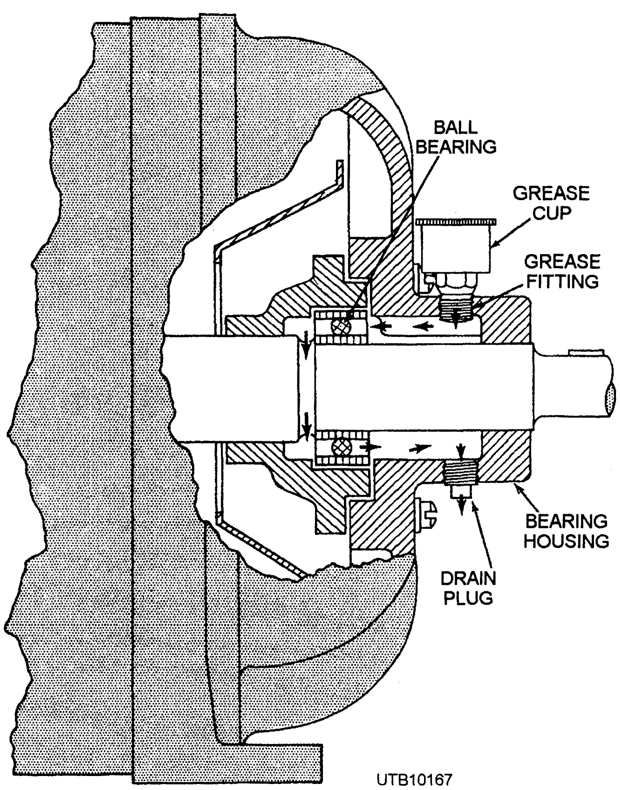


Figure 6-2.—Grease-lubricated ball bearings.

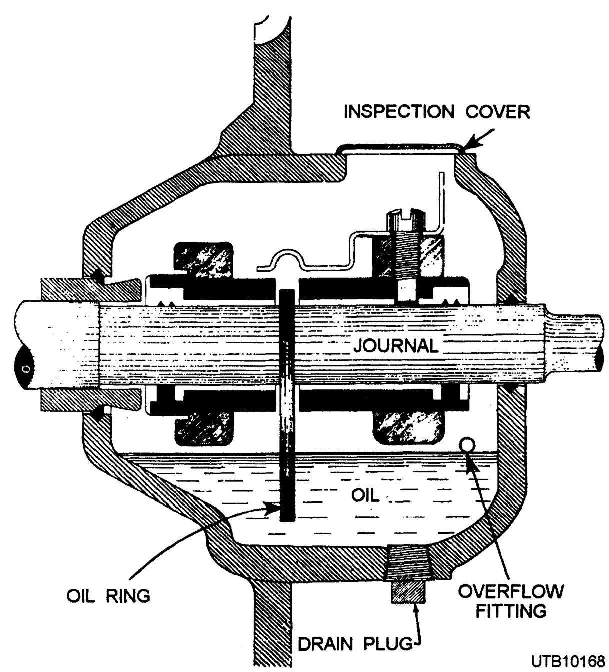


Figure 6-3.—Ring-oiled sleeve bearing.

common problem in the case of grease-lubricated bearings. Too much grease around the bearings insulates and seriously hinders the conduction of heat away from the bearing. The specific lubrication requirements and inspection procedures vary according to the type of bearings and the motor installation. You should always consult your local operator maintenance schedules and instructions for guidance. Other than the inspections cited, the operator should check for the leakage of lubricants from the bearings, especially lubricant oozing toward the windings or other electrical conductors.

At less frequent intervals, maintenance schedules require additional and more detailed inspections for proper lubrication. This requirement often includes dismantling parts of the bearing housing because bearing housings and pressure fittings must be cleaned periodically.

To lubricate grease-lubricated bearings properly, you must flush old grease from the bearing with solvent and add fresh grease. Sleeve bearings must be examined at various intervals and the oil reservoir flushed, cleaned, and refilled.

MAINTENANCE AND ALIGNMENT OF DRIVES.—The mechanism, or linkage, that transmits the motion and the power of the prime mover to the driven equipment is the drive. The drive must be maintained and operated properly, because its alignment and mechanical efficiency affects both the prime mover and the driven equipment. Two fairly common types of drives used with electric motors are the flexible coupling and the belt drive.

The coupling shown in figure 6-4 connects or couples the shaft of the prime mover to the shaft of the driven equipment. The coupling is designed to permit very slight misalignment between the two shafts. This flexibility permits the coupling to absorb some of the torque, or twisting force, resulting from the inertia of the driven equipment when the motor is started and brought up to speed. Caution must be taken, because any misalignment in excess of these small tolerances causes rapid wear of the coupling hubs and bushing pins, vibration of the shafts, and a reduction in the transmission of power from the prime mover. Vibration is transmitted through the shafts to moving or rotating parts of both the prime mover and the driven equipment. Vibration inevitably results in excessive wear of the various bearings that support the moving or rotating parts, which, in turn, results in more misalignment, vibrations, and wear. The point is that small vibrations, which at first may seem insignificant, can develop into major casualties and breakdowns.

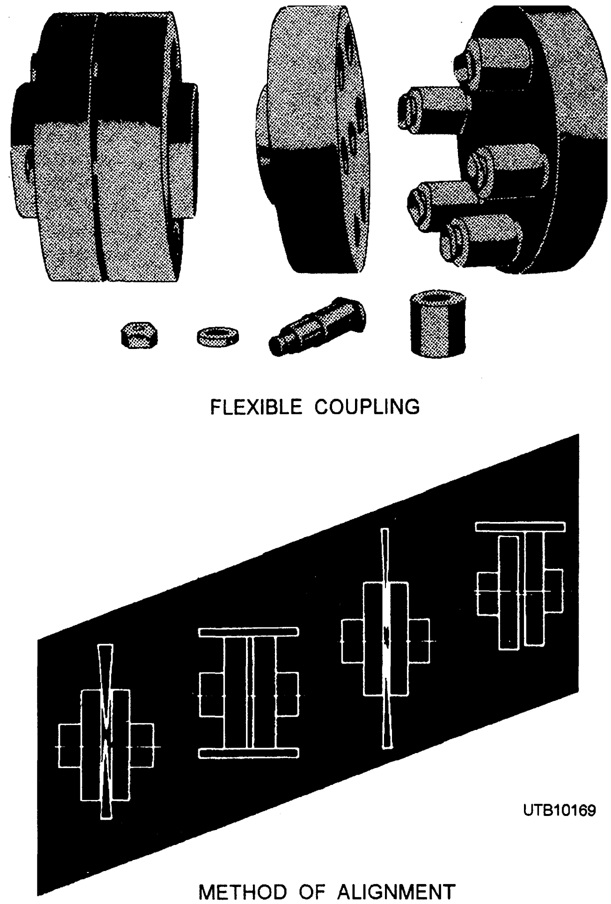


Figure 6-4.—Coupling.

While the motor is in operation, check the coupling for any unusual noise or vibration. At prescribed intervals, maintenance schedules require the operator to check the alignment of the coupling with a straightedge, a dial indicator, a thickness gauge, or a wedge, and realign the coupling as necessary. For detailed instructions for the proper realignment procedure, consult the manufacturer's instructions.

Various belt and pulley arrangements are also used as drives on electric motors. These belt drives are somewhat similar to the fan belt arrangements that drive the fan, the water pump, and the alternator on automobiles. The belt, made either of rubber or leather, rides on grooved pulleys or sheaves-one sheave connected to the shaft of the prime mover and the other sheave connected to the shaft of the driven equipment. In this way, the rotation of the electric motor is transmitted to the shaft of the driven equipment.

Belt drive maintenance requires proper belt tension. If the belt is too loose or slack, the power of the prime mover is not transmitted efficiently. Belt slippage also results in excessive rubbing and wear of the belt on the sheaves. Sheaves worn or out of alignment can also contribute to excessive belt wear. Additionally, belt slippage can be caused by an accumulation of oil or grease on the sheaves. If the belt is too tight, on the other hand, the stress is transmitted to the bearings in the sheaves and along the shafts. This condition causes excessive bearing wear and misalignment.

A properly adjusted belt has a very slight bow in the slack side when running. When idle, the belt has an "alive" springiness when thumped with the hand. Lack of this springiness indicates too little tension. A belt that is too tight feels dead when thumped with the hand.

While the motor is in operation, you should visually inspect the belt drive periodically for any indication of improper tension or slippage. Also, be careful to keep the belt and sheaves clean and free of grease or oil at all times. At prescribed intervals, inspect the belt for fraying, for cracks, or other unusual wear. You should also inspect and check the alignment of the sheaves. Excessive belt rubbing on the sheaves is an indication of belt slippage. Sheaves that are out of alignment are normally a result of excessive belt tension.

Occasionally, it may be necessary to replace a worn and frayed belt. If the drive has multiple belts, ALL the belts must be replaced with a set of matched belts. The belts in a matched set are machine-checked to ensure equal size and tension.

In addition to the maintenance and inspections outlined above, the operator must test and inspect other items related to the motor, such as control switchboards, pilot lamps, alarms, and circuit breakers. Electrical connections and conductors must also be periodically inspected for proper insulation and security.

SAFETY.—Because of the danger in working with electric motors, all safety precautions should be observed. In operating electric motors and in performing operator maintenance on electric motors, remember that you are working on a device which carries a force of energy that is not only useful but also deadly.

CLEANLINESS.—Cleanliness of electric motor operation and maintenance is largely a matter of prevention, rather than inspection and correction. As an operator, you must develop clean housekeeping and maintenance habits. Dirt, dust, and other foreign objects that accumulate on and inside an electric motor can reduce ventilation and foul moving parts. When dirt and grit accumulate on windings, the cooling or ventilation of these electrical conductors is seriously reduced. During the inspection routines, prevent lubricants and lubricant fittings from getting contaminated. Dirt in lube oil, in many cases, settles to the lowest point in the system before doing any extensive damage; however, dirt or grit that gets into lubricating grease can remain suspended indefinitely and result in abrasion of bearings and moving surfaces.

The maintenance schedule usually requires periodic inspection and cleaning of the rotor and the stator windings. Low-pressure compressed air can be used to blow out the dirt and dust; however, in the stator, this method can sometimes result in dirt being driven deeper into the windings. Instead, you should use vacuum suction. In fact, vacuum suction is always the preferred method for removing dust and dirt from stator windings or from any other motor component when compressed air could force dirt and abrasive particles deeper into the mechanism. Accumulations of grease and oil can be removed with the proper type of petroleum solvent. In any case, consult local maintenance schedules and instructions for the specific and precise cleaning method.

INTERNAL COMBUSTION ENGINES

An internal combustion engine is a machine that produces mechanical energy by burning fuel in a confined space (the engine cylinder). The term applies to both diesel and gasoline engines.

The Utilitiesman should have a basic knowledge of the principles of diesel and gasoline operation, since the Utilitiesman has to operate and hold first-echelon maintenance of the engine used to drive various types of pumps and compressors.

Operation and Maintenance of Diesel Engines

Diesel engines change heat energy into mechanical energy. Heat is developed when a mixture of compressed fuel and air burns inside a cylinder. A complete description of the internal combustion engine and its principles of operation is in chapter 12 of *Basic Machines,* NAVEDTRA 12199.

To keep diesel engines in peak operating condition, the operator must give careful attention to the following factors-prestart inspection, starting the diesel, securing the diesel, and operator maintenance.

Before a diesel can be started, the operator must perform a prestart inspection to ensure the engine is ready for operation. The specific inspection routine varies somewhat according to each engine. The basic procedure, however, requires the operator to inspect the engine for a sufficient supply of fuel oil, lube oil, and cooling water. The operator must also be alert for any leakage of these fluids. When replenishment of cooling water is necessary for the radiator, use clean or soft water to keep the engine water jackets and coolant circulating system free of sediment. If the engine is still hot from previous operation, do not add large amounts of cold water. Sudden cooling can crack cylinders or cylinder heads and may cause unequal contraction of the structural and working parts and lead to seizing of the pistons. When topping off batteries, use distilled water.

Accessories and drives should be inspected for loose connections and mountings. If the diesel starting system is battery equipped, check the batteries for cracks and leaks, and ensure the battery cables and vent caps are clean and secure.

As a safety precaution, inspect the fire extinguisher for ease of removal, full charge, security, and cleanliness of valves and nozzles before starting the engine.

Diesel engines rely on some external source of power for starting. The starting mechanism may be an electric motor, an auxiliary gasoline engine, compressed air, or even a hand-cranking mechanism. Whatever system is used, the starter forces the pistons to reciprocate and compresses air drawn into the cylinders. When sufficient compression has been developed with the aid of the starter, the temperature of the air in the cylinders will be high enough to ignite the injected diesel fuel. Thus internal combustion takes place and the engine begins to crank under its own power. Once the engine has been started, the actions the operator must take are as follows:

1. Throttle the engine to normal (fast idle) warm-up speed. The diesel should not be permitted to slow idle for any appreciable length of time because this causes the engine-driven blower to deliver an insufficient amount of air for complete combustion. This condition results in partially burned fuel oil, forming heavy carbon deposits that foul the valves, the piston rings, and the exhaust system.

2. Immediately check the lube oil pressure gauge. If the gauge does not indicate positive and sufficient lube oil pressure within 30 seconds, stop the engine immediately and report the difficulty to the proper authority.

3. Observe the temperature gauge during the warm-up period. The engine must not be placed under load until it reaches the proper warm-up temperature. Placing a cold engine under full load can result in serious damage to the engine because of poor lubrication at low temperature and uneven rates of expansion.

While the engine is in operation, other inspections and checks are required, such as checking of lube oil and fuel oil levels, filters and strainers, accessories and drives, and engine operating temperatures and pressures. Normally, the operator records the results of these inspections in an operating log.

When the diesel is secured, if the engine installation permits, let the engine low idle without load for a short time before stopping to allow for a gradual reduction of engine temperature. Once the diesel has been shut down, the standby lube oil pump should be kept in operation for a short time to allow the lube oil to further cool the engine. The cooling water should also be kept circulating for 15 to 30 minutes to bring the working parts to a low temperature without danger of distortion from one part cooling faster than another.

While the engine is cooling, the operator must check to determine the need for adjustment, for repair, and for replacement or renewal of parts. The required actions are as follows:

- Check the fuel, the oil, and the water as in the prestart inspection.
- Check the engine instruments or the gauges for proper readings.
- Check the accessories and the drives as in the prestart inspection.
- Inspect the air cleaners and the breather caps.
- Inspect the fuel filters.
- Inspect the engine controls and the linkage.
- Inspect the batteries as in the prestart inspection.
- Inspect all electrical wiring, insulation, and security of connections.

According to the prescribed maintenance schedules, the engine operator performs other inspections and maintenance duties. These maintenance routines occur at timed intervals prescribed by manufacturers. Examples of tasks that can be required by a maintenance schedule are as follows:

- Removing and cleaning the oil filterelements
- Inspecting the fuel lines, the fuel filters, and the fuel pump
- Cleaning the battery casings and the terminal posts; checking for proper electrolyte level and specific gravity
- Inspecting and lubricating the starting mechanism
- Inspecting, cleaning, and lubricating the generator; inspecting and testing the voltage and current regulator
- Inspecting the radiator; inspecting the water pump, the fan, and the drive belts
- Disassembling and cleaning the air filters and the breather caps
- Inspecting the crankcase, the valve covers, the timing gears, and the clutch housing
- Inspecting the cylinder heads and the gaskets

Operation and Maintenance of Gasoline Engines

Like the diesel engine, the gasoline engine changes heat energy into mechanical energy. The physical construction of the gasoline engine is very much the same as that of the diesel. Pistons, cylinders, valves, connecting rods, a crankshaft, and an engine block are in each. A cooling system carries heat away; a lubrication system reduces friction of moving parts; an air system supplies air for combustion in the cylinders; and a fuel system supplies fuel.

Most gasoline engines operate on the four-stroke cycle (fig. 6-5). The difference between gasoline and diesel engine operation is the method of introducing the fuel and the air into the cylinders and the means by which the compressed fuel and air are ignited in the cylinders.

In a diesel engine, the air is admitted to the cylinder on the intake stroke of the piston, as shown in view A, figure 6-5. The fuel oil is sprayed into the chamber AFTER the air has been compressed. In a gasoline engine, the fuel (gasoline) and air are mixed together BEFORE being admitted to the cylinder. The intake stroke of the piston sucks air through the air cleaner into the carburetor. In the carburetor, the clean air is mixed with gasoline (vaporized) from the fuel tank. The air and gas mixture continues on to the intake manifold that is connected to the cylinder head. An intake valve admits the air-gas mixture into the cylinder.

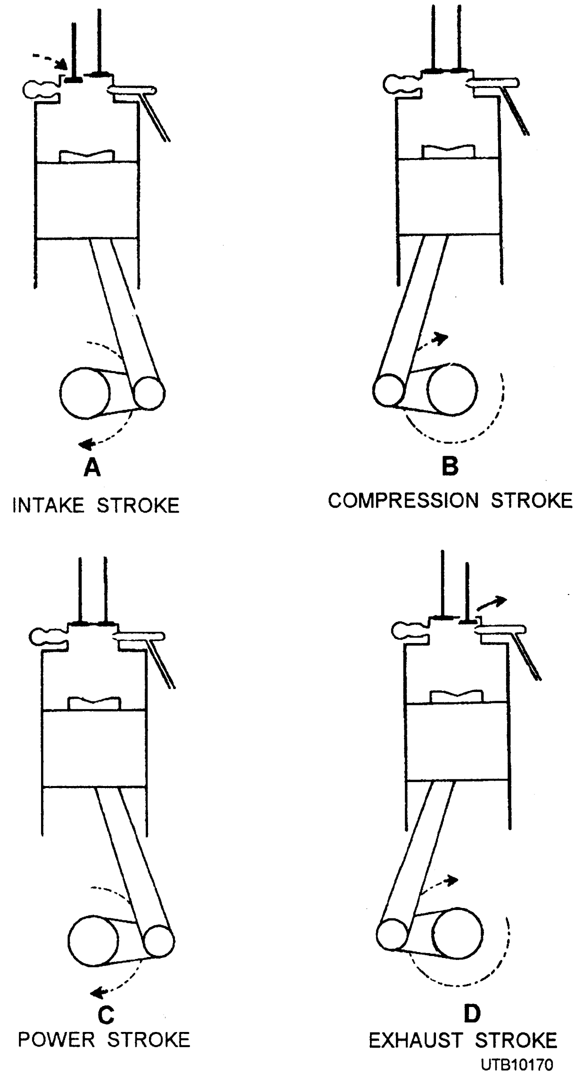


Figure 6-5.—Four-stroke cycle.

The diesel engine produces combustion by using the heat of compression, as shown in view B. In a gasoline engine, an electric SPARK is provided by the spark plug to ignite the air-gas mixture. Ignition occurs as the piston completes its compression stroke. The ignited gases expand and the piston is pushed down on the power stroke, as shown in view C. The exhaust stroke of the piston forces the burned gases out of the cylinder chamber, as shown in view D.

The operating procedures and operator maintenance routines for gasoline engines are essentially the same as those for diesel engines. Starting procedures for gasoline engines are also much the same as those for diesels; however. there is one important exception. Most gasoline engines are equipped with priming or choking devices to aid in starting a cold engine. Generally, these priming devices simply dump raw fuel into the cylinders; that is, the fuel is not thoroughly mixed with air or atomized before induction into the cylinders. This rich mixture of fuel aids in achieving initial combustion; however, not all of the fuel is burned. In other words, we have incomplete combustion. Prolonged or excessive choking during and after the start can lead to carbon deposits being built up in the engine. For this reason, the operator should always use care and restraint in choking or priming the engine. both during and after the start.

Securing procedures for gasoline engines are also basically the same as those for diesels. although some gasoline engine installations may not permit circulation of lube oil and coolant after the engine has been stopped.

As you might expect, operator maintenance routines for gasoline engines differ from those for diesels because of the slight differences in design and construction of gasoline engines. In other words, gasoline engine maintenance and inspection schedules must provide for the inspection, the adjustment, and the maintenance of such items as carburetors, chokes, ignition coils, wiring. distributors. and spark plugs.

SAFETY.—Anytime gasoline or diesel engines are secured for maintenance and inspection purposes, the operator should always guard against intentional or inadvertent starting of the engine by uninformed personnel. This rule applies to all types of prime movers, including electric motors. It also applies to maintenance and inspection operations being performed only on the driven equipment. Regardless of whether the work is being done on the prime mover itself or on the driven equipment alone. unintentional starting of the prime mover during the maintenance operation can result in serious damage to the machinery and serious injury to maintenance personnel. For this reason. YOU are responsible for using the equipment tag-out procedures contained in the current OPNAVINST 3120.32. In most situations, it may be a good idea to disable the starting mechanism completely, so even if personnel fail to see or read the tag, the prime mover cannot be started.

During the maintenance operation, the operator must keep a strict accounting of all tools and parts. Tools, nuts and bolts, or any other material left adrift can foul a moving part and completely disable the machinery during subsequent operation. There is another reason for keeping a strict accounting of parts whenever components are disassembled. Parts that work together wear together. The various parts of valve assemblies, bearing assemblies, and so forth, should be carefully marked and grouped during disassembly and replaced in the same position from which they were removed; otherwise, discrepancies in fitting and joining can result and reduce the mechanical efficiency of the moving parts. This can eventually lead to a breakdown.

WARNING

When an engine or a motor is inspected that is in operation, the operator should always be cautious while working near moving parts. Loose clothing, rags hanging from pockets, dangling key chains, and so forth, can easily become entangled with, or drawn into, moving parts, resulting in a serious accident.

CLEANLINESS.—Engine maintenance and inspection require cleanliness. Dirt allowed to accumulate on and around an engine can find its way inside that engine. It may be carried into the engine with air, fuel, lube oil, or water, or careless personnel may introduce it. Dirt can cause sludge and scale deposits that impair circulation of fuel, oil, and water, and erode moving parts. Large accumulations of dirt on external surfaces can insulate the surface and reduce cooling.

Normally, there are specific instructions available locally concerning cleanliness precautions while handling fuel and lube oil. You must know and observe these precautions. Some fundamental cleanliness precautions are as follows.

- Never use waste or linty rags around fuel or lube oil containers, fuel inspection equipment, or carburetors.
- Keep fuel and lube oil handling equipment, such as measures, funnels, and containers, clean and covered when not in use.
- Use clean, soft water in engine radiators and coolant systems to keep the engine water jackets free of sediment, and use distilled water in topping off batteries.

- Keep engine air intake filters clean to maintain sufficient induction of air.

Q1. An electric motor is what part of a pump?

Q2. Excessive rubbing or wear is a result of what condition caused by improper belt tension?

Q3. Before starting a diesel engine, you must complete what type of inspection?

Q4. Whatfeature is the difference between agasoline and a diesel engine?

PUMPS

LEARNING OBJECTIVE: *Identify specific types of pumps and the operation and maintenance procedures for each; identify methods used for installing piping, valves, and the maintenance of stuffing box, packing, and mechanical seals in pumps; and identify the methods used for the maintenance of internal pump components.*

A Utilitiesman is required to work with pumps of many shapes and size. Some of the primary uses of pumps are as follows:

- To supply feedwater to boilers
- To deliver fuel oil to oil-fired boilers
- To circulate coolants and lubricants in internal combustion engines
- To supply chemical feed in water purification systems,
- To lift water from cells and distribute it throughout a system
- To discharge sewage into setting tanks or mains.

The principles of pump operation, the principle of suction force, the types of valves used in pump operation, the different types of pumps, pump installation, and safety precautions that a Utilitiesman has to know to operate and maintain the various types of pumps used today are discussed in this section.

PUMP OPERATION

Pumps are used to move any substance that flows or can be made to flow. Most commonly, pumps are used to move water, oil, and other liquids; however, steam and other gases are also fluid and can be moved with pumps, as can molten metal, sludge, and mud.

A pump is a device that uses an external source of power to force fluid to move from one place to another. A pump develops no energy of its own; it merely transforms energy from the external source (steam turbine, electric motor) into mechanical kinetic energy, which is manifested by the motion of the fluid. This kinetic energy is then used to do work. For example. to raise liquid from one level to another, as when water is raised from a well. Other examples are to transport liquid through a pipe, as when oil is moved through an oil pipeline; to move liquid against some resistance, as when water is pumped to a boiler under pressure; or to force liquid through a hydraulic system, against resistance. Every pump has a POWER END, whether it is a steam turbine, a reciprocating steam engine, a steam jet. or some type of electric motor. Each pump also has a FLUID END, where the fluid enters (suction) and leaves (discharges) the pump.

The addition of energy to a liquid by a pump usually. results in an increase in pressure, which is generally referred to as HEAD. In pump operation, you should know that there are four types of head-net positive suction head, suction head, discharge head, and total discharge head. The definition of each of the types of head is as follows:

- The NET POSITIVE SUCTION HEAD (NPSH) is the suction pressure minus the vapor pressure expressed in feet of liquid at the pump suction. This type of head pressure is commonly referred to as NPSH.
- The SUCTION HEAD on a pump means the total pressure of the liquid entering the pump. In a de-aerating feed tank operating under saturated conditions. the suction head of the feed booster pump equals the NPSH plus the auxiliary exhaust pressure.
- The DISCHARGE HEAD means the pressureof liquid leaving the pump or the level of liquid with respect to the level of the pump on the discharge side.
- The TOTAL DISCHARGE HEAD is the net difference between the suction head and the discharge head.

NOTE: When positive, suction head is usually expressed in feet of water. When negative, it is expressed in inches of mercury.

When a pump operates below the level of a liquid, its suction end receives the liquid under a gravity flow. When the pump is located above the level of the liquid being pumped, the pump establishes a vacuum at the inlet to move the liquid into the pump. Atmospheric pressure, acting on the surface of the liquid, then provides the necessary pressure to move the liquid into the pump.

SUCTION FORCE

The principle of suction force, or suction lift, as applied to reciprocating pumps, is shown in figure 6-6. In diagram A, the piston cylinder is open at both the top and bottom, so the liquid level at A and B is the same. In diagram B, the cylinder is closed at the bottom. A piston has been inserted and partly withdrawn, thus creating a partial vacuum. When the foot valve (check valve) at the bottom of the cylinder opens (diagram C), as a result of the lower pressure in the cylinder, the liquid rises up into the cylinder, which causes the liquid level in the well to drop. Assuming the liquid is water and there is a perfect vacuum below the piston, atmospheric pressure pushes water up into the cylinder to a height of 34 feet, even though the piston may be raised higher than 34 feet.

You must understand that the preceding example is for the theoretical condition of a perfect vacuum. In practice, leakage between the piston and the cylinder, friction (fluid) in piping, and gases dissolved in the liquid limit the suction lift of a pump to a height of approximately 22 feet, as shown in diagram D of figure 6-6.

When a pump is pumping certain liquids, such as hot water, oil, or gasoline, some of the liquid vaporizes because of the vacuum on the suction side of the pump. The pump may become vapor bound and reduce the possible suction lift; this is called "cavitation."

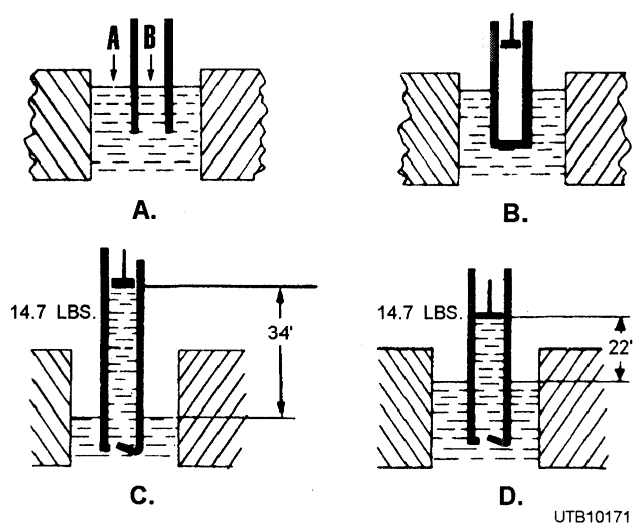


Figure 6-6.—Diagrams showing the principles of suction force.

The suction force principle applies to other types of pumps, as well as to the reciprocating type, though to a lesser degree and in a different manner. The centrifugal, the propeller, and the rotary pumps all use suction force to a certain extent. Here, a partial vacuum can be produced by the revolving mechanisms instead of by the reciprocating plunger. Also, centrifugal pumps are not self-priming because they do not pump air. Their casing must be flooded before they can function. In the eductor (jet pump), flow is maintained by the suction force created by a jet of water, compressed air, or steam passing through a nozzle at high velocity. These principles are explained later in this chapter.

VALVES USED WITH PUMPS

Every pump is equipped with devices for controlling the direction of flow, the volume of flow, and the operating pressure of the pump. A device that performs one or more of these control functions is called a VALVE.

A valve that permits liquid flow in only one direction is classified as a CHECK VALVE. In most cases, check valves open and close automatically; that is, they are kept closed or seated by spring tension or by the force of gravity until the liquid pressure above or below the valve overcomes the spring or gravity resistance and causes the valve to open. Check valves of this type are used with centrifugal pumps to control the suction and discharge of the liquid in the pump end at the proper time automatically. Figure 6-7 shows a vertical check valve. In this case, the valve is kept seated by its own weight or the force of gravity. If desired, it could also be kept closed by a spring.

Another type of valve in pump systems is the STOP VALVE. Stop valves are usually opened or

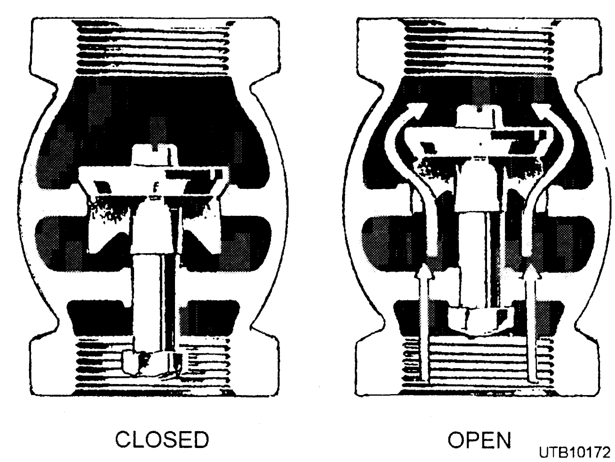


Figure 6-7.—Vertical check valve.

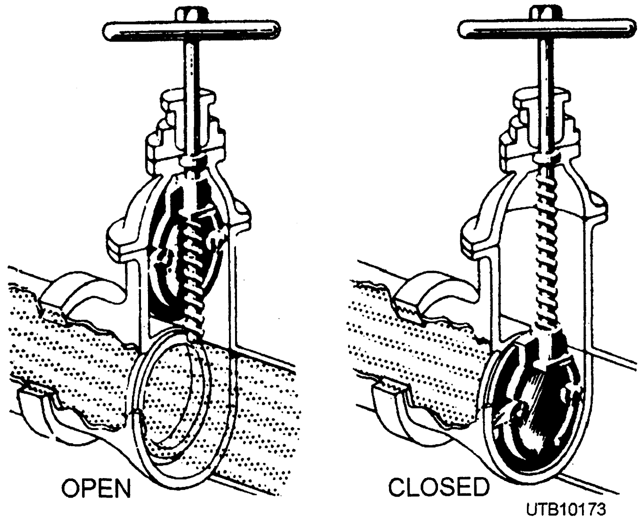


Figure 6-8.—Operation of a gate valve.

closed manually by means of a handwheel. They are used primarily to start or stop the flow of liquid through the pump during certain phases of operation. Thus stop valves are often placed on suction and discharge lines, so the pump is isolated or sealed off from the rest of the liquid system. Figure 6-8 shows the operation of a gate valve. A gate valve is a type of stop valve. A gate, or wedge, is raised or lowered by turning the handwheel. Some types of stop valves are used for throttling purposes; that is, to regulate the flow of liquid. However, gate valves are never recommended for throttling service because the flow of liquid past the partially opened gate can rapidly erode the gate face. Instead, the gate valve can be replaced with a tapered needle valve (another type of stop valve) which gradually opens or closes through the valve seat.

A third type of valve generally found on most types of pumps is the RELIEF VALVE. As you can see from figure 6-9, most relief valves are similar in their design to check valves. These valves are designed to open when the liquid pressure in the pump becomes dangerously high. In most cases, the outlet of the relief valve is connected to a recirculating line that passes the excess liquid back to the suction side of the pump. Almost all pressure relief valves are fitted with an adjusting nut or screw that permits the spring tension to be regulated. In this way, the pressure at which the valve is opened can be varied.

TYPES OF PUMPS

Pumps are classified according to the type of movement that causes their pumping action. The five broad categories of pumps are rotary, reciprocating, centrifugal, air lift, and jet pumps.

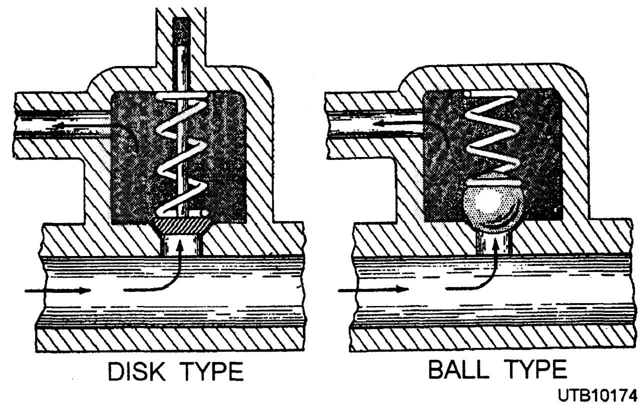


Figure 6-9.—Relief valve.

Rotary Pumps

All rotary pumps use the principle of entrapment and displacement of fluid by the rotating elements of various designs. These rotating parts, which may be gear teeth, screws, lobes, or vanes, trap the fluid at the suction inlet and remove it to the discharge outlet. Instead of “throwing” the water as in a centrifugal pump, a rotary pump traps it, pushes it around inside a closed casing, and discharges it in a continuous flow. Since rotary pumps move liquid by this method, they are often classified under the broad heading of positive displacement pumps.

Most rotary pumps have stuffing boxes provided at the rotor shafts to prevent excessive leakage at the shaft joint. In addition, various types of bearings can be fitted at the ends of the rotor shaft to minimize friction.

Generally, rotary pumps are self-priming; that is, the pump end need not be filled with liquid to initiate pumping action. Instead, the movement of the rotating elements creates a partial vacuum sufficient to lift or draw liquid into the pump and begin the pumping process. Note that self-priming and good suction lift are characteristics of the whole class of positive displacement pumps. Rotary pumps are less expensive and considerably simpler in construction. In the utilities field, rotary pumps are used for pumping fuel oil in boiler houses, for pumping chemical feed in water purification systems, for priming larger pumps, and for special applications, such as emergency pumps at fire-fighting stations.

TYPES OF ROTARY PUMPS.—The classification of a rotary pump is determined by the type of rotating element it has. However, no matter what form of rotating element is used, the basic principles of pump operation remain the same. In this section, two types of rotary pumps are discussed-the gear pump and the screw pump.

The GEAR PUMP is shown in figure 6-10. This type of pump uses two spur gears that rotate in opposite directions and mesh together at the center of the pump. One of the gears is coupled to the prime mover (usually an electric motor) and is called the driving gear. The other gear, which receives its motion by meshing with the driving gear, is called the driven gear. Note that liquid moves as the gear teeth rotate against the casing of the pump, thereby trapping the liquid and pushing it around to the discharge outlet. The meshing together of the two gears does not in itself move or pump liquid. The meshing of the gear teeth, in effect, forms a constant seal between the suction and discharge sides of the pump and thus prevents liquid from leaking back toward the suction inlet.

Very small clearances are permitted between the meshing gears and between the gear teeth and pump casing to avoid unnecessary friction and to allow the liquid being handled to act as a lubricant for the rotating parts. It is clear that when excessive clearances are allowed to develop between the gear teeth and casing or between the gears where they mesh that the efficiency of the pump is considerably reduced. For this reason, rotary pumps are rarely, if ever, used to handle corrosive or abrasive liquids.

Of the several types of SCREW PUMPS, the main difference is the number of intermeshing screws and the pitch of the screws. Figure 6-11 shows a positive displacement, double-screw, and low-pitch pump. Screw pumps are primarily used for pumping viscous fluids, such as JP-5 and diesel oil. Hydraulic systems use the screw-type pump as the pressure supply for the system. The pump may be either motor-driven or turbine-driven.

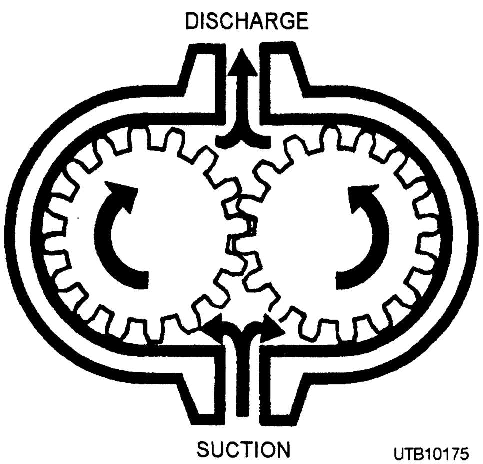


Figure 6-10.—Gear-type rotary pump.

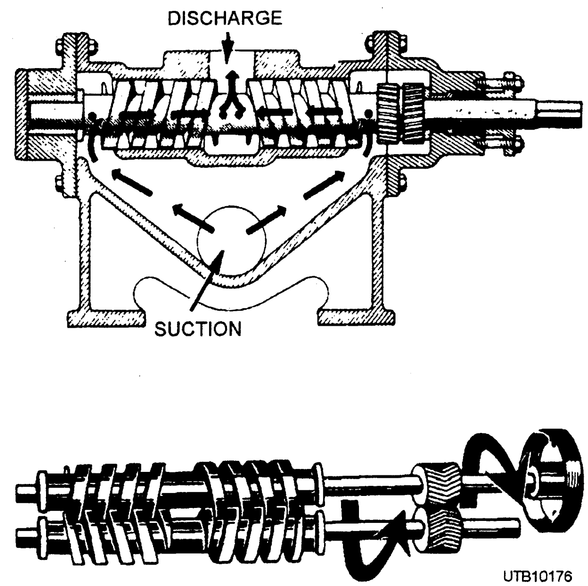


Figure 6-11.—Positive displacement, double-screw, low-pitch pump

In the screw pump, liquid is trapped and forced through the pump by the action of rotating screws. As the rotor turns, the liquid flows in between the threads at the outer end of each pair of screws. The threads carry the liquid along within the housing to the center of the pump where it is discharged.

OPERATION AND MAINTENANCE OF ROTARY PUMPS.—The rotary pump is susceptible to hydraulicking; therefore, the discharge stop valve must be in the OPEN position before the pump is started. In addition, it is a good operating practice to prime these pumps before operation when possible. This is particularly critical when the pump has been standing idle for a period of time. This is true in spite of the fact that rotary pumps are self-priming. Because the liquid handled in the pump lubricates the rotating elements of these pumps, filling the pump end with fluid before starting prevents unnecessary friction and wear of the rotating elements.

Rotary pump maintenance schedules stress that proper clearance be maintained between rotating parts. For this reason, there should be periodic checks for slippage. In addition, when the pump is dismantled, the actual clearances should be carefully measured and compared with the manufacturer's specifications.

Reciprocating Pumps

A reciprocating pump moves water or other liquid by means of a plunger or piston that reciprocates (travels back and forth) inside a cylinder. Reciprocating pumps are positive displacement pumps;

each stroke displaces a definite quantity of liquid, regardless of the resistance against which the pump is operating.

The standard way of designating the size of a reciprocating pump is by giving three dimensions, in the following order:

1. The diameter of the steam piston
2. The diameter of the pump plunger
3. The length of the stroke

For example, a 12- by 11- by 18-inch-reciprocating pump has a steam piston 12 inches in diameter, a pump plunger 11 inches in diameter, and a stroke of 18 inches. The designation enables you to tell immediately whether the pump is a high-pressure or low-pressure pump.

TYPES OF RECIPROCATING PUMPS.— Reciprocating pumps are usually classified as follows:

- Direct acting or indirect acting
- Simplex (single) or duplex (double)
- Single acting or double acting
- High pressure or low pressure
- Vertical or horizontal

The reciprocating pumps used by the Navy are usually one of the following types-direct-acting, simplex, double-acting, or vertical. The types most often used are direct acting pumps. The pump shown in figure 6-12 is direct acting because the pump rod is a DIRECT extension of the piston rod; and, therefore, the piston in the power end is DIRECTLY connected to the plunger in the liquid end. In an indirect-acting pump, there is some intermediate mechanism between the piston and pump plunger. The intermediate mechanism may be a lever or a cam. This arrangement can be used to change the relative length of strokes of piston and plunger or to vary the relative speed between piston and plunger. Or the pump may use a rotating crankshaft, such as a chemical proportioning pump in a distilling unit.

The diaphragm pump shown in figure 6-13 is a direct-acting reciprocating pump. It is commonly used by Utilitiesman to pump water from a ditch or sump.

Diaphragm pumps use a flexible diaphragm to move the liquid. The prime mover is usually a small gasoline or diesel engine with an eccentric connecting rod arrangement that converts rotary motion to reciprocating motion. On the suction stroke, the

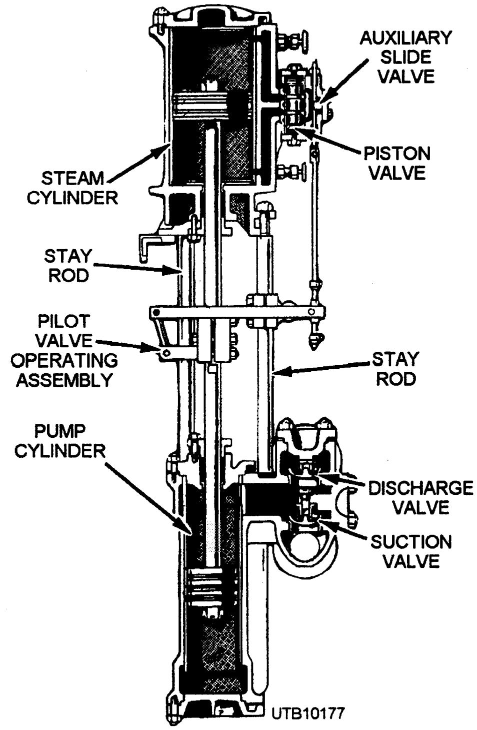


Figure 6-12.—Reciprocating pump.

diaphragm is drawn upward into a concave configuration. This movement of the diaphragm results in a partial vacuum that causes the suction ball valve to unseat (and at the same time keeps the discharge ball valve seated) and to admit the liquid to the pump cylinder. On the discharge stroke, the diaphragm is pushed downward, forcing the trapped liquid out through the discharge valve. Thus the liquid is made to move by the reciprocating motion of a flexible diaphragm.

Since the diaphragm forms an almost perfect seal in the pump cylinder between the liquid being pumped and the rest of the pump and driving mechanism, there is some danger of liquid abrasion or corrosion of moving parts behind the diaphragm. For this reason, diaphragm pumps are especially reliable for pumping mud, slime, silt, and other wastes or heavy liquids containing debris, such as sticks, stones, or rags. Liquid strainers are fitted at the suction inlet to prevent large objects from fouling the suction and discharge valves or from damaging the diaphragm.

You can use the diaphragm pump for dewatering trenches where sewer lines or waterlines are to be laid or for repairing breaks in waterlines or sewer lines.

Two of the most popular types of diaphragm pumps are the mud hog (closed discharge) and the water hog (open discharge). The MUD HOG is for

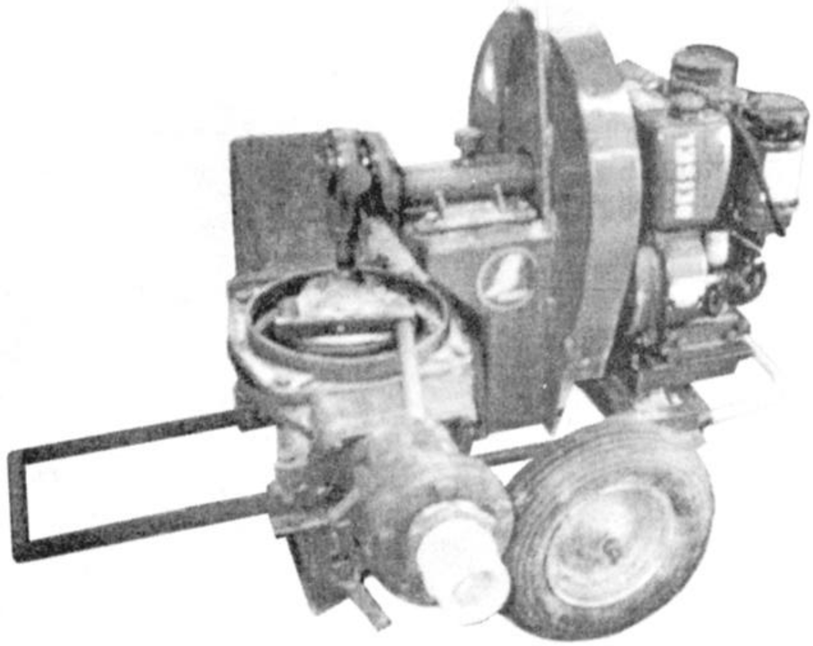


Figure 6-13.—Portable diaphragm pump.

pumping heavy and thick liquid long distances away from the pump. The pump is fitted with discharge hose connections, and the ball valves and chambers are designed to prevent fouling by sticks, stones, rags, and so on. The WATER HOG is used for pumping thinner and less viscous liquids; however, it can handle liquids containing sand, gravel, and mud. The discharge outlet from the water hog is open to permit free flow and increased discharge capacity. Thus the liquid is discharged directly at the pump. However, a discharge hose can be fitted to the pump if desired; but, the efficiency is reduced. Both the mud hog and water hog can be of either the simplex or duplex type.

Because of the nature of the liquids handled by diaphragm pumps, operator inspection during pump operation becomes particularly important. Make frequent inspections of the suction inlet strainer to prevent accumulation of debris that can reduce suction efficiency. Most diaphragm pump installations also permit easy access to the suction and discharge ball valves. The valve mechanisms can be inspected frequently to detect scoring, fouling, and improper valve seating. Because the diaphragm and ball-check valves are subjected to the corrosive action of such material as sand and gravel they require frequent attention. Therefore, operator maintenance schedules stress a continuing program of inspection and cleaning of these parts. In most cases, it is not practical to repair damaged or worn diaphragms and valves. They should be replaced with new ones; therefore, keep an adequate supply of these parts readily available.

The reciprocating pump shown in figure 6-12 is called a single or simplex pump because it has only one liquid cylinder. Simplex pumps are either direct acting or indirect acting. A double or duplex pump is an assembly of two single pumps placed side by side on the same foundation; the two steam cylinders are cast in a single block, and the two liquid cylinders are cast in another block. In a single-acting pump, the liquid is drawn into the liquid cylinder on the first or SUCTION STROKE and is forced out of the cylinder on the return or DISCHARGE STROKE. In a double-acting pump, each stroke serves both to draw in the liquid and to discharge the liquid. As one end of the cylinder is filled, the other end is emptied; on the return stroke, the end that was just emptied is filled and the end that was just filled is emptied. The pump shown in figure 6-12 is double acting, as are most of the reciprocating pumps used in the Navy. (NOTE: Only one of two sets of valves is shown in figure 6-12.)

The pump shown in figure 6-12 is designed to operate with a discharge pressure higher than the pressure of the steam operating the piston in the steam cylinder; in other words, it is a high-pressure pump. In a high-pressure pump, the steam piston is larger in diameter than the plunger in the liquid cylinder. Since the area of the steam piston is greater than the area of the plunger in the liquid cylinder, the total force exerted by the steam against the steam piston is concentrated on a smaller working area of the plunger in the liquid cylinder. Because of this factor, the pressure per square inch is greater in the liquid cylinder than in the steam cylinder. A high-pressure pump discharges a comparatively small volume of liquid against high pressure. A low-pressure pump, on the other hand, has a comparatively low discharge pressure but a larger volume of discharge. In a low-pressure pump, the steam piston is smaller than the plunger in the liquid cylinder.

Finally, the pump shown in figure 6-12 is classified as vertical because the steam piston and the pump plunger move up and down. Most reciprocating pumps in naval use are vertical; however, you may occasionally encounter a horizontal pump where the piston moves back and forth instead of up and down.

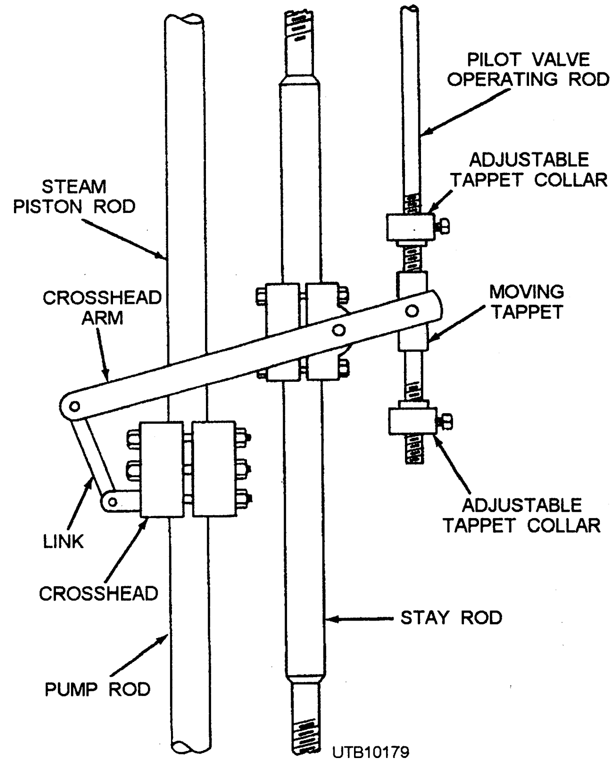


Figure 6-14.—Valve operating assembly for reciprocating pump.

OPERATION AND MAINTENANCE OF RECIPROCATING PUMPS.—The power end of a reciprocating pump consists of a bored cylinder in which the steam piston reciprocates. The steam cylinder is fitted with heads at each end; one head has an opening to accommodate the piston rod. Steam inlet and exhaust ports connect each end of the steam cylinder with the steam chest. Drain valves are installed in the steam cylinder, so water, resulting from condensation, can be drained off.

The admission and release of steam to and from each end of the steam cylinder are automatically timed by a valve operating assembly (fig. 6-14) that connects the pilot valve operating rod and the pump rod. As the crosshead arm (sometimes called the rocker arm) is moved up and down by the movement of the pump rod, the moving tappet slides up and down on the pilot valve rod. The tappet collars are adjusted, so the pump makes the full-designed stroke.

The piston-type valve gear, commonly used for automatic timing, consists of a piston-type slide valve and a pilot slide valve. The position of the pilot slide valve is controlled by the position of the main piston in the steam cylinder. At the completion of the downstroke of the pump, the crosshead arm moves the moving tappet against the upper adjustable tappet collar to actuate the pilot slide valve that admits steam to reposition the floating piston. The movement of the floating piston opens ports to admit steam to the underside of the piston in the steam cylinder and to exhaust the steam above the piston, thus causing the piston to move upward. Once the pump has completed the upstroke, the cycle repeats itself in reverse.

Reciprocating pumps are easy to operate and usually are very reliable units; however, they require routine maintenan ce and occasional repair work. Consult the manufacturer's technical manual for details on the repair of a specific unit. Before repairing or examining a pump, assemble the pertinent blueprints, drawings, and available data. These drawings and data furnish the required clearances, tools to be used, measurements, information on materials to be used, and other important data. In addition, you should have the complete history of the pump being repaired so you know what has been done, when repairs were last made, and what kind of trouble has been encountered before with this pump.

Remember that the steam end of a reciprocating pump should NOT be dismantled until a thorough check reveals that the water end is satisfactory. Most reciprocating pump troubles result from fouled water cylinders, from worn valves, or from faulty conditions in the pipe connections external to the pump.

Centrifugal Pumps

When a body, or a liquid, is made to revolve or whirl around a point, a force is created that impels the body or fluid to move outward from the center of rotation. This phenomenon is called CENTRIFUGAL FORCE. It is from this force that the centrifugal pump got its name.

The basic centrifugal pump has only one moving part-a wheel or impeller that is connected to the drive shaft of a prime mover and rotates within the pump casing. The design, or form, of the impeller varies somewhat. However, whatever its form, the impeller is designed to impart a whirling or revolving motion to the liquid in the pump. When the impeller rotates at relatively high speeds, sufficient centrifugal force is developed to throw the liquid outward and away from the center of rotation. Thus the liquid is sucked in at the center or eye of the impeller (center of rotation) and discharged at the outer rim of the impeller. Note that by the time the liquid leaves the impeller, it has acquired considerable velocity. In this connection, a fundamental law of liquid physics states, in part, that as the velocity of a fluid increases, the pressure or pressure head of that fluid decreases. Therefore, the liquid discharge from the impeller has a high velocity but low pressure. Before the liquid can be discharged from the pump, an INCREASE in pressure is necessary. In other words, the primary concern in practically all pumping systems is to maintain the discharge pressure so liquid can be distributed effectively throughout the system. In centrifugal pumps, a device is required to decrease the velocity of the impeller discharge and thereby increase the liquid pressure at the discharge outlet.

One method of increasing the discharge pressure of centrifugal pumps is by providing additional impellers. Pumps with only one impeller are SINGLE STAGE. Pumps with two or more impellers are MULTISTAGE. In multistage pumps, two or more impellers are placed on a common shaft (within the same pump housing) with the discharge of the first impeller being led into the suction of the next impeller, and so on. As the liquid passes from one stage to the next, additional pressure is imparted to it. In this fashion, the final discharge pressure of the pump can be increased considerably.

TYPES OF CENTRIFUGAL PUMPS.— Centrifugal pumps are also HORIZONTAL or VERTICAL, depending upon the position of the pump shaft. Generally, large, multistage, high-capacity pumps are horizontal. Most other pumps are vertical. The impellers used on centrifugal pumps may be SINGLE SUCTION or DOUBLE SUCTION. The single-suction impeller allows liquid to enter the eye from one direction only; the double-suction type allows liquid to enter the eye from two directions.

Impellers are CLOSED or OPEN. Closed impellers have sidewalls extending from the eye to the outer edge of the vane tips; open impellers do not have these sidewalls. Most centrifugal pumps in the Navy have closed impellers.

In the VOLUTE type of centrifugal pump shown in figure 6-15, the impeller discharges into a volute or gradually widening channel in the pump casing. As the liquid passes into the expanding neck of the volute, its velocity is considerably diminished; and, with this decrease in velocity, the pressure increases.

Another variation is the DIFFUSER or VOLUTE TURBINE type of centrifugal pump shown in figure 6-16. In this pump, the impeller discharges into

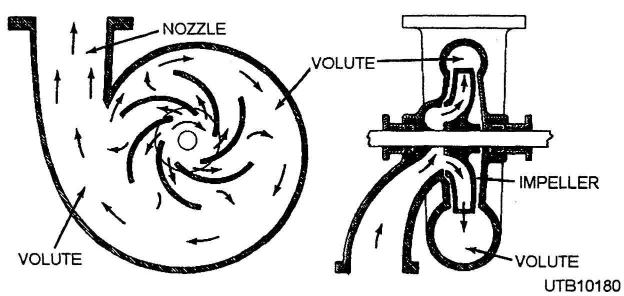


Figure 6-15.—Volute pump.

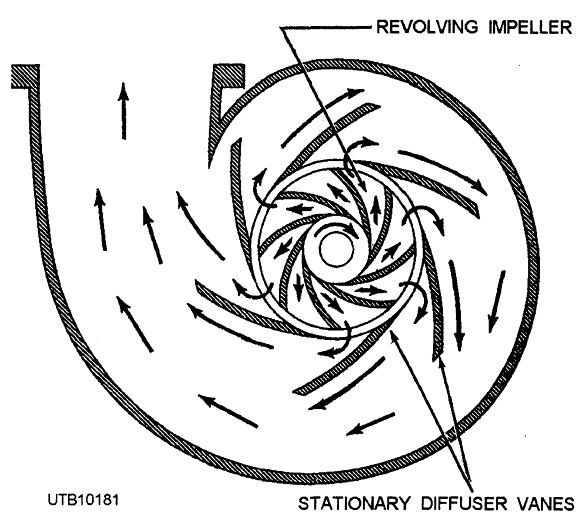


Figure 6-16.—Diffuser-type centrifugal pump.

stationary diffuser vanes surrounding the impeller. The diffuser vanes force a rather radical change in the direction of the impeller discharge, and this, in turn, slows down the discharge. In addition, the diffuser vanes form volutes of their own that further diminish the velocity of the discharge. Finally, the discharge from the diffuser vanes flows along the pump casing which, like the simple volute-type pump, is also in the form of a volute. Thus the diffuser-type pump provides for a nearly complete decrease in velocity and consequently an increase in discharge pressure.

The types of centrifugal pumps used for pumping sewage do not use diffuser vanes. The reason for this is that the rapid change in the direction of the impeller discharge can cause suspended matter in the liquid to come out of suspension and form deposits that corrode and foul moving parts.

Other types of centrifugal pumps, known as turbine well pumps, are used to pump wells. To produce sufficient discharge pressure, you must equip these pumps with a multistage impeller arrangement that is contained in volutes, referred to as bowls. To ensure satisfactory suction, set the impellers and bowls below the lowest drawdown or pumping level that the water in the well is expected to reach.

USE OF CENTRIFUGAL PUMPS.—The applications of centrifugal pumps are numerous; however, these pumps are most often used in buildings for the following purposes:

- To pump the general water supply. This includes both the overhead and pneumatic tank systems. In general water supply systems where the pump takes off directly from the city pressure main or where no suction lift is required, a centrifugal pump can be used. When a centrifugal pump is being used with a suction lift of no more than 15 feet is required, a pump with an automatic primer or a suction line equipped with a foot valve may be used.

- To provide booster service. In booster service, centrifugal pumps with in-take pressures from the city main operate only to boost this pressure. They may run continuously or automatically. When the automatic type is not operating, the water flows by city pressure through the impellers.

- To pump the domestic water supply. In domestic water supply systems, the centrifugal pump is used in shallow wells (suction lift not over 22 feet), in deep wells (for greater depths than 22 feet), and in a complete pneumatic system with electric motors or gasoline engines.

- To support the fire protection systems. Fire pumps usually are the centrifugal type, either single or multistage. Electricity, steam, or gasoline may drive them. Whatever the power supply, it must be permanent and, if steam, must have a constant minimum pressure of 50 pounds of steam. The pumps should agree with the specifications of the NFPA. Booster fire pumps have a low head to boost the pressure of the already available city supply

- To provide a hot-water circulating service. Hot-water circulating pumps are centrifugal. They move water in a closed system and thus usually require only a low head, though the static pressure in the systems may be high. The pumps should be selected with attenti on to strength of casing, efficient stuffing box, freedom from air and vapor binding, and flexible mounting.

- To provide sump drainage. Sump pumps are not classified as sewage pumps; however, they can be used as such. They may be vertical or horizontal centrifugal. The vertical type sump pump usually has the impeller submerged and the motor mounted above the pit. Units are equipped with an automatic switch operated by the float and are available in single or duplextype (fig. 6-17).

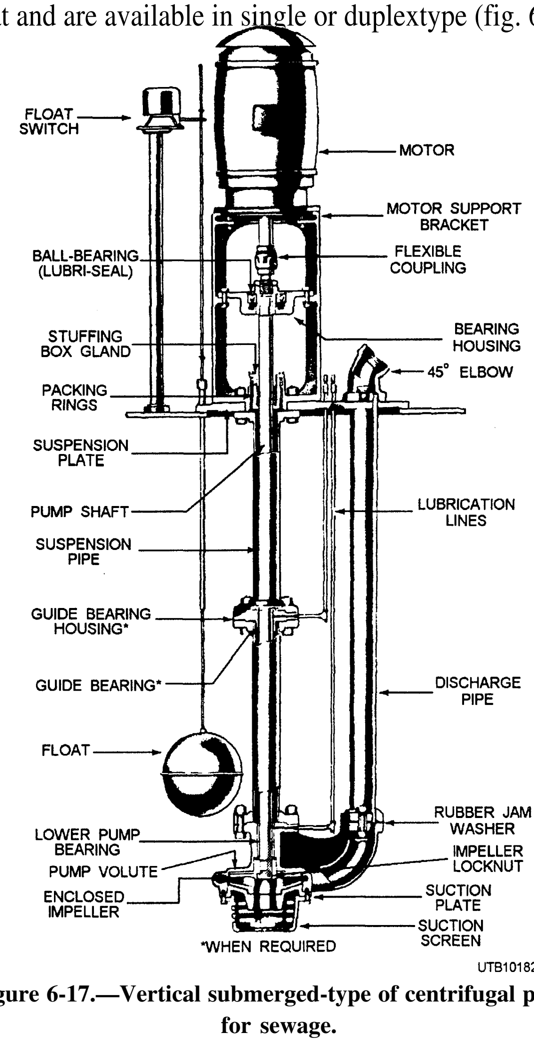


Figure 6-17.—Vertical submerged-type of centrifugal pump for sewage.

- To pump sewage. Sewage ejector pumps (fig. 6-18) for dry-pit installations have a connection on the suction end of the pump that is piped to a separate wet pit.

The dry-basin type of sewage ejector pump equipment includes the following:

- The pump with suction and discharge piping up to the floor plate
- An electric motor, a steel ejector basin with separate sewage and pump compartments
- A high-water alarm
- An automatic alternator
- Float switches
- A floor-mounted control panel
- Motor switches
- Automatic starters
- An iron access ladder
- Complete basin covers welded or riveted to the basin

The wet-basin (duplex wet-basin nonclog sewage ejector) type of sewage ejector pump equipment includes the following:

- The pump and fittings
- Electric motors
- Float switches

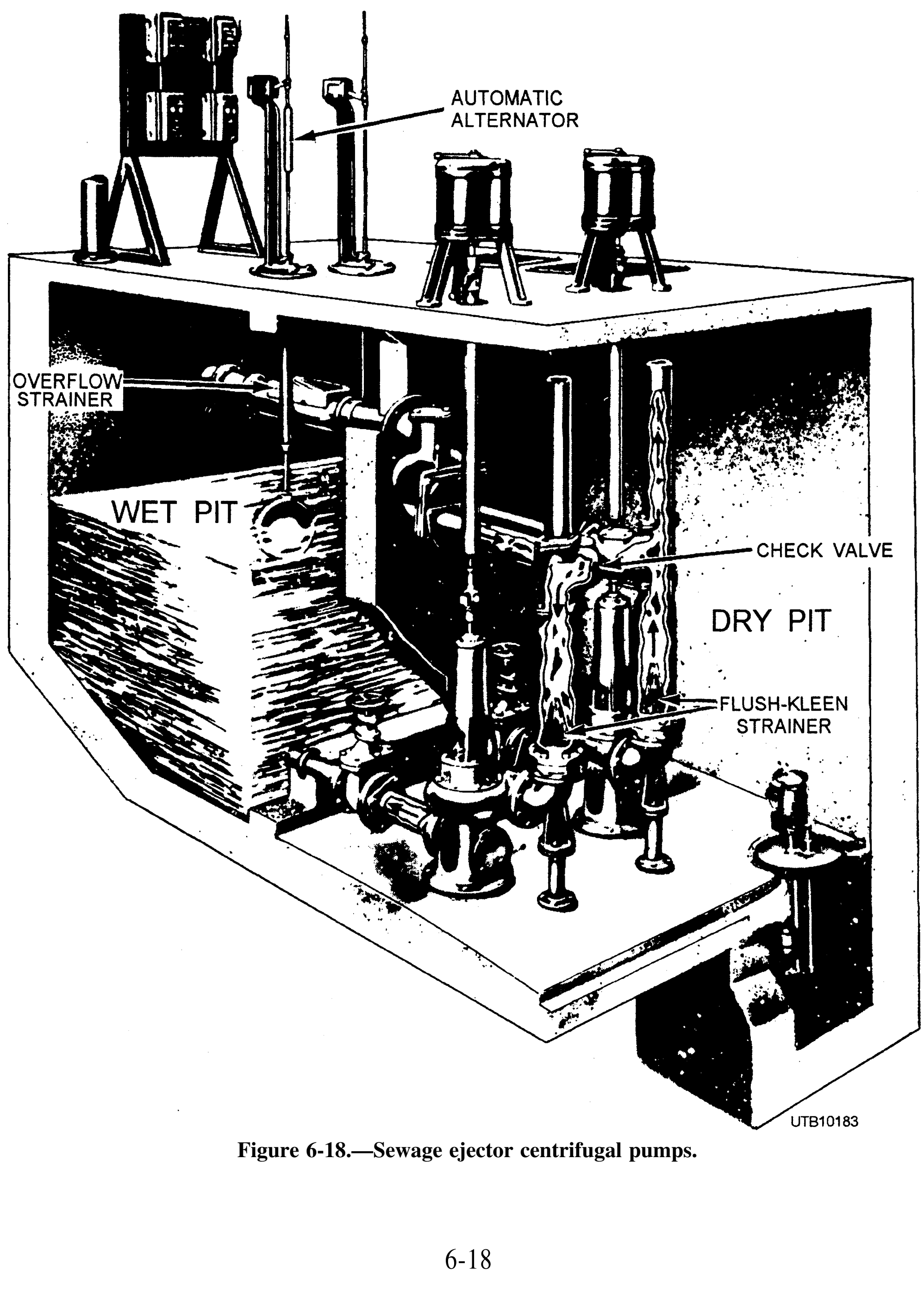


Figure 6-18.—Sewage ejector centrifugal pumps.

- An automatic alternator
- High-water alarm
- Motor switches
- Automatic starters

The centrifugal type of sewage pump has nonclogging impellers. It can be installed in either a horizontal configuration or in a vertical configuration with a suction lift. The centrifugal pump can be placed in either a wet or dry pit and is equipped with a float or diaphragm for automatic operation.

ADVANTAGES AND DISADVANTAGES OF CENTRIFUGAL PUMPS.—The advantages of centrifugal pumps include simplicity, compactness, weight saving, and adaptability to high-speed prime movers. One disadvantage of centrifugal pumps is their relatively poor suction power. When the pump end is dry, the rotation of the impeller, even at high speeds, is simply not sufficient to lift liquid into the pump; therefore, the pump must be primed before pumping can begin. For this reason, the suction lines and inlets of most centrifugal pumps are placed below the source level of the liquid pumped. The pump can then be primed by merely opening the suction stop valve and allowing the force of gravity to fill the pump with liquid. The static pressure of the liquid above the pump also adds to the suction pressure developed by the pump while it is in operation. Another disadvantage of centrifugal pumps is that they develop CAVITATION. Cavitation occurs when the velocity of a liquid increases to the point where the consequent pressure drop reaches the pressure of vaporization of the liquid. When this happens, vapor pockets, or bubbles, form in the liquid and then later collapse when subjected to higher pressure at some other point in the flow. The collapse of the vapor bubbles can take place with considerable force. This effect, coupled with the rather corrosive action of the vapor bubbles moving at high speed, can severely pit and corrode impeller surfaces and sometimes even the pump casing. In extreme instances, cavitation has caused structural failure of the impeller blades. Whenever cavitation occurs, it is frequently signaled by a clearly audible noise and vibration (caused by the violent collapse of vapor bubbles in the pump).

Several conditions can cause cavitation, not the least of which is improper design of the pump or pumping system. For example, if the suction pressure is abnormally low (caused perhaps by high suction lift or friction losses in the suction piping), the subsequent pressure drop across the impellers may be sufficient to reach the pressure of vaporization. A remedy might be to alter the pump design by installing larger piping to reduce friction loss or by installing a foot valve to reduce suction lift.

Cavitation can also be caused by improper operation of the pump. For instance, cavitation can occur when sudden and large demands for liquid are made upon the pump. As the liquid discharged from the pump is rapidly distributed and used downstream, a suction effect is created on the discharge side of the pump. Think of it as a pulling action on the discharge side that serves to increase the velocity of the liquid flowing through the pump. Thus, as the pressure head on the discharge decreases, the velocity of the liquid flowing across the impellers increases to the point where cavitation takes place. Perhaps the easiest way to avoid this condition is to regulate the liquid demand. If this is not possible, then increase the suction pressure by some means to maintain pressure in the pump under these conditions.

OPERATION AND MAINTENANCE OF CENTRIFUGAL PUMPS.—The operating procedures and maintenance schedules for centrifugal pumps are generally similar to those of the other pumps we have discussed previously. Centrifugal pumps are also fitted with stuffing boxes and various types of bearings that, of course, require periodic maintenance and inspection. Always refer to the manufacturer's instructions and locally prepared maintenance schedules for operating and maintenance procedures.

One operating practice is common to nearly all types of centrifugal pumps. Unlike positive displacement pumps, the discharge stop valve on centrifugal pumps must. be CLOSED before starting the pump. This action allows the pump to work against the sealed discharge and builds up an effective pressure head before attempting to move and distribute the liquid downstream. After the pump is up to speed and the discharge valve is opened, the pump continues to maintain that pressure head unless the operating conditions are altered. Note that there is no danger of hydraulicking while the pump is run with the discharge closed. If the centrifugal pump were to continue operation with the discharge sealed, it would simply build up toward its maximum discharge pressure. It would then begin to churn the liquid; that is, the discharge pressure would overcome the suction pressure and the liquid would continually slip back to the suction side of the pump. Nothing more would happen, except the pump would build up heat, since the liquid would not be able to carry away the heat generated by the moving parts.

There are several exceptions to the rule outlined above. For instance, when there are other pumps operating in parallel with the centrifugal pump discharging into a common system, these pumps provide the centrifugal pump with an effective pressure head to start against. Another exception is the turbine well pump. This pump always has a pressure head to start against, provided by the weight or static pressure of the water above the impellers. Therefore, a turbine well pump can usually be started with the discharge valve in the OPEN position. In the paragraphs below a few important aspects of pump operation and maintenance are discussed in detail.

One aspect of pump operation and maintenance is PACKING. Although this topic is included here under the general heading of centrifugal pumps, packing is used on many other types of pumps as well. Figure 6-19 shows packing installation procedures for centrifugal pumps. Packing is a general term that refers to many different types of materials used to seal moving machinery joints (sliding pistons and piston rods, rotating shafts and valve stems, etc.) against leakage of steam or liquids. As such, packing can be thought of as a close fitting bearing that must not onlv

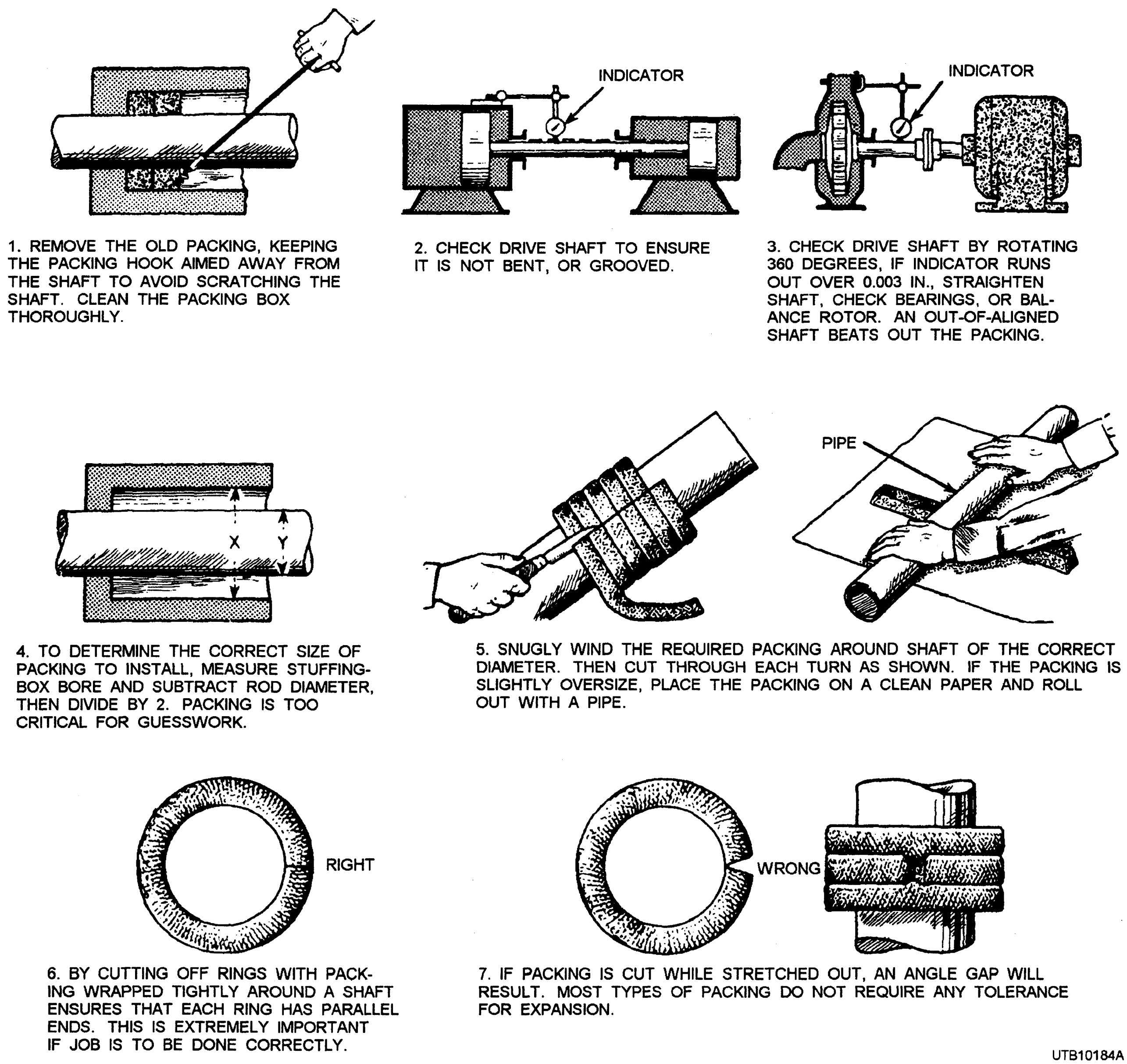


Figure 6-19.—Packing installation procedures.

