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UNITED STATES MARINE CORPS
Utilities Instruction Company
Marine Corps Engineer School
Marine Corps Base
Camp Lejeune, North Carolina 28542

U-10E0
Oct 1983
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STUDENT OUTLINE

M12A1 DECONTAMINATION APPARATUS

PURPOSE: The purpose of this period of instruction is to provide you with knowledge and skill to perform operation procedures on the Decontamination apparatus.

STUDENT REFERENCE(S): TM 3-4230-209-12

TERMINAL LEARNING OBJECTIVE(S): Tasked to operate a decontamination unit for a decontamination team and provided with an M12A1 Decontamination Apparatus, fuel, and water, operate the unit in accordance with TM 3-4230-209-12, chapter 3. (1.5.2)

ENABLING LEARNING OBJECTIVE(S): Provided with an M12A1 Decontamination Apparatus, fuel, and water:

1. point out the major components of the unit. (1.5.2a)

2. install the unit. (1.5.2b)

3. perform before operation maintenance on the unit. (1.5.2c)

4. start the unit. (1.5.2d)

5. adjust the unit. (1.5.2e)

6. shut the unit down. (1.5.2f)

7. perform after operation maintenance on the unit. (1.5.2g)

in accordance with TM 3 4230-209-12, chapter 3.

OUTLINE:

1. DESCRIPTION OF THE UNIT

a. The Decon Unit is not really part of water supply equipment, but since it does contain a water pump and engine, it is in most cases operated and maintained by the Water Supply Men.

b. The Decon Unit consists of three parts: A - Pump Unit Assembly, B - Tank Unit Assembly and C - M2 600 GPH Skid-Mounted Liquid Fuel Water Heater. The Decond Unit Model is ABC-M12A1.

c. The ABC-M12A1 Decon Unit is intended for field use, and it is used for:

(1) Spraying decontaminating materials.

(2) Firefighting with water or foam.

(3) De-icing.

(4) Cleaning vehicles.

(5) Pumping various fluids.

(6) Showering personnel.

d. The Decon Unit is NOT AUTHORIZED for use with:

(1) Defoliants (killing vegetation) Ex: Agent Orange

(2) herbicides (killing plant life)

(3) Insecticides (killing insects)

2. PUMP UNIT ASSEMBLY

a. Consists of

(1) Skid Assembly

(2) Frame Assembly

(3) Cover Panels

(4) Gasoline Engine, which is:

(5) Fuel Tank

(6) Prime-Detergent Tank

(7) Water Pump

(8) Water piping system

(9) Battery

(10) Two 50 ft. discharge hoses

(11) Generator

(12) Control panel

(13) Connector panel located at the back of the unit contains suction hose and two discharge hose connections.

(14) Cover

(15) Exhaust pipe extentions

(16) Three types of nozzles for the gun assembly

(a) Slurry nozzle
(b) Fire hose water nozzle
(c) Fire hose foam nozzle

b. Tank Unit Assembly consists of:

(1) Tank - Maximum working capacity of 447 gallons.

(2) Suction hose

(3) Foot Valve

(4) Blender hose

(5) Tank Drain Valve regulates the flow of water from tank

(6) Hopper-Blender Assembly

(7) Personnel Shower Assembly

c. <u>M2 Water Heater</u>

(ON TP-6)

(1) The M2 Water Heater is a fully enclosed, skid-mounted unit

(2) The M2 Water Heater consists of:

(a) Fuel and ignition system
(b) Combustion system
(c) Control system

(OFF TP-6)

(2) The M2 Water Heater has a multi-fuel capacity.

NOTE: If using gasoline, mix 1 pint of No. 2 burner fuel oil or diesel with each 5 gal. of gasoline. This is to prevent "freezing" of the fuel pump.

d. Controls and Instruments (ON TP-7)

(1) Voltage Regulator Switch

(2) Valve No. 1 - Offset

(3) Valve No. 2

(4) Valve No. 3

(5) Fuel Indicator Switch

(6) Fuel Quantity Gauge

(7) Vacuum Gauge

(8) Generator Warning Light

(9) Fuel Shutoff Valve

(10) Low Oil Pressure Switch

(11) Start-Magneto-Switch

(12) Pressure Gauge

(13) Tachometer-Hourmeter

(14) Valve No. 4

(15) Oil Pressure Gauge

(16) Throttle

(17) Pump Drain Valve

(18) Tank Drain Valve

(19) Water Pressure Gauge

(20) Fuel Pressure Gauge - This gauge indicates the pressure of fuel being supplied to the fuel nozzle. Different fuel atomizing pressures are required for different types of fuels used.

(a) Gasoline - 75 PSI
(b) JP-4 - 75 PSI
(c) Kerosene - 70 PSI
(d) No. 2 Diesel or Fuel Oil - 60 PSI

(21) Water Temperature Gauge

(22) Temperature Selector Control

(23) Heater On-Purge On Switch

3. OPERATION OF THE DECON UNIT

a. Starting Pump Unit Assembly

(1) Pre-Operation Check

(a) Perform visual inspection

(b) Inspect and install gun assembly

(c) If using showers

(d) Close pump drain and valves No. 1, 2, 3 and 4.

(e) Fill prime-detergent tank with water.

(f) Open valve No. 4.

(g) Connect suction hose

(h) Connect the other end of suction hose to the drain valve on the tank unit.

(i) If running the Decon Unit indoors

(j) Check oil level in the engine crankcase

(k) Make sure that the finger nut on the sediment bowl beneath the fuel tank is open.

(l) Open fuel shutoff valve.

(m) See that adequate fuel is in the fuel tank

(n) Check the air cleaner intake shutter.

(o) Set the manual choke control at half throttle position.

(p) Set the air control handle

(q) Make sure that engine cover is properly installed over the engine and clamped in place.

(r) Fill tank unit with water

(s) Open tank unit drain valve

(t) Make sure battery cables are properly connected

(u) Set the throttle at half way open position.

(2) Starting Pump Unit Assembly

(a) Press in the low oil pressure switch and hold it

(b) As soon as the engine starts

(c) Adjust the throttle unit 3850 RPM

(3) Operational Adjustments

(a) The pump suction vacuum gauge may be indicating from 0 to 15 inches of mercury, depending on the height of the pump above the level of water. When the pump is fully primed, pressure gauge indication should be between 60 and 120 PSI.

(b) Close valve No. 4

(c) Open valves No. 1 and 2 or 3

(4) Engine Shut Down

(a) Turn down engine throttle

(b) Turn the start-magneto switch

(c) After engine stops

(d)

b. Water Heater

(I) Pre-Operation Check

(a) Connect the stem and nut end of the blender hose to the open end of the lower discharge pipe connector

(b) Connect the quick-disconnect coupling half end of the blender hose to the quick-disconnect inlet coupling half on the M2 water heater.

(c) Open the cover on top of the M2 water heate,

(d)

(e)

(f) Connect the fuel tank plug end of the fuel hose to the 5-gal gasoline can

(g) Remove caps from the quick-disconnect coupling half hose connectors at the skid assembly base

NOTE: Make certain that the voltage regulator switch is in the OFF position.

(h) Make certain that the power cable or the water hose do not pass over the exhaust stack.

(i) Close Valve No. 1.

(j) Open Valve No. 2 and/or 3

NOTE: Circulate only clear water through the boiler to avoid damage to the M2 water heater.

(2) Starting the M2 Water Heater

(a) Make sure the heater-on purge-on switch on the heater unit is set in purge-on position.

(b) Make sure the voltage regulator switch

(c) Start the pump unit.

(d) Place the voltage regulator switch in the ON position.

(e) Operate the unit in purge-on position for 2 minutes

(f) Place the heater-on purge-on switch in the "heater-on" position.

(g) Adjust the temperature selector

(h) If operation is satisfactory

(i) Readjust for desired water temperature

(3) Deactivate Heater

(a) Place the heater-on purge-on switch to purge-on position.

(b) Continue to cycle water through the boiler until

(c) Place the voltage regulator switch in OFF position.

(d) For short shutdown the unit can be left like it is.

c. Operators Maintenance

Refer to TM 3-4230-209-12, Chapter 3 and TM 3-4410-201-12, Chapter 4 for the weekly and monthly maintenance services.

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STUDENT REFERENCE TEXT

SRT-U- 1010

INTRODUCTION TO WATER SUPPLY

MARINE CORPS ENGINEER SCHOOL
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

INTRODUCTION TO WATER SUPPLY

When primitive man found that his land was unfit for producing water from wells, he joined his tribal brethren in a communal enterprise to put down a well, or convey surface water in channels, where all could get water. An early instance of a community well is recorded in the 26th chapter of Genesis; the herdsmen of Isaac struggled with the natives of the valley of Gerar, for the possession of wells in the valley, one of which was reputedly dug by Abraham, but filled by by the Phillistines. Some centuries later Hezekiah made a pool, and conduit and brought water into the city of Jerusalem (II Kings: 20, 20). The woman of Samiria (John 4:7) drew water from a well donated centuries before by Jacob.

Pliny, the Younger, who had been connected with public works in Rome in the 1st Century A.D. and was a friend of Forontinus, the author of a treatise on the water supply of Rome, praised the early artisans, "if we only take into consideration the abundant supply of water to the public; baths, ponds, canals, household purposes, garden, places in the suburbs, and villas; and the reflect upon the distances that are traversed, the arches that have been constructed, the mountains that have been pierced, the valleys that have been filled up, we must of necessity admit there is nothing to be found more worthy of our admiration throughout the whole universe." The conduits of the Romans were of the gravity type, perforce, as they antedated by centuries the invention of pipes and of pumps that could withstand necessary pressures.

Similarly, of remote antiquity is the appreciation of the relation of the drinking-water supply to disease. In the 4th century before Christ, Hippocrates, termed the Father of Medicine, advocated the boiling and filtering of polluted water before drinking. Pliny, the Elder, in his Natural History (about 70 A.D.) discusses the characteristics of potable water. Water treatment may have originated in China, or India, thousands of years ago. From olden times, the Chinese were accustomed to putting Alum in tubs of water to clarify it. The same thing was done in Egypt. Elisha is recorded in (II Kings 2: 19-22) as treating worthless water (" the water is naught") with salt so that it became usable "unto this day". This probably occured in the reign of Jethosophat about 900 B.C.

The treatment of water to remove pathogenic or organisms which are prevalent in many natural sources of water supply after pollution by man, had its beginning about 1892, after Dr. Robert Koch had traced the cholera epidemic in Hamburg, Germany, to its unfiltered raw water supply, by observing that Altona, on the opposite bank of the Elbe, which used the same river water, but filtered it, had no cholera. Previously, since 1855, London had been required by parliamentary statute, to filter its water supply through slow sand filters, but the efficiency of the process was clearly demonstrated by Dr. Koch. Filters were not introduced in America until about 1870 and were of the slow type; the first important modern rapid-sand filtration plant was built in 1902 at Little Falls, New Jersey, and is still used by the Passaic Valley Water Commission.

In 1912, liquid chlorine was developed for the disinfection of water supplies, and the subsequent development of modern equipment for its automatic supplication has made this procedure standard practise for combating pathogenic bacteria, with less and less reliance being placed on other treatment processes.

MILITARY WATER SUPPLY

WATER PROBLEM: IMPORTANCE

In order that you may understand the importance of water, we must understand the three major essentials of modern warfare.

(1) WATER
(2) AMMUNITION
(3) RATIONS

Of these three WATER is considered to be the most important. Tactical missions cannot succeed unless troops have enough safe water. Depending on the situation, a Marine could live indefinitely without rations or ammunition. If a Marine had no ammunition, he could hide and deceive the enemy for a long time. If he had no rations, he might replenish it by living off the "fat of the land". He could kill animals, eat berries and vegetables that he may find. However, this is not true of water, water is more important than food. A man cannot live without water. During extreme heat or extreme physical exertion lack of water can put a man out of action in 16 hours, less than a day. Untreated or improperly treated water almost always contains enough disease germs to make it dangerous to drink. Water must be rendered safe for human consumption by treatment to eliminate disease germs and injurious chemicals. A Marine's water supply affects his health, general welfare, combat efficiency, and morale. The health of the entire command is in the hands of YOU, the water purification equipment operators. You <u>must</u> know your job and be capable of doing it right.

QUANTITY

The Marine Corps requires large quantities of treated water. The following table shows the minimum daily water requirements for Marines in combat, on the march, and in bivouac, camps, or hospitals, and the daily average requirements for vehicles, and under different climates.

DAILY WATER REQUIREMENTS

CONSUMER	CONDITION OF USE	CONSUMPTION (gal. per day)	REMARKS
Man	Combat Minimum	$\frac{1}{2}$ - 1	For period not exceeding 3 days.
	Normal	2 - 3	Drinking plus small amount for cooking and personal hygiene.
	March or Bivouac	2	Drinking plus small amount for cooking and personal hygiene.

DAILY WATER REQUIREMENTS CONTINUED

CONSUMER	CONDITION OF USE	CONSUMPTION (GAL. PER DAY)	REMARKS
	Temporary camp without bathing or sewage facilities.	5	Desirable for all purposes. (Does not include bathing.)
	Temporary camp w/ bathing facilities.	15	
	Semi-permanent camp	30 - 60	Includes allowances for water borne sewage.
	Permanent camp	60 - 100	Includes allowances for waterborne sewage.
HOSPITAL	Drinking and cooking	10 - per bed	Minimum does not include bathing or waterborne sewage.
	With waterborne sewage.	50 - per bed	Includes water for medical personnel
MOTOR VEHICLE	Level and rolling country	1/8 to 1/2	Depends on size of vehicle.
	Mountainous country	1/4 to 1	Depends on size of vehicle.

(Table 1)

RESPONSIBILITIES

The responsibilities for water in the Marine Corps is shared by the Unit Commander, the Engineer Battalion, and the Medical Department.

UNIT COMMANDER

The Unit Commander is responsible for all units and individuals of his command having the required amount of safe drinking water at all times. He must make clear to every individual the dangers in drinking unsafe water. He must enforce strict water discipline.

ENGINEER BATTALION

The Utility Section of the Engineer Battalion is responsible for making available a supply of treated water for all purposes to all Marine Corps units. It is responsible for the design, procurement, installation, operation, and maintenance of water supply equipment. In addition, it makes water reconnaissance, develops water sources to meet requirements and treats and dispences water. It works closely with the Medical Department to make certain the water is safe to use.

MEDICAL DEPARTMENT

The Medical Department is responsible for determing whether or not water is safe, and for making recommendations to proper commands. To do this, the medical department inspects water points, and sources, tests water, and in general, works closely with the Utility Section of the Engineer Battalion, to insure that water is properly treated and distributed. In addition, the Medical Department studies and makes recommendations about the design and selection of water supply equipment.

WATER DISCIPLINE RULES

The Unit Commanders are responsible for informing his command of the water discipline rules, which are as follows;

1. Drink treated or approved water only.
2. Do not waste purified water.
3. Protect sources of water by practicing good sanitary habits.

WATER SOURCES

1. Existing public systems. (First consideration if safe)
2. Existing wells or springs. (Usually better than surface sources)
3. Surface sources:
   a. Rivers b. Streams c. Lakes d. Ponds
4. New ground water sources (not practical unless in rear echelons, or when surface water sources are highly contaminated (as in Asia)
5. Sea Water (Distillation)

WATER SOURCES CONTINUED

6. Rain water.
7. Snow or Ice.

WATER QUALITY

Water for military use must be treated to the degree required, and be free of disease-producing organisms, poisons, CBR agents, and excessive amounts of mineral or organic matter. Under these conditions the water is safe for drinking, cooking, washing. In addition when time permits, the water should be clear, cool, and free from objectional tastes and odor. Every effort should be made to provide troops with high quality water. Remember, absolutely pure water is never found in nature.

WATER SUPPLY TERMINOLOGY

1. CONTAMINATED WATER This is water that contains germs or other substances which make it unfit for use. The impurities usually cannot be detected by sight taste or smell.

2. POLLUTED WATER Contains substances which make it objectionable because of the appearance, taste, and odor, and can usually be detected very easily. Polluted water is usually contaminated, although contaminated water does not necessarily have to be polluted.

3. PALATABLE WATER Is water that is pleasing to the taste, but not always safe to drink. It can contain harmful impurities which cannot be detected by sight or taste.

4. POTABLE WATER Is water that is both safe and drinkable. All harmful impurities have been destroyed or removed by the complete purification processes that we use.

5. PARTS PER MILLION (ppm) ratio by weight of the parts of a substance in one million parts of water by weight. (Example, one pound of sugar to one million pounds of coffee).

6. GRAINS PER GALLON (gpg) unit expressing the ratio of chemicals in, or to be added to a gallon of water. (One pound equals 7000 grains).

HYDROLOGIC CYCLE

The Hydrologic cycle is the term used to describe the natural circulation of water in, on, and above the earth's surface. Water occurs in many forms as it moves through this cycle. On the next page is a simplified illustration showing the steps in the cycle. The steps in the hydrologic cycle include precipitation, evaporation, infiltration, transpiration and runoff. Water is placed in the air by evaporation from water and land surfaces, and by transpiration from plants. It is then condensed to produce cloud formations, and returned to earth as rain, snow, sleet, or hail. A portion of the percipitation evaporates, some flows over the earth as runoff into lakes and streams, and the remainder goes into the soil and thence into underlying rock formations by seepage or infiltration. Eventually, the water which has seeped through the earth will find its way to the surface through springs, or will flow through porous media until intercepted by streams, lakes, or the ocean.

SOURCES AND COLLECTION Hydrological conditions as to rainfall, runoff and percolation must be understood in developing and collecting a water supply. Rainful infiltrates into the soil, runs off over the surface, or is transpired by vegetation; evaporation follows; then condensation into cloud formations, and returns to earth as rain or snow; this is known as the hydrologic cycle. Although precipitation is the source of all water supply, only a small part is divertible by man to his own uses, since less than half of it appears promptly as stream flow, the remainder undergoing either infiltration into the porous substrata, transpiration from vegetation, or evaporation and transpiration is not available in the immediate phase of the hydrologic cycle for man's use. On Long Island, where there are no surface streams of fresh water of any appreciable size, all the water supplies are derived from the ground-water, rain-water which has infiltrated into the porous substrata. It has been found by the water works officials on the island that the safe yield of the aquifers is about one half the rainfall, the rest running off to the sea over or through the ground, or lost through evaporation and transpiration.

SOURCES OF IMPURITIES

Water gathers impurities as it goes through its natural cycle. It first picks up the organisms, dust, smoke, and gases which fill the air through which rain, snow, hail, and sleet fall. Rain water then is not pure, although it is relatively free from dissolved minerals. Water flowing over the earths surface picks up dirt, disease organisms, chemicals, or anything else in its path which can be dissolved or moved. Water which soaks into the ground loses some of its suspended impurities as it filters through the earth. However, although it becomes clearer, it dissolves minerals and their chemicals at the same time. Ground water then may be clear, but it is not pure and may contain harmful organisms as well as chemicals.

TYPES OF IMPURITIES All impurities in water are either suspended or dissolved. Each of these main classes can be further divided as shown in table 2. 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 the water to be consumed by troops.

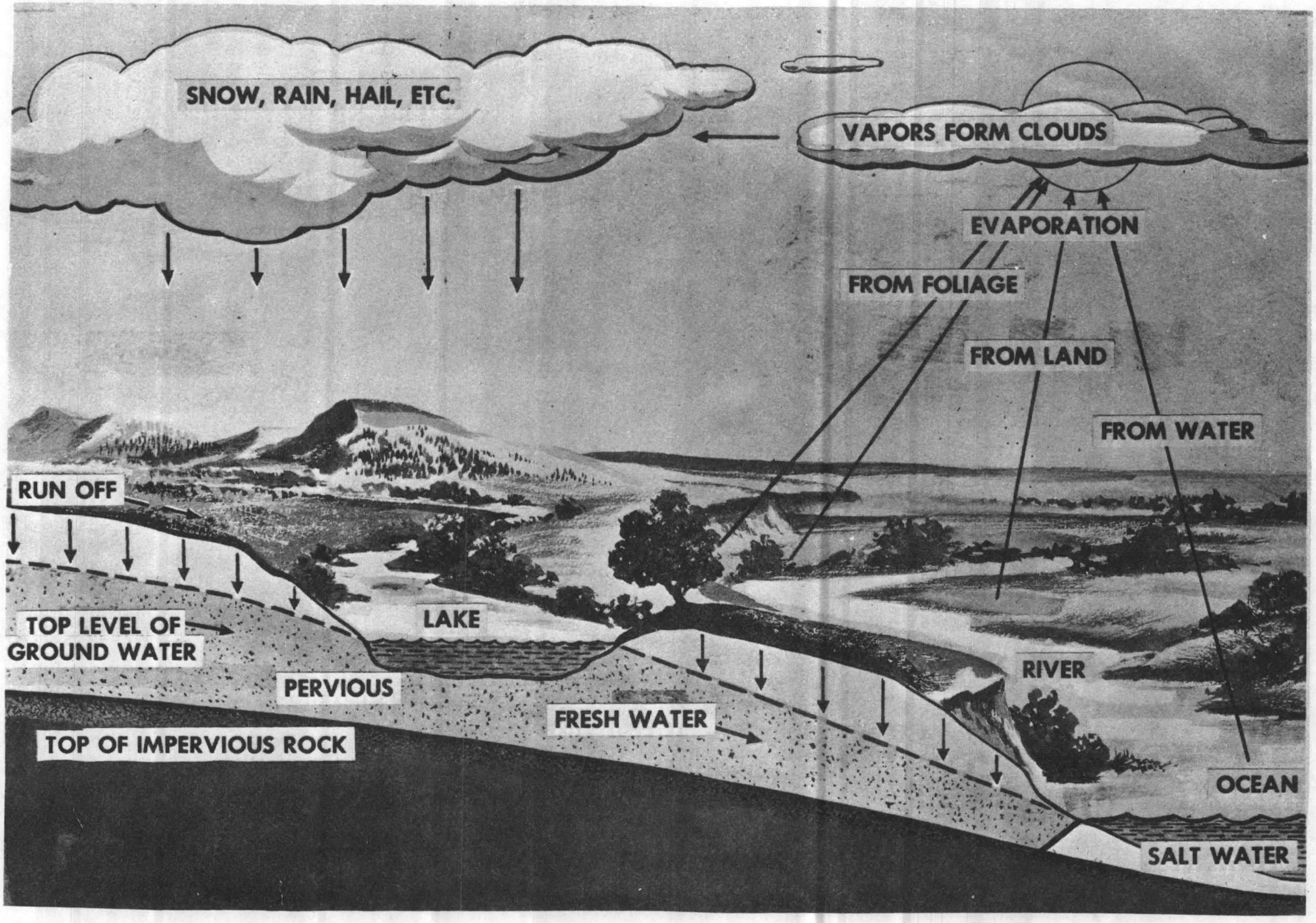


Figure 1 Hydrologic cycle

COMMON IMPURITIES IN WATER

SUSPENDED IMPURITIES	Organisms			Some cause disease.
	Algae			Cause taste, odor, color, turbidity.
	Suspended solids			Cause murkiness or turbidity.
DISSOLVES IMPURITIES	Salts	Calcium and magnesium	Bicarbonate	Causes alkalinity, hardness
			Carbonate	Causes alkalinity, hardness, evaporator scaling.
			Sulfate	Causes hardness, evaporator scaling.
			Chloride	Causes hardness, corrosive to boilers.
		Sodium	Bicarbonate	Causes alkalinity.
			Carbonate	Causes alkalinity.
			Sulfate	Causes foaming in steam boilers.
			Fluoride	Causes mottled enamel of teeth.
			Chloride	Causes salty taste.
	Iron			Causes taste, red water, incrustations on metal.
	Manganese			Causes black or brown water.
	Vegetable dye			Causes color, acidity.
	Gases	Oxygen		Causes corrosion of metals.
		Carbon dioxide		Causes acidity, corrosion of metals.
		Hydrogen sulfide		Causes odor, acidity, corrosion of metals.
		Nitrogen		No effect.

(Table 2)

WATER CHARACTERISTICS

Water takes on various characteristics or properties depending on the substances which it meets. These characteristics and properties include turbidity, color, taste, odor, Ph value, and dissolved gaseous and mineral substances.

TURBIDITY Turbidity is a muddy or unclear condition of water which is caused by suspended material and must be removed to make the water potable.

COLOR Types of color found in water.

1. True color - Caused by dyes from decaying vegetation and organic substances.
2. Apparent color - Caused by suspended solids.

How removed.

True color by aeration and activated carbon.

Apparent color by coagulation and filtering.

Odor and Taste

Caused by algae, decomposing organic matter, dissolved gases, and industrial waste.

Most prevalent in surface water and warm water.

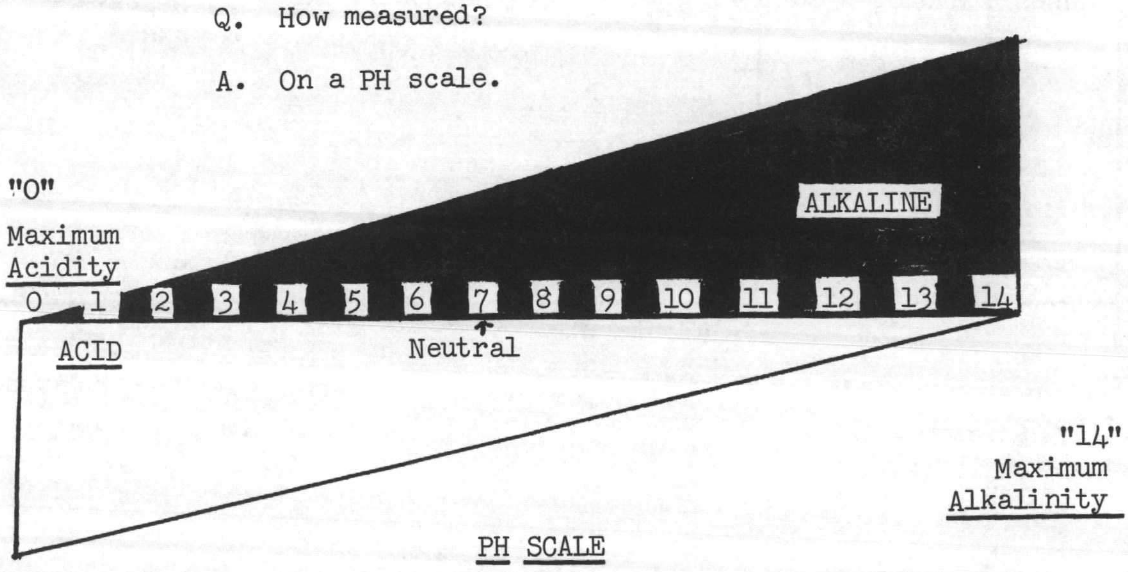
PH VALUE

Q. What is PH value in reference to water?

A. Measurement of acid and alkaline strength in water.

Q. How measured?

A. On a PH scale.



PH SCALE

How Determined - With a water testing comparator.
A Ph of 7.0 is no indication of pure water.

The Ph range of most natural water is 3.4 to 9.0.
The Ph which produces the best treatment has a Ph between 5.5 to 9.0.

DISSOLVED MINERALS

The amount of dissolved minerals in water is dependent upon how long the water stays in contact with the minerals.

IRON AND MANGANESE

Gives water a disagreeable taste and odor and causes red water which stains fixtures.

DISSOLVED GASES

1. Oxygen - Causes corrosion of metals.
2. Carbon dioxide - Causes acidity, corrosion of metals.
3. Hydrogen sulfide - Causes water to have rotten egg odor, acidity.
4. Nitrogen - Causes no effect to water.

WATER-BORNE DISEASES

Water carries many disease germs which, if contacted, may seriously reduce the efficiency of the victim. These disease producing organisms carried by water fall into 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 various treatments.

It is important to understand that water-borne diseases do not appear immediately after drinking contaminated water. These organisms need time to grow and multiply inside a man before they make him sick. The time between drinking contaminated water and the appearance of the disease is called the incubation period. Absence of the disease symptoms for several days after drinking the contaminated water is therefore no guarantee that the water is pure. Lack of disease symptoms among natives is no test of purity either, as they have become immune.

TYPHOID FEVER is an intestinal disease, non-chlorine resistant and can be destroyed by standard field chlorination, the colder the water the longer the organisms live. In ice, they may live three months.

PARATYPHOID FEVER is very much like typhoid fever and readily destroyed by standard field chlorination.