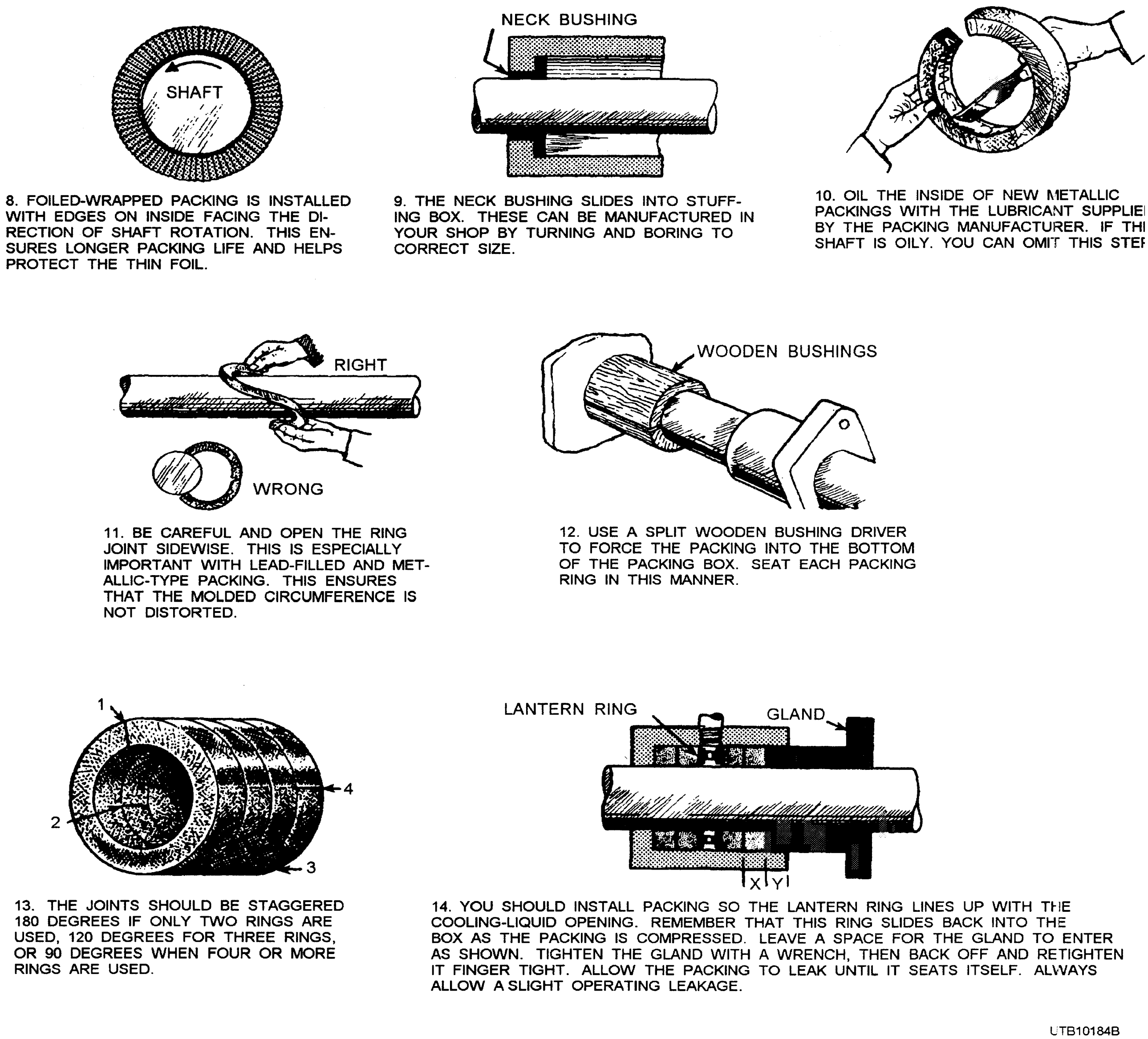


Figure 6-19.—Packing installation procedures-Continued.

prevent leakage but must also do this without causing excessive friction and undue wear of the moving part. Although most packing has definite lubricating qualities of its own, lubrication is enhanced by permitting small amounts of liquid or steam to leak past or through the packing. If the pump is used for corrosive or abrasive fluids, then some other form of lubricant, such as grease or oil, must be fed to the packing through external means.

Packing usually takes the form of coils, rings, or spirals. The packing is inserted into a stuffing box fitted around the sliding or rotating joint. The compression of the packing around the joint is controlled by hand-adjusted gland nuts.

The selection of the proper type of packing for a pump is important. There is no general-purpose or all-purpose packing. The specific type of packing that must be used depends on several factors, such as whether the packing seals a rotating or sliding joint and the type of liquid handled by the pump. In any event, you do not have to select the packing. Locally prepared guides and manufacturer's instructions specify what type of packing material to use. Upon receipt of the packing, note its condition and the use date stamped on the package to help you determine the shelf life of the packing. If a package has become unsealed, reseal it. Better yet, ensure the packing is used before its expiration date.

Packing requires frequent inspection and adjustment, particularly while the pump is in operation. The gland nuts must be adjusted with care, so ail the packing is compressed evenly and equally around the joint. If not, excessive and uneven wear of the packing can result, and the rotating or sliding shaft could become scored or grooved.

When a pump is first started, lubrication of the packing may be relatively poor. Because of initial friction, the packing may heat up and expand, thereby compressing itself around the joint and further reducing lubrication or leakage. Merely loosening or backing off the gland nuts is not always the best solution, because the liquid pressure in the pump can force the complete set of packing to move outward in the stuffing box. In this instance, the pump has to be shut down and the stuffing box allowed to cool. Several restarts may be necessary before the stuffing box runs cool.

Additional packing procedures are too extensive to be covered here. The primary purpose of this discussion of packing is to alert you to the importance of this pump component. It has been said that the proper inspection, adjustment, and upkeep of the packing are the most abused aspects of pump operation and maintenance.

Another important aspect of pump operation and maintenance is the understanding of mechanical seals. Mechanical seals are rapidly replacing conventional packing as the means of controlling leakage on centrifugal pumps. Pumps fitted with mechanical seals eliminate excessive stuffing box leakage that results in pump and motor bearing failures and motor winding failures. Mechanical seals are ideal for pumps operating in closed systems, such as air-conditioning and chilled water systems.

Type 1 mechanical seal is shown in figure 6-20. Spring pressure keeps the rotating seal face snug against the stationary seal face. The rotating seal and all of the assembly below it are affixed to the pump shaft. The stationary seal face is held stationary by the seal gland and packing ring. A static seal is formed between the two seal faces and the sleeve. System pressure within the pump assists the spring in keeping the rotating seal face tight against the stationary seal face. The type of material used for the seal faces

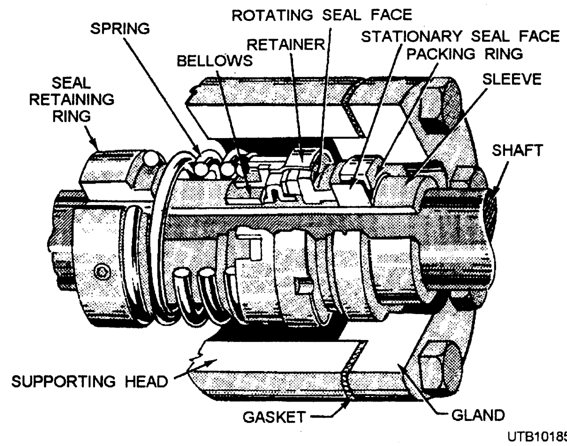


Figure 6-20.—Type 1 mechanical seal.

depends upon the service of the pump. Most water service pumps use a carbon material for the seal faces. When the seals wear out, they are replaced. New seals should not be touched on the sealing face because body acid and grease cause the seal face to pit prematurely and deteriorate.

Mechanical seals should be replaced whenever the seal is removed for any reason or whenever the leakage rate exceeds 5 drops per minute.

Mechanical seals are positioned on the shaft by means of stub or step sleeves. Mechanical seals should not be positioned by the use of setscrews. Shaft sleeves are chamfered on outboard ends to provide ease of mechanical seal mounting. Mechanical seals ensure that positive liquid pressure is always supplied to the seal faces and that the liquid circulates well at the seal faces to minimize the deposit of foreign matter on the seal parts.

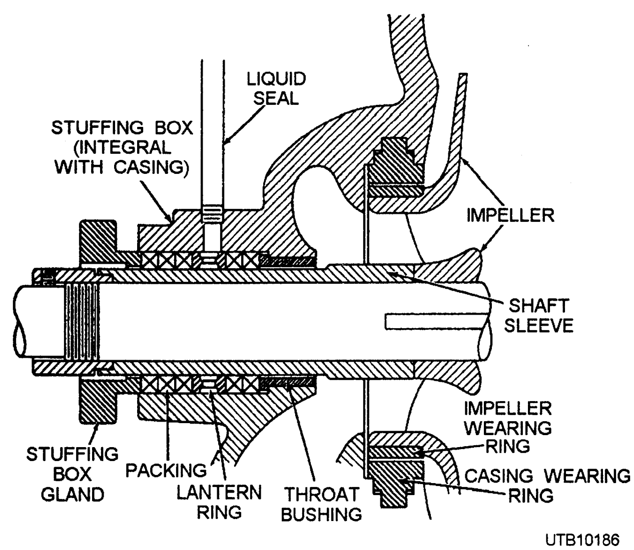


Figure 6-21.—Stuffing box on centrifugal pump.

When a stuffing box is fitted with a lantern ring, be sure to replace the packing beyond the lantern ring at the bottom of the stuffing box, and be sure that the sealing water connection to the lantern ring is not blanked off by the packing (fig. 6-21). Sleeves fitted at the packing on the pump shafts must always be tight. These sleeves are usually made secure by shrinking or keying them to the shaft. Be careful to ensure the water does not leak between the shaft and the shaft sleeves.

In some pumps, the shaft sleeve is pressed onto the shaft tightly by means of a hydraulic press, and the old sleeve must be machined off in a lathe before a new one can be installed. On other centrifugal pumps, the shaft sleeve is a snug slip-on fit, butted up against a shoulder on the shaft and held securely in place with a nut. On some small pumps, new sleeves can be installed by removing the water end casing, impeller, and old shaft sleeves. New sleeves are carried as repair parts, or they can be made in the machine shop. On large pumps, the sleeves are usually pressed on; these pumps must be disassembled and taken to the machine shop, a repair ship, or a Navy yard to have the old sleeve machined off and a new one pressed on.

Some sleeves are packed to prevent water leakage between the shaft and the sleeve, while some have O rings between the shaft and the abutting shoulder. For detailed information, consult the appropriate manufacturer's technical manual or applicable blueprints.

Shaft alignment must be checked frequently. When the shafts are out of line, the unit must be realigned to prevent shaft breakage and damage to the bearings, the pump casing wearing rings, and the throat bushings. Shaft alignment should be checked with all piping in place.

A FLEXIBLE COUPLING may connect the driving unit to the pump. You should remember that flexible couplings (fig. 6-22) are intended to take care of only slight misalignment. Misalignment should never exceed the amount specified by the pump manufacturer. When there is excessive misalignment, the coupling parts are punished severely, and pins, bushings, and bearings have to be frequently replaced.

The driving unit may be connected, or coupled, to the pump by a FLANGE COUPLING. Frequent realignment of the shaft may be necessary. Each pump shaft must be kept in proper alignment with the shaft of the driving unit. Abnormal temperatures, abnormal noises, and worn bearings or bushings indicate misalignments.

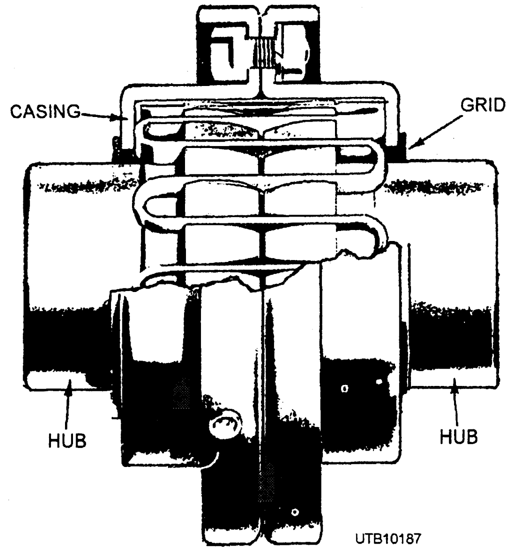


Figure 6-22.—Grid-type flexible coupling.

Wedges, or shims, are placed under the bases of both the driven and driving units to facilitate alignment when the machinery is installed. Jacking screws can also be used to level the units. When the pump or driving unit, or both, need to be shifted sideways to align the couplings, side brackets are welded in convenient spots on the foundations, and large setscrews are used to shift the units sideways or endwise. When the wedges or other packing have been adjusted so the outside diameters and faces of the coupling flanges run true as they are manually revolved, the chocks should be fastened, the units should be securely bolted to the foundation, and the coupling flanges should be bolted together.

These ALIGNMENTS MUST BE CHECKED from time to time and misalignments promptly corrected. There are three devices in use for checking the alignments-a 6-inch scale, a thickness gauge, and a dial indicator.

Shaft alignment should be checked whenever the pump is opened up and whenever a noticeable vibration is observed. When shafts are found out of line or inclined at an angle to each other, the unit should be aligned to avoid shaft breakages and renewal of bearings, pump casing wearing rings, and throat bushings. The appropriate technical manual should be consulted when you are aligning the pump.

In a centrifugal pump installation fitted with an internal water-lubricated bearing inside the pump casing (such as condensate pumps), an adequate supply of clean water must be supplied to the bearing for lubricating and cooling. Several of the following types of materials are used for internal water-lubricated

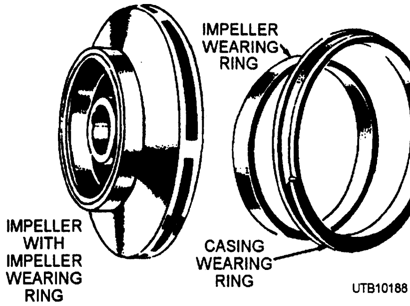


Figure 6-23.—Impeller, impeller wearing ring, and casing wearing ring for a centrifugal pump.

bearings-laminated phenolic material grade FBM (fabric-based Bakelite or Micarta), high lead content bronze, graphite bronze, and lignum vitae.

The condition of all types of internal water-lubricated bearings should be checked frequently to guard against excessive wear which can result in misalignment and shaft failure.

As for oil-lubricated sleeve or shell-type bearings, the bearing clearances should be measured following procedures described for the pump, and clearances should be maintained within the limits specified in the manufacturer's technical manual.

The clearance between the impeller wearing ring and the casing-wearing ring (fig. 6-23) must be maintained, as shown in the manufacturer's plans. When clearances exceed the specified figures, the wearing rings must be replaced. This replacement requires the complete disassembly of the pump. Information on disassembly of the unit, dimensions of the wearing rings, and reassembly of the pump is in the manufacturer's technical manual. (Wearing rings are located on the main feed pump, as shown in figure 6-24.)

When deciding whether the wearing rings need renewing, you must consider the capacity of the pump and the discharge pressure of the pump. On low-pressure pumps, the wearing ring diametrical clearance may be 0.015 to 0.030 inch more than the designed amount without any appreciable effect on the capacity of the pump. For pumps with a discharge pressure up to 75 psi, a wear of 0.030 to 0.050 inch is permissible.

The percentage of capacity loss with a 0.030-inch wearing ring clearance in excess of standard may be large with a small pump but comparatively small with a large pump. For high-pressure boiler feed pumps, the effect of increased wearing ring clearance is readily noticeable in the efficiency and maximum capacity of the pump. For high-pressure pumps, the wearing rings should be renewed when the clearance shown on the manufacturer's plans is exceeded by 100 percent. It is usually not necessary to renew wearing rings uniess the wear is at least 0.015 inch. If a pump has to be disassembled because of some internal trouble, you should check the wearing rings for clearance. Measure

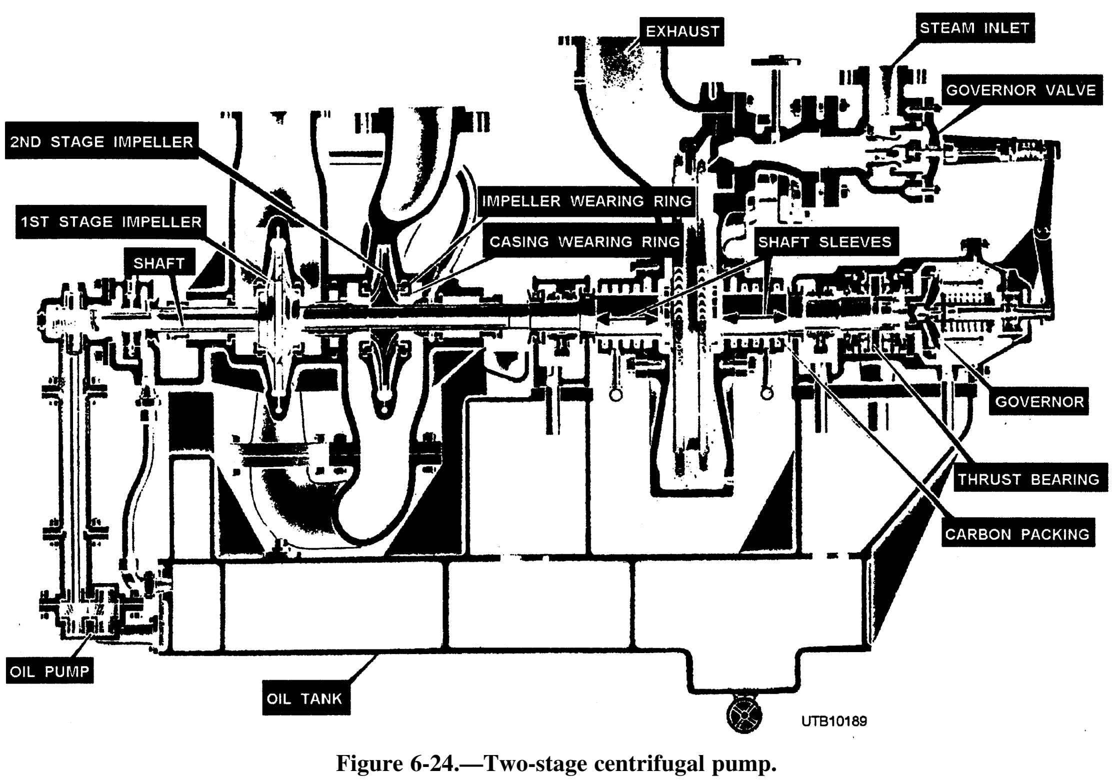


Figure 6-24.—Two-stage centrifugal pump.

the outside diameter of the impeller wearing ring with an outside micrometer and the inside diameter of the casing-wearing ring with an inside micrometer; the difference between the two diameters is the wearing ring diametrical clearance. By checking the wearing ring clearance with the maximum allowable clearance, you can decide whether to renew the rings before reassembling the pump.

The amount of work in disassembling the pump, the length of time the pump can be out of commission without affecting the command, and whether a repair shop or other repair activity are needed are some factors to consider when determining whether to renew wearing rings.

Wearing rings for most small pumps are carried aboard as part of the command's repair parts allowance. These may need only a slight amount of machining before they can be installed. For some pumps, such as main condensate and main feed booster pumps, spare rotors are carried. The new rotor can be installed and the old rotor sent to a repair activity for overhaul. Overhauling a rotor includes renewing the wearing rings, the bearings, and the shaft sleeve.

OPERATING TROUBLES.—Some of the operating troubles with centrifugal pumps and probable causes are given in table 6-1.

Table 6-1.—Centrifugal Pump Operating Troubles

Indication of Trouble	Cause
No liquid delivered	Pump needs primed Pump speed too low Discharge head too high Suction lift too high Impeller plugged up Incorrect pump rotation Impeller installed backward
Not enough liquid delivered	Suction pipe air leak Stuffing box air leak Pump speed too low Pump rotation incorrect Impeller installed backward Suction lift too high Suction line not completely submerged Impeller partially clogged Insufficient suction pressure (indicated by noise and fluctuating pressure when pumping hot or volatile liquids] Worn wearing rings, damaged impeller, worn stuffing box packing or worn seal, or sleeves need replaced
Low pressure	Pump speed low Air or gas in liquid Pump rotation incorrect Pump impeller installed backward Mechanical defects (see causes in not enough liquid delivered above)

Table 6-1.—Centrifugal Pump Operating Trouble—Continued

Pump works a while, and then fails to deliver	Air leak in the suction line Air leak in the stuffing box Stuffing box water seal plugged Suction line not completely submerged Suction lift too high
Stuffing box leaks excessively	Speed too high Misalignment Bent shaft Interference between rotating and stationary parts Worn journal bearings Worn or scored shaft sleeves at packing Rotor out of balance Sealng liquid contains dirt and grit, causing scoring
Short life of packing	Speed too high Misalignment Bent shaft Interference between rotating and stationary parts Worn journal bearings Packing installed wrong Scored shaft sleeves at packing Wrong type of packing Rotor out of balance Packing gland too tight Sealing liquid contains dirt and grit, causing scoring
Pump consumes too much power	Pump speed too high Specific gravity or liquid viscosity is higher than pump is designed to handle Rotor binding, shaft bent, stuffing box too tight, wearing rings worn, or misalignment System head is different than pump rating
Overheating or seizing	Speed too high Misalignment, bent shaft Rotor out of balance Excessive bearing temperature Bearing incorrectly installed Bearing rusted from water entering housing

When the pump fails to build up pressure and the discharge valve is open and the pump speed is increased, the procedure to use consists of four steps as follows:

1. Secure the pump.
2. Prime the pump and ensure that all the air is expelled through the air cocks on the pump casing.
3. Open all valves on the pump suction line.

4. Start the pump again. If the pump is electric-driven, be sure the pump is rotating in the correct direction. If the discharge pressure is not normal when the pump is up to its proper speed, the suction line may be clogged or an impeller broken. It is also possible that air is being drawn into the suction line or into the casing. If any of these conditions exist, stop the pump, try to find the source of the trouble, and correct it, if possible.

Air-Lift Pumps

Air-lift pumps are used entirely in well pumping. Unlike the pumps studied earlier, the air-lift pump needs no moving or rotating mechanism to produce liquid movement. Instead, the pump uses compressed air to move or lift the liquid.

The air-lift pump operates on the principle that water mixed with air has less weight, or is more buoyant, than water without air. When compressed air is introduced, a mixture of water and air is formed in one leg of the U-shaped pipe, as shown in figure 6-25. The solid column of water in the other leg now has greater weight or is exerting a greater static pressure than the column containing air. Thus the air-water column is forced upward until it discharges over the top of the U-shaped pipe.

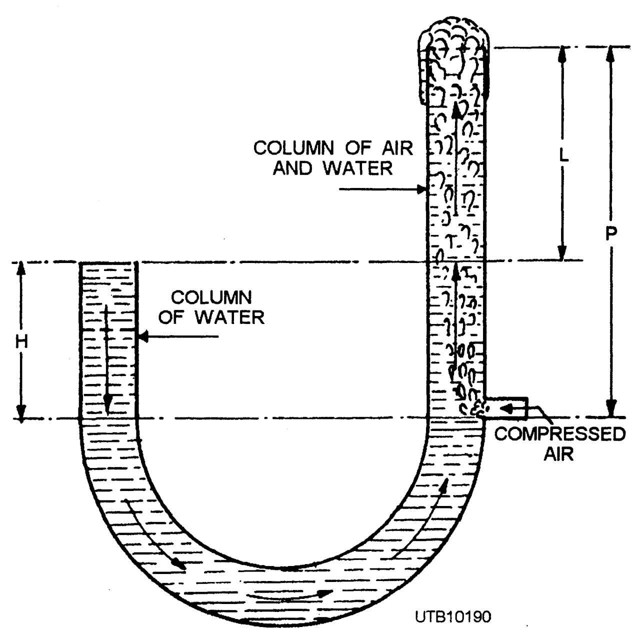


Figure 6-25.—Principles of an air-lift pump.

In practice, of course, wells are not dug in a U-shape. Figure 6-26 shows a CENTRAL AIR-LIFT PUMP. Compressed air is led down an air pipe to a nozzle or foot piece submerged well below the water

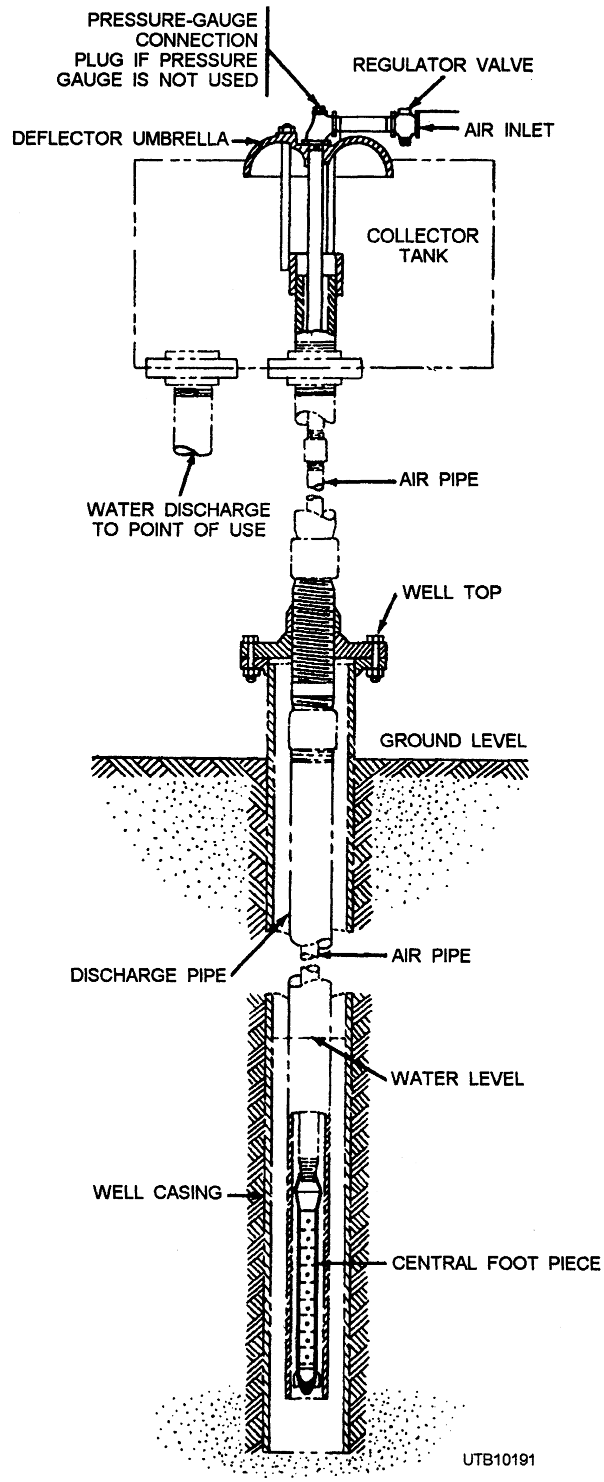


Figure 6-26.—Central air-lift pump.

level. Notice that the foot piece is suspended within a discharge pipe which, in turn, is contained within the well casing. Notice that the discharge pipe is open at the bottom, directly beneath the foot piece. When compressed air is discharged through the foot piece, a column or mixture of air is formed above the foot piece in the discharge pipe. The solid column of water in the well casing, resting high above the foot piece and discharge pipe inlet, now has greater weight or static pressure. This effect forces the air-water mixture upward in the discharge pipe where it is vented to the atmosphere through an open discharge outlet. In effect, the flow of water has a U-shape down the well casing, around the foot piece, and up the discharge pipe. The air-water discharge then strikes a separator or deflector that relieves the water of air bubbles and entrained air vapor. The discharge then settles in a collector tank.

The air-lift pump can deliver considerable quantities of water in the manner just described. The discharge pressure at which it is delivered, however, is relatively low. For this reason air-lift pumps cannot be used to discharge directly into a water distribution system. They do not develop sufficient pressure to distribute water horizontally above the ground for any appreciable distance, and the discharge can only be collected at the well for ground storage.

The capacity of the air-lift pump depends largely on the percentage of submergence of the foot piece; that is, the greater the submergence of the foot piece below the water level in the discharge pipe, the greater the volume (column) of water the pump can deliver per unit of time. However, the deeper the foot piece is submerged, the greater the compressed air pressure must be to lift the column of water. In other words, a higher column of water (in the discharge pipe) above the foot piece exerts a greater weight or pressure at the foot piece. The greater the static water pressure at the foot piece, the greater the air pressure must be to infuse air with the water.

Starting air pressure is always greater than working air pressure. When the pump is started, the static (at rest) level of water is drawn down somewhat to a pumping or working level. In effect, the column of water above the foot piece is decreased or lowered, and this, in turn, decreases the air pressure required to infuse the water with air. In wells where the drawdown is rather large, the pump is sometimes equipped with an auxiliary air compressor, connected in series with the main compressor, for starting. Once the pump has been started and the pumping level reached, the auxiliary compressor is no longer required and is secured.

Air-lift pumps have a low discharge pressure and require more depth so the foot piece can submerge deep enough. Additionally, the entrained oxygen in air-lifted water tends to make it more corrosive. In spite of these drawbacks, air-lift pumps have several advantages especially their simplicity of construction and lack of maintenance problems. Particularly useful in emergencies for deep well pumping, air-lift pumps can be used to pump crooked wells and wells with sand and other impurities. They can also pump hot-water wells with ease.

In air-lift pump operation, compressed air has to be regulated correctly. The amount of compressed air should be the minimum needed to produce a continuous flow of water. Too little air results in water being discharged in spurts, or not at all. Too much air causes an increase in the volume of discharge but at lower discharge pressure. If air is increased still further, discharge volume begins to decrease.

The air-lift pump is so simple in design that nearly all operating and maintenance inspections and procedures relate to the air compressor, which is described later.

Jet Pumps

Pumps that use the rapid flow of a fluid to entrain another fluid and thereby move it from one place to another are jet pumps. A jet pump contains no moving parts.

Jet pumps are EJECTORS that use a jet of steam to entrain air, water, or other fluid, and EDUCTORS that use a flow of water to entrain and thereby pump water. The basic principles of operation of these two devices are identical. The basic principle of operation of a simple jet pump of the ejector type is shown in figure 6-27. Steam under pressure enters the chamber through pipe A, which is fitted with a nozzle, B. As the steam flows through the nozzle, the velocity of the steam is increased. The fluid in the chamber at point F, in front of the nozzle, is driven out of the pump through the discharge line by the force of the steam jet. The size of the discharge line increases gradually beyond the chamber to decrease the velocity of the discharge and thereby transform some of the velocity head into pressure head. As the steam jet forces some of the fluid from the chamber into the discharge line, pressure in the chamber is lowered and the pressure on the surface of the supply fluid forces fluid up through the inlet, D,

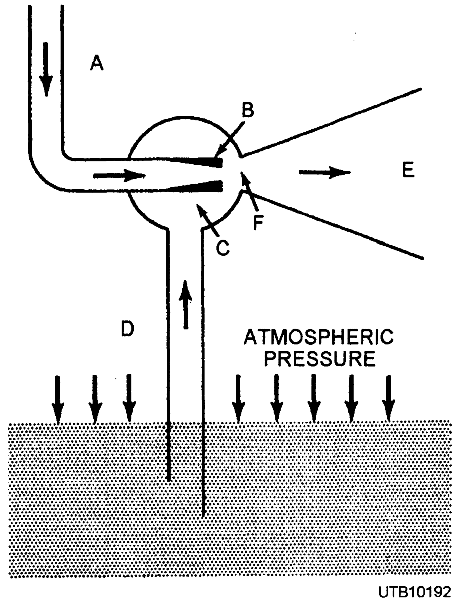


Figure 6-27.—Principle of operation of an ejector-type jet pump.

into the chamber and out through the discharge line. Thus the pumping action is established.

INSTALLATION OF PUMPS

From time to time, you will be installing prime movers, pumps, and air compressors. The secret of success in operating prime movers, pumps, and air compressors is their proper installation. That puts the success of their operation directly in your hands. If you do your job right and the equipment is properly installed, it should perform satisfactorily for a long time. Of course, proper care and maintenance are also essential for continued efficient operation; however, even with the most perfect care and maintenance, you will find it difficult or impossible to overcome faulty installation.

Since the procedures for installing prime movers, pumps, and air compressors are almost the same, only the basic steps of pump installation are discussed in this chapter. Remember that pumps, especially the centrifugal type, are built in many designs and for different purposes. Study the manufacturer's instruction manual for the equipment you are installing. Where specific directions or requirements are furnished, follow them.

When you receive a pump unit from supply, there are a few points to check. First, ensure it is the correct pump for the job by checking the nameplate data against that of the bill of material. Next, check the unit to ensure there are no missing or loose parts. If the unit has a preservative covering (exterior or interior), make certain it is removed before being installed.

When pumps are to be installed, the locations usually are determined in advance by higher authority and indicated on blueprints or sketches. However, you may have to decide where to put a pump. In most cases, place the pump as close as possible to the source of supply of water or other liquid, so the suction pipe is short and direct and the suction lift is comparatively low. With high-temperature liquids, a suction head is necessary. Place the pump where it can be readily inspected during operation, and see that headroom (a trap or ceiling opening) is there for the use of a crane, a hoist, or a tackle. If possible, select a dry place to protect the pump from the weather.

The foundation of a pump must be strong enough to absorb vibration and also to serve as a rigid support for the pump baseplate. A concrete foundation or a solid base is best. Foundation J-bolts are embedded in the concrete foundation according to a blueprint or a template. The bolts should be longer than needed (3/4 to 1 inch) to allow for shimming up the pump to make it level and for grouting under the pump base. A pipe sleeve, about 2 1/2 times the diameter of the bolt, allows for final positioning. If the bolt shown in figure 6-28 were 1 inch in diameter, a 2 1/2-inch pipe sleeve should be used. A small pump is normally aligned and the two major parts bolted together before leaving the factory. The parts normally do not require alignment after the pump has been set on the foundation. Be careful that you do not spring them out of alignment. Level the pump properly and secure it to the foundation. In setting the pump, you need a spirit level; place the level on the machined surfaces in two directions. To level, you may have to remove the top casing or bearing cover. If a large pump is shipped in sections, you have to align the water ends with the power ends after they have been placed on the foundation.

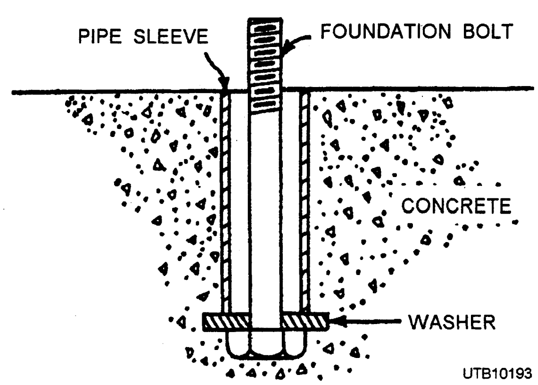


Figure 6-28.—Pipe sleeve and foundation bolt.

In leveling a pump unit, first use small metal wedges (fig. 6-29) and then place metal blocks and shims close to the foundation bolts. In each case, space the supports directly under the part carrying the most weight and close enough to give uniform support. Leave a gap of about 3/4 to 1 inch between the baseplate and the foundation for grouting with cement. (Grout is a mixture of cement, sand, and water, making up a thin mortar.) Figure 6-30 shows a baseplate of a pump unit grouted to the foundation, making angular alignment.

Adjust the supports or wedges until the shafts of the pump and the driver are level. Use a level to check the coupling faces and suction and discharge flanges to ensure that they are plumb and level. Correct the positions by adjusting the supports or wedges as required.

In addition to checking for parallel alignments, you should check the angular alignment between the pump shaft and the drive shaft. Insert a taper gauge or feeler at four points between the coupling faces, as shown in figure 6-31. The points should be spaced at 90-degree intervals around the coupling. When the measurements are all alike and the coupling faces are the same distance apart at the four points, the unit is in angular alignment. Correct any misalignment by adjusting the wedges or shims under the baseplate. Remember that an adjustment in one direction can disturb adjustments in another direction.

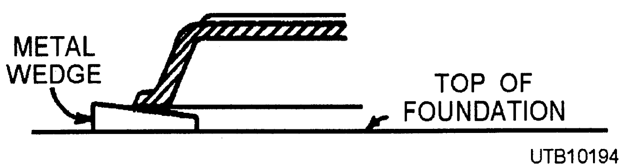


Figure 6-29.—Wedging a baseplate.

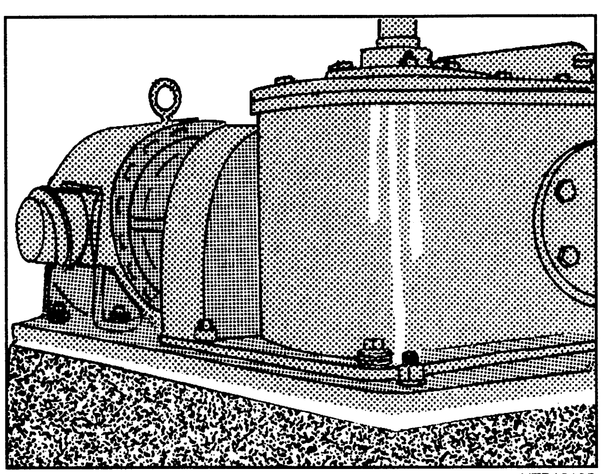


Figure 6-30.—Baseplate of a pump unit grouted to the foundation.

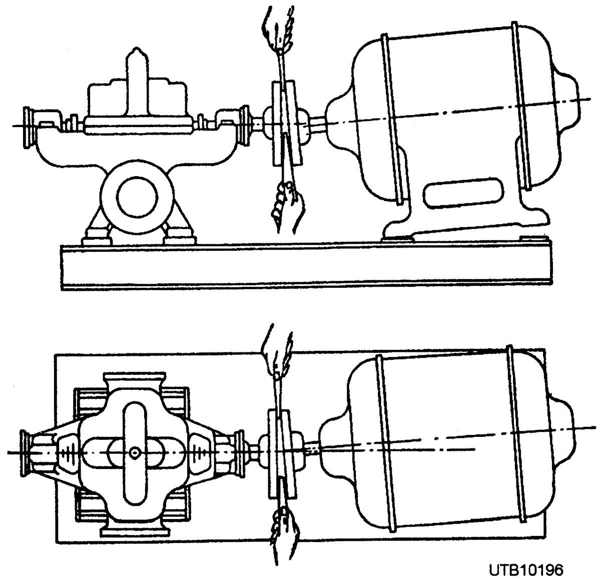


Figure 6-31.—Making angular alignment.

Many of the pumps used by the Navy are centrifugal pumps. Figure 6-32 shows a typical installation of a centrifugal pump. There are two types of assembly in which centrifugal pumps are delivered.

One group has the pump and the driver mounted on a common baseplate at the factory. The other group has only the pump mounted at the factory, so the driver must be positioned at the place of installation. In the former group, factory alignment may not have been maintained, as all baseplates are somewhat flexible. Therefore, you must realign the unit after it has been leveled on the foundation. To do this, first disconnect the coupling halves. Then follow the same alignment steps that have just been given. After completing these steps, reconnect the coupling and check it again for parallel and angular alignment. To install a centrifugal pump of the second group, you have a little extra work. After you have placed the baseplate with the pump on the foundation, you level, align, and bolt it. Next, place the driver on the baseplate according to the blueprints. Adjust the position of the driver and shim it up until the pump and driver half couplings are aligned. Then bolt it securely and proceed as in the other installation.

After you have correctly aligned the pump, tighten the foundation bolts evenly, but not too firmly. Then completely fill the baseplate with grout. Try to grout the leveling pieces, the shims, or the wedges in place. Foundation bolts should not be fully tightened until the grout has hardened, usually about 48 hours after pouring.

After the grout has set and the foundation bolts have been properly tightened, the pump should be

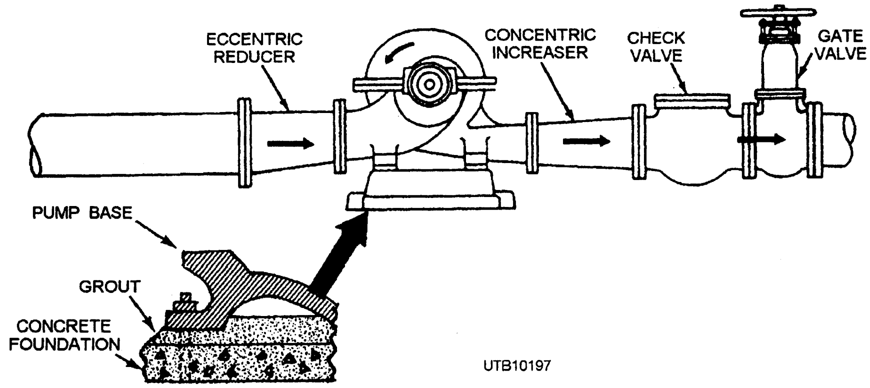


Figure 6-32.—Typical installation of a centrifugal pump.

checked again for parallel and angular alignment. You are now ready to connect the piping.

Piping

When installing the pump piping, be sure to observe the following precautions:

- Piping should always be run to the pump.
- Do not move the pump to the pipe. This could make final alignment impossible.
- Both the suction and discharge piping should be independently supported near the pump and properly aligned, so the strain is not transmitted to the pump when the flange bolts are tightened.
- Use pipe hangers or other supports at necessary intervals to provide support. When expansion joints are used in the piping system, they must be installed beyond the piping supports closest to the pump.
- Tie bolts should be used with expansion joints to prevent pipe strain. Do not install expansion joints next to the pump or in any way that would cause a strain on the pump, resulting from system pressure changes.
- It is usually advisable to increase the size of both the suction and the discharge pipes at the pump connections to decrease the loss of head from friction.
- Install piping as straight as possible, avoiding unnecessary bends. Where necessary, use 45-degree or long sweep 90-degree fittings to decrease friction losses.
- Make sure that all piping joints are airtight.
- Where flange joints are used, you must ensure that their inside diameters match properly.
- Remove burrs and sharp edges when marking up joints.
- Do not "spring" piping when marking connections.
- Provide for pipe expansion when hot fluids are to be pumped.

SUCTION PIPING.—When installing the suction piping, observe the precautions shown in figure 6-33. The sizing and installation of the suction

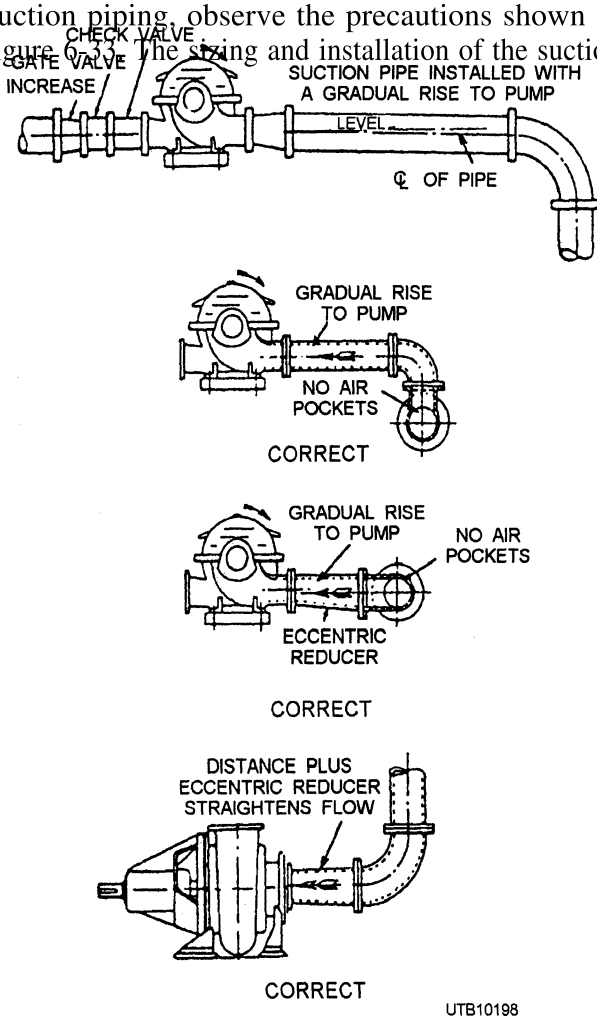


Figure 6-33.—Suction pipe installations.

piping are extremely important. The piping must be selected and installed, so pressure losses are minimized and sufficient liquid can flow into the pump when it is started and operated. Many net positive suction head (NPSH) problems can be directly attributed to improper suction piping systems.

Suction piping should be short in length, as direct as possible, and never smaller in diameter than the pump suction opening. If the suction pipe is short, the pipe diameter can be the same size as the suction opening. If longer suction pipe is required, pipes should be one or two sizes larger than the opening, depending on piping length.

Suction piping for horizontal double-suction pumps should not be installed with an elbow close to the suction flange of the pump. The only exception to this rule is when the elbow is in the vertical plane. A suction pipe of the same size as the suction nozzle approaching at any angle other than straight up or straight down has the elbow located ten pipe diameters from the suction flange of the pump. Vertically mounted pumps and other space limitations require special piping.

There is always an uneven turbulent flow around an elbow, and when it is in a position other than the vertical, it causes more liquid to enter one side of the impeller than the other (fig. 6-34). This results in high unequalled thrust loads that overheat the bearings and cause rapid wear in addition to affecting hydraulic performance.

When operating on a suction lift, you should ensure the suction pipe slopes upward to the pump nozzle. A horizontal suction line must have a gradual rise to the pump. Any high point in the pipe becomes filled with air and thus prevents proper operation of the pump. When reducing the piping to the suction opening diameter, use an eccentric reducer with the eccentric side down to avoid air pockets.

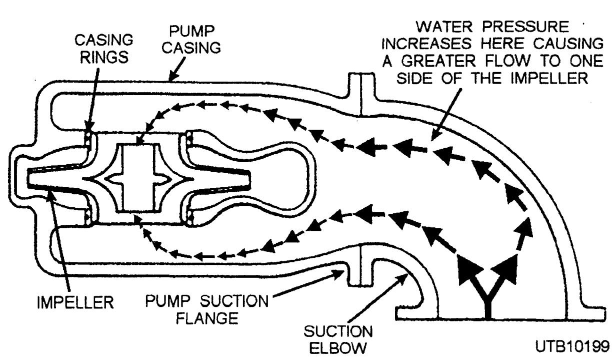


Figure 6-34.—Unbalanced loading of a double-suction impeller.

CAUTION

When operating on a suction lift, you should never use a straight taper reducer in a horizontal suction line, as it tends to form an air pocket in the top of the reducer and the pipe

To clean the pump liquid passage witnout dismantling the pump, bolt an increasing suction nozzle to the suction flange. If this is not done, a short section of pipe (Dutchman or spool piece), so designed that it can be readily dropped out of the line, can be installed adjacent to the suction flange. With this arrangement, any matter clogging the impeller is accessible by removing the nozzle (or pipe section).

DISCHARGE PIPING.—If the discharge piping is short, the pipe diameter can be the same size as the discharge opening. If the piping is long, the pipe diameter should be one or two sizes larger than the discharge opening. On long, horizontal runs, it is desirable to maintain as even a grade as possible. Avoid high spots, such as loops, that collect air and throttle the system or lead to erratic pumping.

VALVES IN PIPING.—When installing valves in the suction piping, observe the following precautions:

If the pump is operating under static suction lift conditions, a foot valve should be installed in the suction line to avoid the necessity of priming each time the pump is started. This valve should be of the flapper type, rather than the multiple spring type, and sized to avoid excessive friction in the suction line. (Under all other conditions, a check valve, if used, should be installed in the discharge line.)

When foot valves are used or where there are other possibilities of "water hammer," close the discharge valve slowly before shutting down the pump.

When two or more pumps are connected to the same suction line, install gate valves so any of the pumps can be isolated from the line. Gate valves should be installed on the suction side of all pumps with a positive pressure for maintenance purposes. Install gate valves with horizontal stems to avoid air pockets. Globe valves should not be used, particularly where NPSH is critical.

The pump must never be throttled by the use of a valve on the suction side of the pump. Suction valves. should be used only to isolate the pump for maintenance purposes and should always be installed in positions to avoid air pockets.

When installing valves in the discharge piping, you should install a check valve and gate valve in the discharge piping. The check valve, placed between the pump and the gate valve, protects the pump from excessive back pressure and prevents liquid from running back through the pump in case of power failure. The gate valve is used in priming, starting, and shutting down the pump.

PRESSURE GAUGES.—Properly sized pressure gauges should be installed in both the suction and the discharge nozzles in the gauge taps. The gauges enable the operator to observe the operation of the pump easily and also to determine if the pump is operating according to the performance curve. If cavitation, vapor binding, or other unstable operation occurs, widely fluctuating discharge pressure will occur.

Stuffing Box

Contaminants in the pumped liquid must not enter the packing space. These contaminants can cause severe abrasion or corrosion of the shaft, or shaft sleeve, and rapid packing deterioration; they can even plug the stuffing box flushing and lubrication system. The stuffing box must be supplied at all times with a source of clean, clear liquid to flush and lubricate the packing. The most important consideration is to establish optimum flushing pressure to eliminate contaminants from the packing. If this pressure is too low, the fluid being pumped may enter the stuffing box. If the pressure is too high, excessive packing wear can result; also, extreme heat may develop in the shaft, causing higher bearing temperatures. The most desirable condition, therefore, is to use the lowest possible flushing pressure that the operating conditions will permit. If the pump system pressure conditions vary during the day, the packing problem becomes difficult. Consideration should be given to using a mechanical seal. (See "Mechanical Seals" below.)

One recommended method to minimize error in regulating flushing is a "controlled pressure system" (fig. 6-35). Most important is the pressure-reducing valve adjusted to a valve slightly exceeding the maximum stuffing box operating pressure (assuming it is reasonably constant). A flow-indicating device serves to indicate a failing of the bottom packing rings, allowing leakage into the pump. With this arrangement, the packing gland must be tightened only against the lowest necessary pressure. Longer packing life is possible with the "controlled pressure system," if it is properly installed and operated.

The actual stuffing box operating pressure may be obtained by installing a pressure gauge on the box. This is done with an extra seal cage temporarily replacing the two rings of packing in the bottom of the box to obtain accurate gauge readings. Take gauge readings with the pump running under various head and capacity conditions. Then set the pressure of flushing or lubricating liquid at a value of 5 to 10 psi above the maximum expected stuffing box operating pressure.

Even under the best conditions, a properly packed stuffing box should be watched closely. When pressure conditions change slightly, there is a resultant change in packing (seating) which should be compensated by a change in gland adjustment. Consideration should also be given to the lubrication pressure. A wide variation in pressure indicates a need for a mechanical seal.

Packing

Standard pumps are normally packed before shipment. If the pump is installed within 60 days after shipment, the packing should be in good condition with a sufficient supply of lubrication. If the pump is stored for a longer period of time, it may become necessary to repack the stuffing box. In all cases, you should inspect the packing before starting the pump.

INTERNAL LIQUID LUIBRICATION.— Pumped liquid may be used to lubricate the packing when the following conditions exist:

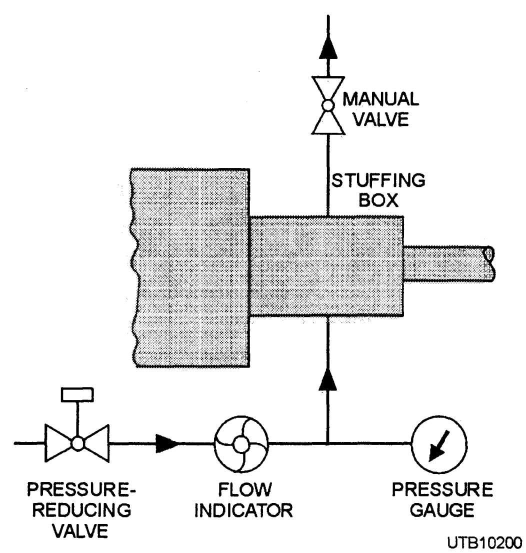


Figure 6-35.—Controlled pressure system for stuffing box.

The liquid is clean, free from sediment and chemical precipitation, and compatible with seal materials.

- The temperature is above 32°F and below 160°F.
- The suction pressure is below 75 psig.
- The liquid has adequate lubricating qualities.
- The liquid is nontoxic and nonvolatile.

EXTERNAL LIQUID LUBRICATION.—When the liquid being pumped contains solids or is otherwise not compatible with packing materials, an outside supply of seal liquid should be furnished. In general, external-injection liquid (from an outside source) is required when the following conditions exist.

- Liquid being pumped contains dirt, grit, or other impurities.
- The temperature of the pumped liquid is below 32°F or above 160°F.
- The liquid being pumped has nonlubricating properties.
- The liquid is toxic or volatile.
- The suction pressure is above 75 psig, vacuum, or high lift.

Mechanical seals are preferred over packing on some applications because of better sealing qualities and longer serviceability. Leakage is eliminated when a seal is properly installed, and normal life is much greater than that of packing on similar applications. A mechanical shaft seal is supplied in place of a packed stuffing box when specifically requested. The change from packing to an alternate arrangement may be made in the field. Conversion kits may be ordered from the manufacturer.

SINGLE SEAL.—Pumps containing single mechanical seals normally use pumped liquid to lubricate the seal faces. This method is preferred when the pumped liquid is neither abrasive nor corrosive. If the liquid being pumped is not suitable, an external flush should be provided. (See "External Liquid Lubrication" above.)

DOUBLE SEAL.—A double mechanical seal consists of two single seals mounted back to back and a suitable sealing liquid that is introduced into the seal chamber. The sealing liquid (preferably clear water) is injected into the box at a higher pressure than exists at the entrance to the seal cavity on the pump side. The pressure differential isolates the sealing faces from the pumped liquid. Double mechanical seals are normally preferred in pumps handling sewage, slurries, or any other solids suspended in the pumped liquid.

Sealing liquid that is introduced through the tap in the seal cavity provides lubrication for the double seal. The sealing liquid pressure must always be higher than the pressure on the seal closest to the suction side. If sufficient sealing pressure is not maintained, the pressure within the pump can force open the lower seal and allow the pumped liquid to enter the box. This can damage the seals.

Two methods are used to provide sealing liquid to the stuffing box. The first method uses a pressure line installed from a tap on the discharge nozzle to the tap in the stuffing box cartridge. A filter is installed in the line to trap the solid particles. The filter must be capable of screening out all particles above 25 microns in size. Since the liquid is bypassed from the high-pressure (discharge) side of the pump and dead-ended in the stuffing box cartridge, there are no problems in maintaining a sufficient pressure differential, provided the filter is not clogged. The second method uses clear, clean water supplied from an external source. City water can be used if there is an air break between the water supply and the water being provided to the pump. Various municipal ordinances require this break to prevent contamination of the city water supply.

PUMP MAINTENANCE

Operating conditions vary so widely that to recommend one schedule of preventive maintenance for all centrifugal pumps is not possible. Yet some sort of regular inspection must be planned and followed. You should maintain a permanent record of the periodic inspections and maintenance performed on a pump. This procedure will assist you in keeping the pump in good working condition and prevent costly breakdowns.

One of the best rules to follow in the proper maintenance of a centrifugal pump is to keep a record of actual operating hours. Then, after a predetermined period of operation has elapsed, the pump should be given a thorough inspection. The length of this operating period varies with different applications and can only be determined from experience. New equipment, however, should be examined after a relatively short period of operation. The next inspection period can be lengthened somewhat. This system can be followed until a maximum period of operation is reached which should be considered the operating schedule between inspections.

Bearing Lubrication—Grease

Grease-lubricated bearings are packed with grease at the factory and ordinarily require no attention before starting, provided the pump has been stored in a clean, dry place before its operation. The bearings should be watched the first hour or so after the pump has been started to see that they are operating properly.

The importance of proper lubrication cannot be overemphasized. It is difficult to say how often a bearing should be greased, since that depends on the conditions of operation. It is important to add 1 ounce of grease at regular intervals, but it is equally important to avoid adding too much grease. For average operating conditions, it is recommended that 1 ounce of grease be added at intervals of 3 to 6 months, and only clean grease should be used. It is always best if the unit can be stopped while the grease is added to avoid overloading.

CAUTION

Excess grease is the most common cause of overheating.

The bearing frame should be kept clean, since contamination of foreign matter that may get into the housing can destroy the bearings within a short period of time. When cleaning bearings, use a bearing or an industrial cleaning solvent. Do not use gasoline. Use a lint-free cloth. Do not use waste rags.

A regular bearing grease should be used, but a standard commercial vaseline can be substituted if necessary. Do not use graphite. A No. 1 or a No. 2 grease is generally satisfactory for operation at ordinary temperatures; the lighter grease should be used for operation at high speed or at low room temperature.

Mineral grease with a soda soap base is recommended. Grease, made from animal or vegetable oils, is not recommended because of the danger of deterioration and the forming of acid. Most of the leading oil companies have special types of bearing grease that are satisfactory. For specific recommendations, consult the manufacturer's manual.

The maximum desirable operating temperature for bearings is 180°F. Should the temperature of the bearing frame rise above 180°F, the pump should be shut down to determine the cause. Grease-lubricated bearings should not be used where temperature of the pumped liquid exceeds 350°F.

CAUTION

A bearing frame that feels hot to the touch is not necessarily running hot. Check the temperature with an accurate measuring device to be sure.

Bearing Lubrication-Oil

An oil-lubricated pump normally has an oiling ring. In these, the oil is picked up from the reservoir by a rotating oil ring and deposited on the shaft and the bearings inside the bearing housing. Some may have an oil slinger that creates a shower of fine droplets of oil over the entire interior of the bearing cavity.

After the pump has been installed, flush the bearing housing to remove dirt, grit, and other impurities that may have entered the bearing housing during shipment or erection. Then refill the bearing housing with proper lubricant. The oil level to be maintained is shown by a line in the sight glass or oil level indicator.

Lubricating oils can be furnished by any of the major oil companies, and it is the responsibility of the oil vendor to supply suitable lubricants. Experience has shown that oils meeting the following specifications provide satisfactory lubrication.

- Saybolt viscosity at 100°F — 150 SSU-200 SSU
- Saybolt viscosity at 210°F — 43 SSU
- Viscosity index, minimum — 95
- API gravity — 28-33
- Pour point, maximum — 20°F
- Flash point, minimum — 390°F
- Additives — Rust and oxidation inhibitors

> **CAUTION**
>
> Oils from different suppliers should not be mixed. The oil must be well-refined, good grade, straight cut, and filtered mineral oil. It must be free from water, sediment, resin, soaps, acid, and fillers of any kind. It should also be nonfoaming with a viscosity of about 150 to 200 SSU at 100°F (approximately SAE-20).

In installations with moderate temperature changes, humidity, and dirt, the oil should be changed after approximately 160 hours of operation. The oil should be inspected at this time to determine the operating period before the next oil change. Oil change periods may be increased from 2,000 to 4,000 hours based on an 8,000-hour year. Check the oil frequently for moisture, dirt, or signs of "breakdown."

> **CAUTION**
>
> DO NOT OVER OIL; THIS CAUSES THE BEARINGS TO RUN HOT. THE MAXIMUM DESIRABLE OPERATING TEMPERATURE FOR BEARINGS IS 180°F. SHOULD THE TEMPERATURE OF THE BEARING FRAME EXCEED 180°F, SHUT DOWN THE PUMP TO DETERMINE THE CAUSE!

Stuffing Box

The standard stuffing box consists of rings of packing, a seal cage, and a gland. A shaft sleeve that extends through the box and under the gland is normally provided to protect the shaft.

A tapped hole is supplied in the stuffing box directly over the seal cage to introduce a clean, clear sealing medium. The stuffing box must be supplied at all times with sealing liquid at a high enough pressure to keep the box free from foreign matter, which would quickly destroy the packing and score the shaft sleeve.

Only a sufficient volume of sealing liquid to create a definite direction of flow from the stuffing box inward to the pump casing is required, but the pressure is important. Apply sealing water at a rate of 0.5 to 1.0 gpm and at 5 to 10 psi above the stuffing box operating pressure.

Piping that supplies sealing liquid to the stuffing box must be sized to supply a sufficient volume of water at the required pressure, based on the location of the pump (or pumps) with respect to the liquid source. A small pipe can be used for the connection to the stuffing box. A valve should be installed to adjust and regulate sealing liquid, and a gauge should be installed to check the pressure to the box.

External sealing liquid should be adjusted to the point where the packing runs only slightly warm with a slow drip from the stuffing box. Excessive pressure from an external source can be destructive to packing. More pressure is required, however, for abrasive slurries than for clear liquids. Examination of the leakage will indicate whether it is necessary to increase external pressure. If slurry is present in the leakage, increase the pressure until only clear liquid drips from the box. If the drippage is corrosive or may be harmful to personnel, it should be collected and piped away.

A common error is to open the external piping valve wide and then control the drippage by tightening the packing gland. Actually, a combination of both adjustments is essential to arrive at the optimum condition. The life of the packing and the sleeve depends on this careful control more than any other factor.

GREASE LUBRICATION.—Pump stuffing boxes are also suitable for grease lubrication. Several types of grease lubricators are available. When you use a grease lubricator, grease pressure to the stuffing box should be equal to the pump discharge pressure.

PACKING.—All pumps are packed before shipment, unless otherwise requested. The packing used is of the highest grade material. Before the pump is put into operation, check the condition of the packing. If the pump is installed within 60 days after shipment, the packing should be in good condition with a sufficient supply of lubrication. If the pump is stored for a longer period, it may become necessary to repack the stuffing box. In all cases, inspect the packing before starting the pump.

The standard packing is made of a soft, square asbestos material that is impregnated with oil and graphite. A soft, well-lubricated packing reduces stuffing box resistance and prevents excessive wear on the shaft, or shaft sleeve. Many brands of packing on the market have the desired qualities. For specific recommendations, consult the manufacturer's manual.

When a pump with fiber packing is first started, it is advisable to have the packing slightly loose without causing an air leak. As the pump breaks in, tighten the gland bolts evenly. The gland should never be drawn to the point where packing is compressed too tightly, and no leakage occurs. This causes the packing to burn the shaft, or shaft sleeve, to be scored, and prevents liquid from circulating through the stuffing box and cooling the packing. The stuffing box is improperly packed or adjusted when friction in the box prevents the rotating element from being turned by hand. A packed stuffing box that is operating properly should run lukewarm with a slow drip of sealing liquid. After the pump has been in operation for some time and the packing has been completely run-in, drippage from the stuffing box should be at least 40 to 60 drops per minute. This indicates that there is proper packing, that the shaft sleeve is adequately lubricated, and that it is cooled properly.

CAUTION

Eccentric operation of the shaft, or shaft sleeve, through the packing could result in excess leakage. Correction of this defect is extremely important.

Packing should be checked frequently and replaced as service indicates. Six months might be a reasonable expected life, depending on operating conditions. It is impossible to furnish an exact prediction. A packing tool may be used to remove old packing from the stuffing box. Never reuse old and lifeless packing or merely add some new rings. Make sure the stuffing box is thoroughly cleaned before new packing is installed. Also, check the condition of the shaft, or shaft sleeve, for possible scoring or eccentricity, making replacements as necessary.

New packing should be placed carefully into the stuffing box. If molded rings are used, the rings should be opened sideways and the joints pushed into the stuffing box first. The rings are installed one at a time, each ring is seated firmly, and the joints are staggered so they are not in line. The joints should be kept toward the upper side of the shaft about a 90-degree angle from each preceding joint.

If coil packing is used, cut one ring to accurate size with either a butt or mitered joint. An accurately cut butt joint is superior to a poor fitting mitered joint. Fit the ring over the shaft to assure proper length. Then remove and cut all other rings to the size of this first sample. When the rings are placed around the shaft, you should form a tight joint. Place the first ring in the bottom of the stuffing box. Then install each succeeding ring, staggering the joints as described above, making sure each ring is firmly seated.

Make sure the seal cage is properly located in the stuffing box under the sealing water inlet. The function of the seal cage is to establish a liquid seal around the shaft, to prevent leakage of air through the stuffing box, and to lubricate the packing. If it is not properly located, it serves no useful purpose.

Mechanical Shaft Seals

A mechanical shaft seal is supplied in place of a packed stuffing box when specifically requested. Mechanical seals are preferred over packing on some applications because they have better sealing qualities and longer serviceability. Leakage is eliminated when a seal is properly installed, and normally, the life of the seal is much greater than that of packing on similar applications.

General instructions for operation of the various mechanical sealing arrangements are included below. It is not feasible to include detailed instructions for all mechanical seals in this chapter because of the almost unlimited number of possible combinations and arrangements. For more information, refer to the manufacturer's instructions.

Mechanical seals are precision products and should be treated with care. Use special care when handling seals. Clean oil and clean parts are essential to prevent scratching the finely lapped sealing faces. Even light surface scratches on these faces could result in leaky seals. Normally, mechanical seals require no adjustment or maintenance except routine replacement of worn or broken parts.

A mechanical seal that has been used should not be placed back into service until the sealing faces have been replaced or relapped. (Relapping is generally economical only in seals that are 2 inches and greater in size.)

Four important rules that should always be followed for optimum seal life are as follows:

1. Keep the seal faces as clean as possible.
2. Keep the seal as cool as possible.
3. Ensure the seal always has proper lubrication.

4. If the seal is lubricated with filtered fluid, clean the filter frequently.

Maintenance Timetable

Equipment cannot operate well without proper care. To keep the pump at top efficiency, follow the recommended installation and servicing procedures outlined in the manufacturer's manual. Table 6-2 is a recommended maintenance timetable for use in keeping a pump at maximum operating capacity with a minimum amount of downtime.

Q5. The locations in a pump where fluid enters (suction) and leaves (discharge) are known by what other term?

Table 6-2.—Maintenance Timetable

Every Month	Check bearing temperature with a thermometer, not by hand. If bearings are running hot (over 180°F), it may be the result of too much lubricant. If changing the lubricant does not correct the condition, disassemble and inspect the bearings.
Every 3 Months	Check grease-lubricated bearings for saponification. This condition is usually incurred by the infiltration of water or other fluid past the bearing shaft seals and can be noticed immediately upon inspection, since it gives the grease a whitish color. Wash out the bearings with a clean industrial solvent and replace the grease with the proper type as recommended.
Every 6 Months	Check the packing and replace if necessary. Use the grade recommended. Be sure the seal cages are centered in the stuffing box at the entrance of the stuffing box piping connection. Check shaft or shaft sleeve for scoring. Scoring accelerates packing wear. Check alignment of pump and motor. Shim up units if necessary. If misalignment recurs frequently, inspect the entire piping system. Unbolt piping at suction and discharge flanges to see if it springs away, thereby indicating strain on the casing. Inspect all piping supports for soundness and effective support of load.
Every Year	Remove the rotating element. Inspect thoroughly for wear, and order replacement parts if necessary. Check wearing clearances. Remove any deposit or scaling. Clean out stuffing box piping. Measure total dynamic suction and discharge head as a test of pipe connection. Record the figures and compare them with the figures of the last test. This is important especially where the fluid being pumped tends to form a deposit on internal surfaces. Inspect foot valves and check valves, especially the check valve which safeguards against water hammer when the pump stops. A faulty foot or check valve will reflect also in poor performance of the pump.

Between regular maintenance inspections, be alert for signs of motor or pump trouble. Common symptoms are listed in table 6-3. Correct any trouble immediately and AVOID COSTLY REPAIR AND SHUTDOWN.

Q6. What is total discharge head?

Q7. The amount of suction lift a pump can provide is determined by what three factors?

Q8. What are the five categories of pumps?

Q9. A rotary pump is classified as what type of pump?

Q10. What are the types of rotary pumps?

Q11. Most reciprocating pumps used in the Navy are of what four types?

Q12. What is the only moving part in a centrifugal pump?

Q13. When the velocity of a fluid in a pump increases, what happens to the pressure head?

Q14. What pumps are used exclusively for well pumping?

Q15. When an elbow is installed horizontally in suction piping, what happens to the liquid entering the pump?

Q16. Why should you avoid high spots, such as loops, in discharge piping?

Q17. Widely fluctuating discharge pressure gauge indicates what type of problem?

Q18. On grease-lubricated bearings, what is the most common problem caused by excessive grease?

Q19. What advantage does a mechanical shaft seal have over packing?

Q20. Using table 6-2, how often should you inspect the packing on a pump?

Q21. Using table 6-2, removal and inspection of the rotating elements of a pump should be accomplished how often?

AIR COMPRESSORS

LEARNING OBJECTIVE: *Recognize types of air compressor components, accessories, systems, operation of these systems, and maintenance procedures.*

Air compressors are devices or machines that compress air. In compression, air at a normal atmospheric temperature is taken in and sqeezed or pressed by a moving element within a confined space. The volume of air is thus reduced, but the pressure, or force, of the volume of air exerted has increased considerably. Thus the air develops energy or power that can be put to some useful purpose in other machines. The compressed air need not be put to work immediately but can be stored in tanks to preserve and maintain its pressure.

Compressed air can be taken from storage bottles or flasks and used to start diesel engines; that is, the compressed air is introduced into the diesel cylinders where, by its pressure, it forces the pistons to reciprocate until ignition temperature is reached. We have seen how compressed air forces water to rise in wells. Air compressors also drive, or power, a wide variety of pneumatic tools in construction work. The types of air compressors include reciprocating, centrifugal, and rotary; however, only reciprocating compressors are discussed in the following paragraphs. In basic design and function, these compressors are similar to the pumps with the same names. In fact, air compressors are sometimes referred to as air pumps. Rather than discharging liquid at relatively high pressure, air compressors discharge air (which is considered a fluid) at high pressure. Like pumps, compressors require some external source of mechanical power to do this work. Prime movers for air compressors may be electric motors, internal combustion engines, steam turbines, and so on. The majority of air compressors used throughout the Navy are driven by electric motors.

RECIPROCATING AIR COMPRESSORS

One of the most commonly used air compressors in the naval service is the reciprocating air compressor. It compresses air in the same manner as a diesel engine. A reciprocating piston alternately draws in and then compresses the trapped air in a cylinder. Since there is no internal combustion, the cycle of the reciprocating air compressor is reduced or simplified to two strokes-suction (intake) and compression. Instead of operating the valves by cam action, as in internal combustion engines, the intake and discharge valves of the reciprocating air compressor operate on the principle of differential pressure overcoming spring tension,

Table 6-3.—Troubleshooting

1. Lack of prime.	Fill pump and suction pipe completely with liquid.
2. Loss of prime.	Check for leaks in suction pipe joints and fittings; vent casing to remove accumulated air.
3. Suction lift too high.	If no obstruction at inlet, check for pipe friction losses. However, static lift may be too great. Measure with mercury column or vacuum gauge while pump operates. If static lift is too high, liquid to pump must be raised or pump must be lowered.
4. Discharge head too high.	Check pipe friction losses. Large piping may correct condition. Check that valves are open.
5. Speed too low.	Check if motor is directly across the line and receiving full voltage. Or frequency may be to low; motor may have an open phase.
6. Wrong direction of rotation.	Check motor rotation with directional arrow on pump casing.
7. Impeller completely plugged.	Dismantle pump and clean impeller.
Not Enough Liquid Delivered	
8. Air leaks in suction piping.	If liquid pumped is water or nonexplosive, and explosive gas or dust is not present, test flanges for leakage with flame or match. For such liquids as gasoline; the suction line can be tested by shutting off or plugging the inlet and putting the line under pressure. A gauge will indicate a leak if pressure drops.
9. Air leaks in stuffing box.	Increase seal lubricant pressure to above atmosphere.
10. Speed too low.	See item 5.
11. Discharge head too high.	See item 4.
12. Suction lift too high.	See item 3.
13. Impeller partially plugged.	See item 7.
14. Cavitation; insufficient NPSH (depending installation).	a. Increase positive suction head on pump by lowering pump. b. Subcool suction piping at inlet to lower entering liquid temperature. c. Pressurized suction vessel.
15. Defective impeller.	Inspect impeller, bearings, and shaft. Replace if damaged or vane sections badly eroded.
16. Defective packing.	Replace packing and sleeves if badly worn.
No Liquid Delivered	
17. Foot valve too small or partially obstructed.	Area through ports of valve should be at least as large as area of suction pipe-preferably 1 1/2 times. If strainer is used, net clear area should be three to four times area of suction pipe
18. Suction inlet not immersed deep enough.	If inlet cannot be lowered or if eddies through which air is sucked persist when it is lowered, chain a board to suction pipe. It will be drawn into eddies, smothering the vortex.
19. Wrong direction of rotation.	Symptoms are an overloaded drive and about 1/3 rated capacity from pump. Compare rotation of motor with directional arrow on pump casing.
20. Too small impeller diameter (probable cause if none of the above).	Check with factory to see if larger impeller can be used; otherwise, cut pipe losses or increase speed-or both, as needed. Be careful not to overload drive

Table 6-3.—Troubleshooting—Continued

Not Enough Pressure	
21. Speed too low.	See item 5.
22. Air leaks in suction piping.	See item 8.
23. Mechanical defects.	See items 15, 16, and 17.
24. Obstruction in liquid passages.	Dismantle pump and inspect passages of impeller and casing. Remove obstructions.
25. Air or gases in liquid (tested in laboratory) reducing pressure on liquid to pressure in the suction line. Watch for bubble formation.	May be possible to overrate pump to point where it will provide adequate pressure despite condition. Better to provide gas separation chamber on suction line near pump, and periodically exhaust accumulated gas. See item 14.
26. Too small impeller diameter. (probable cause if none of the above.)	See item 20.
Pump Operates For Short Time, Then Stops	
27. Incomplete priming.	Free pump, piping, and valves of all air. If high points in suction line prevent this, they need correcting.
28. Suction lift too high.	See item 3.
29. Air leaks in suction piping.	See item 8.
30. Air leaks in stuffing box.	See item 9.
3 1. Air or gases in liquid.	See item 25.
32. Head lower than rating; thereby pumping too much liquid.	Machine impeller's OD to size advised by factory.
33. Cavitation.	See item 14.
34. Mechanical defects.	See item 15, 16, and 17.
35. Suction inlet not immersed enough.	See item 18.
36. Liquid heavier (in viscosity or specific gravity) than allowed for.	Use larger driver. Consult factory for recommended size. Test liquid for viscosity and specific gravity.
37. Wrong direction of rotation.	See item 6.
38. Stuffing boxes too tight.	Release gland pressure. Tighten reasonably. If sealing liquid does not flow while pump operates, replace packing. If packing is wearing too quickly, replace scored shaft sleeves and keep liquid seeping for lubrication.
39. Casing distorted by excessive strains from suction or discharge piping.	Check alignment. Examine pump for friction between impeller and casing. Replace damaged parts.
40. Shaft bent due to damage.	Check deflection of rotor by turning on bearing journals. Total indicator run-off should not exceed 0.002 on shaft and 0.004 inch on impeller wearing surface.
41. Mechanical failure of critical pump parts.	Check bearing and impeller for damage. Any irregularity in any of these parts will cause a drag on shaft.
42. Misalignment.	Realign pump and driver.
43. Speed may be too high.	Check voltage on motor.
44. Electrical defects.	The voltage and frequency of the electric current may be lower than that for which motor was built; or there may be defects in motor. The motor may not be ventilated properly due to a poor location.
45. Mechanical defects in turbine, engine, or other type of drive exclusive of motor.	If trouble cannot be located, consult factory.

much the same as the check valves operate in reciprocating pumps. The suction stroke occurs as the piston moves downward to create a partial vacuum and causes the intake valve to open. Air, at normal atmospheric pressure, is then drawn into the cylinder, as the piston continues downward. When the piston moves on the upward stroke, the intake valve closes. The trapped air is compressed as the piston continues upward. As the piston reaches the top of its compression' stroke, the air pressure developed overcomes the resistance of the spring-loaded discharge valve.

The discharge valve opens momentarily and the compressed air charge then passes into the discharge line. When higher pressure is desired, more cylinders or stages may be provided (fig. 6-36). The discharge of the first stage is led to the intake of the second stage, and so on. The principle here is almost the same as that in the multistage impeller arrangements used to increase the discharge pressure on centrifugal pumps. Figure 6-37 shows a more detailed view of a two-stage reciprocating air compressor. You can see that the second-stage cylinder is noticeably smaller than the first. If there were more cylinders, each would be smaller. This is the compression process, whereby the volume of the air charge is continually reduced as it passes from one stage to the next; and, at the same time, the pressure becomes greater. Figure 6-38 shows an alternate type of low-pressure air compressor.

COMPRESSOR COMPONENTS

The pistons are either TRUNK PISTONS or DIFFERENTIAL PISTONS. Trunk pistons, as shown in view A, figure 6-39, are driven directly by the connecting rods. Since the upper end of a connecting rod is fitted directly to the piston (also referred to as wrist or trunk) pin, the piston tends to develop a side pressure against the cylinder walls. To distribute the side pressure over a wide area of the cylinder walls or liners, use pistons with long skirts. This type of piston minimizes cylinder wall wear. Differential pistons, as shown in view B, figure 6-39, are modified trunk pistons with two or more different diameters. These pistons are fitted into special cylinders arranged so more than one stage of compression is achieved by one piston. The compression for one stage takes place over the piston crown; compression for the other stage(s) takes place in the annular space between the large and small diameters of the piston.

Drain cocks are provided at the bottom of the compressor suction control and the engine speed control. These cocks should be left open when the unit is standing idle, particularly in freezing weather. They must be closed before starting the engine. Check the oil level in the oil storage tanks as indicated by the gauge. If necessary, add oil according to the oil specifications given in the manufacturer's lubrication manual. Drain any condensate that has accumulated in the bottom of the oil storage tanks. A drain cock is provided on the piping at the bottom of the left-hand oil storage tank. Open this cock and keep it open as long as water is draining out. Close the cock quickly when oil starts draining.

LUBRICATION SYSTEM

Except for oil-free (nonlubricated) compressors, high-pressure air compressor cylinders are generally lubricated by an adjustable force-feed lubricator

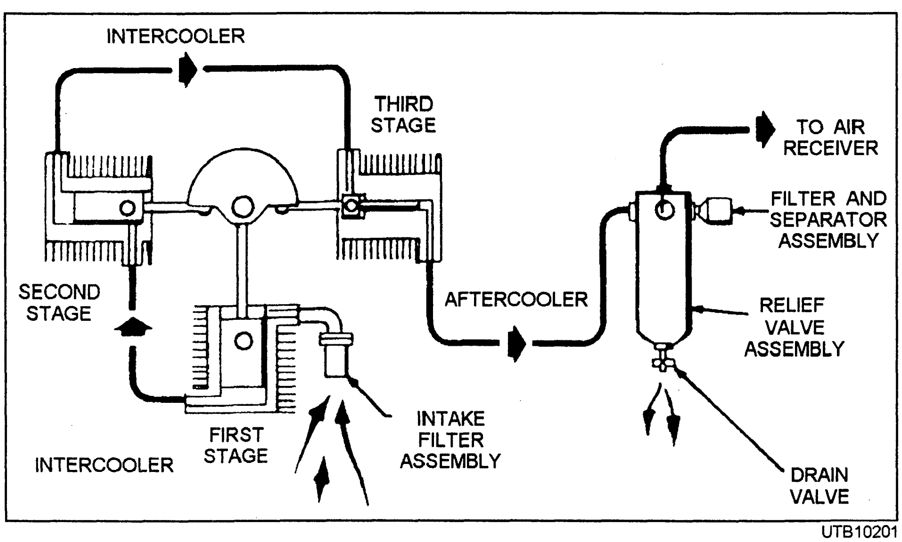


Figure 6-36.—Air compressor assembly.

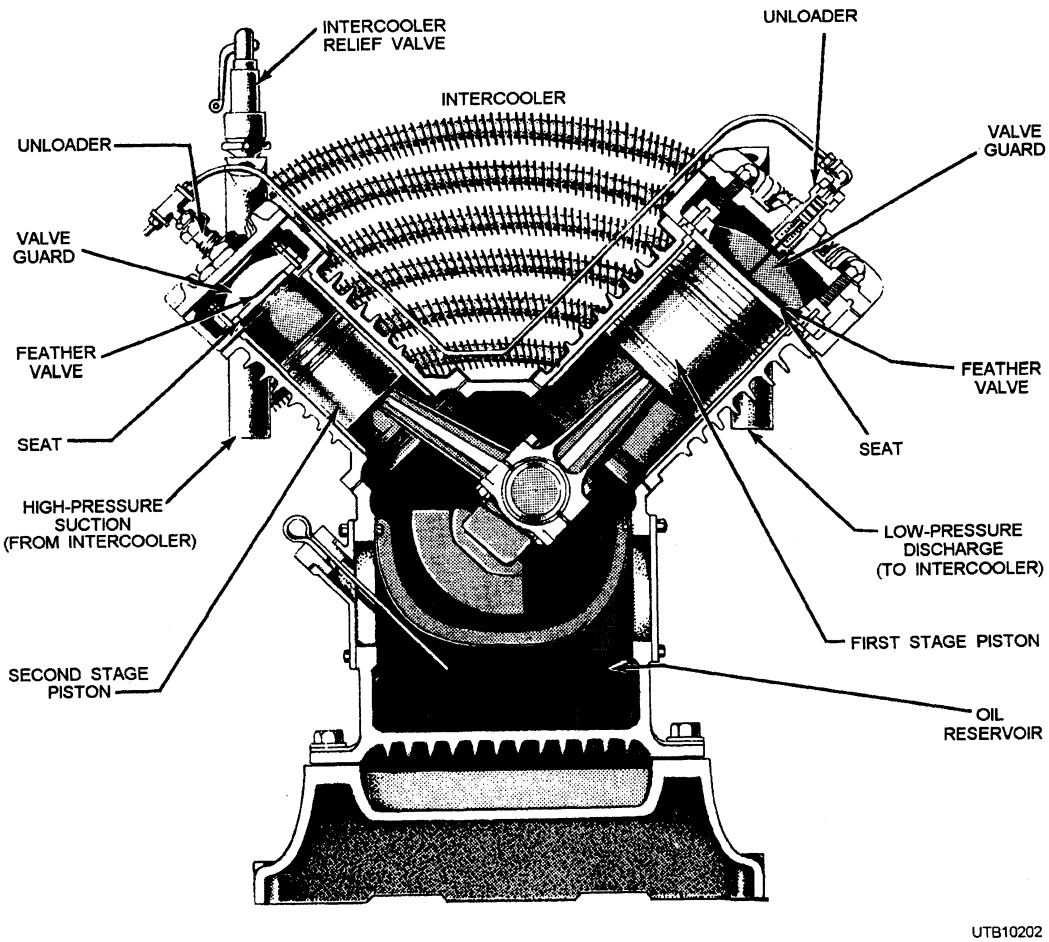


Figure 6-37.—A two-stage reciprocating air compressor.

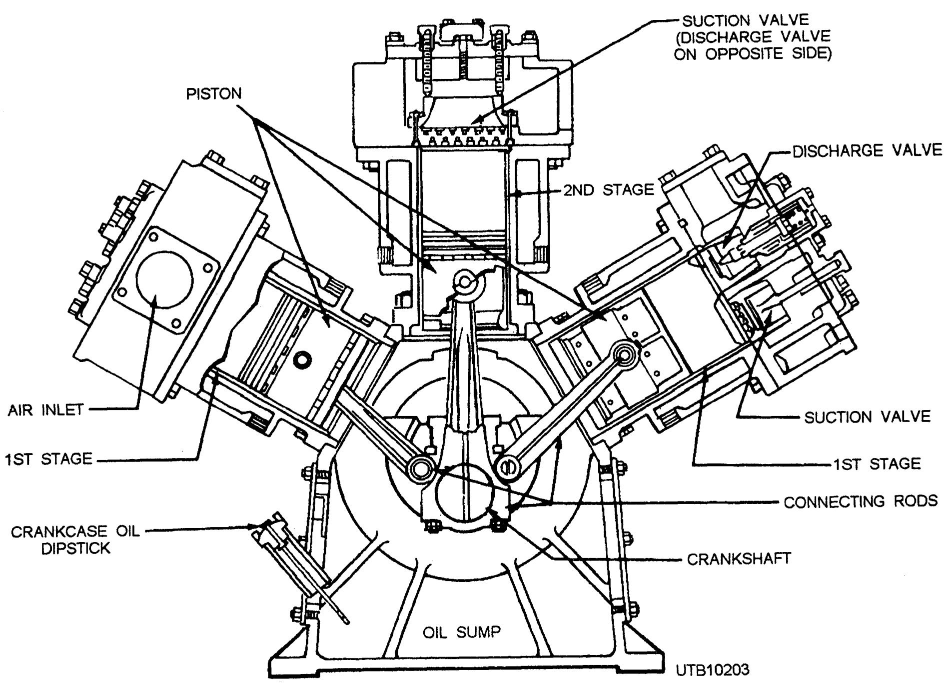


Figure 6-38.—Low-pressure reciprocating air compressor, vertical W configuration.

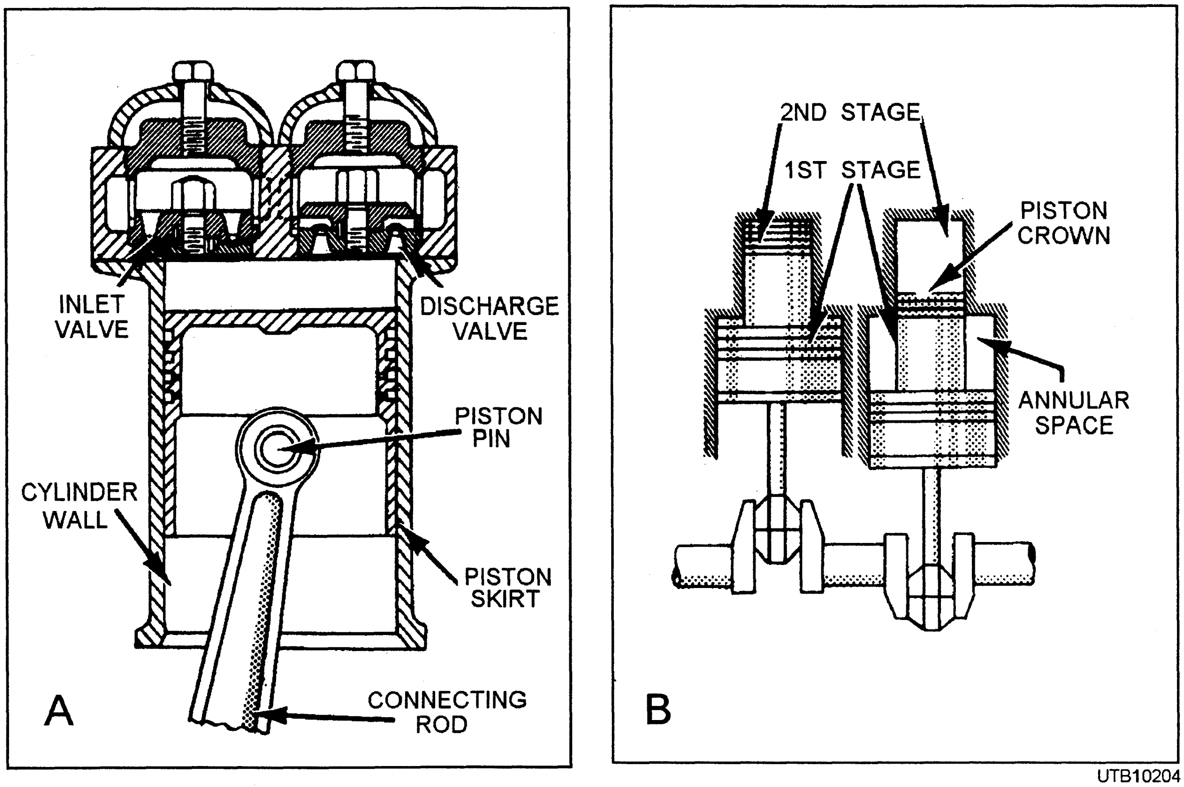


Figure 6-39.—Air compressor pistons: A. Trunk type; B. Differential type.

driven from a reciprocating or rotary part of the compressor. Oil is fed from the cylinder lubricator by separate lines to each cylinder. A check valve is installed at the end of each feed line to keep the compressed air from forcing the oil back into the lubricator. The oil is distributed to the top of each main bearing, to spring nozzles for reduction gears, and to outboard bearings. The crankshaft is drilled so oil fed to the main bearings is picked up at the main bearing journals and carried to the crank journals. The connecting rods contain passages that conduct lubricating oil from the crank bearings up to the piston pin bushings. As oil leaks out from the various bearings, it drips back into the oil sump (in the base of the compressor) and is recirculated. Oil from the outboard bearings is carried back to the stirrup by the drain lines.

Low-pressure air compressor lubrication is shown in figure 6-40. This system is similar to the running gear lubrication system or the high-pressure air compressor.

Nonlubricated reciprocating compressors have lubricated running gears (shaft and bearings) but no lubrication for the pistons and valves. This design produces oil-free air. The lubrication chart in the operator's manual for the make and model of compressor you are operating shows you where the unit should be lubricated, how often to lubricate, and what lubricant to use. The frequency depends upon operating conditions. Operating under abnormal conditions requires more frequent service.

CAUTION

BEFORE SERVICING THE COMPRESSOR AIR SYSTEM OR COMPRESSOR OIL SYSTEM, OPEN THE SERVICE VALVES TO THE ATMOSPHERE TO RELIEVE ALL PRESSURE IN THE SYSTEMS.

UNLOADING SYSTEMS

Air compressor unloading systems are installed to remove all but the friction loads on the compressors; that is, they automatically remove the compression load from the compressor while the unit is starting and automatically apply the load after the unit is up to operating speed. For units with start-stop control, the unloading system is separate from the control system. For compressors equipped with constant-speed control, the unloading and control systems are integrated. A few typical compressor unloading

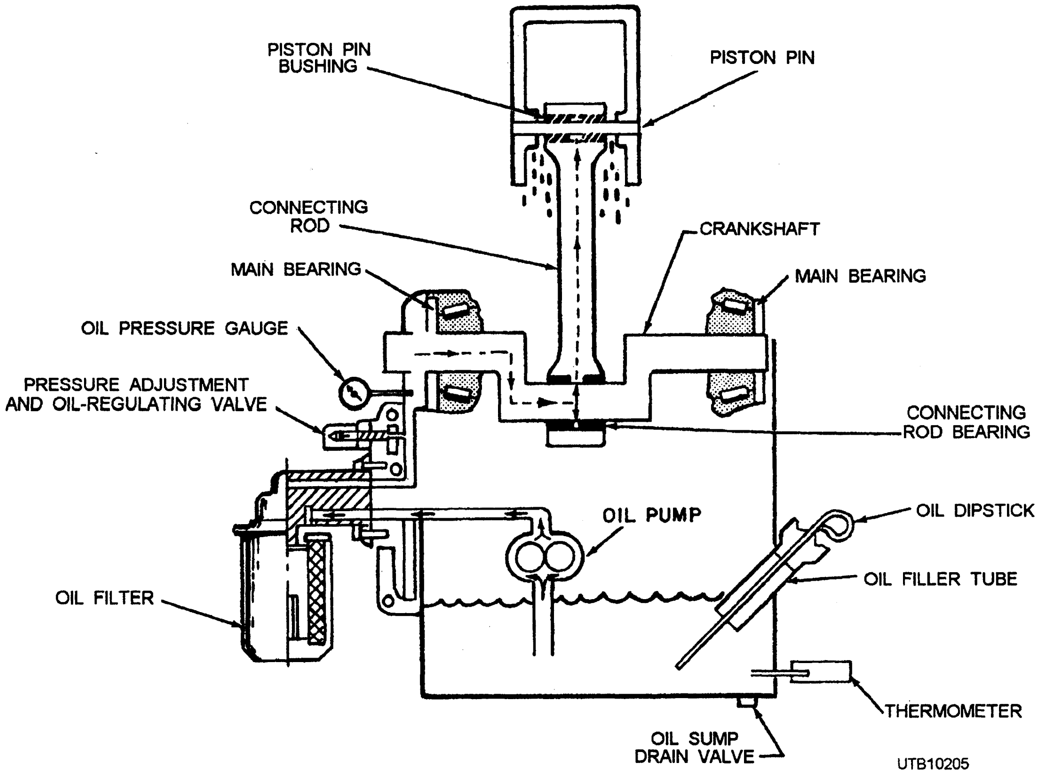


Figure 6-40.—Lubricating oil system of a low-pressure air compressor.

methods are discussed in the paragraphs that follow. These methods include the following:

- Closing or throttling the compressor intake
- Holding intake valves off their seats
- Relieving intercoolers to the atmosphere
- Relieving the final discharge to the atmosphere (or opening a bypass from the discharge to the intake)
- Opening up cylinder clearance pockets
- Using miscellaneous constant-speed unloading devices
- Combinations of the above methods

As an example of a typical compressor unloading device, consider the MAGNETIC-TYPE UNLOADER. Figure 6-41 shows the unloader valve arrangement. This unloader consists of a solenoid-operated valve connected with the motor starter. When the compressor is at rest, the solenoid valve is de-energized to admit air from the receiver to the unloading mechanism. When the compressor reaches near-normal speeds, the solenoid valve is energized to release the pressure from the unloading mechanism and to load the compressor again. For details on the unloading devices, refer to the pertinent manufacturer's technical manuals for compressors installed in your command.

Since compressors draw in ambient air, or the air surrounding the compressor, the intake is fitted with an AIR INTAKE FILTER. This filter keeps the intake air free of dust and other airborne particles. If dust-laden air enters the compressor, internal combustion, triggered by the heat of compression, can take place within the cylinders.

Moist or humid air drawn into the compressor cylinders poses another problem. The air intake filter

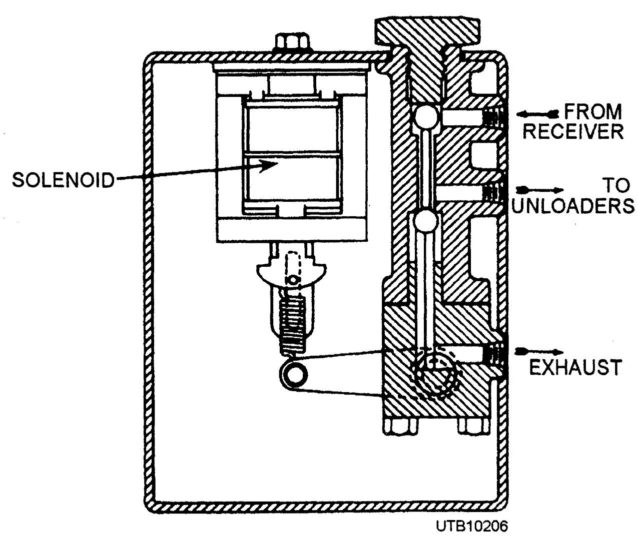


Figure 6-41.—Magnetic-type unloader.

cannot prevent this water vapor from being taken into the compressor. Instead, the water vapor is usually squeezed out of the air during compression and transformed into steam by the heat of compression. The steam condenses to form moisture droplets downstream from the compressor, as the compressed air charge is cooled. Since moisture can damage some of the machines that use compressed air (pneumatic tools, for example), the moisture must be removed from the air before it is sent to the storage tank. So, a FILTER and a MOISTURE SEPARATOR ASSEMBLY are placed between the compressor and the storage tank. The assembly removes most of the moisture, or any other impurities, entrained in the air before it is sent on to storage. The assembly is fitted with a valve or drain cock, so accumulations of water and dirt can be drained now and then by the operator.

The tank that stores the compressed air is called the AIR RECEIVER, as shown in figure 6-42. In this way, demands for compressed air are made upon the receiver, rather than directly on the compressor itself. And there is little chance of the demand for air exceeding the supply. To this end, the air receiver has with it some type of control system or device to monitor the supply of compressed air in the receiver. The control device may be a PRESSURE SWITCH that senses predetermined thresholds or levels of pressure. When the compressor has sufficiently charged the receiver with compressed air, the pressure switch automatically opens and shuts down the compressor. If and when the demand for compressed air begins to drain the receiver to a preset pressure threshold, the pressure switch closes and automatically starts the compressor.

In systems where the demand for air is more or less constant and prolonged, a type of CONSTANT-SPEED CONTROL can be used. The compressor is permitted to run continuously to keep the receiver charged with air, while the constant-speed control functions somewhat like a pressure relief valve. If the pressure of the compressed air in the receiver rises, because of a momentary drop in demand within the system, the control simply vents the excess compressed air to the atmosphere, rather than shut down the compressor.

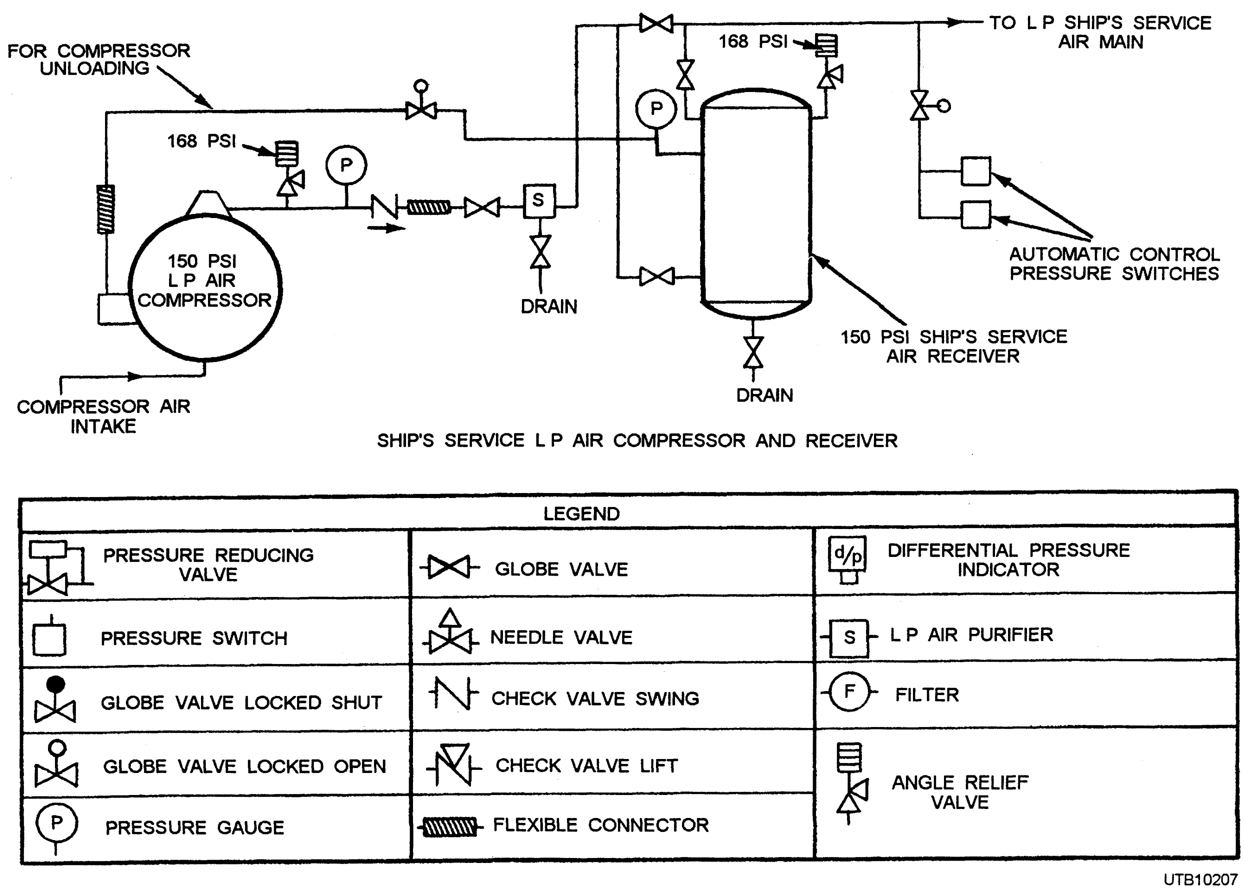


Figure 6-42.—LP air compressor piping arrangements.

COOLING SYSTEM

The generation of heat always accompanies the compression of air. In most low-pressure air compressors, the heat from compression is dissipated before the temperature gets too high. Aluminum cylinders have cooling fins, and a fan forces cooling air past the cylinders. In most medium-pressure and high-pressure air compressors, the compressor has to be cooled with pump-circulated water. The cooling water is circulated in much the same fashion as in an automobile engine with the coolant passing through jackets in the cylinder walls, cylinder heads, and so on. In addition, compressors are fitted with other cooling devices, known as intercoolers and aftercoolers. Generally, these devices consist of a series of tubes, either air-cooled or water-cooled, through which the compressed air charge flows after leaving the cylinders. These devices cool the compressed air. INTERCOOLERS are placed between the stages or cylinders of multistage compressors. Thus they cool the compressed air charge before it is drawn into the next cylinder. The AFTERCOOLERS cool the final discharge of air from the compressor. Both the intercoolers and the aftercoolers are of the same general construction, except the aftercoolers are designed to withstand a higher working pressure.

Perhaps the most important advantage of these coolers is they aid in keeping the air charge in a compressed state. In other words, hot air has a tendency to expand, and if the compressed air charge is not cooled, it, too, tends to expand and thereby liberate much of its pressure or energy.

COMPRESSOR LOCATION

Locate the compressor unit so that it is reasonably level. The design of this unit permits a 15-degree lengthwise and a 15-degree sideways limit on out-of-level operation. The engine, not the compressor, is the limiting factor. When the unit is to be operated out of level, keep the engine crankcase oil level near the high level mark (with the unit level) and have the compressor oil gauge show nearly full (with the unit level). The mechanical parking brake lever is near the bumper. Set the brake by pulling or pushing the lever as directed by a decal or a stencil located beside the lever on the unit. The parking brake should always be set once the air compressor is on location to prevent accidental rolling of the unit, which could cause not only mechanical damage but also possible injury to personnel. As an added precaution, the wheels should be chocked when possible.

Open the side curtains on both sides of the enclosure and leave them open whenever the unit is in operation. When the side curtains are closed and the engine running, the flow of air through the oil cooler and engine radiator is restricted. The curtains may be left closed for a few minutes during starting procedures in cold weather to ease engine warm-up. However, when the compressor goes to work, open the side curtains. For specific operating instructions, check the instruction plate attached to the unit being used.

ENGINE

The heart of the compressor is the engine that furnishes power for the compressor and produces air for the pneumatic tools used during drilling. Know how to start, operate, and maintain the compressor engine properly. In most cases, the general operating procedure is similar to that given below. Check the engine oil level. If necessary, add oil as recommended in the engine manual. Do not overfill.

Check the engine cooling system. The radiator should be filled to the bottom of the filler neck. If necessary, add soft, clean water until full. In cold weather, use a permanent antifreeze with a rust inhibitor. Ethylene glycol solutions are recommended because they do not evaporate and only water is added to maintain a full system. Two fuel tanks are furnished-one on each side. The two tanks are cross-connected to permit filling from either side of the unit. Clean fuel is vitally important. Ensure clean fuel is poured or pumped into the tanks. Be sure no condensate (water) lies in the bottom of the fuel tanks. Drain off any water that may be there. Clear away obstructions in the vents of the fuel tank.

Lubricate all parts of the engine as recommended in the manufacturer's engine manual. Make periodic checks of the oil filter, the fuel filter, and the fuel oil pump screen. Ensure the rain cap on the exhaust pipe swings freely,, so a back pressure on the engine exhaust cannot be created. Check the battery cells for the proper liquid level. A pair of two-stage dry-type air cleaners filters the intake air for the compressor suction and engine air-intake manifold. Both cleaners are under the canopy at the compressor end of the unit.

The first stage of the air cleaner uses centrifugal precleaning which rotates the intake air and separates a large portion of the dust collected in the dust cup. The dust cup should be checked and emptied daily.

The second stage of the air cleaner consists of a group of cylindrical pleated paper elements. The ends of the pleats are molded into a flexible plastic faceplate that seals the cartridge in place in the air cleaner housing without additional gaskets. On the side of the air cleaner housing is mounted a service indicator. As the second-stage cartridge loads up with dirt, a red indicator flag gradually rises in the window. When the cartridge is completely loaded, the window shows all red, and the flag is locked in place. This is the time to replace the second-stage cartridge. Discard the old cartridge and reset the red flag, so the window shows clear. Do not clean used paper cartridges.

OPERATION AND MAINTENANCE OF AIR COMPRESSORS

Before the compressor is started, the operator should make inspections to ensure that both the compressor and the auxiliary components are ready for operation. This procedure includes the following: checks of the control and unloading systems; inspection of safety valves or pressure relief valves; draining condensate from the coolers, the separator, and the receiver; and turning on cooling water services and opening valves to ensure proper circulation of water through the compressor and coolers.

Once the compressor is in operation, the operator must periodically check the temperature and pressure of the cooling water, the lube oil, and the compressed air. The lube oil level must also be checked and maintained at the proper level. Coolers must be inspected for correct temperature and flow of water. Accumulations of moisture in the coolers, the separator, and the air receiver must be drained periodically. In addition, maintenance schedules require more detailed inspections (monthly, quarterly, etc.). In many cases, these inspections require dismantling parts of the compressor and auxiliary equipment. For instance, the operator may be required to inspect intake and discharge valves, cylinders, and pistons. The air intake filter must be inspected periodically and cleaned as necessary. The coolers and the receiver must also be inspected for corrosion and accumulations of dirt and oil.

The lubrication system on most compressors is somewhat similar to that on an automobile engine. Normally, the compressor base is used as the lube oil sump and oil pump housing. The oil level can be measured by a dipstick or an oil level sight gauge mounted on the base. The lube oil is distributed through various passages to lubricate bearings, valves, pistons, and other internal parts. An oil film is also distributed over the cylinder walls. Although small amounts of lube oil may mix with the compressed air, it is usually filtered out at the separator assembly. Note that one of the periodic operator inspections on air-lift pumps is to check the air-water discharge from the pump for contamination by lube oil entrained in the compressed air.

The lube oil used in the cylinders must be of the right type. The auto-ignition point (temperature at which oil vapor bums without the presence of a spark or flame) of these oils must always be well above the highest heat of compression; otherwise, there is the danger of internal combustion in the compressor cylinders. An example of a Seabee operated and maintained compressor is discussed in the paragraphs below. The 600 ft3/min, portable air compressor is a single cylinder, sliding vane, oil-cooled, positive displacement rotary compressor, connected through a friction disk clutch to a heavy-duty industrial diesel engine. The complete assembly is equipped with a semi-elliptical spring mounting, pneumatic tires, and drawbar.

The portable compressor comes equipped with all components essential for proper operation, including the following:

A heavy-duty, single, dry-type air cleaner to provide clean air for the compressor and engine with a minimum of service requirements.

Large, cool radiator elements with ample capacity for efficient, dependable cooling of the compressor oil and engine coolant.

Oil filters with replaceable cartridges for efficient filtration of the compressor oil and engine crankcase oil. Automotive-type instrument panel with easy-to-read gauges and electrical instruments.

Pneumatic regulating controls that provide for economical engine operation under all loads.

A combination thermostatic valve and bypass to assure rapid warm-up and optimum compressor performance over a wide range of surrounding air temperatures.

An electrically operated shutdown system to stop the engine if a malfunction occurs in the compressor and/or engine.

A blowdown valve to relieve the pressure in the receiver and air-flow system automatically each time the engine is shut down.

An oil flow system that eliminates the need for an oil circulating pump.

COMPRESSED-AIR DISTRIBUTION

Compressed air is a powerful energy source which is very useful in military and industrial applications. It is of particular advantage in applications that require intermittent power at some distance from its source, as the air pressure can be maintained nearly constant at work intervals. The rest of this chapter will pertain to proper installation techniques of compressed-air systems. When you are assigned a project that includes compressed air lines, follow the prints and specifications.

Pressures and Uses

Compressed air usually falls into one of three categories-power service, process service, or control purposes.

Power service is when compressed air either moves something or exerts a force. Examples of power service uses are pneumatic tool operation, air lifts, clamps, and cylinders.

Process service is when compressed air is used as part of the process itself. An example is the use of compressed air in a combustion process. Compressed air provides oxygen for the combustion, and, in turn, it becomes a part of the combustion products and is no longer identifiable as air.

Control purpose is when compressed air is used to govern and/or regulate various equipment by monitoring pressure or flow rates of some substance. A pneumatically controlled combustion system is an example of such an application.

Compressed air is distributed at low, medium, or high pressure. A low-pressure system delivers air up to 125 psig. When several different pressures are required within that range, the plant is usually designed for the highest pressure. Typical low-pressure systems include the following: air motors, crane drives, starting motors for combustion engines, shops, laundry and dry-cleaning plants, and general service (tools, cleaning, painting, and soot blowing for HTW generators and steam boilers).

Medium-pressure systems deliver air from 126 to 399 psig. Normally, this type of system provides an individual compressor located near the load. Typical applications are starting diesel engines, hydraulic lifts, and retread tire molds.

High-pressure compressed air systems range from 400 to 6,000 psig. To minimize the hazard that exists with higher pressures and capacities, you can use separate compressors for each required pressure. Some applications are torpedo workshop, ammunitions depot, catapults, wind tunnel, and testing laboratories.

Piping

Distribution piping is either aboveground or underground. Both aboveground and underground piping systems have advantages and disadvantages. The advantages of each system are as follows:

Aboveground	Underground
Initial cost is lower	Less vulnerable target
Less maintenance	Less obstruction to traffic
Easy detection of failure	Less unsightly
Higher continuous operating efficiency	Freeze protected when buried
Longer life	

Some other factors considered are permanent versus temporary use, existence of high water table, annual ownership, operation and maintenance costs, and degree of hazard (example, potential danger that overhead piping may cause to aircraft operations).

Low-pressure and medium-pressure systems use black steel pipe. Preferably the joints are welded. Special conditions may require stainless steel and copper tubing with appropriate fittings. Connections to removable equipment are always flange fittings, except when using small threaded pipe.

High-pressure systems use seamless steel pipe with butt welded fittings. Screwed fittings, when used, have their ends sealed by fillet welds and exposed pipe threads covered with weld.

Piping supports are held in place by U-shaped or similar types of hangers firmly secured to support structures. Support hangers must fit closely around the pipe, but may allow for slight movement. Aboveground pipe is pitched downward a minimum of 3 inches per 100 feet of length, in the direction of the airflow, to low points where the condensate is collected and drained through drip legs. The drip legs are at all low points, bottom of all risers, and every 200 to 300 feet from horizontally pitched pipe.

Underground piping is normally placed as direct burial. Because this type of placement generally lowers the temperature of the air in the piping, more condensation will form within the pipe than in an aboveground system. The provisions to remove the condensation may be building basement drip legs, or manholes may be required. If the soil is corrosive, cathodic protection may be needed. Underground lines are pitched the same as aboveground lines at 3 inches per 100 feet; however, drip legs differ from aboveground lines in that belowground lines require a drip leg at not over 500 feet. Insulation on buried compressed air piping should be shop-coated, wrapped, tested, and handled according to the NAVFAC specification 34-Y, *Bituminous Coating for Steel Surfaces.*

Auxiliary Equipment

Air filters are provided on compressor intakes to prevent atmospheric dust from entering the compressor and causing scoring and excessive wear. Two types of air filters are used-the dry type and the oil-wetted type. Generally, the dry-type filter is more efficient than the oil-wetted type in trapping and removing very fine, solid particles from the incoming air; however, dry-type filters require cleaning and replacement more often than the oil-wetted types. Oil-wetted types are usually used under very dusty, dirty atmospheric conditions.

SILENCERS.-Air compressors are fitted with silencers (fig. 6-43) that are sound-absorbing devices attached at the intake and output of the compressor. In general, air noise silencers are cylindrical housings containing acoustically tuned baffles and sound-absorbing material.

INTERCOOLERS AND AFTERCOOLERS.— Intercoolers and aftercoolers are used to reduce the heat buildup due to the compression of air. The two mediums used are water and air. Normally air is used on smaller compressors. The air-cooled heat exchanger is simply a set of fins and/or tubular radiator. No liquid of any sort is used for cooling. The water-cooled heat exchanger operates as a shell and tube design (fig. 6-44). The tubes commonly consist of

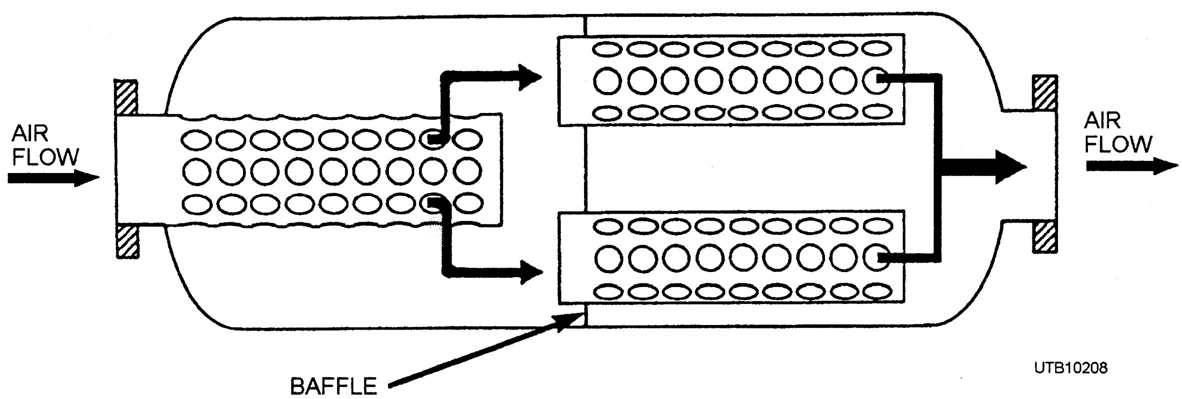


Figure 6-43.—Compressor intake silencer.

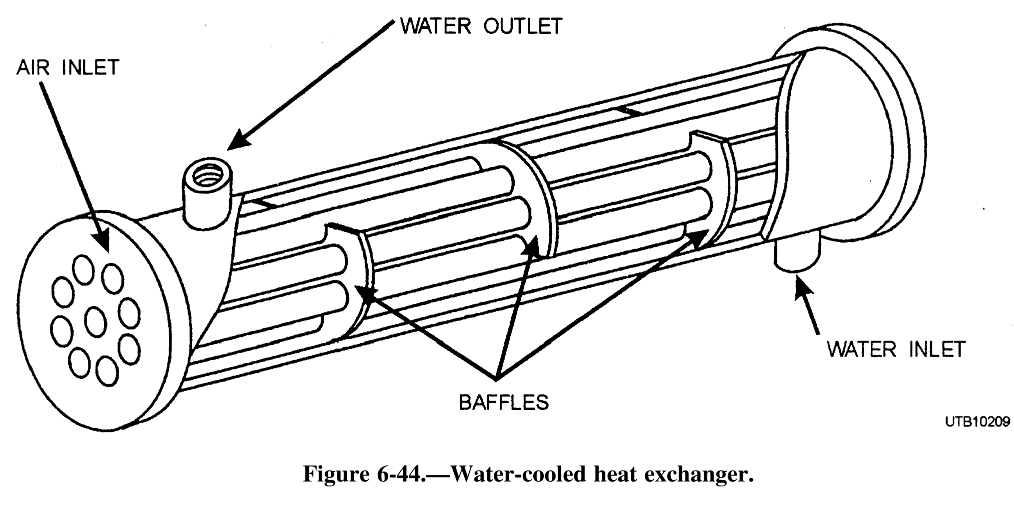


Figure 6-44.—Water-cooled heat exchanger.

a single bundle of tubes enclosed in a cylindrical shell. The air to be cooled passes through the tubes while the water circulates around the outside of the tubes absorbing the heat from' the compressed air. The baffles are used to direct the water flow across the heat exchanger tubes in the most efficient manner. The intercooler is located between the discharge of one cylinder and the intake of the next cylinder on a multistage compressor. The intercooler reduces the temperature and volume of the compressed air for delivery to the next compression stage. The aftercooler is located at the discharge of the last cylinder to cool the air, to reduce the volume, and to liquify any condensable vapors.

SEPARATORS.—Separators remove oil and water from compressed air. Figure 6-45 shows a centrifugal moisture separator. The air enters the unit in a swir ling motion. Centrifugal action forces the moisture to the walls of the separator and then the moisture drains to the bottom of the separator.

Another type of separator is the baffle type. This separator causes the air entering the separator to make sudden changes in direction, causing the heavier moisture particles to strike the baffles and walls and drain to the bottom.

TRAPS.—Compressor plant traps drain moisture from intercoolers, aftercoolers, receivers, and distribution piping. Common traps used are the ball float, the bucket, and the inverted bucket traps (fig. 6-46).

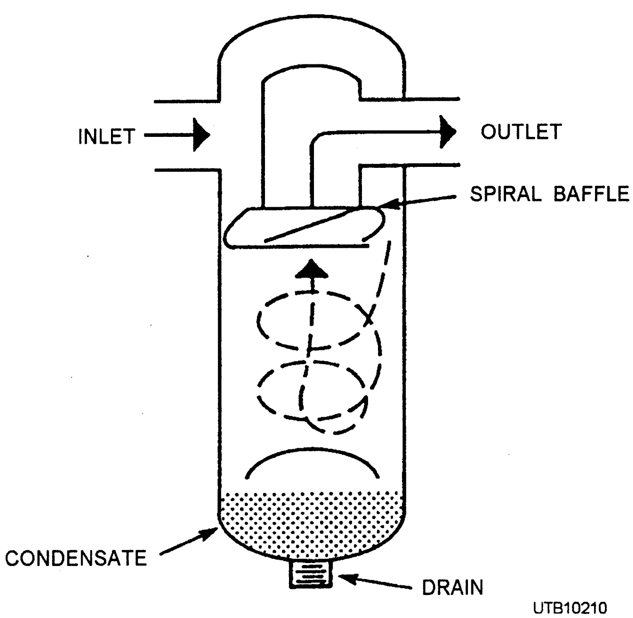


Figure 6-45.—Centrifugal moisture separator.

AIR RECEIVERS.—The receiver is nothing more than a tank designed to hold the -air that is compressed to meet supply peak demands that are in excess of the compressor capacity. Additionally, receivers function as pulsation dampers on reciprocating compressor installations. Figure 6-47 shows an air receiver.

DRYERS.—Dryers remove moisture from compressed air that would condense in air lines, air tools, and pneumatic instruments. Condensation can cause damage to equipment by corrosion, freezing, and water hammer, and will cause instruments to malfunction. The three types of dryers are adsorption, deliquescent, and refrigeration.

The adsorptive dryer is made of some type of desiccant, such as silica gel or activated alumina. The desiccant adsorbs and holds the water vapor from the air. Adsorption-type dryers (fig. 6-48) consist of two drying towers, each containing an adsorbent, plumed in parallel. The drying towers are cycled manually or automatically, so one tower is on stream and the other tower is being reactivated. Reactivation is accomplished by heating the desiccant which drives the moisture out to waste.

Only one type of dryer was discussed in this chapter. Other types of dryers, maintenance, operation of controls, and other interesting information about compressors can be found in NAVFAC MO-206, *Maintenance and Operation of Compressor Plants.*

SAFETY PRECAUTIONS

Listed below are some safety tips on how you can avoid air compressor accidents.

- Keep the hose connections on portable air compressors tight, and inspect these connections often to ensure they remain tight.
- Check the safety valves and gauges frequently to make sure they are working correctly.
- Use fixed tow bars, not chains or ropes, when moving portable air compressors.
- Check the wheels of portable air compressor carriages to ensure proper operation.
- When an air compressor is started, check the safety valves, the pressure controls, and the regulators to determine that they are working properly.
- DO NOT leave the area of an operating compressor unless you are sure that the control,

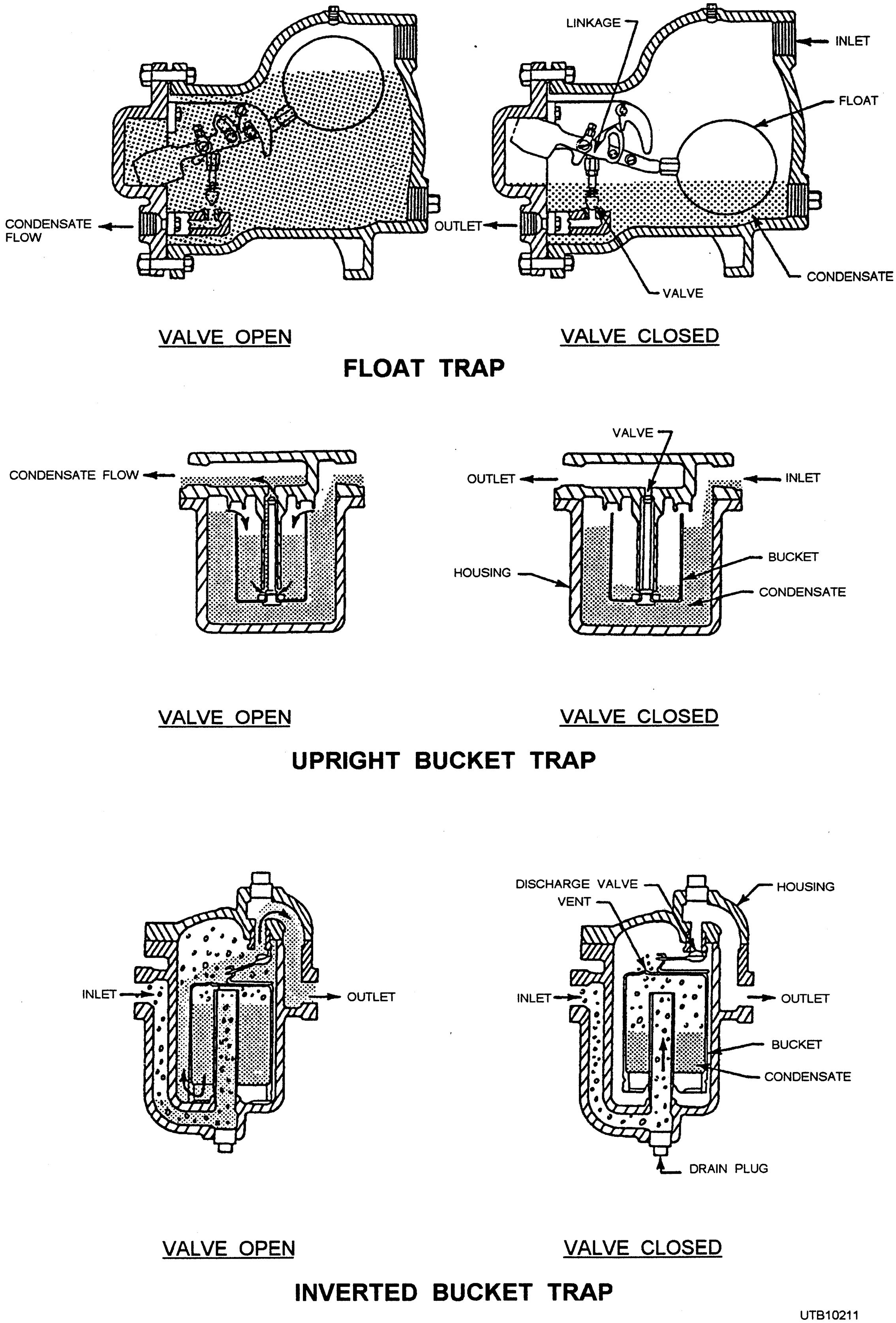


Figure 6-46.—Traps: A. Float; B. Upright bucket; C. Inverted bucket.

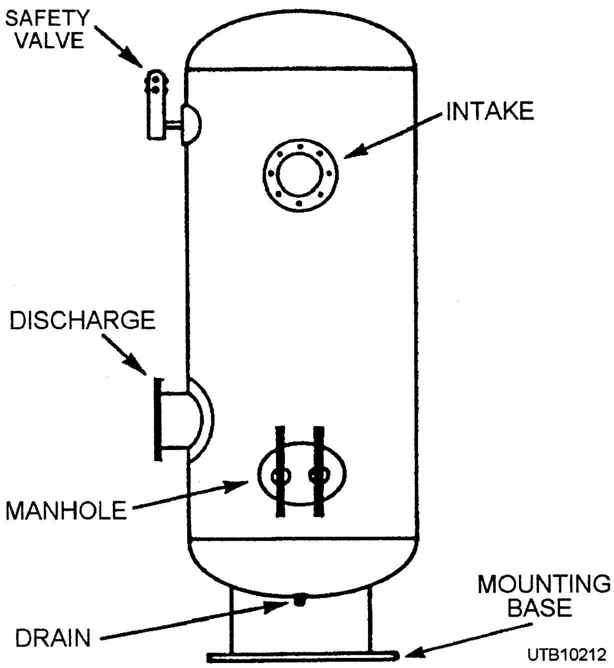


Figure 6-47.—Air receiver.

the unloading, and the governing devices are working properly.

- Do NOT run a compressor faster than the speed recommended by the manufacturer.
- Be sure that air at the compressor intake is cool and free from flammable gases, vapors, and dust.
- Do NOT permit wood or other flammable material to remain in contact with the air discharge pipe.
- Immediately secure a compressor when the temperature of the air discharge from any stage rises unduly or exceeds 400°F.
- Do NOT install a check valve or drop valve between the compressor and receiver unless a relief valve is also fitted between the compressor and the stop or check valve. (If the compressor is started against a closed valve or defective check valve, an explosion can result.)
- Pressure gauges must be in working order unless you have to remove them for repair.
- NEVER kink a hose to stop the air flow, and always keep clamps on the hose tight.
- Keep compressor pipes and tanks clean to guard against an oil vapor explosion. Clean intake air filters periodically.
- Turn off the motor before adjusting and repairing an air compressor.
- Use only soapy water or another suitable nontoxic, nonflammable solution for cleaning compression intake filters, cylinders, or air passages. NEVER use benzene, kerosene, or other light oils to clean these portions of a system. These oils vaporize easily and form a highly explosive mixture under compression.
- Know what compressors can do, realize they are dangerous, and then use them safely

Q22. What are the three types of air compressors?

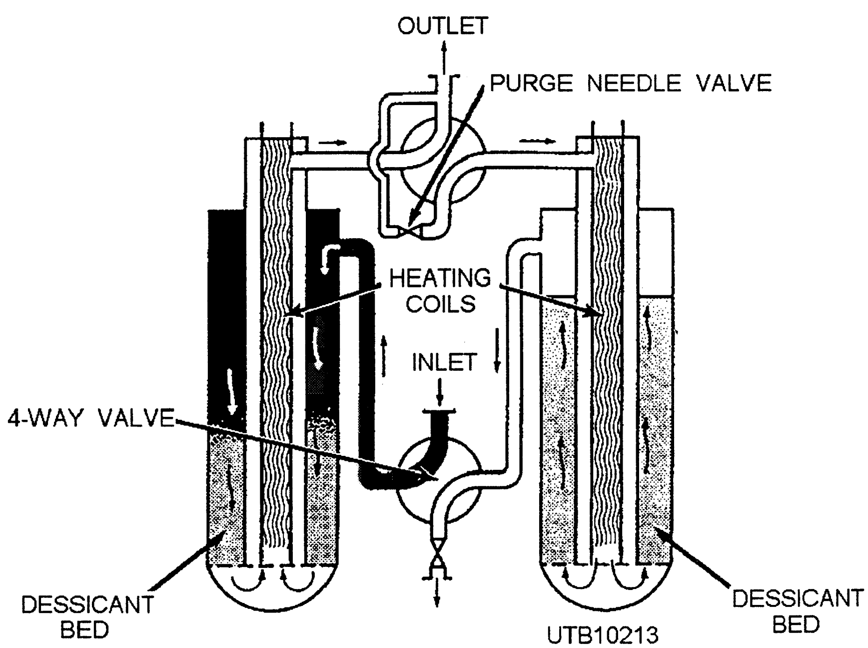


Figure 6-48.—Flow diagram of an electric adsorption dryer.

Q23. What type of prime mover drives the majority of air compressors used in the Navy?

Q24. What is the one type of load that unloading systems on air compressors cannot remove?

Q25. What is the purpose of an after cooler?

Q24. What auxiliary equipment on an air compressor removes moisture from the system?

CHAPTER 7

WATER TREATMENT

LEARNING OBJECTIVE: *Recognize methodology used for water treatment and purification; understand and identify types of water treatment equipment, treatment processes, and water testing procedures.*

Water is never absolutely pure. Impurities in water vary from dissolved gases, chemicals and minerals, to suspended matter, like disease germs and dirt. Some impurities can be seen and some cannot; others can be detected by taste or odor or only by laboratory tests. This chapter explains the water cycle, the quality of water, the chlorination equipment, the water treatment quality control and water testing procedures. Water treatment is vital to the health and well-being of the troops. Improper treatment of water can allow the spread of infectious intestinal diseases and skin fungus. The unit commander and the Navy Medical Service share responsibility of ensuring a supply of pure water in the Seabees. As a Utilitiesman, you will perform major duties involving the treatment and purification of water, so it is safe to use for drinking, cooking, and bathing.

THE WATER CYCLE

LEARNING OBJECTIVE: *Understand the hydrologic cycle and sources* of *water.*

Water is circulated from the oceans to the atmosphere by a series of processes and then to the surface of the earth and beneath it. This is known as the water cycle, or hydrologic cycle (fig. 7-1). An understanding of the occurrence of groundwater is based on a general knowledge of these processes and their relationships to each other. Basically, the cycle consists of the following processes:

- Evaporation of water from oceans
- Condensation of the water to produce cloud formations
- Precipitation of rain, snow, sleet, or hail upon the land surface
- Dissipation of the water by direct runoff into lakes and streams

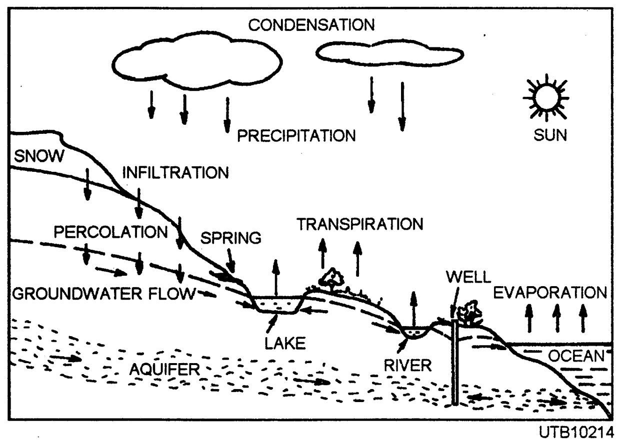


Figure 7-1.—The hydrologic cycle.

- Seepage, or infiltration, of rainwater or melted snow into the soil and then into underlying rock formations
- Movement of water through the openings in the rocks and at the surface through springs, streams, and lakes
- Direct evaporation

The cycle usually does not progress through a regular sequence and may be interrupted or short-circuited at any point. Moisture that condenses over the ocean may fall into it as rain. Rain that falls upon a heavily forested area soon may return to the atmosphere by direct evaporation or through transpiration by plants. Jungle-covered islands of the Southwest Pacific are known to produce more evaporation than adjacent areas of ocean. Water that seeps into the soil may be retained for a time by soil capillarity, or other means, before moving downward through the unsaturated zone to become a part of the groundwater.

As the rainfall and water cycle repeats itself, depending upon climatic and other conditions, a water supply is built up that can be captured and used for a multitude of purposes. Roughly, this basic water supply is divided into two categories-surface water and groundwater.

SURFACE WATER

Surface water is water that is flowing in our streams or rivers, resting in our lakes and ponds, or flowing into the sea. Its origin lies in the water that falls from the atmosphere, together with that which flows from the ground under certain circumstances. The water precipitated upon the surface of the earth from the atmosphere can be in the form of rain, snow, sleet, fog, or dew. Depending upon the character of the soil, this precipitated moisture is partly absorbed by the soil, partly evaporated or transpired by plant growth with the remainder caught in surface depressions or flowing over the surface to natural stream beds where it continues on its way to the sea or into the crevices of the earth. In olden days, it was thought that the vast underground water storage reservoirs were tied by surface streams. This is only partly true. In many cases where geological conditions permit, the groundwater sources feed the stream instead. It is true that the underlying beds of some surface streams are composed of sand and gravel and other materials deposited through the ages by sedimentation or glacial action. In these cases, water from the stream sometimes trickles down by gravity through the stream bottom into the underlying sands or gravel. When this happens, the water in the bottom gravel generally flows in the same direction as the stream itself. In other cases, it may be held in storage by natural barriers in the path of its flow. These underlying sands and gravel, generally referred to as "alluvium," are discussed in the section covering groundwater. In many cases, riverbeds become completely dry while the flow through the alluvium continues. This occurs in many cases in the western sections of the United States and on the Pacific Coast of North America.

GROUNDWATER

Groundwater is that part of the water or moisture that has precipitated from the atmosphere upon the surface of the earth and has been absorbed by the soil and collected below a certain level called the "water line." The waterline is of utmost importance and interest. The uppermost part of the surface of the earth is composed of layers of materials of a varying nature. There is a topsoil capable of sustaining plant growth. This topsoil is composed largely of minute particles of rock mixed with decayed vegetable matter or other material. A layer of material generally referred to as "soil" underlies the topsoil. Soil is composed of minute particles of rock mixed with various materials, sometimes of vegetable or animal origin, but often containing nothing more than materials of mineral origin. The depth of the soil bed is not fixed and may vary from a few inches to several feet.

Under the soil layer is the top layer of rock, which is decomposed in some measure and which at a deeper level becomes more solid. Ultimately this rock becomes solid, as it was in the original cooling process. That part of the crust of the earth between this solid rock and the surface of the earth is of interest in discussing groundwater. Again, the depth of this outer layer is a variable because in many locations the virgin rock appears at the surface with no overlying decomposed rock or soil. Certainly, groundwater could not be found at such locations.

Now, consider the layer of decomposed rock which is between the uppermost layer of soil and the solid or virgin rock itself. Here, during the ages, many things have happened. The action of the elements, atmospheric conditions, earthquakes and upheavals, volcanic action and chemical reactions, as well as pressure conditions and other influences, have caused this layer to become anything from a semisolid rock to a conglomeration of layers of various materials. These layers of materials are referred to as "strata." The layers normally follow the contour of the surface of the earth; however, in some cases, they outcrop at the surface and slant downward. These strata may be composed of sand, gravel, broken stone of all sizes and character, minerals of all kinds, and even layers of solid rock. Some of the softer materials are shales, chalk, clays, and gypsum. The harder materials consist of limestone, granite, quartzite, flint, silica, dolomite, and other minerals. The types of material depend on the geographical location and the conditions under which the top most layers of rock were formed. In the formation process, because of earth movement and other influences, these varying strata were bent, folded, and broken in such fashion that it is not possible to chart their exact course through the upper part of the crust of the earth. Their presence and their position relative to each other are important to the storage and production of groundwater.

Depending upon the composition of these various strata, they either absorb the water which falls from the sky or flows at a level above them, or they reject this water and form a bed upon which the water flows in one direction or the other. The capacity of the material composing any stratum to transmit water under pressure is called its "permeability." The property of the material of any stratum to contain interstices, or openings, is called its "porosity." Both the permeability and porosity of the rock formation determine whether groundwater can be found in suitable amounts at any particular location.

When water falls on the ground, the part of it that becomes groundwater by reason of the soil or surface characteristics is absorbed into the earth. It is then either held in suspension or flows downward by gravity to a point beyond which it cannot pass. It then flows in any direction provided the permeability of the particular stratum holding it permits. When the permeability of the stratum does not permit flow, the water remains confined at that point. As more water percolates downward through the soil or rock, the top level of the confined water rises until flow becomes possible in one direction or the other through a more permeable formation. More water must come from a higher level to sustain such a flow. Finally, the amount of water percolating from the higher levels balances the amount of water flowing laterally away, and the top level of the main body of groundwater is stabilized. The upper surface of this main body of groundwater, when stabilized under any condition of flow, constitutes the water table for any specific locality. However, the water table is not fixed because it rises and falls according to the varying amounts of water percolating from above (called the "influent" supply) and those amounts flowing away or withdrawn (called the "effluent" flow). A stratum that bears groundwater is termed an aquifer.

Water beneath the surface of the earth occurs in three zones (fig. 7-2) as follows:

1. The zone of soil moisture is where water is temporarily held in pore spaces by capillarity and other soil conditions. Water in the zone of soil moisture may evaporate directly or through transpiration by plants or it may percolate downward into the zone of aeration and then to the zone of saturation.

2. The zone of aeration, or zone of percolation, is beneath the soil layer where both water and air are present in the pore spaces. Wells ending in the zone of aeration produce no water. Sometimes in the cooling-off process or because of other external and internal influences, a stratum of material that does not permit the passage of water has been heaved about into a cup-shaped formation at a point in the zone of aeration higher than the established water table. In time, this cup is filled with groundwater and a "perched" or false water table is established. This is a serious problem to those attempting to develop a groundwater supply. The perched supply, if pumped, is soon exhausted and requires seepage from above for replenishment. Many of these perched supplies result from folded clay formations in the zone of aeration that stop the percolation of water downward. Perched water never forms a dependable water supply.

3. The zone of saturation is where all pore spaces are filled with water. The top of the saturated zone is called the "water table." It is not flat, but has a variable depth beneath the surface, depending upon surface topography, rainfall, and direction of water movement, rock structure, and porosity. Permeable rocks in the zone of saturation yield water to wells.

Q1. What are the two categories of water?

Q2. What are the three zones of subsurface groundwater?

THE QUALITY OF WATER

LEARNING OBJECTIVE: *Identify and understand types of waterborne diseases, impurities in water, and types of treatment processes.*

Preliminary to discussion of water production, the "quality" of available water supplies must be briefly considered. Whether the water supply comes from the surface or underground, the supply must suit its intended use. Either source may produce water with too high a concentration of mineral salts, color, suspended matter, incrusting or corrosive agents, or bacteria that prevents the use of water in its natural state for the purpose intended. If suitable water cannot be found, then other available sources must be used. The water must be treated to remove those elements that make its direct use impossible. For human consumption, all harmful bacteria must be destroyed and the concentration of certain mineral salts and

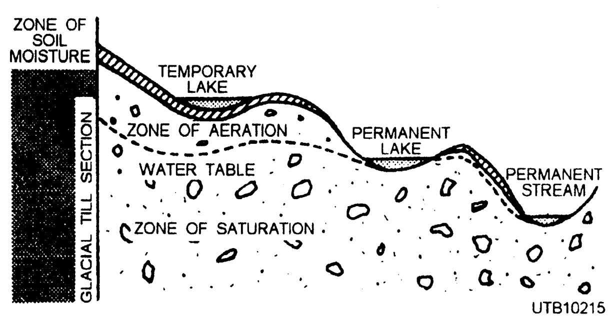


Figure 7-2.—Classification of underground water.

suspended matter reduced to a level that makes the water safe to drink or to use in preparing food. Industries 'sometimes have to treat their raw-water supply to meet the requirements of the manufacturing processes. Boiler feedwater must often be treated to prevent sludge from forming in the boiler and scale from forming on the metal surfaces. Most towns and municipalities must treat their water supply by some method before distributing it as potable water. Water, whatever the source, must be available in quantity and quality to meet its intended use.

WATERBORNE DISEASES

In this section, various diseases caused by the use of water that is impure and unsafe are discussed. Some of the methods of treatment and purification used in the field to eliminate impurities in water are also discussed. Additionally, you are introduced to types of purification equipment with which you, as a Utilitiesman, should be familiar.

Water flowing over the surface of the earth picks up dirt, disease organisms, chemicals, and anything else in its path that can be dissolved or moved. Water that soaks into the ground loses many of its suspended impurities, as it filters through the earth. Although the water becomes clearer, it dissolves minerals and other chemicals at the same time. Groundwater may be clear, but it is not pure and may contain harmful disease organisms and chemicals.

Waterborne diseases do not appear immediately after drinking contaminated water. Disease-producing organisms need time to grow and multiply inside a person before they cause illness. The time between drinking contaminated water and the appearance of the disease is called the incubation period. Absence of disease symptoms for several days after drinking untreated water is no guarantee that the water is pure. Lack of disease symptoms in the natives is no test either, as they may have become immune.

IMPURITIES IN WATER

Any water supply can be a source of danger and destruction because of the many impurities often found in it. Impurities in water can be broken down into two major categories-dissolved impurities and suspended impurities. DISSOLVED IMPURITIES are organic or inorganic materials or chemicals that cause an unpleasant taste, color, or odor in the water. SUSPENDED IMPURITIES include organisms as well as organic and inorganic materials that usually make the water turbid or muddy looking. Suspended impurities are usually more dangerous to health than dissolved impurities. The suspended impurities consist of mineral matter, such as sand, silt, or clay; of disease organisms, such as bacteria or protozoa; and of water plants, such as algae. It is absolutely necessary to remove or destroy the disease-producing organisms in water that will be consumed by people.

TYPES OF WATERBORNE DISEASES

Water carries many of the organisms that produce disease. Disease-producing organisms carried by water occur in two classes-those readily destroyed by chlorination and those that are chlorine resistant. Although the chlorine-resistant organisms require careful treatment, they can be destroyed by purification methods. Waterborne diseases caused by dangerous organisms include typhoid, paratyphoid, cholera, amoebic dysentery, schistosomiasis, and diarrhea. The following discussion stresses continual care and inspection of the water supply, because waterborne diseases spread if not treated properly.

Typhoid Fever

TYPHOID FEVER is an intestinal disease caused by the bacterium known as bacillus typhosus. Symptoms of this disease are rose-colored eruptions of the skin, accompanied by a high fever (lasting about 4 weeks) and frequent bowel movements. Typhoid fever organisms are readily destroyed by field chlorination methods. Most waterborne diseases do not appear immediately after using contaminated water, as they need time to grow after entering a person's system. The time to grow is the incubation period.

Paratyphoid Fever

PARATYPHOID FEVER is similar to typhoid in sources of infection and in symptoms; the organisms are, like the typhoid bacillus, readily destroyed by field chlorination methods. The incubation period varies from 4 to 10 days. An attack gives a person immunity from a second attack of paratyphoid, but does not give immunity from typhoid.

Cholera

CHOLERA germs are discharged from the body in feces where they live for several days. When water in any form contacts this germ, it is carried along and multiplies.

Amoebic Dysentery

AMOEBIC DYSENTERY is an infectious intestinal disease. Symptoms are eruptions of the skin and frequent bowel movements. This disease is caused by a small animal instead of bacteria and resists ordinary chlorination. It is carried by amoebic cysts that foray in the intestines, then are discharged in the feces. Cysts (shell or sack) protect them and, when in water or moistened, they live for many days, but drying destroys them. The diatomite filter removes the cysts and super chlorination destroys them.

Schistosomiasis

SCHISTOSOMIASIS is caused by a small worm that enters the body through consumption of contaminated water. Or, it may enter through the skin while a person is bathing or swimming in contaminated water. Eggs of this parasite (commonly called blood flukes) are discharged from an infected person through the urine or feces. In fresh water, these eggs hatch into very small, free-swimming larvae which are not infectious to humans. However, if these larvae can find freshwater snails to enter, they develop into the next form "cercariae," and become highly infectious to human beings. In water, larvae can live for only 24 hours and cercariae for only 36 hours. The effective remedy is to destroy all the snails at the water source. Once the snails are destroyed, the cycle is broken and the disease ceases.

Diarrhea

DIARRHEA is a name given to several intestinal diseases characterized by cramps and frequent bowel movements with watery feces. Inadequate sanitary protection of food and water can cause diarrhea. When the disease is caused by food, it is restricted to those who consume the contaminated food; however, waterborne infection is likely to be widespread. Proper chlorination measures will eliminate waterborne diarrhea.

In addition to the specific waterborne diseases discussed above, there are several nonspecific disorders caused by impure water. One example is the staining or discoloring of teeth because of the presence of fluorides in drinking water.

TREATMENT AND PURIFICATION OF WATER

Various methods of treatment and purification are used to eliminate impurities in water and make it pleasant to drink. You should be familiar with some of the principal methods commonly used, keeping in mind that safe, pure water is essential to naval operations everywhere. How well you carry out your duties in the treatment and purification of water concerns the health and welfare of all personnel using the water. Methods used in various combinations of field treatment and purification of water include coagulation, flocculation, sedimentation, filtration, and disinfection.

Flocculation

COAGULATION is a formation of gelatinous particles in water by chemical action. FLOCCULATION is the combination of these particles into a heavy precipitate (floc) that absorbs color and entangles bacteria and other suspended matter, as it settles. A common floc-forming chemical is aluminum sulfate (filter alum). When sufficient natural alkali is not present in the water to form a good floc, additional alkali (soda ash) must be added. Figure 7-3 shows how flocculation works. Mechanical devices, such as mixers, agitators, and baffles, are an advantage in flocculation because they keep the precipitate suspended in the water long enough to produce a heavy floc.

Sedimentation

If you were to dip up a glassful of water from a moving stream and proceed promptly to observe its contents, you would probably discover a number of solid particles being held in suspension in the liquid. At first these particles are more or less equally dispersed; but as the water becomes still, they start settling to the bottom of the glass. The settling of solids in this manner is caused by the natural action of gravity. In the field of water treatment, clearing water

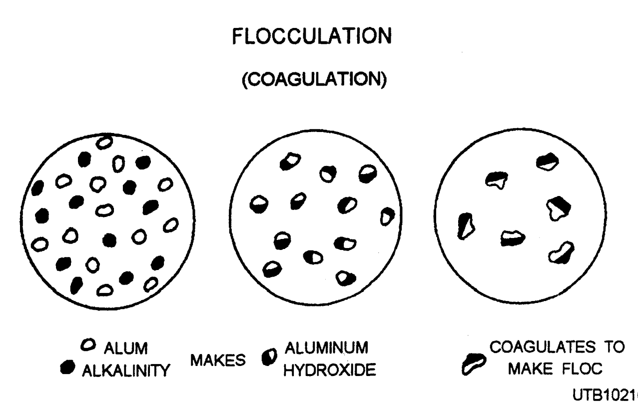


Figure 7-3.—The process of flocculation.

of turbidity (that is foreign suspended matter) by this natural settling process is known as SEDIMENTATION. Sedimentation is accomplished in settling tanks where the water is held for a time to allow the floc to form and settle out turbidity. In conventional treatment, settling immediately follows flocculation. The ideal detention period for settling after slow mixing is about 1 1/2 hours.