CHOLERA (Cholera Asiatica; Cholera Indica) - An acute, specific, infectious and contagious disease affecting the terminal ileum of the small intestines. It is caused by the Vibrio cholerae, the so-called comma bacillus. The casual organism is a small, curved, motile, gram-negative bacillus having a flagellum at one end. The disease is confined entirely to man and the bacillus finds its way into the body through the mouth, by way of contaminated food or drink. The greatest single source of infection is a contaminated water supply, as exemplified especially by serious epidemics occurring in cities near the river Ganges in India throughout many centuries and in the latter part of the 19th century in Hamburg, Germany. The organism can persist in water for as long as 7 days. Other sources are through insect carriers, such as roaches and flies which convey the bacilli from human feces to food.

HISTORY

Cholera has a long history and is said to have originated in the Far East, perhaps thousands of years ago. Sanskrit writings indicate that it existed many centuries before the Christian Era. It was first described adequately, however, in comparatively modern times in the year 1563, by Garcia del Huerto (1490-1570), a Protuguese physician at Goa, India. The mode of communication by infected water was first demonstrated in 1849 by John Snow (1843-1858), a well known physician of London. Robert Koch of Berlin (1843-1910), discovered the bacillus of cholera in 1884. Serious epidemics of the disease occurred in the 17th and 18th centuries but were confined to Asiatic countries. The great epidemics of 1826 to 1837 resulted in chlorea spreading to Europe for the first time. Eventually it reached Marseilles, from the eastern countries, and from there it spread to Paris. In the United States it was first observed about 1832 and was in epidemic from 1835, 1836, 1849, 1854, 1867, 1873 and 1884. The last epidemic was in 1893, but it was not assumed serious proportions since 1873, when it ceased to be a menace. In the Philippine Islands it has existed in sporadic form during the present century. The last epidemic of any size was in 1911.

CHOLERA

Cholera is an infectious intestinal disease. This disease if contacted is 50% fatal. Drinking contaminated water is the chief cause of cholera epidemics. The organism is readily destroyed by standard field chlorination.

BACCILLARY DYSENTARY

Baccillary dysentary is an infectious intestinal disease readily destroyed by standard field chlorination methods. The organism resists cold and will live in soil or on clothing for many days. It is found in tropical and sub-tropical areas.

AMOEBIC DYSENTARY

Amoebic dysentary is an infectious intestinal disease. This organism is a very small animal rather than a bacteria, and it resists ordinary chlorination. Amoebic dysentary is primarily a disease of the tropical and subtropical regions, but it is also widespread in the temperate zones.

SCHISTOSOMIASIS (shis'-toe-so-my'-ah-sis)

Schistosomiasis is a disease caused by a small worm (schistosome) entering the body either through the skin while bathing, swimming or washing in the contaminated water, or by drinking the water. There are three types of schistosomes:

1. Schistosome Haemotobium, found principally in Africa.

2. Schistosome Mansoni, found in northern South America and Africa.

3. Schistosome Japonica, found principally in Japan and China.

All types of schistosomes have a similar complicated life cycle.

Eggs

Eggs hatch into very small free swimming larva which cannot infect the human body.

Larva

Before becoming infectious to humans, they must find fresh water snails inside of which they change into the next form called cercariae. If the larva does not enter a snail within 24 hours of hatching they die.

Cercariae

They are highly infectious to humans, since they can go through the skin. The cercariae can live only 36 hours in water. Therefore, snail-free water which has been stored more than 36 hours is safe. Water highly contaminated with schistosomes can be detected by its milky turbid appearnce.

COMMON DIARRHEA

Diarrhea is the name given to a number of intestinal diseases which cramps and frequent emptying of the bowels. Usually caused by dirty mess gear, food or drinking contaminated water.

HEPATITIS, VIRAL Infectious disease of the liver occurring in two known forms, each caused by a different virus and producing acute illness with or without jaundice. One form, designated also as epidemic infectious hepatitis, has been known for thousands of years. Epidemics of this type affect both rural and urban parts of the world and reach tremendous proportions during wartime in army camps. The second type of the disease was first recognized during World War II in the course of an investigation of the cause of over 50,000 cases of jaundice. The cases occurred about three months after innoculations with yellow fever vaccine containing human serum. Experimental studies of the serum demonstrated the presence of an infectious agent differing in several respects from the virus known to cause infectious hepititis. The newly identified type, called originally serum hepatitis, is transmitted by injection of human blood or certain of its products and by improperly sterilized needles used in hypodermic injections. The two forms of viral hepatitis greatly resemble each other. Organs other than the liver become involved as the disease progresses. Early symptoms characteristic of the acute phase in adults are abdominal pains, nausea and fever accompanied often by chills. In children the disease is generally milder and some cases are entirely symptomatic. The incubation period of epidemic infectious hepatitis average about 25 days. It primarily affects the young, the incidence decreasing sharply among individuals over 30 year of age. The virus known to be present in feces during the acute and convalescent stage and in the blood during the incubation period and acute phase. The mode of transmission is from person to person or by fetal contamintion of food or water. The case mortality in epidemics is estimated to be less than 0.2 percent. In so-called serum hepatitis, the incubation period is much longer, ranging from 6 weeks to 6 months. In addition, the virus has been demonstrated in the blood only and it produces illness more severe and of longer duration than that associated with the other virus. Mortality rates as high as 20 percent have been observed during outbreaks. In sporadic cases developing in patients over 30 years old after blood or plasma transfusions, the mortality rate was as high as 30 percent; it rose to 40 percent in the over 50 year age group. By 1956 no specific immunologic or diagnostic tests had been found for either type of viral hepatitis.

POISONED WATER

Water may be poisoned by mistake or on purpose. Lead in water, certain industrial wastes, are the two major types of accidental poisoning. Chemicals like those used in chemical warfare are the most important of the substances used to poison water deliberately. This section discusses the various poisons.

LEAD POISONING

Because the human body cannot rid itself of lead, the continual drinking of water containing small amounts of lead eventually cause lead poisoning. Often acid water such as rain or swamp water is likely to pick up lead, especially if it is run through lead pipes.

FLOURIDES

Flouride in water is not a poison. Its only effect is to stain the teeth of some childeren. It is believed that flouride may be beneficial to the teeth.

CHEMICAL POISONS

Poisonous chemicals which may be used to poison water are; chemical warfare agents, chemical agents are the greatest threat of large-scale poisoning, because they can be sprayed from airplanes or spread by aerial bombs and by shells over wide areas.

ALKALOIDS

Alkaloids such as nicotine, strychnine or colchicine can be used to poison small water sources. Generally they are too difficult to obtain for large-scale use.

CYANIDES

Cyanides represent a definite threat while in industrial areas. These compounds, common in plating and other metal industries, are highly soluble and poisonous in water.

HEAVY METAL SALTS

Very few heavy metal salts are soluble enough to poison water. The more soluble ones are the acetates and nitrates of lead and mercury.

Manual of the Medical Department

Chapter 22 - General Provisions Concerning Preventive Medicine
Section V - Food and Water Supply

22-14. Water

1. The Medical Department is charged with the responsibility for advising and making recommendations to insure an adequate supply of potable water. The medical officer shall make periodic inspections and special surveys of water supply systems, including all measures for purification, and make necessary recommendations for the correction of any sanitary defects. In the event of an acute water shortage, the medical officer shall advise the Commanding Officer relative to the rationing of water.

2. In determining the potability of water, the medical officer may use as a guide the Public Health Service Drinking Water Standards.

3. For purification of drinking water in the field, reference should be made to the Landing Party Manual, U. S. Navy.

4. References should be made to the Bureau of Ships Manual for the proper operation of water supply plants aboard ships and to the Bureau of Yards and Docks Manual for Installations ashore.

Extract from Division Memorandum No. 255-54, Preventive Medicine and Sanitation (1st Marine Division (Reinf), FMF, c/o FPO, San Francisco, California) dated 19 November 1954:

. . . . .9. Water Supply

a. All water shall be considered contaminated until properly treated or otherwise proven to be potable. Water shall not be used for drinking, cooking, washing of mess gear, or bathing until approved by a medical officer.

b. Water points, as required, will be operated by Engineer units.

c. Units or personnel unable to obtain water from authorized water points or sources shall chemically treat water according to established procedures in individual canteens or lister bags.

d. A minimum chlorine residual of 5 ppm shall be maintained in all water use for potable purposes.

e. Activities shall submit water samples for bacteriological analysis at weekly intervals. The Division Sanitation and Preventive Medicine Officer shall maintain medical surveillance over all water points and collect water samples for bacteriological analysis as required.

10. Ice Supply

a. Only ice from authorized military sources will be used for cooling foods and beverages including canned or bottled beverages. Under no circumstances will indigenous or native manufactured ice be used.

11. Showers

a. Every effort shall be made to use only chlorinated water for all shower purposes.

b. Showers shall be provided with wooden duck boards. Duck boards shall be removed daily, weather permitting, scrubbed with soap and water and sunned.

c. Shower deck shall be scrubbed with soap and water daily.

d. Signs to the effect that the shower water is not potable shall be conspicuously posted in all showers.

e. Proper drainage and disposal of shower water shall be provided so that it will not create a nuisance or an unsanitary condition.

12. Laundries

a. Where adequate facilities are available all laundry water shall be chlorinated (5 to 7 parts per million chlorine, per million parts water.)

b. Clothing drying lines shall be of sufficient height that the lower part of clothing will be at least two (2) feet above ground or vegetation.

Extract from actual Sanitation & Preventive Medicine Section, 1st Medical Battalion, 1st Marine Division (Reinf), FMF, letter to Division Surgeon, 1st Marine Division (Reinf), FMF regarding "Weekly water and ice cream analysis, report of:

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DETAILED OUTLINE

INTRODUCTION TO MILITARY WATER SUPPLY

INTRODUCTION (5 MIN)

1. GAIN ATTENTION: How long do you think you can go without food before finally succumbing to starvation? Five, ten, maybe fifteen days? Actually you could survive for thirty days without food, maybe even longer. However, you could only live about four days without water and that is under ideal conditions.

2. PURPOSE: To provide the student with the knowledge about characteristics of water, terms used in water supply, types of impurities found in water, water borne diseases, and poisons which may be found in water.

3. INTRODUCE LEARNING OBJECTIVE(S)

a. ENABLING LEARNING OBJECTIVE(S)

(1) Provided with a list of seven characteristics of water and a list of the causes of the characteristics, match each characteristic to its cause in accordance with TM 5-700, Chapter 2. (1.3.1a)

(2) Provided with seven definitions of terms used in water supply and a list of terms used in water supply, for each definition, in writing select the term it defines in accordance with TM 5-700, Chapter 2. (1.3.1b)

(3) Provided with descriptions of four phases of the hydrologic cycle and a list of four phases of the hydrologic cycle, for each description, in writing specify the proper phase of the hydrologic cycle in accordance with TM 5-700, Chapter 2. (1.3.1c)

(4) Provided with a list of eight impurities found in water and a list of the effects of impurities found in water, match each impurity to its effect in accordance with TM 5-700, Chapter 2. (1.3.1d)

(5) Provided with a list of six water borne diseases and a list of three categories of disease, for each water borne disease, in writing select the category of the disease in accordance with TM 5-700, chapter 5. (1.3.1e)

(6) Provided with a list of six poisons which may be found in water and a list of water treatments to neutralize each poison, match each poison to its water treatment in accordance with TM 5-700, chapter 5. (1.3.1f)

b. I will do this by lecture.

TRANSITION: One of the first things we must understand are some important facts about demand and quality.

BODY (ON TP #1) (40 MIN)

1. IMPORTANCE

a. In modern warfare there are three major essentials needed to survive.

(1) Water

(2) Ammunition

(3) Rations

b. It only seems logical that water should be at the top of the list. We are trained to evade the enemy and even destroy the enemy at close combat if our supply of ammunition should be depleted. We could survive off of small animals and vegetation should the rations run out. You can get water from various sources, however, you cannot be certain if this water is safe to drink and you might cause severe harm to yourself.

TRANSITION: With this in mind, let us direct our attention to the water requirements.

2. WATER REQUIREMENTS

a. The mission of the water supply man is to supply the troops with enough drinking water that is both safe and pleasing to the taste. Therefore, you should be familiar with the amount of water required for each man per day under various conditions.

(ON TP #2 DAILY WATER REQUIREMENTS)

(1) Combat - One half to one gallon for periods not exceeding three days when mess rations are used. This is the minimum.

(2) Combat (Normal Conditions) - Two gallons when field rations are used. One gallon is for drinking and the other gallon is for a small amount of cooking or personal hygiene.

(3) March or Bivouac - Two gallons minimum for all purposes.

(4) Temporary Camp - Five gallons which is desirable for all purposes, but does not include bathing and sewage.

(5) Temporary Camp (with bathing facilities) - Fifteen gallons minimum.

(6) Semipermanent Camp - 30 to 60 gallons including allowances for water borne sewage.

(7) Permanent Camp - 60 to 100 gallons.

(8) Hospital - Ten gallons per bed for drinking and cooking and fifty gallons per bed with water sewage.

b. Quality drinking water must be free of disease producing organisms, poisonous chemicals, and objectionable color, odor, and taste. All untreated water is considered unsafe until approved by a medical officer.

TRANSITION: Now that we know a little about what the water requirements are, lets look at where we obtain this water from.

3. SOURCES

a. Water may be obtained from streams, rivers, lakes, wells, springs, snow, or ice.

b. In populated areas, established municipal facilities should be utilized when possible. The first consideration should always be given to existing public sources.

c. Other possible sources should be considered in the following order.

(ON TP #3 SOURCES)

(1) Existing wells or springs.

(2) Surface water sources, such as rivers, streams or lakes.

(3) New ground water sources.

(4) Distillation of sea water.

(5) Snow and ice.

(6) Rain water.

TRANSITION: Lets talk about the responsibilities that we have in assuring that water is safe for drinking.

4. RESPONSIBILITIES

(ON TP #4 RESPONSIBILITIES)

a. The responsibilities are shared by the unit commander, engineer battalion, and the medical department.

b. The unit commander is responsible for all units and individuals of his command having the required amount of safe drinking water at all times. He must make clear to every individual the danger in drinking unsafe water. He must enforce strict water discipline.

c. The utility section of the engineer battalion is responsible for making available a supply of treated water for all purposes to all Marine Corps units. It is also responsible for making water reconnaissance to determine the type of equipment that is going to be used and the amount of chemicals required to support these units. It works closely with the medical department to make certain the water is safe to use.

d. The medical department is responsible for determining whether or not the water is safe, and for making recommendations to proper commands. To do this, the medical department inspects water points and sources, tests water, and in general, works closely with the utilities section of the engineer battalion to insure that the water is properly treated and distributed. In addition, the medical department studies and makes recommendations about the design and selection of water equipment.

TRANSITION: Another area of concern dealing with water is water discipline.

5. WATER DISCIPLINE

(ON TP #5 WATER DISCIPLINE)

a. The unit commander is responsible for water discipline.

b. Water discipline rules.

(1) Drink treated or approved water only.

(2) Do not waste purified water.

(3) Protect sources of water by practicing good sanitary habits.

TRANSITION: Let's look at terms pertaining to water supply.

6. WATER QUALITY TERMS

(ON TP #6 WATER QUALITY)

a. Contaminated water - water that contains germs or other substances which make it unfit for use. These impurities usually cannot be detected by sight, taste, or smell.

b. Polluted water - Contains substances which make it objectionable because of the appearance, taste, or odor and can usually be detected very easily. Polluted water is usually contaminated, however, contaminated water does not necessarily have to be polluted.

c. Palatable water - water that is pleasing to the taste, but not always safe to drink.

d. Potable water - water that is both safe and drinkable.

e. Parts per Million - A ratio by weight of the parts of a substance in one million parts of water. The abbreviation is ppm.

f. Grains per Gallon - Unit expressing the ratio of chemicals in or to be added to a gallon of water. The abbreviation is gpg.

g. pH - amount of acid or alkaline present in water.

OPPORTUNITY FOR QUESTIONS (5 MIN)

1. Questions from the class

2. Questions to the class

a. Which of the three major essentials of modern warfare is the most important?

A. Water.

b. Does water have to be polluted to be contaminated?

A. No.

SUMMARY: During the past hour, we have discussed:

1. The military importance of water.

2. Water requirements.

3. Sources.

4. Responsibilities.

5. Water discipline.

6. Water quality.

BREAK (10 MIN)

INTRODUCTORY TRANSITION: Now that we know what water is all about, let's talk about the hydrologic cycle.

BODY (40 MIN)

7. HYDROLOGIC CYCLE

(ON TP #7 HYDROLOGIC CYCLE)

a. The hydrologic cycle is defined as a series of processes by which water and condensed moisture circulate from the various water sources through the atmosphere, into surface water and ground water, and returns to the ocean.

b. The hydrologic cycle is the term used to describe the natural circulation of water in, on, and above the earth's surface. Water occurs in many forms as it moves through this cycle.

c. The processes in the hydrologic cycle include:

(1) Evaporation - Water is evaporated from water surfaces and land surfaces.

(2) Transpiration - Moisture given off by plant life. It is then condensed to produce cloud formations.

(3) Precipitation - The water returns to the earth as rain, sleet, snow, or hail. A portion of the precipitation evaporates. Some flows over the earth as runoff into lakes and streams. The remainder goes into the soil and then into rock formations by seepage or by infiltration.

(4) Infiltration - Eventually the water which seeped through the earth will find its way to the surface through springs or will flow through porous material until intercepted by streams, lakes, or the ocean.

(5) The cycle does not always proceed through the same sequences and steps may be omitted or repeated at any point. For example, precipitation in hot climates may be almost wholly evaporated and returned to the atmosphere. In such an instance the steps of infiltration, transpiration, and runoff are omitted.

TRANSITION: As water flows over the earth as runoff, it may pick up suspended materials as well as disease producing organisms and chemical properties which will give the water different properties.

Impurities are gathered as water passes through its natural cycle. Dust, smoke, and gases which fill the air make rain, snow, hail, and sleet slightly impure. As runoff, the water picks up silt.

8. TYPES OF IMPURITIES

The two types of impurities found in water are either suspended or dissolved.

(ON TP #8)

a. Suspended impurities - are usually the most dangerous to your health. They include mineral matter, disease organisms, silt, bacteria, and algae. The common suspended impurities follow:

(1) Organisms - some cause disease.

(2) Algae - causes taste, odor, color, and turbidity.

(3) Suspended Solids - causes murkiness or turbidity.

(4) These impurities are either removed by coagulation or the use of disinfecting agents.

b. Dissolved impurities include:

(1) Salts

(a) Calcium and magnesium

1. Bicarbonate - causes alkalinity and hardness.

2. Carbonate - causes alkalinity and hardness.

3. Sulfate - causes hardness.

4. Chloride - causes hardness to boilers.

(b) Sodium

1. Bicarbonate - causes alkalinity.

2. Carbonate - causes alkalinity.

3. Sulfate - causes foaming in steam boilers.

4. Fluoride - causes mottled enamel on teeth.

5. Chloride - causes salty taste.

(2) Iron - causes taste, red water, and incrustations on metals.

(3) Manganese - causes black or gray water.

(4) Vegetable Dye - causes color and acidity.

(5) Gases

(a) Oxygen - causes corrosions on metals.

(b) Carbon Dioxide - causes acidity and corrosion on metals.

(c) Hydrogen Sulfide - causes water to have a rotten egg odor, acidity, and corrosion on metals.

(d) Nitrogen - has no effect to the water.

TRANSITION: The most important things which one must take into consideration when working with water are water characteristics.

9. WATER CHARACTERISTICS

a. As water passes over or through the earth, it takes on various characteristics or properties. These vary and are dependent on the materials encountered. The most important are turbidity, color, odor, taste, pH value, dissolved gases and mineral substances. Each of these has an effect on water quality.

(ON TP #9 CHARACTERISTICS)

b. Turbidity is a muddy or unclear condition of the water caused by suspended material which has to be removed to make the water potable. Suspended material may contain imprisoned germs and continued drinking of turbid water may cause diarrhea.

c. Color - There are two general types of color found in water. These are apparent and true color. Apparent color is caused by suspended material and true color is caused by dyes from decaying vegetation and organic substances. The methods of removing each type of color differ. Therefore, these colors must be distinguished.

d. Odor and taste in water are caused by algae, decomposing organic matter, dissolved gases, or industrial wastes. Mineral substances may also be a cause. Tastes and odors are more prevalent in surface water than in ground water. Warm water has more taste and odor than cold water. Disagreeable tastes and odors can be caused by hydrogen sulfide and free chlorine.

(ON TP #10 pH)

e. pH value - As water travels over or through the soil, it picks up many impurities. These fall into two general groups.

NOTE: Since water usually contains alkaline or acidity, it is necessary to know the quantity of each because these impurities may effect the purification process. The pH value is a measure of the strength of acidity of alkalinity expressed as a number ranging from 0 which is the maximum acidity, to 14 which is the maximum alkalinity. It can be used to determine the amount chemicals needed.

(1) Acidity - if acid predominates in the water, the pH will be below 7.0 on the pH scale.

(a) Vinegar, cider, soft drinks and wines are acidic with pH values below 4.0.

(b) Fruits, vegetables, cheese and bread have a pH value below 6.0.

(c) Milk has pH of about 6.5.

(d) Water having a pH of 6.0 or less, may be a good indication that the water may contain some type of poison.

(2) Alkalinity - if alkaline predominates in the water, the pH value will be above 7.0 on the pH scale. Eggs may have a pH of 7.6 to 8.0.

(3) Since the pH in water varies and affects purification processes, its level must be determined and allowed for in properly treating water for consumption.

(4) Neutral water is seldom found in nature and is not necessary.

(5) A pH of 7.0 is not an indication that the water is pure.

(6) The pH value used to produce the best treatment varies between 5.5 to 9.0. Water in its natural state will have a pH of 3.4 to 9.0.

(OFF TP #10)

f. Dissolved minerals - The amount of dissolved minerals present in the water depends on the length of time the water is in contact with the minerals. Iron in water is undesirable because it has a taste, a red color which stains plumbing fixtures, and causes incrustations to form inside piping. Iron is often found in water in the form of ferrous bicarbonate. This in turn reacts with oxygen in the air and forms oxides which gives the water a rust color and a bad taste. Iron in water is sometimes accompanied with bacteria called Crenothrix which oxidizes the iron. These growths may be expected to cause taste, odor, and pipe clogging if iron is present in the water in amounts greater than .3 ppm. The water in the Courthouse Bay area contains 1.3 ppm, one ppm over the concentration that is allowed in TM 5-700. This is a common and troublesome impurity found in this part of the country. Manganese is less common than iron, but has similar though more pronounced effects and causes water to have a black or gray color.

g. Dissolved gases.

(1) Oxygen - large amounts found in rain water which causes many metals to corrode.

(2) Carbon dioxide - enters water from decomposing vegetation.

(3) Hydrogen sulfide - A dissolved gas which gives water a rotten egg odor. It has corrosive effects on metal. In small amounts, it is unpleasant, but not dangerous. In large amounts, it is harmful. It is produced by decomposition of organic matter.

<u>TRANSITION</u>: The next area of concern is water borne diseases.

(ON TP #11)

10. <u>WATER BORNE DISEASES</u>

a. General - Water is a carrier of many organisms responsible for intestinal diseases. Water borne diseases are classified as <u>chlorine resistant</u>, and <u>nonchlorine resistant</u>. Chlorine resistant diseases are the ones that are not readily killed by chlorine. Nonchlorine resistant are the ones that are killed right away.

b. Water borne diseases do not appear immediately after drinking contaminated water. It takes a period of time called the incubation period for the organisms to grow and multiply inside the body before a man becomes sick. Absence of disease symptoms for several days after drinking contaminated water does not mean that the water is free from germs or that the water is safe to drink. The absence of disease among natives does not assure you that the water is safe. The natives will be immune to the diseases that are present in the area. Remember pure water is never found in nature and disease producing organisms are microscopic and cannot be seen by the human eye.

(1) Typhoid fever - An intestinal disease, can be easily destroyed by standard chlorinization.

(2) Paratyphoid fever - Similar to typhoid fever, also destroyed easily by chlorinization.

(3) Cholera - This is one of the most dreaded diseases. If contracted and early medical attention is not instituted 50% of the cases may be fatal. Adequate sanitary measures are the best protection and the organisms can be destroyed by standard chlorinization.

(4) Bacillary Dysentery - This is usually caused by bad sanitary habits. This disease is common to tropical and sub-tropical climates. Chlorinization insures destruction of this organism.

(5) Amoebic Dysentery - This organism is a small animal rather than a bacteria. It is protected by a cyst, which is a shell or a sack surrounding the organism making it resistant to chlorinization. Adequate treatment of water containing this organism is important because the cure is long and difficult.

(6) Schistosomiasis - This is a disease caused by a small worm (schistosome). This worm can enter the body through the skin while bathing, swimming or washing in the contaminated water, or by drinking the water. There are three types of schistosomes.

(a) Schistosome Haemotobium - found principally in Africa.

(b) Schistosome Mansoni - found in Northern South America, Africa, and Puerto Rico.

(c) Schistosome Japonicum - found in Japan, China, and Orient.

Schistosomiasis is the result of infection by the larvae (cercariae) of the blood flukes (schistosomes). Once the egg of the schistosome hatches, the larvae must find it's way into a fresh water snail or it will die. The snails will release large amounts of the cercariae into the water. When the water dries on the skin, the cercariae burrow into the skin. Treatment of water containing schistosomes, and protection of personnel working with the water, is very important. If you should get some of the contaminated water on your skin, you should dry it immediately and swab the area down with alcohol.

TRANSITION: We have covered water-borne diseases. We found how the diseases get into the water and what diseases may come from water. You have now found, or you are now finding out how important water supply is.

11. POISONED WATER

There are two ways water can be poisoned. They are by mistake and on purpose. Chemicals such as those used in chemical warfare and radiological poisons which are now encountered in modern warfare are the most important of the substances used to poison water deliberately. Lead and certain industrial wastes are the two major types of accidental poisoning. The various poisons which may be encountered are:

(ON TP #12 POISONS)

a. Lead - Lead poisoning may result from drinking water containing small amounts of lead, because the human body cannot rid itself of it. Continued drinking of this water will result in death. Soft or acid water, such as rain or swamp water is likely to pick up lead, especially if it is run through lead pipes. The use of lead pipes in plumbing has declined for this reason.

b. Chemical poisons

(1) Chemical warfare agents, although not used in recent wars, are still a serious threat in large scale poisoning because there are many ways they may be spread. They can be spread by planes, bombs, shells, etc. They include gases used in World War I and World War II. Our biggest problem in purifying this water is in handling. We have chemicals and equipment which will remove all types of known poisons.

(2) Alkaloids - Alkaloids such as strychnine, nicotine, or colchicine will poison water, but generally they are too difficult to obtain for large scale poisoning.

(3) Organic Arsenic Compounds - Organic arsenic compounds call arsenicals, are also limited in their use. Generally, activated carbon will remove them.

(4) Inorganic Arsenic Compounds - Inorganic arsenic compounds called arsenites and arsenates, are more common than the organic compounds. Many commercial rodent and insect poisons contain these compounds. Activated carbon is ineffective in removing the arsenic compounds.

(5) Cyanides - Cyanides are common to many processes in modern industry. They are readily soluble in water and could poison water supplies.

(6) Heavy Metal Salts - Heavy metal salts are not a serious threat because most are only slightly soluble in water. Acetates and nitrates of lead and mercury are more soluble than most and may poison water.

(7) Nerve Gases - Nerve gases or G agents were first produced by the Germans during World War II. The most effective method of treatment appears to be promotion of hydrolosis at a high pH by the addition of soda ash, lime, or caustic followed by the reduction of the pH by addition of an acid, or by use of excess coagulants such as alum or ferric chloride.

OPPORTUNITY FOR QUESTIONS (5 MIN)

1. Questions from the class

2. Questions to the class

a. What are the three common types of suspended impurities?

A. Organisms, Algae, and Suspended Solids.

b. Which water characteristic is a muddy or unclear condition of the water?

A. Turbidity.

SUMMARY: During the two hours, we have discussed:

1. The military importance of water.
2. Water requirements.
3. Sources.
4. Responsibility.
5. Water discipline.
6. Water Quality.
7. Hydrologic Cycle.
8. Sources of Impurities.
9. Types of Impurities.
10. Water Characteristics.
11. Water Borne Diseases.
12. Poisoned Water.

BREAK (10 MIN)

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1. TP #1 Introduction to Military Water Supply
2. TP #2 Daily Water Requirements
3. TP #3 Sources
4. TP #4 Responsibilities
5. TP #5 Water Discipline
6. TP #6 Water Quality
7. TP #7 Hydrologic Cycle
8. TP #8 Types of Impurities
9. TP #9 Water Characteristics
10. TP #10 pH
11. TP #11 Water Borne Diseases
12. TP #12 Poisons
13. SRT-U-1010 Introduction to Military Water Supply
14. Advance Sheet/Student Outline

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WATER PURIFICATION UNIT
MODEL U-22446

FRAME MOUNTED
DIATOMITE TYPE
10-40 GPM
SRT U-1504

NOVEMBER 1974

MARINE CORPS ENGINEER SCHOOL
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

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GLOSSARY - CHEMICAL TERMS AND DEFINITIONS

The following terms and definitions have been modified to apply specifically to this particular water purification equipment.