Filtration

Not all suspended matter is removed by sedimentation. Therefore, another process known as FILTRATION is used. An effective type of filter used in the filtration process is the diatomite. Because it is lightweight, this filter is widely used at overseas bases. It removes suspended matter from water by passing it through a porous mat of diatomaceous silica. Diatomaceous silica is the skeletal remains of tiny algae, called diatoms, found in marine deposits that have been lifted above sea level. The diatomite (also called diatomaceous earth or filter aid) is supported by a filter element. This supporting base is porous endugh to permit maximum flow. It is also fine enough to support the filter cake that coats the element. Diatomite filters are backwashed by reversing the flow of water and drawing filtered water through the filter to keep the filter output from falling off. The turbidity of the water is largely determined by the frequency of backwash.

Disinfection

Except in rare instances, all water supplies require disinfection. Disinfection is the chemical destruction of bacteria. Because of its economy, dependability, efficiency, and ease of handling, chlorine is almost always used for this purpose. For this reason, the term *chlorination* generally means the same as DISINFECTION.

Disinfection is a necessary step in ensuring a safe water supply. Ali new, altered, or repaired water-supply facilities must be disinfected before they are placed in service. Water from surface supplies may be disinfected before filtration or before coagulation and sedimentation to prevent the growth of organisms. This procedure is known as precholorination. The water must also be disinfected after filtration to destroy organisms that still remain and to provide a safeguard against recontamination. This procedure is known as postchlorination.

Chlorine is the disinfectant specified for Navy use. In'the form of chlorine gas or of hypochlorites that yield chlorine in water, chlorine is presently the only widely accepted agent that destroys organisms in the water and leaves an easily detectable residual that serves as an indicator of the completeness of treatment. The sudden disappearance of residual chlorine may signal contamination in the system. Under ordinary temperatures and pressures, chlorine gas is greenish yellow and is heavier than air. Its effectiveness as a disinfectant depends on the temperature and the hydrogen-ion concentration (pH) of the water to which it is added. Disinfecting action is faster at higher temperatures, but is retarded by pH. When the pH is above 8.4, the rate of disinfection decreases sharply.

Ozone, potassium permanganate, bromine, and. iodine are also used to a limited extent as disinfectants. If excess lime is used for softening water, it makes the water alkaline and disinfects after about 10 hours of contact. However, the general applicability and economic advantage of chlorine have established it as the preferred disinfectant.

CHLORINE DISINFECTION.—Chlorine disinfectants are available in a number of different forms as described in the following paragraphs

LIQUID CHLORINE is liquefied gas under pressure and is shipped in seamless steel cylinders under the regulations established by the Interstate Commerce Commission. The standard sizes of shipping containers are 150-pound cylinders, 1-ton containers, and 30-ton tank trailers.

Each pound of liquid chlorine produces about 5 cubic feet of chlorine gas at atmospheric pressure and at a temperature of 68°F. A standard Chlorine Institute valve and a protective valve hood are screwed into the neck of each cylinder. 'The valve has a safety plug containing fusible metal that softens between 157°F and 162°F to protect the cylinder from bursting in case of fire. All cylinders must be factory tested every 5 years; 150-pound cylinders are tested at 500 pounds of pressure; and I-ton containers are tested at 800 pounds of pressure.

HIGH-TEST CALCIUM HYPOCHLORITE is a relatively stable, dry granular solid or powder that is readily soluble to form a chlorine solution. Prepared under a number of trade names, including HTH, Perchloron, and Pittchlor, it is furnished in 3- to 100-pound containers and has 65 to 70 percent available chlorine by weight. Because of its concentrated form and ease of handling, calcium hypochlorite is preferred over other hypochlorites.

SODIUM HYPOCHLORITE is generally furnished as a solution that is highly alkaline, and therefore reasonably stable. Federal specifications call for solutions with 5 and 10 percent available chlorine by weight. Shipping costs limit its use to areas where it is available locally. It is also furnished as powder under various trade names, such as Lobax and HTH-15. The powder generally consists of calcium hypochlorite and soda ash that react in water to form sodium hypochlorite. Ordinary household bleach is a sodium hypochlorite solution containing 2.5 percent available chlorine and is sometimes used at small installations.

CHLORINATED LIME, also known as CHLORIDE OF LIME or BLEACHING POWDER, is seldom used in water disinfection. It is a mixture of calcium chloride and calcium oxychloride that yields about 35 percent available chlorine when fresh. It deteriorates rapidly in a hot, moist atmosphere and should be purchased in small packages that can be kept sealed. Chlorinated lime contains an excess of insoluble lime; therefore, the solution should be prepared in a separate container, the lime permitted to settle, and the liquid decanted into a separate tank for use.

CHLORINE TERMS.—When chlorine gas is introduced into pure water, some of it reacts to form hypochlorous acid, and the rest remains as dissolved chlorine. These forms of chlorine are termed *free available chlorine* because their oxidizing and disinfecting ability is fully available. Because most natural water contains small amounts of ammonia and nitrogenous organic substances, free available chlorine reacts with these substances to form chloramines and other complex chlorine-nitrogen compounds. These forms of chlorine compounds are termed *combined available chlorine* because part of the chlorine oxidizing disinfecting ability is lost. Both free available chlorine and combined chlorine react with oxidizable substances in water until their oxidizing and disinfecting ability is depleted. The amount of chlorine consumed in reacting with organic substances in water in a given time (usually 10 minutes) is called the CHLORINE DEMAND. Chlorine remaining in excess of the chlorine demand is the TOTAL CHLORINE RESIDUAL or RESIDUAL CHLORINE. Residual chlorine is composed of both free available chlorine and combined available chlorine. The time elapsing between the introduction of chlorine and use of the water is 30 minutes and is termed the *contact period.*

BACTERICIDAL EFFECTIVENESS.—The bactericidal effectiveness of chlorine depends upon the pH chlorine residual, contact period, and temperature. The pH value is a measure of the acidic or alkaline nature of the water. The pH of water is technically defined as the negative logarithm of the hydrogen in concentration. The pH value ranges from 0 to 14. A value of 7 is neutral. Values decreasing downward from 7 represent increasing numbers of hydrogen ions. Values increasing upward from 7 represent decreasing numbers of hydrogen ions. A low pH value indicates a very strong acid solution. A high pH value indicates a very strong alkaline solution. The alkalinity of water is the amount of "alkaline" substances in a given sample of water when titrating downward to a pH of 4.2 with sulfuric acid. The acidity of water is the amount of "acid" substances in a given sample of water when titrating upward to a pH of 4.2 with sodium carbonate. The pH value of natural water can vary from 3.4 to 9.0, depending on the impurities present in the water.

The pH influences the corrosiveness of the water, the amount of chemical dosages necessary for proper disinfection, and the ability of an analyst to detect contaminants. The pH scale is shown in figure 7-4.

Chlorine effectiveness increases rapidly with an increase in the residual. However, free available chlorine is 20 to 30 times as effective as combined chlorine under the most favorable conditions of pH (7.0) and water temperature (68°F to 77°F). Therefore, the relative amounts of free and combined available chlorine in the total residual are important.

Within normal limits, the higher the chlorine residual, the lower the required contact period. If the residual is halved, the required contact period is doubled. The effectiveness of free available chlorine at 35°F to 40°F is approximately half of what it is at 70°F to 75°F. The effectiveness of free chlorine is highest at pH 7 and below. At pH 8.5, it is one sixth as effective as at pH 7, and at pH 9.8, it may require 10 to 100 times as long for a 99 percent bacteria kill as at pH 7.

POINTS OF APPLICATION.—Plain or simple chlorination is the single application of chlorine as the

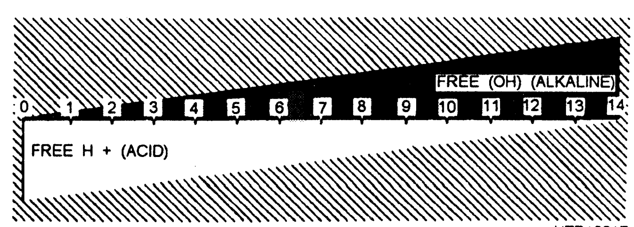


Figure 7-4.—The pH scale.

only treatment before discharge to the distribution system, as in the chlorination of groundwater supplies and previously unchlorinated purchased supplies. Prechlorination is the application of chlorine to raw water before coagulation, sedimentation, or filtration. Postchlorination is the application of chlorine after filtration, but before the water leaves the treatment plant. Rechlorination is the application of chlorine into the distribution system or into a previously chlorinated purchased supply to maintain the chlorine residual.

The above applications are normally continuous. Very heavy chlorination for a limited period is sometimes applied at specific points in the distribution system to destroy localized contamination.

OTHER USES OF CHLORINE.—Chlorine is also used to control tastes and odors in water. It reacts with the substances causing taste and odor, such as hydrogen sulfide, minute organisms, algae, and organic compounds.

If the reaction is incomplete, the taste and odor of some substances may be intensified or become more objectionable. Chlorine is also used to a limited extent to oxidize iron and manganese and to remove color.

SAFETY.—Safety is important in the handling of chlorine. Some of these important factors are as follows:

- Provide self-generating oxygen-breathing apparatus or self-contained oxygen-breathing apparatus designed to cope with chlorine.
- Maintain only the supply of chlorine in any chlorinator room that will do for normal daily demands. Store the main supply in a detached noncombustible building or in a fireproof room that is vented only to the outside and separated from the main part of the building. Keep the chlorinator and chlorine storage building or rooms locked to prevent the entrance of unauthorized personnel and restrict these areas from any other use.
- Allow only reliable and trained personnel to handle chlorine.
- Handle containers carefully to avoid dropping or bumping them.
- Avoid hoisting containers; if hoisting is necessary, use safe lifting clamps.
- Store cylinders in a cool place, away from dampness, steam lines and fire, and in an upright position secured from tilting and falling.
- Keep protective valve caps on containers when not in use; never tamper with safety devices on containers.
- Never connect a full cylinder to a manifold with another cylinder unless the temperatures of both are nearly the same.
- When not withdrawing chlorine or when cylinders are empty, keep the valves closed.
- Disconnect the valves as soon as the containers are empty, and check for chlorine leaks at the valve outlets. Test for leaks by passing an opened bottle of strong ammonia solution around the valve. White fumes of ammonium chlorine will appear if there is any leakage. Leaks around fittings, connections, and line can be detected in the same way. Do not apply ammonia solution to plated metal parts, as it will remove the plating.
- When chlorine is noticed, workers should avoid panic, refrain from coughing, keep mouth closed, avoid deep breathing, keep head high, and get out of the affected area. Only qualified personnel with suitable respiratory equipment should be assigned to investigate and correct the cause of chlorine leaks. If chlorine is being discharged, close the container valve immediately. If chlorine is escaping in liquid form, turn the containers so the chlorine escapes as gas. This will reduce leakage. Do not apply water to the leak; this dangerous practice causes corrosion that may increase the leakage. Electronic chlorine gas detector warning devices are widely used in plants and mechanical rooms that contain chlorine.
- The handling of a persistent chlorine leak in a plant is best left to the chlorine supplier or local fire department.
- Never apply a flame, blowtorch, or other direct heat to chlorine containers; discharge them in a room with a temperature of about 70°F.
- Never ship a defective or leaky cylinder unless it is completely empty. Paint "DEFECTIVE" plainly on all such cylinders.
- Follow all regulations on shipping, storing, and using compressed gas cylinders.
- Provide proper means of exit from areas where chlorine is stored or used.
- Never use a chlorine cylinder except to hold chlorine gas.

Q3. In reference to waterborne diseases, what does "incubation period" mean?

Q4. What are the two major categories of impurities in water?

Q5. Eruptions of the skin and frequent bowel movements, without fever are symptoms of what waterborne disease?

Q6. Natural gravity action is the mechanism for what method of water treatment?

Q7. What is the most commonly used disinfectant in water treatment?

CHLORINATION EQUIPMENT

LEARNING OBJECTIVE: *Recognize types, functions, and safety precautions associated with chlorinators.*

Chlorination equipment used to feed chlorine gas or hypochlorite solution may be classified by type, depending on the methods of control. The three methods of control are manual, semiautomatic, and fully automatic.

1. The manually controlled type equipment must be started and stopped manually, and the rate of feed must be manually adjusted to the rate of water flow.

2. In the semiautomatic type, equipment starts and stops automatically as water flow starts and stops; however, it must be manually adjusted to the rate of water flow. This type is normally used with water pumped at a fairly uniform rate.

3. In the fully automatic type, the rate of feed is automatically adjusted to the rate of flow of the water being treated through pressure of a metering device.

In a!! three types, the ratio of feed to water treated, or dosage, is set by manual adjustment.

Chlorinators may also be classified generally by type of feed. Here you have two types of machines—DIRECT-FEED and SOLUTION-FEED. Direct-feed machines are designed to operate without a pressure water supply, feeding the chlorine gas directly into the flow to be treated. Solution-feed machines dissolve the gas in a minor flow of water and inject the resultant solution into the flow to be treated and require a pressure water supply for operation.

Another method of classifying chlorinators is by the type of diaphragm used in controlling the chlorine feed. There are two types-the water diaphragm and the mechanical diaphragm. The water diaphragm is always a vacuum type, solution -feed machine and has the advantages of being friction-free and punctureproof. The mechanical diaphragm machine may be either direct- or solution-feed pressure type or solution-feed vacuum type only.

DIRECT-FEED CHLORINATORS

Direct-feed chlorinators are used chiefly as emergency equipment and on small installations where it is not possible to obtain a water supply suitable for operating a solution-feed machine. They cannot be used where the pressure of the water being treated is more than 20 psi and are limited in the types of semiautomatic and automatic controls that may be used. Because the chlorine is under pressure as a gas at all times, direct-feed machines may easily leak gas into a confined or poorly ventilated space where the leakage could corrode adjacent equipment and structures. If you should be called upon to operate a direct-feed chlorinator, carefully follow the recommendations and instructions of the equipment manufacturer. You, as the operator, must be thoroughly familiar with the equipment to ensure its proper operation, adjustment, and minor repair.

SOLUTION-FEED CHLORINATORS

A solution-feed chlorinator introduces chlorine gas into the water supply by means of a chlorine solution. This supply is usually formed by drawing chlorine gas into a jet stream of water at the low-pressure point of the injector mechanism of the chlorinator.

The chlorinator (figs. 7-5 and 7-6) controls and indicates the rate of flow of chlorine; provides a simple means of manually setting the feed rate; mixes chlorine gas and water; and delivers the solution to the point of application. Figures 7-7 and 7-8 show a typical cylinder connection and scales.

The chlorinator operates under a vacuum, produced by a flow of water through the injector. The installation must allow a 5-inch vacuum.

Chlorine gas under pressure enters the chlorinator at the chlorine inlet connection where it is electrically heated to reduce the deposit of impurities and to prevent reliquefaction of the gas when the chlorinator is shut down with the supply turned on. Chlorine expands into a gas at a ratio of 1:460; that is, 1 cubic inch of chlorine expands into 460 cubic inches of gas. This volummetric expansion can rupture lines. For the same reason, there should be no dips or traps in any piping installation.

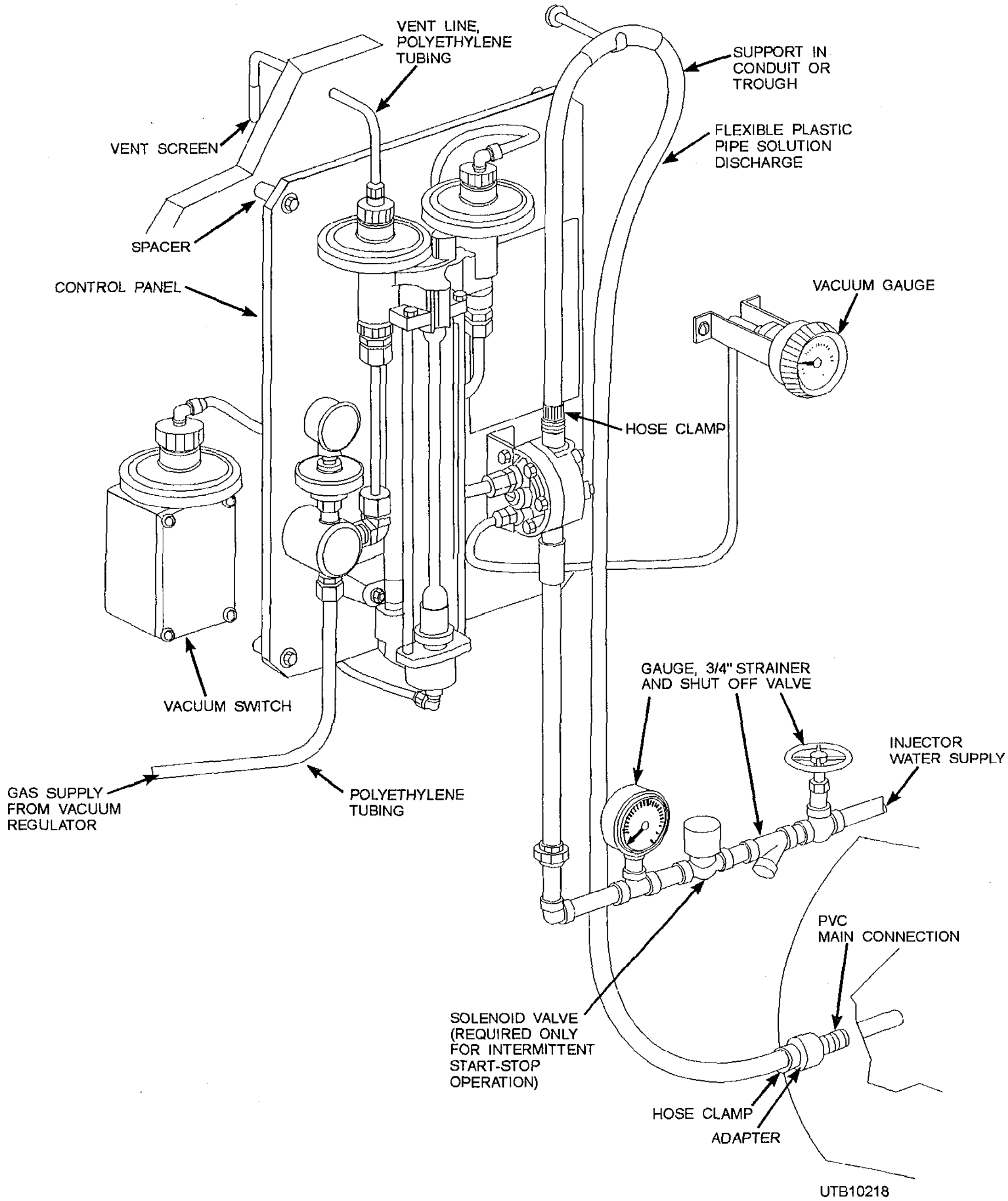


Figure 7-5.—V-Notch Gas Feeder-typical installation, 3 to 200 lb/24 hr.

Figure 7-7 shows a typical chlorine piping installation. A vacuum will pull on the diaphragm in the gas pressure-regulating valve and open the inlet valve. The entrance of chlorine will hold this vacuum at a fairly constant value. Since the vacuum on the upstream side of the V-notch variable orifice is somewhat higher, the vacuum-regulating valve is designed to maintain a constant drop across the V-notch variable orifice. The V-notch plug can be manually, electrically, or pneumatically operated.

NOTE: For variable vacuum operation, the injector vacuum must be at least 10 inches of mercury.

OTHER TYPES OF CHLORINATORS

You may find other types of chlorinators at naval activities. Among other types that may be at your activity are the vacuum-type mechanical-diaphragm chlorinator, the volumetric vacuum-type chlorinator, the vacuum-type diaphragm-controlled chlorinator,

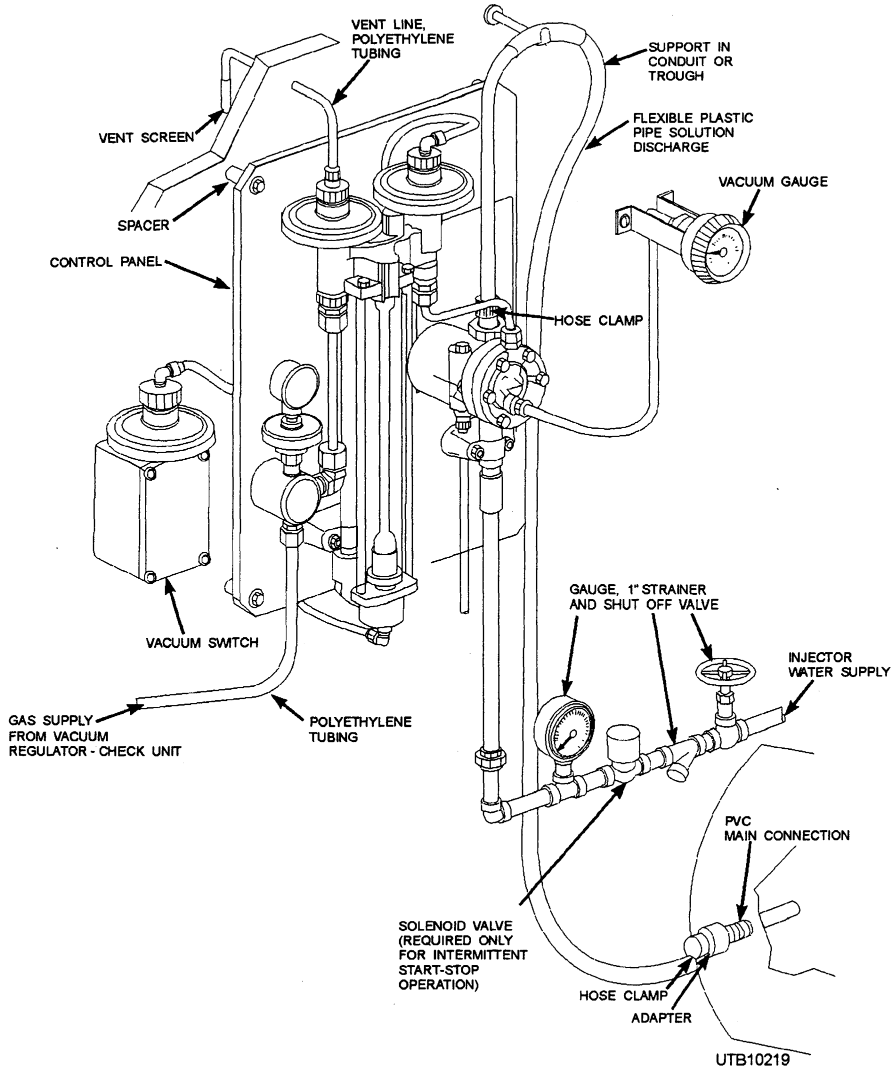


Figure 7-6.—V-Notch Gas Feeder-typical installation, 250 to 500 lb/24 hr.

and the pulsating-type chlorinator. Regardless of the type of chlorinator, make sure that you follow the manufacturer's recommendations and instructions applicable to the operation and maintenance of the equipment.

HYPOCHLORINATORS

Hypochlorinators are solution chemical feeders that introduce chlorine into the water supply as hypochlorite solution. They are usually modified positive displacement piston or diaphragm mechanical pumps. However, hydraulic displacement Hypochlorinators are also used. Fully automatic types are actuated by the pressure differentials produced by orifices, venturis, valves, meters, or similar devices. Hypochlorinators are sometimes used as standby equipment for gas chlorinators. Portable equipment is also available which may be used for main disinfection or during emergencies. Hypochlorinators can also be used to feed chemicals for scale and corrosion control. Of course, you may have to use various types of Hypochlorinators. As part of this discussion on chlorination equipment, a brief treatment is given on additional types of Hypochlorinators of interest to the Utilitiesman.

The Proportioneers Chlor-O-Feeder is a positive displacement diaphragm-type pump with an electrically driven or hydraulically operated head. The electrically driven Proportioneers Chlor-O-Feeder is shown in figure 7-9. The capacity of the most popular type, the heavy-duty Midget Chlor-O-Feeder, is 95 gallons of solution in 24 hours.

The motor-driven type of hypochlorinator may be electrically interconnected with the pump motor

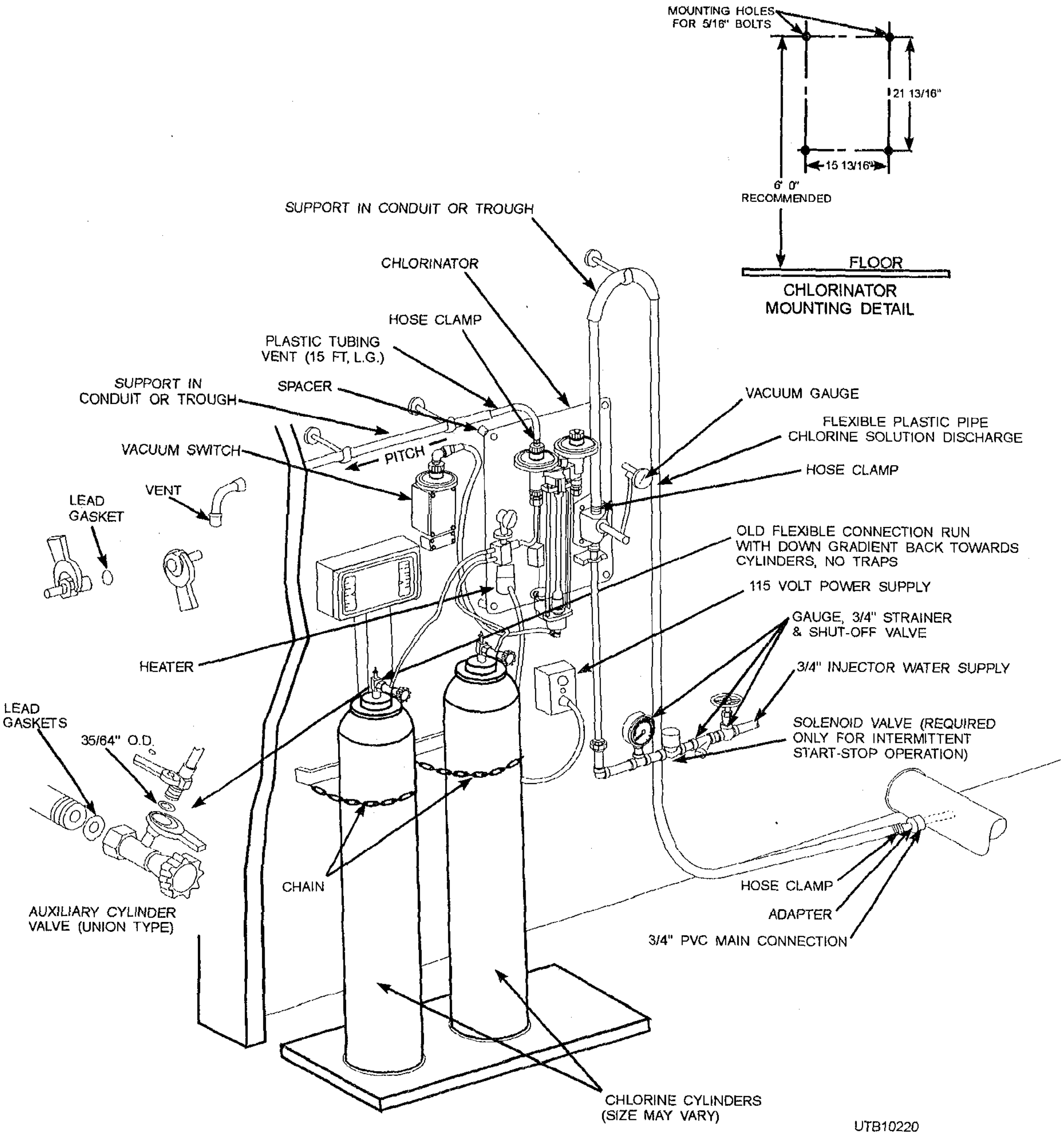


Figure 7-7.—V-Notch Chlorinator—typical installation, 3 to 200 lb124 hr.

controls for semiautomatic operation (fig. 7-10). The hydraulic type can be synchronized with pump operation by means of a solenoid valve.

Motor-driven types of Hypochlorinators are made fully automatic by use of a secondary electrical control circuit actuated by a switch inserted in a disk or compound-meter gearbox (fig. 7-11). This switch closes momentarily each time a definite volume of water passes through the meter, thus starting the feeder. A timing element in the secondary circuit shuts off the feeder after a predetermined, adjustable number of feeder strokes. In the hydraulic type, the meter actuates gears in a gearbox, which, in turn, controls operation of a pilot valve in the water or air supply operating the feeder. The dosage rate is controlled by water flow through the meter, thus automatically proportioning the treatment chemical. The opening and closing frequency of the valve determines the frequency of operation of the hypochlorinator.

Other types of Hypochlorinators available include the Model S, manufactured by the Precision Chemical Pump Corporation, The Model S Hypochlorinator is a

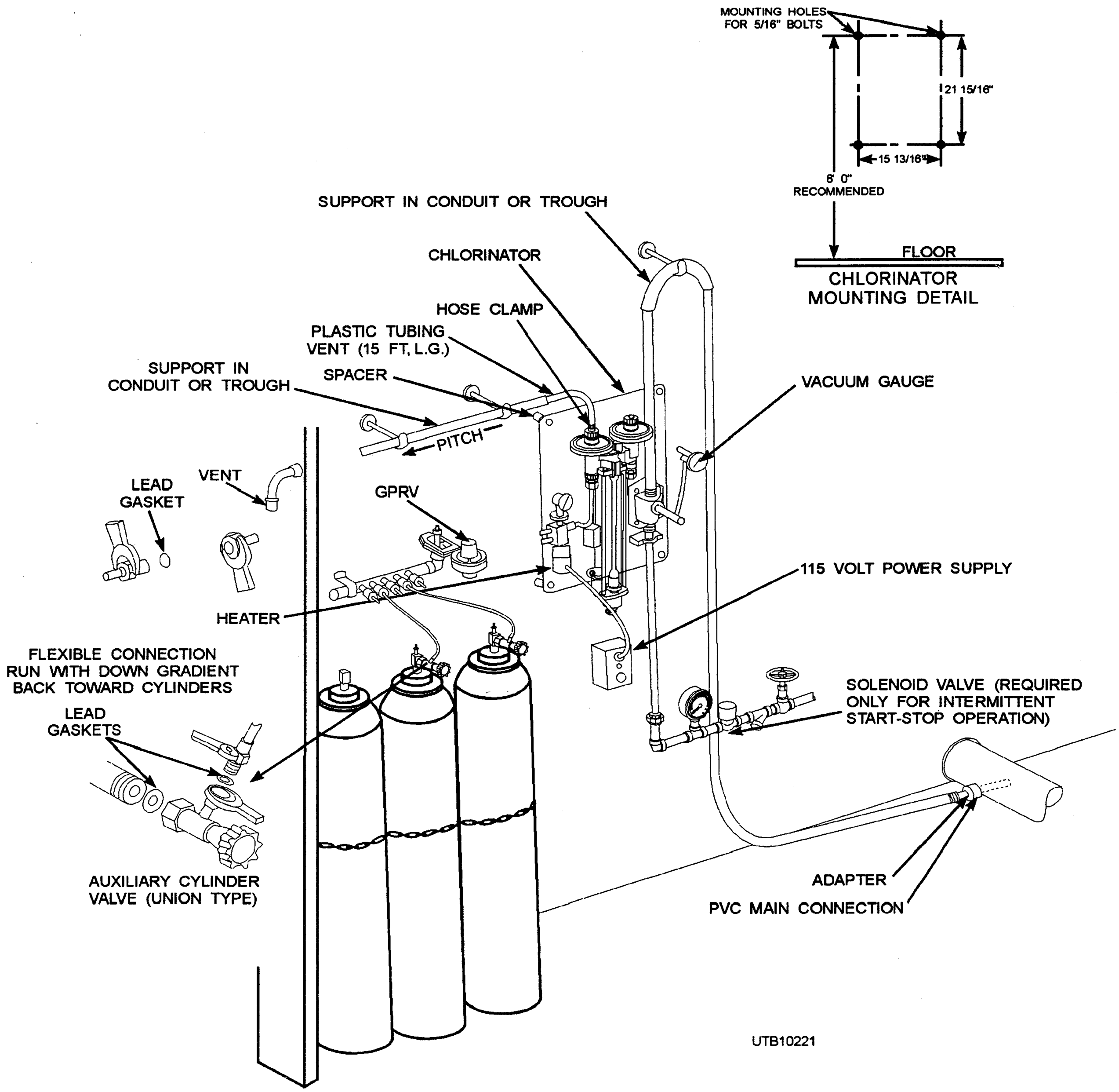


Figure 7-8.—V-Notch Chlorinator-typical installation, 250 to 500 lb/24 hr.

positive displacement diaphragm pump with a manually adjustable feeding capacity of 3 to 60 gallons per day (fig. 7-12). A motor-driven eccentric cam reciprocates the diaphragm, injecting the solution into the main supply. The use of chemically resistant plastic and synthetic rubber in critical parts contributes to its long operating life.

LOCATION OF EQUIPMENT

Chlorination equipment must be properly located with proper ventilation. All gas-chlorinating equipment and chlorine gas cylinders, filled or empty, should be in a separate room opening only from the outside and should not be in the same room or enclosure with operating equipment, other than equipment required for chlorination. If these conditions do not exist, take up the matter with your supervising petty officer. As we said earlier, a typical chlorinator installation is shown in figure 7-7.

If the chlorination room is not at such an elevation that the floor is level with or above the surrounding ground area, an exhaust. fan (positive pressure blower

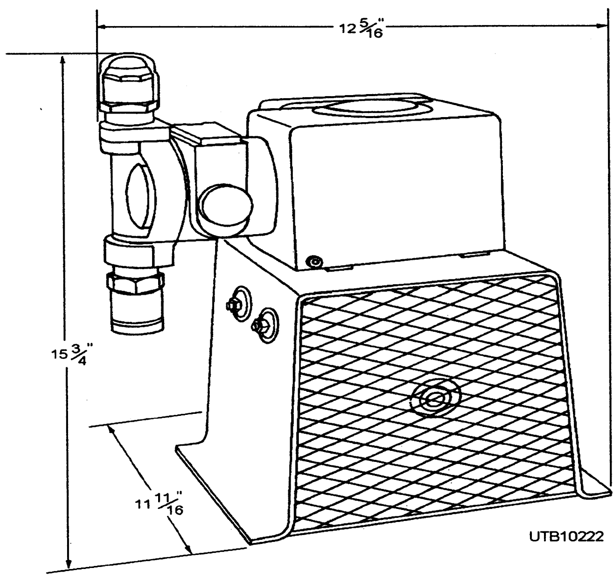


Figure 7-9.—Electrically driven Proportioneers Chlor-O-Feeder.

type) should be installed to remove gas or air at the floor level. Mechanical exhaust ventilation is provided at floor level in any case. Doors should open outward, and two-way lighting switches should be provided, both outside and inside the room. If standard design conditions have not been met, get advice on what to do from your supervising petty officer.

It is normal to put Hypochlorinators in the same room with other equipment, such as pumps, switchboards, meters, and the like. However, because of the corrosiveness of the solutions, it is better to put them in a separate room. If adequate floor drains have not been provided for waste water, spillage, sludge, and washdown water, a 6-inch curbing should be provided around the entire area used for this purpose, whether in a separate room or in the same room with other equipment.

LOCATING LEAKS

Even small leaks can be detected because of the characteristically sharp chlorine odor. When a chlorine odor is noted, authorized personnel should start the ventilating system, put on self-contained oxygen-breathing apparatus or self-generating oxygen-breathing apparatus and locate the leak by holding an open bottle of ammonia water close to pipes, fittings, and valves. Ammonia vapor and chlorine gas form heavy white fumes, thus revealing the point from which chlorine is issuing. If the leak is in a line, shut off the flow of chlorine and repair the leak. If it is in the cylinder head and cannot be stopped by closing the valve, waste the gas from the cylinder outdoors in a good wind or run it into a caustic soda solution.

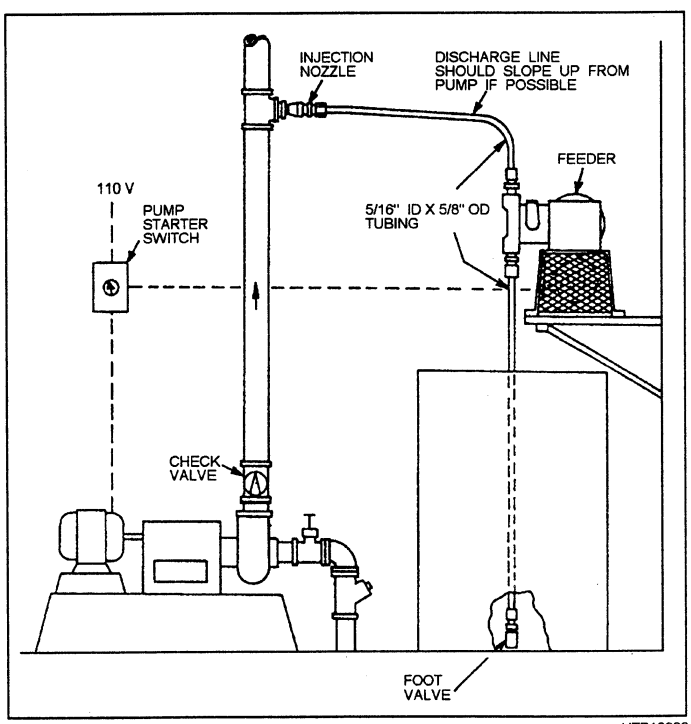


Figure 7-10.—Hypochlorinator arrangement.

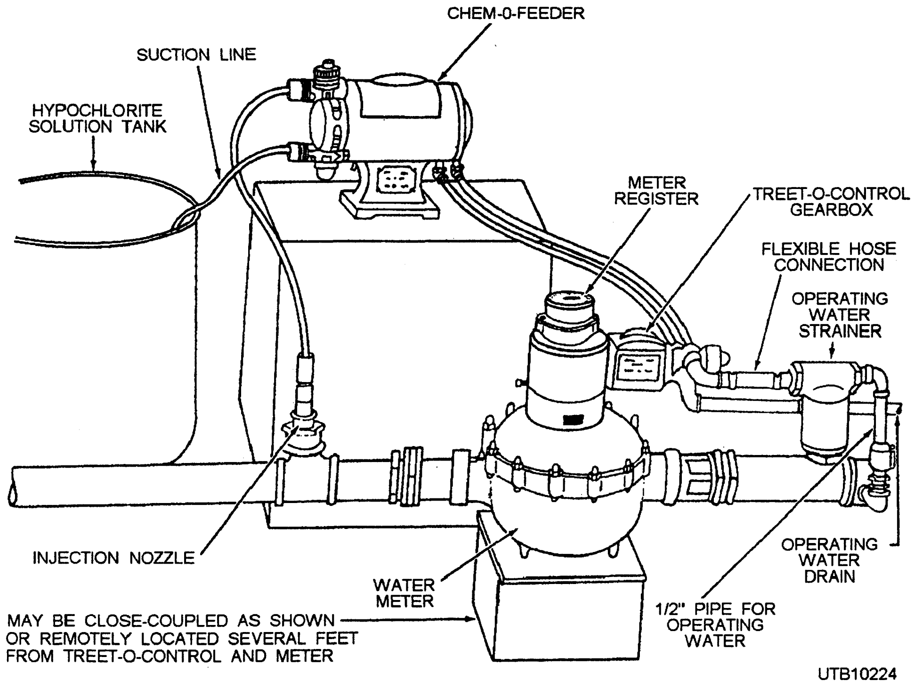


Figure 7-11.—Motor driven hypochlorinator with fully automatic control.

For emergencies, a standby alkali absorption system with a suitable tank should be provided. The alkali should be stored so a solution can be readily prepared. Chlorine should be passed into the solution through a suitable connection properly submerged and weighted to hold it secure. DO NOT IMMERSE CHLORINE CONTAINERS IN SOLUTION. Table 7-1 shows a chemical equivalent. Try to use quantities in excess to allow absorption.

HYPOCHLORITES

To prevent accidents caused by the corrosive action of hypochlorite solutions, use vitreous crocks or steel tanks lined with rubber or chlorine-resistant plastic as solution containers. Store calcium hypochlorite in a dry, cool location, and keep the cans sealed. Wear rubber gloves and protective aprons when preparing and handling hypochlorite solutions.

The liquid CO, recarbonization system uses carbon dioxide gas to lower the pH of softened and settled potable water. This unit is designed for operation between -10°F and +3°F that corresponds to pressure of 242.8 psig and 306.8 psig. The pressure vessel is designed for temperatures as low as -20°F and up to 350 psig. The unit comes with or without a vaporizer, depending on the quantity of CO, required. (If large amounts of CO_2 are removed, it is possible to cause the temperature to go below -20°F.)Once the unit is installed and in proper operation, it requires little attention. At the beginning and end of each day, the operator should check the pressure and liquid level gauges. The supply valve should be turned off when the unit is not in use. The standard unit is equipped with

Table 7-1.—Recommended Alkaline Solutions for Absorbing Chlorine

Container Capacity	Caustic Soda 100 Water		Soda Ash Water		Hydrated Lime Water	
lb (net)	lb	gal	lb	gal	lb	gal
100	125	40	300	100	125	125
150	188	60	450	150	183	183
2000	2500	800	6000	2000	2500	2500

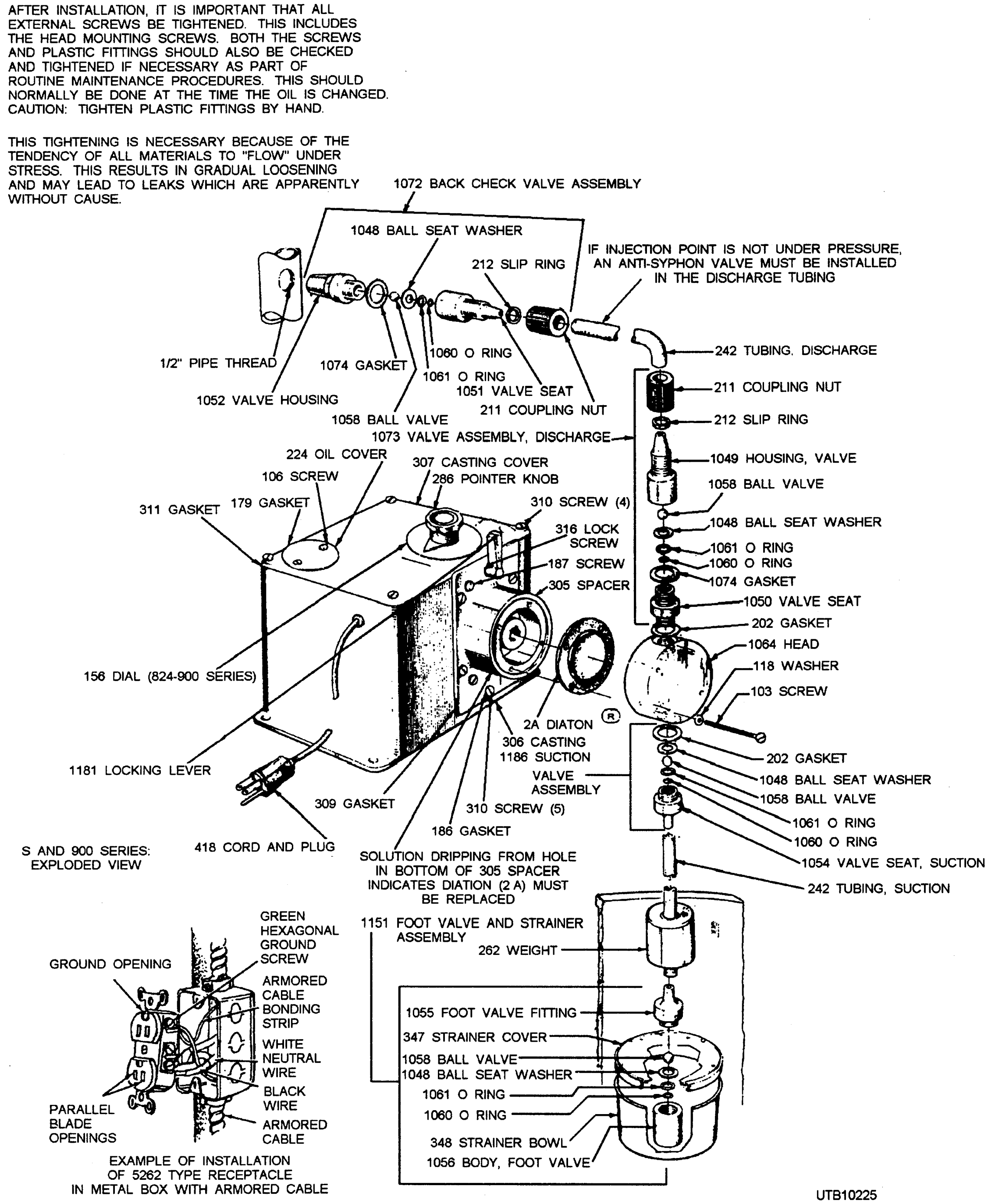


Figure 7-12.—Model S Hypochlorinator.

a pressure vessel, piping and valves, safeties, a refrigeration unit, and a vaporizer. All of these devices require normal maintenance.

AMMONIA

Ammonia fumes are poisonous, but even small concentrations of ammonia are quickly noticeable by the characteristic odor. Because the gas is extremely soluble, a water spray can pick up ammonia, which has escaped. The same precautions used with chlorine are used in handling ammonia with the following exceptions and additions:

- Because ammonia is lighter than air, install vents at the top of the room.

- Ammonia cylinders do not have fusible plugs because no fusible ammonia-resistant material is available. This presents an acute hazard because an ammonia cylinder filled to the legal limit becomes completely liquid at 145°F, and higher temperature results in a buildup of hydrostatic pressure. Cylinders are tested at 700 psi under Interstate Commerce Commission Regulations.

- Test for leaks in ammonia gas piping with a bottle of diluted muriatic acid. White fumes form as with chlorine.

- Ammonia solution or aqua ammonia can be stored indefinitely, but ammonia gas is created at about 80°F if the container is open. Store it in a cool place and keep the container tightly plugged. Dilute with cool water to 15 percent ammonia content before feeding. Keep the room housing the feeder well ventilated.

SULFUR DIOXIDE

Precautions in storing and handling chlorine also apply to sulfur dioxide (SO,). Leaks are located with a bottle of ammonia water.

Q8. *Chlorination equipment can be classified by type, depending on what factor?*

Q9. *What type of chlorinator, in most applications, is used as emergency equipment?*

Q10. *When deciding on a location for chlorination equipment, what factor should be the primary safety concern?*

Q11. *What chemical solution is used to detect chlorine leaks?*

Q12. *If a leak develops on a chlorine cylinder that can not be stopped, you should take what action?*

WATER TREATMENT QUALITY CONTROL

LEARNING OBJECTIVE: *Identify material, equipment, and procedures required to perform water treatment control effectively.*

Frequent chemical analyses and bacteriological examinations of raw and treated water are required to determine and control treatment to ensure a safe, potable water. Chemical analyses will determine proper water treatment and the safety of the water in respect to chemical content. Bacteriological examinations will determine the necessity for disinfection, as well as the safety of the water, following treatment in terms of bacteria content.

You may be called upon to collect samples of water for chemical analysis and bacteriological examination. You may also have to make various types of treatment control tests. (See appendix I). This information will aid you in performing these duties. Safety precautions to be observed by personnel engaged in laboratory work are also covered.

SAMPLING METHODS

The collection of samples for testing for quality control and safety is an important function, because, unless the water sample is representative and uncontaminated, test results will not indicate the actual condition of the water supply. Sample containers should be of materials that will not contaminate the sample and, before use, should be cleaned thoroughly with a detergent and freshwater rinse to remove all surface dirt. Chemically resistant glass is a suitable material for all sample containers, and polyethylene may be used for samples for chemical analyses. The size of the sample container used will depend upon the amount of water needed for a test.

To make certain that representative, uncontaminated samples are obtained, you must observe normal precautions against accidental contamination. Sample containers and caps should always be rinsed well with the water to be tested. Direct hand contact with the mouth of the container, or with the cap, is to be avoided. Take samples with a minimum of splashing.

CHEMICAL ANALYSIS SAMPLES

When collecting samples for chemical analysis, you will find a gallon of water usually enough to determine the mineral content. To obtain accurate test results, flush the sampling lines thoroughly. The bottles should be rinsed out several times with the water to be collected. Procedures for obtaining samples from water supplies for chemical analysis are given below. These procedures should be carefully followed.

Wells

To obtain a representative sample from a well, pump the well until the normal drawdown is reached. Rinse the chemically cleaned sample container and cap several times with the water to be tested and then fill with a minimum of splashing.

Surface Supplies

When sampling surface supplies, fill chemically cleaned raw water sample containers with water from the pump discharge ONLY after the pump has operated long enough to flush the discharge line. Take the sample from the pond, the lake, or the stream at the intake depth and location with a submerged sampler. Submerged samplers are equipped with automatic or manual valve systems that permit the collection of water at the desired depth.

Treatment Plants

Take samples inside a treatment plant from channels, pipe taps, or other points where good mixing is obtained. At some Navy installations, special sample taps are provided for this purpose.

Distribution System Taps

In the case of taps on a distribution system, let the tap run long enough to draw water from the main before taking samples.

BACTERIOLOGICAL EXAMINATION SAMPLES

In obtaining samples for bacteriological examination, avoid contaminating the bottle, stopper, or sample, because contamination often causes a potable water supply to be reported as nonpotable. Follow these precautions and get valid results.

Sample Containers

Use only clean, sterilized bottles furnished by the medical department of the installation or another qualified laboratory. If bottles are not available from these sources, sterilization may be carried out in emergencies. The tops and necks of sample bottles with glass closures should be covered with metal foil, rubberized cloth, or heavy impermeable paper or milk bottle cover tops before sterilization. Before sterilizing the sample bottle to be used for a chlorinated water sample, place 0.02 to 0.05 gram of thiosulfate, powdered or in solution, into each bottle to neutralize the chlorine residual in the sample. Keep the sterilization temperature under 393°F (200°C) to avoid decomposition of the thiosulfate.

Sampling from a Tap

When sampling from a tap, heat the outlet with an alcohol or gasoline torch for a few seconds to destroy any contaminating material that may be on the tip of the faucet. Occasionally, extra samples may be collected without flaming the faucet to determine whether certain faucet outlets are contaminated.

Flush the tap long enough to draw water from the main. Never use a rubber hose or another temporary attachment when drawing a sample for bacteriological examination from the tap.

Next, without removing the protective cover, remove the bottle stopper and hold both the cover and the stopper in one hand. Do not touch the bottle mouth or the sides of the stopper. Fill the bottle without rinsing (to avoid loss of thiosulfate). Replace the cap and fasten the protective covering carefully.

Sampling from Lakes, Ponds, Streams, and Pools

When collecting samples from standing water, remove the stopper as above, and plunge the bottle, mouth down, and hold it at about a 45° angle at least 3 inches below the surface. Tilt the bottle and allow air to escape and fill, moving it in a direction away from the hand holding it, so water that has touched the hand does not enter the bottle. Discard a quarter of the water and replace the stopper.

When collecting a sample from lakes or ponds, take the water 25 feet or more from the shore (from boat or pier) and preferably in water at least 4 feet deep. Do not collect the sample at the shore.

A stream sample should be collected where the water is flowing, not from still areas. In a meandering stream, collect the sample where flow velocity is normal. Use the procedure given above for standing water samples.

When collecting water from a swimming pool, take the water from the side of the pool near the deepest part. Sample the pool while it is in use, preferably during the heaviest bathing load. Use the bottle containing thiosulfate. Fill according to the sampling procedure given above for standing water.

Q13. To ensure accurate results of water testing when collecting water samples, you should take all precautions to ensure that the samples are not in what condition?

Q14. To obtain a proper sample from a well, you should take what action first?

Q15. When taking samples from a standing water supply, you take the samples from how far below the surface and at what angle?

TREATMENT CONTROL TEST PROCEDURES

LEARNING OBJECTIVE: *Understand procedures and analysis for different types* of *water tests.*

Various analyses of water must be performed by trained chemists or skilled laboratory technicians. As a Utilitiesman, however, you must be able to perform various types of treatment control tests. These tests are used during treatment to ensure proper operation and the output of safe water of acceptable quality. We will describe the procedures to follow in carrying out a number of treatment processes, such as chlorination, corrosion control, and clarification.

Before proceeding, note that certain tests which we will cover are based on the simple principle of adding a chemical to the sample that forms a color with the substance to be measured and matching the treated sample with color standards containing known amounts of the substance. There are several colorimeter sets available commercially which vary slightly in use and operation. For that reason, make a careful study of the manufacturer's instructions before using such equipment. Other tests are performed by titration or by special instruments. "Titration" means finding out how much of a substance is in a given solution by measuring how much of another substance or reagent has to be added to the given solution to produce a given reaction.

Various reagents required for the tests discussed below are available from a number of manufacturers and laboratory supply houses. Some of these reagents require special preparation and handling before test use. This is customarily the responsibility of the laboratory technician, since, in some cases, the preparation of reagents requires a thorough knowledge of the chemical procedures. For complete information on the preparation of reagents, refer to the manufacturer's instructions or consult your supervising petty officer.

CHLORINE RESIDUALS

Two tests are frequently used in testing water for chlorine resid uals. They are the orthotolidine test and the orthotolidine-arsenite (OTA) test. Each of these tests is discussed separately below.

Orthotolidine Test

Chlorine residuals can be measured easily by using a commercial comparator and orthotolidine reagents.

EQUIPMENT.—Either a disk or slide comparator may be used in performing the orthotolidine test. A disk comparator is shown in figure 7-13. This comparator consists of a standard color disk and two sample tubes. Water to be tested is placed in both tubes. Reagent is added to one and the resulting color matched with the disk. The other tube is placed behind the disk to eliminate any color error that might be caused by turbidity in the test sample.

A slide comparator, also referred to as a block comparator, is shown in figure 7-14. This comparator consists of standard color ampoules for more accurate color matching. The other two sample tubes are used as compensators and are placed behind the color ampoules.

— only reagent used is a standard orthotolidine solution.

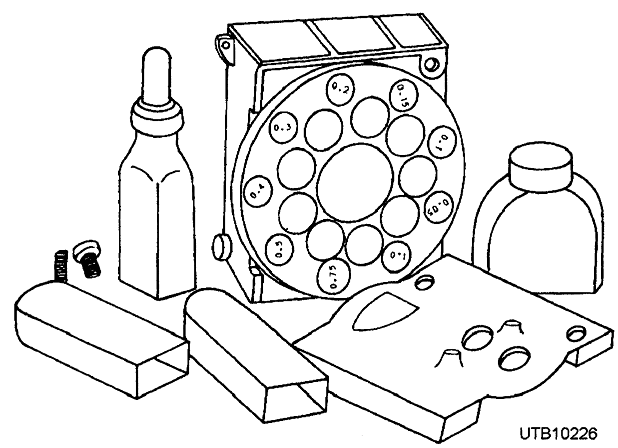


Figure 7-13.—Disk comparator with the front removed show construction.

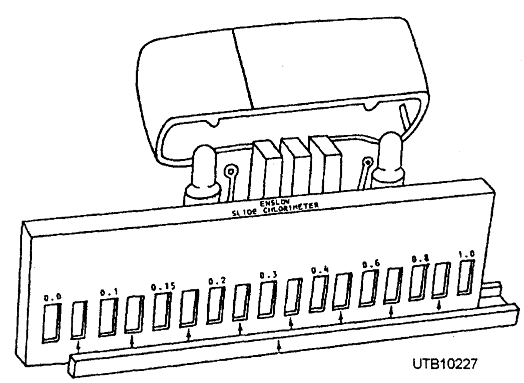


Figure 7-14.—Slide comparator for chlorine residual test.

manufacturer of the comparator used. The general procedure consists of four steps as follows:

1. Fill the tubes to the mark with the water.

2. Place the compensating tube or tubes behind the color standard

3. Add 10 to 15 drops of orthotolidine to the test sample; mix and let stand for 5 minutes. Keep the sample in the dark during the 5-minute color development to reduce false color caused by manganese and nitrate compounds. If a blue color appears after 5 minutes, add more orthotolidine. If water is colder than 50°F, warm it by holding the tube in your hand. Place the sample tube in the comparator and match the color, holding the comparator toward the light, preferably daylight.

4. Select the standard color nearest that of the sample and read the residual. If color appears to be halfway between two standards, report the residual as an average of two standards. Thus, if color appears halfway between 0.3 and 0.4 ppm, report the residual as 0.35 ppm.

Note that the orthotolidine test is not wholly accurate because the false color introduced by nitrates and manganese compounds cannot be entirely eliminated. However, the orthotolidine-arsenite test, described in the following section, does eliminate the false color error completely.

Orthotolidine-Arsenite Test

The orthotolidine-arsenite (OTA) test permits the measurement of relative amounts of total residual chlorine, free available chlorine, and combined available chlorine. This test has some limitations. Samples containing a high proportion of combined available chlorine may indicate more free available chlorine than is actually present, while samples containing a low proportion of combined available chlorine may indicate less free available chlorine than is actually present. Precise results depend on strict adherence to the conditions of the test. The conditions are the time intervals between the addition of reagents and the relative concentration of free available chlorine and combined available chlorine in the sample and the temperature of the water. The temperature of the sample under examination should never be above 68°F (20°C). The precision of the test increases with decreasing temperature.

EQUIPMENT.—You will need a color and turbidity-compensating residual chlorine comparator with commercial permanent standards.

REAGENTS.—The reagents used are orthotolidine (OT) and arsenite (A).

TEST PROCEDURES.—In testing, follow the procedures outlined below.

1. Label three comparator cells A, B, and OT.

2. Use 0.05 milliliter (ml) of OT reagent for each ml of the sample taken. For example, use 0.5 ml of OT reagent for a 10-ml sample and 0.75 ml for a 15-ml sample. Use the same volume of a reagent as is specified above for OT reagent.

3. To tube A, first add OT reagent, then add a measured volume of the water sample; mix quickly.

4. Within 5 seconds, add arsenite reagent; mix quickly.

5. Compare with color standards as rapidly as possible.

6. Record the result; the value obtained represents free available chlorine and interfering colors.

7. To tube B, first add arsenite reagent; then add a measured volume of water sample; mix quickly.

8. Immediately add OT reagent; mix quickly.

9. Compare with color standards as rapidly as possible.

10. Record the results as the B-1 value.

11. Compare the color standards again in exactly 5 minutes and record the results as the B-2 value; these values represent the interfering colors present in the immediate reading B-1 and in the 5-minute reading B-2.

12. To tube OT, containing orthotolidine reagent, add a measured volume of the water sample.

13. Mix quickly and compare with color standards in exactly 5 minutes.

14. Record the result; the value obtained represents the total residual chlorine present and total interfering colors.

CALCULATION OF RESULTS.—In calculating results of the orthotolidine-arsenite (OTA) test, follow the procedure below.

Total residual chlorine. From the value of OT, subtract the value of B-2. The difference'equals total residual chlorine.

(OT) - (B-2) = total residual chlorine

Free available chlorine. From the value of A, subtract the value of B-l. The difference equals free

(OT) - (B-2) = total residual chlorine

Free available chlorine. From the value of A, subtract the value of B-1. The difference equals free available chlorine.

(A) - (B-1) = free available chlorine.

Combined available chlorine. From the value of total residual chlorine, subtract the value of free available chlorine. The difference represents combined available chlorine.

(Total residual chlorine) - (free available chlorine) = combined available chlorine.

pH TEST

The pH test measures the strength of acid or alkali in water. It is reported on a scale that ranges from 0 to 14. A pH reading of 7 is neutral (in a technical sense), values below 7 are acidic, and those above 7 are alkaline. Color comparators can be used to find pH by methods similar to those for determining chlorine residuals. The determination of pH in three simple operations is shown in figure 7-15.

Indicators

Many pH indicators are available, each with a limited range. The indicators used for treated water supplies are as follows:

pH RANGE	INDICATOR
5.2 to 6.8	Chlorphenol red
6.0 to 7.6	Bromthymol blue
6.8 to 8.4	Phenol red
7.2 to 8.8	Cresol red

The correct standards must be used with each indicator.

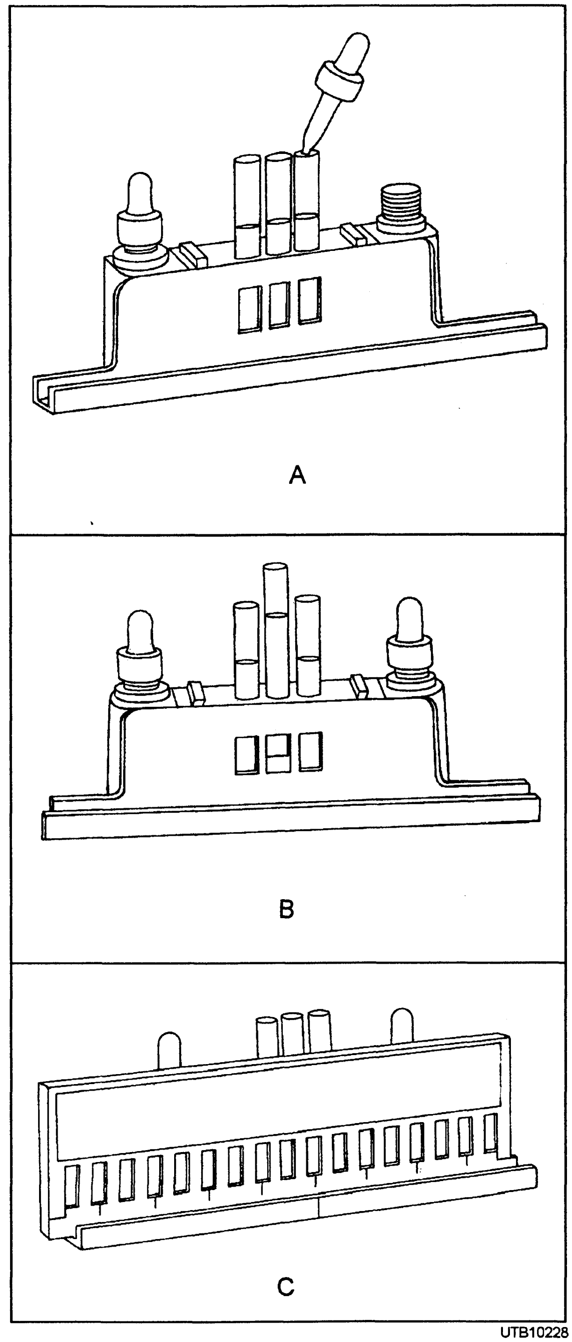


Figure 7-15.—pH determinations in three steps: A. Add reagent; B. Remove tube; and C. Compare colors.

Procedures

In making the pH test, proceed as follows:

1. Fill the tubes to the mark with the sample.

2. Add the indicator to one tube in the amount specified by the manufacturer.

NOTE: Usually 0.5 ml (10 drops) for a 10-ml sample tube and proportionately more for larger tubes.

3. Mix and place the tube in the comparator.

4. Match for color and read the pH directly.

5. If the color matches the standard at either the upper or the lower end of the range of the indicator, repeat the test with the next higher or lower indicator. For instance, if bromthymol blue is used and the sample matches the blue color of the 7.6 standard, the pH is 7.6 or higher. Therefore, use a phenol red indicator to check this value.

SALINITY TESTS

At times you may be assigned to perform salinity tests with a field water, quality control kit. These tests serve to identify mineral characteristics of the water.

The quality control kit provides the necessary materials and equipment for the tests. Two bottles of reagents, one small and one large, are included. As the solution is used up during the test, the small bottle is refilled from the larger bottler The test bottles have two marks-the lower one at 50-ml capacity and the upper one at 100-ml capacity. The test solutions are measured with pipettes. These pipettes deliver a total of 1 ml from the upper graduation mark and are calibrated in 1/10-ml divisions. Each pipette is to be used only for the test for which it is marked in the pipette case and is to be returned directly to its place when the test is completed.

Four types of salinity tests, which you may perform, are as follows-the alkalinity test, the hardness test, the chloride test, and the sulfate test. Each of these tests is discussed in subsections below.

The Alkalinity Test

Alkalinity of water results from the presence of bicarbonate, carbonate, hydroxides of calcium, magnesium, sodium, and other minerals. The term *alkalinity* has little or no relation to the pH of the water but refers to the acid-neutralizing capacity of the water. In other words, alkalinity of water refers to the amount of various alkalies in the water that are capable of neutralizing acids. One method of determining the alkalinity of a water sample is by titration with standard sulfuric acid first to the phenolphthalein (PT) end point, and then to the methyl purple or methyl orange end point. Although methyl orange is the "standard indicator," methyl purple is much easier for the average operator to use because its color change is easier to see, and the results obtained with it are good enough for almost all uses.

REAGENTS—The reagents used in testing the alkalinity of water are as follows:

Phenolphthalein (PT) Indicator Solution
Methyl Purple Indicator Solution
Methyl Orange Indicator Solution
Standard Sulfuric Acid (N/50)

PROCEDURE WITH METHYL PURPLE—In determining the alkalinity of water with methyl purple, use the following procedure:

1. Measure 100 ml of the clear sample (filtered if necessary) into an evaporating dish or Erlenmeyer flask.

2. Add 4 drops of phenolphthalein indicator solution. If a pink or red color develops, phenolphthalein alkalinity (alkalinity fraction contributed by hydroxide and half of carbonate) is present.

3. Fill the burette with acid and add to the sample slowly just until the pink color disappears.

4. Record the ml of acid used.

5. Now, add 2 to 4 drops of methyl purple indicator.

6. Continue titration, adding the acid in 0.5-ml portions until a greenish tint appears where the acid hits the sample. Then continue the addition more slowly, about 3 drops at a time. The color will change from green to gray and then to purple. The appearance of the purple tint marks the end point.

7. Record the total ml of acid required to reach this end point. This includes the ml of acid used in the phenolphthalein alkalinity titration and that used in the methyl purple titration.

PROCEDURE WITH METHYL ORANGE—In determining the alkalinity of water with methyl orange, follow the procedure given below.

1. Measure 100 ml of the clear sample (filtered if necessary) into an evaporating dish or Erlenmeyer flask.

NOTE: If an evaporating dish is used to get a white background for better color observation, the sample must be stirred with a stirring rod during addition of the standard acid.

2. Add 4 drops of phenolphthalein indicator solution. If a pink or red color develops, phenolphthalein alkalinity (alkalinity fraction contributed by hydroxide and half of carbonate) is present.

3. Fill the burette with the acid and add to the sample slowly just until the pink color disappears.

4. Record the ml of acid used.

5. Now, add 2 to 4 drops of methyl orange indicator.

6. Continue titration, adding the acid in 0.5-ml portions until the reddish color that appears where the acid hits the sample begins to persist. Then continue the addition more slowly, about 3 drops at a time, until the first pinkish tinge is seen throughout the sample. This is the end point.

7. Record the total ml of acid required to reach this end point. This includes the ml consumed in the phenolphthalein alkalinity titration and that consumed in the methyl orange titration.

CALCULATIONS—The phenolphthalein (PT) alkalinity is calculated as ppm of calcium carbonate by multiplying the ml of acid used in the phenolphthalein titration by 20.

ppm PT alkalinity as calcium carbonate
= ml of acid used in step × 20

The total alkalinity, as ppm of calcium carbonate, is found by multiplying the total number of ml of acid used (Step 6 above) by 20. This applies to both the methyl orange and the methyl purple procedures.

ppm total alkalinity as calcium carbonate
= total ml acid used × 20

The Hardness Test

The titration method for determining water hardness is vastly superior to the old soap test that is slow, tedious, and often may give misleading results. The procedure is based on the fact that when a sample of water is titrated with a solution of EDTA (sodium ethylene, diamine tetra-acetate), calcium and magnesium react with the EDTA to form soluble compounds in which calcium and magnesium are tied up so firmly that they cannot react with other materials. Standard EDTA solution is added to a water sample and the end point is detected by an indicator that is red in the presence of calcium and magnesium ions and blue in their absence. A total hardness test set (EDTA) is shown in figure 7-16.

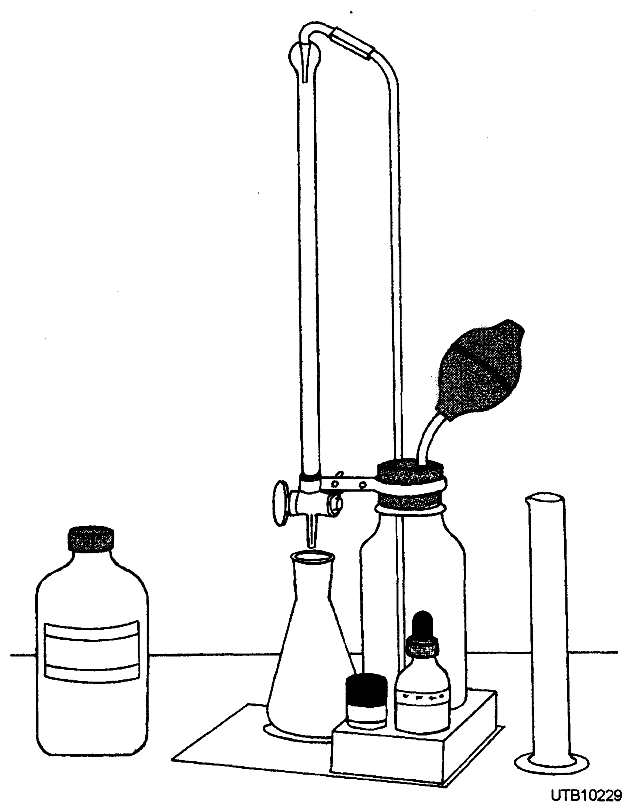


Figure 7-16.—Total hardness test set (EDTA).

REAGENTS—The following reagents are used in testing for water hardness:

EDTA solution
Hardness indicator powder
Hardness buffer
Hardness reagent

PROCEDURES—In determining water hardness, here is the procedure to follow.

1. Place a 50-ml sample in a 250-ml Erlenmeyer flask.

2. Add 1 dipper of hardness indicator powder.

3. Add 0.50 ml of hardness buffer to hold the pH at around 10. The color of the mixture will be red if any hardness is present.

4. Add the hardness reagent from a burette until the red color just disappears, giving way to a pure blue.

CALCULATIONS—The burette reading in ml is multiplied by 20 to give the total hardness.

ppm total hardness as calcium carbonate
= ml burette readingg × 20

The Chloride Test

The purpose of the chloride test is to measure the amount of chloride ions and common salt (NaCl) in water. This test also indicates the presence of possible sewage pollution.

REAGENTS—The reagents used in making the chloride tests are as follows:

Phenolphthalein Indicator
Methyl Orange Indicator
Potassium Chromate
Silver Nitrate Standard
Aluminum Hydroxide
Sulfuric Acid (1 to 3)

PROCEDURES—When making a chloride test, follow the procedure below.

1. Pipette 50 ml of the sample into a 6-inch white porcelain evaporation dish.

2. Place the same quantity of distilled water into a second dish for color comparison.

3. To both dishes, add 1 ml of potassium chromate. Titrate the dish with the sample. Add standard silver nitrate solution (2.4 grams per liter) from a burette, a few drops at a time, with constant stirring until the first permanent reddish coloration appears. (This can be determined by comparison with the distilled water blank.) Record the ml of silver nitrate used.

4. If more than 7 or 8 ml of silver nitrate solution is required, the entire procedure should be repeated by using a smaller sample diluted to 50 ml with distilled water.

CALCULATIONS—When making calculations for chloride, use the formula below.

$$\text{Ppm chloride (C l)} = \frac{\text{ml of AgNo}_3 \text{ used - } 0.2 \times 500}{\text{ml of sample}}$$

Three precautions to bear in mind are as follows:

1. If the sample is highly colored, it should be decolorized by shaking with washed aluminum hydroxide and filtering.

2. If the sample is highly acid, add 10 percent sodium carbonate solution until it is slightly alkaline to methyl orange.

3. If the sample is highly alkaline, add diluted sulfuric acid until it is just acid to phenolphthalein.

The Sulfate Test

The sulfate test determines whether sulfates are present in sufficient quantities in water to cause undesirable physiological effects because sulfates can cause diarrhea in human beings. In the sulfate test, the sulfate value is found by trial, as the test merely determines approximate values. For this reason, you may have to repeat the test several times. The test is begun by testing for sulfates at 100 ppm as follows:

1. Fill a clean test bottle to the 100-ml mark with the water sample.

2. Add 1 ml of barium chloride solution to the same and use a barium chloride pipette. Shake intermittently for 10 minutes.

3. Tear a piece of filter paper into small pieces and place the pieces in the solution.

4. Shake the bottle for 5 minutes or until the paper becomes fluffy and gelatinous.

5. Place a funnel and filter paper in a second bottle.

6. Filter about 25 ml of the sample into the second bottle. Rinse the second bottle with this amount of filtrate, and discard the filtrate. Replace the funnel and continue filtration until 50 ml of filtrate is collected.

7. Add 1 ml of barium chloride solution to the filtrate with the barium chloride pipette. Shake for 5 seconds, and observe immediately for a precipitate or clear solution.

If a clear solution is obtained, record the sulfates as less than 100 ppm. As an immediate precipitate or milky solution indicates the sulfates are greater than 100 ppm, a new sample must be tested for 200-ppm sulfate. For each additional 100-ppm sulfate test required, add 1 ml of barium chloride solution. Therefore, 3 ml of barium chloride solution must be added to test for 300-ppm sulfate. However, the 1 ml of barium chloride solution added after filtration is not changed.

If a clear solution is obtained, the sulfates are less than the ppm for which they were tested, and the value is recorded as being between the values of the last preceding tests. A precipitate or milky solution requires that a new sample of the water be tested for the next higher value.

COLOR TEST

Color in water is due to various materials in solution, although suspended turbidity occasionally adds an apparent color to water that may add to or disguise the true color. In water with low turbidity, the apparent color corresponds closely to the true color. However, if turbidity is high, the apparent color may be misleading. To determine the true color, first filter the water through clean white filter paper before it is compared with the standards. Because the filter paper often removes some true color from the first portion of the sample, discard the first 100-ml which pass through the filter and use the next portion for the color comparison. Make the color determination by matching the sample color with color standards in a color comparator.

TASTE, ODOR, AND THRESHOLD ODOR TEST

Unless the water has a definite taste (sweet, sour, salty, or bitter), the sensation produced upon the observer is generally due to the presence of odor, rather than taste. These two senses work in unison. Sulfur water, for instance, apparently tastes “terrible” when it is really only its rotten egg odor that is registering on our senses.

In measured observations, odor determinations are much to be preferred to taste determinations. There is no method for measuring tastes quantitatively.

The threshold odor test is the most widely used method of determining odor levels. It consists of comparing different dilutions of the sample (diluted with odor-free water) to an odor-free standard. The dilution at which the odor can just be detected is called the threshold point. The odor at the threshold point is expressed quantitatively by the threshold number. This is simply the number of times the odor-bearing sample is diluted with odor-free water. For example, if odor-bearing water requires dilution to ten times its volume with odor-free water to make the odor just perceptible, its threshold number will be 10, A more concentrated odor-bearing water will require dilution to 100 times its volume to make the odor just perceptible; its threshold number will be 100. Here are some basic principles of measuring odor values consistently.

1. Some practice with the test is desirable to develop consistent threshold sensitivity. The consistency can be developed readily in most individuals. An acute sense of smell is not essential.

2. An adequate supply of freshly prepared odor-free water must be available before starting the test.

3. All glass must be clean and free of odor. Rinse all glassware several times with odor-free water before each test and between dilutions.

4. Tests should be run in a room free from foreign odors. Odors caused by fresh paint, volatile solvents, tobacco smoke, food, and the like, will decrease the accuracy of the observations.

5. Each dilution should be compared with the odorless standard to check judgment and minimize reliance on odor memory.

Equipment

The following items of equipment are needed to carry out the threshold odor test:

- Six 500-ml Erlenmeyer flasks with ground glass stoppers
- Two thermometers (0°C-110°C)
- One 250-ml graduated cylinder
- One 100-ml graduated cylinder
- One 50-ml graduated cylinder
- One 25-ml graduated cylinder
- One 10-ml Mohr pipette
- One large hot plate
- One odor-free water generator (fig. 7-17)
- Several large flasks for collecting and heating odor-free water

PROCEDURES

In carrying out the threshold test, determine first the approximate range of the threshold odor number. Carefully follow these steps.

1. Add 250-ml, 63-ml, 16-ml, and 4-ml portions of the odor-bearing water to separate 500ml glass-stoppered Erlenmeyer flasks.

2. Dilute the last three to 250 ml with odor-free water.

3. Add 250 ml of odor-free water to another flask that will be the reference for comparison.

4. Heat the flasks to 140°F (60°C) on a hot plate.

5. Shake the odor-free flask, remove the stopper, and sniff the vapors.

6. Do the same with the flask containing the least amount of odor-bearing water and observe by comparison whether it contains an odor, and, if so, what type of odor. (See table 7-2.)

7. Repeat steps 5 and 6 and use the sample containing the next higher concentration of the water sample.

8. Continue the process until all dilutions have been observed.

9. Record which flasks contain an odor and which do not. Experience will enable an operator to estimate the

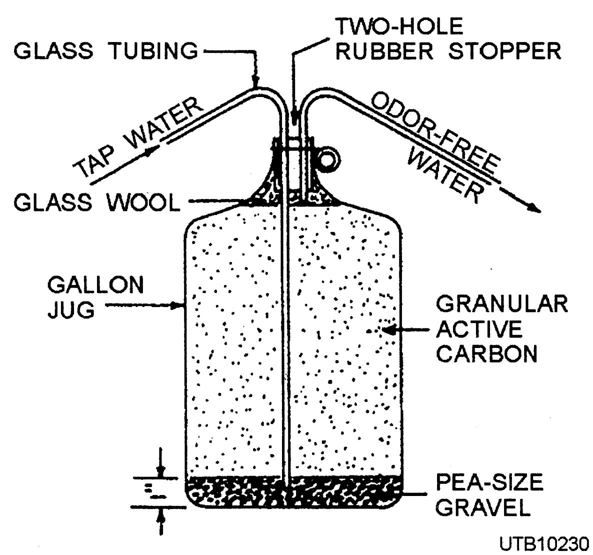


Figure 7-17.—Odor-free water generator.

Table 7-2.—Types of Odors Commonly Found in Water Supplies

Aromatic (spicy)	Disagreeable
Cucumber	Fishy
Balsamic (flowerly)	Pigpen
Geranium	Septic (sewage)
Nasturtium	Earthly
Sweetish	Peaty
Violet	Grassy
Chemical	Musty
Chlorinous	Moldy
Hydrocarbon (gasoline)	Vegetable
Medicinal	
Sulfuretted (rotten egg)	

approximate odor range by sniffing the undiluted sample, thereby eliminating the preliminary test.

10. Based on the results obtained in the preliminary test, prepare a set of dilutions and use the amount of the sample diluted with odor-free water in the range corresponding to the lowest dilution in which the odor was detected. For example, if odor was detected in the 63-ml dilution, but not in the 16-ml dilution, use series II in table 7-3.

11. Repeat steps 5 through 9. The threshold number is read from table 7-4.

JAR TEST (COAGULATION)

The jar test is a reliable method for determining the proper chemical dosages and conditions for coagulation of water to remove color and turbidity.

The type of chemicals that should be used for coagulating raw water can be determined by using the results from jar tests, plant tests, or by using the data shown in table 7-5. Theoretically table 7-5 is correct; however, these values can be misleading when applied to some types of raw water. The chemical content of water may have a considerable influence on the optimum pH range for the various coagulants. For example, coagulation with ferrous sulfate is usually best accomplished at relatively high pH values in the alkaline zone. With soft, colored waters, ferric coagulants may sometimes be used with considerable success at pH values of 4.0 or less. Because of this wide variation in the optimum pH range of coagulants (caused by individual characteristics of the raw water), the coagulant dosage and the optimum zone for floc formation should be determined by jar tests, rather than just relying on table 7-5.

Table 7-3.—Dilution Series for Determining the Threshold Odor Number

Series	I	II	III
Amount of sample diluted to 250 ml	250	63	16
	177	44	11
	125	31	8
	88	22	5.5
	63	16	4

The jar test is the most common method of determining proper coagulant dosages. When there is a question as to which chemical should be used as a coagulant, it is often necessary to run more than one series of jar tests. Different coagulant chemicals and pH ranges should be used to determine which one produces the most satisfactory results at the lowest cost. The step-by-step procedures for a jar test are as follows:

1. Prepare a standard solution of each coagulant selected for trial by adding 10 grams of coagulant to 1 liter of distilled water.

2. Correct the pH of a sample of raw water to within the optimum range for the coagulant being tested (only if the pH is to be adjusted to the same extent in actual plant operation). Divide the raw water into six 1-liter samples.

Table 7-4.—Threshold Odor Numbers

Amount of sample diluted to 250 ml	Threshold odor Number
250	1
177	1.4
125	2
88	2.8
63	4
44	5.6
31	8
22	11
16	16
11	22
8	32
5.5	45
4	64

Table 7-5.—Optimum pH Ranges for Common Coagulants

COAGULANT	pH
Aluminum sulfate	5.0 to 7.0
Ferrous sulfate	9.5 and above
Chlorinated copperas	4.0 to 6.5 and above 9.5
Ferric chloride	4.0 to 6.5 and above 9.5
Ferric sulfate	4.0 to 10.0

3. Add 0.5 ml of standard coagulant solution to one sample of raw water, 1.0 ml to the second sample, 2.0 ml to the third sample, 3.0 ml to the fourth sample, 4.0 ml to the fifth sample, and 5.0 ml to the sixth sample. The result is a dosage of 5, 10, 20, 30, 40, and 50 mg/1, respectively.

4. Agitate samples in the jar test apparatus at a velocity about equal to the treatment equipment you are using and for the same length of time as the treatment equipment mixing time.

5. Keep the samples at the same temperature as water passing through your treatment equipment.

6. After stirring, let the samples settle for 30 minutes.

7. Siphon off a sample of the supernatant and determine the turbidity by using a turbidimeter.

8. The smallest amount of coagulant that produces the lowest turbidity represents the optimum dosage. Multiply the coagulant dosage in mg/1 (step 5 above) by 8.33 to get the correct chemical feed in pounds per million gallons.

9. Repeat the steps for each chemical used until satisfactory results are obtained.

TURBIDITY TEST

Special instruments are available for measuring turbidity (fig. 7-18). These instruments greatly simplify the work of the operator performing a turbidity test. Results are reliable and accurate. Complete instructions are available from manufacturers of these instruments. In general, however, the principles of operation are the same. Usually an easy, five-step procedure is followed.

1. The sample tube is filled with the water to be tested.

2. The glass plunger is inserted in the tube.

3. The tube is placed in the instrument.

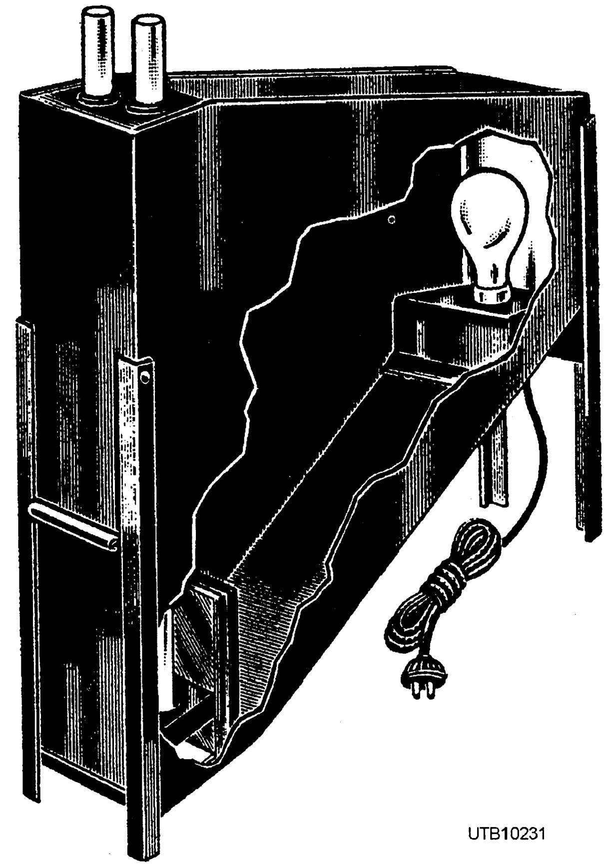


Figure 7-18.—Turbidimeter.

4. The dial at the side of the instrument is turned until the field seen in the eyepiece becomes uniform.

5. The value indicated on the dial is read and the turbidity content of the sample being tested is determined directly from a chart furnished with the instrument.

RECORDS

Results of all findings made in the laboratory should be recorded on laboratory data forms. Two forms for recording data are the Potable Water Supply and Distribution Operating Record and the Potable Water Treatment Plant Operating Record.

The Potable Water Supply and Distribution Operating Record are designed as a management tool for analysis of operating data and evaluation of the potable water supply and distribution performance. Complete instructions on the method of daily entries on this form are on its reverse side.

The Potable Water Treatment Plant Operating Record is designed as a management tool for the analysis of operating data and the evaluation of potable water treatment plant performance. A separate form should be prepared for each potable water treatment plant at an activity. Complete instructions on the method of daily entries on this form are on its reverse side.

Both of these records should be prepared in duplicate, and both should be summarized at the end of the month. The original should be retained on file and the carbon copy forwarded to the district public works officer not later than the tenth of the following month. Activity files should include records of the current and two preceding years.

Keep forms clean, concise, and hand print with a pencil or a pen so as not to smear. Information on forms must be understandable and legible for future reference. Constant reference is made to the data as a means of checking and increasing plant efficiency. It provides a control measure to obtain the maximum efficiency of operation and to SAVE, not WASTE, chemicals used in water treatment.

Q16. Why is water analysis, through water testing, done during treatment?

Q17. What are the two types of water tests used to determine chlorine residual?

Q18. On the pH scale, what does a reading of 7 indicate?

Q19. You are performinga chloride test and have used 2.5 ml of $AgNo_3$ in a 25 ml water sample . What will the ppm of chloride be?

Q20. What is the purpose of the jar test?

CHAPTER 8

EQUIPMENT MAINTENANCE

LEARNING OBJECTIVE: *Identify safe maintenance procedures and precautions that apply to water treatment equipment.*

Properly maintained equipment within a water treatment plant ensures smooth and efficient operation of water treatment. It is not possible to provide detailed instructions on the maintenance of each type of equipment in a water treatment plant. Therefore, this chapter covers general maintenance requirements and safety procedures on some of the more common types of water treatment. For specific and detailed maintenance instructions, refer to the manufacturer's manual for the type and make of equipment at your facility. In addition, this chapter provides information regarding different types of water storage facilities and the maintenance procedures applying to them.

CHLORINATORS

LEARNING OBJECTIVE: *Understand basic operation and preventive maintenance of chlorinators.*

Chlorinators are most often classified as direct feed or solution feed; however, they are also classified by the type of diaphragm used in controlling the chlorine feed. A description of each follows:

- Direct-feed machines operate without a water pressure supply, as they feed the chlorine gas directly to the flow to be treated
- Solution-feed machines dissolve the gas in a minor flow of water and inject the solution into the flow to be treated. They require a water pressure supply for operation.
- The water diaphragm machine is always a vacuum-type, solution-fed machine. The frictionless, punctureproof water diaphragm is an advantage,
- The mechanical diaphragm machine may be either a direct-feed or solution-feed pressure type, or the solution-feed vacuum type only.

DIRECT-FEED CHLORINATORS

Direct-feed chlorinators are used chiefly as emergency equipment and on small installations where it is not possible to obtain a water supply suitable for operating a solution-feed machine. They cannot be used where the pressure of the water being treated is more than 20 psi and are limited in the types of semiautomatic or automatic controls that may be used. Because of the chlorine always being under pressure as a gas, direct-feed machines leak gas easily to the atmosphere and cause corrosion on nearby equipment and structures.

Direct-feed chlorinators require the same maintenance of gas-piping and gas-feeding mechanisms as described for solution-type feeders. But direct-feed chlorinators do not require maintenance of equipment in contact with chlorine solutions, because there is no contact.

SOLUTION-FEED CHLORINATORS

Solution-feed chlorinators introduce chlorine gas into the water supply by means of a chlorine solution. This solution is usually formed by drawing chlorine gas into the jet stream of water at the low-pressure point of the injector mechanism of the chlorinator. Two general types are used in waterworks: the bubbling or pulsating reduced-pressure type and the vacuum type. Because they keep the chlorine under a partial vacuum, they cause fewer chlorine leaks than pressure gas chlorinators and direct diffusers.

CHLORINATION EQUIPMENT

Chlorination equipment to feed chlorine gas or hypochlorite solution is of three general types, depending on methods of control as follows:

- In the manually controlled type, equipment must be started and stopped manually, and rate of feed must be manually adjusted to rate of water flow.

- In the semiautomatic type, equipment starts and stops automatically as water flow starts and stops but must be manually adjusted to rate of water flow; this type is normally used with a water pump having a fairly uniform delivery.
- In the fully automatic type, rate of feed is automatically adjusted to rate of flow of water being treated by the differential pressure of a metering device. In all types, the ratio of feed to water treated, or dosage, is set manually.

Figure 8-1 shows a typical gas chlorination equipment piping diagram.

Hypochlorinators, or solution feeders, (fig. 8-2) introduce chlorine into the water supply in the form of hypochlorite solution. They are usually modified positive displacement piston or diaphragm mechanical pumps. However, hydraulic displacement hypochlorinators are used. Figure 8-3 shows a typical hypochlorination hookup.

Fully automatic types of hypochlorinators are actuated by pressure differentials produced by orifices, venturis, valves, meters, or similar devices. Care is necessary in their installation in mains to avoid restricted flows, which may limit the required amount of water for fighting a fire. Hypochlorinators are sometimes used as standby equipment for gas chlorinators.

Portable hypochlorination equipment is also available which may be used for primary disinfection or during emergencies. They can also be used to feed chemicals for scale and corrosion control. A common type of portable Hypochlorinator used is the Proportioneers Chlor-O-Feeder. The Proportioneers Chlor-O-Feeder is a positive displacement diaphragm-type pump with an electric drive or a hydraulic operating head. The maximum capacity of the most popular type, the heavy-duty Midget Chlor-O-Feeder, is 95 gallons of solution in 24 hours. This unit can be operated in a semiautomatic or automatic application as follows:

- Semiautomatic control. The motor-driven type may be cross connected with a pump motor for semiautomatic control. The hydraulic type can be synchronized with pump operation by means of a solenoid valve.
- Fully automatic control. Motor-driven types are made fully automatic by the use of a secondary electrical control circuit actuated by a switch inserted in a disk or compound meter gearbox. This switch closes momentarily each time a definite volume of water passes through the meter, thus starting the feeder. A

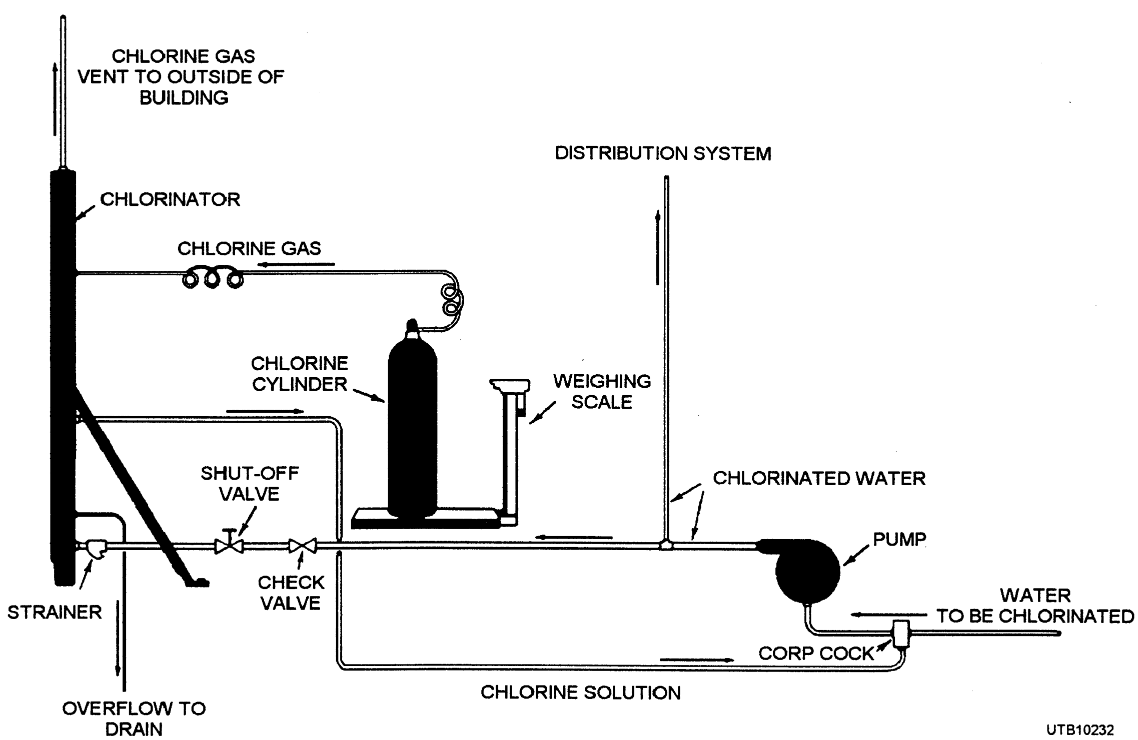


Figure 8-1.—Typical gas chlorination equipment piping diagram.

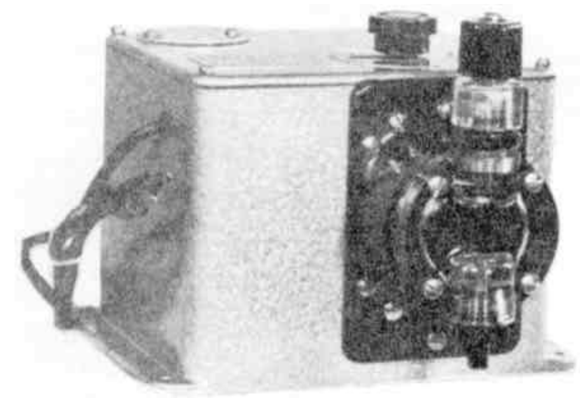


Figure 8-2.—Model S Hypochlorinator feeder (or pump).

timing element in the secondary circuit shuts off the feeder after a predetermined number of feeder strokes; the number of strokes is adjustable. In the hydraulic type (fig. 8-3) the meter actuates gears in a Treet-O-Control gearbox which, in turn, controls operating the feeder. The dosage rate is controlled by water flow through the meter, thus automatically proportioning the treatment chemical. Opening and closing frequency of the valve thus determines frequency of operation of the Chlor-O-Feeder.

The Model S Hypochlorinator (fig. 8-2) is a positive displacement diaphragm pump with a manually adjustable feeding capacity of 3 to 60 gallons per day. A motor-driven eccentric cam reciprocates the diaphragm, injecting the solution into the main supply. The use of chemically resistant plastic and synthetic rubber in critical parts contributes to a long operating life.

It is not normal practice to locate hypochlorinators in the same room with other equipment, such as pumps, switchboard, meters, and the like. Because of the corrosiveness of the solutions, it is better practice to locate them in a separate room. In any event, adequate floor drains should be provided for carrying away wastewater, spillage, sludge, and washdown water. A curbing at least 6 inches in height should be

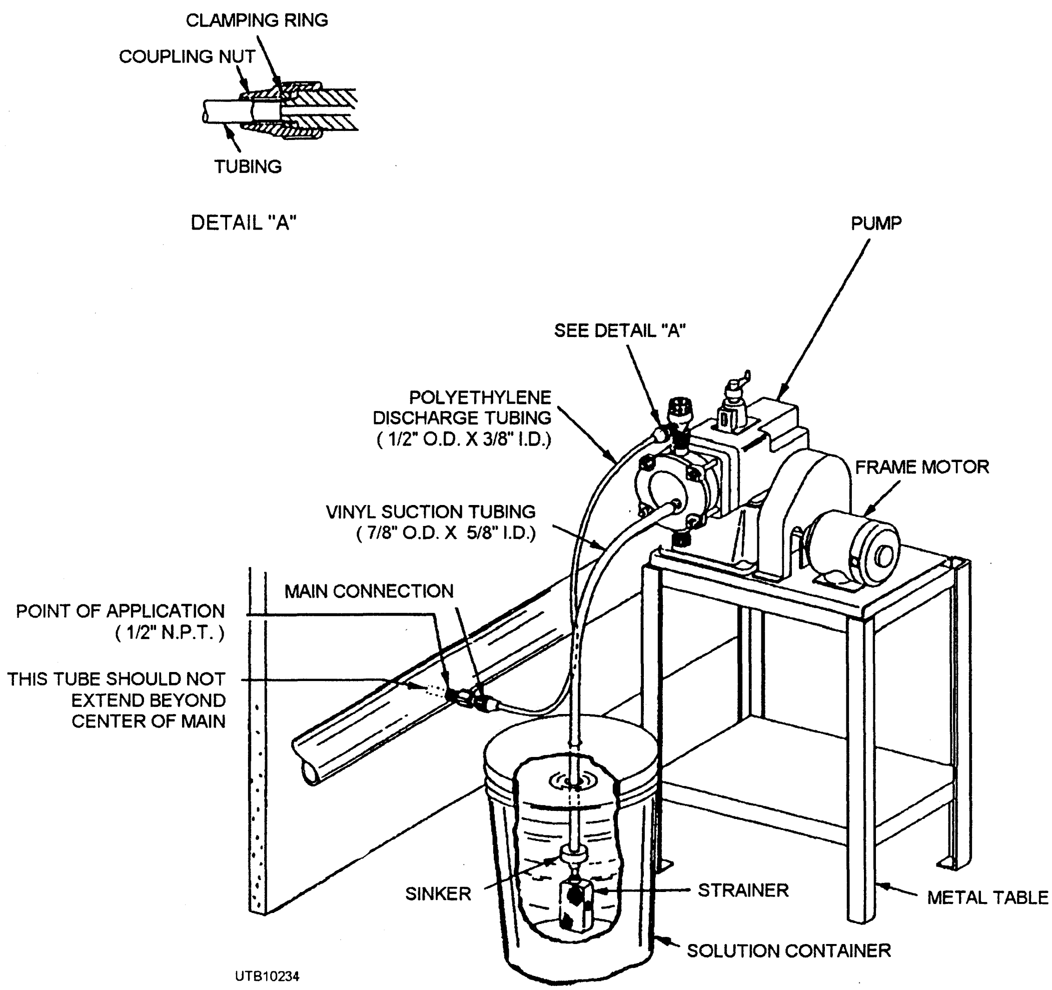


Figure 8-3.—Typical hypochlorination hookup.

provided around the entire area used for this purpose, whether in a separate room or in the same room with other equipment.

MAINTENANCE OPERATIONS

The maintenance operations described below apply to all gaseous chlorinators, regardless of type. Some preventive maintenance practices are fundamentally a part of normal equipment operations. Follow these precautions.

- When connecting chlorine valves or tubes to cylinders or equipment, use a new lead gasket each time, and use only one gasket in each connection.
- Guard against condensation on chlorine cylinder walls by maintaining proper ventilation around the equipment. Condensation may corrode scales or other equipment. An electric fan may be enough to keep the equipment dry.

> **CAUTION**
>
> Do not use direct heat to dry cylinder surfaces.

Chlorinators and all piping should be inspected daily for leaks. For chlorine leak detection, an opened bottle of aqua ammonia (or an aspirator-type bottle) should be used near all joints, valves, and piping. White fumes indicate chlorine leaks. Repair immediately, no matter how small, as they will increase in size and cause corrosion and damage which may become extensive. (Keep the ammonia bottle tightly closed when not in use.)

In addition to leak inspection, all parts and piping in contact with chlorine gas should be inspected daily to ensure that operations are satisfactory. This includes metering devices, valves, tubing, and so on, which should be disassembled and cleaned where necessary; the source of trouble should be determined; and faulty parts should be replaced at the first indication of weakening.

> **CAUTION**
>
> Tools should not be used on hard-rubber parts, except a strap wrench, if necessary; threaded, hard-rubber parts should be hand tightened.

> Operation of the relief line should be checked daily; it should be open and contain no obstructions, such as wasp's nests.

The maintenance operation frequency and schedule of inspections for chlorination equipment are shown in appendix III, table A. In this and other tables used throughout the remainder of this chapter, note that the frequencies shown are suggested frequencies and may be changed by the local command, as individual installation conditions call for. The frequency code used in tables presented in our discussion is as follows:

D–daily

W–weekly

M–monthly

Q–quarterly

SA–semiannually

A–annually

V–variable, as conditions may indicate

Q1. Chlorinators can be classified in two different ways. What are they?

Q2. In a semiautomatic type chlorinator, equipment starts and stops automatically with the water flow; however, the rate of waterflow is adjusted in what manner?

Q3. Hypochlorinators are sometimes used as standby equipment for what type of chlorinators?

Q4. How often should chlorinators and piping be checked for leaks?

MAINTENANCE OF CHEMICAL FEEDERS

LEARNING OBJECTIVE: *Identify and understand basic maintenance guidelines for chemical feeders.*

DRY CHEMICAL FEEDERS

The instructions given apply to all types of volummetric and gravimetric dry feeders, including disk, oscillating, rotary gate, belt-type, screw, and loss-in-weight.

The basic maintenance operations that should be applied daily to all dry chemical feeders are as follows:

- Clean the feeder, the feeder mechanism, and the feeder surroundings. Use a vacuum cleaner or brush to remove spilled chemicals or chemical dust. Make certain that the orifice, knife edges, scrapers, shakers, and openings are free of chemical accumulations in volummetric feeders, and that both belt rolls and belt, in belt-gravimetric feeders, are free of chemical accumulations.

> **NOTE**
>
> When working with chemical dust, wear chemical goggles or a mask.

- Check the feeder for general performance. Note and investigate unusual noises.
- Observe the condition of electrical wiring, fuses, and connections
- Check for oil drips and general deterioration,
- Make necessary repairs to overcome deterioration and lack of good performance.
- Wipe all parts of the feeder and inspect for loose bolts, cracks, defective parts, and leaks. Make the necessary repairs to eliminate undesirable conditions.
- Check the solution tank for sediment or undissolved chemicals and remove accumulated material.
- When the dissolver is lined with asphalt, check the lining, which should not be skinned away from the steel. Follow the manufacturer's instructions to repair such linings.
- Quarterly, service moving parts and lubricate, following the manufacturer's instructions.

The maintenance operation frequency and schedule of inspections for dry chemical feeders are shown in appendix III, table B

SOLUTION FEEDERS

Maintenance procedures for pot-type solution feeders include the following:

- Daily operator inspection which includes observations of the amount of chemical feed to determine whether flow through the post is effective.
- Monthly cleaning of the sediment trap and check of the valve.
- Cleaning of the chemical pot and orifice every 6 months.
- Annual overhaul that includes cleaning and painting the pot feeder and accessories.

With the decanter or swing-pipe feeder, the swing pipe should be checked monthly. The reducing gears, pawl, ratchet, and motor should be checked semiannually and overhauled annually, or as necessary. Overhauling includes cleaning, repairing, and painting all parts that require attention.

The maintenance operation frequency and schedules of inspection for liquid and solution chemical feeders are shown in appendix III, table C.

Q5. *What personal safety equipment should you use when working with dry chemical feeders and chemical dust?*

Q6. *Moving parts and lubrication of a dry chemical feeder should by done at what intervals?*

Q7. *Overhauling a solution-feed chlorinator includes what three operations?*

MAINTENANCE OF ION-EXCHANGE UNITS

LEARNING OBJECTIVE: *Identify and understand basic maintenance requirements for Ion-exchange units and equipment.*

An ion-exchange unit is shown in figure 8-4. Some of the maintenance procedures for this type of unit are given in the following sections.

SOFTENER UNIT

The softener unit itself consists of a steel shell, containing a supporting grid in the bottom, a layer of gravel, and a layer of ion-exchange resin. The shell is equipped with openings, valves, and fittings. Maintenance procedures for the unit are as follows:

- Annually, the exterior of the shell should be cleaned and brushed with a wire brush and then painted to protect it against corrosion.
- Quarterly, the fittings for the distribution of water and brine should be checked for possible obstructions, corrosion, and security fastness.

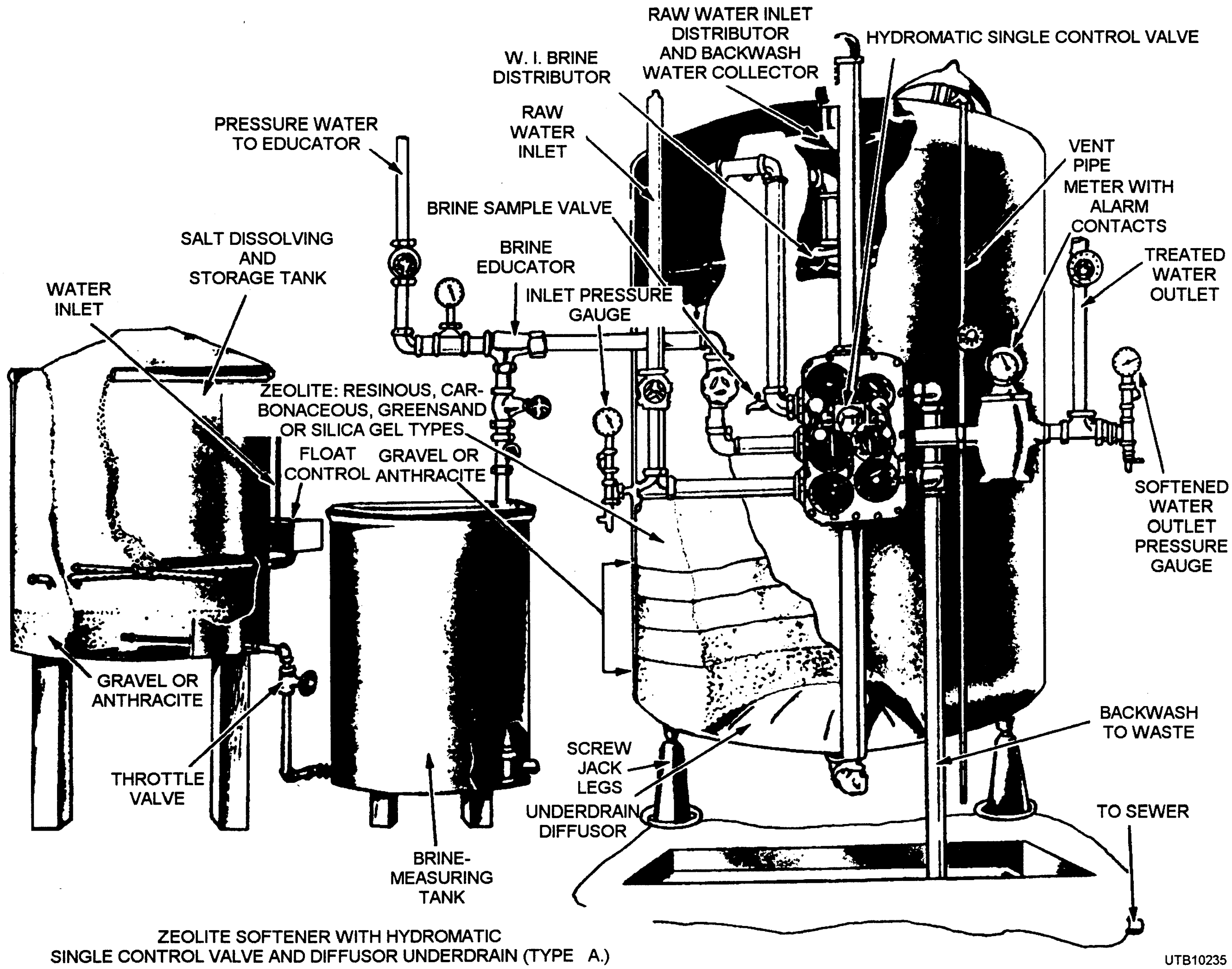


Figure 8-4.—Ion-exchange unit for water softening.

- Every 6 months, each individual valve should be inspected and tested for leaks and repacked if necessary.
- Where multiport valves are used, they should be serviced and lubricated under the manufacturer's instructions. Lubricate this type of valve with grease as follows:

1. Add grease by a pressure gun to each grease fitting while the valve is set in "service" or "wash" position.

2. Turn valve one-half turn and add more grease.

3. Give valve several full turns to spread the lubricant.

This lubrication does not require that the softener be removed from service, but when the water flow is stopped, no grease will get into the water.

Quarterly, flush ion-exchange beds with chlorinated water containing at least 2 ppm of chlorine. Do not use water with a hardness greater than 170 ppm, and be certain that the pH of the water is about neutral. Also, follow these directions.

1. Check the bed surface for dirt, fines, organic growths, and smoothness. Scrape excess foreign matter off and replace with new resin. When the surface is uneven, the gravel bed underneath is not distributing the wash water evenly. The remedy consists of removing the resin and gravel and replacing both in proper fashion.

2. Check the height of the ion-exchange bed surface; remove or add ion-exchange resin to maintain proper elevation. (A low elevation will allow excess fines and foreign matter to accumulate on the surface of the bed; a high elevation allows resin to be washed out during backwashing.) Extra ion-exchange resin may be

added through a 2- or 3-inch half-coupling (with brass plug), provided in the upper head of the shell or through the manhole cover plate.

3. Replace the ion-exchange bed with new resin whenever the inspection indicates the need, or when the exchange capacity has decreased and cannot be restored by cleaning and special procedures recommended by the manufacturer.

4. Quarterly, probe through the resin bed to determine the surface of the supporting gravel. The surface should be relatively even with a maximum difference of 4 inches between high and low spots. Any indication of shifting gravel bed, caking, or other difficulties, calls for repair efforts. Uneven gravel may be raked smooth, through the open manhole, during backwashing operations.

When gravel needs to be removed, it may be cheaper to install new gravel than to remove, wash, and regrade old gravel. New gravel should be lime-free (do not use ordinary river gravel). When old gravel is reused, screen out all resin particles. Spraying with water is the best method of removing the resin from the gravel on the screen.

Replace or add new gravel in four layers. Fill the shell with water to the depth desired, then add the coarsest grade first; level the gravel layer to fill low spots; next, raise the water level to the next depth required and add the next smaller grade. Repeat the process; then, add the resin to the desired depth and classify by backwashing the bed.

Annually, or as necessary, the condition of underdrains may be learned from the pressure drop across the underdrain system with a full backwash flow being discharged from the manhole. A greater pressure drop than existed at the time of installation shows plugging underdrains; a lesser pressure drop reveals displaced or corroded nozzles. Underdrains should be inspected, removed, cleaned, painted (where necessary), and replaced every 3 years

Manifold-type underdrains should be inspected when gravel is removed. Remove several laterals at random and check for clogging. Where clogging is evident, remove all laterals and clean mechanically, or treat with inhibited muriatic acid.

Plate-type underdrains should be removed, inspected, painted, and replaced every 3 years; make certain that the clearance space between the plate and lower head is the same at all points.

REGENERATION EQUIPMENT

For regeneration equipment, the maintenance procedures are as follows:

1. The salt storage tank should be cleaned at varying periods, depending on the amount of insolubles in the salt, tank size, and the salt usage. Rock salt contains more insolubles than evaporated salt. (The greater the salt usage, the more frequent the cleaning required.)

2. The brine-measuring tank should be cleaned every 6 months, and both exterior and interior surfaces painted.

3. At annual intervals, the brine ejector should be cleaned, disassembled, and checked for erosion or corrosion; any clogging of piping should be removed before the ejector is reassembled and replaced.

The maintenance operation frequency and schedule of inspections for ion-exchange softening units are shown in appendix III, table D.

Q8. The exterior shell of a water softener unit should be cleaned a minimum of what frequency?

Q9. Does a water softener need to be removed from service when multiport valves are lubricated?

Q10. When flushing ion-exchange beds with chlorinated water, the water used should be of what pH?.

Q11. Of the salts used in softening water, which contains less insolubles, rocksalt, or evaporated salt?

MAINTENANCE OF CLARIFICATION EQUIPMENT

LEARNING OBJECTIVE: *Identify and understand basic maintenance procedures for clarification equipment.*

Maintenance procedures for clarification equipment are discussed below. The equipment includes mixers, flocculator basins, and sedimentation basins.

MIXERS

Mixing basins, whether baffled or mechanically stirred (rapid or flash), require attention and cleaning semiannually. The maintenance requirements are as follows:

1. After draining, wash down the walls with a hose and flush the sediment to the drain. Repair spalled spots on walls or bottom as necessary.

2. Check the valves or sluice gates for corrosion and ease of operation; clean and lubricate; paint valves as necessary.

FLOCCULATOR BASINS

The following maintenance procedures apply to flocculator basins:

- Monthly, during operation, check paddle rotation to assure that all flocculators are operating. Lower a light pole (bamboo fishing rod) into the water until the paddles strike the pole, revealing paddle operation. Broken shafts or chains may cause the paddles to become inoperative.

- Semiannually, drain and clean the basin, walls, and floor; inspect the flocculator mechanism, drive, bearings, gears, and other mechanical parts; clean and lubricate. Especially check underwater bearings for silt penetration. Replace scored bearings. Paint mechanism parts where necessary.

SEDIMENTATION BASINS

All types of settling basins require the same basic maintenance, such as lubricating, cleaning, flushing, and painting. Basins, which have mechanical devices, should be maintained under the manufacturer's instructions.

Revolving-Sludge Collector Basins

Specific maintenance procedures for revolving-sludge collector basins should agree with the manufacturer's instructions. The procedures described here are the minimum.

Regular lubrication is required where the basin is in continuous operation. Intermittent operation affects the lubrication schedule, making it possible to increase the interval between lubrication periods. When operating periods are intermittent and infrequent, the mechanism should be operated briefly between operating periods and lubricated. Devices subject to wide seasonal temperature changes must have seasonal changes in lubricant grades, especially where summer grade oils thicken below freezing and reduce the flow capability. Daily or weekly lubrication of operating units is a part of operator inspection. The choice of lubricant and its frequency of application are established by the manufacturer or by local command.

Other devices found in the equipment require attention on a regular basis. Some examples of these devices and required care are as follows:

1. The speed reducer should be inspected weekly to ensure that the oil is at the proper level, is free of water and grit, and has the right body. When a reducer runs hot during its operation, the oil level may be too high or too low. (Where the reducer is out of service for a long time, make certain it is filled above the level of the seals to prevent the seals from drying out. Be sure it is tagged to reflect this condition. The reducer must be drained to proper level before being placed back in service.) Replace oil whenever necessary.

2. The drive head should be lubricated daily, but not too much.

3. The worm gear oil level should be checked at least weekly, and the water drained from the housing monthly.

4. The turntable bearings should be lubricated monthly and the oil changed twice yearly.

5. Lubrication procedures for chains depend on the design of the chain and chain guard. Inspect monthly and add oil as necessary; drain off the accumulated oil as necessary; and change the oil twice yearly.

6. Ball bearings and thrust bearings are lubricated annually. They should be inspected monthly for wear and proper lubrication.

7. Center bearings, shaft bearings, bushings, and so on, are lubricated under the manufacturer's instructions.

Tank equipment requires annual inspection. The steps for this inspection are as follow:

1. Check bolts and tighten nuts to maintain original alignments and adjustments.

2. Check for excessive wear of moving parts, including gears.

3. Flush and back blow the sludge withdrawal line by using high-pressure water or compressed air.

> **NOTE**
>
> Do not allow the waterline to be cross connected to the drinking water supply system.

4. Check the plows or rakes and straighten them if necessary.

5. Check the motor condition, couplings, and service shear pins.

6. Clean equipment and paint as necessary.

When the equipment has an overload alarm, check it for operation. If the alarm sounds at any time, shut off the equipment, locate the source of trouble, and correct it. Under no condition should the alarm switch be nullified to provide continuous operation. If the overload is caused by a sludge buildup leading to cutout of the starter switch or pin shearing, the tank must then be drained and the sludge flushed out.

Conveyor-Type Collector Basins

As with the revolving-sludge collectors, specific maintenance procedures in conveyor-type collector basins are in the manufacturer's instructions. Maintenance procedures on the tanks and structures are the same for this type of sedimentation basin as they are for the circular-type basin. Generally, the maintenance procedures for gears, chains, sprockets, reducers, and so on, are also the same as those for circular-type basins.

Cathodic Protection

Where stubborn water problems exist in water supplies, the sedimentation tank equipment may be protected by cathodic protection. Cathodic protection is a method of protecting metal surfaces from corrosion through the use of a direct-current voltage. The voltage is applied so that the current tends to flow from the direct-current source through the soil or water to the metal surface to be protected. This flow of current applies electrical energy that reverses the natural process of corrosion.

There are two well-known methods of cathodic protection: the impressed current system and the galvanic anode system. The impressed current system requires graphite rods and an external power source to establish enough voltage. The galvanic anode system, which requires no external power supply, uses metallic anodes, such as magnesium, zinc, or aluminum.

Cathodic protection systems may be maintained by activity personnel or by service contract. The field engineering officer will provide guidance in developing maintenance procedures or in contracting for such services.

IMPRESSED CURRENT SYSTEM.—Make inspections and necessary maintenance repairs at monthly intervals. The steps for the inspection include the following:

1. Check exterior of enclosure for rust, corrosion, or mechanical damage; check hinges and locks for inadequate lubrication, rust, or other deficiencies; check wiring and fastenings and rectifier for broken or damaged insulation, and for rust or corrosion on conduit; and, check exposed wires and cables and all electrical connections for insecurity, frayed or broken insulation, and other deficiencies.

2. Check interior of enclosure for rust, moisture condensation, loose wiring, and signs of excessive heating. (Do not put hand tools inside the enclosure.)

3. Check anode suspensions for rust, corrosion, bent or broken suspension members, frayed or broken suspension lines or cables, loose bolts, loose cable connections, and frayed or broken wiring.

4. Whenever necessary, replace or repair any item which will not pass inspection for continued service, and paint switch cans and exposed rectifier housing and other electrical gear as necessary.

GALVANIC ANODE SYSTEM.—The only maintenance required for a galvanic anode system or a sacrificial anode system is monthly inspection and potential tests to determine when replacement of anodes is necessary and to ensure continuity of the electric circuit. The procedures that apply are as follows:

1. When an abnormal decrease in current output (or potential of the protected structure) occurs, the

anodes should be inspected for excessive disintegration.

2. Check terminals and jumpers of test leads for rust, corrosion, broken or frayed wires, loose connections, and similar deficiencies. Tighten all connections.

3. Check the bushing supporting the anode for rust and corrosion. Where resistors are installed in the circuit, examine these units for corrosion, broken and frayed wires, and loose connections. Tighten all connections.

4. Check the anode suspensions for rust, corrosion, bent or broken suspension members, frayed or broken suspensions lines or cables, loose bolts, loose cable connections, and frayed or broken wiring. Install new anodes when necessary.

WARNING

Do NOT bridge insulated couplings or break electrical connections without engineering advice.

The maintenance operation frequency and schedule of inspections for clarification equipment are shown in appendix III, table E.

Q12. Collector basins should never be cross connected with what type of water system?

Ql3. What are the two methods of cathodicprotection for sedimentation basins?

Q14. What cathodic method requires no external power supply?

MAINTENANCE OF FILTRATION EQUIPMENT

LEARNING OBJECTIVE: *Identify and understand basic maintenanee for filtration equipment.*

Maintenance procedures on both gravity and pressure filters are essentially the same, differing only in detail. Some of the maintenance operations for diatomite filters are similar to those for sand filters; others are not.

GRAVITY FILTERS

Regardless of the type of filter medium used (sand or anthrafilt), the material filtered out of the water must be removed from the filter at regular intervals. (See fig. 8-5.)

Filter Media

During daily backwashing, as an operating procedure, the operator should observe any conditions which may indicate a need for more complete inspection. The MINIMUM procedures are as follows:

- At monthly intervals, drain the filter to the surface of the filter medium; inspect the surface for unevenness, sinkholes, cracks, algae, mud balls, or slime.

- When depressions or craters on the surface are of appreciable size, dig out the sand and gravel, and locate and repair any break in the underdrain system.

When a filter bed is not backwashed correctly, sand grains and foreign matter begin to stick together. Over a period of time, large clumps, called mud balls, are formed. They lower the efficiency of the filter bed and must be removed. Surface washing usually breaks down these formations, and they can then be removed by backwashing. When the plant does not have surface wash equipment, mud balls may be removed by the steps of the procedure as follows:

1. Wash the filter bed completely clean at 2- to 3-week intervals by using about twice the usual amount of backwash to make sure the bed is cleaned thoroughly.

- When the wash water is clear, reduce the rate until the bed is expanded about 20 to 25 percent to expose mud balls on the sand surface.
- Remove the mud balls manually with a 10-mesh screen attached to a long handle.
- When sand shows evidence of algae, prechlorinate ahead of filters. Where severe algae growths exist on sand or walls, remove the filter from service and treat the filter with a strong hypochlorite solution. Add enough hypochlorite to produce 2 to 4 ppm of free residual chlorine in a volume of water 6 inches deep above the filter surface. Draw down the filter until the water level is just above the bed surface. Allow it to stand for 6 to 8 hours, then backwash the surface, and follow this by a complete backwashing. Repeat if necessary.

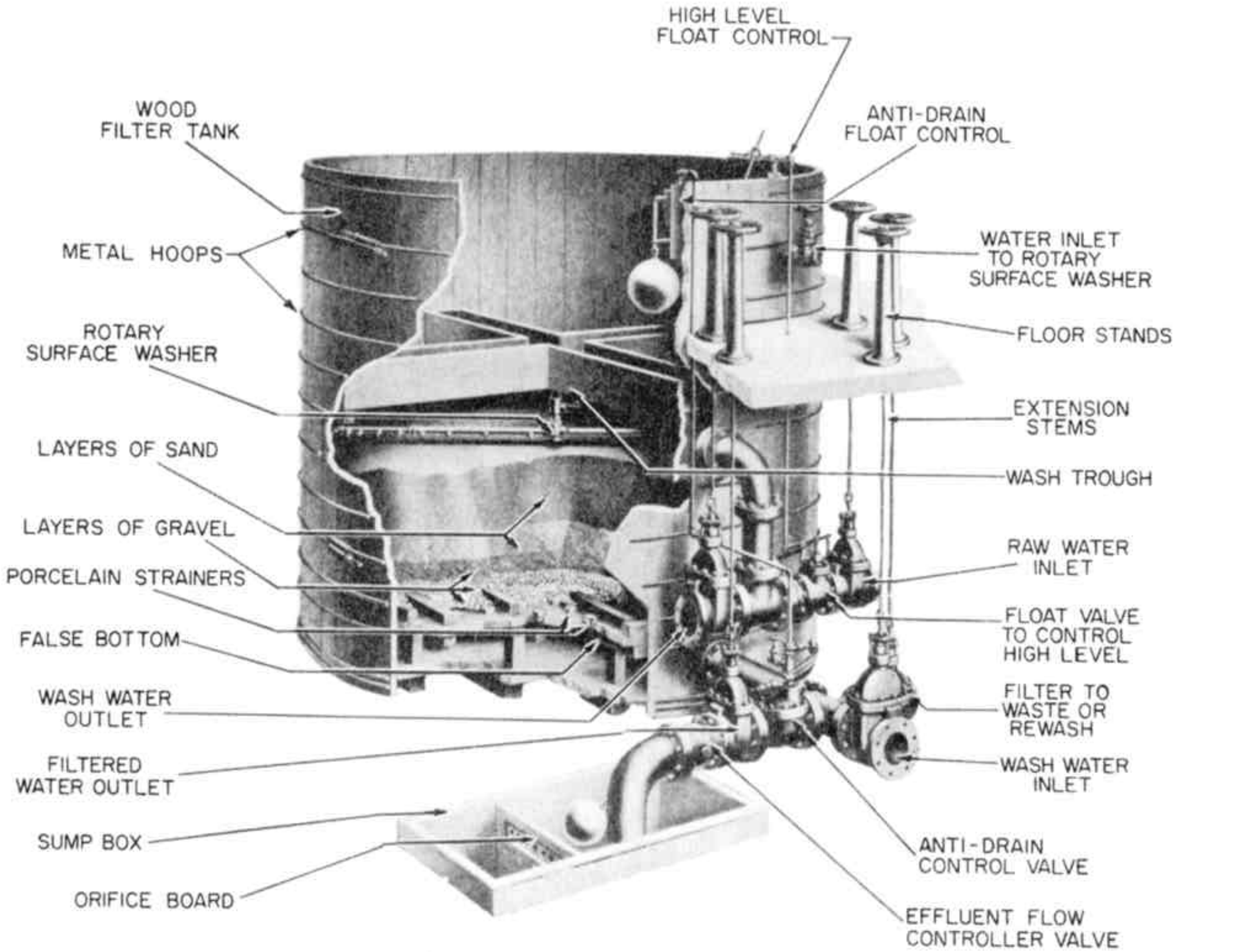


Figure 8-5.—Cutaway view of gravity sand filter with rotary surface wash.

2. Quarterly, during a backwashing period, probe the filter for hard spots and uneven gravel. Examine the sand below the surface by digging to gravel with the water drawn down to the gravel level. When clogged areas appear because of cementation of sand grains with mud balls or because of carbonate deposits or if the sand (or anthrafilt) grains have increased in size because of incrustation (e.g., in softening plants or where lime and ferrous sulfate are used for coagulation), clean the sand by treating the idle filter with an inhibited muriatic acid or sulfurous acid. The advice of the public works officer should be obtained if the operator is unfamiliar with the use of these chemicals.

- Add the inhibited muriatic acid at the surface and allow it to pass downward through the bed and out the filter drain or "rewash" the line or add it to an empty filter through a small tap on the bed side of the ash-water line.

- Use sulfurous acid as follows: Allow the sulfur dioxide gas from a cylinder to discharge into the filter wash waterline while slowly filling the filter bed with wash water. Use one 150-pound cylinder to 6,000 gallons of water to produce a 0.3-percent solution. Allow it to stand for 6 hours.

- Semiannually, ascertain any change in the rate of wash water rise, as determined during operating procedures, and check sand expansion. Inspect the sand and, if you do not see the condition of the medium, locate the elevation of the top of the bed to determine if the bed has "grown" in depth. Also, remove a sand sample and analyze it as follows:

- Make a sampling tube 12 inches square by 36 inches deep. Force a tube to the gravel level and drain the bed. Remove the sand from within the tube.

- Collect several such samples from well-scattered locations on the filter bed, mixing until about 2 pounds remain. Dry this sample; mix, quarter, and reduce to a usable sample size.
- Determine loss of weight of a 10-gram sample during acid treatment. Treat the sample with 10 percent hypochloric acid in a Pyrex evaporating dish in a water bath for 24 hours. Replace acid loss during treatment period. Wash, dry, and weigh the sand. Determine the weight loss and compare it to the previous analysis.
- From the remainder of the sand sample, remove 100 grams and run a sieve test. Compare the results to previous tests.

When either inspection, weight loss or sieve analysis shows growth of sand grains to a point where filtration efficiency is impaired, treat the sand as follows:

- Add inhibited muriatic acid at the surface and allow it to pass downward through the bed and out the filter drain, or "rewash" the line; or add it to an empty filter through a small tap on the bed side of the wash waterline.
- Adjust the water treatment process as necessary. If treatment is not effective, replace the filter medium.

Gravel Inspections

Gravel inspection procedures include the following:

1. At monthly intervals, check the gravel bed surface for unevenness, using a garden rake or a pole as a probe during backwashing. When ridges or sinkholes are shown, the filter may need overhauling.

2. Every 6 months, remove sand from an area about 3 square feet, taking care not to distribute the gravel. Examine the gravel by hand to determine if the gravel is cemented with incrustation or mud balls, or if it is not layered properly.

3. When any undesirable conditions exist to a marked degree, the sand should be removed and the filter gravel relaid. When unevenness or layer mixing is caused by a faulty underdrain system, repair it; when it is caused by faulty backwashing, correct the backwashing procedure.

Filter Underdrain Systems

Annually, or as observations indicate the need, the filter bottom should be inspected. Sand boiling during backwashing or sand craters on the surface indicate trouble in the underdrain system, as does marked unevenness of the gravel layers. Inspection and treatment procedures are as follows:

1. To inspect the bottom, remove the sand over an area of about 10 feet square. Select an area where sand boils or other indications of trouble have been noticed. Place planking over the gravel to stand on, and remove the gravel from areas about 2 feet square. Check the underdrains for deterioration. When the underdrains need repair, remove all sand and gravel, make repairs to the underdrain, and replace the gravel and sand in proper layers.

2. Where the underdrains are porous plate and are clogged with alum floc penetration, flood the underdrain system with a 2 percent sodium hydroxide solution for 12 to 16 hours.

Wash Water Troughs

At quarterly intervals, the level and elevation of troughs should be checked. Water should be drawn below the trough lip, the wash water valve cracked, and any low points observed where water spills over the lip, before the lip is covered completely.

The troughs should be adjusted as necessary to produce an even flow throughout their lengths on both sides.

At 6 month intervals, metal troughs should be inspected for corrosion. When corrosion exists, the troughs should be allowed to dry, and then cleaned by wire brush and painted with a protective paint or coating.

Operating Tables

Operating controls for filter valves may be mounted on a console, panel, or table. The controls actuate the filter valves which may be powered either by hydraulic or pneumatic means. The controls may be connected to the valve mechanism either mechanically, electrically, hydraulically, or pneumatically.

Maintenance operations that should be performed weekly are as follows:

1. Clean the table, the console, or the panel inside and out, using soap and water if necessary.

2. When mechanically operated, check the tension on the cables or the chains, used for connection to the valve operator or for connection to the valve-position indicators.

3. When hydraulically operated, inspect for leaks and stop any leakage; when pneumatically operated, check tubing for possible leakage.

Maintenance operations that should be performed monthly are as follows:

1. Transfer valves (four-way) and handles should be adjusted monthly to make certain that all filter valves open at the same rate. Packing glands should be tightened or new packing added if needed.

2. Transfer valves should be lubricated monthly with grease. They should not be overlubricated; one-half turn of the grease screw (cup) should be enough.

3. The valve-position indicator should be inspected monthly and adjusted to ensure that it reads correctly in all positions.

Maintenance operations that should be performed annually are as follows:

1. The four-way transfer valves in the table should be disassembled annually and any worn parts, seats, or washers should be cleaned or replaced with new ones.

2. The inside of the table, console, or panel should be painted annually to protect against corrosion.

Rate Controllers

Rate-of-flow controllers (fig. 8-5) may be either direct acting or indirect acting.

Maintenance procedures for a direct acting rate-of-flow controller is as follows:

1. Weekly, clean the exterior, check for leakage through the diaphragm pot, and lubricate or tighten packing to stop any existing leakage. Also, ensure that both the diaphragm and the control gate move freely between zero differential and the open and closed positions.

2. At intervals of 1 or more years, remove and disassemble the diaphragm pot, including the rubber diaphragm. When the water does not cause tubercles, this operation may not have to be done more than once every 3 to 5 years. The term *tubercles* refers to small, more or less hemispherical lumps on the walls of the pipe, which increase the friction loss and, by reducing the velocity, also reduce the capacity of the pipe. Tubercles result from tuberculation, a condition which develops on the interior of ferrous pipelines, caused by corrosive materials present in the water passing through the pipe.

3. Every 3 years, disassemble and service the controller gate and mechanism. Inspect the venturi throat. Paint or apply protective coating as necessary.

With indirect-acting controllers, the following maintenance procedures apply:

1. At weekly intervals, clean the outside of the controller; adjust the packing; lubricate or tighten the fittings as necessary to stop any leakage from the hydraulic cylinder, the controller valve, the piping, or the pilot valve. Make sure that the knife edges seat correctly and are free of paint or other foreign matter. Also, be sure that the piston has free vertical travel and does not bind. Replace packing if necessary.

2. Annually, disassemble, clean, and lubricate the pilot valve. Remove foreign matter from the piston with a cloth. Never use an abrasive to clean the piston. Make certain that no foreign matter enters the pilot valve during the cleaning operation. Check for leaks or cracks in the diaphragm.

3. Every third year, disassemble and service the controller gate and mechanism; inspect the venturi throat and apply protective coatings where necessary. Check the hydraulic cylinders, and maintain them under the manufacturer's instructions.

Gauges

Various types of indicating and recording instruments may be mounted on the operating table or control panel. Here, we will take up one device, the diaphragm-pendulum unit loss-of-head gauge. Where the actuating mechanism is of this type, the general maintenance procedures given here apply. For a more detailed discussion of these procedures, consult the manufacturer's instructions.

The following maintenance operations are required on a monthly basis:

1. Purge the diaphragm cases of air, and check the cable to be sure that it leaves the segment at a tangent to the lower end when a zero reading exists on the unit.

2. Remove dirt from the knife edges; when necessary, tighten the cam hubs on their shafts.

3. Drain mud from the mud leg. In doing this, flush the mud out of the water pipeline running from above the sand to the loss-of-head gauge. Drain the mud leg until the water runs free of sediment.

Annually, inspect the diaphragms for leakage, and replace when necessary.

NOTE

Diaphragms in stock should be stored underwater.

Also, disassemble the unit to clean and lubricate it when necessary. Check the working parts and the cables. (They should be free of knots, splices, or fraying.) Repack the stuffing box when it is leaking. Make certain that the knife edges rest solely on their edges where the pendulum is hung vertically, and be sure that all cable ends are knotted tightly.

PRESSURE FILTERS

Except where the filter medium is housed in an enclosed pressure shell, pressure filters (fig. 8-6) are constructed like gravity filters with respect to the underdrain system, gravel, and the filter medium (sand or anthrafilt). Pressure filters need the same care and attention as gravity filters. Since their backwashing operations cannot be observed, the filter must be opened regularly and inspected carefully. The recommended maintenance procedures are as follows:

- Weekly, inspect piping and valves for leaks. Lubricate and repack valves if necessary.
- Quarterly, open the pressure shell and inspect the filter bed surface. The inspection procedures are as follows:

1. Use a garden rake during backwashing while the manhole is open to test for mud balls in the lower part of the filter bed and for evenness of the gravel layer surface.

2. Determine when the sand bed level has changed since the last inspection by comparing the bed surface elevation with some reference point.

3. When the filter does not have a surface wash system and shows evidence of mud balls, backwash it at the highest rate possible while jetting the surface with a stream of water from a high-pressure hose nozzle.

- Annual maintenance requirements are as follows:

1. Open the filter, remove the sand from an area large enough to permit the inspection of the gravel. When the sand or gravel distribution indicates nonuniform distribution of backwash water, the filter media and gravel may need to be removed, and the underdrain system checked.

2. Clean and paint the exterior of the shell.

- Every 3 years (or more often ifnecessary), the filter medium and gravel should be removed and the underdrain system checked for the distribution of wash water, and repaired if necessary. Clean the under-drain system, and paint it or apply a protective coating to all parts subject to corrosion, including the inside shell. Replace the gravel and the filter medium.

DIATOMITE FILTERS

Most diatomite filter installations in potable water supply plants are of the pressure type, although there are vacuum-type filters that can be used in certain installations. In general, the maintenance procedures for cleaning the filter element are the same for both types. The following procedures apply:

At monthly intervals, or as often as operating conditions show the need, check the filter elements. Cleaning is needed if the precoat has apparent bare spots on the elements. Causes of element clogging are iron oxide, manganese dioxide deposits, and algae growths.

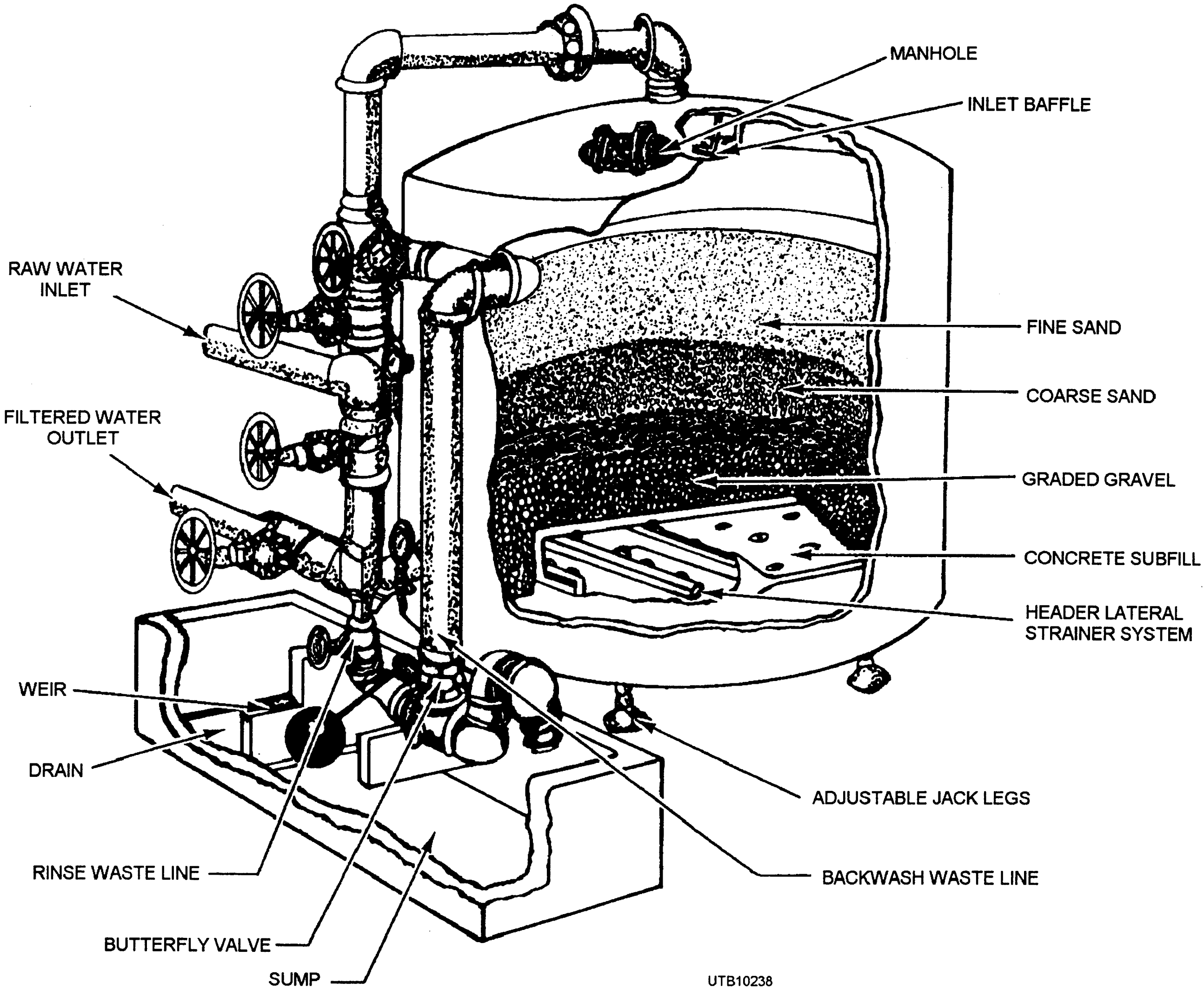


Figure 8-6.—Pressure-type rapid sand filter.

For iron oxide removal, treat the elements with a 0.5-percent solution of oxalic acid. Information is available from manufacturers on the amount of oxalic acid to use on different size units. The procedures used to remove iron oxide are as follows:

1. Start with an empty filter after a regular washing.
2. Close the drain valve and the main outlet valve; open the recirculation valve.
3. Fill the tank to a level covering the top of the elements.
4. Add the proper quantity of oxalic acid, and recirculate for 1 hour.
5. Drain and hose down the elements and the tank interior.
6. Close the drain valve; refill, circulate a few minutes, and then drain again. When the cleaning is not completely effective, repeat the procedure.

The procedure for manganese dioxide removal is the same as for the removal of iron oxide, except that anhydrous sodium bisulfite must be added to the solution. (See the manufacturer's instructions for the correct amount.)

To remove algae growths, add a 12 ½ percent hypochlorite solution to the tank volume after filling the tank to the proper level. (See the manufacturer's instructions for the proper amounts to use for different size units.)

Semiannually, check the piping and valves and other equipment, including the body feed equipment. Make whatever adjustments the manufacturer's instruction says.

Clean and paint all exterior surfaces annually if necessary.

The maintenance operation frequency and schedule of inspections for filtration equipment are shown in appendix III, table F.

Q15. Backwashing should be performed on gravity filters at what intervals?

Q16. When severe algae growth exists on filter sand or walls, what corrective action should be taken?

Q17. Sodium hydroxide is used in filter underdrain systems of porous plate to correct what condition?

Q18. What are the two types of flow rate controllers?

Q19. What is the major difference between a pressure filter system and a gravity filter?

Q20. To remove iron oxide in a diatomite filter, a solution of what chemical and at what percent should you use?

MAINTENANCE OF AERATION EQUIPMENT

LEARNING OBJECTIVE: *Identify and understand basic maintenance for aeration equipment.*

Proper maintenance of aerators is another important area in water treatment activities.

WATERFALL AERATORS

The recommended maintenance procedures for waterfall-type aerators (cascade or step, and tray or splash pan) is as follows:

- Weekly, inspect the aerator surfaces for algae or other growths, precipitated iron oxide, and for nonuniformity of water distribution and staining. Clean when necessary. Treat with copper sulfate or hypochlorite solution to destroy growths.
- Every 6 months, clean and repair tray aerators, removing the trays as necessary. Inspect the coke tray aerators for biological growths and coke deterioration. Replace the coke if the cleaning is not effective. Repair the screen and enclosures if necessary.
- Annually, repair or replace the surfaces on cascade or step aerators.

INJECTION OR DIFFUSER AERATORS

Injection or diffuser aerators may be either porous medium design or injection nozzles.

Porous Ceramic Diffusers

The maintenance procedures for porous ceramic diffusers-plate or tube-is as follows:

1. Upon evidence of the nonuniform distribution of air or clogging that impairs operation, dewater the tank; inspect and clean diffusers if necessary.
2. Every 6 months, drain the aeration tank and inspect the diffusers for joint leaks, broken diffusers, and clogging. Porous ceramic diffusers may suffer clogging of either the waterside or the air side (underside).
   - For waterside (porous plate diffusers), use oxidizing acids to clean organic growths from the plate surface.

NOTE: Chlorine gas introduced into the air line at intervals between inspections will help hold down organic growths.

   - Removable plates should be soaked in 50 percent nitric acid. Plates grouted in place cannot be treated with nitric acid; use chromic acid (made by adding 1 gram of sodium dichromate to 50 ml of sulfuric acid). Pour approximately 2 fluid ounces on each plate 2 days in a row.

WARNING

Acids must be handled carefully. DO NOT pour water into sulfuric or chromic acid, as it will explode or splatter. Such acid will cause severe burns to the skin and clothes. ALWAYS pour acid SLOWLY into the water, while stirring continuously. Acid treatment should only be done only upon the approval of the Public Works Officer under supervision of a chemist or other qualified personnel.

   - Air side (porous plate diffusers). When clogging is caused by iron oxide particles from pipes, treat this condition with a

30-percent solution of hydrochloric acid. If clogging is by soot, oil, or dust from improperly filtered air, remove the diffusers and burn off the extraneous material in a furnace.

- Porous ceramic tubes. Tubes may be removed and cleaned by soaking in acids or by burning (as described for porous plate diffusers).

Porous Saran-Wound Tube Diffusers

These diffusers should be inspected and cleaned semiannually as necessary. This material cannot be subjected to strong acids or heat. It must be scrubbed with a brush and soap or detergent.

Injection Nozzles

Injection nozzles should be inspected and cleaned semiannually as necessary. Diffuser nozzles on header lines may become clogged from deposits inside from iron oxide particles, or on the outside from organic growths. Clogging from the inside may require removal of the individual nozzles for cleaning. Chlorine gas injection into the air line header between inspections will hold down organic growths. At inspection periods, if growths are present, scrub them off with a brush and detergent solution to which hypochloride has been added.

SPRAY NOZZLE AERATORS

The maintenance procedures for spray nozzle aerators is as follows:

- At weekly intervals, check the nozzles for clogging, and clean when necessary. Remove the nozzles only when necessary. Check for adequate spread.
- Quarterly, check air line manifolds, remove caps and clean out sediment; check for joint leaks. Check pipe supports, replace or repair, and paint as necessary.
- When spray fences exist, repair and paint them annually.

BLOWERS AND ACCESSORY EQUIPMENT

The procedures for injection aeration is as follows:

- Daily, lubricate the blower or compressor under the manufacturer's instructions. Check output pressures.
- Weekly, inspect the air filters; clean, repair, or replace them as necessary.
- Annually, open the blower or compressor and inspect for internal erosion or deterioration; repair as necessary. Paint exterior surfaces.

Maintenance operation frequencies and the schedule of inspections for aeration equipment are shown in appendix III, table G.

Q21. Waterfall-type of aerators use what type of action to areate water?

Q22. What reaction will occur when water is poured into sulfuric or chromic acid?

Q23. Chlorine gas injection into the air line header of injection nozzles will reduce what condition?

SAFETY AND EMERGENCIES

LEARNING OBJECTIVE: *Recognize and understand basic safety procedures for use, handling, and storage of water treatment chemicals. Understand first aid for chlorine gas.*

The operation of water treatment plants is a hazardous occupation, with dangers from noxious gases and vapors, physical injury, and infections. Work should be carried on only under the supervision of an experienced workman or operator who is trained in first aid and is familiar with the hazards of the work.

CHLORINATION

Specific precautions in handling ammonia, chlorine, and chlorine-yielding compounds were shown in an earlier chapter on water treatment plants. A number of chlorination safety precautions are given below.

- Provide self-generating oxygen-breathing apparatus or self-contained oxygen-breathing apparatus designed to cope with chlorine.
- Maintain only the supply of chlorine in any chlorinator room that will do for normal daily demands. Store the main supply in a detached noncombustible building or in a fireproof room which is vented only to the outside and which is separated from the main part of the building. Keep the chlorinator and chlorine storage. buildings or rooms locked to prevent the entrance of unauthorized personnel and restrict these areas from any other use.