Acid - See pH value.

Algae - Microscopic plants some of which form a green scum on water and which may give the water unpleasant tastes and odors.

Alkalinity - See pH value.

Alum - A coagulating chemical. See pH value.

Amoebic dysentery - See Endamoeba histolytica.

Backwashing - The procedure by which water flow is reversed through the filter elements with sufficient velocity to break and dislodge the filter cake with accumulated dirt, organisms and bacteria. "Air-bump backwashing" is the method used to clean the filter elements in this equipment, and is described in detail in the text (par. 2-5).

Body feed - A slurry of diatomite and water fed during the filter run by the slurry feeder to maintain the porosity of the filter cake.

Calcium hypochlorite - A chemical compound in granular form containing available chlorine, used to disinfect water by chlorination.

Cercariae - One form in the life of schistosomes which cause schistosomiasis. See Schistosomes.

Chlorination - The purification or disinfection of water by adding chlorine in the form of calcium hypochlorite.

Chlorine demand - The amount of chlorine absorbed by foreign matter in the water; the difference between chlorine dosage and residual chlorine.

Coagulants - Chemicals, such as alum, used to produce a floc. See Flocculation.

Color - True color is caused by dyes from decaying vegetation in swamps, weedy lakes and streams, and should not be confused with apparent color caused by turbidity of the water.

Comparator - An instrument to determine chlorine residual and pH values colormetrically.

Contamination - Water is said to be contaminated when it is unsuitable for drinking or consumption because of harmful bacteria or other harmful substances in it.

Cysts - The shell or sac surrounding certain amoeba which makes them resistant to ordinary chlorination.

Diatomite - (also called diatomaceous earth or filter-aid). Consists of the skeleton remains of small algae called diatoms and is found in marine deposits which have been lifted above sea level. The diatomite is quarried and processed before use. It is an excellent filter medium which permits maximum flow without great loss of head.

Dosage - The quantity of chemical necessary to obtain a desired result; the amount of calcium hypochlorite necessary to disinfect water.

Effluent - Discharge, water flowing out.

Endamoeba histolytica - A microscopic, one cell animal or parasite which causes an intestinal disease called amoebic dysentery. In one stage of its development, the animal is covered by a shell or sac called a cyst. In the cyst form the organism is difficult to kill by chlorination but can be removed by proper treatment and filtering of the water.

Filter section - A device in which suspended solids are separated from water by passing the water through a porous medium such as diatomite.

Filteraid - See Diatomite.

Filtering - The process of forcing raw water through a fine porous medium to remove suspended dirt, organisms and bacteria from the water.

Floc - Jelly-like curd formed by flocculation. See Flocculation.

Flocculation - The term used to describe the formation of the jelly-like curd called floc, following the addition of alum to the raw water as the water is agitated. The irregular shaped, feathery particles of floc enmesh most of the suspended bacteria, dirt and coloring matter and settle with it to the bottom of the tank leaving the water relatively clear. Flocculation or coagulation does not purify the water. It must still be chlorinated and filtered.

Head - The pressure exerted by a column of water. A head of 2.31 feet of water exerts a pressure of 1 pound per square inch.

Influent - Inlet or intake, water flowing in.

GLOSSARY - CHEMICAL TERMS AND DEFINITIONS (cont)

Optimum pH - The pH for a particular raw water at which the best floc formation occurs in the shortest time.

pH value - A term used to represent the degree of acidity or alkalinity of water. The pH scale ranges from 0.0 to 14.0. The neutral point is 7.0. A pH below 7.0 represents an acid condition, a pH above 7 represents an alkaline condition. Alum is acid in reaction and when added to water lowers the pH. Soda ash is alkaline in reaction and when added to water raises the pH. pH is measured to help determine the amount of alum (or soda ash) needed to produce a floc.

Post-chlorination - The addition of calcium hypochlorite to the clear water storage tanks.

Pre-chlorination - The addition of calcium hypochlorite to the raw water in the settling tanks.

Precoating - The process of depositing a cake of diatomite filteraid on the filter elements prior to filtering water.

Raw water - Water as it is taken from a stream, lake or pond before it has been settled, chlorinated and filtered.

Residual chlorine - The amount of chlorine remaining in the water after satisfying the chlorine demand. A chlorine residual of 1.0 ppm (part per million) is generally sufficient to guarantee water purity.

Schistosomes - A small worm parasite or blood fluke which can enter the body through the skin while bathing, swimming or washing in contaminated water, or by drinking the water. It causes a disease called schistosomiasis. In one stage of life, as cercariae, the animal is highly infectious to humans as it can go through the skin.

Slurry - A thin mixture of water and chemical, such as diatomite and water.

Soda ash - A chemical used for adjustment of pH during coagulation.

Turbidity - Mud, sediment or other suspended matter in water. Turbidity ruins the appearance and generally makes water undesirable for drinking purposes. Bacteria become lodged in the suspended matter and are protected from sterilizing agents such as calcium hypochlorite. Turbidity must be removed by flocculation and filtering before the water is used.

Water-borne - A term meaning conveyed or carried by water.

Water point (or: water site) - The location where water is treated and distributed.

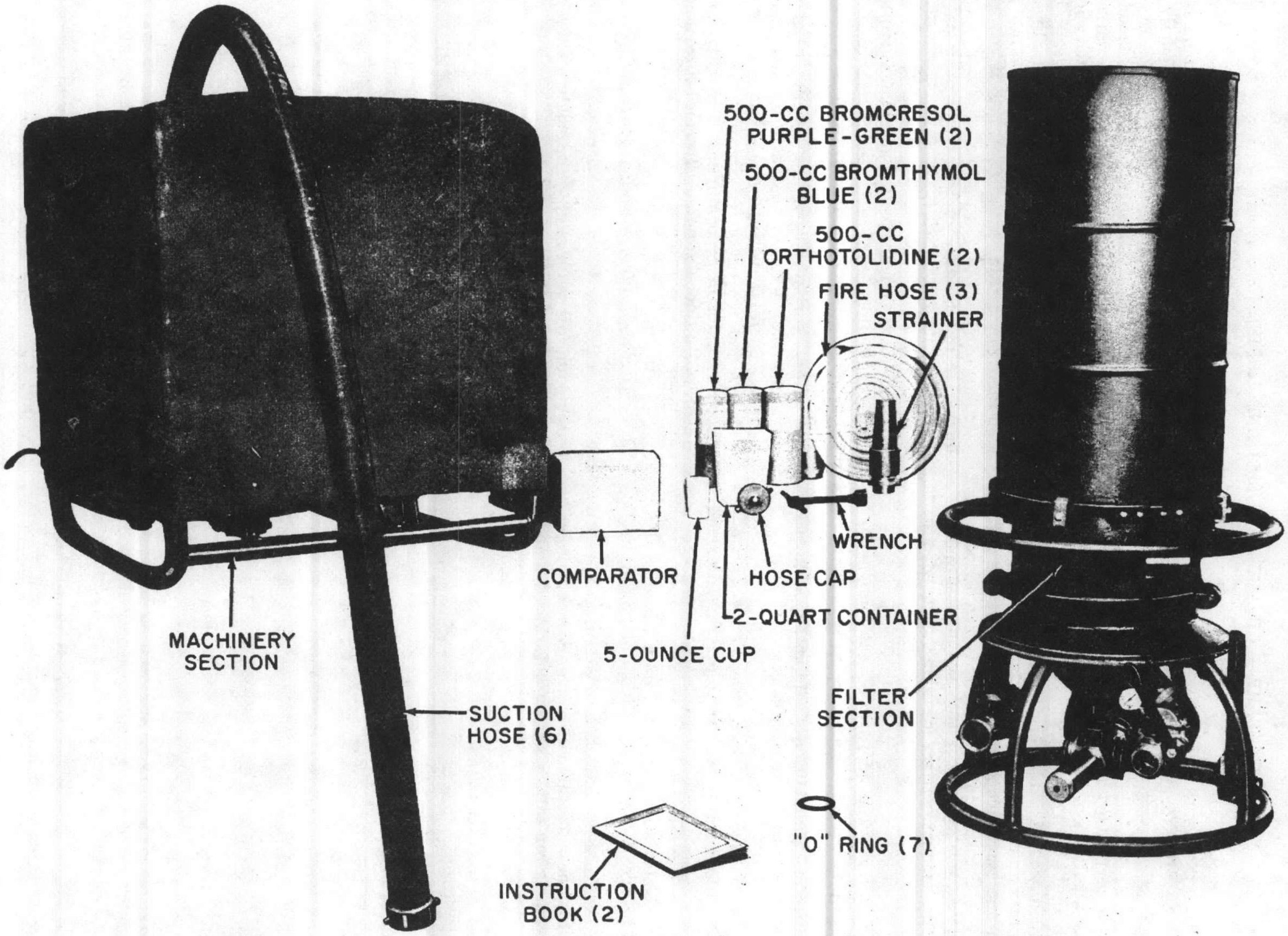


Figure 1-1. Water Purification Unit.

SECTION 1

SELECTION OF WATER SOURCE

1-1. RESPONSIBILITIES.

a. Commanding Officer or Officer-in-Charge. The Commanding Officer or Officer-in-Charge is responsible for the supply of safe drinking water to all individuals under his command. Accordingly, he directs the establishment of the water supply system and the rules governing its operation. In addition he promulgates water discipline rules and is vested with full authority to enforce them.

b. Medical Officer. The Medical Officer, who is responsible to the Commanding Officer or the Officer-in-Charge, closely supervises the testing and treating of all contaminated water.

1-2. GENERAL WATER TREATMENT INFORMATION.

a. General. Field water purification consists of removing or destroying impurities in water so that it is safe and pleasant to drink. The first and most important step in purification is to select the correct treatment processes and then arrange them in the right order to do the job. No single treatment process will do a complete job of purification. Generally, good results are obtained by the following arrangement of water treatment processes, however, specific purification problems can require additional processes or a different arrangement:

(1). Sedimentation - coagulation and flocculation.
(2). Filtration.
(3). Disinfection.
(4). Distribution.

b. What the Equipment Does. The equipment covered in this manual is used for the filtration and disinfection of water. Auxiliary equipment is necessary for pretreatment and distribution of this water.

1-3. SELECT THE WATER SOURCE.

a. General. The selection of a source of water and the location of the equipment is of primary importance and must be coordinated with the Medical Officer. The following factors should be taken into consideration:- type, quality, and quantity of water available; accessibility to using personnel or transporting vehicles; characteristics of the site and space available to erect equipment; concealment or natural camouflage; drainage; and bivouac for operating personnel.

b. Factors Influencing the Selection of Water Source.

(1). Quantity. The most important factor in the selection of a new water source is adequacy. Adequacy depends on the quantity of water needed and the length of stay at the location.

(2). Type of Supply. Where there is a choice of water sources of equal and adequate capacities, the order of selection ordinarily would be wells, springs, streams, and lakes or ponds.

(3). Quality. Even though purification is used, careful consideration should be given to the probable bacterial content of the water selected. For instance, it is only common sense to avoid taking waters that are near a bathing area, a sewer outlet, or a latrine.

(4). Sewers. Take water from a point well above sewer discharges. Never take water from directly below such discharges. Sewage contains bacteria, and the bacteria in a small amount of sewage can cause sickness just as quickly as bacteria from a large amount of sewage.

(5). Swimming and Bathing Area. Try to avoid taking water from a swimming or bathing area, or from a point below such an area. At such points the water will contain considerable suspended matter and many bacteria.

(6). Latrines. Keep upstream of latrines. The dangers of not doing so are obvious.

(7). Camp Sites. Locate the bivouac area for the operating personnel at a point below the water source. Beware of drainage and refuse from camp areas. Such drainage and refuse can be highly contaminated and of sufficient quantity to seriously pollute the water source.

(8). Oily Areas. Keep away from oily areas. Oil from spent oil dumps may seep through river banks and impart oily or chemical tastes to the water. Oily or chemical tastes in water may drive personnel to drink more palatable but less safe water.

(9). Clear Water. Use clear water whenever possible. Avoid ponds, or any water source where the surface is bright green. A bright green surface usually denotes an overabundance of algae which will quickly seal the filter elements and prevent the passage of water.

(10). Turbid Water. Use the least turbid water available, unless the alternate source is visibly polluted with sewage or refuse. Turbid water (water containing suspended dirt) reduces the yield of each filter run by clogging the filter elements more quickly than clear water.

(11). Colored Water. Clear colored water is usually acceptable. Its main disadvantage is high coagulant requirements.

(12). Water Containing Iron Deposits. Water containing visible soft red deposits of iron should be used only as a last resort. Such iron deposits are not harmful to health, but they do make clarification difficult.

(13). Green Slimes and Gray Slimes. Ordinary green slimes that are often found on the shores of swamps or in shallow water are not detrimental to health, but they do plug the filter elements. Water containing gray slimes should be avoided. Gray slimes are usually an indication of sewage pollution.

(14). Rotten Egg Odor. If the water source smells like rotten eggs, it contains hydrogen sulphide. Such water is not pleasant to drink. The taste and odor can be overcome by chlorination, but it will be impossible to maintain a chlorine residual in such water until the hydrogen sulphide is eliminated or neutralized.

(15). Dissolved Oxygen. Water devoid of dissolved oxygen tastes flat. Many well waters have no dissolved oxygen; most surface waters contain dissolved oxygen.

(16). Camouflage. Locate equipment in well-camouflaged positions consistent with good military practice.

(17). Site Characteristics. Select a water point near using personnel and accessible to transporting vehicles. There must be enough space to set up the equipment. Drainage is important, otherwise spillage may turn the water site into a mud hole. Always locate raw water pumps close to the water source to reduce the suction lift and increase the pump output. Keep hose lines short to reduce friction. Avoid bends which might kink the hose.

SECTION 2

DESCRIPTION OF EQUIPMENT

2-1. GENERAL DESCRIPTION OF WATER PURIFICATION EQUIPMENT. A typical arrangement of water purification equipment is shown in figure 2-1. This manual is primarily concerned with the filter section, the machinery section, and accessory equipment furnished by Wallace and Tiernan Belleville, New Jersey. As can be seen in figure 2-1, auxiliary equipment is needed for a complete, operating, water purification system.

2-2. GENERAL DESCRIPTION OF WALLACE AND TIERNAN MODEL U22446 WATER PURIFICATION UNIT. The 10-40 g.p.m. (gallon per minute), frame mounted, diatomite type, water purification unit, consists primarily of:

a. The pressure filter section (Model A694020) containing:

(1). Seven filter elements mounted in and enclosed by a steel shell (figure 2-3).

(2). A precoat and recirculating tank (figure 2-2).

(3). Control valves.

b. The machinery section (A695020 containing:

(1). A centrifugal pump.

(2). A gasoline engine that drives the pump.

(3). Reservoir and apparatus (slurry feeder) for feeding diatomite filteraid slurry during the filter run.

(4). Reservoir and apparatus (hypochlorinator) for feeding calcium hypochlorite solution into the water being filtered.

(5). A tool box.

(6). Operating controls.

(7). A mounting frame.

c. Residual chlorine and pH testing comparator with indicating solutions.

d. Suction strainer.

2-3. GENERAL DESCRIPTION OF AUXILIARY EQUIPMENT. The following auxiliary equipment and accessories are required for a complete operating water purification system:

a. Tanks for settling and storing water.

b. Suction and discharge hoses as dictated by requirements of the water point and layout of equipment.

c. A raw water pumping unit, and equipment for water distribution.

d. Filteraid, calcium hypochlorite, and alum and soda ash, as required for continuing operation.

e. Chemical feed baskets.

f. A supply of diatomite.

2-4. PURPOSE OF THE EQUIPMENT. The primary purpose of water purification is to make water safe for human consumption by removing or killing harmful bacteria which could cause sickness or death. The water must be made free of objectionable suspended matter, color and odors, otherwise personnel may turn to more pleasing appearing water that might be unsafe to drink. Chlorination, by the addition of calcium hypochlorite to the water, will kill most bacteria. Other organisms such as amoebic cysts, endamoeba histolytica and schistosomes must be removed by coagulation, settling, and filtering through a diatomite filter cake. Coagulation and settling is accomplished by adding alum and soda ash which coagulate and enmesh most of the suspended small particles in the water carrying them to the bottom of the tank; this process is called flocculation. After settling, the water from the top of the tank is drawn off and filtered. The water purification equipment described in this manual will purify fresh water but will not remove salt from water.

2-5. BASIC PRINCIPLES OF EQUIPMENT OPERATION. Figure 2-1 shows a typical arrangement of water purification equipment. Other arrangements are possible, and often desirable, depending on many factors. In the arrangement shown in figure 2-1 raw water is pumped from the source into settling tanks. Chemicals (alum and soda ash) are added during filling. Coagulation tests are made to determine the amounts of chemicals to use. Several tanks are used for settling to allow time for as much suspended matter as possible to be deposited on the bottom of the tank before the water is pumped through the filter. Settling is important, for suspended matter in the water will quickly clog the filter elements. The machinery section draws water from the settling tanks and forces it through the filter elements in the filter section. Before the settled water can be filtered, a mixture of water and diatomite filteraid (called a slurry) is made in the precoat tank and pumped through the filter section where the filteraid is deposited on the seven filter elements in the form of a cake. This cake will pass water but screen out any suspended matter and bacteria. In the machinery section a slurry feeder adds a small amount of filteraid slurry (called body feed) to the water. This slurry maintains the porosity of the filter cake and permits longer filter runs. The hypochlorinator in the machinery section adds a controlled amount of calcium hypochlorite solution (a sterilizing agent) to the water. When the filter elements become clogged as indicated by the pressure gages, and by the reduction in the output of filtered water, the filter elements must be backwashed. "Air-bump backwashing" is used to dislodge the filter cake with accumulated suspended matter from the filter elements so it may be easily drained from the filter shell. After draining, the bottom of the filter shell must be flushed to wash waste through the drain. (See figure 2-6.) Before filtering is resumed, the filter elements must again be precoated with filteraid. The filtered water is stored in the filtered water storage tank pending delivery to using personnel. Filtered water must be tested for residual chlorine (using the comparator) before it is distributed, to make sure it is safe.

2-6. FILTER SECTION.

a. General. The filter section (figures 2-4 and 2-5) is generally placed close to and between the settling

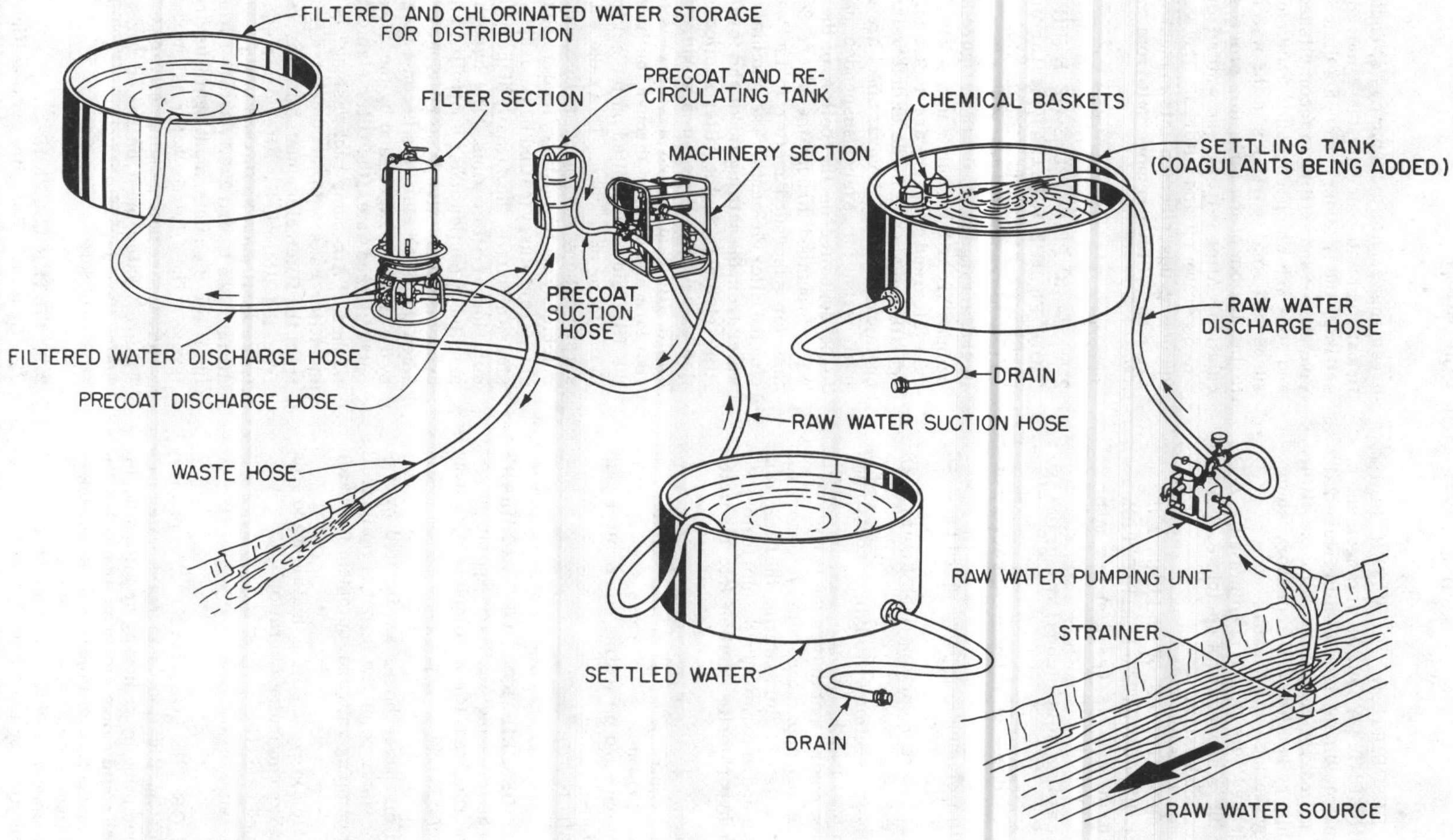


Figure 2-1. Typical Arrangement of Water Purification Equipment

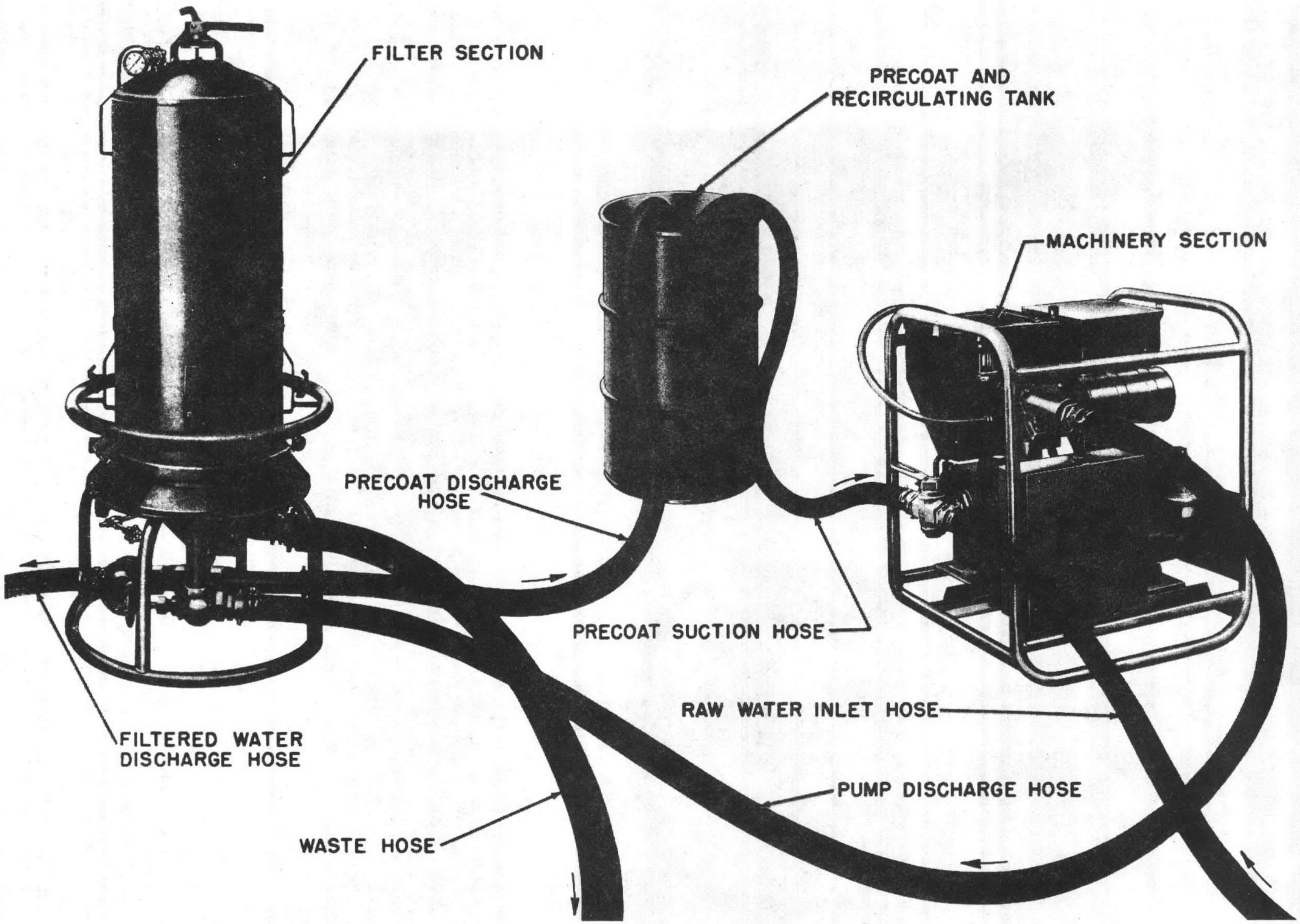


Figure 2-2. Pressure Filter Section and Machinery Section, Set in Operating Position

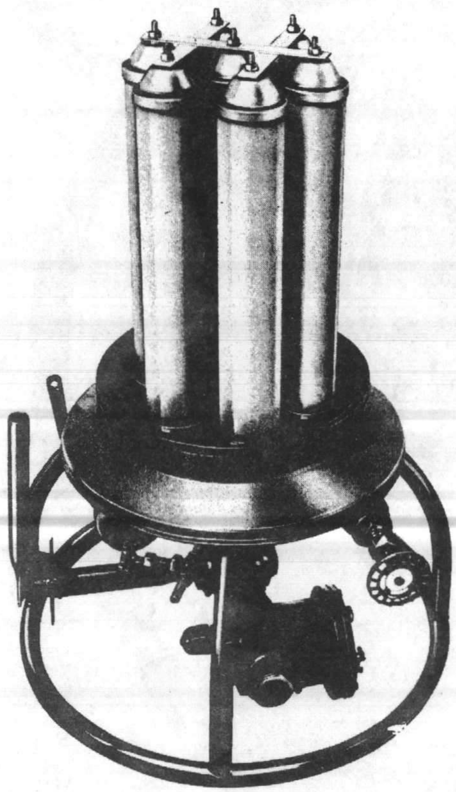


Figure 2-3. Pressure Filter Section Dismantled to Show Filter Elements

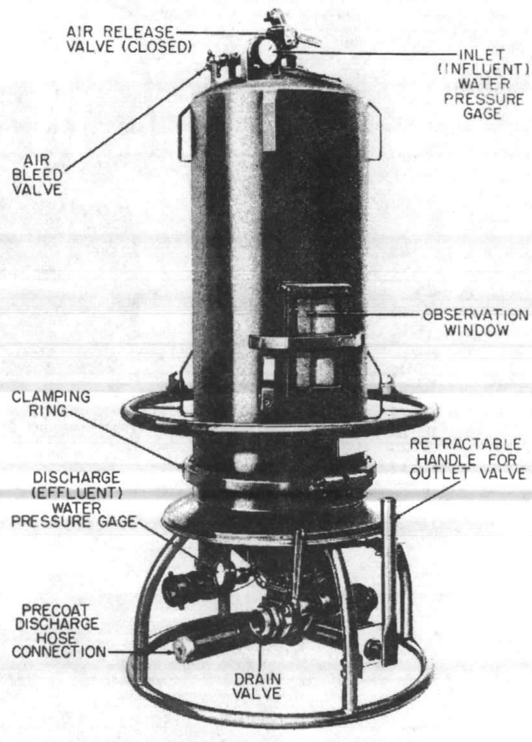


Figure 2-4. Filter Section (Front View)

and storage tanks (figure 2-1). This is for convenience in operation and to keep the hose lines as short as possible. The filter is of the pressure type having a steel shell attached to a steel base in which are mounted 7 cylindrical filter elements (c. below). Valves, controls and hose adapters are mounted on the filter section. By proper manipulation of the valves the basic operations of precoating, filtering and air-bump backwashing are performed. A steel cover (b. below) protects the top of the filter during transportation and is used as a precoat and recirculating tank during operation. Test samples are withdrawn through a filtered water sample valve. The adjustable flow control valve (d. below) maintains a constant preset flow during filtering. The air release valve (e. below) is mounted on top of the filter shell. A window in the filter shell permits visual observation during operation. The filter section is equipped with a tubular pipe ring for protection and ease in handling. 2-inch hose adapters and fittings are furnished on the unit. The inlet valve is a 2-inch globe valve. The drain valve is a quick-acting lever-operated 2-inch valve. The outlet valve is a 3-way valve with retractable handle that slides inside the tubular frame when the filter is out of service.