- Allow only reliable and trained personnel to handle chlorine.
- Handle containers carefully to avoid dropping or bumping them.
- Avoid hoisting containers as much as possible; when hoisting is necessary, use safe lifting clamps.
- Store cylinders in a cool place, away from dampness, steam lines and fire, and in an upright position secured from tilting and falling.
- Keep protective valve caps on containers when not in use; never tamper with safety devices on containers.
- Never connect a full cylinder to a manifold with another cylinder, unless temperatures of both are nearly the same.
- When not withdrawing chlorine or when cylinders are empty, keep the valves closed.
- Disconnect the valves as soon as the containers are empty, and check for chlorine leaks at the valve outlets. Test for leaks by passing an opened bottle of strong ammonia solution around the valve. White fumes of ammonium chloride will appear if there is any leakage. Leaks around fittings, connections, and lines can be detected in the same way. Do not apply ammonia solution to plated metal parts because it will remove the plating.
- When chlorine is noticed, workers should avoid panic, refrain from coughing, keep the mouth closed, avoid deep breathing, keep the head high, and get out of the affected area. Only qualified personnel with suitable respiratory equipment will be assigned to investigate and correct the cause of chlorine leaks. When chlorine is being discharged, close the container valve immediately. When chlorine is escaping in liquid form, turn the containers so the chlorine escapes as gas, which will reduce leakage. Do not apply water to the leak; this dangerous practice causes corrosion that may increase the leakage. Electronic chlorine gas detectors are widely used in water plants today.
- The handling of a persistent chlorine leak in a plant is best left to the chlorine supplier.
- Never apply a flame, blowtorch, or other direct heat to chlorine containers; discharge them in a room with a temperature of about 70°F.
- Never ship a defective or leaky cylinder unless it is completely empty. Paint Defective plainly on all such cylinders.
- Follow all regulations on shipping, storing, and using compressed gas cyl inders.
- Provide proper means of exit from areas where chlorine is stored or used.
- Never use a chlorine cylinder except to hold chlorine gas.

First Aid for Chlorine Poisoning

Should any of the plant personnel become affected by chlorine gas or be overcome by its action, the steps for providing the victim first aid are as follows:

1. Remove the affected person at once to open air and away from gas fumes.

2. Call a physician.

3. Place the patient flat on the back with the head slightly elevated. Keep the patient warm and calm.

4. If conscious, give the patient one-half teaspoonful of essence of peppermint or a moderate stimulant. Do NOT give milk, as milk or cream will usually curdle in the stomach and cause vomiting which adds to the discomfort of the patient.

5. If able, the person affected should try not to cough.

6. If the patient is unconscious and not breathing, apply artificial respiration.

Emergency Treatment

For almost any chemical spillage on personnel, quick, thorough, and continued flooding of the affected body area with water is the best general first-aid measure. Call a medical officer for chemical bums, and ALWAYS for eyes affected by the accident.

HANDLING LIME

Operators must be particularly attentive to the commonsense rules of good housekeeping in handling lime. This chemical should be carefully stored in a dry area.

Other safety precautions for the handling of lime are as follows:

- An efficient dust-collecting system should be used whenever dust is present at handling points.
- A dry-pickup vacuum cleaner should be used for removing dust around unloading equipment and chemical feeders.
- Protective clothing should always be worn for persona! safety in case bags break or the dust-collection system fails. The proper dress is heavy-denim clothing with long sleeves, heavy gloves, bandanas, and trousers tied around the shoe tops. Chemical goggles and suitable dust masks should be worn. Any exposed skin areas should be covered with protective creams.

> **WARNING**
>
> Avoid accidental contact of quicklime or slaked lime with water as it generates excessive heat. Serious skin bums and eye damage can be caused by contact with hot lime solution. ALWAYS WEAR CHEMICAL GOGGLES OR FACE SHEILDS WHEN LIME FEEDING EQUIPMENT IS BEING OPERATED.

HANDLING AND STORING CHEMICALS

In handling and storing chemicals, observe all safety precautions.

- General.

1. Wear appropriate-type chemical cartridge dust masks when bags of chemicals or bulk material are unloaded or otherwise handled. When the chemical is particularly irritating or dust is excessive, wear chemical goggles.
2. In handling toxic solutions, a face shield, boots, gloves, and a rubber apron afford required protection from splashes or sprays.
3. Store chemicals in a clean, dry place. Store bagged or mixed chemicals in single or double rows with access aisles around each stack for frequent fire inspection. This type of storage makes it easier to remove burning chemicals.
4. Store chemicals in separate areas free from contact with flammable chemicals.
5. Prohibit smoking when loading and unloading flammable chemicals.
6. Do not store flammable chemicals where sparks from overhead electrical equipment can start a fire.
7. Use explosionproof wiring and electrical equipment where flammable chemicals are stored or handled.
8. Provide adequate shower facilities for all personnel handling chemicals.
9. Give all personnel handling fluorides detailed safety instructions.

- Fluorides.

1. Avoid breathing fluoride dust; wash thoroughly after handling fluorides and clean up all spillage.
2. Respirators, chemical goggles, rubber gloves, and protective clothing must be worn by all personnel likely to be exposed to sodium fluoride or sodium silicofluoride dust. Rubber gloves and boots and acidproof aprons are necessary where acids, such as hydrofluoric, fluosilicic, and hydrofluosilicic, are handled. Wash protective equipment thoroughly before and after using.
3. Take care to prevent dust or acids from entering open cuts, sores, or lesions.
4. Provide all fluoride-handling equipment, such as storage bunkers, weight hoppers, and dry-feed machines, with devices to keep the dust hazard down. Acid pumps will be provided with a clear plastic shield around glands and parts to protect personnel from acid spray.
5. Store fluorides in a specific, well-identified area. Storage in various or changing locations may result in a mistake in identifying the chemical. All acid containers will be covered, well vented, and stored where there is no fire hazard.
6. Containers that have held fluoride compounds will be disposed of in a safe manner by personnel protected as described above.

HOUSEKEEPING

Promote good housekeeping at the water treatment plant. Some good housekeeping rules to adhere to are as follows:

- Tools should be returned to their proper place when no longer needed.
- Empty bottles or other such objects should not be left around on the floor where someone is likely to trip or fall over them.
- See that the plant is kept neat and clean at all times.
- Among other things, ensure that passageways are kept free of grease and oil.
- Switchboards must not be used as clothes racks. Do not work around electrical apparatus or wiring with wet hands or in wet shoes or clothes.
- Workers on night watch or otherwise required to perform duties alone around water treatment plants should be capable of swimming at least 100 feet while dressed in the usual type of work clothing.
- An employee performing duties inside the tank guardrail should wear a safety belt and lifeline attached to the guardrail.
- Guardrails should be maintained around all water treatment plant open tanks. Handholds or suitable ladders should be maintained on one side wall of each open tank. Suitable handrails 8 to 12 inches above the waterline should be maintained on each side of open tanks.

Q24. To reduce chlorine hazards, what maximum amount of chlorine should you store in the chlorinator room?

Q25. What do you use to test for leaks on chlorine cylinders, equipment and systems?

Q26. If someone is affected or overcome by chlorine or its action, what is the first thing you should do?

RESPIRATORY PROTECTIVE APPARATUS

LEARNING OBJECTIVE: Recognize *and understand procedures for operation, donning, use, and maintenance of different types of personal respiratory protective gear.*

In water treatment and sewage maintenance work, you may use various types of respiratory protective apparatus, such as self-generating oxygen-breathing apparatus (OBA) and self-contained oxygen-breathing apparatus. Personnel directed to use this equipment should practice regularly with it to become proficient in putting it on quickly and to become accustomed to breathing through it.

SELF-GENERATING OXYGEN-BREATHING APPARATUS

Self-generating oxygen-breathing apparatus (OBA) gives respiratory protection in moderately and extremely high concentration of toxic gases or vapors or in an atmosphere deficient in oxygen. This equipment includes the following parts: a canister that holds chemicals to absorb carbon dioxide and moisture from the exhaled air and generates oxygen, and a breathing bag that serves as an air reservoir and a cooling chamber for inhaled air. Inhalation and exhalation check valves are parts of this equipment. Figure 8-7 shows a self-generating A-4 oxygen-breathing apparatus.

NOTE

Do not use the OBA in an explosive area as it is a fire hazard.

You must become thoroughly acquainted with oxygen-breathing equipment before wearing it in service. More information on the A-4 oxygen breathing apparatus can be found in the *Basic Military Requirements,* NAVEDTRA 12043.

SELF-CONTAINEDOXYGEN-BREATHING APPARATUS

The self-contained oxygen-breathing apparatus (figs. 8-8 and 8-9) is effective for limited use against any poisonous gas or oxygen-deficient atmosphere, such as when you are inspecting long, large sewers where a hose mask would be impractical. This equipment generally includes the following parts: a steel cylinder or bottle containing oxygen as needed at slightly higher than normal pressure.

The respiratory apparatus should be kept in access ible locations, but in quarters segregated from probable gas hazards.

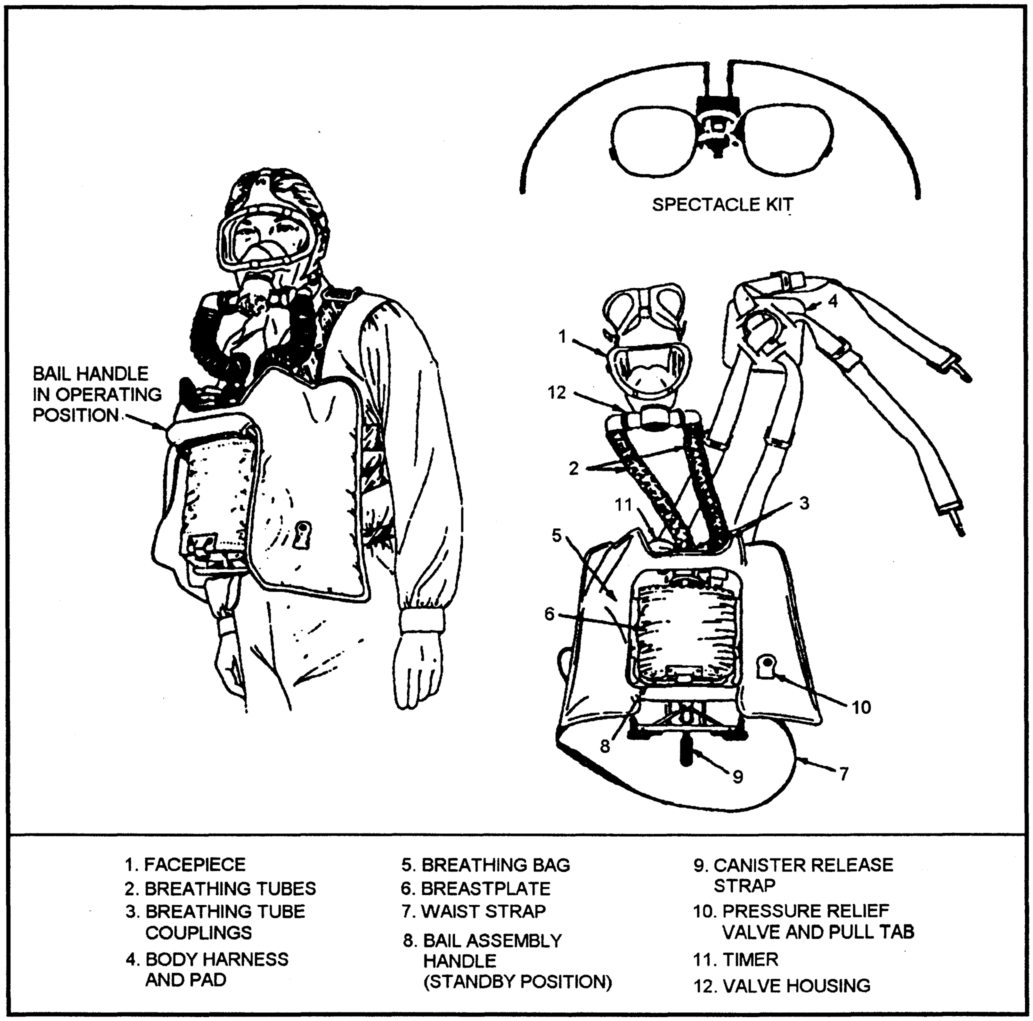


Figure 8-7.—Self-generating A-4 oxygen-breathing apparatus.

Self-Contained Demand Regulator Equipment

The demand regulator type of self-contained breathing equipment provides face and respiratory protection for the user but is limited to the amount of air or oxygen carried in the supply cylinder. This equipment consists of a full face mask, corrugated flexible breathing tube, demand regulator, air or oxygen supply cylinder, and harness.

A regulator pressure gauge should be in view of the user at all times. This gauge shows the cylinder pressure and reserve supply. During normal operation, the emergency bypass valve should be fully closed (turn clockwise for closing), and the regulator control valve to the main line should be fully opened (turn counterclockwise for opening) and locked in position by the locking device. This valve shuts off the automatic demand regulator if it fails or is damaged. It should be closed only after the emergency bypass has been opened. ONCE THE VALVES ARE SET IN THIS POSITION, THEY SHOULD NOT BE CHANGED UNLESS THE EMERGENCY BYPASS VALVE IS NEEDED. The air or oxygen supply is controlled by a main valve on the cylinder. (Open and close these valves with your fingers; do not use force.)

The operations described are intended for one brand of demand regulator equipment. Operations for other types of brands are similar, but the location of some of their parts may be different. This manual suggests these operations as a guide for all demand regulator equipment.

Donning the Facepiece (six-strap model)

Since facepieces for most breathing apparatus are applied in a similar manner, a step-by-step method of applying a six-strap model will be described only once and will be referred to throughout this manual. Head

Figure 8-8.—Self-contained oxygen-brreathing apparatus with bottle.

harness straps should be snug, not too tight. Although other types of facepieces may have fewer head harness straps or may have various sizes and shapes of lenses, most facepieces are similar in design. Because of this close similarity, the methods of application can be adapted to the one described and shown by figures 8-9, 8-10, and 8-11.

The six steps for donning the facepiece are as follows:

1. Loosen the head harness strap so that the tab end of each strap is against the facepiece buckle. With both hands, fold these straps in a bundle across the top of the facepiece. Hold the facepiece and straps by grasping the upper sides with both hands (fig. 8-10).
2. Place the chin well into the small pocket at the bottom of the facepiece and fit the facepiece to the temples and forehead.
3. Release the facepiece with both hands, but hold secure to the harness and pull the harness over the top of the head.
4. Tighten the chin straps first by pulling out and back on the tabs provided. This operation secures the facepiece in position and places the head harness on the back of the head so that the bottom strap is across the back of the neck and below the ears.
5. Tighten the temple straps next and secure the facepiece snugly to the head.
6. Tighten the top straps last, as shown in figure 8-10.

Notice that the head harness is placed at the back of the head, not on top. If the top straps are tightened first, the head harness may be pulled out of position. The facepiece is now ready to be tested for leakage. Hold one hand over the end of the breathing tube, or squeeze the breathing tube, and then try to inhale. If the facepiece fits snugly, it should collapse against the face.

Donning the Side Shoulder Strap Model

The harness of the side shoulder strap model must be prepared before the equipment is lifted from the floor. The only place necessary to grasp the harness or equipment is where the takeup strap and shoulder strap are buckled together. The takeup strap should be arranged without twist, although the wide shoulder strap may appear to have a half twist. This twist is normal for proper fitting to the back and shoulder. The steps for donning the side shoulder strap model (fig. 8-10) are as follows:

1. Fold the loop end of the harness takeup strap over upon itself and grasp the takeup strap with the right hand, at this point, with the palm down.
2. Lift the equipment up along the left side of the body by raising the right hand and arm toward the head. At the same time, run the left arm through the loop formed by the harness and

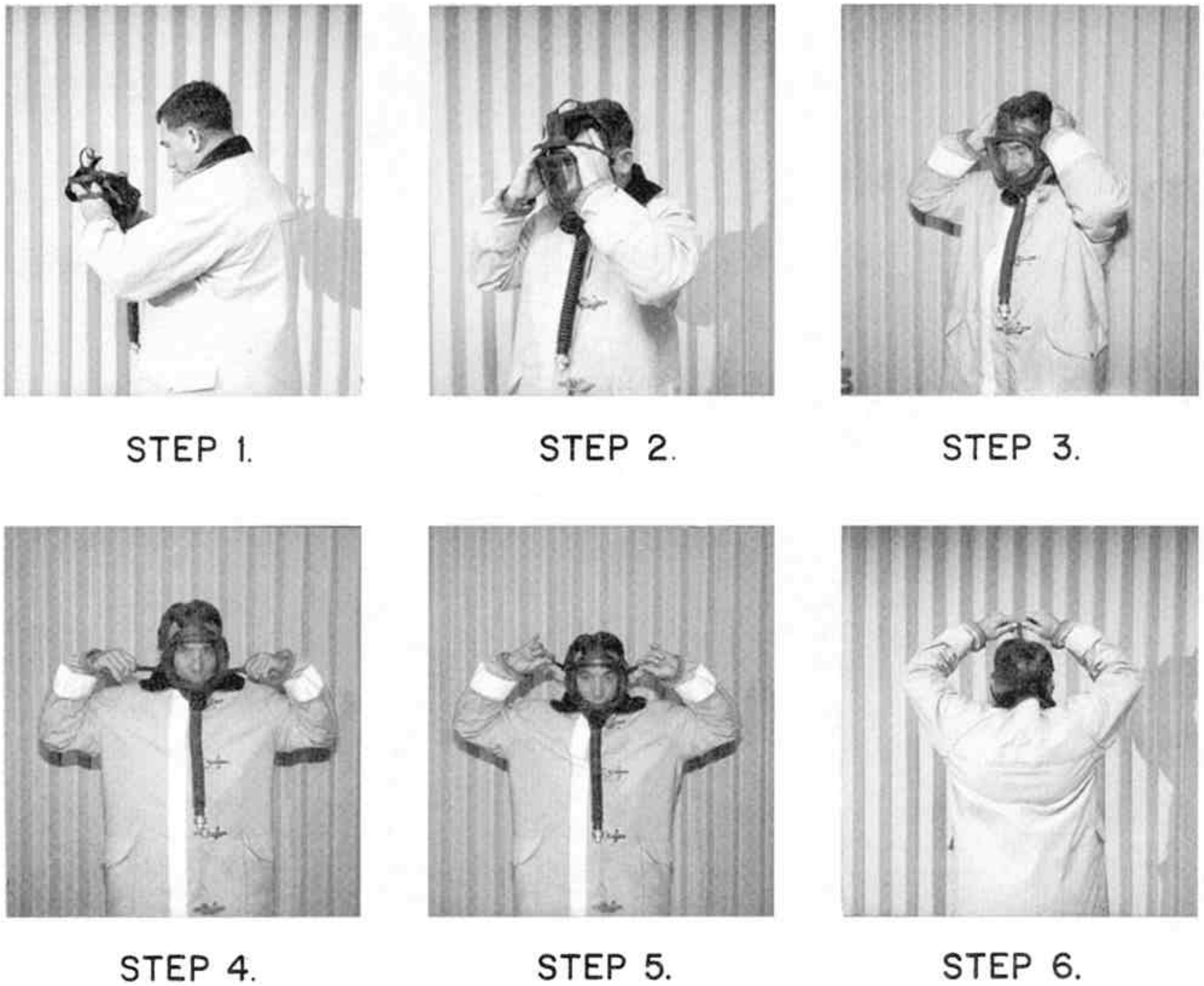


Figure 8-9.—Donning the facepiece (six-strap model).

cylinder, and grasp the cylinder control valve with the left hand. This action allows the left hand to open the cylinder control valve and to help boost the cylinder toward the back.

3. Continue the swinging movement; bring the right hand and arm over the head and place the wide shoulder strap on the right shoulder. Boost the cylinder into position on the back as shown.

4. Release the main line of the shoulder takeup strap from the right hand but hold firmly to the loop end. Pull down and out on the loop end to tighten the harness to fit the body.

5. Fully open the cylinder control valve before it has been released by the left hand.

6. Reach behind the body with the right hand and secure the waist strap hanging from the lower part of the cylinder. Bring this waist strap around the waist from the right side and snap it into the ring just below the demand regulator valve.

7. With the right hand, pull to the right and out on the loop end of the waist strap to tighten. The equipment is now in the standby position, and the facepiece may be applied to the head any time before entering the contaminated area.

8. Donning the facepiece is the same as has been described (fig. 8-9). The facepiece will not yet have been connected to the equipment.

9. The breathing tube can be connected to the demand regulator any time the wearer desires, usually just before entering the contaminated area to conserve the cylinder supply. As long as

Figure 8-10.—Donning the side shoulder strap model of the self-contained oxygen-breathing apparatus.

the breathing tube is not connected, the wearer is breathing air from the atmosphere.

10. The minute the connection has been made to the demand regulator, the wearer breathes entirely from the cylinder.

Donning the Back Strap Model (overhead method)

Before starting the donning procedures for the back strap model (fig. 8-11) and as described below, open the air or oxygen supply cylinder valve two full turns or more, and check the pressure gauge on the regulator to see that it is operating properly. Then proceed as follows:

Step 1: Grasp the backplate in a convenient manner with one hand on each side of the plate in preparation to lift the equipment from the case.

Step 2: Lift the equipment from the case and permit the demand regulator and harness to hang freely.

Step 3: Raise the cylinder overhead and permit the elbows to find their respective harness shoulder strap loops.

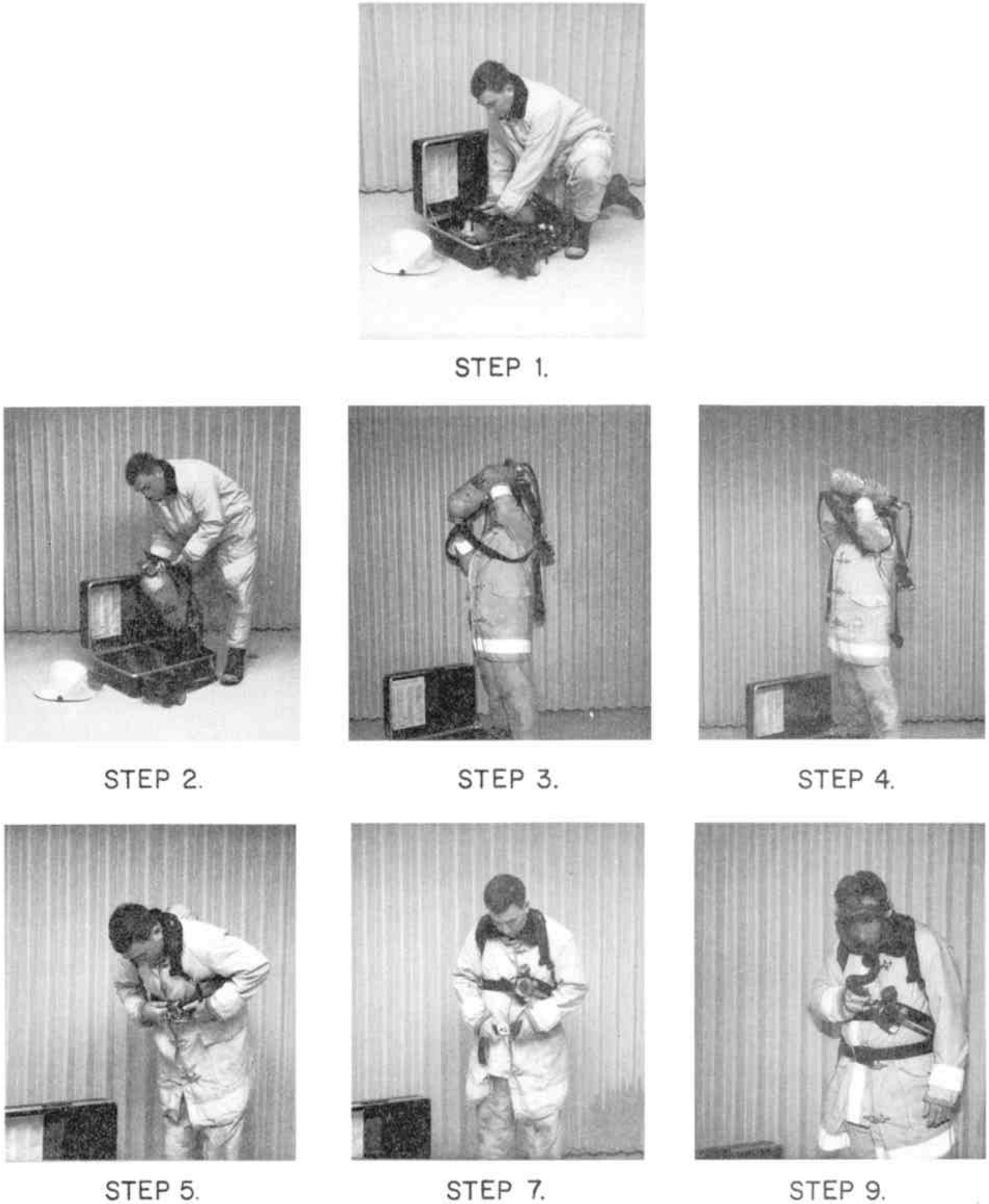


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Figure 8-11—Donning the back strap model of the self-contained breathing apparatus.

Step 4: Continue to carry the cylinder overhead toward the back where it can be released to the back.

Step 5: Lean forward when the cylinder is released so that the cylinder will not slide down the back. Fasten and adjust the upper chest strap to hold the demand regulator in position. If equipment is donned with the chest strap fastened, adjustment is enough.

Step 6: With both hands on their respective sides, grasp the two harness takeup straps located near the chest, just below the armpits, and pull down and out to tighten the equipment firmly to the back.

Step 7: Fasten and adjust the lower waist strap which will conclude harness adjustment to secure the equipment to the body.

Step 8: Donning the facepiece is the same as has been previously described.

Step 9: The breathing tube can be connected to the demand regulator any time the wearer desires.

Daily Inspections

Self-contained, demand-type breathing apparatus must be kept perfect to protect it as designed.

The first step to ensure that breathing apparatus is safe for immediate use is daily inspection. The breathing apparatus must be inspected daily by the fire fighter who will be using the equipment. Items that must be daily are as follows:

1. Cylinder air pressure should be no less than 1,850 psi or normal pressure recommended by the manufacturer.
2. The regulator and low-air alarm bell must be tested by opening the tank valve to charge the high-pressure lines and regulator; then, close the tank valve and breathe pressure off the regulator to assure proper operation of "main line valve" and "low-air alarm bell."
3. Check all body harness straps. The harness should be tangle-free and all straps extended to their limit.
4. The facepiece should be checked for cracks, tears, and broken head straps. All head straps should be extended to their limit.

The next two steps, to ensure proper operation of breathing apparatus, are performed immediately after the apparatus has been used. These steps are cleaning and sanitizing and recharging air cylinders.

A poorly maintained breathing apparatus is not only unsafe to use, but in most cases, very unpleasant. Dirty moving parts may not work. A facepiece that has not been cleaned and sanitized is not only unpleasant to wear but can spread cold and influenza germs throughout a departmen t. An air cylinder with less air than prescribed by the manufacturer renders the apparatus inefficient or useless.

The facepiece should be thoroughly washed with warm water, any mild commercial disinfectant, and then rinsed with clear, warm water. Special care should be given to the exhalation valve to ensure proper operation. The air hose should be inspected for cracks or tears. Then the facepiece should be dried with a lint-free cloth. The entire apparatus, including the storage box, should then be wiped down with a sponge, using the same disinfectant solution.

Periodic Inspection and Care

After each 3-month period, remove the equipment from service and check valves, pressure regulators, gauges, harness, and facepiece. The following functional test and inspection should then be made: check the facepiece, hose, and exhalation valve by inhaling slowly with the thumb over the end of the hose connection. Make the hose connection and check the performance of the regulator. Inhale deeply and quickly. The regulator should supply a full flow to give the user all the oxygen demanded. If, on slow inhalation, a "honking" sound is heard in the regulator, it can usually be stopped by inhaling faster. The sound is caused by the bellows vibrating and in no way affects the performance or safety of the regulator. If the bellows vibrate continuously or excessively, competent technicians recommended by the manufacturer should overhaul the regulator. If the demand valve sticks open slightly (this may be caused by a cold diaphragm), the breathing gas will continue to flow when the wearer is not inhaling. This condition can usually be corrected by "blowing back" on the regulator. Operate the regulator several minutes to exercise the diaphragm and valves before condemning the regulator. With the hose out of the connection, close off the cylinder valve. With 1,980 pi indicated on the regulator gauge, the regulator and the regulator hose assembly should hold the trapped-in pressure.

After 2 1/2 years, the regulator and regulator hose should be returned to the factory or to its representative for test and/or repair. After each 5-year period, these cylinders should be hydrostatically tested. Each cylinder is stamped with the month and the year of manufacture and the date of the last test to meet requirements of the United States Department of Transportation (formerly Interstate Commerce Commission). Always empty cylinders before returning them for service and test.

Testing Cylinder Valve for Leaks

Use a soap solution to inspect the place where the cylinder pressure gauge connects to the valve body and the safety plugs. With the regulator hose and regulator attached to the cylinder valve, open the cylinder valve.

When bubbles appear around the valve stem and packing gland nut when a soap solution test is being made, the packing nut should be tightened or the gland packings should be replaced.

With the regulator hose disconnected, close the cylinder valve. When bubbles form at the regulator hose connection when a soap solution is applied, the valve seat is leaking. Open and close the valve quickly several times and allow pressure to blow through quickly. This procedure may clear the valve seat of dirt and correct the trouble. If the leak continues, the cylinder should be returned to the factory for test and repair.

Q27. A self-generating oxygen-breathing apparatus protects you from what type of atmospheres?

Q28. What is the last step in donning a facepiece?

Q29. Oxygen cylinders are hydrostatically tested how often?

WATER STORAGE FACILITIES

LEARNING OBJECTIVE: *Identify different types of water storage facilities and their associated support equipment. Understand their operation, uses, and maintenance.*

The operation of storage facilities in the distribution system is largely a matter of maintaining sufficient levels through adequate pumping and controlling water flow through appropriate valves.

Live storage, where water is constantly circulating from the supply into the distribution system, is preferred to noncirculating storage because the latter depletes the chlorine in the water and allows tastes and odors to develop. If dead storage is necessary, the operator must maintain a close watch on chlorine residuals and the development of odors and tastes, and report conditions regularly to higher authority.

TYPES OF STORAGE

Facilities for storage of water include open reservoirs, underground reservoirs, and elevated storage tanks. Ground storage reservoirs may be the same or similar to those shown in figure 8-12. Three types of elevated storage tanks, which you may find at naval activities, are pictured in figure 8-13. You may also see standpipes, like the one shown in figure 8-14, used at some activities. Standpipes are, in effect, ground level storage tanks. The distinguishing characteristic of a standpipe is its relatively small diameter and extra height to provide head pressure. Under no conditions should the amount of stored water be reduced to a point below that necessary for fire fighting. Daily records maintained by the operator help ensure against such a condition.

Pneumatic water tanks are usually found in use at smaller installations. They consist of a pressure vessel partly filled with water, and a compressor unit that supplies air pressure to produce the desired water pressure. Pneumatic tanks may be within buildings, on outside surface locations, or underground. While the operation of these units is usually automatic, the operator is responsible for the effective operating of pressure equipment. The manufacturer's instructions should be consulted for methods of starting, stopping, and operating this pressure equipment.

MAINTENANCE OF STORAGE FACILITIES

Here are the elements in the maintenance of storage facilities: the construction materials- concrete or steel; and the location of the tank-ground level, belowground, or elevated.

Foundations

All tanks have foundations of concrete, wood, or steel. Each material has its own maintenance procedures.

Concrete foundations should be inspected semiannually for settlement, cracks, spalling, and exposed reinforcing. When deterioration has set in, the foundation should be repaired with a mixture of 1 part cement to 1 part sand.

Wood foundations and pads should be inspected for split members, rot, termite infestation, and for direct soil contact of untreated wood. Any repairs necessary to remove the undesirable condition should be made.

Maintenance procedures for steel foundations are similar to those given later in this chapter for elevated storage tanks.

Concrete Storage Tanks

Concrete storage tanks may be either prestressed or nonstressed design. There is little difference in the maintenance procedures, which depend mainly on the location of the tank-aboveground or belowground.

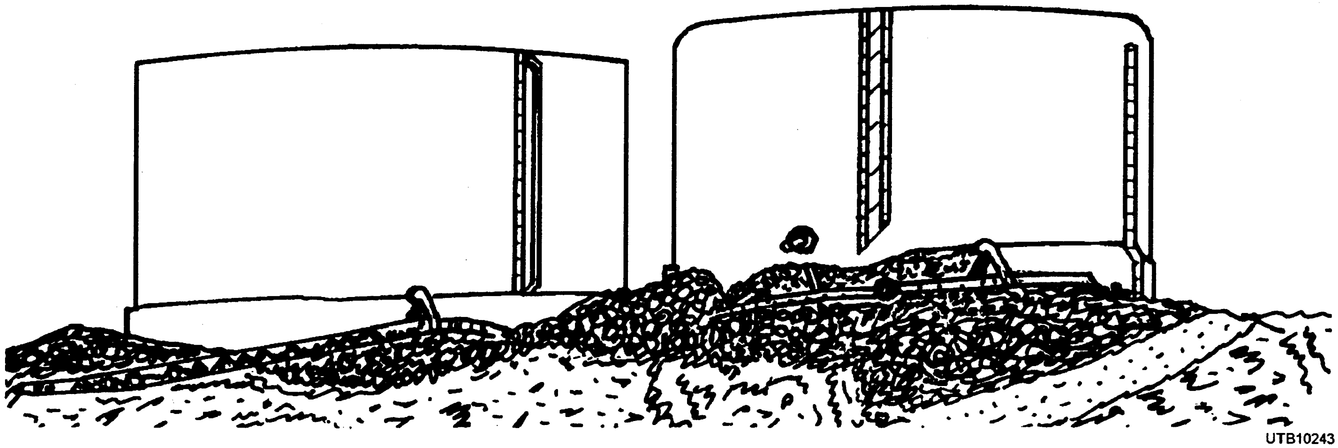

Figure 8-12.—Ground storage reservoir.

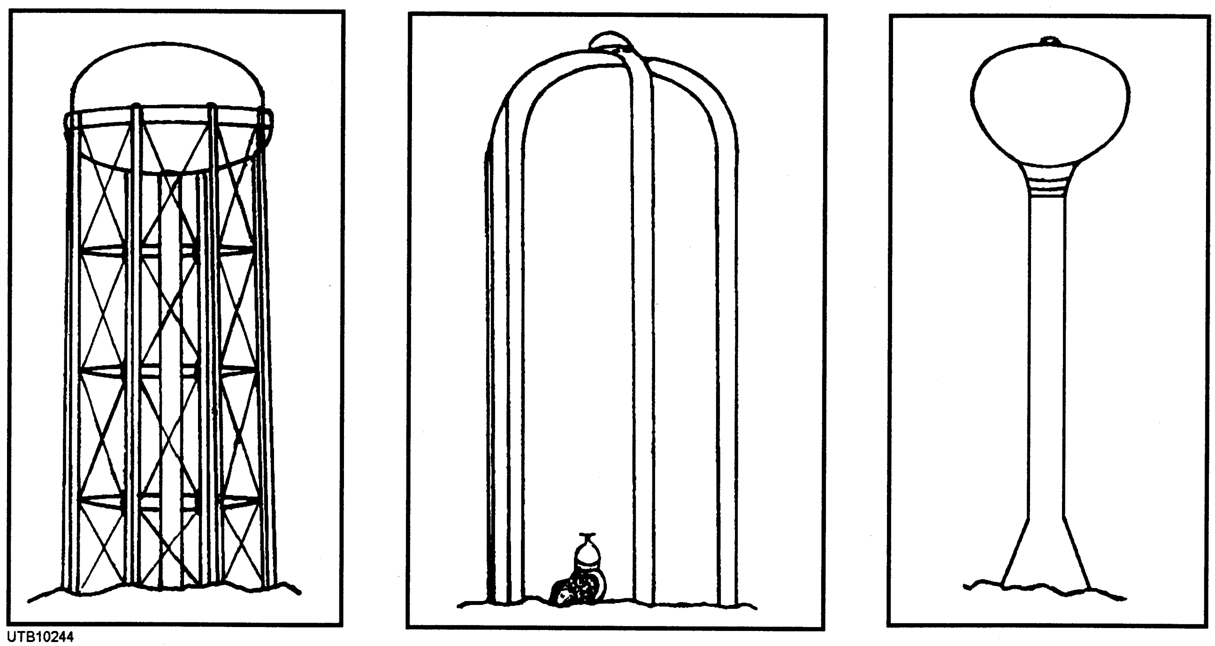

Figure 8-13.—Three types of elevated storage tanks.

GROUND LEVEL STORAGE.—During early spring, ground level storage facilities should be inspected for watertightness and structural conditions and repairs made as necessary; at other intervals, the maintenance procedures set forth in the following paragraphs should be performed.

Semiannually, exterior walls should be marked where leakage or seepage occurs. Every spring, they should be inspected for seepage or leakage from cracks-breaks or cracks in the interior seal membrane. Dewater the tank and check both the interior and exterior surfaces for spalling caused by frost action, as well as settlement, cracks, and exposed reinforcing.

All loose, scaly, or crumbly concrete should be removed and the wall patched with rich cement grout after wetting and painting with portland cement slurry. Hardened grout should be painted with iron waterproofing compound or a similar preparation.

Cracks of 1/4-inch width and l-inch depth should be chipped out. The cleaned crack should be moistened and painted with a cement slurry. The crack should be filled with a rich cement grout, dry enough to stay in place in the crack, but not dry enough to allow it to slough off. When the grout has hardened, it should be painted with iron waterproofing compound, or a similar preparation.

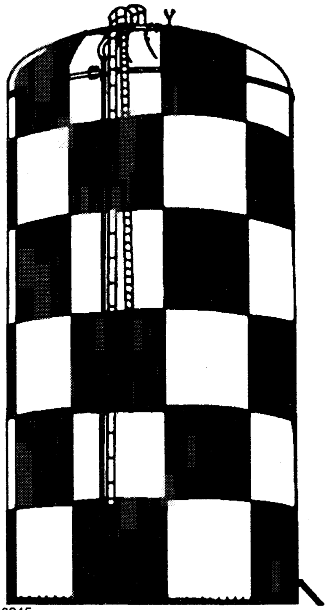
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Figure 8-14.—Standpipe.

When cracks appear in prestressed concrete tanks, the problem should be referred to the erecting company for recommendations, even if the guarantee has expired or does not cover maintenance.

Every 6 months, joints should be checked for leakage at the juncture of the floor and the walls, and for loose or missing filler, debris, or trash. They should be cleaned and repaired as necessary.

Every 6 months, the roof should be inspected for the condition of the covering. Are roof hatches and other covers locked? Are the screens on the overflow or at other locations in place? They should be cleaned as necessary.

Where the tank rests on an earth embankment, it should be checked for erosion from the lack of full sod or vegetation coverage, and for damage from burrowing animals, improper drainage, ponding water along the base, or leakage through the embankment or along the outlet piping. When leakage exists through the embankment, the tank should be drained and the bottom inspected for failure or cracks.

UNDERGROUND STORAGE.—If storage tanks are constructed belowground or are surrounded by an earth embankment, the semiannual inspection and repair comprise only the interior walls, roofs, accessories, and embankment. The inspection procedures and maintenance operations are the same as described above for ground level storage facilities. When the earth embankment, surrounding soil, or interior of the tank shows evidence of tank leakage, the earth may need to be excavated and repairs made on the walls.

ELEVATED STORAGE.—Concrete storage tanks elevated aboveground require the same inspection and repairs as outlined above, where applicable.

Steel Storage Tanks

Usually, outside contractors maintain and repair steel tanks. At times, though, you may have to perform various inspection and maintenance duties, such as those discussed in the following section.

GROUND LEVEL STORAGE.—Annually, after the winter season, steel storage tanks should be inspected for ice damage, watertightness, and structural conditions. Twice each year, the maintenance procedures set forth in the following paragraphs should be followed.

Tanks walls (exterior and interior) and bottom (interior) should be inspected semiannually for rust corrosion, loose scale, leaky seams and rivets, and for the condition of the paint (both inside and out). Maintenance procedures to adhere to are as follows:

1. Replace rivets, or patch-leaking areas, and follow by cleaning and painting.
2. Check painted surfaces for rust, corrosion, cracking, peeling, alligatoring, caulking, fading, or complete loss of paint. Empty the tank and examine the interior paint, as corrosion is more likely on the inside. When the interior needs painting, arrange to take the tank out of service. Paint the tank interior as often as the exterior (more often if the stored water is corrosive); unless the tank is equipped with cathodic protection.

- Make certain that the paint used will protect the metal against corrosion,. Consult the applicable guide specifications for paint selection and application.
- Use only new coat if the previously applied coat is in fair condition. Bare spots of steel should be painted with a spot or patch coat before the finish coat is applied. When the condition of the old paint is bad, use a complete primer coat.

Every 6 months, the roof and its appurtenances– screens on overflows, hatches, and manholes, as well as the condition of the paint, should be inspected. Maintenance procedures to adhere to are as follows:

1. Make certain that hatch covers and manholes are in place and locked and that screens are in place to prevent the entrance of birds, insects, and animals.

2. If the spider rods under the roof have corroded, remove them, as they are needed only during erection.

3. Paint the roof, selecting the proper paint for the particular location.

As pointed out earlier, standpipes are, in effect, ground level storage tanks. Inspection and maintenance procedures for standpipes are the same as those for ground level steel storage tanks.

UNDERGROUND STORAGE.—When steel storage tanks are constructed belowground or are surrounded by an earth embankment, the semiannual inspection and repair include only the interior of the tank, the roof, and the accessories. The inspection and maintenance procedures are the same as given for ground storage steel tanks.

ELEVATED STORAGE.—Besides the inspection and maintenance procedures set forth above for ground storage steel tanks, the following specific procedures apply to elevated storage steel tanks.

Semiannually, tower structures should be checked for rust and corrosion, loose, missing, bowed, bent, or broken members; loose sway bracing; misalignment of tower legs; and evidence of unstableness. Items that must be covered are as follows:

1. Inspect the back surface of the lattice bars and anchor bolts, the inside of boxed channel columns, and pockets where batten-plate connections and column bases form pockets for collecting trash and water. Clean and paint these enclosures, and fill with concrete as necessary to shed water.

2. Check the bases and the baseplates for evidence that water has collected at that point; if water is found, drill a 1 1/2-inch hole through the channel-boxed section to allow complete drainage. Then grout the baseplate with a mixture of sand and asphalt to prevent water from running under the plates. Taper the grout from the top edge of the plate to the pier.

3. Check the sway bracing and tighten the turnbuckles if necessary. Examine under clevis pins and rod loops where corrosion may be greatest. Drill holes in the bal cony floor to eliminate stand ing water.

Besides general roof inspection and repair, as described for ground storage steel tanks, obstruction and navigation lights should be inspected and relamped if necessary. Additional items that should be covered are as follows:

1. Check the operation of all other lights; check hoods, shields, and receptacle fittings; look for missing or damaged parts. Repair or replace parts as necessary.

2. Check lightning rods, terminals, cables, and ground connections.

In cold climates, potable water storage tanks (with small riser pipes) and elevated storage tanks (for fire protection only) usually have heating equipment to prevent freezing in severe low temperatures. Checks that must be conducted are as follows:

1. Annually, 2 months before the freezing season, inspect the riser for deterioration of the frost covering. Seal any openings to reduce heat loss. Also, check the heating system to ensure proper operation during the next cold season.

2. Annually, 1 month before the freezing season, operate the heating system for 8 hours to check all elements under operation.

CATHODIC PROTECTION EQUIPMENT.—Only impressed current cathodic protection systems are used for protecting steel water storage tanks against corrosion. This system of protection may be applied to all types of steel water tanks-ground level standpipe, underground, and elevated. Refer to the material presented earlier in this chapter for a discussion of inspection and maintenance procedures for impressed current systems. Also, other applicable procedures are as follows:

- Annually, note and record the current flow during the operation. If the current does not flow, check the fuses, electrodes, which contact the tank, ground wire connection to the tank, and the immersion of electrodes. If the equipment is operating at voltages or amperages above those listed on the nameplate, the rectifier may be damaged.

CAUTION

Make certain that the connections to the rectifier are not reversed. Reversed connections will result in tank damage.

Annually, check the operating record to determine if the electrodes are immersed at all times, or almost all the time. If the electrodes are not immersed, there will be no damage to the unit; however, protection is not provided when the electrodes are not immersed.

- Annually, check the anode condition and replace the anodes as necessary. Also, check the current flow; if it has diminished since the previous inspection, the anode probably needs to be renewed.

- Annually, in freezing climates, protect electrodes from ice, which may tear them from their hangings or damage them. If ice formation is severe, turn off the current, remove the electrodes, store them until the freezing season is past, and then reinstall them.

- Annually, test the effectiveness of the cathodic protection system in one of two ways.

1. Scrape and polish a spot on the tank wall at a point always immersed. At quarterly intervals, lower the water and inspect the spot; if protection is adequate, the spot will remain uncorroded.

2. Suspend two polished mild steel test plates in the tank at an elevation where they will always be immersed (use No. 6 galvanized steel wire). Ground one plate to the tank wall, but have the other plate insulated from the tank. The extent of corrosion on the grounded plate will come close to the corrosion of the protected tank; the extent of corrosion on the other plate is a measure of the corrosion that would occur if the tank were not protected.

Pneumatic Tanks

As pneumatic tanks are usually on smaller installations, they may be too small for interior inspection, except for observations through a removable hand plate. The size, therefore, shows the inspection procedures to be followed. Standard inspection procedures are as follows:

Quarterly, inspect the air pump and motor to make certain both are operating properly. Check the operating record to determine the time cycle of air pump operation. If the records show a decreasing time cycle, check for possible air line leaks.

Quarterly, check valve operations; particularly, check the pressure-relief valve. Repair or replace as necessary.

Annually, check the tank for signs of corrosion, both internally and externally. If corrosion products are apparent, take the following action:

1. If the tank is large enough to permit the entry of personnel, paint the inside with corrosion-resistant paint, or line it with cement. If the tank is too small to permit entry, consider changes in operation or in chemical treatment to reduce corrosiveness of water. Corrosion is most likely in areas alternately exposed to air and water.

2. Paint the exterior as needed.

Appurtenances

Every 6 months, ladders, walkways, guardrails, handrails, stairways, and risers should be inspected for rust, corrosion, poor anchorage, loose or missing pieces, or other deterioration or damage. Standard inspection procedures include the following:

1. Be sure to check ladders inside as well as outside the tank. Replace worn, corroded, or missing parts; check for deteriorated lugs and rungs as necessary; and, make other repairs to ensure safety for the operators. Check revolving ladders on the roof for the condition of connection at the final hookups.

2. Ensure that bolts, screws, rivets, and other connections are tight.

3. Inspect the condition of the altitude valve vault and the valves for proper operation. Repair, clean, and paint all equipment when necessary.

4. Check the water level indicator for improper operation and repair when necessary.

5. Inspect the cathodic protection equipment and repair when necessary (follow instructions given in previous portions of this chapter).

6. At semiannual intervals, check the electrical connections to lights, cathodic protection, and so forth, for breaks in the conduit. Remove the conduit inspection plates and examine the internal connections for tightness and adequacy; also check relays for weak springs, worn or pitted contacts, and defective operation. Repair and eliminate all undesirable conditions.

Grounds

At semiannual intervals, remove all accumulations of dirt, trash, debris, and excess foliage in the area surrounding the storage tank.

Maintenance Procedure Schedule

The maintenance operation frequency and schedule of inspections for storage facilities are shown in appendix III, table H.

Q30. What are the three types of water storage?

Q31. Water storage tanks are made of what two materials?

Q32. Rich cement grout should be used during interior wall repairs of a ground level concrete storage tank after application of what type of tank preparation?

Q33. What type of cathodic protection is used to protect elevated steel water tanks from corrosion?

APPENDIX I

GLOSSARY

(**NOTE:** Refer to page AI-4 for a glossary of chemicals used in water treatment.)

ABFC—Advanced Base Functional Components.

AERATOR—Device for removing certain dissolved gases during water treatment.

AEROBIC DECOMPOSITION—Bacterial decomposition that occurs in the presence of oxygen.

AFTERCOOLER—A device which cools the final discharge from a compressor.

ANAEROBIC DECOMPOSITION—Bacterial decomposition occurring in the absence of free oxygen.

ANGLE—A figure formed by two lines or planes extending from, or diverging at, the same point.

ANGLE VALVE—A stop valve that is actually a combination valve and elbow since its outlet branch is at right angles to its inlet branch.

AQUIFER—A geological water-bearing formation that can provide water for wells.

ARCHITECTURAL PLAN—Show design and composition of a structure, including floor plans, building sections, and elevations.

BACK-PRESSURE VALVE—A valve similar in design to a low-pressure valve that is capable of opening independently of the pressure, thereby giving free exhaust.

BACTERIA—Living organisms, microscopic in size, which consist of a single cell. Most bacteria use organic matter for their food and produce waste products as a result of their life processes.

BILL OF MATERIAL—A list of all materials required to complete an installation based on takeoffs and estimates.

BLUEPRINT—A photographic print consisting of white lines on a blue background. It is used for copying architect's plans, drawings, and so forth.

BUSHING—A plumbing fitting used to reduce from one size of pipe to another size of pipe.

BUTTERFLY VALVE—A two-position valve with a vertical or horizontal disk.

BTU—British thermal unit, a measurement of heat.

CALCIUM HYPOCHLORITE—$CaC1_2O_2$, a granular white powder used to disinfect water.

CAP—A plumbing fitting used to close off a length of pipe.

CAULKING IRON—A plumbing tool used to compact or caulk lead wool or poured lead into a cast-iron pipe joint.

CBMU—Construction Battalion Maintenance Unit.

CBR—Chemical, Biological, and Radiological.

CBU—Construction Battalion Unit.

CEC—Civil Engineer Corps.

CENTIGRADE—A thermometric scale in which 0 degrees represents the freezing point and 100 degrees represents the boiling point of water at a pressure of 1 atmosphere. Is used with metric units of measure. Equal to the international thermometric scale of Celsius.

CHECK VALVE—An automatic nonreturn valve or a valve which permits a fluid to pass in one direction but automatically closes if the fluid begins to pass in the opposite direction.

CHLORINATION—The disinfection of a substance or container by a chlorine chemical or gas.

CHLORINE—A natural chemical element (Cl). A powerful disinfectant, used extensively in water treatment. As a gas, its color is greenish yellow, and it is 2 1/2 times heavier than air. As a liquid, its color is amber, and it is about 1 1/2 times heavier than water. It is an oxidizer and is toxic to all organisms and corrosive (in the presence of water) to most metals.

CIVIL PLANS—The essential data for layout, location, and site for a construction project, including boundaries, elevations, roads, utilities, structures, and references of both existing and finished construction.

CLARIFICATION OF WATER—The removal of suspended materials to produce a clear, clean liquid.

CLEANOUT—A fitting installed in waste lines to permit removal of stoppages and cleaning lines.

COAGULANTS—The chemicals added to destabilize, to aggregate, and to bind together colloids and emulsions to improve settleability, filterability, or drainability.

COLIFORM—The coliform groups of organisms are a bacterial indicator of contamination. This group has as one of its primary habitats, the intestinal tract of human beings. Coliforms also may be found in the intestinal tract of warm—blooded animals and in plants, soil, air, and the aquatic environment.

COMSECONDNCB—Commander, Second Naval Construction Brigade.

COMTHIRDNCB—Commander, Third Naval Construction Brigade.

COPPER SULFATE—(Blue Vitriol) Chemical used to remove tree roots from sewer lines.

COUPLING—A plumbing fitting used to join two lengths of pipe in a straight run.

CROSS-CONNECTION—In plumbing, a physical connection through which a supply of potable water could be contaminated, polluted, or infected. A physical connection between a potable water supply and one of questionable origin.

DEGREE OF TEMPERATURE—Measurement of heat intensity.

DIATOMACEOUS EARTH—A porous mineral powder, used as a filtering medium for the removal of suspended materials.

DIRECT LABOR—All labor that contributes directly to construction tasks.

DISINFECTION—The chemical destruction of bacteria.

EFFLUENT—Discharge water from a sewage or water treatment plant or equipment.

ELECTRICAL PLANS—All electrical interior and exterior wiring, electrical systems and equipment, including receptacles and light circuits, and power supplies to building and electrical appliances.

ELBOW—A plumbing fitting used to change the direction of a length of pipe at 90° and 45° angles.

EVAPORATION—A process of converting a liquid, by heat, into a vapor or gas.

FERRIC CHLORIDE—$FeCl_3$, a dark salt that hydrates to a yellow-orange form. Used in sewage treatment as an astringent.

FILTRATION—The process of removing organisms, minerals, turbidity, color, taste, and odor in water during the water treatment process.

FITTINGS—Devices which when placed in a pipe system make branch connections or changes in a direction of a line.

FORMULA CHART—Chart used to control the wash cycle of the skid-mounted laundry unit.

GATE VALVE—A sluice with two inclined seats between which the valve wedges down in closing. The passage through the valve is in an uninterrupted line, and when the valve is opened, the sluice is drawn up into a dome or recess, leaving an unobstructed passage to the full diameter of the pipe.

GENERAL REQUIREMENTS—First division of a set of specifications that describe general materials, characteristics, and methods for a project.

GLOBE VALVE—A valve with a round, ball-like shell, that is used for regulating or controlling the flow of gases or steam.

GPD—Gallons per day.

GPH—Gallons per hour.

GPM—Gallons per minute.

GROUNDWATER—Water absorbed by the earth's surface and collected below the waterline.

HEAD—The increase of pressure resulting from the addition of energy to a liquid by a pump.

HEAT—The energy that is measured in British thermal units.

HTH—High-Test Calcium Hypochlorite.

HYDRATED LIME—(Caustic Lime) A dry white powder, a strong base (alkaline), consists of calcium hydroxide made by treating caustic lime with water. Used to balance water pH and absorb chlorine.

HYDROLOGIC CYCLE—Process by which water is circulated from ocean to atmosphere to earth's surface.

ID—Inside diameter.

INCUBATION PERIOD—The period between the infection of an individual by a pathogen (bacteria) and the manifestation of the waterborne disease.

INFLUENT—Water flow into a sewage or water treatment plant or equipment.

INTERCOOLER—Device that cools compressed gases between stages in a compressor.

ISOMETRIC DRAWING—A drawing that visualizes a three-dimensional picture in one drawing.

JOINING—All the procedures used to connect pipes together.

MAIN SOIL AND WASTE VENT—The portion of the waste stack that extends above the highest fixture branch.

MAN-HOUR—A unit of measure used in estimating project labor hours. One man-hour is equal to one man doing 8 hours of work in 1 day.

MAPP—An all-purpose industrial fuel used with gas-welding equipment—methyl-acetylene propadiene.

MATERIAL TAKEOFF—The estimate of materials required for a job based on plans and specifications.

MECHANICAL PLANS—-All layouts and details for systems of plumbing, heating, ventilating, air conditioning, and refrigeration.

METHANE—An organic gas, produced in a sewage system by the decomposition of organic materials.

MULTISTAGE PUMP—A pump having two or more devices for imparting a moving force upon a liquid.

NAVFAC—Naval Facilities Engineering Command.

NET POSITIVE SUCTION HEAD—Pump suction pressure minus vapor pressure expressed in feet of liquid at the pump suction.

NCR—Naval Construction Regiment.

NCTC—Naval Construction Training Center.

NMCB—Naval Mobile Construction Battalion.

OD—Outside diameter.

ORANGEBURG ALKACID—Bituminous fiber drainage pipe designed with an alkaline base.

ORTHOGRAPHIC DRAWING—A drawing that visualizes a two-dimensional picture in one drawing.

PACKING—Materials used to seal moving machinery joints against leakage.

PERMEABILITY—The capacity of stratum material to transmit water under pressure.

pH—A value used to measure the acidity or alkalinity (basic) of a substance. A pH scale is from 0 to 14, with 7.0 as neutral. Below 7.0 on the scale is acid, and above 7.0 on the scale is alkaline or basic. Used in water treatment and purification.

PLUG—A plumbing fitting used to close off a fitting or a length of pipe by screwing into the fitting or pipe.

POROSITY—The property of stratum material that contains openings through which water may flow.

POSTCHLORINATION—Disinfection after filtration during the water treatment process.

POTABLE WATER—Water suitable for drinking, cooking, and personal use.

POTASSIUM HYDROXIDE—(Caustic Potash) KOH, a white powder, strongly basic (alkaline), when dissolved in water produces heat. Used to balance water pH and absorb chlorine. Also used as a reagent.

PPM—Parts per million.

PRECHLORINATION—Disinfection before filtration during the water treatment process.

PRESSURE-RELIEF VALVE—A spring-loaded valve that opens when pressure is applied to the spring and relieves the pressure in a pressure vessel when the pressure of the vessel is beyond its safe working pressure.

P-TRAP—A type of fixture trap, used to seal sewer gases in the sewer piping.

PSI—Pounds per square inch.

PUMP—A mechanical device which applies a force to move any substance that flows or can be made to flow.

REDUCING VALVE—A spring-loaded or lever-loaded valve similar to a safety valve, designed to maintain a lower-end constant pressure beyond the valve.

REVERSE OSMOSIS—A process whereby a solution flows through a semipermeable membrane into an area of lower solute concentration.

ROUGHING IN—The installation of all parts of a plumbing system; completed before installation of fixtures.

ROWPU—Reverse Osmosis Water Purification Unit. A mobile, lightweight unit capable of being air lifted to a deployment site.

SINGLE-STAGE PUMP—A pump having one device for imparting moving force upon a liquid.

SODIUM CARBONATE—Na_2CO_3, salt of carbonic acid, strongly basic (alkaline). Used in water softening and balancing water pH.

SODIUM HYDROXIDE—(Caustic Soda) NaOH, a strong base (alkaline), white powder used to balance pH in water and absorb chlorine.

SODIUM HYPOCHLORITE—NaOCl, a salt usually furnished in solution, used for disinfection of water.

SPECIFICATIONS—Statements that specify types and quality of materials and installation methods.

STRUCTURAL PLANS—All structural members of the building, including foundation, details and sections, walls, columns and beam sections, or details.

SUCTION HEAD—Total pressure of the liquid entering the pump.

SUPERVISION—To oversee or monitor in order to direct, as in employees.

SURFACE WATER—Water in exposed streams, rivers, lakes, and ponds.

TOTAL DISCHARGE HEAD—The difference between pump suction head and the discharge head.

TURBIDITY—Cloudiness in water caused by suspended solids.

UNLOADERS—System for removing all but friction loads from a compressor.

VALVE—A device for regulating, stopping, or starting flow in a system, and for controlling direction of flow.

VALVE BOX—A pipe over a valve stem or wheel, capped to exclude dirt that might interfere with valve operation but permits access to the valve stem for opening or closing purposes.

VENT—A piping system that prevents siphonage of the trap seal by equalizing the pressure on the outlet side of a trap with the inlet side.

YARNING IRON—A plumbing tool used to peak oakum into a cast-iron hub and spigot lead joint.

CHEMICALS USED IN WATER TREATMENT

ALUMINUM HYDROXIDE—AlOH, reagent, used to decolorize water samples when performing chloride tests on water.

ALUMINUM SULFATE—(Alum), $Al_3(SO_4)_3$, a white salt, a coagulant, used to flocculate dissolved solids in a weak acid water environment.

AMMONIA—NH_3, an alkaline colorless gas, used in solution to detect leaks in chlorine equipment and systems.

BARIUM CHLORIDE—$BaCl_2$, reagent, used to test for sulfates in water.

CALCIUM HYPOCHLORITE—$CaCl_2O_2$, a granular white powder used to disinfect water.

CARBON DIOXIDE—CO_2, a liquid, is used to lower pH of softened and settled potable water.

CHLORINE—Cl_2, a natural chemical element (Cl). A powerful disinfectant, used extensively in water treatment. As a gas, its color is greenish yellow, and it is 2 1/2 times heavier than air. As a liquid, its color is amber, and it is about 1 1/2 times heavier than water. It is an oxidizer and is toxic to all organisms and corrosive (in the presence of water) to most metals.

DIAMINETETRACETATE—(EDTA), reagent, used in solution with Sodium Ethylene to detect minerals which cause hardness in water.

FERRIC CHLORIDE—$FeCl_3$, a dark salt that hydrates to a yellow-orange form. A coagulant, used to flocculate dissolved solids in a strong acid water environment.

FERRIC SULFATE—FeS_3, a coagulant, used to flocculate dissolved solids in a strong acid water environment.

FERROUS SULFATE—$FeSO_4$, a coagulant, used to flocculate dissolved solids in a strong base (alkaline) water environment.

HYDRATED LIME—(Caustic Lime) $CaOH_2$, a dry white powder, a strong base (alkaline), consists of calcium hydroxide made by treating caustic lime with water. Used to balance water pH and absorb chlorine.

METHYL ORANGE—Reagent, used in solution to determine the alkalinity of water.

METHYL PURPLE—Reagent, used in solution to determine the alkalinity of water

PHENOLPHTHALEIN—$C_{20}H_{14}O_4$, reagent, used as an pH indicator for water testing. Red color in bases (alkalines) or decolorized in an acid.

POTASSIUM CHROMATE—KCr, reagent, used in testing for chlorine levels in water.

POTASSIUM HYDROXIDE—(Caustic Potash) K_2CrO_7, a white powder, strongly basic (alkaline), when dissolved in water produces heat. Used to balance water pH and absorb chlorine. Also used as a reagent to test water salinity.

SILVER NITRATE—$AgNO_3$, reagent, used to determine amount of salinity and chloride in water.

SODIUM CARBONATE—(Soda ash), Na_2CO_3, salt of carbonic acid, strongly basic (alkaline). Used in water softening and balancing water pH to aid coagulation.

SODIUM ETHYLENE—(EDTA), $Na_2CH_3CH_2$, reagent, used in solution with Diaminetetracetate to detect minerals which cause hardness in water.

SODIUM HYDROXIDE—(Caustic Soda) NaOH, a strong base (alkaline), white powder used to balance pH in water to aid coagulation, and absorb chlorine.

SODIUM HYPOCHLORITE—NaOCl, a salt usually furnished in solution, used for disinfection of water.

SULFURIC ACID—(Standard), H_2SO_4, strong acid, used to balance water pH and aid in coagulation.

THIOSULFATE—A salt, used to neutralize chlorine water. Used to sterilize water sample containers.

APPENDIX II

ANSWER KEY

CHAPTER 1 - PLANS, SPECIFICATIONS, AND COLOR CODING

PLANS

Q1. Five.

Q2. Architects and engineers.

Q3. Architectural drawings.

Q4. Working drawings.

ISOMETRIC SKETCHING

Q5. Three-dimensional.

Q6. 30° and 60°.

Q7. There is only a single view, which decreases room for dimensions.

SPECIFICATIONS

Q8. No.

Q9. Division 11 - Equipment.

Q10. 15.1a-05.

Q11. When the material is not available and a substitute is needed:

CREW LEADER

Q12. Save time and money.

Q13. Ensure the crew is clear on what is required to construct the project.

COLOR CODING

Q14. Oxidizing materials.

Q15. Written titles.

Q16. White.

Q17. The secondary hazard of the material.

Q18. Indicates direction of flow.

CHAPTER 2 - ADVANCED BASE FUNCTIONAL COMPONENTS

ABFC SYSTEM

Q1. The construction of advanced bases.

Q2. Inventory all parts and check them against the Bill of Material.

Q3. Upstream.

Q4. Wood or coal.

Q5. A burner compartment and a flue compartment.

Q6. Hinged hood that covers the top of the burner.

Q7. In the top position.

Q8. Quantity of sewage and leaching characteristics of the percolating area.

Q9. Two times the width.

Q10. Three feet.

Q11. Sixteen seat.

Q12. Formula chart.

Q13. Purified or distilled water.

Q14. Fifteen feet.

Q15. 600-GPH Reverse Osmosis Water Purification Unit.

CHAPTER 3 - PLUMBING

TOOLS

Q1. Proper tool for the proper job.

Q2. Table of Allowance (TOA).

UNDERGROUND SANITARY PIPING

Q3. To transfer sewage from the source to the plant.

Q4. 1) Trenching & grading; 2) measuring & cutting; 3)laying pipe; 4) joining pipe; 5) testing; and 6) backfilling & tamping.

Q5. The direction of flow.

Q6. Engineering Aids.

Q7. 1) Cast-iron; 2) vitrified clay; 3) concrete; and 4) plastic.

Q8. Five and ten feet.

Q9. Snap off or chain cutter.

Q10. Polyvinylchloride.

Q11. Fillet welding uses a rod to weld the pipe together; whereas, fusion welding uses only the pipes themselves.

SANITARY DRAINAGE INSTALLATION

Q12. Ten feet.

Q13. Fifteen minutes.

Q14. Peppermint oil.

Q15. Four feet.

Q16. Four inch layers.

ABOVEGROUND SANTITARY DRAINAGE

Q17. Cast-iron and silicon.

Q18. Water that is held in the bent portion of the fixture trap. Seals against passage of sewer gases.

Q19. Pipe vents.

WATER SERVICE

Q20. Twenty foot lengths.

Q21. One foot above and ten feet away.

Q22. Type L copper.

Q23. Type M copper.

Q24. Seven.

Q25. Measurement is made from the end of the pipe to the center of the fitting.

Q26. It causes corrosion.

Q27. Heating (Steam & hot-water), and Air compressor systems.

Q28. Eight inches or greater.

Q29. Cement-asbestos.

CHAPTER 4 - PLUMBING VALVES AND ACCESSORIES

VALVES

Q1. The internal structure of the valve.

Q2. An arrow or the word "Inlet".

Q3. Fire sprinkler systems.

Q4. The inside of the valve bonnet flange is bored true with the valve seat.

VALVE ACCESSORIES

Q5. Non-rising stem gate valves below the ground or floor level.

Q6. Valve Box.

WATER METERS

Q7. To measure the flow of water within a line to a point of distribution.

Q8. If the meter is measuring cubic feet or gallons.

Q9. Clockwise.

FIRE HYDRANTS

Q10. The Fire Department.

Q11. Dry barrel and wet barrel.

DISINFECTION OF WATER SUPPLY SYSTEM COMPONENTS

Q12. 150 ppm.

Q13. 2.61 gallons.

Q14. Three feet per second.

Q15. To prevent separation of the pipe due to water pressure in the pipe.

SHORING AND SCAFFOLDING

Q16. More than 5 feet in height.

WASTEWATER SYSTEMS

Q17. 3.4 inches per foot.

Q18. Changes in the direction of the sewer line.

WATER DISTRIBUTION SYSTEMS

Q19. At least 50 feet.

Q20. Twenty four inches.

CHAPTER 5 - PLUMBING FIXTURES AND PLUMBING REPAIRS

PLUMBING FIXTURES

Q1. Rough-in measurements.

Q2. One cubic foot per minute.

Q3. Twenty five fixture units.

Q4. Less.

Q5. Floor and wall mounted urinals.

Q6. Slop sink.

Q7. Hose bib

Q8. Manufacturer's specifications.

PLUMBING REPAIRS

Q9. Thawing.

Q10. 500 amperes.

PIPE LEAKS

Q11. Fracture or rupture.

Q12. Leaky seams and corroded areas.

WATER CLOSETS

Q13. Failed seal or gasket.

Q14. Inlet valve (ball cock) assembly.

FLUSHOMETERS

Q15. Diaphragm and piston.

Q16. The relief valve does not seat properly.

Q17. Causes swelling of the diaphragm and inproper operation.

FAUCETS

Q18. Faucet seat.

Q19. A flat or beveled washer of the same size and design.

SEWER MAINTENANCE AND REPAIR

Q20. Determine the cause of the problem.

Q21. A 2 ½" diameter.

Q22. At a manhole.

CLEARING STOPPAGES IN FIXTURES

Q23. False.

Q24. True.

SAFETY

Q25. Ensure the manhole has been inspected and cleared for entry by a qualified person in Confined Space Entry.

Q26. Goggles and gloves.

GAUGES

Q27. Weight is applied to a plunger.

Q28. Diaphragm type gauge.

CHAPTER 6 - PRIME MOVERS, PUMPS, AND COMPRESSORS

PRIME MOVERS

Q1. Driving equipment.

Q2. Belt slippage.

Q3. Prestart inspection.

Q4. Method of introduction of the fuel and air into the cylinders.

PUMPS

Q5. Fluid end.

Q6. The net difference between the suction head and the discharge head.

Q7. Leakage, fluid friction, and dissolved gases in the liquid.

Q8. Rotary, reciprocating, centrifugal, air-lift, and jet.

Q9. A positive displacement pump.

Q10. The gear and screw type.

Q11. Direct-acting, simplex, double-acting, and vertical.

Q12. A wheel or impeller.

Q13. It decreases.

Q14. Air-lift.

INSTALLATION OF PUMPS

Q15. More liquid will enter one side of the impeller than the other.

Q16. To avoid air pockets that throttle the system or lead to erratic pumping.

Q17. An unstable operation, such as cavitation.

Q18. Overheating.

Q19. Better sealing qualities and longer serviceability.

Q20. Every 6 months.

Q21. Every year.

AIR COMPRESSORS

Q22. Reciprocating, centrifugal, and rotary.

Q23. Electric motors.

Q24. Friction loads.

Q25. To cool the final discharge air from the compressor.

Q26. Traps.

CHAPTER 7 - WATER TREATMENT

THE WATER CYCLE

Q1. Surface and groundwater.

Q2. Zones of soil moisture, aeration (precolation), and saturation.

QUALITY OF WATER

Q3. Time between contact with water and appearance of the disease.

Q4. Dissolved and suspended.

Q5. Amoebic dysentary.

Q6. Sedimentation.

Q7. Chlorine.

SANITARY DRAINAGE PIPING

Q8. Method of control.

Q9. Direct-feed.

Q10. Proper ventilation.

Q11. Ammonia.

Q12. Waste gas into a caustic soda solution.

WATER TREATMENT QUALITY CONTROL

Q13. Uncontaminated.

Q14. Pump the well until normal draw-down is reached.

Q15. Three inches below the surface at a 45° angle.

TREATMENT CONTROL TEST PROCEDURES

Q16. Proper operation and acceptable water quality.

Q17. Orthotolidine and Orthotoline-arsenite tests.

Q18. Neutral pH.

Q19. 3.9 ppm of chloride.

Q20. Determine proper chemical dosage and conditions for coagulation.

CHAPTER 8 - EQUIPMENT MAINTENANCE

CHLORINATORS

Q1. By method of feed and type of diaphragm controlling chlorine feed.

Q2. Manually.

Q3. Gas chlorinators.

Q4. Daily.

MAINTENANCE OF CHEMICAL FEEDERS

Q5. Chemical goggles or a mask.

Q6. Quarterly.

Q7. Cleaning, repairing, and painting.

MAINTENANCE OF ION-EXCHANGE UNITS

Q8. Annually.

Q9. No, but grease will get into the water if left in service during lubrication.

Q10. 7.0 or neutral.

Q11. Evaporated salt.

MAINTENANCE OF CLARIFICATION EQUIPMENT

Q12. Drinking water supply.

Q13. .Impressed current and galvanic anode systems.

Q14. Galvanic anode.

MAINTENANCE OF FILTRATION EQUIPMENT

Q15. Daily.

Q16. Remove filter from service and treat with a strong hypochlorite solution.

Q17. Alum floc penetration.

Q18. Direct or indirect acting.

Q19. Filter medium is housed in a enclosed pressure shell.

Q20. Oxalic acid at 5%.

MAINTENANCE OF AREATION EQUIPMENT

Q21. Cascade or step action.

Q22. An explosion and acid splatter.

Q23. Organic growths, such as algae.

SAFETY AND EMERGENCIES

Q24. Only what is required for daily use.

Q25. Ammonia solution.

Q26. Remove them to open air away from gas fumes.

RESPIRATORY BREATHING APPARATUS

Q27. Toxic gases or vapors and oxygen deficient.

Q28. Test for leakage.

Q29. Every 5 years.

WATER STORAGE FACILITIES

Q30. Ground level, underground, and elevated.

Q31. Steel and concrete.

Q32. Portland cement slurry.

Q33. Impressed current.

APPENDIX III

TABLES FOR MAINTENANCE PROCEDURES

Maintenance Procedures for Chlorination Equipment
Table A

Inspection	Action	Frequency
Operator maintenance	Insert new lead gasket in chlorine valves or tubes to cylinders or equipment	V
Condensation on chlorine cylinders	Ventilate	V
Chlorine leak detection	Use unstoppered bottle of aqua-ammonia to detect leaks; repair immediately	D
Gas system	Inspect, clean, and replace faulty parts in piping, meters, valves and tubing	D
Chlorine valves	Open and close valves to ensure that none are frozen in a set position; check stuffing boxes, and repair or replace faulty valves or packing	D
Chlorine feeder water supply	Clean water strainers and pressure reducing valves; adjust float valves and ejector capacity	M
Hard-rubber threads, valves and parts	Disassemble or operate; use graphic grease to prevent freezing; hand tighten only, do not use tools	Q
Vacuum relief	Clean out any obstructions	D
Cabinet and working parts	Clean all parts where accumulation may interfere with proper operation	W
Direct feed chlorinators	Use same procedures as for solution feed machines where they apply	
Hypochlorinators	See table C	

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Maintenance Procedures for Dry Chemical Feeders
Table B

Inspection	Action	Frequency
Dry feeders	Remove chemical dust accumulations; check feeder performance; check for loose bolts; clean solution tank of accumulated sediment; lubricate moving parts	D
Drive mechanisms and moving parts	Service and lubricate	Q
Calibration	Check feed-rate accuracy and adjust as necessary	M
Feeders out-of-service	Clean, remove all chemicals from hopper and feeder mechanism	V
Disk feeders	Clean rotating disk and plow	M
Oscillating feeders	Check and adjust mechanism and adjustable stroke rod	M
Rotary gate feeders	Clean pockets of star feeder and scraper	M
Belt-type feeders	Check vibratory mechanism, tare-balance, feeding gate, belt drive and belt; calibrate delivery	M
Loss-in-weight feeders	Check feeder scale sensitivity, tare-weight, and null balance	M
Screw feeders	Clean screw, check ratchet drive, or variable speed drive	M
Lime slakers	Clean dust-removal and vapor-removal equipment; remove clinker	D
	Clean equipment; wipe off feeder; check operation of vapor-removal equipment; clean compartments	W
	Repair agitators, stirrers, and heat exchanger baffles	M
Dust collectors		
Motors	Lubricate motors	V
Dust collector filter bags	Check conditions and attachment; securely attach sound bags; replace damaged or tom bags	V

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Maintenance Procedures for Liquid and Solution Chemical Feeders
Table C

Inspection	Action	Frequency
Pot feeders		
Flow through pot	Determine amount of chemical fed to ascertain if flow through pot is effective	D
Sediment trap	Clean trap and check needle valve	M
Chemical pot	Clean pot and orifice	SA
Differential solution feeders		
Chemical storage tank	Inspect and clean	SA
Oil volume	Check and replenish	SA
Pilot tubes and needle valve	Check and replace as necessary	A
All equipment	Paint as necessary	V
Decanter or swing-pipe feeder		
Swing-pipe	Check to make certain it does not bind	M
Motor ratchet, pawl, reducing gears	Check and lubricate	SA
Rotating dipper feeder		
Motor	Follow manufacturer's instructions	V
Transmission	Change oil after 100 hours operation Drain and flush, clean interior, and refill	100 hrs SA
Shaft bearings	Lubricate	W
Drive chain	Clean, check alignment; check sprocket teeth; lubricate chain and sprockets	M
Agitator	If used, clean and lubricate according to manufacture's instructions	V
Belt drives	Check alignment, tension, and inner cords of belt drives	M
Dipper and float valve	Check dipper clearance and adjust float valve setting	SA
Portioning pumps (Hypochlorinators)		
Operator inspection	Inspect sight feeders, rate of flow, piping, joints	D
Feeder	Clean feeder	W
Solution tank	Clean tank	M
Linings	If cracks occur, special linings should be repaired	A

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Maintenance Procedures for Ion-Exchange Softening Units
Table D

Inspection	Action	Frequency
Softener unit		
Shell	Clean and wire brush; paint	A
Valves and fittings	Check for obstructions, corrosion, and fastness	Q
Multi-port valves	Check for leaks; repack if necessary	SA
	Lubricate with grease; follow directions for lubrication procedures	SA
Ion-exchangemedium	Check bed surface for dirt, fines and organic growths; remove foreign matter and resin to desired to desired level	Q
Gravel	Probe through resin to determine gravel surface; level gravel surface with rake during backwash flow; replace gravel when caked, or if resin is being lost to effluent; wash and grade gravel and place in four separate layers; use new lime-free gravel at discretion of inspector	Q
Underdrains	Check pressure drop through underdrains; if necessary, remove manifold or plate underdrains; clean and replace	A or V
Regeneration equipment		
Salt storage unit	Clean tank as necessary to remove dirt	V
Brine tank	Clean out dirt and insolubles; allow to dry; paint both exterior and interior surface	SA
Ejector	Clean, disassemble, check erosion, and corrosion; clear clogged piping; assemble and replace	A
Operating conditions		
Flow rates	Check rate of flow through bed; adjust controls to optimum rate, depending on type of resin	Q
Backwash rates	Check rate and adjust controls to optimum rate	Q
Pressure	Check difference between inlet and outlet pressures; if undersirable changes in pressure drop have occurred, seek cause and remedy	Q
Efficiency	Compare total softening capacity with previous inspection; determine cause of decrease, if any, and remedy the situation	Q
Out-of-service softeners	Drain; keep synthetic resins damp; do not regenerate before draining	V

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Maintenance Procedures for Clarification Equipment
Table E

Inspection	Action	Frequency
Mixing basins	Drain, wash down walls, flush sediment to waste line; repair spalled spots on walls and bottom; check valves on sluice gates; lubricate and paint valves as necessary	SA
Baffled mixing chambers	Clean baffles and clean as necessary	SA
Flocculator basins	Check paddle rotation to ascertain if any flocculators are inoperative	M
	Clean and lubricate drive, bearings, gears, and other mechanical parts; check underwater bearings for silt penetration; replace scored bearings	SA
Rapid (flash) mixers	Check paddles; clean bearings and drive shaft; lubricate and paint as necessary	SA
Revolving-sludge-collector basins	Drain tank, check submerged parts	SA
Operating parts	Lubricate	D or W
Speed reducers and oil baths	Remove water and grit, replace oil as necessary	W
Drive head	Lubricate	D
Worm gear	Check oil level	W
	Drain water from housing	M
Turntable bearings	Lubricate	M
	Change oil	SA
Chains	Drain off water, add oil as necessary	M
	Change oil	SA
Annular ball bearings	Lubricate	D
Center bearings, shaft bearings, bushings, etc.	See manufacturer's instructions	V
Tank equipment	Tighten bolts and nuts; check for excessive wear; flush and back blow sludge line; check motors, couplings and shear pins; check rakes, clean and paint equipment	A
Conveyor-type-collector basins	Consult manufacturer's instructions	V
Upflow clarifier	See manufacturer's instructions	V
Cathodic protection rectifier-type	Check exterior and interior for condition; see manufacturer's instruction; repair, replace, or paint	M
Sacrificial anode	Check anode condition and all connections, and replace as necessary	M

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Maintenance Procedures for Filtration Equipment
Table F

Inspection	Action	Frequency
Gravity filters		
Filter media	Inspect surface for unevenness sinkholes, cracks, algae, mud balls, or slime	M
	Dig out sand and gravel at craters of appreciable size; locate and repair underdrain system breaks	V
	Chlorinate to kill algae growths	V
	Probe for hard spots and uneven gravel layers; if present, treat filter with acid	Q
	Check wash water rise rate and sand expansion during back-washing	SA
	Check sand condition for grain size growth; sample sand, determine weight loss on acid digestion, and run sieve test; acid-treat if necessary, or replace sand if necessary	SA
Gravel	Check elevation of gravel surface	M
	Examine gravel for incrustation, cementation, alum penetration, mud balls; if necessary, remove, clean, and relay gravel	SA
Underdrain system	Remove sand from area of 10 sq. ft., and inspect 2 sq. ft. area of gravel (or more); if underdrains are deteriorated, remove all sand and gravel, repair underdrains, replace gravel and sand	A
	If porous underdrain, clogged by alum floc, treat with 2% sodium hydroxide solution for 12 to 16 hours	V
Wash water troughs	Check level and elevation, adjust	Q
	Check for corrosion; if present, dry troughs, wire brush, and paint	SA
Operating tables	Clean table (console or panel) inside and out	W
Cables	Adjust tension	V

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Inspection	Action	Frequency
Hydraulic lines (or pneumatic)	Check for leakage	V
Four-way valves	Adjust, tighten packing glands or add new packing	M
Transfer valves	Lubricate with grease	M
Valve-position indicator	Adjust if necessary	M
Four-way transfer valves	Disassemble, clean, lubricate, and replace worn parts	A
Table	Paint inside	A
Rate controllers		
Direct-acting	Clean exterior, check diaphragm leakage, tighten packing, check freedom of movement and zero differential	W
Diaphragm pot	Disassemble, clean and replace	V
Controller mechanism	Disassemble, service; clean venturi; paint surfaces needing protection	Every 3 Yrs.
Indirect-acting	Clean outside, adjust packing, lubricate and tighten fittings; check knife edges, check piston travel; repack as necessary	W
Pilot valves	Disassemble, clean and lubricate; check piston travel; clean piping and strainers; check for leaks in diaphragm	A
Controller mechanism	Disassemble, service; clean venturi; clean hydraulic cylinders; paint as necessary	Every 3 Yrs.
Mechanically-operated loss-of head gauges	Check zero setting; adjust stop collars or cable; release air from float chamber	M
Mud leg	Flush out sediment	M
Float chamber	Remove float, clean; remove mercury, clean and replace; check pressure pipelines; paint interior and exterior	A
Diaphragm-pendulum loss-of-head unit	Check zero setting; purge diaphragm cases of air; check cable at segment; remove dirt form knife edges; tighten can hubs on shafts; drain mud from mud leg	M
Pipelines to diaphragm	Check for free flow and absence of incrustation	SA
Diaphragm-pendulum unit	Check for leakage; disassemble unit; clean and lubricate; check working parts, cables; repack stuffing box	A

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Inspection	Action	Frequency
Mercury-float-type rate-of-flow gauges	Check at zero differential, adjust indicator arm and recording pens; check stop collars on cables	-
	Check accuracy and percent error; if greater than ± 3%, adjust	SA
Pressure lines	Check and clean as necessary	SA
Float chamber	Clean float and mercury; paint all parts requiring protection	A
Piping and valves	Check for joint leaks; check pipe hangers, replace if necessary; paint as necessary	M
Pressure filters		
Piping and valves	Check for leaks; lubricate and repack valves as necessary	W
Filter bed	Open pressure shell, check sand surface for mud balls, unevenness; check sand surface elevation; remove mud balls	Q
	Remove sand in sizable area and check gravel	A
Pressure she	Clean and paint exterior	A
Underdrains	Remove sand, check gravel; remove gravel, check underdrains; clean, paint, and repair; replace gravel and sand	Every 3 Yrs.
Diatomite filters		
Filter elements	Check for clogging; clean as necessary (e.g., treat to remove iron oxide, manganese dioxide, and algae)	M
Piping and appurtenant equipment	Check for leaks; clean and repair auxiliaries	SA
Exterior surfaces	Clean and paint	A

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Maintenance Procedures for Aeration Equipment
Table G

Inspection	Action	Frequency
Waterfall-type aerators (cascade)	Inspect aerator surfaces; remove algae; Repair or replace surfaces as necessary	D A
Waterfall-type aerators (tray)	Clean and repair trays; clean coke or replace	SA
Injection aerators porous ceramic plate or tube	Check discharge pressure; if clogging is evident, dewater tank; clean diffusers	V
	Drain aeration tank, check for joint leaks, broken diffusers, clogging	SA
Waterside of ceramic diffusers	Clean with acid, in place, or remove and soak in acid	SA
Air side of ceramic diffusers	If plates are clogged by iron oxide, treat with HCl; if clogged by soot, oil, etc., remove diffusers and burn	SA
Saran-wound diffusers	Clean by scrubbing with soap or detergent	SA
Nozzles	Clean nozzles inside and out	SA
Spray nozzle aerators		
Nozzles	Check for clogging; clean, remove if necessary to clean	W
Manifolds	Remove caps and clean out sediment; check pipe supports, repair as necessary; paint as necessary	Q
Spray fence	Paint	A
Blowers and accessory equiment		
Compressor or blower	Lubricate, check output pressure for indications of clogging	D
Air filters		
Compressors or blower	Clean, repair, or replace	W
	Open, inspect, clean, repair, and paint exterior surfaces	A

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Maintenance Procedures for Storage Facilities
Table H

Inspection	Action	Frequency
Foundations, concrete	Check for settlement, cracks, spalling and exposed reinforcing; repair as necessary with 1 part cement to 1 part sand	SA
Foundations, wood	Check wood foundations and pads for cracked, split, rotted or termite infected members; also check for direct contact of untreated wood with soil; repair or eliminate undesirable conditions as necessary	SA
Concrete tanks (ground level storage)		
Walls	Check exterior for seepage and mark spots	SA
	Check exterior and interior for cracks, leaks, spalling, etc.	A (Spring)
	Remove loose, scaly, or crumbly concrete; patch with rich cement grout; paint grout with iron waterproofing compound	A
	Chip out cracks, repair with cement slurry	A
	For cracks in prestressed tanks, consult designing and/or erecting company	A
Expansion joints	Check for leakage; check for missing filler; clean and repair as necessary	SA
Roofs	Check condition; check hatches; check screens or openings	SA
Earth embankments	Check for erosion, burrowing animals, improper drainage and leakage through embankment; repair as necessary; if leakage through embankment exists, drain tank and look for cracks in tank walls or bottom	SA
Concrete tanks (underground storage)	Check interior walls, roof, appurtenances and embankment; if leakage is evident, excavate and repair walls	SA

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Inspection	Action	Frequency
Concrete tanks (elevated storage)	Check and repair	SA
Steel tanks (ground level storage)	Check for ice damage in Spring; repair as necessary	A
Walls and bottom	Examine exterior and interior for rust, corrosion products, loose scale, leaky seams, and rivets and for condition of paint	SA
	Replace rivets or patch leaking areas as necessary	V
	Check painted surfaces for deterioration; paint as necessary	
Roofs	Check conditions, hatches, screens, manholes and paint; lock hatches; remove spider rods if corroded; repair, replace, as necessary	SA
Steel tanks (standpipes)	Follow instructions for ground level storage given earlier in this chapter	SA
Steel tanks (underground storage)	Check tank interior, roof, and appurtenances; follow instructions given earlier in this chapter	SA
Steel tanks (elevated storage)	For general procedures follow instructions given earlier in this chapter; for specific procedures see following paragraphs	SA
Tanks	Follow instructions given earlier	SA

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Inspection	Action	Frequency
Tower structures	Check for corrosion; loose, missing, bowed, bent or broken members; loose sway bracing; misalignment of tower legs; evidence of instability; repair as necessary	SA
	Check surface of lattice bars, anchor bolts, boxed channel columns and pockets where water or trash collects; clean, repair, provide drainage or fill pockets; paint as necessary	SA
Roofs	Follow the general instructions given earlier in this chapter	SA
	Check obstruction and navigation lights, hoods, shields, receptacle and fittings for missing or damaged parts, or inoperation; also check lighting rods, terminals, cables, and ground connections; repair, replace, or renew; paint as necessary	SA
Risers and heating systems	Two months before freezing weather, check riser pipe insulation and repair as necessary; also check heating system operation	A
	One month before freezing weather, operate heating system for eight hours; repair or adjust defective parts	A
Cathodic protection	In addition to the following instructions, observe those given earlier in this discussion regarding cathodic protection of sedimentation tank equipment	V (at least A)
	Check flow of current; if absent, check fuses, electrodes, ground wire connections and immersion of electrodes; adjust or repair as necessary; if current flow or amperage is above desired level, adjust as necessary; make certain that connections to rectifier are not reversed	V
	Check operating records to make sure that electrodes are immersed at all times	V
	Check anode condition; replace as necessary	V
	In freezing climates, protect electrodes against ice damage, or remove and store for winter season	V

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Inspection	Action	Frequency
Pneumatic tanks	Inspect air pump and motor; check operating record of time cycle; check for air leaks, if time cycle is too short; check valve operations, particularly pressure relief valves Check tank for signs of corrosion; take steps necessary to eliminate corrosion or protect against it	Q
Appurtenances	Check ladders, walkways, guardrails, handrails, stairways, and risers for rust, corrosion, poor anchorage, missing pieces, general deterioration or damage; replace or repair parts as necessary	A
Miscellaneous appurtenance	Check all electrical connections and conduits leading to tanks; make any repairs or adjustments necessary	SA
Grounds	Check for accumulations of debris, trash and foliage; clean the area	SA

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APPENDIX IV

MATH TABLES, EQUIVALENTS, AND USEFUL FORMULAS

TABLE FOR CONVERSION OF
ENGLISH AND METRICMEASUREMENTS

MULTIPLY	BY	TO OBTAIN
Cubic feet	2.832×10^{6}	Cubic cms
Cubic feet	1728	cubic inches
Cubic feet	0.02832	cubic meters
Cubic feet	0.03704	cubic yards
Cubic feet	7.481	gallons
Cubic feet	28.32	liters
Cubic feet	59.84	pints (liq)
Cubic feet	29.92	quarts (liq)
Cubic inches	16.39	cubic centimeters
Cubic inches	5.787×10^{-4}	cubic feet
Cubic inches	1.639×10^{-5}	cubic meters
Cubic inches	2.143×10^{-5}	cubic yards
Cubic inches	4.329×10^{-2}	gallons
Cubic inches	1.639×10^{-2}	liters
Cubic inches	0.03463	pints (liq)
Cubic inches	0.01732	quarts (liq)
Cubic yards	7.636×10^{5}	cubic centimeters
Cubic yards	27	cubic feet
Cubic yards	46.656	cubic inches
Cubic yards	0.7646	cubic meters
Cubic yards	202.0	gallons
Cubic yards	764.6	liters
Cubic yards	1616	pints (liq)
Cubic yards	807.9	quarts (liq)
Feet	30.48	centimeters
Feet	0.3048	meters
Feet	.36	yards
Feet	1/3	yards
Feet of water	0.02950	atmosphere
Feet of water	0.8826	inches of mercury
Feet of water	304.8	kgs per sq meter
Feet of water	62.43	pounds per sq ft
Feet of water	0.4335	pounds per sq inch
Gallons	3785	cubic centimeters
Gallons	0.1337	cubic feet
Gallons	231	cubic inches
Gallons	3.785×10^{-3}	cubic meters
Gallons	4.951×10^{-3}	cubic yards
Gallons	3.785	liters

TABLE FOR CONVERSION OF
ENGLISH AND METRICMEASUREMENTS (CONTINUED)

MULTIPLY	BY	TO OBTAIN
Inches	2.540	centimeters
Inches	10^4	mils
Inches	.03	yards
Inches of mercury	0.63342	atmosphere
Inches of mercury	1.133	feet of water
Inches of mercury	345.3	kgs per sq meter
Inches of mercury	70.73	pounds per sq ft
Inches of mercury	0.4912	pounds per sq inch
Inches of water	0.002458	atmospheres
Inches of water	0.07355	inches of mercury
Inches of water	25.40	kgs per sq meter
Inches of water	0.5781	ounces per sq in
Inches of water	5.204	pounds per sq ft
Inches of water	0.03613	pounds per sq inch
Ounces	8	drams
Ounces	437.5	grains
Ounces	28.35	grams
Ounces	0.0625	pounds
Ounces (fluid)	1.805	cubic inches
Ounces (fluid)	0.02957	liters
Pounds	7000	grains
Pounds	453.6	grams
Pounds	16	ounces
Pounds	32.17	poundals
Pounds	0.8229	pounds (av)
Pounds of water	0.01602	cubic feet
Pounds of water	27.68	cubic inches
Pounds of water	0.1198	gallons

MULTIPLY	BY	TO OBTAIN
Centiliters	0.01	Liters
Centimeters	0.3937	inches
Centimeters	0.01	meters
Centimeters	393.7	mils
Centimeters	10	millimeters
Cubic centimeters	3.531×10^{-3}	cubic feet
Cubic centimeters	6.102×10^{-2}	cubic inches
Cubic centimeters	10-6	cubic meters
Cubic centimeters	1.306×10^{-6}	cubic yards
Cubic centimeters	2.642×10^{-4}	gallons
Cubic centimetersCubic	10-2	liters
centimeters	2.113×10^{-3}	pints (liq)
Cubic centimeters	1.057×10^{-3}	quarts (liq)
	10^{4}	
Cubic meters	35.31	cubic centimeters
Cubic meters	81.023	cubic feet
Cubic meters		cubic inches
	1.303	
Cubic meters		cubic yards
	264.2	
Cubic meters	10^{2}	gallons
Cubic meters		liters
	2113	
Cubic meters		pints (liq)
	1057	
Cubic meters	10^{2}	quarts (liq)
Kilograms		grams
	70.93	
Kilograms	2.2046	poundals
Kilograms		pounds
	1.102×10^{-2}	
Kilograms	3281	tons (short)
Kilometers	10^{7}	feet
Kilometers	1093.6	meters
Kilometers	10^{2}	yards
Liters	0.03531	cubic centimeters
Liters	61.02	cubic feet
Liters	10^{3}	cubic inches
Liters	1.308×10^{-2}	cubic meters
Liters	0.2642	cubic yards
Liters	2.113	gallons
Liters	1.057	pints (liq)
Liters	100	quarts (liq)
Meters	3.2808	centimeters
Meters	39.37	feet
Meters	10^{-3}	inches
Meters	10^{3}	kilometers
Meters	1.0936	millimeters
Meters	25	yards
Millimeters		inches

EQUIVALENTS

EQUIVALENTS

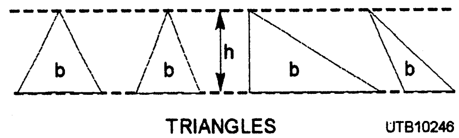
1 inch	=	25 millimeters
1 foot	=	0.3 meter
1 yard	=	0.9 meter
1 mile	=	1.6 kilometers
1 square inch	=	6.5 square centimeters
1 square foot	=	0.09 square meter
1 square yard	=	0.8 square meter
1 cubic inch	=	16 cubic centimeters
1 cubic foot	=	0.03 cubic meter
1 cubic yard	=	0.8 cubic meter
1 quart (lq.)	=	1 liter
1 gallon	=	0.004 cubic meter
1 ounce (avdp)	=	28 grams
1 pound (avdp)	=	0.45 kilogram
1 horsepower	=	0.75 kilowatt
1 pound per square inch	=	0.07 kilograms per square centimeter
1 millimeter	=	0.04 inch
1 meter	=	3.3 feet
1 meter	=	1.1 yards
1 kilometer	=	0.6 mile
1 square centimeter	=	0.16 square inch
1 square meter	=	11 square feet
1 square meter	=	1.2 square yards
1 cubic centimeter	=	0.06 cubic inch
1 cubic meter	=	35 cubic feet
1 cubic meter	-	1.3 cubic yards
1 liter	=	1 quart (lq)
1 cubic meter	=	250 gallons
1 gram	=	0.035 ounces (avdp)
1 kilogram	=	2.2 pounds (avdp)
1 Kilowatt	=	1.3 horsepower
1 kilogram per square centimeter	=	14.2 pounds per square inch

USEFUL FORMULAS

Triangle:

Area $= \dfrac{b \times h}{2}$

Volume $= \dfrac{b \times h}{2} \times \text{length}$

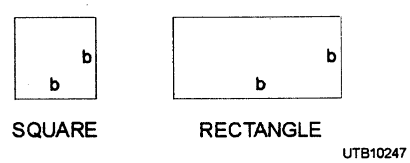


Square/Rectangle:

Area = $b \; x \; b$

Volume = $b \times b \times b$

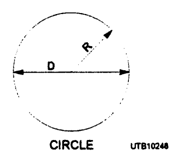
Perimeter = $2b + 2b$



Circle:

Area= $\pi \times R^2$

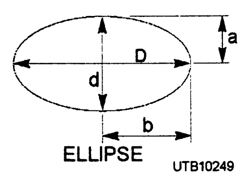
Volume= $\pi \times R^2 \times \text{length}$



Ellipse:

Area $= \dfrac{\pi \times D \times d}{4}$

Volume $= \dfrac{\pi \times D \times d}{4} \times \text{length}$



Circular cone:

Lateral area = $s \times \pi \times R$

Volume $= \dfrac{\pi \times R^2 \times h}{3}$

APPENDIX V

REFERENCES USED TO DEVELOP THE TRAMAN

NOTE: "Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. When consulting these references, keep in mind that they may have been revised to reflect new technology or revised methods, practices, or procedures. You therefore need to ensure that you are studying the latest references."

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Ridgid 535 Pipe and Bolt Threading Machine Operator's Manual, The Ridge Tool Company, 400 Clark St., Elyria, OH, 1990.

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Assignment Questions

Information: The text pages that you are to study are provided at the beginning of the assignment questions.

ASSIGNMENT 1

Textbook Assignment: "Plans, Specifications, and Color Coding" and "Advanced Base Functional Components (ABFC)," chapters 1 and 2, pages 1-1 through 2-5.

1-1. Utilitiesmen use different types of plans and drawings. These plans and drawings are developed by immediate supervisors, architects, and engineers.

1. True
2. False

1-2. You are excavating a trench for a 6-inch main sewer line. You should refer to what type of plan to identify possible underground utilities?

1. Structural
2. Electrical
3. Civil
4. Mechanical

1-3. Before installing a 3/4-inch waterline in a facility wall, you may need to know the construction of the wall by looking at what plan?

1. Structural
2. Architectural
3. Civil
4. Mechanical

1-4. You must identify the location of the power disconnect for a water heater. What plan contains this information?

1. Mechanical
2. Electrical
3. Structural
4. Architectural

1-5. The primary parts of a mechanical plan are the views of fixtures and equipment and information and notes.

1. True
2. False

1-6. There is what total number of dimensions in an isometric drawing?

1. Six
2. Two
3. Three
4. Nine

1-7. Many Utilitiesman cannot picture the piping installation when working from a floor plan to elevation and back again. For this reason, they need an isometric drawing that combines

1. elevation views and the floor plan
2. two dimensions
3. three dimensions
4. pictorial views and elevations

1-8. Isometric drawings are always drawn to scale.

1. True
2. False

1-9. What lines in an orthographic projection remain the same in an isometric sketch?

1. Horizontal
2. Projected
3. Rectangular
4. Vertical

1-10. Horizontal lines in an isometric drawing are projected at what angles?

1. 45° and 30°
2. 60° and 90°
3. 90° and 45°
4. 60° and 30°

l-l 1. In an isometric pipe diagram, the lines of the room are drawn with light lines and the lines of the pipe diagram with dark lines for which of the following reasons?

1. To give the effect of sections in the room
2. To make the room transparent
3. To make the walls look invisible
4. Each of the above

1-12. When dimensioning an isometric pipe diagram, you should use what documents to ensure accurate information in the drawing?

1. Architect's plans and "rough in" sheets
2. Technical manuals and mechanical plans
3. Mechanical plans only
4. Technical manuals and "rough in" sheets

1-13. A bathroom is 5 feet wide, 8 feet long, and 7 feet 6 inches high in your isometric drawing. Your scale is 1/2 inch = 1 foot. Your line for the height of the bathroom should measure

1. 3.25 inches
2. 3.5 inches
3. 3.0 inches
4. 3.75 inches

1-14. Draw a room 8 feet by 10 feet by 8 feet in an isometric representation with the ceiling and two walls removed. Use a scale of 1/4 inch = 1 foot. If the walls are 6 inches thick, your line should be what length?

1. 0.0125 inch
2. 0.125 inch
3. 0.1375 inch
4. 0.387 inch

1-15. Project guide specifications are divided into what number of specification divisions?

1. 8
2. 13
3. 17
4. 21

1-16. What division of the specifications includes site utilities?

1. Site work
2. Mechanical
3. Conveying systems
4. Specialties

1-17. You are installing warning signs for a new water treatment plant. Specifications for the signs are covered in what division?

1. Mechanical
2. Specialties
3. Wood and plastics
4. Metals

1-18. You are installing plumbing in a K-span building. Other than the mechanical division, you can obtain additional plumbing information from what other specification division?

1. Expeditionary structures
2. Special construction
3. Specialties
4. Doors and windows

1-19. In what section of the specific plumbing requirements is the grade of the belowground level sanitary sewer specified?

1. 1a-01
2. 1a-02
3. 1a-03
4. 1a-04

1-20. In what section of the specific plumbing requirements does it say what distance the sanitary sewer vent should extend through the roof?

1. 1a-02
2. 1a-03
3. 1a-04
4. 1a-05

1-21. In the specific working requirements, what type of copper tubing is specified for water piping buried in the ground?

1. "L" hard
2. "L" soft
3. "K" soft
4. "K" hard

1-22. In the specific working requirements, what is the distance of the kitchen sink from the floor to the top of the rim?

1. 33 inches
2. 34 inches
3. 35 inches
4. 36 inches

1-23. In the specific plumbing requirements, what type of water supply valve is required on a water closet?

1. Brass gate valve
2. Brass I.P. valve
3. Chromium gate valve
4. Chromium I.P. valve

1-24. In the specific plumbing requirements, what is the kilowatt requirement for the heating elements of the water heater?

1. 11 and 3
2. 14 and 3
3. 15 and 1
4. 16 and 1

1-25. In the specific plumbing requirements, if the working pressure of the hot- and cold-water piping is 40 psi, what is the required test pressure?

1. 40 psi
2. 50 psi
3. 60 psi
4. 70 psi

1-26. In what section of the specific plumbing requirements does it say whether insulation is required on aboveground piping?

1. 1a-11
2. 1a-10
3. 1a-09
4. 1a-08

1-27. What types of specifications are written technical descriptions of materials and supplies used by the Navy and other federal government departments?

1. Military
2. Federal
3. NAVFAC
4. MIL-SPECS

1-28. What manual lists specifications developed by NAVFAC?

1. NAVFAC MO-327
2. NAVFAC MO-119
3. NAVFAC P-455
4. NAVFAC P-405

1-29. Determining requirements and developing methods and schemes of action for construction of a project defines what term?

1. Designing
2. Programing
3. Planning
4. Estimating

1-30. You have been assigned as crew leader to renovate a bathroom. What is the first action you should take?

1. Select a crew
2. Gather materials
3. Study guides on ways to accomplish the job
4. Comprehend what is to be done

1-31. When planning a job, ask yourself what the crew can reasonably accomplish. Which of the following questions can be answered by using this technique?

1. What length of time is required to complete the job
2. Who is to accomplish what
3. Both 1 and 2 above
4. What types of materials and tools are needed

1-32. Set realistic goals for each workday. To realize these goals, you should encourage your crew to

1. work independently
2. work as fast as possible
3. work together as a team
4. analyze each goal assignment

1-33. In planning the time to complete a job, you must think of man-hours of direct labor as well as which of the following factors?

1. Administration, leave, and liberty
2. Training, safety, and operations
3. Safety, leave, liberty, and administration
4. Leave, liberty, safety, and training

1-34. Stress safety on the job. This attitude also applies to tools. The primary consideration for tool safety is that

1. the tools are sized correctly
2. the people are checked out properly on their use
3. the tools are on the job on time
4. the supervisor knows how to use the tools

1-35. Before starting a job, be sure your people

1. understand the plans and specifications
2. know what is to be done on the job
3. know the project supervisor
4. have transportation available to and from the job

1-36. What question should be your first concern when checking tools and equipment before their use?

1. Are the tools safe
2. Are the people expendable
3. Are the tools absolutely necessary
4. Is the government saving money

1-37. As a crew leader, you should ensure power tools have what marking that indicates they are safe for use?

1. Manufacturer safety notice
2. Minor property number
3. Preventive maintenance check date
4. Current safety color code

1-38. What is the primary reason for inspecting the work of your crew?

1. To criticize shortcomings
2. To use available man-hours most productively
3. To teach, guide, and direct crew members
4. To point out sloppy workmanship

1-39. A crew leader gets a varied level of crew experience by performing which of the following actions?

1. Inspecting work regularly
2. Being on the job at all times
3. Placing crew members in special schools
4. Rotating crew member assignments on the job

1-40. What is the standard color code for toxic and poisonous materials?

1. Green
2. Gray
3. Yellow
4. Brown

1-41. What color code indicates flammable material?

1. Green
2. Yellow
3. Gray
4. Blue

1-42. You find a gray cylinder in the mechanical room of the dental clinic. This cylinder may contain what type of dangerous material?

1. Physically dangerous
2. Anesthetics and harmful
3. Oxidizing
4. Toxic and poisonous

1-43. When the diameter of a pipeline for hazardous material is smaller than 3/4 inch, you should use what method to identify the material conveyed by the piping?

1. Etched metal tags that are securely fastened to the pipe
2. Standard-sized lettering stenciled on the pipe
3. Paint on the pipe that matches the surrounding color
4. Black or white lettering on the pipe

1-44. You are installing a 6-inch POL line on a fuel pier. What size should the lettering on the pipe be to identify the material hazard present?

1. 1 inch
2. 2 inches
3. 1 1/4 inches
4. 1 1/2 inches

1-45. Within the primary color coding system, there is a total of how many colors for use in identifying hazardous materials?

1. Six
2. Five
3. Four
4. Three

1-46. The title should be painted in what color if the background color of a cylinder is brown?

1. Red
2. Green
3. White
4. Orange

1-47. MIL-STD-101B is a complete listing of the

1. primary warning colors for toxic materials
2. secondary warning colors for toxic materials
3. types of compressed gas cylinders
4. exact specifications for piping systems

1-48. Shatterproof cylinders must be stenciled with the phrase "Non-Shat" at what position from the title?

1. Horizontally at 60 degrees
2. Longitudinally at 90 degrees
3. Horizontally at 90 degrees
4. Longitudinally at 60 degrees

1-49 You can locate information concerning the Advanced Base Functional Component (ABFC) system in what NAVFAC publication?

1. MO-212
2. P-335
3. P-404
4. P-437

1-50. The Facilities Planning Guide has two volumes, each with three parts. You can locate plot plans for components in

1. Volume 1, Part 1
2. Volume 2, Part 1
3. Volume 1, Part 2
4. Volume 1, Part 2

1-51. The ABFC system revolves around a building-block type of system. What is the largest type of block?

1. An assembly
2. A facility
3. A component
4. A plot plan

1-52. The portable bath unit operates on what voltage?

1. 110 V
2. 208 V
3. 220 V
4. 440 V

1-53. Each shower stand assembly is equipped with what total number of shower heads?

1. One
2. Two
3. Three
4. Four

1-54. What total number of 1-inch-diameter 7 1/2 foot hoses are supplied for the water hose assembly?

1. Seven
2. Six
3. Five
4. Four

1-55. The mixing valve assembly provides heated water to the shower heads at what temperature?

1. 105°F
2. 110°F
3. 115°F
4. 120°F

1-56. When setting up the bath unit, you should locate it so that drainage from the shower area is carried downstream or downhill to prevent wastewater from being drawn back into the water source. If this is not possible, what should be done?

1. Dig a ditch or build a dike around the shower stands to allow wastewater to drain away
2. Have the drainage pumped into another water source
3. Have the drainage re-utilized within the camp
4. Dig a catchment basin to hold the drainage

1-57. For what reason should you never connect the bath unit water heater to an untested water supply?

1. To prevent using water with possible floating debris
2. To prevent equipment damage
3. To avoid excessive strain on the water pump
4. To prevent use of water that is possibly contaminated

1-58. You should locate the water pump on a level surface that is approximately how many feet from the water source?

1. 10
2. 20
3. 30
4. 40

1-59. You should locate the water heater on level ground that is approximately what distance from the water pump?

1. 5 feet
2. 6 feet
3. 7 feet
4. 8 feet

1-60. The shower stand should be erected at what distance from the mixing valve?

1. 40 feet
2. 30 feet
3. 20 feet
4. 10 feet

1-61. To provide internal lubrication for the fuel pump when firing the fuel burner with gasoline, you should mix what amount of oil with every 5 gallons of gasoline?

1. 1 pint
2. 5 pints
3. 3 pints
4. 2 pints

1-62. During the start-up procedure, you should perform what step first?

1. Open the fuel valve and turn ON the load limit switch and power
2. Remove the plug and fill the coupling with water
3. Ensure the fuel pressure gauge is at 100 psi
4. Turn the limit switch to the OFF position and connect the power

ASSIGNMENT 2

Textbook Assignment: "Advanced Base Functional Components (ABFC)" (continued), chapter 2, pages 2-1 to 2-37.

QUESTIONS 2-1 THROUGH 2-4 REFER TO THE PORTABLE BATH UNIT.

2-1. After performing all before operation PMCS, you are preparing the unit for use. Of the following steps, which one is NOT correct?

1. Open the blower shutter approximately halfway
2. Ensure the water heater drain cock is closed
3. Make sure the manual fuel valve is open
4. Check all waterlines to ensure they are connected

2-2. After you have the unit on line, the fuel pressure gauge should indicate what amount of pressure?

1. 120 psi
2. 110 psi
3. 100 psi
4. 90 psi

2-3. After start-up, the exhaust gases from the stack should be transparent and smokeless. What should be done when smoke is present?

1. Open the air band on the blower assembly slowly until the exhaust gases are transparent
2. Adjust the electrodes and check for proper ignition
3. Clean the burner firebox and stack
4. Check the fuel lines for contaminated fuel

2-4. When there is a danger of freezing, you should perform which of the following procedures?

1. Open the drain cock to the heater
2. Open the drain cock on the water pump
3. Disconnect and drain all water hoses
4. All of the above

IN ANSWERING QUESTIONS 2-5 THROUGH 2-10, REFER TO TABLE 2-1 IN THE TEXTBOOK.

2-5. A water pump fails to deliver water. To locate the problem, you should take what action?

1. Check the pump shaft seals for leaks
2. Check the blower for an obstruction
3. Ensure the solenoid valve activates
4. Ensure the strainer cover is not too loose

2-6. A fuel pump is noisy. What is the most likely problem?

1. The pump rotation is reversed
2. The fuel filter is clogged or dirty
3. The fuel nozzle is defective
4. The flame-safeguard control switch is inoperative

2-7. The fuel pressure gauge indicates the pressure is too high. You can determine the location of the problem by performing which of the following troubleshooting procedures?

1. Check the fuel pump for defects
2. Ensure the fuel pump is primed
3. Check the fuel nozzle for defects
4. Ensure the fuel is not contaminated

2-8. The fuel pump fails to deliver fuel to the burner. What is the most likely cause?

1. The fuel contains water
2. The low-water probe is defective
3. The power source is providing low voltage
4. The supply and return fuel hoses are reversed

2-9. The burner fails to ignite. You can determine the problem by performing which of the following troubleshooting procedures?

1. Check for water in the fuel
2. Ensure the electrodes are adjusted properly
3. Ensure the porcelain surrounding each electrode is not cracked
4. Each of the above

2-10. The water pump fails to rotate. What is the problem?

1. The electric motor is inoperative
2. The solenoid control valve is defective
3. The water-flow control valve is damaged
4. The low-water relay is defective

2-11. The Type 2 space heater can operate on 5 gallons of either gasoline or oil for how many hours?

1. 5 to 10
2. 8 to 20
3. 10 to 30
4. 20 to 35

2-12. In a tent with a wooden floor, the space heater should be set up in a sandbox. You should construct the sandbox 4 inches high and no smaller than how many inches long and wide, respectively?

1. 36 by 24
2. 38 by 26
3. 40 by 28
4. 42 by 30

2-13. You should invert the fuel can on a support no less than 1 foot or more than how many feet above the float valve?

1. 9
2. 8
3. 6
4. 4

2-14. The stove should be placed with a sand barrier between the bottom of the stove and the insulation shield. The sand barrier should have a minimum depth of how many inches?

1. 3 1/2
2. 3 3/4
3. 4 1/2
4. 4 3/4

2-15. Combustible materials should be no closer than how many feet from the heater in any direction?

1. 6
2. 5
3. 3
4. 4

2-16. You are assembling a Type I space heater. After the top of the space heater is placed on the adapter ring, you should take what step next?

1. Install the spark arrester
2. Assemble the air-conditioning smoke pipe
3. Assemble the grate
4. Place the adapter ring on the bottom of the heater

2-17. When using the immersion heater, you notice dark smoke coming out of the flue pipe. What adjustment should you make?

1. Reduce the amount of water in the container
2. Increase the fuel flow
3. Clean the flue pipe
4. Reduce the fuel flow

2-18. Eight quarts of mogas should fuel the field range for what length of time?

1. 10 hours
2. 8 hours
3. 6 hours
4. 4 hours

2-19. What should be the minimum distance between leaching cesspools?

1. 20 feet center-to-center apart
2. 20 feet out-to-out measurement of the walls
3. 40 feet intake-to-intake
4. 10 feet center-to-wall from the septic tank

2-20. The porous subsoil required for cesspools must have a minimum depth that ranges between

1. 10 to 12 feet
2. 8 to 10 feet
3. 6 to 8 feet
4. 4 to 6 feet

2-21. What combinations of (a) width and (b) length, in feet, is suitable for a 675-gallon septic tank with a depth of 5 feet? (1 cu ft equals 7.5 gal)

1. (a) 2.0 (b) 9.0
2. (a) 2.5 (b) 7.2
3. (a) 3.0 (b) 3.5
4. (a) 4.0 (b) 4.5

2-22. What percentage of the effluent from a septic tank is composed of suspended solids?

1. 10% to 20%
2. 20% to 30%
3. 30% to 40%
4. 40% to 60%

2-23. What type of pump should you use to clean a septic tank?

1. Diaphragm
2. Rotary
3. Centrifugal
4. Turbine

2-24. The leaching test indicates water penetrated the soil 1 inch in 5 minutes. A total of how many gallons of sewage per square foot per day can be fed to a tiled trench in this area?

1. 1.7
2. 2.4
3. 3.2
4. 4.0

2-25. In laying a tile system, you should use a 4-inch to 6-inch pipe with a 3/8-inch clear opening at each joint for which of the following reasons?

1. To permit better liquid flow
2. To permit settling without the pipe breaking
3. To allow for pipe expansion and contraction
4. To allow for more storage capacity of solids and space for solids to drain into the surrounding gravel

2-26. The bed for a tile field should have approximately how many inches of course gravel around and over the pipe?

1. 6
2. 15
3. 3
4. 18

2-27. In a trench 24 inches wide, what should be the distance, in inches, between laterals?

1. 24
2. 36
3. 48
4. 72

2-28. Normally, what is the maximum length of a lateral?

1. 100 feet
2. 75 feet
3. 50 feet
4. 25 feet

2-29. What action should you take to keep surface water out of a pit being used under an eight-seat field-type latrine?

1. Line the pit with plastic material
2. Place a layer of oil-soaked burlap in a 4-foot by 6-inch margin dug around the pit, then backfill it with oil-soaked earth
3. Build a 6-inch berm around the latrine
4. Dig an 18-inch ditch around the latrine leading the water away from it

2-30. What is the size of the urinal seepage pit for an eight-seat latrine?

1. 6 feet by 6 feet
2. 2 feet by 2 feet
3. 8 feet by 8 feet
4. 4 feet by 4 feet

2-31. As a minimum, grease must be removed from a galley grease trap at what intervals?

1. Weekly
2. Twice weekly
3. Daily
4. Twice daily

2-32. The skid-mounted laundry unit is comprised of what number of major components?

1. Five
2. Six
3. Seven
4. Eight

2-33. What is the drying capacity, in pounds per hour, of a skid-mounted laundry unit?

1. 90
2. 75
3. 50
4. 25

2-34. When starting up the unit, you should alwavs place the unit as close to the

1. intended water and electrical source as possible
2. intended water source and discharge area as possible
3. intended electrical source as possible
4. intended water discharge area as possible

2-35. During start-up, you should open the air-relief valve after opening what other valve?

1. Blowdown
2. Washer supply
3. Water shutoff
4. Pump discharge

2-36. What amount of water should you use to wash three loads of clothes that took 1 hour for each load?

1. 350 gallons
2. 375 gallons
3. 400 gallons
4. 450 gallons

2-37. The moisture extractor cycle programmer can be set for a 5- to 8-minute cycle..

1. True
2. False

2-38. What is included in the water heater "drawer assembly"?

1. The insulators, nozzle adapter, fuel pump relay, electrodes, and electrode support
2. The nozzle adapter, electrode support, electrodes, flame sensor, and flame shield
3. The insulators, fuel pump relay, electrodes, electrode support, and flame sensor
4. The electrodes, insulators, nozzle adapter, electrode support, and flame sensor

2-39. An 18-gallon storage tank can be operated at what maximum working pressure?

1. 80 psi
2. 85 psi
3. 95 psi
4. 100 psi

2-40. When starting up or operating the laundry unit, you should always refer to what manufacturer's manual?

1. Parts manual
2. Maintenance manual
3. Instruction manual
4. Troubleshooting manual

2-41. What three controls operate the dryer or tumbler air temperature and drying cycle?

1. Temperature-regulating thermostat, drying timer, and cool-down timer
2. Drying timer, cool-down timer, and speed control
3. Cool-down timer, temperature-regulating thermostat, and air pressure-temperature regulator
4. Temperature-regulating thermostat, drying timer, and speed control

2-42. What dryer cycle control can be set from 0 to a maximum of 60 minutes?

1. The barrel speed control
2. The temperature-regulating thermostat
3. The dryer timer
4. The cool-down timer

2-43. The moisture programmer controls the cycle of what major component of the laundry unit?

1. Water heater
2. Extractor
3. Dryer
4. Washer

2-44. The moisture programmer on the extractor can be set from 1 minute to 15 minutes.

1. True
2. False

2-45. Field water purification units employ a number of treatment processes. What treatment processes are normally used?

1. Filtration, sanitation, coagulation, and sedimentation
2. Coagulation, sedimentation, filtration, and disinfection
3. Disinfection, sedimentation, aeration, and coagulation
4. Sedimentation, disinfection, flocculation, and aeration

2-46. Refer to the three charts in table 2-2. You are treating a water bladder with a capacity of 500 gallons of water with 69% granular calcium hypochloride (HTH). What amount of HTH, in ounces, is required to receive a 100 ppm FAC?

1. 10
2. 8
3. 6
4. 4

2-47. You should take a FAC reading approximately how many minutes after adding HTH?

1. 5
2. 10
3. 20
4. 30

2-48. Refer to table 2-3. What is the required chlorine residual in a public water system for the first 30 minutes?

1. 7.0
2. 2.0
3. 5.0
4. 4.0

2-49. The FAC level must be maintained above 50 ppm during superchlorination for what length of time to disinfect a water source?

1. 16 hours
2. 12 hours
3. 8 hours
4. 4 hours

2-50. The diatomite water purification unit can produce a maximum of how many gallons of water per day?

1. 20,000
2. 25,000
3. 30,000
4. 35,000

2-51. The 3000D water purification unit is composed of how many modules?

1. Five
2. Two
3. Three
4. Four

2-52. You are tasked to run the 3000D unit. It has been 3 days since the unit was used, and a cold start is required. The automatic decompression device should be placed in what position?

1. OPERATE
2. START
3. RUN
4. NEUTRAL

2-53. Backwashing of the filter must be performed when the pressure difference between the filter inlet and outlet exceeds what psi?

1. 10
2. 20
3. 30
4. 40

2-54. The reverse osmosis water purification unit treats fresh, brackish, and sea water. It can also be used to treat water with what type of contamination?

1. Sewage
2. Industrial waste
3. CBR agents
4. Hazardous gases

2-55. A pump forces water through what type of membrane in the ROWPU elements?

1. Semiporous
2. Porous
3. Permeable
4. Semipermeable

2-56. What type of solution should be added to water to induce coagulation in the ROWPU?

1. Citric acid
2. Soda ash
3. Chlorine
4. Polyelectrolyte

2-57. When a solution of sodium hexamethphosate is added to the ROWPU, it prevents what condition from occurring in the filters?

1. Scaling
2. Algae
3. Pitting
4. Erosion

2-58. Diluted citric acid is used to clean the ROWPU elements. What effect does it have on the water the unit treats?

1. It raises the pH level and improves coagulation
2. It lowers the pH level and improves the salt rejection of the elements
3. It lowers the pH level and decreases the filtering ability for a short period of time
4. It raises the pH level and neutralizes the polyelectrolyte solution

2-59. To fill a 3,000-gallon bladder with potable water requires what amount of time?

1. 3.40 hours
2. 3.70 hours
3. 4.16 hours
4. 4.00 hours

2-60. The higher the temperature of the raw water entering the ROWPU, the

1. lower the amount of water lost through the blowdown
2. lower the amount of product water produced
3. higher the amount of water lost through the blowdown
4. higher the amount of product water produced

2-61. What type of Seabee unit requires eight Utilitiesmen to be qualified on the ROWPU?

1. UCT
2. PWC
3. NMCB
4. CBU

ASSIGNMENT 3

Textbook Assignment: "Plumbing," chapter 3, pages 3-1 to 3-35.

3-1. Plumbing kit assemblies are listed in the Naval Construction Force Table of Allowance (TOA).

1. True
2. False

3-2. Procedures for issue and accounting of tools in an NMCB are contained in what publication?

1. NAVFAC MO-231
2. OPNAV 1600.3
3. NAVSUP 3400.6
4. COMTHRIDNCB/ COMSECONDNCB 4400.3

3-3. What is the rule of thumb for grading a sewer line?

1. 1/4 inch per foot
2. 1/2 inch per foot
3. 1/4 inch per yard
4. 1/2 inch per yard

3-4. When a pipeline must cross under a road, the trench must be at least what depth?

1. 5 feet
2. 6 feet
3. 3 feet
4. 4 feet

3-5. What weight of pipe is adequate for most Navy base construction?

1. XV
2. XH
3. SV
4. SH

3-6. What tools for cutting CSIP should be used only if the most appropriate tools are not available?

1. Hammer and chisel
2. Abrasive cutter
3. Band saw
4. Hydraulic snap cutter

3-7. A 1/16th bend changes the direction of a pipeline a total of how many degrees?

1. 11 1/4
2. 22 1/2
3. 45
4. 90

3-8. What type of tee should you use to connect lines of different sizes?

1. Tapped
2. Sanitary
3. Test
4. Reducing

3-9. Which of the following types of 90-degree Y-branches can be used as an individual vent?

1. Reducing
2. Double
3. Straight
4. Box

3-10. Horizontal 4-inch building drain lines in a straight run should have cleanouts placed at what minimum intervals?

1. 35 feet
2. 45 feet
3. 50 feet
4. 60 feet

3-11. A long-hubbed fitting used for insertion into an existing line is called a/an

1. adaptor
2. tucker
3. sisson
4. tap tee

3-12. What special fitting should be inserted into a soil branch for use with a water closet?

1. A closet bend
2. An offset
3. An increaser
4. A sewer saddle

3-13. If the gas pressure of a propane furnace puts out the lighter flame, you should

1. look for leaks
2. light another piece of paper
3. close the fuel valve
4. detach the portable propane tank

3-14. What action should you take if you suspect the lead for melting contains moisture?

1. Add lead to the melting pot
2. Let the moisture turn into steam
3. Let the lead splash until the moisture is gone
4. Dry the lead

3-15. Before starting to pour a joint with melted lead, you notice slag on top of the molten metal. What action should you take?

1. Disregard the slag and pour the joint
2. Remove the slag from the lead
3. Let the molten metal cool
4. Heat the molten metal to evaporate the slag

3-16. What tool should you use to tamp oakum into the hub of a bell-and-spigot pipe when you are making a joint?

1. A small ball peen hammer
2. A dull, cold chisel
3. A caulking iron
4. A yarning iron

3-17. When dipping up lead to pour a joint, you should take what precaution?

1. Dip enough lead to make the joint in one pour
2. Fill the tub within one half of an inch of the rim
3. Fill the ladle no more than three-fourths full
4. Preheat the hub to prevent splattering the lead

3-18. Being sure no moisture gets into the molten lead is one safety consideration. What other safety precaution should you take when working with molten lead?

1. Wear fire-retardant clothing and shoes
2. Wear a face shield and gloves
3. Maintain a large burner flame
4. Melt the burner rapidly to burn off the slag

3-19. You are using a caulking iron around a joint after the lead has hardened. You should tamp it firmly but gently with a hammer because striking the iron too hard can cause what problem?

1. A broken caulking iron
2. A cracked cast-iron hub
3. A broken clamp around the joint runner
4. A cracked lead seal

3-20. When pouring an upside down joint, you need what device that is not used in pouring vertical joints?

1. Joint runner
2. Caulking iron
3. Plumber's ladle
4. Yarning iron

3-21. When laying a cast-iron sewer line through a marshy area, you should seal the joints with

1. grout
2. molten lead
3. lead wool
4. bituminous compound

3-22. A lead-wool joint in a cast-iron pipe should be packed with oakum to within what distance of the top of the hub?

1. 1 inch
2. 3/4 inch
3. 1/2 inch
4. 1/4 inch

3-23. In what type of joint should you use a gasket?

1. Vertical caulked
2. Upside down
3. Lead wool
4. Compression

3-24. In what type of joint should you tighten stainless steel clamps to about 60 inch-pounds of torque?

1. No hub
2. Compression
3. Lead wool
4. Horizontal caulked

3-25. Vitrified clay pipe does NOT come in which of the following laying lengths?

1. 36 inches
2. 30 inches
3. 24 inches
4. 18 inches

3-26. When making a cement joint between two lengths of vitrified clay pipe, you should use grout made of what materials?

1. Bituminous compounds and water
2. Portland cement and water
3. Cement, sand, and water
4. Cement, water, and pieces of oakum

3-27. While making a grout joint, you caulk about 3/4 inch of oakum into the bell, fill the joint with grout, and then pack the grout into the joint. Before finishing the joint, you should recaulk it after waiting what length of time?

1. 45 minutes
2. 30 minutes
3. 10 minutes
4. 5 minutes

3-28. What is another name for plastisol joint connection?

1. Speed seal joint
2. Gasket joint
3. No-grout joint
4. Rootproof joint

3-29. Scratches and gouges affect plastic pipe in which of the following ways?

1. It becomes toxic
2. It rusts easier
3. It reduces pressure-carrying capacity
4. It causes electrolytic corrosion

3-30. To prevent plastic pipe from flattening during prolonged storage, you should not stack it more than how many feet high?

1. 1
2. 2
3. 3
4. 4

3-31. What are the four methods of joining plastic pipe?

1. Threading, solvent welding, fusion welding, and flare
2. Solvent welding, fusion welding, flare, and fillet welding
3. Fusion welding, fillet welding, threading, and solvent welding
4. Fillet welding, threading, solvent welding, and flare

3-32. To ensure plastic pipe and fittings are thermally balanced, you should keep them at the same temperature for what length of time before welding?

1. 60 minutes
2. 15 minutes
3. 30 minutes
4. 120 minutes

3-33. After having applied the second coat of cement to your solvent-welded PVC joint, you should insert the pipe to full-socket depth and rotate it how many turns?

1. One
2. Three-fourths
3. One half
4. One fourth

3-34. When you solvent weld PVC pipe, the surrounding air should NOT be above what temperature?

1. 75°F
2. 80°F
3. 85°F
4. 90°F

3-35. During what plastic pipe joining procedure(s) is it especially important not to rotate the pipe when it is joined with the fitting?

1. Fusion welding only
2. Fillet welding only
3. Fusion and fillet welding
4. Solvent and fillet welding

3-36. What type of plastic pipe should be used only as a temporary piping system?

1. Threaded
2. Fusion welded
3. Solvent welded
4. Fillet welded

3-37. The initial testing of a plastic pipeline should NOT exceed which of the following pressures?

1. 1 l/2 times the working pressure
2. 50 psig
3. 60 psig
4. l/2 of the full-working pressure

3-38. The high-pressure test of a PVC pipeline should be maintained for what minimum length of time?

1. 8 hours
2. 10 hours
3. 12 hours
4. 15 hours

3-39. Plastic pipe should be backfilled with material free of rocks or debris to a depth of at least how many inches above the pipe?

1. 1 to 2
2. 2 to 3
3. 6 to 8
4. 9 to 11

3-40. When sewer pipe is laid in a trench, the pipe should be placed on what type of bed?

1. Compacted sand or gravel
2. Loose fill
3. 3-inch concrete slab
4. 4-inch-diameter rock or larger

3-41. You are starting to lay sewer pipe in a trench that slopes downward from point X to point Y. At what point should you lay the first pipe, and what end of the pipe should you point upstream?

1. X, hub end
2. X, spigot end
3. Y, hub end
4. Y, spigot end

3-42. The invert of a pipe is defined as the

1. lowest point on the outside of the pipe
2. lowest point on the inside of the pipe
3. highest point on the outside of the pipe
4. highest point on the inside of the pipe

3-43. What is the most popular test for checking leakage of sewer pipe after the roughing-in is completed?

1. Air
2. Steam
3. Odor
4. Water

3-44. What action should you take when a pipeline you are testing for leaks, by the air method, does not hold a pressure of 5 psi for 15 minutes?

1. Fill the pipe with water and look for leaks
2. Apply a soapy water solution to the joints and look for bubbles
3. Apply more sealing material to each joint
4. Remove oakum and lead from each joint and repack them

3-45. Changes in sizes of sewer lines should be made only at what part of the sewer system?

1. Siphons
2. Grease traps
3. Manholes
4. Sewage regulators

3-46. When the invert of the inlet pipe is more'than 2 feet above that of the sewer outlet pipe, drop manholes are used for what purpose?

1. To trap grit
2. To reduce pressure
3. To reduce turbulence
4. To find the level of groundwater

3-47. When backfilling sewer systems, you fill to 2 feet above the pipe by hand with clean material. When, if ever, should you tamp the backfill material?

1. Every 4 inches
2. Every 6 inches
3. After the full 24-inch covering
4. Never

3-48. What type of aboveground pipe has a zinc coating to protect it against acid waste?

1. Steel
2. Copper
3. Galvanized wrought iron
4. Brass

3-49. What type of pipe consists of an alloy of zinc and copper?

1. Steel
2. Brass
3. Copper
4. Galvanized wrought iron

3-50. What is the most important function of a trap?

1. To prevent sewer gases from entering a building
2. To collect sediment before it enters the waste system
3. To serve as a connection between waste fixtures and waste systems
4. To help reduce the time for roughing-in

3-51. What does the term "trap seal" mean in plumbing?

1. An outlet that expels sewer gas to the atmosphere
2. A rubber seal that secures the trap in the system
3. The water held in the bent portion of a fixture
4. The sewer gas trapped from a building P-trap

3-52. What is the purpose of vent piping in a plumbing system?

1. To provide an outlet for sewer fumes
2. To maintain the seals of fixture traps
3. To permit the installation of sight drains
4. To ensure the grease traps works properly

3-53. What portion of the venting system extends above the highest fixture branch?

1. The back vent
2. The common vent
3. The main soil and waste stack
4. The main soil and waste vent

3-54. When installing two or more fixtures with individual vents, you should determine the size of the leg piping that connects to the main vent in what manner?

1. The leg pipe should be large enough to carry the total fixture load
2. The leg pipe should be the same size as the back vent piping
3. The leg pipe should be sized with the main stack
4. The leg pipe should be the same size as the main vent

3-55. What type of vent is used to vent two traps to a single pipe?

1. Wet
2. Circuit
3. Common
4. Back

3-56. What maximum number of fixtures is permitted on a circuit vent system?

1. Six
2. Two
3. Eight
4. Four

3-57. A wet vent that drains five fixture units must have a diameter that is what size, in inches?

1. 3.5
2. 2.0
3. 2.5
4. 3.0

3-58. The part of the main soil and waste vent extending above the roof should be at least what length?

1. 6 inches
2. 8 inches
3. 10 inches
4. 12 inches

3-59. When waterproofing the opening in a roof through which the soil and waste vent passes, you should perform what step last?

1. Solder the roof flashing to the vent
2. Install roof flashing over the top of the roofing material
3. Place a layer of roofing material over the top of the roof flashing
4. Apply roofing cement to the joint

3-60. What should be the size of the stack vent compared to that of the waste stack when a building is vented effectively?

1. Smaller than the waste stack
2. Half the size of the waste stack
3. Three fourths the size of the waste vent
4. At least as large as the waste stack

3-61. The type of trench used for a sewer line differs from that used for a waterline in that the sewer line must be

1. sloped
2. dug 2 feet wide
3. backfilled after a pipe-leakage test
4. backfilled with soil free of rocks and debris

3-62. When laying an underground waterline, you should ensure that it does NOT come closer than how many feet of nearby sewers?

1. 10
2. 12
3. 14
4. 16

3-63. When you are laying an underground waterline, what is the worst hazard in a distribution system?

1. Back siphonage
2. Faulty plumbing
3. A cross-connection
4. A leak

3-64. To permit air to escape and enter a water main, you should install what components?

1. Vacuum and air release valves
2. Service lines with vacuum valves
3. Vents tied to sewer stacks
4. Service lines and wet vents

3-65. Cast-iron pipe for water supply systems comes in standard lengths of how many feet?

1. 5
2. 10
3. 15
4. 20

3-66. What are the three major types of fittings used with cast-iron water pipes?

1. Tees, elbows, and couplings
2. Tees, bends, and elbows
3. Elbows, traps, and bends
4. Bends, tees, and traps

3-67. The joining of bell-and-spigot cast-iron pipe in water service does not depend on caulking for a tight fit when the pipe is joined with

1. poured lead
2. sulfur compound
3. lead wool
4. yam and lead

3-68. After annealing a piece of copper by heating it until it is dull red, you should cool the copper by using what procedure?

1. By quenching it in an oil bath
2. By cooling it slowly
3. By work-hardening it
4. By dipping it in water

3-69. To bend a piece of copper tubing 90 degrees, what method is best for you to use?

1. Wrap the tubing with string and bend it by hand
2. Fill the tubing with sand and bend it by hand
3. Bend the tubing with a tube bender
4. Wrap the tubing with soft wire and bend it by hand

3-70. A measurement was taken from the end of a pipe to the center of a fitting. What type of measurement was used?

1. Center to back
2. End to center
3. End to end
4. Center to center

3-71. Which of the following methods are used to join two pieces of copper tubing?

1. By soldered or flared fittings
2. By flared or threaded fittings
3. By solder or lead
4. By flared fittings and lead

3-72. You have hacksawed a piece of copper tubing for flaring. Before making the flare on one end, you should perform which of the following actions?

1. Ream the end
2. Clean the end until new metal shows
3. Slip a flare nut on the copper tubing
4. Anneal the end of the copper tubing

3-73. The tighter the fit between the copper tubing and fitting, the farther the solder or filler metal is drawn into the joint. What rule is applied?

1. Heat conduction
2. Capillary attraction
3. Flux attraction
4. Copper conduction

3-74. What are the two methods of brazing with a silver-based filler metal?

1. Filler and caulking
2. Insert and filler
3. Feed-in and insert
4. Caulking and insert

3-75. In silver brazing a joint on copper tubing by the insert method, you see the flux flow freely. You should apply heat to the fitting hub farthest from the junction of the tube and fitting until which of the following conditions occurs?

1. The fitting glows cherry red
2. The flux is drawn from the joint
3. The tubing turns dark red
4. The filler metal appears at the fitting junction

ASSIGNMENT 4

Textbook Assignment: "Plumbing" (continued)" and "Plumbing Valves and Accessories," chapters 3 and 4, pages 3-36 through 4-18.

4-1. One of the advantages of MAPP gas over acetylene is that one 70-pound cylinder of MAPP gas can do the work of more than how many 225-cubic-foot cylinders of acetylene?

1. 5.5
2. 6.5
3. 7.5
4. 8.5

4-2. In most cases, the welding tips used with acetylene are suitable for use with MAPP gas. How much larger should the tips be sized to get the best results from MAPP gas?

1. One to two times
2. Two to three times
3. Three to four times
4. One half to one time

4-3. What is the full-cylinder pressure of MAPP gas at 70°F?

1. 15 psi
2. 45 psi
3. 75 psi
4. 95 psi

4-4. When welding, you desire what color(s) of flame to be produced from MAPP gas and oxygen equipment?

1. Very blue
2. Greenish
3. Slightly yellow
4. Blue and yellow

4-5. What are the three basic types of gas flames?

1. Carburizing, biased, and neutral
2. Counterboring, neutral, and oxidizing
3. Neutral, oxidizing, and biased
4. Oxidizing, neutral, and caburizing

4-6. Which of the following factors is a safety hazard when working with MAPP gas?

1, Leaks hard to detect
2. Explosive limits in air
3. Frostlike bums from the liquid fuel
4. Local eye or skin irritation

4-7. What size of oxygen cylinder is generally used for gas-welding and gas-cutting operations?

1. 100 cubic foot
2. 145 cubic foot
3. 200 cubic foot
4. 300 cubic foot

4-8. What is the function of an oxygen regulator?

1. To reduce gas pressure to a usable working pressure
2. To reduce working pressure to a usable gas pressure
3. To withstand high pressures of working gases
4. To increase gas pressure

4-9. On regulators designed for heavy cutting, the working pressure is graduated in psi from 0 to

1. 150
2. 200
3. 300
4. 400

4-10. What are the two general types of welding torches?

1. Low pressure and medium pressure
2. Balanced pressure and medium pressure
3. High pressure and low pressure
4. High pressure and medium pressure

4-11. Because it has explosive qualities, acetylene pressure must never exceed what maximum working pressure?

1. 10 psi
2. 13 psi
3. 15 psi
4. 17 psi

4-12. What color are the hoses used for oxygen and MAPP gas?

1. Oxygen hose is yellow; MAPP gas hose is red
2. Oxygen hose is green; MAPP gas hose is yellow
3. Oxygen hose is yellow; MAPP gas hose is brown
4. Oxygen hose is green; MAPP gas hose is red

4-13. Which of the following safety precautions should you observe in maintaining oxygen-MAPP welding equipment?

1. Do not use lubricants on any of the parts
2. Keep oxygen away from water
3. Use only trace amounts of oil to lubricate parts
4. Use only government-approved grease

4-14. Filler rods are often copper-coated for which of the following reasons?

1. To better supply filler metal to the joint
2. To protect them from corrosion during storage
3. To allow them to be used on ferrous metals
4. To allow them to be used on nonferrous metals

4-15. When securing oxygas welding equipment, you should close what valve first?

1. Oxygen regulator
2. MAPP-gas regulator
3. MAPP-gas needle
4. Oxygen needle

4-16. If the needle valve of your welding torch does not shut off, you should take what action?

1. Use a wrench to get a tighter seat
2. Loosen it by hand and then tighten the seat with a wrench
3. Remove the stem assembly and then wipe the seat clean
4. Replace the seat assembly

4-17. To recondition a torch tip, rub it back and forth across a

1. piece of emery cloth
2. piece of cheesecloth
3. piece of sandpaper
4. fine file

4-18. The major cause of flashback at the torch consists of

1. needle valves that fail to seat
2. a mixing-head seat that leaks
3. regulator valves that leak
4. torch valve stems that leak

4-19. Leaking between the regulator seat and nozzle caused by worn or cracked seats can be detected by what indication?

1. A gradual drop in working-pressure gauge
2. A rise in the working-pressure gauge
3. An inability to adjust the working-pressure gauge
4. A torch flame that gradually starves

4-20. An acetylene bottle has been stored on its side. What minimum time should the bottle be in the upright position before it is used?

1. 1 day
2. 6 hours
3. 8 hours
4. 12 hours

4-21. In which of the following systems is black iron NOT used?

1. Sewage
2. Fuel oil
3. Compressed air
4. Hot-water heating

4-22. To what factor does the weight of galvanized pipe refer?

1. The wall thickness
2. The weight per foot of length
3. The number of support devices for hanging
4. The maximum thread depth of fittings

4-23. You are installing a drainage system by using steel galvanized pipe. What type of fittings should you use?

1. Pressure
2. Street
3. Durham
4. Plastic

4-24. Recessed fittings are designed in such a way that horizontal lines have how much pitch?

1. 1/8 inch per foot
2. 1/4 inch per foot
3. 1/2 inch per foot
4. 5/8 inch per foot

4-25. Which of the following fittings should you use to change the direction of a pipeline 90 degrees when the use of a nipple and elbow is impractical?

1. Tee
2. Union
3. Y-branch
4. Street elbow

4-26. What type of tee has three openings of the same diameter?

1. Reducing
2. Standard
3. Straight
4. Recessed

4-27. When connecting two pipes, you desire to obtain optimum drainage of the line by not having the pipes in line with each other. To accomplish this, you should use which of the following fittings?

1. Union
2. Reducer coupling
3. Eccentric reducer
4. Straight coupling

4-28. What fitting has both male and female threads and reduces the size of an opening?

1. Reducing coupling
2. Bushing
3. Nipple
4. Close nipple

4-29. When using the power vise to cut pipe, you should place the power switch in what position during cutting operations?

1. Forward
2. Reverse
3. On
4. Thread

4-30. Removing burrs from the inside of a freshly cut pipe is called

1. filing
2. reaming
3. boring
4. smoothing

4-31. During which of the following operations should you use plenty of cutting oil?

1. Cutting only
2. Reaming and cutting
3. Threading only
4. Cutting, reaming, and threading

4-32. When making up a threaded pipe joint, apply thread lubricant to the

1. female threads only
2. male threads only
3. male and female threads
4. inside of the pipe and female threads

4-33. You should have several unused threads on a properly threaded pipe for which of the following reasons?

1. They are cost effective
2. They allow for more tightening if the joint is not sealed
3. They compensate for overtightening
4. They prevent over-tightening the fitting

4-34. What type of pipe is corrosion-resistant, does not rust or rot, and can be cut with a carpenter's saw?

1. Cast-iron soil
2. Cement-asbestos
3. Vitrified clay
4. Galvanized steel

4-35. The specially designed coupling that connects lengths of cement-asbestos pipe has how many sealing rings?

1. One
2. Two
3. Three
4. Four

4-36. When laying ductile iron pipe, you should ensure that both the bell and plain ends are in what condition?

1. Square
2. Machined
3. Rough
4. Clean

4-37. Because of the high-impact strength of ductile iron, rocks and boulders in excess of what diameter must be removed from the backfill?

1. 6 inches
2. 8 inches
3. 10 inches
4. 4 inches

4-38. What is the most common joint used to connect two lengths of concrete pipe?

1. Gland
2. Mechanical
3. Lead
4. Slip joint

4-39. Flexibility in operating a water supply is provided by the proper selection of

1. pipe
2. fittings
3. valves
4. joining techniques

4-40. When installing a water system where frequent valves settings are required for flow regulation, you should use what type of valve?

1. Gate
2. Globe
3. Check
4. Pressure reducing

4-41. To close a butterfly valve, you must turn the handle one-quarter turn to rotate the disk what distance?

1. 30°
2. 50°
3. 75°
4. 90°

4-42. What is the primary purpose of a check valve?

1. To reduce the amount of liquid going through a line
2. To control the direction of flow through a line
3. To check the amount of residue going through a drain line
4. To drain condensate from steam, drain, and exhaust lines

4-43. When back pressure builds up, a swing- or lift-check valve performs which of the following functions?

1. It restricts the flow to a minimum
2. It partially closes
3. It stops the flow automatically
4. It maintains a continuous flow

4-44. In a pressure-reducing valve, which of the following devices may be used as a water seal between the valve inlet and the diaphragm chamber?

1. An aluminum ring
2. A neoprene O ring
3. A fiber packing ring
4. A graphite packing washer

4-45. When should a lift-check valve be used?

1. Full flow is desired
2. Frequent reversal of flow is expected
3. Limited operation of system is expected
4. Positive seating is less important

4-46. What is the theory behind the function of a pressure-reducing valve?

1. The supply pressure is at least as high as delivery pressure
2. The discharge pressure equals supply pressure
3. The discharge pressure exceeds supply pressure
4. The supply pressure never resists the flow

4-47. What feature of the spring-loaded pressure-reducing valve opens the main valve disk in spite of the entrance of water tending to close the main valve?

1. The low-pressure port
2. The high-pressure port
3. The larger surface of the main valve piston
4. The larger surface of the main valve disk

4-48. When the upper limit of pressure in a system may be exceeded, you should install what type of valve?

1. Globe
2. Check
3. Pressure reducing
4. Pressure relief

4-49. What forces hold the piston of the hydraulic control valve in a closed position?

1. Hydraulic pressure and friction
2. Spring tension and gravity
3. Line pressure and spring tension
4. Line pressure and hydraulic pressure

4-50. A valve is installed in the most desirable position when the valve stem is pointing in what direction?

1. Horizontally
2. Straight down
3. Straight up
4. Diagonally

4-51. You should use which of the following materials to spot-in a valve?

1. Red lead
2. Prussian blue
3. Lubricating oil
4. Grinding compound

4-52. In a properly ground-in valve, the contact area should cover approximately what fraction of the seating surface?

1. One fourth
2. One third
3. One half
4. Two thirds

4-53. When using pencil marks to spot-in a valve seat that has been refaced, you should place the marks on the seat at approximately what intervals?

1 1 inch
2. 1/8 inch
3. l/4 inch
4. l/2 inch

4-54. When packing the gland of a valve, you should lay the string packing in what direction?

1. In the same direction that you would tighten the gland nut
2. In the direction opposite to that of the tightening of the gland nut
3. In the same direction that the valve turns
4. It does not matter what direction you use

4-55. What is the best way of correcting damage to a gate valve that has been caused by pitting or scoring?

1. By lapping
2. By grinding
3. By scoring
4. By burnishing

4-56. Post indicators are used for what purpose?

1. To distingush fire valves from normal valves
2. To indicate an open or closed valve belowground level
3. To indicate the type of valve in use
4. To distingush water valves from sewer manholes

4-57. Valves belowground are accessed through what device?

1. A manifold
2. A header
3. A valve cabinet
4. A valve box

4-58. When a straight-reading dial on a water meter reads 000782, you should record the reading in what manner?

1. 78.2000
2. 782.0000
3. 0.000782
4. 00000782

4-59. With a circular reading dial on a water meter, you should take what action when the scale you are reading is exactly on 1?

1. Let your reading be governed by the next higher scale
2. Let your reading be governed by the next lower scale
3. Suspect the meter; this cannot happen
4. Replace the meter with a straight-reading dial

4-60. Since the registers are never reset, you must determine the amount used for the current period in what manner?

1. By dividing the last recorded reading into the current reading
2. By multiplying the current reading by the last recorded reading
3. By subtracting the last recorded reading from the current reading
4. By adding the last recorded reading and the current reading

4-61. What type of fire hydrant is designed for use in freezing temperatures?