b. Precoat and Recirculating Tank. When the filter is not in use the steel precoat and recirculating tank (which is part of the filter section) fits over the filter shell and protects the top of the filter from damage. The tank is secured by 4 clamps. When the filter is in service the precoat diatomite filteraid slurry is mixed in the tank and then applied to the filter elements by recirculating the slurry through the filter (par. 6-4). Figure 2-2 shows the precoat tank in its normal operating position. The tank is also used for recirculating water during filtering as explained in par. 6-5h.

c. Filter Elements. Seven identical filter elements (figure 2-3) are individually mounted on nipples welded to a false bottom of the filter base. The elements extend vertically inside the filter shell. Each filter element is made up of a plastic sleeve and perforated steel tube assembly, a brass top cap, a tie rod, 12 plastic air cups, 2 spacers, a cast bronze base, and an "O" ring gasket. The filter element assembly is essentially a fine strainer which is rigid and strong enough to support a cake of diatomite filteraid. During precoating the filteraid builds up on the surface of the filter elements, covering all holes with a layer of filteraid (figure 2-6 (1)). The filteraid will allow water to pass through the filter element into the bottom of the filter base, but will screen out dirt, suspended matter, coagulant floc, and any other solid particles in the water (figure 2-6 (2)). During the filter run it is necessary to add filteraid slurry body feed continuously by means of the slurry feeder to maintain the porosity of the filter cake. At the start of the precoat cycle air is trapped

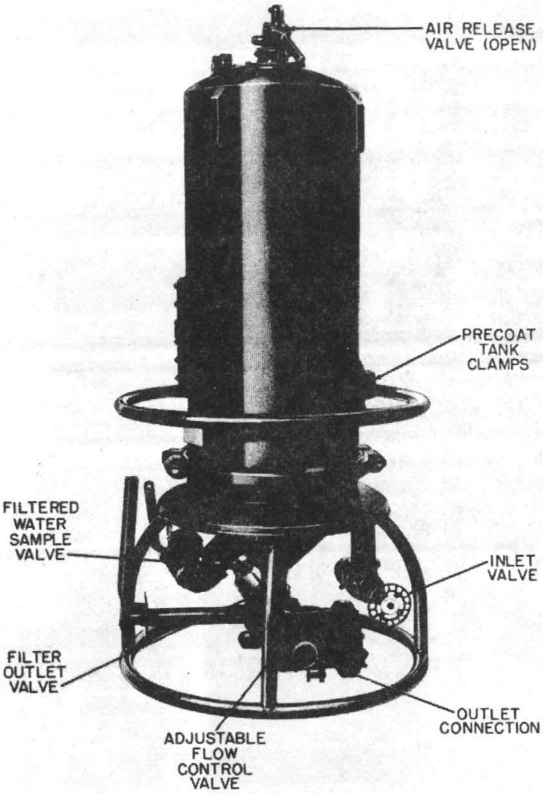


Figure 2-5. Filter Section (Rear View)

in the plastic cups inside the filter elements, and in the dome of the filter shell above the elements. As filtering progresses, the pressure loss through the filter cake increases (as shown by the difference between inlet and outlet pressure gages). Loss of outlet pressure, accompanied by a reduction of flow of filtered water, indicates that the filter cake has lost its porosity and the elements should be backwashed. In backwashing the filter outlet valve (figure 2-5) is closed and as the pump continues to pump water into the filter shell the inlet and outlet pressure increases thus compressing the air trapped in the plastic cups inside the elements and the air in the filter shell dome. When the inlet valve is closed the filter section is a sealed unit under about 25 psi pressure. Opening the air release valve (e. below) causes an instantaneous loss of pressure in the filter shell. The air trapped in the plastic cups expands and pushes a small amount of filtered water from within each filter element outward through the perforations of the element at an extremely high velocity. This high velocity water movement blasts the filter cake from the elements. The broken cake and contents of the shell are then drained to waste. Elements must be backwashed at the end of each filter run or whenever operation is interrupted.

d. Adjustable Flow Control Valve. The flow control valve (figure 2-5) is located at the bottom of the filter base where the filtered water leaves the filter. This valve automatically maintains a constant flow throughout the filter run. The rate of flow can be adjusted between 10-40 gpm by turning the adjustment knob to the rate of flow desired.

e. Air Release Valve. The quick-acting manually operated air release valve (figure 2-4) is located on top of the filter shell. The valve releases pressure inside the filter shell instantaneously to permit air-bump backwashing (see c. above).

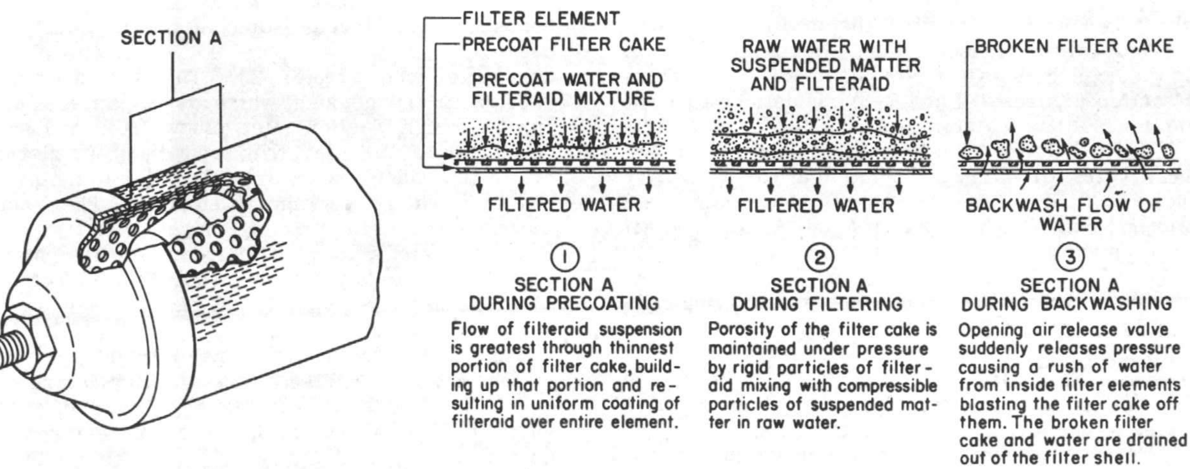


Figure 2-6. Filter Element With Section Removed

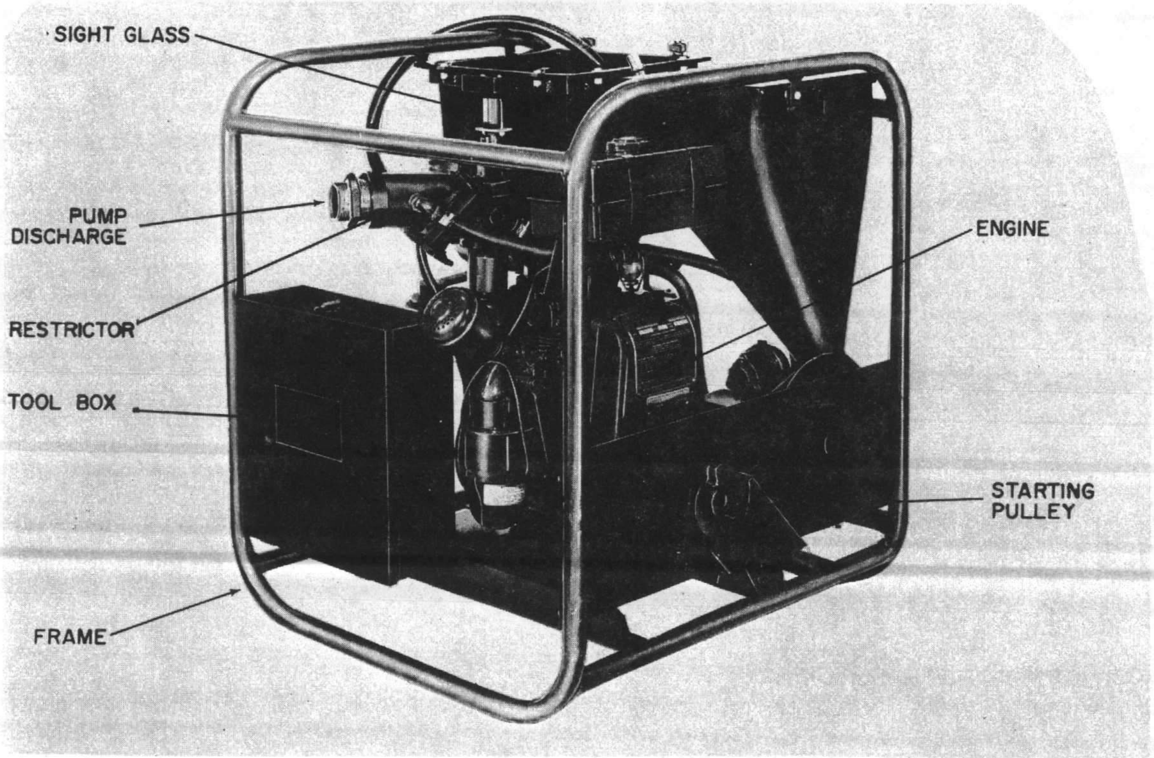


Figure 2-7. Machinery Section (Front View)

2-7. MACHINERY SECTION.

a. General. The machinery section is placed close to the filter section and near the settling tanks (figure 2-1). This is for convenience in operation and to keep the hose lines as short as possible. The machinery section (figures 2-7 and 2-8) consists of a pumping unit, a tool box, a diatomite slurry feeder, a calcium hypochlorite solution feeder (hypochlorinator), hoppers or reservoirs for slurry and solution and all necessary valves and fittings for connection to 2-inch hose. A canvas cover (figure 1-1) is also supplied to protect the equipment during inclement weather.

b. Pumping Unit. The pumping unit (figure 2-9) consists of a centrifugal pump capable of delivering continuously 55-gpm against a total head of 50 feet including a 15-foot suction lift, and a single cylinder, four-cycle, air-cooled gasoline engine. The pump and engine are close coupled, with the pump impeller mounted on the end of the engine crankshaft. The engine is capable of operating the pump continuously at rated capacity. By proper manipulation of the pump suction valve (figure 2-8) and the valves on the filter section the unit performs the pumping necessary for precoat, filter and backwash operations. A power take-off from the engine starting pulley drives the slurry feeder.

(1). Pump. The general features of the pump are shown in figure 2-10. The pump housing mounting flange (13) connects the pump directing to the engine. Before the pump is placed in operation the priming chamber (18) must be filled with water through priming plug (2). Impeller (12) screwed on the engine crankshaft (16) forces some of the priming charge out pump discharge nipple (1), restrictor (3), and discharge hose adapter (4). This action creates a vacuum in the housing which draws water into the pump through suction inlet elbow (10), and suction fitting (9) to impeller (10); and then out discharge nipple (1). Check valve (8) holds water in the priming chamber when the pump is stopped. The retained water serves as the priming charge when the pump is restarted, and acts as a lubricant for the pump and seal ring assembly (14). The seal is further lubricated through oil cup (17). Clean out plug (19) provides access for removing sediment from the pump. Drain plug (7) provides a means of draining the pump.

(2). Engine. A Wisconsin model ACND single cylinder, four-cycle, air-cooled, rope-started, gasoline engine drives the pump. The general features of the engine are shown in figure 2-11. Air enters the carburetor (6) through oil both cleaner (8). Gasoline from the tank and air are mixed in the carburetor in the proper proportions by the manipulation of needle valve (7) and choke lever (5). The mixture is ignited in the engine cylinder by a high tension spark produced by the ignition system consisting of magneto (10), ignition cable (1), and spark plug (2). Exhaust is through muffler (4). Engine valves are located under inspection plate (11). The engine is stopped by pushing in on magneto stop switch (9). Gasoline flows by gravity

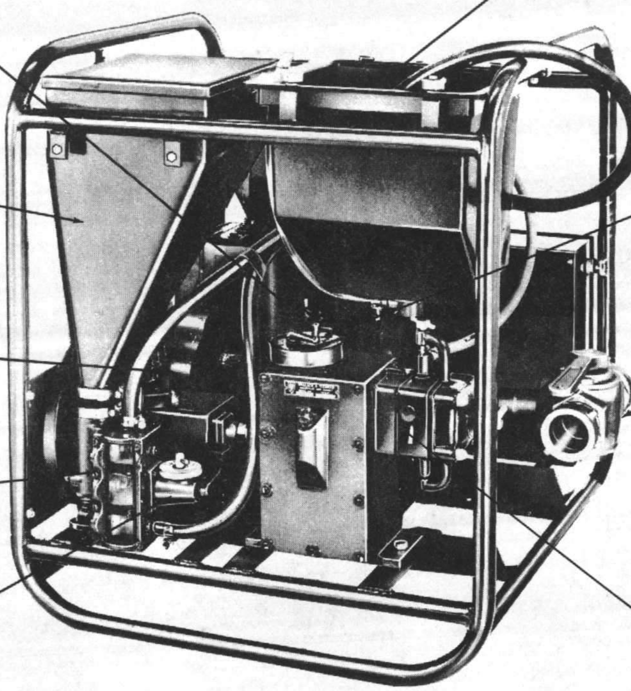


Figure 2-8. Machinery Section (Rear View)

from the fuel tank mounted above the engine, through a fuel filter to the carburetor. A speed governor control is connected to the carburetor to control the engine speed. Air cooling is accomplished by a flow of air over the cylinder head, circulated by a combination fan-flywheel encased in a shroud (2). The engine is more fully described in Wisconsin Motor Corporation Instruction Book, Issue MM-270-E, and is shipped with this manual.

c. Tool Box. The tool box (figure 2-7) has compartments for storing the comparator and any tools and spare parts. Flow diagrams similar to figures 6-1, 6-2 and 6-3 are mounted inside the hinged cover.

d. Slurry Feeder. The slurry feeder (figure 2-8) is mounted alongside of the gasoline engine and is driven at approximately one-quarter engine speed by a V-belt and pulleys. A slurry of filteraid and water is made in the slurry hopper (figure 2-8). The hopper has a strainer, to keep leaves, stones, debris and other foreign matter from the feeder mechanism, and a clamp-on cover. A diaphgram type air compressor, powered by the slurry feeder shaft, pumps air to the slurry hopper. This air agitates the slury and keeps the filteraid from settling to the bottom of the hopper. The slurry feeder draws a small amount of slurry from the hopper into the feeder. By means of valves in the feeder and a pressure differential caused by the restrictor (f. below) flushing water flows through the feeder and automatically flushes the charge of slurry from the feeder to the pump discharge where it is pumped to the filter via the pump discharge hose (figure 2-1). In the filter the filteraid in the slurry is deposited on the elements (par. 2-5c). The amount of slurry feed required depends on the amount of foreign matter in the water being filtered, which in turn de-

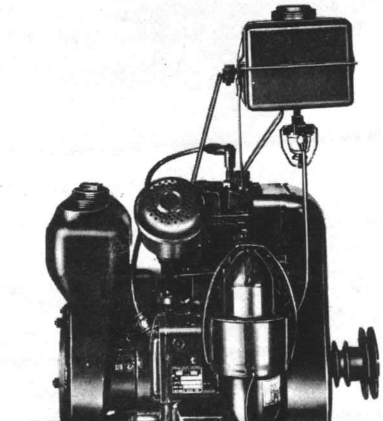
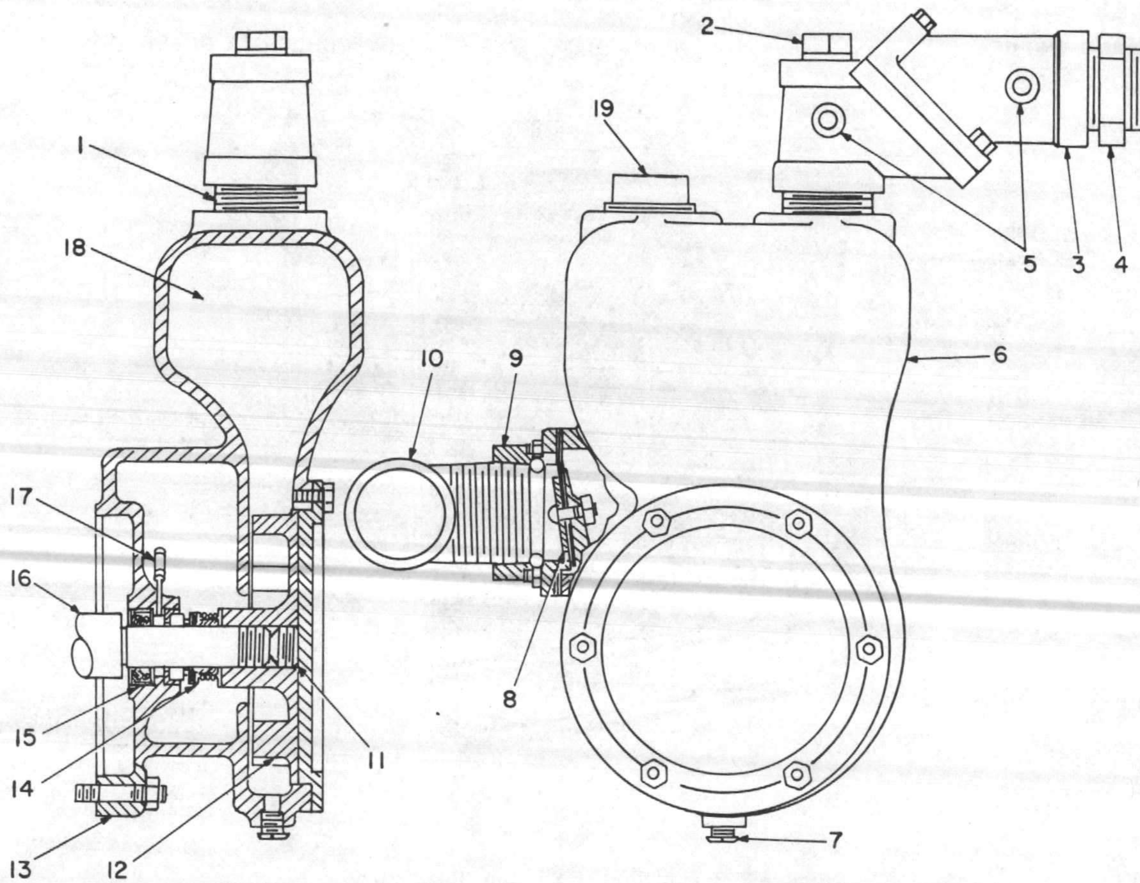


Figure 2-9. Model UXA21410 Pumping Unit



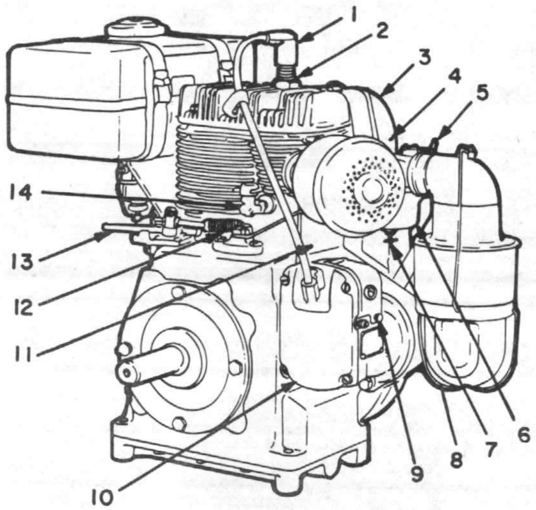
1. Pump discharge nipple
2. Priming plug
3. Restrictor
4. Hose adapter
5. Slurry feeder and flushing water connections
6. Pump housing
7. Drain plug
8. Check valve
9. Suction fitting
10. Pump inlet street elbow
11. Impeller lockscrew
12. Impeller
13. Mounting flange
14. Seal ring assembly
15. Oil seal
16. Engine crankshaft
17. Oil cup
18. Priming chamber
19. Clean out plug

Figure 2-10. Cross Section of Pump

pends on the efficiency of coagulation. The more foreign matter in the water the more slurry is required. Rate of slurry feed is changed by moving the rate of feed adjuster (figure 2-8).

e. Hypochlorinator. The hypochlorinator (figure 2-8) is mounted in line with the slurry feeder and is driven through a flexible coupling from an extension shaft of the slurry feeder. A solution of calcium hypochlorite and water is put in the hypochlorite reservoir. The pumping action of the hypochlorinator draws a small amount of solution from the plastic hypochlorite reservoir through a strainer, hose and sight glass to the hypochlorinator. The charge of solution is then pumped from the hypochlorinator to the pump discharge. The solution kills harmful bacteria that may be in the water. The amount of calcium hypochlorite required for purification depends on the amount of foreign matter and bacteria in the water. The amount is varied by mixing different strength solutions and/or changing the rate of solution feed. Rate of feed is altered by moving the control handle (figure 2-8). The sight glass (figure 2-7) provides a visual check on the operation of the hypochlorinator.

f. Restrictor. The restrictor (figure 2-7) is located between the pump and the pump discharge hose connection. Water flowing from the pump is restricted by a flap valve and weight inside the restrictor housing which action produces a small differential in pressure. Water drawn from the restrictor at a point of higher pressure provides flushing water to the slurry feeder (d. above). This flushing water dilutes the slurry in the feeder, prevents filteraid from settling in the feeder and flushes the slurry to the pump discharge. There are hose connections on the restrictor housing for



1. Ignition cable
2. Spark plug
3. Flywheel shroud
4. Muffler
5. Choke lever
6. Carburetor
7. Needle valve
8. Oil bath air cleaner
9. Magneto stop switch
10. Magneto breaker cover
11. Valve tappet inspection plate
12. Governor spring
13. Governor control
14. Breather

Figure 2-11. Wisconsin ACND Engine, Carburetor and Magneto Side

make-up water to fill the slurry hopper and hypochlorite reservoir, and for discharge hoses from the slurry feeder and hypochlorinator.

g. Pump Suction Valve. The pump suction valve (figure 2-8) is a 2-way valve. By positioning the handle water can be drawn from the precoat tank during precoating or from the settling tanks for filtering.

2-8. ACCESSORY EQUIPMENT SHIPPED WITH FILTER AND MACHINERY SECTIONS.

a. Comparator. The comparator (figure 2-12) with its accessories is used to measure the residual chlorine content of the filtered water to make sure the water is safe to drink. The comparator is also used to determine the pH value of the water prior to coagulation.

b. Operating accessories, tools, and spare parts. Accessories, tools, and spare parts are listed below (figure 1-1).

(1). One polyethelene 2-quart measuring cup for filteraid.

(2). One polyethelene 5-ounce (fluid measure) cup for hypochlorite.

(3). One 2-inch hose cap.

(4). One 2-inch strainer assembly for stopping debris from the raw water source from entering the suction hose.

(5). One 15/16-inch hexagon T-handle socket wrench.

(6). Seven filter element "O" rings.

(7). Two instruction books.

(8). Two 500-cc bottles, each, of orthotolidine, bromthymol blue, and bromcresol purple-green indicator solutions.

2-9. PERFORMANCE, CAPACITY AND WEIGHT DATA.

a. Performance. Under normal operating conditions, the water purification system will produce filtered and chlorinated water at a constant rate, except for the short time required for backwashing and precoating the elements. This system delivers **40**-gpm, plus or minus 4 -gpm, from beginning to end of the filter run.

(1). Hypochlorinator. The hypochlorinator will pump from 0.6 to 2.4 gallons of solution per hour when driven at a speed of 600 rpm. This gallonage corresponds to from 0.05 to 0.2 pounds of available chlorine when using a 1% solution.

(2). Slurry Feeder. The slurry feeder will pump from 0.33 to 1.66 gallons of slurry per hour when driven at a speed of 600 rpm. This gallonage corresponds to 0.5 to 2.5 pounds of filteraid (dry weight) when using a slurry made from 5 pounds of filteraid and 3 gallons of water.

(3). Adjustable Flow Control Valve. Once the flow control valve is set, as long as the pressure drop through the filter cake is small, the valve will maintain the flow rate at any gallonage from 10 to 40 gpm. As the pressure drop through the filter cake rises, the amount of water passed by the filter cake becomes the controlling factor and the flow rate will fall below that set on the flow control valve.

(4). Pump. The Carter 8T-2 centrifugal pump can deliver 55 gpm against a total head of 50 feet and a suction lift of 15 feet.

(5). Engine. The Wisconsin ACND four-cycle, air-cooled, gasoline engine, at governed speed of 2600 rpm delivers 4.5 horsepower and a crankshaft torque of 110 pound-inches.

b. Capacities.

(1). Slurry Feeder. The slurry feeder gear box requires slightly less than one quart of oil.

(2). Slurry Feeder Hopper. The slurry hopper when filled to within 2.5 inches of the top holds 3 gallons of water.

(3). Hypochlorinator. The hypochlorinator case holds 3-1/2 quarts of oil.

(4). Hypochlorite Reservoir. The hypochlorite reservoir when filled to within 2 inches of the top holds 5 gallons of solution.

(5). Engine Crankcase. The engine crankcase holds 2 pints of oil.

(6). Engine Fuel Tank. The fuel tank holds 1 gallon of gasoline.

(7). Engine Air Cleaner. The air cleaner bowl holds 1/4 quart of oil.

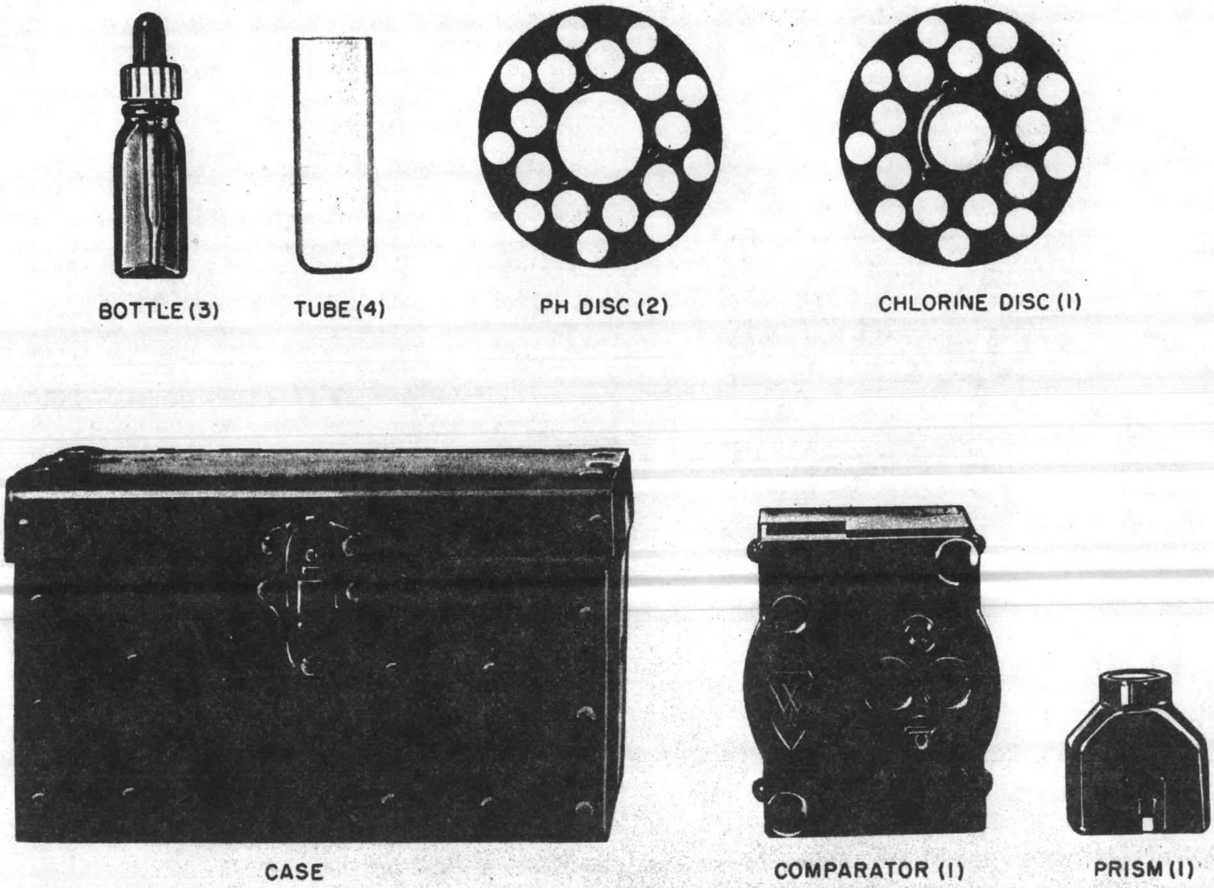


Figure 2-12. Comparator with Accessories

(8). Filteraid Measuring Cup. This is a 2-quart polyethelene cup that holds approximately 1-pound of filteraid.