1. Dry barrel
2. Wet barrel
3. Double barrel
4. Single barrel

4-62. Which of the following methods should you use to prevent a fire hydrant from freezing?

1. Keep groundwater from backing up into the barrel
2. Keep the weep hole plugged at all times
3. Keep the drain valve open
4. Each of the above

4-63. What type of fire hydrant is generally installed where freezing temperatures do not occur?

1. Dry barrel, California
2. Dry barrel, foot valve
3. Wet barrel, California
4. California, foot valve

4-64. What should you do, if anything, to throttle the discharge from a fire hydrant?

1. Use a gate valve at the hydrant discharge outlet
2. Adjust the hydrant valve slowly
3. Use separate globe valves at the hydrant discharge
4. Nothing; hydrant discharge flow should never be regulated

4-65. Which of the following items should you use to air test a waterline, for leaks?

1. A soapy water solution
2. Chlorinated water
3. A hydrostatic hand pump
4. Soapstone

4-66. During testing you should repair a new waterline leak on which of the following occasions?

1. As each leak is located
2. After the line has been completely tested
3. At every 100 feet
4. Before the test pressure is relieved

4-67. You have conducted a water test. After all air is removed from the pipe and the water pressure is built up to operating pressure, you should allow the pipe to stand beteween 12 to 24 hours before inspecting it for leaks.

1. True
2. False

4-68. What is the first step in disinfecting a water system after it is installed?

1. Fill the lines with chlorine gas
2. Flush the system
3. Flush the system with hypochlorite solution
4. Flush the system with hypochloric acid

4-69. The chlorine dosage for ensuring complete disinfection of a waterline depends upon which of the following factors?

1. The amount of jute and untarred hemp in the system
2. The organic chlorine-consuming material present
3. The length of time the chlorine is in contact with the water
4. Each of the above

4-70. What is the volume of water in a 20-foot pipe of 6-inch diameter?

1. 29.40 gallons
2. 16.32 gallons
3. 14.70 gallons
4. 12.08 gallons

4-71. Because of the possibility of severe corrosion and hazardous leakage, which of the following safety precautions should you observe when using a portable gas chlorinator?

1. Never use it below the room temperature of 68°F
2. Never connect it directly to the main line
3. Use rubber connections and lines
4. Each of the above

4-72. Before disinfecting a water system, flush it with water at a minimum flow velocity of

1. 6 feet per second
2. 2 feet per second
3. 3 feet per second
4. 4 feet per second

4-73. Defective piping has been replaced in a section of a water-supply system. After the main has been throughly flushed, you should feed chlorine disinfectant into the water main for what length of time?

1. Until all the predetermined dosage has been added
2. Until the desired amount of chlorine residual is in the water at the discharge end of the main
3. At least 24 hours
4. Until all air pockets have been bled from the main

4-74. Vertical fixture risers must be supported at a change of direction and at

1. each floor level
2. 4-foot intervals
3. 3-foot intervals
4. every other floor level

4-75. To prevent belowground water mains from separating under pressure, what devices should you install?

1. Hangers
2. Thrust bars
3. Thrust blocks at each pipe joint
4. Thrust blocks at all changes in the direction of water flow

ASSIGNMENT 5

Textbook Assignment: "Plumbing Valves and Accessories" (continued) and "Plumbing Fixtures and Plumbing Repairs," chapters 4 and 5, pages 4-18 through 5-30.

5-1. Pipe insulation is installed on pipe mainly to prevent which of the following problems?

1. The vibration at pipe joints
2. The passage of heat to or from liquids being carried in a nearby pipe
3. The need to paint the pipe for appearance and labeling
4. The pipe from wearing when placed in contact with surrounding surfaces

5-2. What are the two types of duct insulation?

1. Inside and outside
2. Fiber glass and cement-asbestos
3. Modular and elongated
4. Preformed and blown-in

5-3. What form of insulation provides protection from fire?

1. Rigid
2. Blanket
3. Preformed
4. Cork

5-4. What is the standard length of sponge felt paper?

1. 1 foot
2. 2 feet
3. 3 feet
4. 4 feet

5-5. What type of insulation is made up of millions of uniform closed cells?

1. Fiber glass
2. Flex rubber
3. Wool felt
4. Sponge felt

5-6. What type of insulation keeps water colder in pipes than do most other kinds of insulation?

1. Frostproof
2. Flex rubber
3. Cork pipe
4. Antisweat

5-7. What type of insulation 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 1/2-inch layer of pure wool felt, and an outer layer of deading felts with asphalt-saturated felts?

1. Antisweat
2. Frostproof
3. Wool felt
4. Sponge felt

5-8. Trenches should have their sides supported or protected by sloping when they are deeper than how many feet?

1. 5
2. 6
3. 3
4. 4

5-9. Lateral travel to an exit ladder within a trench should not exceed what distance?

1. 25 feet
2. 50 feet
3. 75 feet
4. 100 feet

5-10. There is a total of how many primary categories of scaffolds?

1. One
2. Two
3. Three
4. Four

5-11. The working load on a medium-duty scaffold must not exceed how many pounds per square foot of platform surface?

1. 25
2. 50
3. 75
4. 100

5-12. The grade of a wastewater line should be installed so the wastewater moves at not less than how many feet per second?

1. 1
2. 2
3. 3
4. 4

5-13. Scouring and damage to the pipe may happen when wastewater moves more than how many feet per second?

1. 6
2. 7
3. 8
4. 9

5-14. On an inverted siphon, the wastewater should move at least how many feet per second?

1. 1
2. 2
3. 3
4. 4

5-15. Manholes should be installed how many feet apart on a straight run of pipe up to 59 inches in diameter?

1. 200 to 400
2. 250 to 450
3. 300 to 400
4. 350 to 450

5-16. The pipe for a wastewater system should be layed with the bell end on what grade, if any, to have a good joint?

1. Upstream
2. Downstream
3. Cross stream
4. None

5-17. If you should run into a rock at the grade you are laying the pipe, you should cut the trench how many inches below the grade before backfilling it with sand?

1. 5
2. 6
3. 3
4. 4

5-18. After the pipe has been tested, you should backfill the trench in layers of

1. 5 inches
2. 6 inches
3. 7 inches
4. 8 inches

5-19. What is the largest tap that can be made in a main under pressure?

1. 1 inch
2. 2 inches
3. 3 inches
4. 4 inches

5-20. The tap is normally in what location on a water main?

1. Right side
2. Left side
3. Bottom
4. Top

5-21. The large-size lines that interconnect with smaller distribution mains are called the trunk main.

1. True
2. False

5-22. What system accessories are used for fire-fighting purposes?

1. Valves
2. Hydrants
3. Booster stations
4. Backflow preventers

5-23. You should install which of the following components to protect the water from contamination?

1. Booster valve
2. Main-line meter
3. Backflow preventer
4. Service connection

5-24. What type of branch is the best for water distribution?

1. Loop
2. Tree
3. Cross
4. Lateral

5-25. On branch mains, you should install the valve at what distance from the feeder?

1. 25 feet
2. 50 feet
3. 75 feet
4. As close as practical

5-26. A hydrant should be located approximately how many feet from a building?

1. 25
2. 50
3. 75
4. 100

5-27. When you are installing hydrants, the center of the lower outlet should not be less than how many feet above the surrounding grade?

1. 1
2. 2
3. 1.5
4. 1.75

5-28. What term describes the plumbing receptacles into which wastes are put before being discharged into the sewer?

1. Faucets
2. Pipes
3. Fixtures
4. Vent systems

5-29. The amount of water being discharged from a plumbing fixture per minute is measured in fixture units. How many gallons equal one fixture unit?

1. 5 3/4
2. 7
3. 7 1/2
4. 8 1/2

5-30. Refer to table 5-1 in the text. What number of fixture units are discharged by a head containing five water closets, three showers, five lavatories, and five urinals?

1. 52
2. 56
3. 61
4. 66

5-31. You should use what diameter of pipe to supply water to a urinal equipped with a flushing valve?

1. 7/8 inch
2. 3/4 inch
3. 1/2 inch
4. 3/8 inch

5-32. What type seal is commonly used between a water closet bowl and a water closet flange?

1. Putty
2. Concrete
3. Asbestos-cement
4. Preformed sealing ring

5-33. What is the advantage in supplying cold water to water closets by means of flush valves instead of closet tanks?

1. Repairs are easier to make
2. Reflushing is unnecessary
3. Less water is used for flushing
4. Less maintenance is required

5-34. Movement of the flush handle of a diaphragm flush valve starts the flushing action in the valve by

1. forcing the diaphragm down
2. opening the relief valve
3. opening the passage between the lower chamber and the supply line
4. raising the diaphragm off the flushing seat

5-35. In the piston type of flush valve, the piston returns to the closed position after flushing when the upper chamber fills with water through what component?

1. The main seat
2. The crown cover
3. The orifice tube
4. The handle coupling

5-36. When installing a kitchen sink, you should ensure the top of the drainboard is at least how many inches above the finished floor?

1. 30
2. 33
3. 36
4. 40

5-37. In just about all cases., domestic tub and shower combinations use what size of drain fittings?

1. 1 1/8 inch
2. 1 1/4 inch
3. 1 3/8 inch
4. 1 1/2 inch

5-38. The bathtub spout should be placed above the tub at a distance ranging between 2 inches to

1. 6 inches
2. 5 inches
3. 3 inches
4. 4 inches

5-39 Which of the following types of shower mixing valves do not allow for different pressures in the supply line?

1. Thermostatically controlled
2. Hydrostatically controlled
3. Manually controlled
4. Pressure controlled

5-40. What valve senses changes in both temperature and pressure?

1. Pressure controlled
2. Thermostatically controlled
3. Manually controlled
4. Pressure controlled

5-41. What is the most important requirement in a shower installation?

1. The type of mixing valve
2. The water pressure control
3. The spacing of the spout above the rim of the tub
4. The waterproofing of the walls and the floor

5-42. When a wall-mounted urinal is installed, the distance between the floor and the lip of the urinal should not exceed

1. 36 inches
2. 30 inches
3. 25 inches
4. 20 inches

5-43. The orifice of a drinking fountain should be at least what distance from the floor?

1. 45 inches
2. 40 inches
3. 35 inches
4. 30 inches

5-44. A 2-inch floor drain is rated at how many drainage fixture units?

1. One
2. Two
3. Three
4. Four

5-45. Domestic water heaters come in what sizes?

1. 20 to 50 gallons
2. 10 to 20 gallons
3. 10 to 30 gallons
4. 20 to 45 gallons

5-46. What feature of a water heater tank resists corrosion and prevents contamination of the water?

1. Galvanized sheet metal construction
2. Reinforced aluminum base
3. Corrosionproof combustion chamber
4. Composition glass tank lining

5-47. You can determine which pipe on a water heater tank is the inlet for the cold water or the outlet for hot water because

1. the cold water inlet pipe is the larger fitting
2. the cold water inlet pipe extends over halfway into the tank
3. the hot water inlet pipe extends over halfway into the tank
4. the hot water inlet pipe is the larger fitting

5-48. What is the purpose of the dip tube?

1. To allow cold water to go to the bottom of the tank
2. To allow hot water to go to the top of the tank
3. To cool the water at the top of the tank
4. To heat the water at the top of the tank

5-49. To aid in proper repair of breaks in water distribution systems, you must determine current conditions of the system by referring to which of the following sources?

1. Red-line blueprints of the system
2. The installer of the system
3. A system monitoring system
4. Trained personnel

5-50. When flushing a water distribution system, you should begin

1. at hydrants near the dead ends of the system
2. at the hydrants nearest the point of supply
3. at the building closest to the source of supply
4. at a hydrant that is convenient

5-51. Water main breaks require the rapid response of maintenance personnel. What precaution should you take before such an emergency occurs?

1. Ensure a recall bill is available and everyone is trained
2. Ensure everyone is trained and the public works officer is notified
3. Ensure the public works officer is notified and a recall bill is available
4. Ensure repair plans are made and everyone is trained

5-52. Small leaks in water mains can be temporarily plugged with what type of material?

1. Wood
2. Brass
3. Copper
4. Lead

5-53. What must you do before trying to thaw a frozen water pipe?

1. Isolate the section to be thawed
2. Open all valves affected by the frozen section
3. Remove valves in the frozen section
4. Secure all valves affected in the frozen section

5-54. To tnaw a frozen pipe, you should apply heat at what general location?

1. At either end of the section
2. At the center of the pipe
3. At the lowest open end of the frozen section
4. At an easily accessible section of the pipe

5-55. Under what condition may an open flame from a blowtorch be used to thaw a waterline?

1. There is no danger of fire
2. The line is less than 1 inch in diameter
3. The line is not made of copper
4. There is some water flow

5-56. When using a funnel and a tube to thaw a pipe with hot water, you should hold the funnel above the level of the frozen section of pipe for which of the following reasons?

1. To allow more hot water to be used
2. To give the hot water a head
3. To make it easier to pour the hot water
4. To prevent cold water from backing up into the tube

5-57. To thaw a frozen pipe electrically, you should apply electricity for what length of time?

1. About 30 minutes
2. Until the water begins to flow
3. About 1 hour
4. Until the water flows freely

5-58. What device controls the amperage in an alternating-current circuit to thaw a frozen pipe?

1. Rheostat
2. Thermostat
3. Transformer
4. Thermister

5-59. Electrical thawing has what primary advantage over steam thawing?

1. It is faster
2. It is safer
3. It is cheaper
4. It is easier

5-60. When the water pressure varies frequently, you should check what factor first?

1. The size of the water main
2. The pressure carried on the main line
3. The diameter of the pipes in relation to their length and height
4. The source of supply

5-61. If the pressure at a shower changes only when other outlets are open, you can usually correct the trouble by

1. removing lime and corrosion inside the pipes
2. installing automatic mixing valves
3. changing the fittings leading to the shower
4. replacing the pipe leading to the shower with larger piping

5-62. Fractures caused by water hammer usually occur at what location?

1. At the end of the pipe
2. In the middle of the pipe
3. In the fitting attached to the pipe
4. At various locations in the pipe

5-63. You have found a leak in a piece of galvanized pipe, but the nearest fitting at one end of the pipe is in a concrete wall. You should repair the leak in which of the following ways?

1. By cutting out the defective piece of pipe, rethreading the end of the pipe extending out of the wall by using a pipe wrench and a hand-type threader, and replacing the piece of pipe by using a union and a coupling
2. By cutting out the bad piece of pipe and replacing it by welding one end
3. By cutting out the bad piece of pipe and replacing it by using a piece of rubber hose to connect near the inaccessible fitting
4. By abandoning the existing pipe and installing a new piece

5-64. A leaky pipe may be repaired for temporary use by which of the following means?

1. Wrapping the leaky area with sheet rubber
2. Placing a sheet metal clamp on each side of the pipe over a sheet rubber covering
3. Fastening the sheet metal clamps in place with bolts and nuts
4. Each of the above

5-65. What are the two most common kinds of failure in water tanks?

1. Lining ruptures and accumulation of scale
2. Leaky seams and corrosion
3. Lining ruptures and corrosion
4. Leaky seams and pressure ruptures

5-66. What type of material should be used for permanent water tank patching?

1. Black steel
2. Any nonferrous metal
3. Metal that matches the tank wall in thickness and type
4. Any metal with the same thickness as that of the tank wall

5-67. The plunger in the inlet valve assembly of most flush tanks is opened by

1. lowering the float arm
2. raising the float arm
3. lowering the stopper ball
4. raising the stopper ball

5-68. Trouble in the ball cock assembly of a water closet is indicated by which of the following conditions?

1. An empty tank and no flushing
2. A full tank and incomplete flushing
3. A full tank and continuous running
4. An empty tank and continuous running

5-69. Normally, a flush tank should empty within what period of time?

1. 5 seconds
2. 10 seconds
3. 15 seconds
4. 20 seconds

5-70. What condition most likely exists if a water tempering valve has been installed on a flush tank?

1. Slow filling of the flush tank
2. Excessive water used in flushing
3. Condensation dripping from the exterior of the flush tank
4. Low water pressure entering the flush tank

5-71. What are the two most common problems with flushometer valves?

1. Intermittent flushing and long flushing
2. Intermittent flushing and short flushing
3. Long flushing and continuous flushing
4. Continuous flushing and short flushing

5-72. What is the primary reason for installing flush valves?

1. To enable automatic flushing
2. To avoid wasting water
3. To save maintenance costs
4. To improve sanitation

5-73. The closing of a piston-type flush valve is regulated by

1. the spring located in the handle
2. a screw that controls the amount of time the valve stays open
3. loss of pressure in the dashpot
4. the water pressure entering the valve

5-74. Unneeded lubrication of components or damage to the bypass tube are probable causes of which of the following problems?

1. Continuous flushing
2. Leaking closet flange
3. Irregular flushing
4. Short flushing

ASSIGNMENT 6

Textbook Assignment: "Plumbing Fixtures and Plumbing Repairs" (continued) and "Prime Movers, Pumps, and Compressors," chapters 5 and 6, pages 5-31 through 6-16.

6-1. Replacement washers for a compression type of faucet should be flat on one side, slightly rounded on the other, and made of what type of material?

1. Leather
2. Brass or copper
3. Hard composition
4. Soft composition

6-2. When the washer of a compression faucet is replaced, what other component of the faucet should be examined and replaced, if needed?

1. Threaded spindle
2. Packing nut
3. Faucet stem
4. Valve seat

6-3. What is the purpose of a ball-bearing washer installed on a faucet?

1. Reduces wear of the washer
2. Ensures tightness of the stem
3. Holds the seat washer in place
4. Reduces wear on stem

6-4. Mud, sand, or gravel in the sewer reveals what type of problem?

1. An improperly working sewage disposal plant
2. A loose joint or broken pipe in the sewer system
3. A stopped-up manhole
4. A lateral run that is plugged

6-5. What should be your first step in correcting a problem in a sewer system?

1. Inspect the system regularly
2. Determine the cause of the problem
3. Decide on the course of action for needed repairs
4. Obtain the proper tools

6-6. Routine sewer maintenance consists of which of the following actions?

1. Flushing only
2. Cleaning only
3. Repairing only
4. Flushing, cleaning, and repairing

6-7. The efficiency of flushing a sewer depends directly upon which factor?

1. Velocity of the water being used
2. Volume of water being used
3. Amount of solids in the sewer
4. Size of the sewer line

6-8. What precaution should you take with a fire hose for flushing a sewer?

1. Flush the hose thoroughly with clean water
2. Destroy the hose after use
3. Color the ends of the hose to prevent use on potable water systems
4. Flush the hose with a strong solution of calcium hypochloride

6-9. When flushing a sewer with a pneumatic ball and the sewage flow is low, you should take what action?

1. Follow up the pneumatic ball with a fire hose
2. Attach a line to the pneumatic ball
3. Add water to the upper manhole
4. Precede the pneumatic ball with a sewer rod to loosen the mass of solids

6-10. Accumulated sand deposits are removed at a manhole by using which of the following methods?

1. Sand traps
2. Water flushing
3. Turbine flushing tools
4. Each of the above

6-11. What tools are especially useful for removing masses of grease and other large obstructions from a sewer line?

1. Sand cups
2. Flat sewer rods
3. Power-driven buckets
4. Turbine-driven cleaning tools

6-12. What is the most economical means of removing roots from a sewer line?

1. Cable-drawn scrapers
2. Copper sulfate
3. Phenol blue
4. Turbine-driven cleaning tools

6-13. You should use what criteria to determine the most appropriate method for clearing a fixture stoppage?

1. Nature and seriousness of the stoppage
2. Size of the pipe
3. Location of the stoppage
4. Location of the fixture

6-14. Which of the following tools is commonly used for clearing stoppages in service sinks, lavatories, bathtubs, and water closets?

1. Closet auger
2. Force cup
3. Plumber's snake
4. Sewer snake

6-15. Trap and drain augers are commonly referred to by which of the following terms?

1. Drain busters
2. Plumber's friends
3. Sink snakes
4. Trap cleaners

6-16. When clearing stoppages in fixtures, you should maintain caution for which of the following reasons?

1. Clearing tools have sharp edges that can cause severe cuts
2. Infection is almost inevitable
3. Caustic chemicals may have been used to try and clear the stoppage
4. Broken fittings and fixtures can cause eye injuries

6-17. Before using chemicals to clear a stoppage, you must take what action to partially clear a completely blocked drain?

1. Pour hot water into the drain
2. Establish a small amount of flow manually
3. Add caustic soda and hot water to the drain
4. Place 8 ounces of baurite in the drain and pour in hot water

6-18. Acids used with pipework should be stored in a container made of what type of material?

1. Plastic or lead
2. Plastic or glass
3. Glass or lead
4. Lead or ceramic

6-19 Before personnel begin work that requires entering sewer manholes or tanks, they must take which of the following precautions?

1. Ensure they know proper use of respiratory equipment
2. Ensure space has been inspected by personnel qualified for Confined Space Entry
3. Have lifelines and standby personnel.
4. Each of the above

6-20. Wearing of goggles, gloves, or other protective clothing is governed by what primary factor?

1. The supervisor
2. The type of work to be performed
3. The written job specifications
4. The climate and location of the job

6-21. The jaws of an adjustable pipe wrench should be positioned in what manner to grip a pipe or fixture?

1. Back of the jaws only
2. Middle of the jaws only
3. Back or middle of the jaws
4. Front of the jaws

6-22. To lift a heavy piece of pipe safely, you should lift it in such a way that the weight is primarily concentrated on what part(s) of your body?

1. Arms
2. Back
3. Torso
4. Legs

6-23. You are part of a crew carrying a long and heavy pipe, and you get the signal to lower the load. You should react to the signal in which of the following ways?

1. Lower the load fast with the rest of the crew, and bend at the knees
2. Lower the load slowly with the rest of the crew, and bend at the knees
3. Lower the load in unison, but use more of your back
4. Lower the load in unison, but let your arms feel the weight

6-24. What is the authorized fluid in the vertical cylinder of a deadweight tester?

1. Mineral oil
2. SAE oil
3. Water-base hydraulic fluid
4. Mineral-base hydraulic fluid

6-25. The distance between the pointer spindle and the link connection in the sector gear of a Bourdon-tube pressure gauge must be reset if what condition is present?

1. The pointer does not travel the correct distance as a test weight is added
2. The reading is correct at the working pressure
3. The amount of increase for each weight is correct but the total reading is wrong
4. The readings are incorrect over the entire scale

6-26. The reading on a diaphragm type of air pressure gauge should be zero

1. when the three-way cock handle is at right angles to the valve body
2. when the handle of the three-way cock is parallel with the valve body
3. when the gauge is open to the pressure in the line
4. when the outside zero adjustment screw is pulled out as far as possible

6-27. What type of power can you expect from a prime mover?

1. Electrical
2. Mechanical
3. Electromechanical
4. Pneumatic

6-28. The transfer of mechanical power from a prime mover to a pump is accomplished through what type of mechanism?

1. Power train
2. Drive
3. Linkage
4. Transmission

6-29. The rotating field induction ac motor is popular for which of the following reasons?

1. It is cheap and reliable
2. It is simple and cheap
3. It is expensive and reliable
4. It is simple and reliable

6-30. What type of current produces the magnetic field in the rotor of a rotating-field induction ac motor?

1. Alternating
2. Direct
3. Induced
4. Capacitive

6-31. When an induction motor is overloaded, it draws an excessive amount of

1. resistance
2. reluctance
3. voltage
4. current

6-32. What device provides more power during the starting of a split-phase motor?

1. Relay
2. Capacitor
3. Stator
4. Rotor

6-33. The primary function of motor bearings is to reduce

1. ac power needs
2. dc power needs
3. friction
4. slippage

6-34. What problem condition could result from too much grease on the bearings?

1. Reduced conduction of heat
2. Increased resistance
3. Slippage
4. Increased friction

6-35. The flexible coupling is designed to absorb torque that is caused by

1. the inertia of the driven equipment
2. the inertia of the driving equipment
3. slight misalignment
4. too much misalignment

6-36. When inspecting the sheaves, you see evidence that the belt was rubbing on the sheaves. The probable cause is

1. a frayed belt
2. a slipping belt
3. the belt is too tight
4. a belt with grease on it

6-37. What precautions should you take when replacing a worn belt on a multiple-belt drive mechanism?

1. Replace only the worn belt
2. Replace all belts with a matched set
3. Replaces all belts and sheaves
4. Prestretch the new belt

6-38. What is the preferred way of removing dust and dirt from stator windings?

1. Use a petroleum solvent only
2. Forced compressed air into the windings only
3. Use a solvent first, then use compressed air
4. Use vacuum suction

6-39 The Utilitiesman should understand the operation of diesel and gasoline engines for which of the following reasons?

1. A CM may not be around when trouble occurs
2. The trouble could take place during off-duty hours
3. The UT must conduct first echelon maintenance on the engine
4. The UT may have subordinate CMs learning engine operations

6-40. The minimum basic procedures of a prestart inspection includes which of the following series of checks, regardless of engine type?

1. Fuel, oil, water, and fluid leaks
2. Tires, oil, belts, and water
3. Fuel, oil, water, and pressure
4. Oil, water, battery, and tires

6-41. Once a diesel engine is started, the operator should take what action to keep the valves from fouling?

1. Throttle the engine to slow idle
2. Throttle the engine to fast idle
3. Set the fuel-air mixture to a leaner mixture
4. Set the fuel-air mixture to a richer mixture

6-42. When warming up a diesel engine, you should allow how much time for the lube oil pressure gauge to show enough positive pressure?

1. 5 seconds
2. 10 seconds
3. 20 seconds
4. 30 seconds

6-43. On what stroke of a gasoline engine is air admitted to the engine?

1. Power
2. Intake
3. Compression
4. Exhaust

6-44. What is the function of a choke in a gasoline engine?

1. To increase the idling speed
2. To decrease the idling speed
3. To lean the air-fuel mixture
4. To enrich the air-fuel mixture

6-45. What type of water should be used in engine radiators to keep the coolant system free of sediment?

1. Rainwater
2. Distilled water
3. Hard water
4. Soft water

6-46. A pump transforms energy from an external source into what type of energy?

1. Internal
2. Potential
3. Kinetic
4. Latent

6-47. What two ends are contained in every pump?

1. Suction end and discharge end
2. Power end and fluid end
3. Positive end and negative end
4. Input end and output end

6-48. Head in a pump is defined as a/an

1. increase in suction
2. net positive suction
3. increase in pressure
4. total discharge

6-49. What does the term "suction head" on a pump mean?

1. The suction pressure less the vapor pressure
2. The pressure of the liquid leaving the pump
3. The difference between the suction head and the discharge head
4. The total pressure of the liquid entering the pump

6-50. What term is used to describe the process whereby a pump becomes vapor bound and reduces suction lift?

1. Reverse suction
2. Reverse compression
3. Cavitation
4. Reciprocation

6-51. What device(s) on a relief valve permits the spring tension to be regulated?

1. Needle
2. Ball
3. Disk and stem
4. Nut or screw

6-52. Rotary pumps use which of the following principles to discharge water in a continuous flow?

1. Throwing and plunging
2. Entrapment and displacement
3. Plunging and reciprocation
4. Reciprocation and throwing

6-53. There is a total of how many gears in the gear type of rotary pump?

1. One
2. Two
3. Three
4. Four

6-54. Screw pumps are used mainly to pump what kind of fluid?

1. Viscous
2. Abrasive
3. Corrosive
4. Volatile

6-55. What is the source of lubrication for the elements of a rotating pump?

1. Oil from the fittings
2. Grease forced between the spur gears
3. The liquid handled by the pump
4. Graphite added to the liquid in the pump

6-56. Most reciprocating pumps in the Navy are of what type?

1. Direct acting
2. Indirect acting
3. Horizontal acting
4. Single acting

6-57. What part of a diaphragm pump converts rotary motion to reciprocating motion?

1. The drive shaft
2. The camshaft
3. The eccentric connecting rod
4. The centrifugal cam

6-58. The liquid in a diaphragm is made to move by what kind of motion?

1. Centrifugal
2. Centripetal
3. Rotary
4. Reciprocating

6-59. Because of the makeup of the liquids handled by the diaphragm pump, operator maintenance means frequent inspection of the

1. suction inlet strainer
2. pressure outlet strainer
3. liquid cylinder
4. debris collector

6-60. In a double-acting pump, what number of strokes does it take to draw in and discharge liquid?

1. One
2. Two
3. Three
4. Four

6-61. Which of the following features is indicative of a low-pressure pump?

1. The steam piston has a larger diameter than the plunger in the liquid cylinder
2. The pressure per square inch is greater in the liquid cylinder than in the steam cylinder
3. A small volume of liquid with a high pressure is discharged
4. A large volume of liquid with a low-discharge pressure

6-62. What part of a reciprocating pump automatically times the admission and release of steam to and from each end of the steam cylinder?

1. Rocker arm
2. Tappet collar
3. Valve assembly
4. Pump rod

6-63. What action should you take first before examining or repairing a reciprocating pump?

1. Gather the tools required
2. Assemble blueprints, drawings, and other data
3. Measure the main cylinders and valve chest cylinders
4. Draw a diagrammatic sketch of the pump

6-64. There are what number of moving parts in the basic centrifugal pump?

1. One
2. Two
3. Three
4. Four

6-65. Which of the following laws of physics applies to the centrifugal pump?

1. As the velocity of fluid increases, the pressure increases
2. The suction at the center of rotation is inversely proportional to the pressure away from the center of the rotation
3. As the velocity of a fluid increases, the pressure decreases
4. The pressure at the center of rotation equals the pressure away from the center of rotation

6-66. Multistage centrifugal pumps have two or more of what type of devices?

1. Shafts
2. Impellers
3. Volutes
4. Diffusers

6-67. What type of impeller has sidewalls extending from the eye to the outer edge of the vane tips?

1. Volute
2. Vertical
3. Closed
4. Open

ASSIGNMENT 7

Textbook Assignment: "Prime Movers, Pumps, and Compressors," chapter 6, pages 6-16 through 6-53.

7-1. What is the purpose of the volute type of centrifugal pump?

1. To increase the velocity of the fluid
2. To allow liquid to enter the eye from more than one direction
3. To change the direction of the impeller discharge
4. To increase the pressure of the liquid

7-2. What part of a volute turbine type of centrifugal pump forces a change of directionof the impeller discharge?

1. Closed impeller
2. Open impeller
3. Multistage impeller
4. Diffuser vanes

7-3. To produce sufficient discharge pressure, a turbine well centrifugal pump uses a

1. single-stage impeller with volute
2. single-stage impeller with pressure jets
3. multistage impeller with volute
4. multistage impeller with pressure jets

7-4. For a domestic water supply, a centrifugal pump is used in shallow wells that do not exceed what depth?

1. 20 feet
2. 22 feet
3. 24 feet
4. 26 feet

7-5. Even though not classified as such, vertical and horizontal centrifugal sump pumps are used as what type of pumps?

1. Sewage
2. Water
3. Steam
4. Fuel

7-6. Which of the following characteristics is a disadvantage of centrifugal pumps?

1. Complexity
2. Poor suction power
3. Heaviness
4. Limited adaptabillity

7-7. The suction lines and inlets of most centrifugal pumps are placed below the source level of the liquid being pumped for which of the following reasons?

1. To make primer easier
2. To reduce the need for priming
3. To reduce clogging
4. To reduce cavitation

7-8 The velocity of a liquid increases to the point where the pressure drop reaches the pressure of vaporization of the fluid. What is this phenomenon called?

1. Capitulation
2. Cavitation
3. Vitiation
4. Decomposition

7-9. When cavitation occurs in extreme instances, what damage can the pump experience?

1. Severe cracking of the pump housing around bolts
2. Lock-up of the pump impeller
3. Disintegration of the pump bearings
4. Structural failure of the impeller blades

7-10. When the design of a pump causes cavitation, you can use which of the following methods to remedy the condition?

1. Increase suction lift with a foot valve
2. Install smaller piping
3. Decrease suction lift with a foot valve
4. Regulate the liquid demand

7-11. You close the discharge stop valve of a centrifugal pump and then start the pump. After the pump is at normal operating speed, you neglect to open the discharge stop valve. What happens as the pump builds up to its maximum discharge pressure?

1. The liquid begins to churn
2. The suction pressure overcomes the discharge pressure
3. The liquid passes to the discharge side of the pump
4. The heat is dissipated as the discharge pressure builds up

7-12. Packing is a general term that refers to

1. materials used to repair moving machinery
2. equipment used to seal leaks
3. materials used to seal water tanks
4. materials used to seal moving machinery joints

7-13. What material should you use to replace the packing on a pump?

1. Cork
2. All-purpose material
3. The product specified by the manufacturer
4. A combination of asbestos and babbitt

7-14. Uneven adjustment of the gland nuts on packing can cause what condition to occur on a pump?

1. Cracking of the suction flange
2. Scoring or grooving of the pump shaft
3. Overheating of the pump motor
4. Misalignment of the shaft between the pump and the motor

7-15. Which of the following materials do most water service pumps use for the seal faces in mechanical seals?

1. Babbitt
2. Brass
3. Wool felt
4. Carbon

7-16. By what means are mechanical seals positioned on the shaft?

1. Stub or step sleeves
2. Setscrews
3. Spring pressure
4. Seal gland or packing ring

7-17. Flexible couplings conpensate for

1. excessive shaft slippage
2. slight misalignment
3. excessive misalignment
4. slight shaft slippage

7-18. When both the pump and the driving unit of a centrifugal pump need to be shifted sidewise or endwise for alignment, you should use what device?

1. Large setscrews
2. Wedges or shims
3. Jacking screws
4. Side brackets

7-19. Which of the following instruments should you use to check alignment of the shaft in a centrifugal pump?

1. A micrometer
2. A 12-inch scale
3. A dial indicator
4. An inside caliper

7-20. Which of the following is NOT one of the materials used for internal water-lubricated bearings?

1. Lignum vitae
2. Graphited bronze
3. High-lead content bronze
4. Low-lead content brass

7-21. On low-pressure pumps, the wearing rings need replacing when the wearing ring diametrical clearance exceeds the designed amount by .015 inch to .030 inch.

1. True
2. False

7-22. On high-pressure pumps, the wearing rings should be renewed when the clearance of the ring exceeds the manufacturer's plans by what percentage?

1. 100%
2. 90%
3. 80%
4. 70%

7-23. You must take a total of how many measurements of wearing rings with a micrometer to determine the wearing ring diametrical clearance?

1. One
2. Two
3. Three
4. Four

7-24 What factors are considered when replacing wearing rings?

1. Amount of work required to diassemble the pump
2. Downtime allowed by the command
3. Outside repair activity assistance
4. All of the above

FOR QUESTIONS 7-25 THROUGH 7-27, REFER TO TABLE 6-1 ON PAGES 6-25 AND 6-26.

7-25. When a centrifugal pump rotates in the wrong direction, which of the following symptoms is indicated?

1. It does not develop enough discharge pressure
2. It operates at a low capacity
3. It works a while then fails to deliver liquid
4. It does not deliver any liquid

7-26. Which of the following conditions can cause a motor-driven centrifugal pump to require too much power?

1. Misalignment
2. Lack of rigidity in the foundation
3. Low viscosity of the liquid being pumped
4. Too much heat in the liquid being pumped

7-27. A continual low pressure is found on a circulating pump. What is the most likely cause?

1. Blockage in the suction piping
2. Air or gas in the liquid being pumped
3. Clogged strainer
4. Cracked pump housing

7-28. When a pump fails to build up pressure after the discharge valve opens and the pump speed increases, you should take what action first?

1. Prime the pump
2. Open all valves on the pump suction line
3. Close the discharge valve
4. Secure the pump

7-29. Air-lift pumps are used for which of the following pumping applications?

1. Fuel-oil storage
2. Feedwater tanks
3. Wells
4. Chemical feeders

7-30. What does an air-lift pump use instead of a rotating mechanism to move liquid?

1. Centrifugal force
2. Water
3. Compressed air
4. Static pressure

7-31. When the air-water mixture of an air-lift pump reaches the top of the discharge pipe, how is the air separated from the water?

1. The mixture enters an air discharge tank that lets the air discharge naturally
2. The mixture strikes a deflector or separator which relieves the water from the air
3. The mixture is pumped into an open air tank and agitated
4. The mixture is funneled through a baffled pipe which separates the water from the air

7-32. The air-lift pump can deliver large quantities of water at

1. relatively low pressures
2. average household pressures
3. relatively high pressures
4. extremely high pressures

7-33. The capacity of an air-lift pump depends largely on what factor?

1. Length of time submerged in the well
2. Percent of air supplied to the pump
3. Length of time the pump is in operation
4. Percent of submergence of a foot piece

7-34. What condition tends to be accelerated by the entrained oxygen in air-lifted water?

1. Water contamination
2. The life of the well casing
3. Corrosion of the pipes
4. Maintenance problems

7-35. What procedure should you follow when operating an air-lift pump?

1. Use as much compressed air as possible
2. Regulate the compressed air correctly
3. Change foot pieces monthly
4. Lubricate the regulator valve daily

7-36. Pumps that use rapid flow of a fluid to entrain another fluid and thereby move it from one place to another are called

1. centrifugal pumps
2. rotary pumps
3. air-lift pumps
4. jet pumps

7-37. The ejector type of jet pump uses which of the following substances to entrain the fluid being pumped?

1. Steam
2. Air
3. Water
4. Compressed gas

7-38. After receiving a new pump from supply, you should immediately check

1. to ensure there are no loose or missing parts
2. to ensure the unit has a preservative covering
3. the site where the pump is to be installed
4. the nameplate data against the bill of material

7-39. When placing a water pump, you should ensure it is installed in a dry spot that is in easy reach for inspection and maintenance and is located

1. midway between the source and the major water-using equipment
2. as far from the source as possible
3. as near as possible to the source
4. in the utility room

7-40. You are installing a pump unit on a concrete base. What inspection should you make before grouting around the base?

1. Ensure the pump is aligned and level
2. Ensure the pipes are connected to the pump
3. Ensure the bolts are tight
4. Ensure the foundation is level

7-41. Grout is a mixture of what types of materials?

1. Cement, sand, and ‘water
2. Pumice, sand, and water
3. Gravel, cement, and water
4. Gravel, sand, and water

7-42. In checking for angular adjustment between the pump shaft and the drive shaft, you should insert a feeler or taper gauge at how many points to ensure all readings are the same?

1. One
2. Two
3. Three
4. Four

7-43. Pump assemblies are supplied by the manufacturer with pump and driver on the same baseplate or with just the pump on the baseplate with the driver separate.

1. True
2. False

7-44. You are installing a pump and driver that are separate. What part should you bolt down and align first?

1. The pump
2. The driver
3. The shaft couplings
4. The pump rotor

7-45. You should grout a baseplate in which of the following ways?

1. By placing grout around the foundation bolts only
2. By removing shims and leveling pieces before grouting
3. By grouting the complete baseplate, including the leveling pieces and shims
4. By grouting only the pump baseplate

7-46. After the grout has set and the foundation bolts have been tightened, the pump should be checked for

1. alignment of the discharge and suction piping
2. level of the pump
3. parallel and angular alignment
4. shaft coupling tightness

7-47. When expansion joints are used in the piping system, they should be located at what point?

1. Next to the pump to support connections
2. At the first branch from the discharge and suction piping to aid in support
3. Should not be used in the system
4. Beyond the pipe supports close to the pump but not next to it

7-48. Suction piping must be selected and sized properly to minimize

1. volume restrictions
2. pressure loss
3. overheating of the driver
4. corrosion of the pump impeller

7-49. What device should you use to prevent air pockets in the suction line of a centrifugal pump?

1. Pipe seals for all joints
2. Eccentric reducers in the suction line
3. Check valves in the suction line
4. Unions on the discharge line

7-50. What type of valve should you install on the suction line to avoid priming the pump every time it is started?

1. Foot
2. Gate
3. Check
4. Globe

7-51. The stuffing box uses liquid to flush and lubricate the packing. The quality of this liquid is not important.

1. True
2. False

7-52. The pressure of flushing or lubricating liquid is set at what pressure above the stuffing box maximum operating pressure?

1. 5 to 12 psi
2. 5 to 10 psi
3. 3 to 8 psi
4. 3 to 6 psi

7-53. You are able to pump which of the following types of waste with a pump that has double mechanical seals?

1. Solids
2. Sewage
3. Slurries
4. Each of the above

7-54. For average operating conditions, it is recommended that 1 ounce of grease be added to the bearings in a pump at what intervals?

1. 3 to 5 months
2. 4 to 5 months
3. 3 to 6 months
4. 4 to 6 months

7-55. What type of grease is recommended for bearing lubrication?

1. Mineral grease with soda-soap base
2. Grease from vegetable oil
3. Grease from animal oil
4. Each of the above

7-56. When air is compressed, its volume is reduced and its pressure is increased.

1. True
2. False

7-57. Most air compressors in the Navy are driven by what type of prime mover?

1. Turboprop
2. Steam turbine
3. Internal combustion engine
4. Electric motor

7-58. What principle is used in a reciprocating air compressor to replace the cam actions of valves in an internal combustion engine?

1. Equal pressure overcomes spring tension
2. Spring pressure overcomes differential pressure
3. Differential pressure overcomes spring pressure
4. Equal pressure overcomes differential pressure

7-59. What change must be made in the design of a multistage arrangement of compressors to obtain higher air pressure?

1. The second-stage cylinder must be smaller than the first
2. The first-stage cylinder must be smaller than the second
3. The first-stage cylinder must be smaller than the third
4. The third-stage cylinder must be smaller than the first

7-60. An air compressor unloading system serves what function?

1. To relieve the compressor prime mover of the compression load during starting
2. To remove vapor from the airstream
3. To relieve the air cylinders and heads of heat
4. To remove oil from the airstream

7-61. What is a function of the air intake filter on an air compressor?

1. To exclude moisture
2. To keep the intake air free of dust
3. To dry humid air
4. Each of the above

7-62. What part of an air compressor removes moisture and dirt from the compressed air before it reaches the storage tank?

1. The air intake filter
2. The air receiver
3. The filter receiver
4. The filter and moisture separator assembly

7-63. When an air compressor cannot be placed on level ground, what are the limits on out-of-level operation?

1. 5° lengthwise and 5° sidewise
2. 10° lengthwise and 10° sidewise
3. 15° lengthwise and 15° sidewise
4. 20° lengthwise and 20° sidewise

7-64. The first stage of the air cleaner rotates the intake air and separates a lot of the dust collected in the dust cup. What is the process called?

1. Centripetal precleaning
2. Centrifugal precleaning
3. First-stage cleaning
4. First-stage precleaning

7-65. Which of the following checks should you make while the compressor is working?

1. Turn on the cooling water to ensure circulation through the compressor
2. Drain condensate from the coolers
3. Inspect the safety valves
4. Check the pressure of the cooling water

7-66. Compressed air falls into what three categories?

1. Power, process, and control
2. Process, control, and operation
3. Control, power, and operation
4. Power, operation, and industrial

7-67. A low-pressure air compressor system can deliver air up to what maximum psig?

1. 100
2. 115
3. 125
4. 130

7-68. What type of pipe is used for air distribution on a medium-pressure system?

1. Galvanized
2. Copper
3. Ductile cast iron
4. Black steel

7-69. Air compressor piping should be pitched in the direction of flow at how many inches per 100 feet?

1. One
2. Two
3. Three
4. Four

7-70. What device is used to absorb sound made by the intake and output of a compressor?

1. Quieter
2. Silencer
3. Muffler
4. Filter

7-71. What device removes moisture from air lines that would otherwise condense in the lines?

1. Dryer
2. Trap
3. Separator
4. Receiver

7-72. Which of the following agents should you use to clean compressor intake filters, cylinders, and air passages?

1. Soapy water
2. Kerosene
3. Benzene
4. Hydraulic oil

ASSIGNMENT 8

Textbook Assignment: "Water Treatment," chapter 7, pages 7-1 through 7-25.

8-1. The hydrologic (water) cycle is the process of circulation of water from the

1. oceans, to the atmosphere, to the earth, and beneath the earth
2. oceans, to the earth, and beneath the earth, and to the atmosphere
3. atmosphere, to the earth, and beneath the earth, and to the ocean
4. earth, and beneath the earth, to the ocean, and to the atmosphere

8-2. The flow of rainwater or melted snow into the soil is known by what term?

1. Evaporation
2. Infiltration
3. Dissipation
4. Condensation

8-3. What process in the hydrologic cycle forms clouds?

1. Evaporation
2. Infiltration
3. Condensation
4. Dissipation

8-4. In what way do plants influence the water cycle?

1. By evaporating water
2. By dissipating water
3. By condensing water
4. By transpiring water

8-5. The basic water supply is composed of what two classes?

1. Surface water and groundwater
2. Aquifers and wells
3. Moving water and still water
4. Artificial and natural

8-6. Water as rain, snow, sleet, fog, or dew falls upon the surface of the earth. What is the process called?

1. Condensation
2. Evaporation
3. Precipitation
4. Dissipation

8-7. The water precipitated from the atmosphere on the surface of the earth, absorbed by the soil, and collected below a certain level is known as

1. surface water
2. groundwater
3. precipitation
4. infiltration

8-8. Groundwater is NOT found under which of the following conditions?

1. A layer of decomposed rock is between the uppermost layer of soil and the virgin rock itself
2. The depth of the soil varies from a few inches to many feet
3. Part of the earth's crust is between solid rock and the surface of the earth
4. Virgin rock appears at the surface with no overlying decomposed rock or soil

8-9. Strata may be composed of hard materials, such as

1. silica
2. gypsum
3. clay
4. chalk

8-10. What term describes the capacity of the material in any stratum to transmit water under pressure?

1. Impermeability
2. Porosity
3. Permeability
4. Osmosis

8-11. What condition must be present for groundwater to constitute a water table?

1. Permeable
2. Porous
3. Percolated
4. Stabilized

8-12. Any stratum that bears groundwater is called a/an

1. well
2. aquifer
3. water table
4. interstice

8-13. Water beneath the surface occurs in a total of how many zones?

1. Five
2. Four
3. Three
4. Two

8-14. Perched water comes about because water is caught in a zone higher than the established water table. In what zone does this occur?

1. Soil moisture zone
2. Saturation zone
3. Percolation zone
4. Aeration zone

8-15. What conclusion can be drawn from the discussion in the textbook on the quality of water?

1. All water is impure to start with
2. Most water must be treated to make it safe for human consumption
3. Only industry does not have to treat water
4. Most water is pure to start with

8-16. Simply because water is clear may lead you to make what dangerous assumption?

1. It is potable
2. It is impure
3. It is contaminated
4. It is a carrier of disease

8-17. What are the two major classes of impurities in water?

1. Organic and inorganic
2. Odorless and smelly
3. Suspended and free
4. Dissolved and suspended

8-18. Algae is an example of what type of impurity?

1. Suspended
2. Dissolved
3. Inorganic
4. Decontaminated

8-19. What term is used to describe the time a waterborne disease requires to grow within a person's system?

1. Bacteriological period
2. Incubation period
3. Contamination period
4. Immunization period

8-20. An attack of paratyphoid immunes a person from what future disease?

1. Typhoid
2. Cholera
3. Paratyphoid
4. Amoebic dysentery

8-21. What type of waterborne disease requires a carrier to infect people?

1. Diarrhea
2. Cholera
3. Typhoid
4. Schistosomiasis

8-22. The formation of gelatinous particles in water by chemical action is known as

1. coagulation
2. flocculation
3. sedimentation
4. suspension

8-23. Clearing water of foreign suspended matter by a natural settling process is known as

1. filtration
2. coagulation
3. sedimentation
4. flocculation

8-24. What water purification process follows sedimentation to remove suspended matter?

1. Disinfection
2. Filtration
3. Coagulation
4. Flocculation

8-25. What is an effective filtration device used at overseas locations?

1. Diatomite filter
2. Filter alum
3. Floc chamber
4. Settling tank

8-26. Which of the following disinfectants is most often used because it is both economical and dependable used?

1. Bromine
2. Chlorine
3. Ozone
4. Potassium permanganate

8-27. What process comes first and last in making water safer for consumption?

1. Sedimentation
2. Coagulation
3. Chlorination
4. Filtration

8-28. The rate of disinfection of water drops drastically when the pH exceeds what level?

1. 7.5
2. 7.8
3. 8.0
4. 8.4

8-29. Each pound of liquid chlorine produces approximately how many cubic feet of chlorine gas?

1. 8
2. 7
3. 6
4. 5

8-30. What disinfectant is seldom used in water treatment because of rapid deterioration and low available chlorine yield?

1. HTH
2. Pittchlor
3. Lobax
4. Chlorinated lime

8-31. The amount of chlorine consumed in reacting with organic substances in water within a given time is called the

1. available chlorine
2. combined available chlorine
3. residual chlorine
4. chlorine demand

8-32. What minimum length of time must elapse from the time chlorine is introduced until the water can be used?

1. 10 minutes
2. 15 minutes
3. 30 minutes
4. 60 minutes

8-33. The amount of alkaline substances in a given sample of water when titrating downward to a pH of 4.2 with sulfuric acid defines the

1. pH of water
2. alkalinity of water
3. acidity of water
4. positive logarithm of hydrogen

8-34. What term describes the application of chlorine after filtration but before the water leaves the treatment plant?

1. Postchlorination
2. Rechlorination
3. Prechlorination
4. Residual chlorination

8-35. How much chlorine should be maintained in the chlorinator room?

1. Enough needed for anticipated emergencies
2. Enough for normal daily demands
3. Enough for a 48-hour supply
4. Enough for a 72-hour supply

8-36. What type of solution is used to detect a chlorine leak?

1. Ammonia
2. Soapy
3. Acetone
4. Peroxide

8-37. Chlorination equipment is classified by type, such as manual, semi-automatic, and fully automatic. This style of classification depends on what factor?

1. The rate of feed
2. The method of control
3. The installation procedures
4. The type of chlorine required

8-38. What do the three types of chlorinators have in common?

1. They are used in locations where water flows at a uniform rate
2. They start and stop when the water flow starts and stops
3. They meter chlorine through the pressure of a metering device
4. They require the chlorine dosage to be set manually

8-39. Chlorinators may be classified by what two types of feed?

1. Direct and indirect
2. Solution and direct
3. Direct and automatic
4. Solution and automatic

8-40. What type of chlorinator is used mainly as emergency equipment?

1. Direct feed
2. Indirect feed
3. Solution feed
4. Automatic feed

8-41. At which of the following points of an injector mechanism of the chlorinator is chlorine gas drawn into a jet stream of water?

1. Midpressure
2. High pressure
3. Low pressure
4. Each of the above

8-42. What is the expansion ratio of chlorine to gas?

1. 1:230
2. 1:320
3. 1:460
4. 1:640

8-43. What is the 24-hour capacity of the heavy-duty Midget Chlor-O-Feeder?

1. 95 gallons
2. 85 gallons
3. 75 gallons
4. 65 gallons

8-44. Empty chlorine cylinders should be stored in which of the following locations?

1. A room with a connecting door to the equipment room
2. The same room as the operating equipment
3. A separate room opening only from the outside
4. Any covered storage area

8-45. The clorination room in a water treatment plant is on sloping ground. Part of the floor level is aboveground and part is belowground. Which of the following features should the room contain?

1. Doors that open outward
2. A positive-pressure, blower-type exhaust fan
3. Two-way lighting switches on the outside and on the inside
4. Each of the above

8-46. For emergencies, what type of standby system should be used for discharge of chlorine cylinders?

1. Non-potable water
2. Alkali absorption
3. Chlorine containment
4. None of the above

8-47. When preparing and handling hypochlorite solutions, you should wear what type of safety clothing?

1. Goggles and plastic gloves
2. Rubber gloves and a protective apron
3. Protective apron and goggles
4. Plastic gloves and a protective apron

8-48. You are testing for leaks in ammonia gas piping with a bottle of diluted muriatic acid. If a leak is discovered, the fumes will be what color?

1. Yellow
2. Blue
3. Red
4. White

8-49. A Utilitiesman is NOT expected to perform which of the following tasks when conducting water treatment quality control?

1. Collect samples for chemical analysis
2. Collect samples for bacteriological examination
3. Run treatment control tests
4. Conduct a spectrographic analysis

8-50. For test results to show the actual condition of the water, what should be the condition of the samples?

1. Representative and uncontaminated
2. Abundant and realistic
3. Comprehensive and random
4. Typical and abundant

8-51. When you are collecting samples for chemical analysis and mineral content, the sample is usually what size?

1. 1 pint
2. 1 liter
3. 1 quart
4. 1 gallon

8-52. Before raw water from a lake or stream is taken for a testing sample, the discharge pump of a submerged water sampler should be operated until the discharge line is

1. flushed completely
2. free of water
3. free of trapped air
4. delivering water

8-53. A small amount (0.02 to 0.05 grams) of thiosulfate should be added to a water sample bottle to be used in a bacteriological examination of what type of water sample?

1. Water that comes from a lake
2. Water that contains harmful bacteria
3. Water that contains chlorine residual
4. Water that comes from a pipe tap

8-54. In collecting a water sample from a tap for bacteriological examination, you should take what action to prevent further contamination of the water?

1. Flush the tap
2. Heat the tap with an alcohol/gasoline torch
3. Remove the bottle stopper
4. Attach a rubber hose to the tap

8-55. To collect samples of water from lakes or ponds, you should be (a) what appropriate distance from the shore and select samples from (b) what minimum depth of water?

1. (a) 15 feet (b) 4 feet
2. (a) 25 feet (b) 5 feet
3. (a) 25 feet (b) 4 feet
4. (a) 15 feet (b) 5 feet

8-56. You are trying to determine how much of a substance is in a given solution by measuring the amount of another substance or reagent that must be added to the given solution to produce a given reaction. What is the name of this process?

1. Clarification
2. Titration
3. Colorimetric analysis
4. Colorimetric synthesis

8-57. What two tests are used to test water for chlorine residual?

1. Orthotolidine and orthomangesium
2. Orthomagnesium and orthocalcium
3. Orthotolidine and orthotolidine-arsenite
4. Orthotolidine-arsenite and orthomagnesium

8-58. What advantage does the OTA test have over the orthotolidine test?

1. It has no false color
2. It is less expensive
3. It is simpler
4. It has fewer procedural steps

8-59. When the chlorine residuals are measured during the OTA test, the sample should never exceed what temperature?

1. 20°C
2. 15°C
3. 10°C
4. 0°C

8-60. You have added a measured volume of water to the orthotolidine reagent in tube OT, mix the tube contents quickly, and 5 minutes later you have compared the results with the color standards. What value(s) have you obtained?

1. Free available chlorine
2. Total chlorine residual
3. Free available chlorine and interfering colors
4. Total chlorine residual and interfering colors

8-61. After the test procedure has been completed, the total chlorine residual may be calculated by subtracting what values?

1. (B-1) from (OT)
2. (B-2) from (OT)
3. (B-1) from (A)
4. (B-2) from (A)

8-62. What reading on a pH scale indicates a sample of water is neutral and that it exhibits no acidic or alkaline characteristics?

1. 5.2
2. 6.0
3. 7.0
4. 8.4

8-63. What pH indicator is used for testing water with a pH range of 6.0 to 7.6?

1. Cresol red
2. Thymol blue
3. Chlorophenol red
4. Bromothymol blue

8-64. In the salinity test, test solutions are measured with pipettes calibrated in

1. 0.10 mg
2. 0.10 ml
3. 0.01 mg
4. 0.01 ml

8-65. You are determining the alkalinity of a water sample by the methyl purple procedure. What color appears when the end point has been reached?

1. Green
2. Red
3. Gray
4. Purple

8-66. When determining the alkalinity of water with the methyl orange procedure, you should add what amount of acid?

1. 0.1 ml
2. 0.2 ml
3. 0.3 ml
4. 0.5 ml

8-67. In the titration method of determining water hardness, standard ETDA solution is added to the water sample until the end point is reached. The indicator should be what color?

1. Red in the presence of calcium and magnesium ions and blue in their absence
2. Blue in the presence of calcium and magnesium ions and red in their absence
3. Green in the presence of calcium and magnesium ions and pink in their absence
4. Pink in the presence of calcium and magnesium ions and green in their absence

8-68. To hold the pH value of a 50-ml water sample to the desired level of 10, you should add how many milliliters of hardness buffer?

1. 1.00
2. 2.00
3. 0.50
4. 4.00

8-69. In addition to the amount of chloride ions in the water, the chlorine test measures the amount of

1. magnesium
2. calcium
3. sodium chloride
4. calcium carbonate

8-70. What reagent is used to decolorize the sample in a chloride test?

1. Sulfuric acid
2. Aluminum hydroxide
3. Sodium carbonate
4. Silver nitrate

8-71. You are performing a sulfate test. After you add 1 ml of barium chloride solution to the filtrate, a clear solution appears after shaking the bottle. The result can be recorded in what manner?

1. Over 100 ppm
2. Under 100 ppm
3. Over 200 ppm
4. Between 100 and 300 ppm

8-72. When a water sample is filtered to remove turbidity before a color determination is made, what amount of the first portion of the filtered water should be discarded before a sample for the comparator test is selected?

1. 25 ml
2. 50 ml
3. 75 ml
4. 100 ml

8-73. When carrying out the threshold odor test, you must dilute how many glass-stoppered Erlenmeyer flasks to 250 ml of odor-free water?

1. One
2. Two
3. Three
4. Four

8-74. Ten gallons of odor-bearing water are diluted with 100 gallons of odor-free water. A barely perceptible odor remains. What threshold number should be assigned to the water?

1. 10
2. 100
3. 1,000
4. 10,000

8-75. In the threshold odor test, you heated the flask to 140°F on a hot plate. You then shook the odor-free flask, removed the stopper, and sniffed the vapors. Now, you should do the same with the flask containing how many ml of odor-bearing water?

1. 250
2. 63
3. 16
4. 4

ASSIGNMENT 9

Textbook Assignment: "Water Treatment" (continued) and "Maintenance of Water Treatment Equipment," chapters 7 and 8, pages 7-26 through 8-31.

9-1. What water treatment control test is used to find the coagulation of water to remove color and turbidity?

1. Hardness
2. Alkalinity
3. Jar
4. Taste and odor

9-2. How many times do you repeat the steps of the jar test?

1. Until satisfactory results are obtained
2. Two times
3. Three times
4. Four times

9-3. There is a total of how many steps required to perform the turbidity test of water with special instruments?

1. Five
2. Two
3. Three
4. Four

9-4. What step in the instrument procedure for measuring the turbidity in a sample of water determines the turbidity content of the sample?

1. Inserting the glass plunger in the water
2. Placing the tube in the instrument
3. Relating the dial reading on the instrument to the instrument chart
4. Seeing a uniform field through the eyeglass

9-5. Data should be recorded on the Potable Water Supply and Distribution Operating Record at what intervals?

1. Hourly
2. Daily
3. Weekly
4. Monthly

9-6. Activity files concerning the operating records for Potable Water Supply and Potable Water Treatment should include the current year and how many preceding years?

1. 1
2. 2
3. 3
4. 4

9-7. What type of chlorinator dissolves the gas in a minor flow of water and injects the solution into the flow that is to be treated?

1. Direct feed
2. Solution feed
3. Automatic feed
4. Semiautomatic feed

9-8. What types of diaphragms are used in chlorinators to control chlorine feed?

1. Water and mechanical
2. Automatic and water
3. Mechanical and automatic
4. Semiautomatic and water

9-9. What type of chlorinator is designed for use as emergency equipment or on small installations?

1. Solution feed
2. Volumetric feed
3. Direct feed
4. Gravimetric feed

9-10. Direct feed chlorinators can NOT be used where the pressure of the water being treated exceeds what level?

1. 10 psi
2. 20 psi
3. 30 psi
4. 40 psi

9-11. What type of chlorinator causes fewer chlorine leaks because the chlorine is under a partial vacuum?

1. Direct feed
2. Gravimetric feed
3. Volumetric feed
4. Solution feed

9-12. The type of chlorination equipment used to feed chlorine gas or hypochlorite solution depends on what factor?

1. The water supply pressure
2. The ratio of feed to water treated
3. The method of control
4. The type of chlorine gas being used

9-13. The semiautomatic type of chlorination equipment must be manually adjusted to the

1. dosage
2. type of chlorine
3. start and stop of water flow
4. rate of water flow

9-14. Portable hypochlorination equipment can be used for main disinfection, scale control, and corrosion control.

1. True
2. False

9-15. The maximum capacity of the heavy-duty Midget Chlor-O-Feeder is 95 gallons in what number of hours?

1. 24
2. 18
3. 12
4. 10

9-16 Motor-driven types of hypochlorinators are made fully automatic by the use of what component(s)?

1. A primary electrical control circuit
2. Gears in a Treat-O-Control gearbox.
3. A secondary electrical control circuit
4. A pilot valve in the water supply

9-17. What device in the Model S Hypochlorinator reciprocates the diaphragm?

1. A hydraulically driven eccentric cam
2. A centrifugally actuated flyweight
3. A motor-driven eccentric cam
4. A centripetally actuated flyweight

9-18. When connecting chlorine valves or tubes to cylinders or equipment, you should use one gasket made of what material?

1. Plastic
2. Rubber
3. Lead
4. Fiber

9-19. You can guard against condensation on chlorine cylinder walls by following which of the following preventive maintenance practices?

1. By direct heat to dry the cylinder surfaces
2. By keeping the cylinders wiped dry
3. By treating the cylinders with moisture-resistant compound
4. By ventilating around the equipment

9-20. The daily inspection to detect chlorine leaks in a gaseous chlorinator system should be carried on with the aid of

1. the dissolving action of aqua ammonia in the presence of metals
2. an open bottle of aqua ammonia held near all joints, valves, and piping
3. an open bottle of hydrochloric acid held near all joints, valves, and piping
4. the fuming action of hypochloric acid in the presence of chlorine

9-21. Using tables in appendix III, water strainers and pressure-reducing valves should be checked for proper level at what regular intervals?

1. Daily
2. Weekly
3. Monthly
4. Quarterly

9-22. Chemical dust or spilled chemicals accumulating from the cleaning of dry chemical feeders should be removed with a/an

1. air hose
2. wet sponge
3. cold-water spray
4. vacuum cleaner or brush

9-23. A pot type of solution feeder sediment trap should be cleaned at which of the following times?

1. Quarterly
2. Monthly
3. Weekly
4. Daily

9-24. How often should the exterior shell of the ion-exchange unit be cleaned and painted?

1. Monthly
2. Annually
3. Semiannually
4. Quarterly

9-25. The semiannual servicing of the multiport valve on the ion-exchange water softener includes which of the following steps?

1. Applying grease from a pressure gun to all the fittings
2. Turning the valve through one-half turn and adding more grease
3. Spreading the grease by giving the valve several full turns
4. Each of the above

9-26. The ion-exchange bed must be kept at a certain level during the quarterly flushing to prevent which of the following problems?

1. Loss of resin during backwashing when the elevation is too high
2. Loss of resin during backwashing when the elevation is too low
3. Accumulation of foreign matter when the elevation is too high
4. Accumulation of excess fines when the elevation is too high

9-27. The surface of the supporting gravel under the resin of an ion-exchange bed should be limited to high and low spots differing in elevation by no more than

1. 3.5 inches
2. 2.0 inches
3. 3.0 inches
4. 4.0 inches

9-28. You should replace or add new gravel to the ion-exchange softener unit in how many layers?

1. One
2. Two
3. Three
4. Four

9-29. In a system using an ion-exchange filter, what condition is indicated when the pressure drop across the underdrain is greater than at the time of installation of the filters?

1. Corroded nozzles
2. Displaced nozzles
3. Plugged underdrains
4. Plugged nozzles

9-30. What part of the regeneration unit should be cleaned thoroughly every 6 months?

1. The brine ejector
2. The brine measuring tank
3. The salt storage tank
4. The filter ejector

9-31. Baffled mixing basins require cleaning at what regular frequency?

1. Semianually
2. Annually
3. Quarterly
4. Monthly

9-32. To make sure all flocculators are working, you should check the paddle rotation on flocculator basins at what intervals?

1. Weekly
2. Monthly
3. Bimonthly
4. Quarterly

9-33. What part(s) of a flocculator basin should be checked for silt penetration?

1. The underwater bearings
2. The flocculator gears
3. The drive mechanism
4. The flocculator floor

9-34. For which of the following reasons should the speed reducer of a revolving sludge collector basin be filled with oil to a level above the seals when the reducer is out of service for a long period of time?

1. To protect the basin from corrosion
2. To prevent the seals from drying out
3. To make sure water cannot enter the reducer
4. All of the above

9-35. What action(s) should you take if the sludge buildup in a revolving sludge collector basin causes an overload resulting in a cutout of the overload alarm starter switch?

1. Deactivate the alarm switch
2. Continue operations
3. Find the cause of the trouble
4. Shut down the equipment, drain the tank, and flush out the tank

9-36. Cathodic protection fights corrosion in what manner?

1. Current flows from the ac source directly to the metal surface to be protected
2. Current flows from the ac source through the soil or water to the metal to be protected
3. The flow of current applies electrical energy that reverses the process of corrosion
4. The flow of current applies electrical energy that parallels the process of corrosion

9-37. Which of the following elements is part of the impressed current system of cathodic protection?

1. Graphite anode
2. Magnesium anode
3. Zinc anode
4. Aluminum anode

9-38. Under what circumstances are you allowed to bridge insulated couplings in galvanic anode systems?

1. The damage is obvious
2. The damage can be easily repaired
3. Only with engineering advice
4. Only with consent of a superior

9-39. What action should you take if the monthly filter inspection shows signs of mild algae growth?

1. Backwash the filter surface
2. Remove the filter from service and treat it with hypochlorite solution
3. Lower the water level to bed surface and then chlorinate
4. Chlorinate the water before it enters the filter

9-40. The quarterly inspection of a gravity filter reveals that the sand grains are so incrusted that affected areas of the filter bed have become clogged. What is one action to remedy this situation?

1. Dig out the incrustation
2. Treat the filter bed with a strong hypochlorite solution
3. Backwash the filter completely
4. Allow inhibited muriatic acid to pass downward through the bed

9-41. Sulfurous acid is to be used as the chemical agent for removing carbonate deposits from the gravity filters in a water treatment plant. A maximum of how many 150-pound cylinders of sulfur dioxide will be needed to produce the required 0.3-percent solution of sulfurous acid if 30,000 gallons of water are to be treated?

1. One
2. Five
3. Three
4. Seven

9-42. After several samples of sand are removed from well-scattered locations during the semiannual inspection of a gravity filter, these samples should be processed in what manner before drying?

1. Each sample should be reduced to 2 pounds of sand, mixed, driven, and quartered
2. Each sample should be quartered and then mixed with another quartered sample
3. The samples should be mixed thoroughly and then reduced by quartering them to about 2 pounds of sand
4. The samples should be mixed thoroughly and then reduced by halving them to about 4 pounds of sand

9-43. What should you be looking for in your semiannual sieve analysis for filter media?

1. A break in the underdrain system
2. Algae, mud balls, or slime
3. Growth of sand size that impairs filtration efficiency
4. Cementation of sand grains with mud balls

9-44. When examining the gravel in a filter bed, you should look for mud balls, improper layering, and clogged filter media.

1. True
2. False

9-45. How often should wash water troughs be inspected for corrosion?

1. Every 2 years
2. Annually
3. Semiannually
4. Quarterly

9-46. Which of the following maintenance operations should NOT be performed weekly on an operating table?

1. Lubrication of transfer valves
2. Cleaning the table inside and out
3. Checking the tension of cable-operated controls
4. Inspection of hydraulic connections

9-47. When water does not cause tubercles, what maintenance care is applicable for gravity filter, direct-action rate-of-flow controllers on an average of once every 4 years?

1. Lubricating or tightening the packing
2. Disassembling the diaphragm pot and rubber diaphragm
3. Disassembling the controller gate
4. Inspecting the venturi throat

9-48. What maintenance operation is performed once each year in the servicing of the diaphragm pendulum unit loss-of-head gauge?

1. Draining mud from the mud leg
2. Purging air from the diaphragm
3. Checking the diaphragm for leakage
4. Removing dirt from the knife edges

9-49. How should in-stock diaphragms be stored?

1. Underwater
2. In oil
3. In grease
4. In a clean air environment

9-50. In which of the following respects is the construction of a pressure filter identical to that of a gravity filter?

1. Gravel medium
2. Filter medium
3. Underdrain system
4. Each of the above

9-51. Most diatomite filter installations in potable water supply plants are of what type?

1. Pressure
2. Vacuum
3. Hydraulic
4. Pneumatic

9-52. You are removing iron oxide from a diatomite filter. You have completed the cleaning procedures; however, the filter is still contaminated. What is your next step?

1. Use a different method of cleaning
2. Repeat the procedures
3. Consult your supervisor
4. Send the filter to DRMO

9-53. In diatomite filter elements, the procedure for removing manganese dioxide differs from that of removing iron dioxide in which of the following wavs?

1. Anhydrous sodium bisulfite is added to the solution
2. The manganese dioxide treatment takes longer
3. The iron dioxide treatment needs no recirculation
4. The percentage of hypochlorite solution to tank volume is greater

9-54. Trays of the waterfall aerator are inspected semiannually for which of the following reasons?

1. Staining
2. Biological growth
3. Precipitated iron oxide
4. Uneven water distribution

9-55. To remove organic growth from the watersides of the removable plates of a porous ceramic diffuser, you should use a 50-percent solution of what type of acid?

1. Hydrochloric
2. Nitric
3. Sulfuric
4. Chromic

9-56. A 30-percent solution of hydrochloric acid should be used to clean porous plate diffusers clogged with

1. dust, soot, or oil
2. manganese oxide
3. grease or debris
4. iron oxide

9-57. Spray nozzle aerators should have nozzles removed at what intervals?

1. Weekly
2. Every 2 weeks
3. Monthly
4. Only as necessary

9-58. The blower should be inspected for internal corrosion or deterioration at what intervals?

1. Annually
2. Semiannually
3. Quarterly
4. Monthly

9-59. The main supply of chlorine for a chlorinator should be stored in a/an

1. separate isolated fireproof room vented only to the outside
2. room next to the chlorinator room
3. unvented fireproof room
4. detached building

9-60. Qualified personnel with suitable respiratory equipment should respond to chlorine escaping in liquid form in what manner?

1. By opening the container valve to let chlorine gas escape
2. By applying water to the leak
3. By moving the leaking chlorine container outside
4. By turning the container so the chlorine escapes in gas form

9-61. One of your men has been overcome by chlorine gas but is conscious. After moving him to the open air and away from the chlorine gas fumes, you should take which of the following steps?

1. Place him flat on his back with his head slightly elevated
2. Put a blanket over him and keep him warm
3. Give him one-half teaspoon of moderate stimulant and call a doctor
4. All of the above

9-62. What factor is NOT a precaution to take when lime is being handled?

1. Wear heavy denim clothing, heavy gloves, and a bandana
2. Flush lime away with water
3. Remove lime dust with a dry pickup vacuum
4. Cover exposed skin with a protective cream

9-63. In a water treatment plant, which of the following safety devices should be maintained on the open tanks?

1. Handholds or ladders on the floor of each tank
2. Handrails 8 to 12 inches above the waterline on each side of the tank
3. Guardrails leading to the tank
4. Enclosed ladders

9-64. What type of breathing apparatus that is effective against poisonous gas can be used in an oxygen deficient atmosphere?

1. Self-contained oxygen breathing apparatus
2. Self-generating oxygen breathing apparatus
3. Hose mask
4. Type N all-purpose gas mask

9-65. During normal operation, in what position should the (a) emergency bypass valve and the (b) regulator control valve of the self-contained OBA be set?

1. (a) Open (b) open
2. (a) Closed (b) closed
3. (a) Closed (b) open
4. (a) Open (b) closed

9-66. In what sequence should the straps of the facepiece (six-strap model) be tightened?

1. Chinstrap, temple straps, top strap
2. Chinstrap, top strap, temple straps
3. Temple straps, chinstrap, top strap
4. Top strap, chinstrap, temple straps

9-67. When donning the side shoulder strap model, you should grasp the harness in what location?

1. Where the waist strap and wrist strap are bound together
2. Where the take-up strap and the shoulder strap are bound together
3. Where the take-up strap and waist strap are bound together
4. Where the wrist strap and take-up strap are bound together

9-68. A ground storage reservoir that depends on its extra height and small diameter to provide enough head pressure for fire fighting is called a/an

1. standpipe
2. elevated storage tank
3. open reservoir
4. underground reservoir

9-69. In what season of the year should ground level concrete storage facilities be inspected for water tightness and structural conditions?

1. Fall
2. Summer
3. Spring
4. Winter

9-70. During the semiannual maintenance of a ground level concrete storage tank, you chip and clean out a wall crack to a depth of one inch and a width of one-quarter inch. What action do you now take to repair the crack?

1. Paint the crack with Portland cement slurry
2. Rough sand the clean crack
3. Fill the crack with rich cement grout
4. Apply iron waterproofing compound to the crack

9-71. One of the baseplates of the tower structure supporting a steel storage tank has collected water. After drilling a 1 1/2-inch hole through the channel-boxed section to allow for drainage, you take what action to complete the repair?

1. Paint the baseplate
2. Apply concrete to the baseplate
3. Grout the baseplate with a mixture of sand and asphalt
4. Grout the baseplate with a mixture of sand and Portland cement

9-72. What condition in the cathodic protection equipment of a steel storage tank will cause damage to the tank?

1. Immersed electrodes
2. Unimmersed electrodes
3. Reversed connections to the rectifier
4. Higher current or voltage than specified on the nameplate of the equipment