(9). Hypochlorite Measuring Cup. This is a 5-fluid ounce polyethelene cup that holds sufficient calcium hypochlorite to make a 0.375% solution when mixed with 5 gallons of water (see paragraph 6-2e).

c. Weights.

(1). Machinery Section. The uncrated weight of the machinery section is about 450 pounds.

(2). Filter Section. The uncrated weight of the filter section is about 325 pounds.

2-10. DIFFERENCES IN MODELS. This instruction book and parts catalog covers the Wallace and Tiernan, 10-40 gpm, frame-mounted, diatomite type, water purification unit No. U22446 . Minor differences in attaching parts, water connections, hardware, or finish may be found in later units -- however, operating practices and repair procedures will still apply.

2-11. AUXILIARY EQUIPMENT.

a. General. For a complete water supply system, the auxiliary equipment discussed in paragraph 2-3 must be available. This paragraph lists the auxiliary equipment needed for normal operation.

b. Equipment Required When Water is Not Pretreated. Very clear water need not be coagulated and settled but may be pumped by the machinery section right from the raw water source. For such water sources only the following auxiliary equipment will generally be required:

(1). Calcium hypochlorite (U.S.P.).

(2). Filteraid (diatomite).

(3). Hose. 2-inch suction hose must be used on connections to the suction of any pumping unit. Suction or discharge (pressure) hose may be used where the water carried is under pressure. Hose needed for the distribution system will depend on the water plant layout.

(4). Tanks. When the water is pumped directly from the clear water source, the capacity of the system is usually greater than 25,000 gallons per day. All available tanks, including those supplied for settling, should be set up and used for water storage.

(5). Distribution System. Other equipment (pumping units, hose, water cans, tanks, and so on) is needed for water storage and distribution, depending on the way the treated water is to be utilized.

c. Equipment Required When Water is Pretreated. Turbid water must be coagulated and settled before it is filtered. For such water sources, in addition to the auxiliary equipment listed in b. above, the following additional auxiliary equipment will be needed:

(1). Ground alum (aluminum sulfate, U.S.P.).

(2). Soda ash (U.S.P.).

(3). Chemical baskets (figure 5-1).

(4). Raw water pumping unit (figure 2-1).

4

SECTION 3

INSTALLATION AND SET-UP OF EQUIPMENT

3-1. UNPACK THE EQUIPMENT AND REMOVE PRESERVATIVES. Unpack, clean and inspect the equipment away from the water point if it will be difficult to camouflage or dispose of packing material at the water point. Save boxes and packing material for re-use if practical. No special protective materials have been used for any of the equipment other than that required for equipment packed for overseas shipment. Protective tape, cloth, and waterproof coverings may be slit with a knife and removed. Flush out the pump housing with chlorinated water.

3-2. ASSEMBLE PARTS REMOVED FOR SHIPMENT. The filter section is shipped completely assembled. The machinery section is shipped completely assembled, except for the pump suction valve which would protrude if left in place. The pump suction valve is packed in a regular slotted carton and fastened inside the machinery section frame. The valve and the pump suction fitting are tagged for easy reassembly. Examine the equipment for damage from shipment, storage, or handling, by visually checking fittings, valves, frames, mounting parts, connections, hose, accessories, tool box, and other parts.

3-3. LUBRICATION. Fill the engine, hypochlorinator and slurry feeder with oil (par. 7-2). Grease the pump seal. Prime the pump. If plug type valves are hard to turn, loosen the nut (par. 7-5f.).

3-4. SET UP EQUIPMENT AT WATER POINT.

a. General. Before the system is erected the location of each item of equipment must be planned and the site prepared as explained in the following paragraphs. If water is required in the shortest possible time the filter and machinery sections may be set in place (figure 2-1) and raw water filtered direct from the source without settling. The unsettled water will clog the elements faster than settled water but a limited amount of filtered and chlorinated water can be obtained quickly. If the water is very turbid but quick production is required set up one settling tank and fill it. During filling add coagulants so that the water will be well settled by the time the filter is ready for operation. Set up other settling tanks and fill them as soon as possible to have additional settled water available. If time is not a factor, erect settling tanks and fill them, set up the machinery and filter sections and then the storage tank and distribution system.

b. Drainage. Waste from backwashing is highly contaminated. Always have the waste hose directed away from the site and to a point down stream from the raw water inlet. There is usually considerable spillage at a water point and all material should be located on slightly higher ground that will drain away from other items of equipment. A muddy water point is unsightly, unsanitary, and unpleasant for operating personnel. Erect duck boards around and between the equipment if necessary.

c. Settling Tanks. The ground location for settling tanks should be as level as possible, for sloping ground will cause excessive strain when the tank is filled with water. Tanks are made of fabric and must be protected from stones, sticks, roots, nails, or other objects that may puncture them. Do not drop heavy or sharp tools on the tank. Do not walk on the collapsed tank as shoes or boots may scuff or damage the fabric. Stakes may not be supplied with the tanks. Five stakes are required for each tank. Place the collapsed tank on the ground cloth. The cloth must be free of wrinkles. If no ground cloth is provided, and if possible, erect the tank so it does not have direct contact with the ground. This will prevent mildew and mold. Insert the wood staves in the loops of the tank. Raise the tank by pulling on the guy ropes and anchor guy ropes to stakes. As the water level rises in the tank coagulants must be added and the horizontal supporting ropes around the tank adjusted to relieve pressure on the walls. See that the staves remain vertical.

d. Hose. All hose connections must be tight and made with gaskets. Suction hose must be used for each suction connection and there must be no leaks or the efficiency and operation of the pump will be reduced. A small suction leak may prevent the pump from delivering any water. Pressure leaks mean loss of water and cause muddy water points. Keep hose runs as short as practical to conserve hose, reduce friction losses and prevent kinks. Do not walk on or drive over hose.

e. Raw Water Pumping Unit.

(1). General. The raw water pumping unit must be located no more than 15 feet above the water and it is advisable to have the suction lift as short as possible for maximum pump efficiency. The total lift from the surface of the raw water source to the top of the settling tank should be no more than 10 feet. Always prime the pump before starting the engine.

(2). Pump Suction. Connect the strainer to the one end of a length of 2-inch suction hose and connect the other end of the hose to the fitting on the pump suction. The strainer will be under water and a tight connection is not required except to prevent losing the strainer. The pump suction connection must be tight. Use nonhardening pipe compound if hose is connected to tapered pipe but do not permit the compound to enter the hose or pump as it may impart a taste to the water. The strainer must be submerged and off the bottom or it will clog quickly. Never operate the pumping unit without a strainer as debris will damage the pump impeller. If the raw water source will have a constant level, drive a stake in the bottom and tie the strainer to the stake at a point where bottom and surface debris will be at a minimum. If water level will change tie the strainer to an anchored float. If the source is shallow it may be necessary to sink a clear well made of a perforated drum. Some strainer clogging will always occur and the strainer should be accessible for easy inspection and cleaning.

(3). Pump Discharge. Use suction or pressure 2-inch hose from the pump discharge to the settling tanks. The hose must be long enough to reach well over the side of each tank (figure 5-1).

f. Filter and Machinery Sections. Set up the filter and machinery sections as illustrated in figures 2-1 and 2-2. This equipment should be approximately on the same level as, and near the settling tanks. The machinery section cannot be more than 15 feet above the bottom of the tanks or the pump will not operate. Use 10 foot lengths of 2-inch suction hose for pre-coat hoses and the pump discharge hose. Suction hose must be used between the machinery section and the settling tanks. The hose must be long enough to reach almost to the bottom of each tank. Tie a float to the tank end of the hose so that the end will be just under the water. When the water level in the tank becomes so low that sludge, which accumulates in the bottom, may be drawn into the filter the hose should be moved to the second tank. Run 2-inch suction hose from the filter section waste connection to the point where waste water is to be discharged. If water will eventually drain back into the raw water source, make sure that the point of entry is downstream from the raw water intake and not upstream from it.

g. Storage Tank. If a fabric tank is used for storage set it up the same as the settling tanks. If a steel or wood tank is used follow directions shipped with the tank. For efficient operation the storage tank should be in a cool spot, near the filter section, with the top water level no more than 10 feet above the machinery section unless a booster pump is installed between the tank and the filter section. Suction or discharge 1-1/2-inch hose may be used between the filter outlet connection and the tank. The hose must be long enough to reach over the side of the tank. Direct the hose into the tank and tie it in place. The storage tank should be covered at all times.

h. Distribution System. The distribution system will depend on many factors. Water should be drawn from the bottom of the storage tank as it will be cooler and the pressure of the water in the tank will help distribution. Shut-off valves, as required, should be installed at the tank outlet. Distribution piping may be hose or pipe as required. Long runs or high lift will require booster pumps. If distribution is to be into tank trucks and/or 5-gallon cans proper facilities must be provided. Provision must be made for drawing off the small quantity of water needed to conduct the frequent tests for residual chlorine. This outlet should be near the tank outlet to make sure that the tests are made of water that is being delivered.

SECTION 4

CONTROLS AND INSTRUMENTS

4-1. GENERAL. This section describes, locates, illustrates and furnishes sufficient information about the various controls and instruments for the proper operation of the equipment.

4-2. COMPARATOR.

a. Description and Purpose. Both chlorine residual and pH values may be determined colorimetrically. The Wallace and Tiernan permanent glass standard type comparator (figure 2-12) is designed to give convenient and accurate colorimetric measurements. The colorimetric method is based on the fact that when orthotolidine indicator solution is added to a water sample containing chlorine, a characteristic color is produced which is indicative of the amount of chlorine present. The same principle applies to pH measurements except that a different indicator solution is used. In either case, with a calibrated set of color standards, the value of the sample may be determined by comparing its color with those of the standards. Permanent glass color standards are employed in the comparator and the comparator is constructed so that the water sample is easily compared with the standards. A prismatic eyepiece brings the sample and standard side by side for accurate comparison.

b. Test Procedure, Chlorine Residual. The measurement of chlorine in water is extremely important since the bacterial purity of the water is governed by the amount of chlorine present. It is generally agreed that if water contains a chlorine residual of 1 ppm (part per million) 10 minutes after the calcium hypochlorite solution is added, the water will be bacterially safe after an additional 20 minutes contact. Chlorine residual test procedure is as follows:

(1). See general test precautions (par. d. below).

(2). Remove two knurled screws on front of comparator and lift off front cover (figure 4-1). Install chlorine disc on comparator body so that the recess at the center of the disc fits over a hub on the body, replace front cover and install knurled screws.

(3). Install prism assembly (figure 4-2) by engaging two pins in the prism in matching holes in the front cover.

(4). Wash two sample tubes in the water to be tested. Fill both tubes to the graduation mark with the water to be tested. The samples should not be collected until

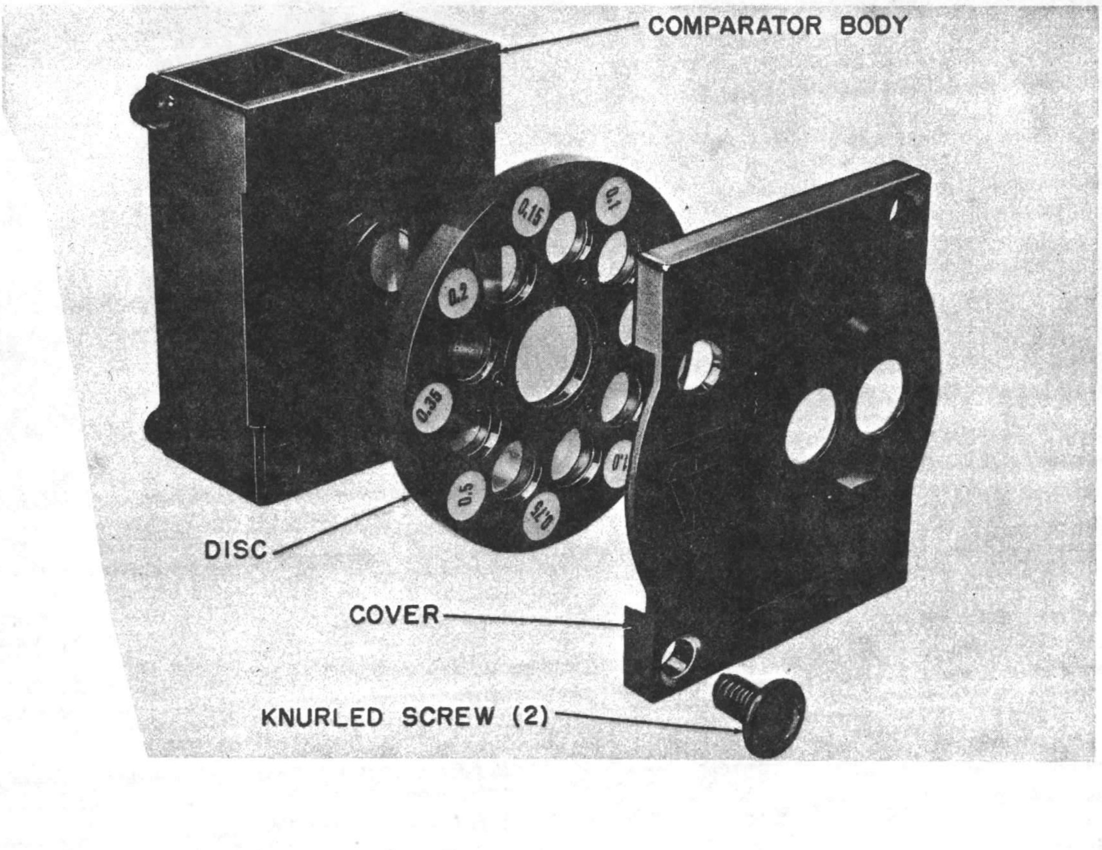


Figure 4-1. Installation of Comparator Disc

Figure 4-2. Installation of Comparator Prism

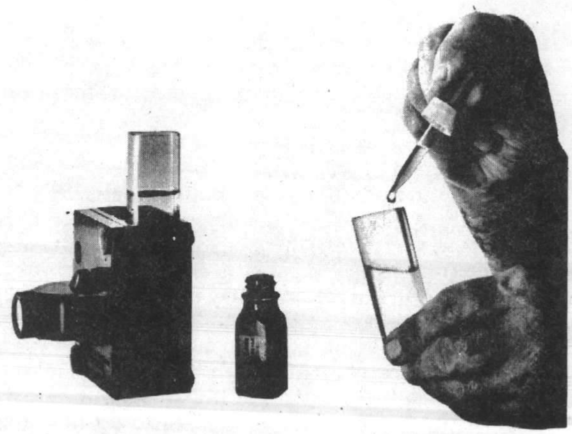


Figure 4-3. Addition of Indicator Solution

the water and calcium hypochlorite have been in contact for 10 minutes. This will allow proper time for mixing. Place one of the sample tubes in the right-hand compartment of the comparator (figure 4-3).

(5). Fill the dropper to the graduation mark with the orthotolidine indicator solution, then add this solution to the second sample tube (figure 4-3).

(6). Place the second tube (containing the water to be tested and the orthotolidine solution) in the center compartment of the comparator (figure 4-4). Make sure that both sample tubes are pushed down as far as they will go. Wait until the sample in the center compartment has developed its maximum color. This should occur within 5 minutes after the reagent is added.

(7). Compare the sample color with that of the standard by rotating the disc until the best match is obtained between the sample and the glass standard. Hold comparator so prism is approximately 12 inches from the eye (figure 4-5). Read the residual value in the opening in the front upper left-hand corner of the comparator. If the sample color falls between that of two of the glass standards, the chlorine residual value must be estimated.

(8). When the test has been completed, remove both sample tubes from the comparator, empty out the samples and wash the tubes with clean water.

c. Test Procedure, pH. See general test precautions (par. d. below). The general procedure for making pH determinations is the same as for residual chlorine determinations. A pH indicator solution must be used and a pH color disc substituted for the chlorine disc. The range of the solution and disc must be the same. Two pH discs are furnished: one with a pH range of 6.0 to 7.6 for use with bromthymol blue indicator solution; the other with a pH range of 4.4 to 6.0 for use with bromcresol purple-green indicator solution. The pH test procedure is modified by the fact that time is not a factor. In this test, to insure proper mixing, the correct amount of pH solution should be put in the second sample tube before the sample tubes are filled with the water being tested. The color development is practically instantaneous and the pH value may be read as soon as the sample tubes are placed in the comparator.

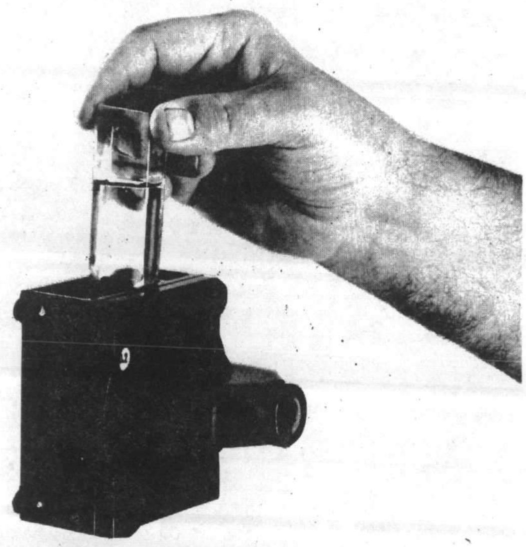


Figure 4-4. Insertion of Second Sample Tube

d. General Test Precautions. Because of the small quantities being measured, the color tests described in b. and c. above are delicate chemical tests and, to insure greatest accuracy, several precautions should be followed.

(1). Color Discs and Indicator Solutions. All color discs and solutions are adjusted for sample tubes having a 26-mm depth and on the basis of 15-cc water

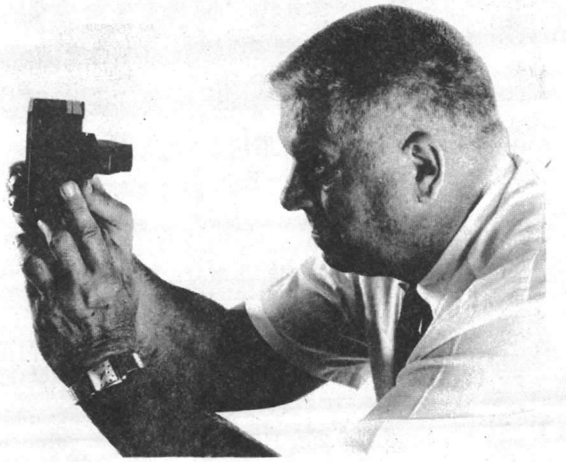


Figure 4-5. Reading the Comparator

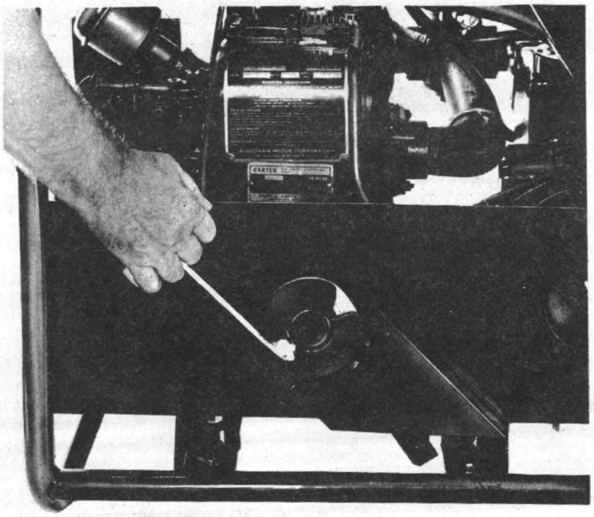


Figure 4-6. Use of Engine Starting Rope

sample and 0.75-cc of orthotolidine indicator solution, or 0.5-cc of pH indicator solution. For correct results, it is essential that only Wallace and Tiernan color discs and solutions be used with the comparator. The graduated mark on the sample tubes is at 15-cc. The graduated mark on the orthotolidine dropper is at 0.75-cc, and the mark on the pH droppers is at 0.5-cc. The discs supplied will measure 0.1 to 5.0 ppm chlorine residual, 4.4 to 6.0 pH and 6.0 to 7.6 pH value.

(2). Clean Equipment. Before taking readings be sure that the glass color standards in the disc and the white frosted glass plate in the back of the case are clean.

(3). Color and Turbidity. To eliminate errors due to natural color and turbidity of the sample make sure that water is added to the right-hand tube before making a color comparison.

(4). Sunlight. Do not allow direct sunlight to fall on the samples being tested. Sunlight causes the color developed by the indicator solution to fade.

(5). Cleanliness. When taking samples, adding solutions and mixing solutions with water in the sample tubes be sure that the hands are free of all traces of chemical so that the sample will not be contaminated. Any contamination of the samples will change the true chlorine residual or pH.

(6). Clean Droppers. The solutions used in making pH determinations are susceptible to change through bacterial action if the solution becomes contaminated. Care must be taken, therefore, not to contaminate the indicator solution by the introduction of droppers that are not perfectly clean.

(7). Adding Indicator Solution. In carrying out the test for pH it is recommended that the correct amount of indicator solution be introduced into the tube before the water is added. In so doing, do not touch the dropper with the fingers or allow it to come in contact with the side of the tube. Never use the dropper to stir the sample. As soon as the solution has been introduced into the tube, replace the dropper in the bottle of indicator solution.

4-3. PUMPING UNIT.

a. Rope Starter. The engine is equipped with a rope starter (figure 4-6) consisting of a notched starting pulley (mounted on the flywheel end of the crankshaft) and a starting rope. Proper application of the rope in conjunction with the pulley imparts two full revolutions to the crankshaft. The knot of the starting rope is placed in a notch of the starting pulley. The rope is then wound clockwise in the pulley groove. The rope is pulled gently until an increased resistance is felt on the compression stroke. At this point the pulley is turned back a half turn. The rope is then rewound fully and pulled briskly to turn the crankshaft over rapidly. The operation is repeated until the engine starts.

b. Governor Control. A variable speed governor control lever (figure 4-7) is mounted on the engine crankcase housing under the pump end of the fuel tank. This lever, connected by a linkage to the governor shaft and carburetor, increases or decreases the governed speed of the engine. Moving the lever towards the pump decreases the governed speed. Moving the lever towards the fuel tank increases the governed speed of the engine.

c. Carburetor Controls (figure 4-8).

(1). Choke Lever. The lever (1), located on top of the carburetor at the air cleaner end, controls the choke valve. The choke is closed, when starting the engine, by turning the lever counterclockwise. The choke will remain closed until the engine starts, at which time it will open automatically.

(2). Idle Valve Adjusting Screw. The idle valve adjusting screw (2), located on the fuel inlet side of the carburetor, controls the fuel-air mixture at low engine speed. Turning the screw IN restricts the flow of fuel. Turning the screw OUT increases the flow of fuel.

(3). Main Fuel Valve Adjusting Screw. The adjusting screw (4) for the main fuel needle valve extends from the underside of the carburetor float bowl. Turning the screw IN restricts the flow of fuel through the main nozzle; turning the screw OUT increases the flow.

(4). Throttle Stop Adjustment. The throttle stop screw (3) provides the means of obtaining the proper idle speed after the idle valve adjusting screw (2) has been set. Turn the screw left to reduce engine idle speed and turn it right to increase engine idle speed.

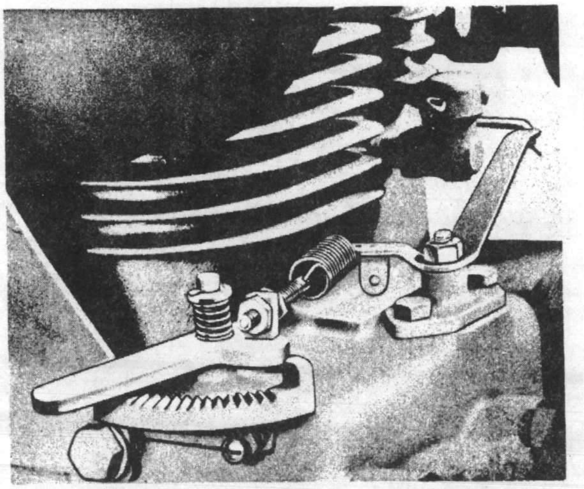
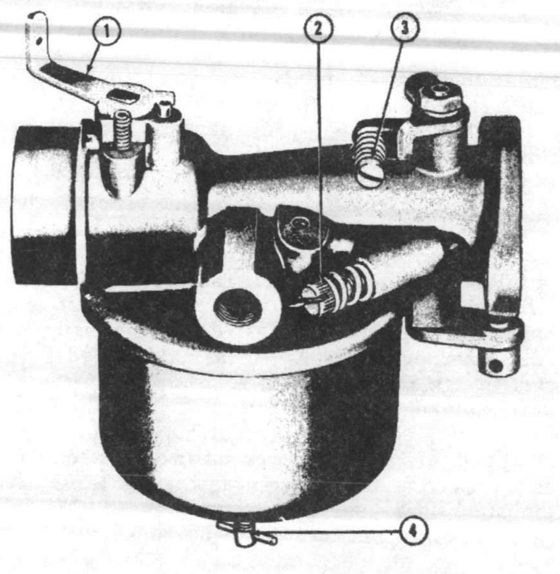


Figure 4-7. Engine Speed Governor Control



1. Choke lever
2. Idle valve adjusting screw
3. Throttle stop adjustment
4. Main fuel valve adjusting screw

Figure 4-8. Carburetor Controls

(5). Carburetor Adjustments. Detailed adjustment procedures for the carburetor are given in Wisconsin Motor Corporation Instruction Book, Issue MM-270-E. Once the carburetor is properly adjusted the adjusting screws usually require no further attention.

4-4. ADJUSTABLE FLOW CONTROL VALVE.

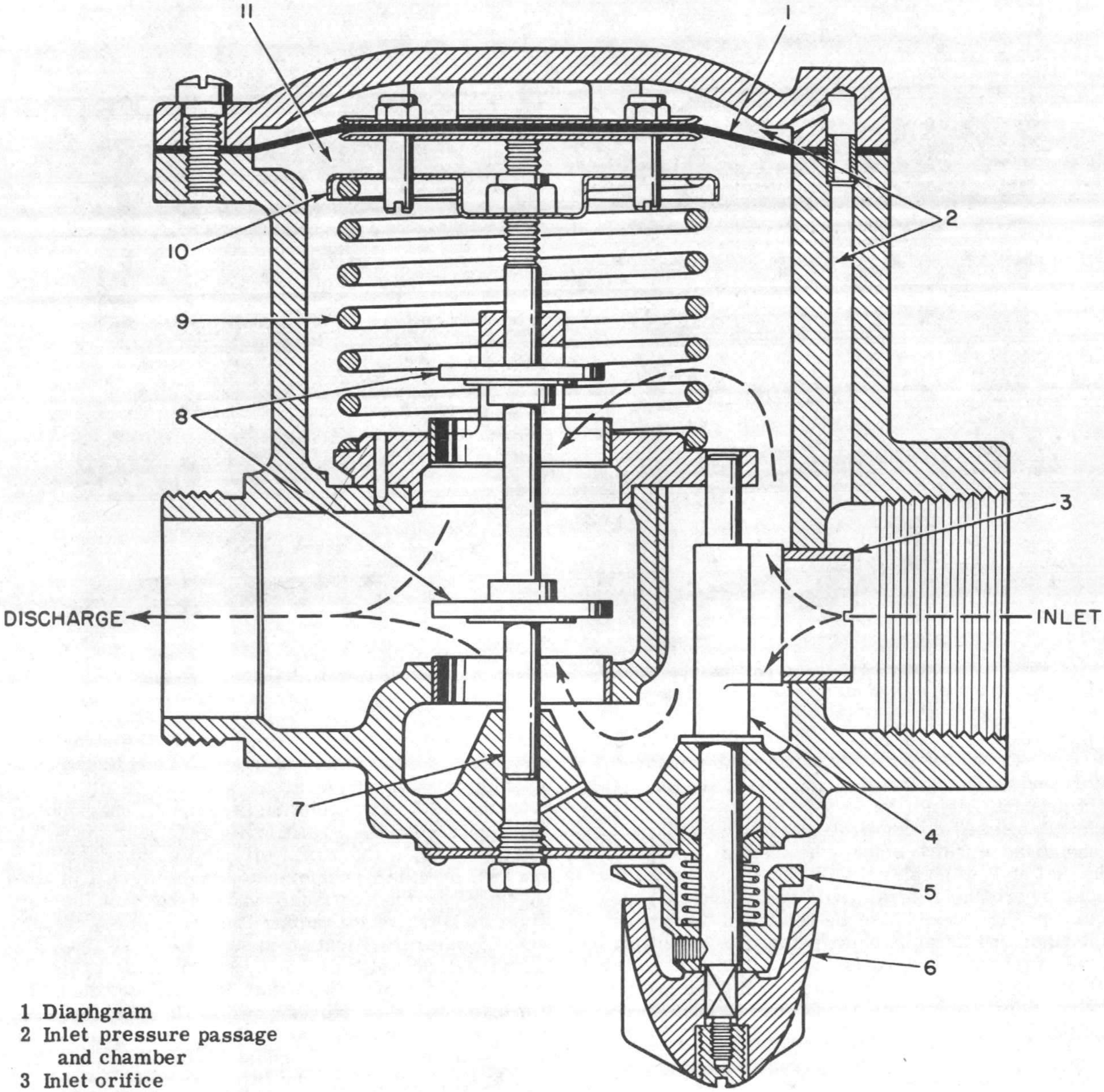
a. Location, Description and Purpose. The adjustable flow control valve (figure 4-9) is attached to the outlet valve at the bottom of the filter section. After the water leaves the filter section it goes to the flow control valve. The valve is a diaphragm-operated, balanced seat, differential pressure controlled, water throttling valve designed to maintain the rate of flow at the rate set on the pointer (5) (figure 4-9). The flow control valve will maintain the preset rate of flow, plus or minus 10 percent, from beginning to end of the filter run thus providing more even filter output. The valve is adjusted by turning knob (6) and pointer (5) to the desired rate of flow. During operation check the rate of delivery of filtered water to check the performance of the flow control valve.

b. Operation. At the start of a filter run pressure of the filtered water (as indicated by the discharge water pressure gage) is high and gradually decreases as the filter cake on the elements becomes less porous. High pressure at the flow control valve inlet is transferred through the inlet pressure passage (2) (figure 4-9) to the diaphragm (1). This high pressure acts against the spring (9) and the reduced pressure in the valve body (11). The reduced pressure is caused by the pressure drop as the water flows through the inlet orifice (3). The inlet orifice can be opened wide, or closed completely, by turning knob (6) which rotates gate (4) across the front of the orifice. The pressure difference moves the valve disc shaft (7) and valve discs (8) causing them to close the valve outlet thereby increasing the pressure in the valve body chamber (11). This action balances the pressure on the diaphragm (1) with the result that the valve is automatically opened just enough to allow the preset rate of flow. As the filter run progresses, the pressure at the valve inlet decreases, and the spring pressure opens the valve to its full-open position to help maintain the rate of flow.

4-5. SLURRY FEEDER.

a. Location, Description and Purpose. The rate of feed control for the slurry feeder is located on the slurry feeder diaphragm cap assembly (figure 4-10). The control consists of a dial plate graduated from 0 to 10 mounted on a knurled feed cam and a vertical pin which serves as an indicating pointer. Once the dial is set for the desired rate of feed it is locked in place by a screw protruding from the center of the dial. The rate of feed control changes the length of stroke of the slurry feeder pumping diaphragm and consequently the volume of filteraid slurry drawn into the feeder during the diaphragm suction stroke. The rate of filteraid slurry feed required will depend on the turbidity of the water being filtered which in turn depends on the efficiency of coagulation.

b. Operation. Slurry in the hopper is usually made in the proportion of 5 large cups of filteraid to 3 gallons of water. With this slurry, and input shaft speed of 600 rpm, slurry will be pumped at the rate of 0.33 gph (gallons per hour) when the dial is set at "2", and 1.66 gph at a dial setting of "10". This corresponds to from 0.5 to 2.5 pph (pounds per hour) of filteraid. If the water is very clear it may be desirable to reduce the concentration of filteraid slurry. When the concentration is reduced, the rate of feed for each dial setting will be reduced proportionally. When a system is first started the dial should be set at 2 during precoating and the operation of the feeder valves checked by observation through the valve chamber window. Before the filter run is made the dial should be set to the desired rate of feed which is determined by experience as being best for filtering water of that particular turbidity, say about 5. Too much filteraid with clear water will shorten the filter run as will too little filteraid with turbid water. The optimum rate of feed



1 Diaphgram
2 Inlet pressure passage and chamber
3 Inlet orifice
4 Gate
5 Pointer
6 Knob
7 Valve disc shaft
8 Valve discs
9 Valve spring
10 Spring seat
11 Valve body reduced pressure chamber

Figure 4-9. Adjustable Flow Control Valve - Cross Section

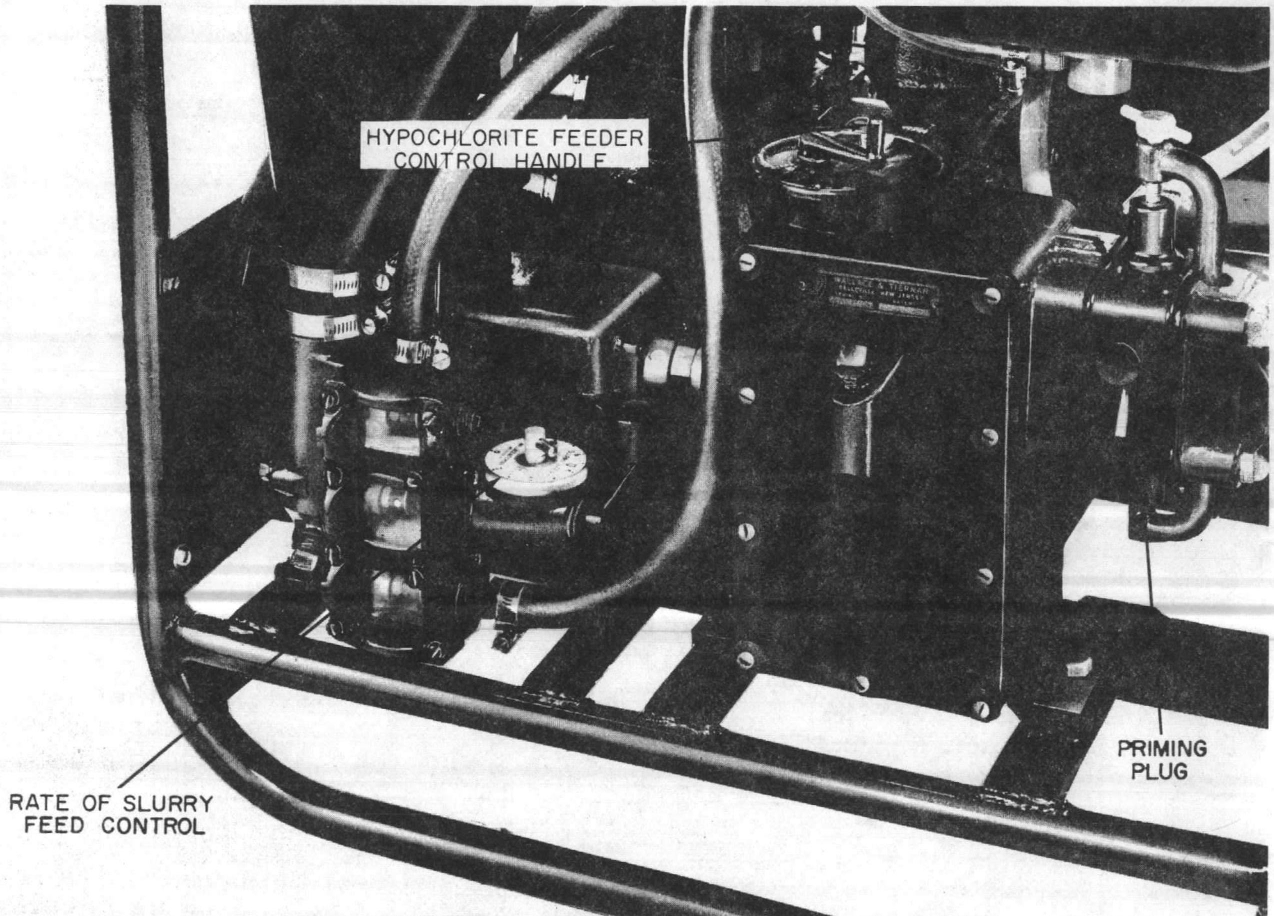


Figure 4-10. Slurry Feeder and Hypochlorinator Controls

for the particular water must be determined by trial and error. Once the optimum setting is determined the dial need not be changed during any of the operations of precoat, filter or backwash. A little extra filteraid will be used during precoat and backwash, but this should be minor. Before the engine is stopped set the dial at 0 so no slurry will remain in the valve chamber where the filteraid will settle and clog the valves. The dial should also be set at 0 if the engine is running and no water is being pumped to the filter. This will prevent build-up of filteraid in the valve chamber. The dial may be turned easily while the feeder is in operation if the actual turn is made during the pumping stroke.

4-6. HYPOCHLORINATOR.

a. Location, Description and Purpose. The hypochlorinator control handle is located on top of the hypochlorinator (figure 4-10). Turning the control handle changes the amount of solution pumped. When the dial is set at "2" a minimum amount of solution is fed. When the dial is set at "10" the maximum amount of solution is fed. The handle can be turned and the rate of solution feed changed while the hypochlorinator is in operation or at rest.

b. Operation. The hypochlorinator is a diaphragm pump. The movement of the hypochlorinator diaphragm is controlled by the action of a cam which actuates a rocker arm. With a setting of "2" on the hypochlorinator dial, the rocker arm stroke is short and only about 0.6 gph of solution is pumped. The stroke increases as the dial is turned up to "10", and the amount of solution pumped increases with the result that at "10" about 2.3 gph of solution is pumped. The solution is pumped from the hypochlorite reservoir through a strainer (inside the reservoir) and sight glass (figure 2-7) into the hypochlorinator from which it is discharged into the restrictor and mixed with the raw water as it leaves the pump. It is recommended that when a water purification system is first set up a 0.375% solution of calcium hypochlorite be prepared and the hypochlorinator set at "10" to start the solution pumping, then moved down to "2" while the elements are precoated, and finally turned up to "6" or "7" for the filter run. Depending on the chlorine residual to be maintained in the filtered water, the rate of solution feed may be either increased or decreased. The chlorine residual can also be changed by changing the strength of the calcium hypochlorite solution. The optimum setting and solution strength for the particular water being treated can only be found by trial and error. Generally, it is best to use a relatively weak solution (under 1%) of the hypochlorite solution and a dial setting of "6" or "7" which will allow quick changes in the amount of solution pumped either up or down.

c. Priming the Hypochlorinator. When the hypochlorinator is functioning normally, solution will spurt into the sight glass at regular intervals. At start-up, with the stroke control handle set at 10, observe the sight glass to see if solution is being pumped. If no spurting is observed it will be necessary to bleed air on the pump stroke and seal off the pump body on the suction stroke. To do this loosen priming plug (figure 4-10) on the pump stroke and tighten it at the start of the suction stroke. If this does not produce results, remove the solution strainer from the suction hose and fill the sight glass by pouring water down the hose. Replace the strainer on the hose and place in the hypochlorite reservoir. If the unit still does not prime, then the suction line, the sight glass, the pump body and the valve body should be checked for air leaks.

4-7. AIR RELEASE VALVE.

a. Location, Description and Purpose. The air release valve is bolted to the top of the filter shell. This is a quick-acting valve which moves from closed to open position in 1/60 of a second. The valve is designed to release the pressure in the filter instantaneously to permit air-bump backwash of the elements at the end of a filter run.

b. Operation. To open the air release valve slap the handle down with the heel of the hand. To close the valve press the disc down with both thumbs (figure 4-11) and while holding the disc down with one thumb lift up on the handle with the other hand (figure 4-12).

4-8. WATER PRESSURE GAGES.

a. Location, Description and Purpose. The inlet water pressure gage (figure 2-4) is attached to a tee at the top of the filter shell. The discharge water pressure gage (figure 2-4) is attached to a nipple at the bottom of the filter base. Both gages are standard 2-inch dial, steel case and brass movement, reading from 0 to 60 psi with 1/4-inch male pipe connection. The inlet gage gives the pressure of the unfiltered water in the filter shell. The discharge gage gives the pressure of filtered water in the bottom of the filter base after the water has passed through the elements. The gages give the operator an indication of how the filter is working and when to backwash the elements.

b. Operation. At the start of the filter run both gages will have the same reading. As the filter run progresses the inlet gage reading will increase and the discharge gage reading will decrease. During the filter run the inlet gage will remain farily constant or rise slowly 2 to 4 psi until the flow control valve (par. 4-4) is wide open. From this point the output of the filter starts to drop and the inlet pressure will rise about 4 pounds during a relatively short time, say about 5 to 10 percent of the total filter run. This indicates that the filter cake on the elements is losing its porosity and the elements should be backwashed. The discharge gage will drop gradually during the filter run as the flow control valve opens wider (par. 4-4). If the storage tank is about the same level as the filter, the discharge gage will drop to about 4 psi at which time the elements should be backwashed. However, if the storage tank is above the filter, back pressure will give a higher discharge pressure reading. A noticeable drop in the flow of filtered water is a definite indication that the elements should be backwashed. It is recommended that the flow of filtered water be watched during the first few filter runs at a new water site and the gage readings noted when output decreases. These readings may then be used for future filter runs. At the end of a filter run, the filter outlet valve (figure 2-5) is closed and the pressure on the discharge gage is allowed to build to that on the inlet pressure gage as a preliminary to air-bump backwashing.

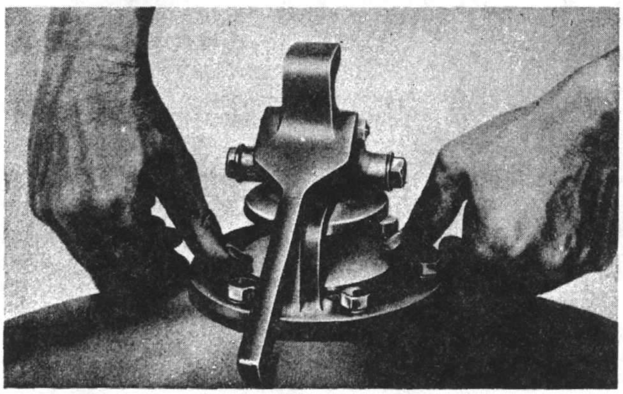


Figure 4-11. Air Release Valve - Positioned for Closing

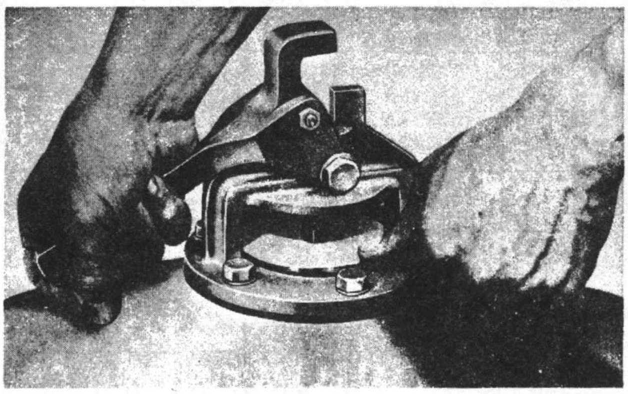


Figure 4-12. Air Release Valve - Setting Valve Handle in Closed Position

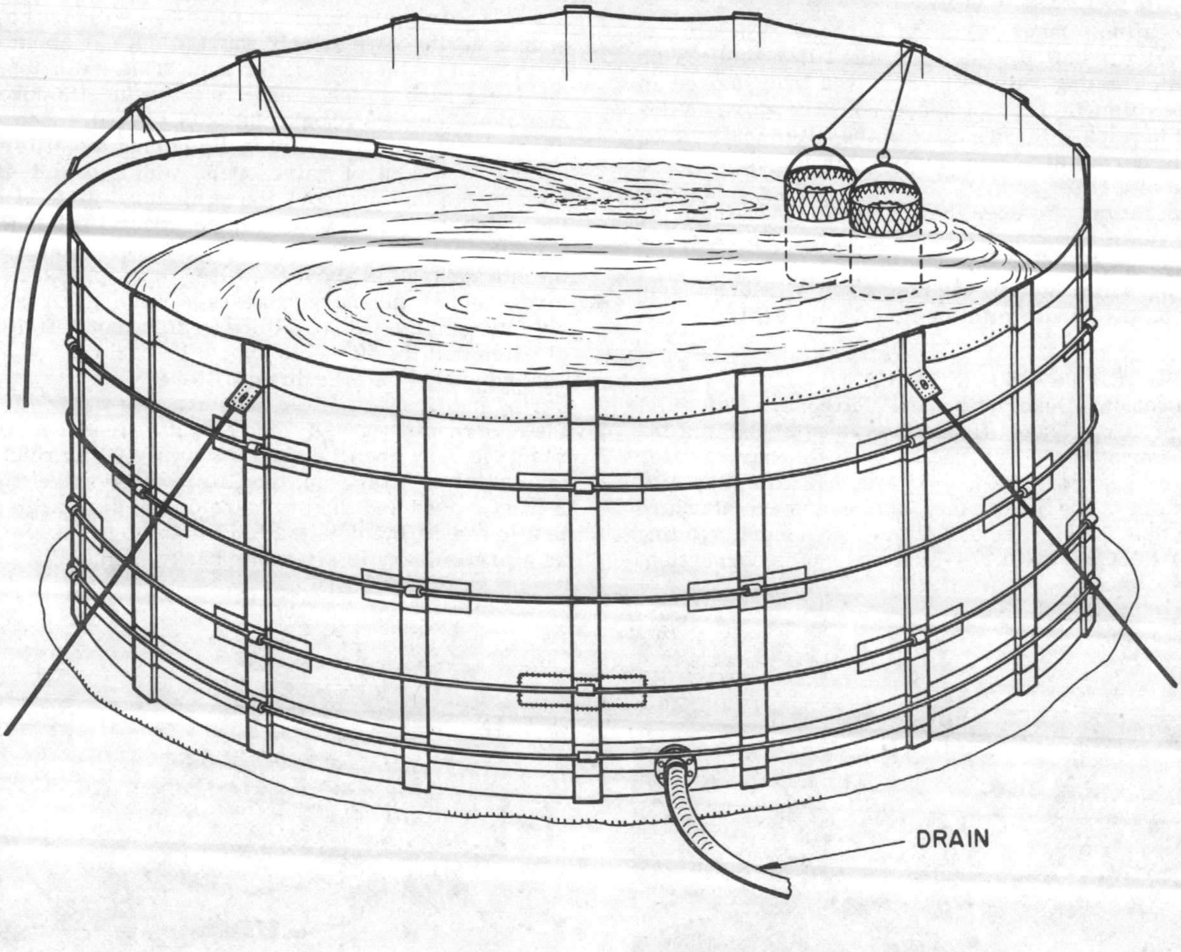


Figure 5-1. Filling Settling Tank

SECTION 5

PRETREATMENT OF WATER

5-1. GENERAL. Surface water usually has disease organisms and dirt, sand, silt, clay, decaying vegetation, or chemicals in it. Suspended particles make the water turbid, as opposed to clear water which has little or no visible suspended matter. All water, regardless of turbidity, must be filtered and chlorinated since even clear water can contain microscopic organisms and bacteria that will be injurious to personnel using or drinking it. Very clear water may be filtered direct from the raw water source. Most water is turbid and must be pumped into settling tanks where the suspended matter is removed by the pretreatment process explained in this section.

5-2. OPTIMUM pH. All water has a pH value at which the best flocculation occurs in the shortest time. This is called the optimum pH. The optimum pH may be determined by a series of trial and error tests using equal samples of the water to be tested and adding varying measured amounts of alum and sometimes soda ash. Coagulation test procedure is explained in paragraph 5-5. The optimum pH generally falls between 4.5 and 7.5. Turbid water with considerable natural alkalinity flocculates best at a pH of between 6.0 and 7.5. Colored water usually flocculates best between 4.5 and 6.0. It is not usually advisable to add soda ash during coagulation of colored water as this may fix the color. If good coagulation occurs for a number of pH values use the pH that will require the least amount of coagulating chemicals.

5-3. FILLING SETTLING TANKS. Tie the raw water filling hose on the side of the tank (figure 5-1) and direct the water along the wall of the tank so the water swirls inside the tank. The whirling motion helps to distribute the coagulating chemicals and should be allowed to continue even when the tank is full as the circular movement will aid in flocculation. While the tank is being filled, coagulants and sometimes calcium hypochlorite are added as explained in paragraphs 5-4 and 5-6.

5-4. COAGULATION PROCEDURE. From coagulation tests (par. 5-5) determine the optimum pH value of the water. This is the pH that should be maintained in the settling tanks to obtain the best and fastest flocculation. The optimum pH may change from day to day for a particular water and coagulation tests should be repeated if flocculation is not satisfactory. Estimate (par. 5-5c) the amount of coagulants required to obtain the optimum pH for 3000 gallons of water. Put twice the amount of alum in one chemical basket and, if soda ash must be used, put twice the amount of soda ash in the other basket. More than the required dosage is needed as all of the chemical does not dissolve.

a. Add Coagulants to Water. Use a rope or cord to suspend the alum basket (and if soda ash is required, the soda ash basket) in the tank (figure 5-1). The baskets should be about 4 or 5 feet from the stream of water from the hose and immersed in the water. As the water rises in the tank the baskets must be raised. When the tank is about half full remove the baskets, take the pH, and note the quantity of chemicals dissolved. The nearer the baskets are to the stream of water, the faster the chemicals will dissolve. If the coagulants are dissolving too fast for optimum pH, move the baskets away from the stream of water. If the coagulants are not dissolving fast enough, move the baskets closer to the stream. It may be necessary to remove the baskets from the tank for a short while if too much chemical has dissolved. If the tank is full and too little coagulant has dissolved leave the baskets in the tank after the filling hose has been removed. If necessary to maintain the circular motion, stir the water with a piece of clean wood. The direction of flow must be the same as when the tank was filling.

b. Flocculation. The purpose of adding coagulants is to obtain a good floc that will trap suspended matter and carry it to the bottom of the tank. The jelly-like floc first appears in particles so small that the water has a milky appearance. As the water swirls, the small particles join with others to form large particles. If the alum dosage is correct a distinct floc will appear shortly after the tank is full. If too much alum was dissolved the floc will be large and feathery. If too little was dissolved the floc will be fine and indistinct. A good floc is between the two and should be large enough to enmesh suspended matter and heavy enough to settle to the bottom. The settled floc and suspended matter form a sludge at the bottom of the tank. This sludge in the tank aids settling. Do not remove it except as required to draw clear water. To remove sludge attach the drain hose to the suction of a pumping unit and pump to waste. At the same time pump raw water into the tank in such a way as to disturb the sludge and keep it in suspension.

c. Settling Time. After the tank is full and the filling hose has been removed, the water will still continue to swirl for some time. The floc and suspended matter will gradually settle to the bottom. Settling time is at least 30 minutes and will vary with the water to be treated and the efficiency of the treatment. The longer the water has settled the faster it can be filtered. Always let water settle as long as is practical and use all available settling tanks to settle water overnight or during inactive periods.

5-5. COAGULATION TESTS. Expedient apparatus for conducting coagulation tests can be made by using a series of clear jars, glasses, bottles or similar containers. The containers used need not be of the same size or shape but must contain the same amounts of water to be tested (about 1 pint). It is suggested that one container be used to measure the water placed in all of the containers.

a. Prepare Test Solutions. Saturated solutions of alum and soda ash are made by dissolving alum in one small jar of water and soda ash in another until no more chemical dissolves in the water despite vigorous stirring. In each case, leave a few undissolved crystals to be sure of saturation. The saturated solutions are too strong for use so adjusted-strength solutions must be formed. Diluting 1 part of the saturated alum solution with 10 parts of water produces approximately the desired strength alum solution. Diluting 1 part of the saturated soda ash solution with 20 parts of water produces approximately the desired strength soda ash solution.

b. Conduct the Test. Use the comparator to determine the pH of the raw water.

(1). If pH is above 6.4 and the water is practically colorless, or if the pH is below 6.4 and the water has a high color, place equal volumes of water in six jars. Add increasing amounts of adjusted alum solution to each jar of water. As a start, add 1 cc to the first jar, 2 to the second, 3 to the third, etc., for all the jars. The pH dropper (par. 4-2d.(1)) holds 0.5 cc.

(2). Quickly stir all jars with a clean stick, but do not use more than two circular movements to mix the chemical and water. Continue stirring only enough to keep water barely moving for a period not less than 5 minutes. Violent stirring breaks up the floc and does not allow it to form into visible particles.

(3). Observe all jars while stirring and note the jar or jars in which the floc forms first. Record the stirring time at which the floc first becomes visible. If floc forms within 2 minutes after chemical solution is added, the result may be of value. Observe the characteristics of the floc and of the water between the particles after stirring has stopped. A clear, sparkling water between well-formed floc particles is desired. For completeness the test should be continued, after a good floc is obtained, until poor floc is obtained when increased amounts of alum are added. A series of jars in which a good floc or series of good flocs is preceded and followed by a series of jars having poor flocs indicates a complete test.

(4). Determine the pH of the water in each jar to which alum solution was added. The pH value of the water in the jar having the best floc is the optimum pH. The pH values of all jars in which good floc has formed may be included within the pH range.

(5). If the pH value of the raw water is below 6.4 and the water is practically colorless, or if the results of the jar test using alum alone indicate that the water has insufficient alkalinity, soda ash must be added. The series of jars are filled with raw water. A measured amount of adjusted soda ash solution sufficient to raise the pH value to 7.6 is added to each jar. An additional 4 cc are added to each jar and the adjusted alum solution is added (see (1), (2), (3) and (4), above).

(6). If an optimum pH has not been found or the floc takes too long to form, the test is repeated with increased amounts of soda ash and alum.

c. Summary. When soda ash is added in the final treatment, approximately the same ratio of soda ash to alum is used as in the jar test. In general, the optimum pH can be determined with alum alone. Soda ash should be used only when absolutely necessary.

5-6. PRE-CHLORINATION IN SETTLING TANKS. The hypochlorinator in the machinery section is capable of chlorinating most raw waters. However, if hard to kill organisms as schistosomes or amoebic cysts are in the water it may be advisable to pre-chlorinate the water in the settling tanks. The advantage is that the longer period of contact with the chlorine will kill more of the resistant organisms, and the hypochlorite solution in the hypochlorinator will not have to be too strong to maintain a 2 ppm chlorine residual in the filtered water. The disadvantage is that more calcium hypochlorite is required since it must disinfect all the bacteria and suspended matter that normally would remain in the settling tank. To pre-chlorinate make a slurry of 3 tablespoons of calcium hypochlorite in the large measuring cup. Add this slurry to the settling tank at the start of the filling operation. When the tank is full, test the water for residual chlorine. If the residual is less than 1.5 ppm add sufficient calcium hypochlorite slurry to bring the residual to this level. The hypochlorinator should be adjusted to give a chlorine residual of 2 ppm in the filtered water when schistosomes or amoebic cysts are in the raw water.

SECTION 6

OPERATING INSTRUCTIONS

6-1. STARTING AND STOPPING. When water is flowing through the equipment, it is started or in operation. When water ceases to flow, the equipment is stopped or at rest. Therefore, starting and stopping of the water purification equipment coincides with the starting and stopping of the pumping unit. This section gives all the instructions needed for satisfactory operation of the water purification equipment.

6-2. PREPARATORY OPERATIONS.

a. Visual Inspection. Make a complete visual inspection of the equipment set-up to make sure that hose connections are secure, there are no broken or damaged parts, and all units are securely mounted. Check equipment for leaks in any of the water hoses, the fuel line, and leaks in any of the machinery section components. Check that all equipment is on firm level footing.

b. Lubrication. Give the equipment a complete daily lubrication (par. 7-2).

c. Precoat Tank. Fill the precoat tank with clean, settled water. Add 1/4 of the 5-ounce measuring cup of calcium hypochlorite to sterilize the water in the precoat tank, and to sterilize the pump and filter. Sterilization is necessary only when the equipment is first started and no chlorinated water is available. During normal operation filtered and chlorinated water will be left in the precoat tank ready for use. Stir one measuring container (2-quart) of filteraid into the water in the precoat tank.

WARNING

Keep calcium hypochlorite away from the eyes. Be especially careful when opening cans and turn the head so the chemical dust does not fly up into the eyes.

d. Slurry Feeder. Fill the slurry hopper with clean settled water to within 2.5 inches of the top (3 gallons). Add 5 measuring containers (2-quart) of filteraid to make the slurry (par. 4-5b). After the equipment is in operation, water for preparing the slurry can be obtained through the make-up water valve. The slurry rate of feed adjuster should be set at "0" until the equipment is in operation.

e. Hypochlorinator. Make a solution in the large measuring cup of one small cup (5 ounces) of calcium hypochlorite and two quarts of water. Stir the mixture, until all the chemical dissolves, then allow the solution to settle. Decant the clear liquid into the hypochlorite reservoir. Add water to bring the level in the hypochlorite reservoir to within 2 inches of the top, making a total of 5 gallons of solution in the reservoir. The strength of the hypochlorite solution prepared in this way is about 0.375%. Depending on the amount of chlorine required to sterilize the water, the strength of the solution can be increased or decreased by using more or less calcium hypochlorite. In any case, do not make the hypochlorite solution stronger than 1%.

NOTE

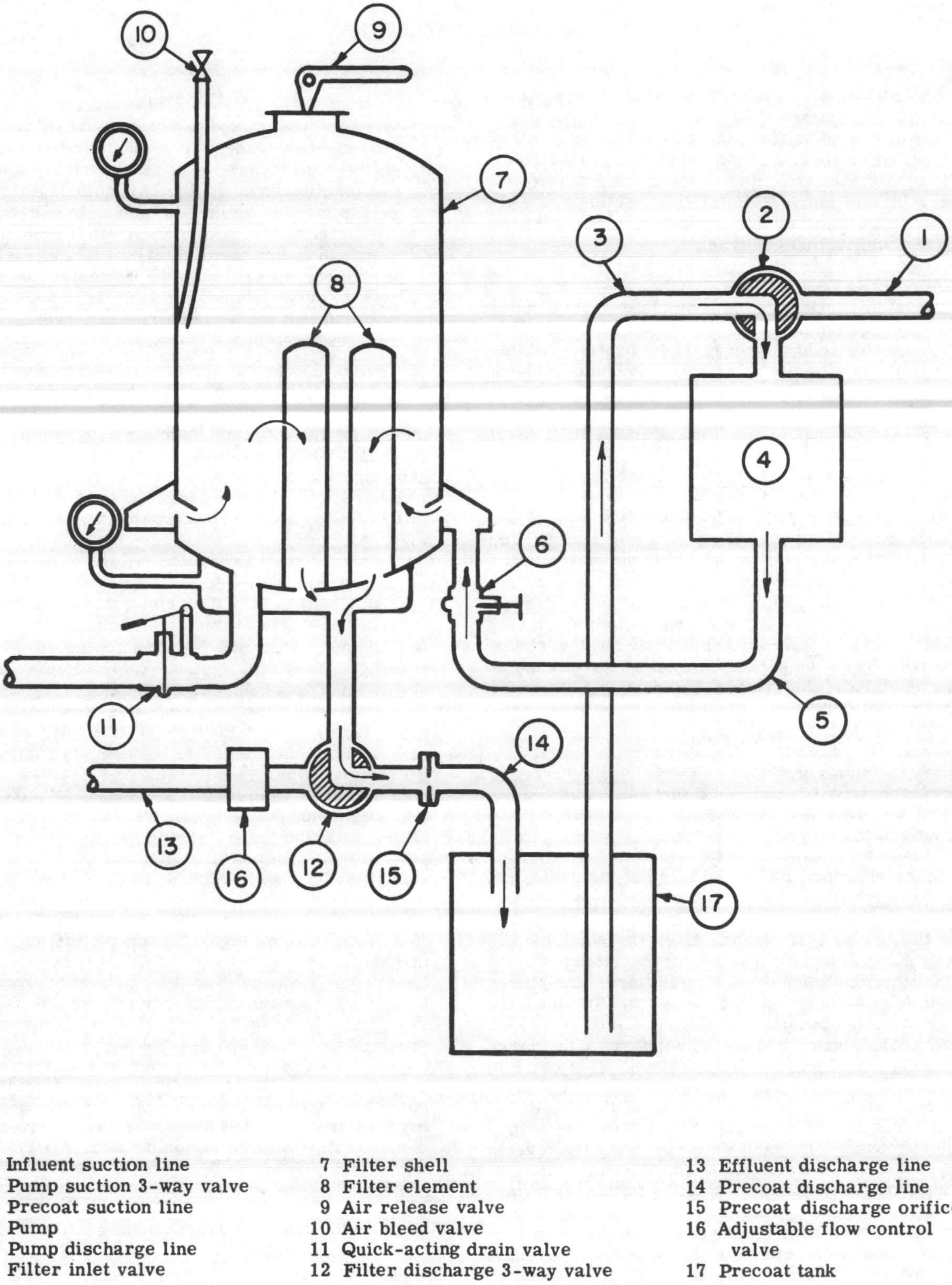
When the water used to prepare the solution is "hard", it is necessary to precipitate as much of the "hardness" as possible before passing the solution through the hypochlorinator. To precipitate the "hardness" add soda ash (washing soda) to the solution. A slight excess of soda ash is not harmful. Allow the precipitate that forms to settle to the bottom of the container, then syphon off the clear hypochlorite solution into the hypochlorite reservoir. Discard the precipitate.

f. Pump. Never run the pump without lubrication or without water in the housing. Prime the pump by removing the priming plug in the top of the restrictor and filling the priming chamber with water. Replace the plug. When the engine is started, air in the suction hose will be drawn into the pump, mixed with the priming water and discharged out the discharge hose until the pump starts to draw water through the suction hose. All pump connections subject to suction must be air tight or reduced capacity, failure to prime, or delay in priming will result. During normal operation the pump will retain its prime, and the pump can be stopped and started without repriming.

g. Engine. Fill the fuel tank with 70-75 octane gasoline. Open fuel shut-off valve. If the engine is new, or if it has been out of operation for some time, the compression may be poor due to oil draining off the cylinder. This may cause difficulty in starting and it will be necessary to restore the compression. To restore compression, remove the spark plug and pour about a tablespoon of crankcase oil through the spark plug hole. Turn the engine over several times with the rope starter to distribute the oil over the cylinder wall. Replace the spark plug. Compression should now be restored. When proper compression is present considerably more resistance is felt in cranking on one stroke of the piston (the compression stroke) than on the other three strokes.

h. Valves. Check that the values operate freely before starting the pumping unit. Set the valves for the filter operation to be performed (generally precoating, see paragraph 6-4 below) before starting the engine. Valves may be opened and closed with the engine running to change from precoat to filter, to backwash, and back to precoat. The valves must be manipulated in a definite order, however, to avoid contaminating a batch of clean water. Always service the engine and pump between backwash and precoat when shut-down will not interrupt a filter run. Always have a supply of settled water available, and be prepared to switch from one tank to the other without interrupting the flow, to insure continuous operation.

i. Pretreatment of Water. Pretreat the water in settling tanks as described in Section 5.



1 Influent suction line
2 Pump suction 3-way valve
3 Precoat suction line
4 Pump
5 Pump discharge line
6 Filter inlet valve
7 Filter shell
8 Filter element
9 Air release valve
10 Air bleed valve
11 Quick-acting drain valve
12 Filter discharge 3-way valve
13 Effluent discharge line
14 Precoat discharge line
15 Precoat discharge orifice
16 Adjustable flow control valve
17 Precoat tank

Figure 6-1. Precoat Operation - Flow Diagram

6-3. STARTING, OPERATING, AND STOPPING THE PUMPING UNIT.

a. Starting the Engine.

(1). If the equipment is being started for the first time and hoses are empty, position the valves for filter bottom flush-out (par. 6-6f). After the pump is started allow it to operate until water issues from the filter drain line, then proceed with precoating operation (par. 6-4). If equipment is being restarted use normal precoat procedure.

(2). Open the carburetor main fuel adjustment valve between three-quarters to one and a quarter turns. Close the carburetor choke lever (par. 4-3c).

(3). Wind the starting rope on the starting pulley (figure 4-6). Pull gently on the top until increased resistance indicates the compression stroke, then turn the starting pulley back half a turn. Rewind the rope fully and pull briskly to turn the crankshaft over rapidly. Repeat this operation until the engine starts. If the choke accidentally snaps open before the engine starts, close it again.

(4). If, after several attempts, the engine fails to start, and gasoline starts to drip from the carburetor, open the choke. Continue the starting procedure with the rope starter leaving the choke open. Less choking is necessary in warmer weather, or when the engine is warm, than when it is cold.

(5). After the engine is started and warmed up for several minutes, the carburetor main fuel adjustment valve should be readjusted for best operation (par. 7-9c). This adjustment need only be made the first time the engine is started.

(6). The engine may fail to start due to defects in either the fuel or ignition systems. To determine the cause, prime the engine by removing the spark plug and pouring a half teaspoonful of gasoline into the spark plug opening. Replace the spark plug and perform starting procedure with the starting rope. If the engine fires for three or four revolutions and stops, the defect is in the fuel system. If the engine does not fire at all, check the compression (par. 6-2g) and ignition system.

b. Operating the Pumping Unit.

(1). After the engine is started, allow a sufficient length of time for the pump to operate and pick up its prime. The longer the suction line, the longer the priming time required.

(2). The engine speed during pumping should be 2600 rpm. Adjust the governor control (par. 4-3b) as necessary to change the engine speed.

(3). Check for any unusual operation, such as engine running below governed speed, engine overheating, excessive pump vibration, and pump not delivering full volume. Look for leaks in all connections, hoses, fuel line, in the casing, and at the pump impeller shaft seal.

(4). Stop operation immediately if any unusual noise develops in the pump or engine.

c. Stopping the Pumping Unit.

(1). Backwash and flush out the filter (par. 6-6). Leave valves set for filter bottom flush out.

(2). Stop the engine by pressing in the grounding switch (7) (figure 2-11) on the magneto and holding it until the engine stops.

6-4. PRECOAT OPERATION (figure 6-1).

a. Before water can be filtered, it is necessary to coat the filter elements (8) inside the filter shell (7) with a cake of diatomite filteraid that will screen out the suspended matter and organisms that remain in the settled water. This paragraph gives the proper procedure for precoating.

b. Close the air release valve (9) and open the air bleed valve (10).

c. Set the filter discharge valve (12) in "precoat" position. In this position the water is returned to the precoat tank after it passes through the filter elements (8).

d. Close the drain valve (11).

e. Turn the pump suction valve (2) to "precoat" position. In this position the pump draws from the precoat tank (17) through the precoat suction line (3).

f. Stir one large measuring cup of filteraid into the precoat tank water.

g. Start the pumping unit (par. 6-3a).

h. Bleed air from the filter shell (7) through the air bleed valve (10) until the water spurts out of the valve. Close the air bleed valve.

i. As soon as the equipment is operating, adjust the rate of slurry feed (par. 4-5) and the hypochlorinator control (par. 4-6). Check the operation of the slurry feeder and the hypochlorinator during the precoat operation.

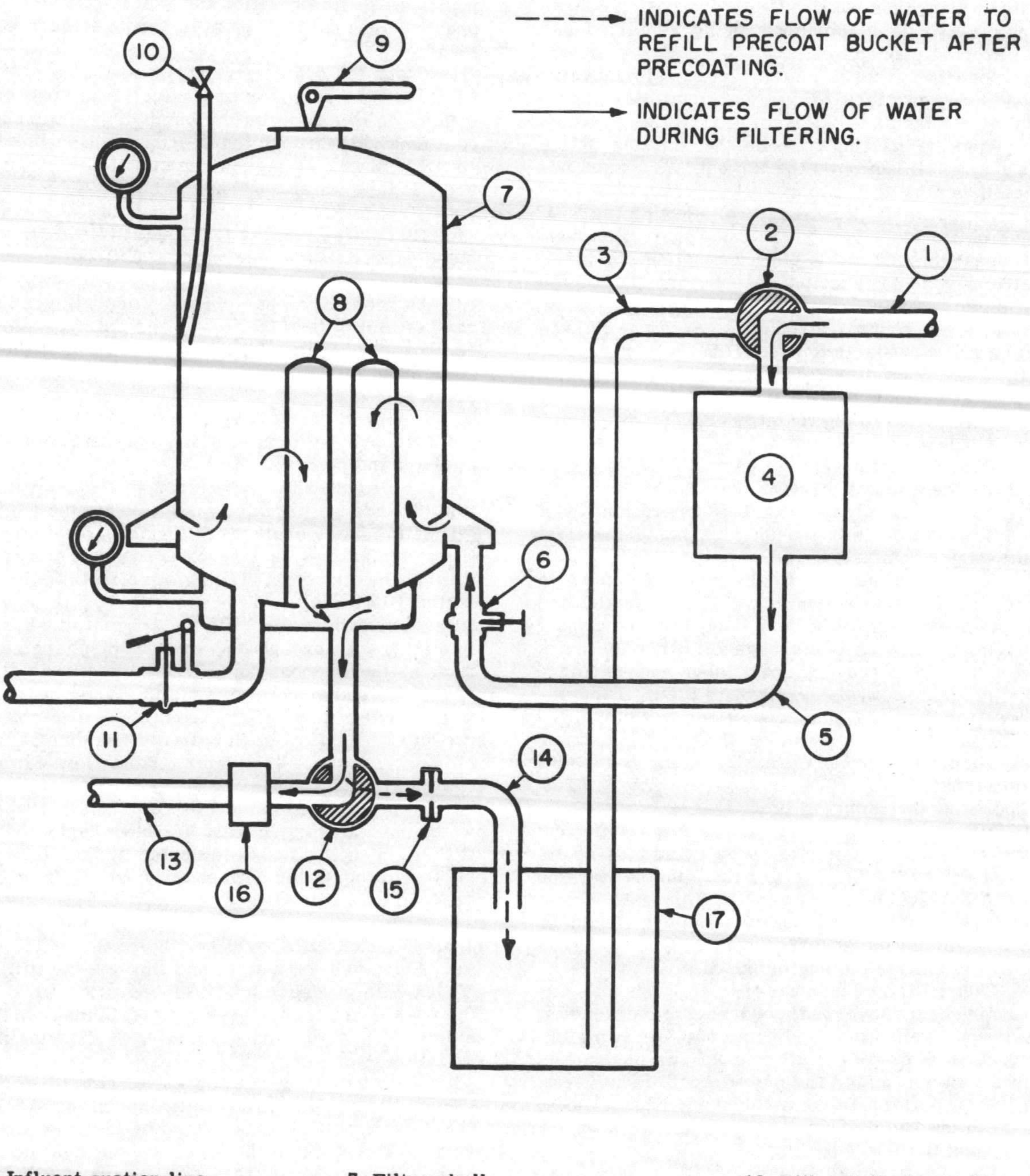
j. During the precoating the filteraid slurry is drawn from the precoat tank (17) through the precoat suction hose (3) and pump suction valve (2) to the pump (4). The pump forces the slurry through the pump discharge line (5), through the inlet valve (6) into the filter shell (7). In the filter shell the filteraid is deposited on the filter elements (8) and the water from the slurry passes through the elements. The water collects in the bottom of the filter shell and pressure forces it through the filter discharge valve (12), the precoat discharge orifice (15), and through the precoat discharge line (14) back to the precoat tank (17). Slots around the base of the filter shell (7) distribute the incoming slurry or water giving more even exposure to all elements and preventing the flow of liquid from scouring any of the elements. Orifice (15) controls the flow during precoating.

k. The pump continues to recirculate the precoat water until all the filteraid has been deposited on the filter elements. This is indicated by the clarity of the recirculating water. When precoating is complete, proceed with filter operation (par. 6-5).

6-5. FILTER OPERATION (figure 6-2).

a. Flow must be maintained through the filter shell (7) between precoat and filter operation to eliminate the possibility of the filter cake dropping off the elements (8). To go from precoating to filtering proceed as follows:

b. Turn the pump suction valve (2) to "filter" position so the pump draws water through the suction line (1) from the settling tank. Stand by the filter discharge valve (12) and watch the level of water in the precoat tank (17). As soon as the precoat tank is full, turn the filter discharge valve (12) to "filter" position so the filtered water is delivered to the effluent discharge hose (13). The discharge hose (13) should now deliver clear filtered water to the storage tank. If the water is not clear the filter is not operating properly -- the discharge valve (12) should be shut, the elements backwashed and the trouble located, before filtering is resumed.



1 Influent suction line
2 Pump suction 3-way valve
3 Precoat suction line
4 Pump
5 Pump discharge line
6 Filter inlet valve
7 Filter shell
8 Filter element
9 Air release valve
10 Air bleed valve
11 Quick-acting drain valve
12 Filter discharge 3-way valve
13 Effluent discharge line
14 Precoat discharge line
15 Precoat discharge orifice
16 Adjustable flow control valve
17 Precoat tank

Figure 6-2. Filter Operation - Flow Diagram

6 c. During filtering, settled raw water is drawn from the settling tank through the suction line (1) and pump suction valve (2) to the pump (4). The pump forces the raw water through the pump discharge line (5) and the inlet valve (6) into the filter shell (7). The water passes through the filter elements (8) depositing suspended matter, organisms, and the filteraid added by the slurry feeder. The chlorinated and filtered water is forced out the bottom of the filter shell through the filter discharge valve (12), flow control valve (16) and the discharge hose (13) to the filtered water storage tank.

d. Check the operation of the slurry feeder (par. 4-5) to make sure it is operating properly and is feeding the required amount of filteraid to the raw water. The continuous feeding of slurry during the filter run is important to maintain the porosity of the filter cake.

e. Check the operation of the hypochlorinator (par. 4-6). Check the chlorine residual (par. 4-2b) of the filtered water to make sure the chlorine demand of the water is being met. Make chlorine residual tests on a filtered water sample drawn through the sampling valve on the bottom of the filter shell. Adjust the hypochlorinator as necessary (par. 4-6) to achieve the desired chlorine residual.

f. Continue the filter run until one of the following occurs:

(1). The discharge water pressure gage drops to 4 psi and the filtered water flow drops noticeably (see par. 4-8b).

(2). The supply of settled water is exhausted.

(3). The filtered water storage tank is full.

(4). The filter run is interrupted for any reason.

g. To terminate a filter run, backwash the elements and flush-out the filter bottom (par. 6-6). The equipment may now be stopped, or the elements precoated and the filter cycle resumed.

h. Sometimes it may be necessary to switch the raw water suction line (1) from one settling tank to the other in the middle of a filter run. For such short interruptions in the continuous flow of raw water it is not necessary to stop the filter run, instead proceed as follows:

(1). Turn the pump suction valve (2) and the filter discharge valve (12) to their "precoat" positions.

(2). Water will circulate from the precoat tank (17) through the elements maintaining a filter flow and preventing the filter cake from falling off the elements (8).

(3). Switch the raw water suction line to the fresh settling tank without emptying the line.

(4). Turn pump suction valve (2) and the filter discharge valve (12) back to their "filter" positions.

(5). Open air bleed valve (10) until water flows out, then close the valve.

6-6. BACKWASH AND FILTER BOTTOM FLUSH-OUT OPERATION (figure 6-3).

a. Backwashing is necessary whenever the filter run is to be stopped. Backwashing removes the old filter cake from the elements, and drains it out of the bottom of the filter shell through the drain valve (11). To go from filtering to backwashing proceed as follows:

b. Close the filter discharge valve (12) and watch the pressure on the discharge water pressure gage (18). When the pressure on the discharge gage is the same as the pressure on the inlet gage (19) close the filter inlet valve (6). This shuts off water pressure from the pump (4) and seals the filter shell (7).

c. Slap open the air release valve (9). There will be a loud "bang" caused by the instantaneous rush of air from the filter (par. 2-6c). With this action the filter cake is blasted off the outside of the filter elements.

d. Open the drain valve (11). The broken cake and water will drain out of the filter shell.

e. Flush out the bottom of the shell by opening the filter inlet valve (6) one turn. Water from the pump (4) will flow into the filter shell and flush out any filter cake or foreign matter remaining in the filter bottom. Re-backwash should not be necessary but, if observation through the filter window discloses that all of a sticky cake was not completely removed, re-backwash. To re-backwash, close the drain valve (11) and the air release valve (9). Open inlet valve (6) and open the air bleed valve (10) until water flows out of it, then close the air bleed valve. Allow the discharge pressure to build up to the inlet pressure, then close the filter inlet valve (6). If re-backwash is necessary, subsequent precoat water must be chlorinated with 1/4 cup of calcium hypochlorite.

f. Backwash and flush the filter repeating the procedures of steps c, d, and e above.

g. The waste from backwashing is contaminated. Keep this waste off hands and clothing and direct it away from the working area. Personnel should be warned to avoid contact with it.

h. If more raw water is to be filtered immediately, check the settling tanks to make sure enough water remains for a full filter run. Check that storage capacity is adequate for a full filter run. Begin filter cycle by precoating the elements (par. 6-4).

6-7. SHUTTING DOWN.

a. After backwashing, if no more water is to be filtered, set all valves for filter bottom flush-out, and set the slurry feeder dial at zero.

b. Allow engine to operate at idling speed for a few minutes before stopping it. Stop the engine (par. 6-3c(2)).

c. If freezing temperatures are expected drain the water from all equipment and hose.

d. Lubricate the equipment as necessary (see par. 7-2).

e. Clean the equipment of all dirt and grease. Make sure engine cooling fins are clean. Clean strainers of accumulated debris. If shut-down is to be for more than a day, drain slurry hopper and flush out any settled filteraid.

f. Give all equipment units a complete inspection checking for loose mounting, bent or broken parts, or signs of improper operation. Make necessary repairs or replace defective units.

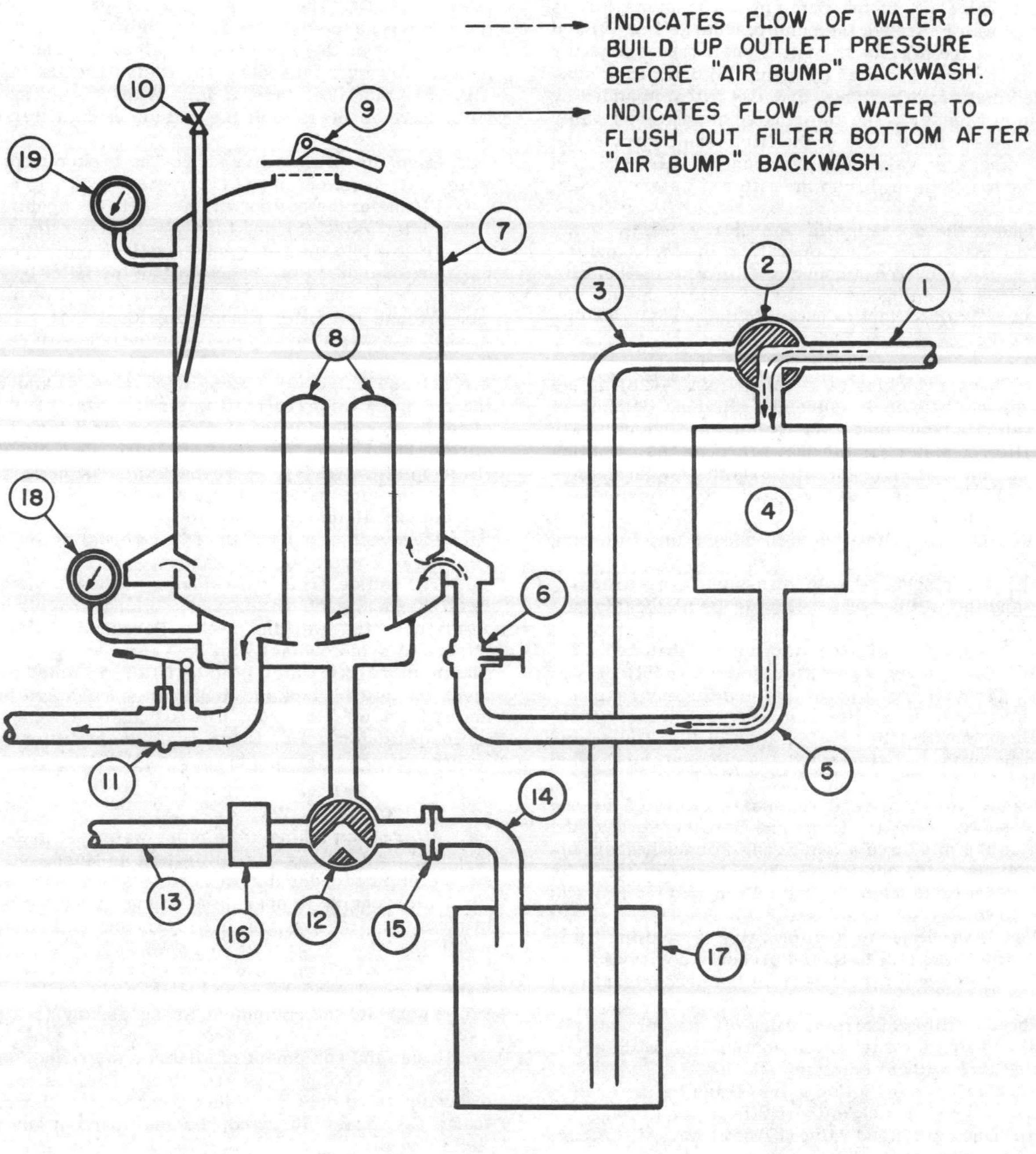
6-8. OPERATION SUMMARY.

a. General. This paragraph provides a quick reference for the operator giving all the basic motions required to filter water.

b. Preparatory Operations.

(1). Give equipment a complete visual inspection.

(2). Lubricate equipment as necessary.



1 Influent suction line
2 Pump suction 3-way valve
3 Precoat suction line
4 Pump
5 Pump discharge line
6 Filter inlet valve
7 Filter shell
8 Filter element
9 Air release valve
10 Air bleed valve
11 Quick-acting drain valve
12 Filter discharge 3-way valve
13 Effluent discharge line
14 Precoat discharge line
15 Precoat discharge orifice
16 Adjustable flow control valve
17 Precoat tank
18 Discharge gage
19 Inlet gage

Figure 6-3. Backwash and Filter Bottom Flush-out - Flow Diagram

(3). Fill precoat tank. Add 1/4 cup of calcium hypochlorite if filtered and chlorinated water is not available. This step is necessary only when equipment is first started.

(4). Fill slurry hopper with 3 gallons of water. Add 5 large measuring containers of filteraid.

(5). Pour solution of 1 small cup of dry calcium hypochlorite and 2 quarts of water into the hypochlorite reservoir. Fill the reservoir to within 2 inches of the top to make a total of 5 gallons of hypochlorite solution.

(6). Prime pump.

(7). Fill fuel tank. Open fuel shut-off valve.

(8). Check operation and settings of valves. Set the adjustable flow control valve for the flow desired.

(9). Check settling tanks and pretreatment of water.

c. Precoat Operation.

(1). Pump suction valve - open to settling tank ("filter" position).

(2). Inlet valve - open.

(3). Air release valve - open.

(4). Air bleed valve - open.

(5). Drain valve - open.

(6). Filter discharge valve - closed.

(7). Start engine - discharge some water to waste.

(8). Close air release valve.

(9). Turn filter discharge valve to "precoat" position.

(10). Close drain valve.

(11). Add 1 large measuring container of filteraid to precoat tank.

(12). Turn pump suction valve to "precoat" position.

(13). Close air bleed valve as soon as water flows out of it.

(14). Adjust rate of slurry feed and hypochlorinator control. Check operation of slurry feeder and hypochlorinator.

(15). Precoat until the water returning to the precoat tank is clear.

d. Filter Operation.

(1). As the precoat operation is completed, turn the pump suction valve to "filter" position.

(2). Allow the precoat tank to fill with clear water.

(3). Turn the filter discharge valve to "filter" position.

(4). Check slurry feeder and hypochlorinator adjustments.

(5). Continue filtering until discharge pressure reaches 4 psi, or filter output falls off noticeably.

e. Backwash and Filter Flush-out.

(1). When the filter operation is completed, close the filter discharge valve. Allow the discharge pressure to build up to equal the inlet pressure.

(2). Close the filter inlet valve.

(3). Open the air release valve.

(4). Open the drain valve.

(5). Open the filter inlet valve one turn to admit flushing water.

(6). Precoat - repeating cycle from c. (8) above.

6-9. FILTERED WATER STORAGE TANK.

a. General. The filtered water storage tank should be kept clean and covered at all times to prevent contamination of the water. Further, if covered, the water will stay cooler, making it more pleasant to drink. Do not dip containers into the tank for filling; use the distribution system. Keep the tank full of chlorinated and filtered water so it will be available for quick distribution.

b. Chlorination. The filtered water storage tank is always subject to contamination and a chlorine residual of at least 1.0 ppm ten minutes after the final addition of calcium hypochlorite should be maintained at all times (par. 4-2b). Make sure the water distributed to using personnel is pure and attractive.

6-10. DISTRIBUTION SYSTEM.

a. General. There are no special problems involved in operating the distribution system. Keep hose lines free of kinks and from damage by personnel or vehicles. Excessive spillage at water delivery points wastes water, causes mud, and should be avoided. Keep nozzles and the open end of hose off the ground, clean and uncontaminated.

b. By-passing Storage Tank. Sometimes it may be necessary to distribute water direct from the filter section into a tank trailer, by-passing the storage tank. If this must be done in the middle of a filter run, or if the trailer is full in the middle of a run, it is not necessary to stop the run, backwash and precoat in order to move the filtered water discharge line. Simply recirculate water from the precoat tank to keep the cake on the elements as explained in paragraph 6-5h.

6-11. COLD WEATHER OPERATION.

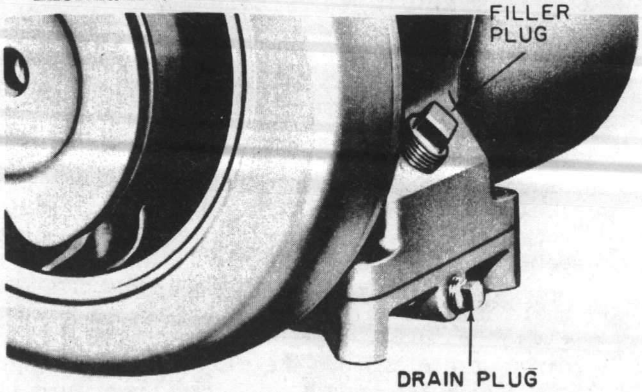
When operating the unit where freezing temperatures are likely to be encountered, drain slurry, solution, and water from all equipment, except the tanks, during shutdown periods. Be sure to drain water from the pump by removing drain plug. Disconnect pump suction line and drain it completely, then reconnect to pump. Check fuel strainer bowl for signs of water. If water is present, remove bowl and empty it of accumulated water. Keep fuel tank full. Drain slurry feeder and hypochlorinator following procedures given in paragraphs 7-6c(1) and 7-7b.

6-12. OPERATION WITH EXTREMELY TURBID WATER.

Extremely turbid water may not settle when treated with the normal amount of coagulants. If water of such turbidity must be used, continue to add coagulants to the settling tank after the tank is full and agitate by stirring the water with a clean piece of wood. The direction of flow must be the same as when the tank was filling.

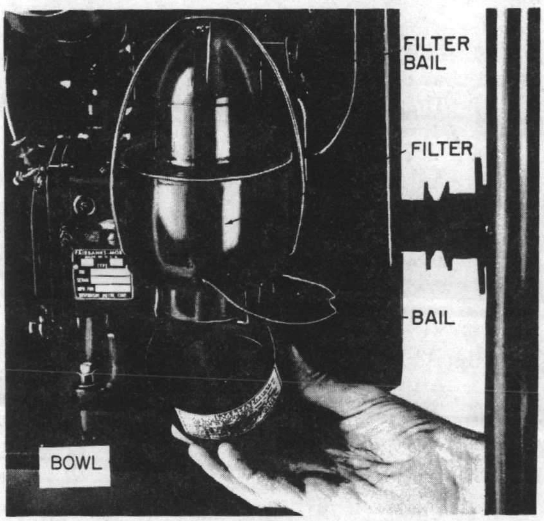
ENGINE CRANKCASE OIL, DRAIN AND FILLER PLUGS:

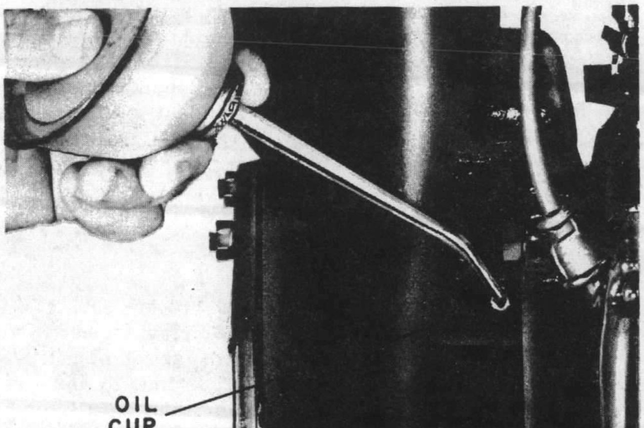
Weekly (each 50 hours of operation) drain oil from crankcase when unit is hot after operation. Wipe plug clean and replace. Remove filler plug and install oil. Use SAE 30 between 120°F and 40°F, SAE 20-20W between 40°F and 5°F, and SAE 10W between 5°F and -20°F ambient temperature. Fill crankcase to top of filler plug. Every 8 hours check oil level, and add oil as necessary to maintain oil level at top of filler opening. Refer to Wisconsin Motor Corporation Issue MM-270-E Instruction Book for complete engine lubrication information.



AIR CLEANER:

Daily (each 8 hours of operation) replace oil in air cleaner bowl. Use SAE 30 above 32°F and SAE 10 below 32°F. Fill bowl to level mark. Weekly, disassemble unit, clean parts, and reassemble.





PUMP SHAFT SEAL:

Daily (each 8 hours of operation) fill oil cup in pump seal area with SAE 10 oil.

Figure 7-1. Lubrication Instructions - Engine And Water Pump

SECTION 7

MAINTENANCE INSTRUCTIONS

7-1. GENERAL. Keep the equipment clean and free of dirt, mud, and grease. Where paint chips off or rust occurs repaint as required. Keep hoses clean and out of the sun insofar as possible. Do not walk on or drive over hoses. Be careful not to damage hose threads and make sure gaskets are in good condition. Hose and hose fittings or adapters have straight threads and cannot be rechased with a tapered tap or die as can be done with pipe fittings. Use a file to repair damaged threads. Keep storage tanks covered to keep the water cool and to prevent contamination. Tighten tank guy and supporting ropes as required. If a fabric tank is punctured, cement and sew a patch of canvas on the inside so the water pressure will help hold the patch in place. If plug-type valves are hard to turn, remove nut and clean the plug and body. Coat the plug with a small amount of water pump grease, but do not use too much as it may impart a taste to the water.

7-2. LUBRICATION.

a. Engine and Water Pump. Complete lubrication instructions for the engine and water pump are given in figure 7-1 and in the Wisconsin Motor Corporation Issue MM-270-E Instruction Book.

b. Hypochlorinator. Keep the hypochlorinator case (8) (figure 7-15) filled with SAE 30 engine oil to the level of the filler plug (43). Drain oil through drain plug (49) when necessary to drain gear case. No other lubrication is required.

c. Slurry Feeder. Keep the slurry feeder gear box (43) (figure 7-12) filled with SAE 30 engine oil to the level of the filler plug (27). Drain oil through drain plug (44) when necessary to open gear case. No other lubrication is required.

7-3. TROUBLE SHOOTING.

PROBABLE CAUSE	POSSIBLE REMEDY
a. Filter Run is Too Short	
(1) Inefficient pretreatment of raw water.	Pretreat water properly (Section 5).
(2) Too little or too much slurry feed.	Adjust slurry feed (par. 4-5) or repair feeder (par. 7-6).
(3) Filteraid settled in hopper or feeder chamber (see f. below).	Clean out hopper, chamber, and valves. Check air compressor and feeder.
(4) Sludge in settling tank entering filter.	Clean sludge from tank or watch that sludge is not drawn from bottom of tank.
(5) Filter was not backwashed and flushed.	Backwash and flush (par. 6-6).
(6) Raw water extremely turbid and will not settle.	Add alum and stir water (par. 6-12).
(7) Filter elements plugged.	Remove elements and clean (par. 7-5c).
b. Water Not Clear After Filtering.	
(1) Elements were not precoated.	Backwash (par. 6-6) and then precoat (par. 6-4).
(2) Filteraid cake is broken.	Backwash and then precoat.
(3) One or more filter elements are broken.	Replace broken elements or cap openings (par. 7-5c).
c. Discharge Pressure Gage Reading Drops Faster Than Usual Over A Series of Runs.	
(1) Elements are plugged.	Remove elements and clean (par. 7-5c).
d. Discharge Pressure Gage Reading Rises Suddenly.	
(1) Filteraid cake is broken.	Backwash (par. 6-6) and precoat (par. 6-4).

TROUBLE SHOOTING (CONT)

PROBABLE CAUSE	POSSIBLE REMEDY
(2) One or more elements are broken.	Replace broken elements or cap openings (par. 7-5c).
e. Filteraid Settles in Slurry Tank.	
(1) No air from air compressor.	Repair air compressor (par. 7-6c).
(2) Filteraid caked at bottom of hopper.	Clean out hopper (par. 7-6c).
f. Filter Will Not Deliver Water at Start of Filter Run with Engine Running.	
(1) A valve may be in wrong position.	Check valves (par. 6-5).
(2) Hose is collapsed, kinked, or clogged.	Straighten hose. Locate clogged hose by loosening connections at various joints and observing flow.
(3) Suction leak in hose, fitting, or valve, or clogged strainer.	Check all connections, valves, and washers.
(4) Pump trouble.	See i below.
g. Hypochlorinator Does Not Maintain Proper Chlorine Residual in Filter Water.	
(1) Chlorine demand of water may have increased.	Adjust hypochlorinator control (par. 4-6b).
(2) Hypochlorite solution too weak.	Increase strength of solution.
h. No Solution Flowing Through Hypochlorinator Sight Glass.	
(1) Solution below strainer level.	Add more hypochlorite solution to reservoir.
(2) Air leak in suction line hose, hose connections, sight glass, suction nipple, or in body.	Check system for leaks. Tighten connections or repair as necessary.
(3) Obstruction in hypochlorinator suction line, discharge line, or suction inlet connection.	Check lines for obstructions and remove if present.
(4) Priming plug is not seated properly, plug is defective, or plug gasket leaks.	Prime hypochlorinator (par. 4-6c) and seat plug so it is air tight.
(5) Poppet valves are not seating properly.	Disassemble hypochlorinator pumping body and repair as necessary (par. 7-7b).
i. Pump Fails to Prime.	
(1) Insufficient priming water.	Fill priming chamber (par. 6-2f).
(2) Air leaks in suction line.	Check connections in suction line. If line is damaged, replace.
(3) Clogged Suction Strainer.	Clean strainer.
j. Pump Fails to Pump to Capacity.	
(1) Impeller worn or out of adjustment.	Adjust or replace impeller as necessary (par. 7-9).
(2) Engine not running at recommended speed.	Increase engine speed to recommended rpm.

PROBABLE CAUSE	POSSIBLE REMEDY
k. Engine Fails to Start.	
(1) No fuel in tank or fuel shut-off valve closed.	Fill gas tank. Open fuel shut-off valve.
(2) Carburetor not choked sufficiently.	Close choke.
(3) Carburetor clogged.	Replace carburetor (par. 7-9c).
(4) Needle valve of carburetor insufficiently open.	Turn needle valve one and a quarter turns open.
(5) Engine flooded.	Remove spark plug and turn engine over a few times with starting rope to blow out excess fuel.
(6) Defective ignition continuity.	Check spark plug and magneto connection. Check condition of ignition cable. Secure connection, replace ignition cable if defective.
(7) Spark plug wet or dirty.	Remove spark plug, dry out, and clean electrodes.
(8) Improper spark plug gap.	Reset spark plug electrodes (par. 7-9g).
l. Engine Hard to Start or Malfunctioning. Refer to Wisconsin Motor Corporation Instruction Book Issue MM-270-E for detailed description of engine troubles, causes, and remedies.	

7-4. COMPARATOR MAINTENANCE.

a. General. Handle the comparator with care so as not to break the plastic case, milk glass, or other parts. Do not disassemble unless it is necessary to replace a broken or damaged part. This paragraph gives the essential disassembly and reassembly procedures.

b. Comparator Disassembly.

(1). Remove Front Cover and Prism (figure 7-2). Remove prism (1) by pulling it straight out from the front cover (3). Remove two screws (2) which hold front cover (3) to body (5) and detach front cover from body. Remove disc (4). Remove tubes (11) and bottle (10).

(2). Disassemble Back Cover, Body, Milk Glass, and Spring (figure 7-2). Remove screws (9); then remove back cover (8) from body (5). Pry spring (6) and milk glass (7) from back cover (8).

c. Comparator Reassembly.

(1). Reassemble Back Cover, Milk Glass, Spring and Body (figure 7-2). Apply a few drops of cement to sides of milk glass (7) and place in back cover (8) recess. Apply a few drops of cement to the back of spring (6) and place spring on back cover (8) so that the rectangular portion of the spring frames the milk glass. Place back cover (8) against body (5), making sure that the two small bent portions of the spring fit into the sample compartment and point upward; then secure back cover to body with screws (9).

(2). Installation of Front Cover, Prism, and Disc (figure 7-2). Replace parts by reversing the procedure given in paragraph b. (1) above.

7-5. FILTER SECTION MAINTENANCE.

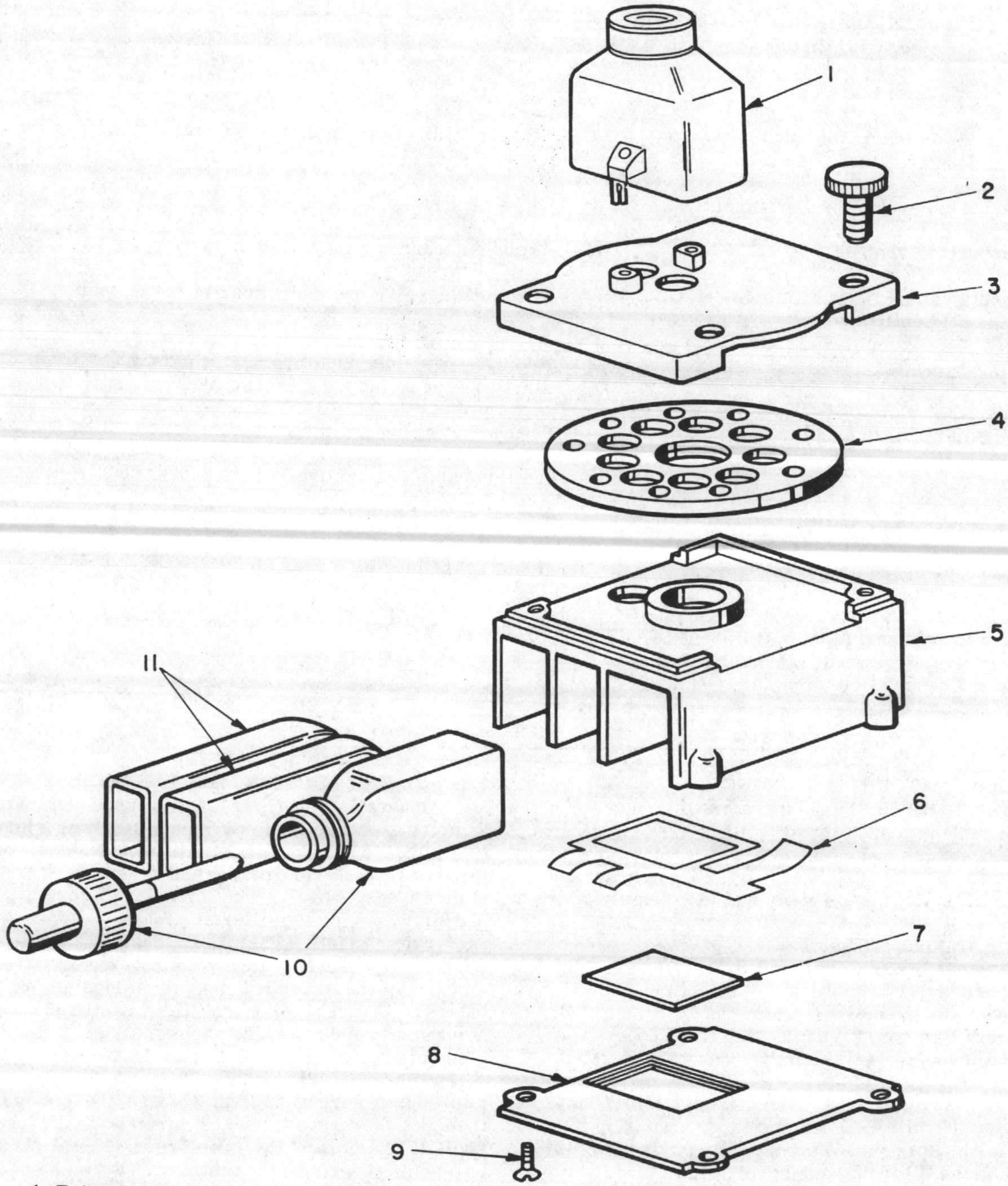
a. General. The filter section need not be disassembled except to clean or repair the filter elements, to replace a leaking gasket, broken window, or defective valve. This paragraph gives the necessary maintenance, repair, and cleaning information to properly service the filter section.

b. Filter Shell. The filter shell (1) (figure 7-3) encloses the seven filter elements (figure 7-4) that mount on the threaded nipples welded in the filter base (1) (figure 7-4). The filter shell must be removed to repair any damage to it, or to the filter elements.

(1). Remove Filter Shell (figure 7-3). Loosen the four clamp screws (13) to release the clamps (15), then lift the precoat tank (2) straight up off the filter shell (1). Remove the two screws (6) that clamp the halves of the ring (7) together. Two men should lift the filter shell straight up off the filter base. Take care not to hit or damage the filter elements.

(2). Clean and Repair Filter Shell (figure 7-3). Clean inside of filter shell (1) with filtered and chlorinated water. Do not use solvents to clean any part of the equipment. Rinse shell thoroughly after cleaning. Straighten dents in filter shell. Weld, or braze, any cracks in the shell. Replace window (11) and gaskets (10) and (12) if they are damaged.

(3). Install Filter Shell (figure 7-3). Make sure the gasket (3) is in good condition and properly positioned on the filter base. Install filter shell (1) on filter base reversing the procedure for removal (see (1) above). Precoat tank (2) is placed over the filter



1 Prism
2 Screw, bakelite (4)
3 Cover, front
4 Disc, bromocresol purple-green, 4.4-6.0 pH
4 Disc, bromothymol blue, 6.0-7.6 pH
4 Disc, ortho-tolidine, 0.1-5.0 ppm chlorine residual
5 Body
6 Spring
7 Milk glass
8 Cover, back
9 Screw, No. 2-56 x 5/16 in. long (4)
10 1/2-oz. bottle bromocresol purple-green solution, 0.5 cc graduated dropper, pH indicator
10 1/2-oz. bottle bromothymol blue solution, 0.5 cc graduated dropper, pH indicator
10 1/2-oz. bottle ortho-tolidine solution, 0.75 cc graduated dropper, chlorine residual indicator
11 Tube (cell), 26-mm sample (2)

Figure 7-2. Comparator - Exploded

shell (1) only when the unit is being transported or is to be out of service for some time.

c. Filter Elements. Observation of the filter ele-
7 ments (figure 7-4) can be made through the plastic window (11) (figure 7-3) to help determine when the elements must be cleaned. Generally, backwashing will remove all the filter cake from the elements, however, if the cake has built up and hardened between the elements, or if the filter cake is particularly sticky, the elements must be cleaned by removing and washing. Plugged elements are indicated by a high pressure drop at the start of the filter run. If the difference in pressure between the inlet gage (19) (figure 7-3) and the outlet gage (2) (figure 7-4) is more than 5 psi at the start of two successive filter runs, the elements must be cleaned. An element is broken if the filtered water is turbid, if the discharge pressure rises suddenly, or if it is difficult or impossible to precoat the filter elements.

(1). Remove and Disassemble Filter Element. Remove the filter shell (see b. (1) above). Remove seven nuts (20) (figure 7-4) and lockwashers (19) and lift off the filter element brace (18). If elements merely need cleaning, clean them by washing in clean water. If an element must be removed, it should be disassembled as it is removed. Attempting to remove a filter element as an assembled unit would probably damage the plastic filter sleeve or the perforated tube. Remove the filter element by unscrewing the nut (1) (figure 7-5) from the tie rod (7). Lift the dome (2), plastic sleeve and tube assembly (4) and (5), then slide the top spacer (3), 12 plastic air cups (6), and bottom spacer (8) off the tie rod. If necessary to unscrew the filter element base (9) off nipple welded on filter base, use a suitable wrench. The tie rod (7) should be left tightly screwed in the top of the base (9).

(2). Inspect and Repair Filter Element. If the element is leaking due to the dome (2) (figure 7-5) or the base (9) not seating properly with the plastic sleeve (4) assembly, correct this by straightening and reseating the parts. Assemble element and tighten the top nut (1) until all parts are secure. If the plastic sleeve has been damaged it must be replaced. The plastic sleeve and perforated tube assembly consists of a plastic sleeve (4) perforated with 0.004 inch slots 1/32 inch long and mounted on a perforated stainless steel tube (5). The plastic sleeve can be stretched to permit removal from, or insertion of, the steel tube. If a replacement part is not available, the nipple on the filter base (1) (figure 7-4) should be capped with a 2-inch hose cap. A capped nipple reduces the filter area by one seventh. Install a new filter element as soon as possible so the equipment can again be operated at full capacity.

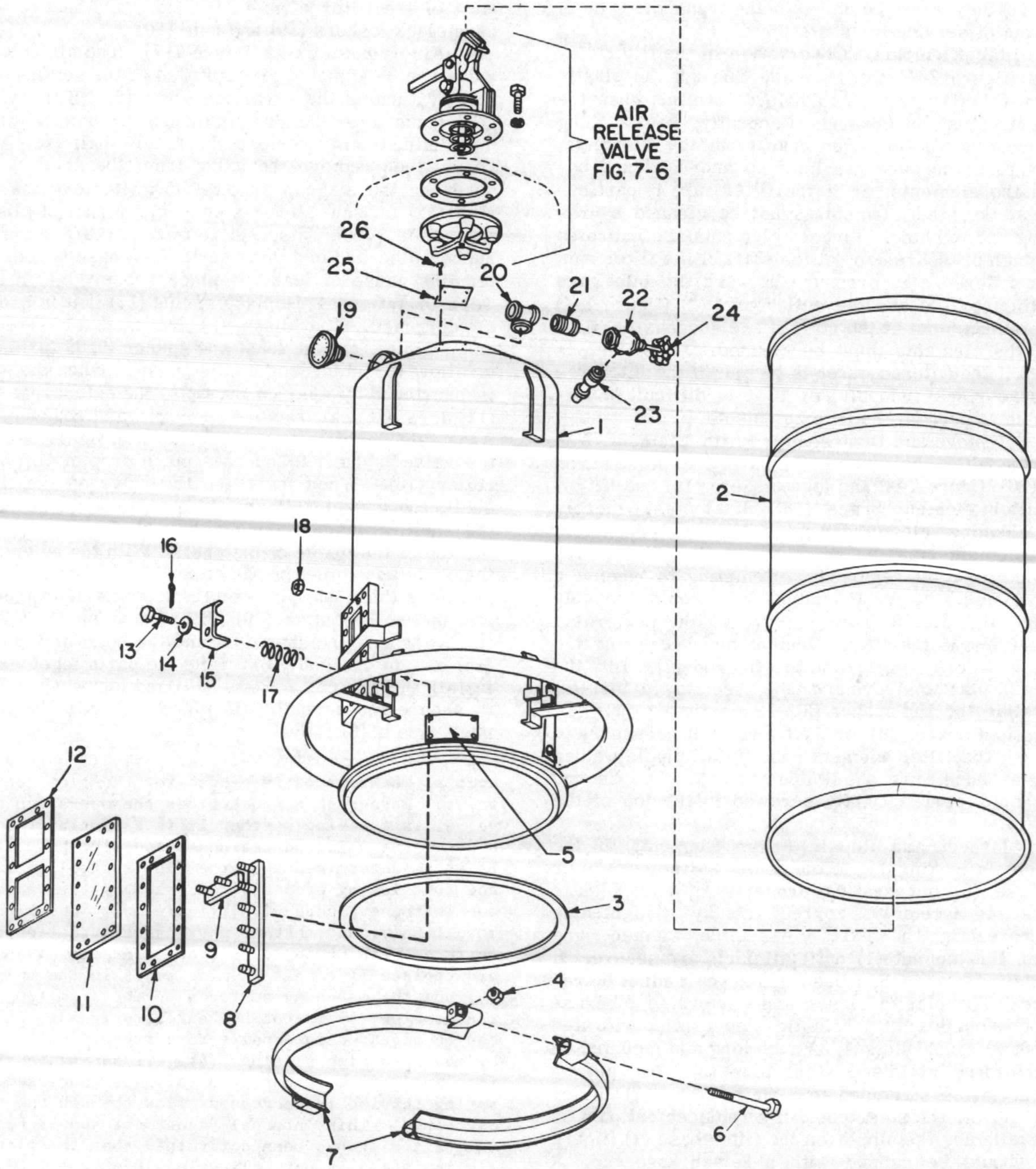
(3). Reassemble and Install Filter Element. Check that "O" ring (10) (figure 7-5) is in place inside the element base (9), then screw base on threaded nipple in filter base (1) (figure 7-4). Slide bottom spacer (8) (figure 7-5), 12 plastic air cups (6) and top spacer (3) on tie rod (7) screwed in top of element base (9). Slide assembly of plastic sleeve (4) and perforated tube (5) down into base (9), then place dome (2) on top of plastic sleeve. Check that parts are seating properly. Turn nut (1) on tie rod and tighten until all parts of filter element are snug and secure. Place filter element brace (18) (figure 7-5) on protruding ends of the filter element tie rods, and secure with seven lockwashers (19) and nuts (20).

d. Air Release Valve (figure 7-7). The air release valve can be adjusted for tightness of the sealing disc (11) by turning the eccentric shaft (5). If the valve still leaks after the shaft is turned through its maximum adjustment, remove the filter shell (see b. (1) above) then remove the valve from the shell by unscrewing the six cap screws (17). Remove the clip ring (12) by squeezing its ends with a pair of pliers, then slide rubber disc (11) off stem (10). Examine rubber disc and matching surface on base (15) to determine cause of leak. Replace rubber disc if it is worn or fatigued. Replace spring (13) if it is broken or distorted. Two discs (8) are used for strength and rigidity, and at least one spacer (9) is furnished to allow for stem length adjustment. When the stem is shortened by wear on the tip to the extent that disc (11) does not seal, remove spacer (9) and reassemble. Assemble parts in sequence shown in figure 7-7. If the valve is hard to operate put a drop of oil on the roller (18). When installing the valve on the filter shell, the gasket (14) and base (15) should be inside the shell. Line up holes and hold these parts against the top of the inside of the shell. With the balance of the parts assembled on the stem (10) and body (6), lift and guide them into place on the top outside of the filter shell. The stem (10) should have spring (13) on its lower end and should fit into the holes in the base (15) and in the body (6). Hold the parts together and install the six cap screws (17) and lockwashers (16) to secure the assembly in place. Install the filter shell (see b. (3) above).

e. Flow Controller Valve Assembly (figure 7-7). No special maintenance is needed for the flow controller valve. Paragraph 4-4 describes the operation of the valve. In freezing weather it is essential that the body of the valve be drained by opening petcock (8). If it is determined that the flow controller valve is not functioning properly, disassemble the valve as shown in the exploded view, figure 7-7. Check that parts move freely, and that no physical obstruction has interfered with proper operation. Inspect diaphragm (3) and replace if torn. Examine seats in the valve body (9) and the matching surfaces on the stem (20). Check that spring (5) is not broken or fatigued. The valve can be adjusted internally to correctly calibrate it, by moving spring retainer (4). If spring tension is increased, flow through the valve is increased. If spring tension is decreased, flow through the valve is decreased. This internal adjustment should be made only after it has been determined that the flow controller valve is not delivering 10-40 gpm ±10% of flow, and that the machinery and filter sections are functioning normally.

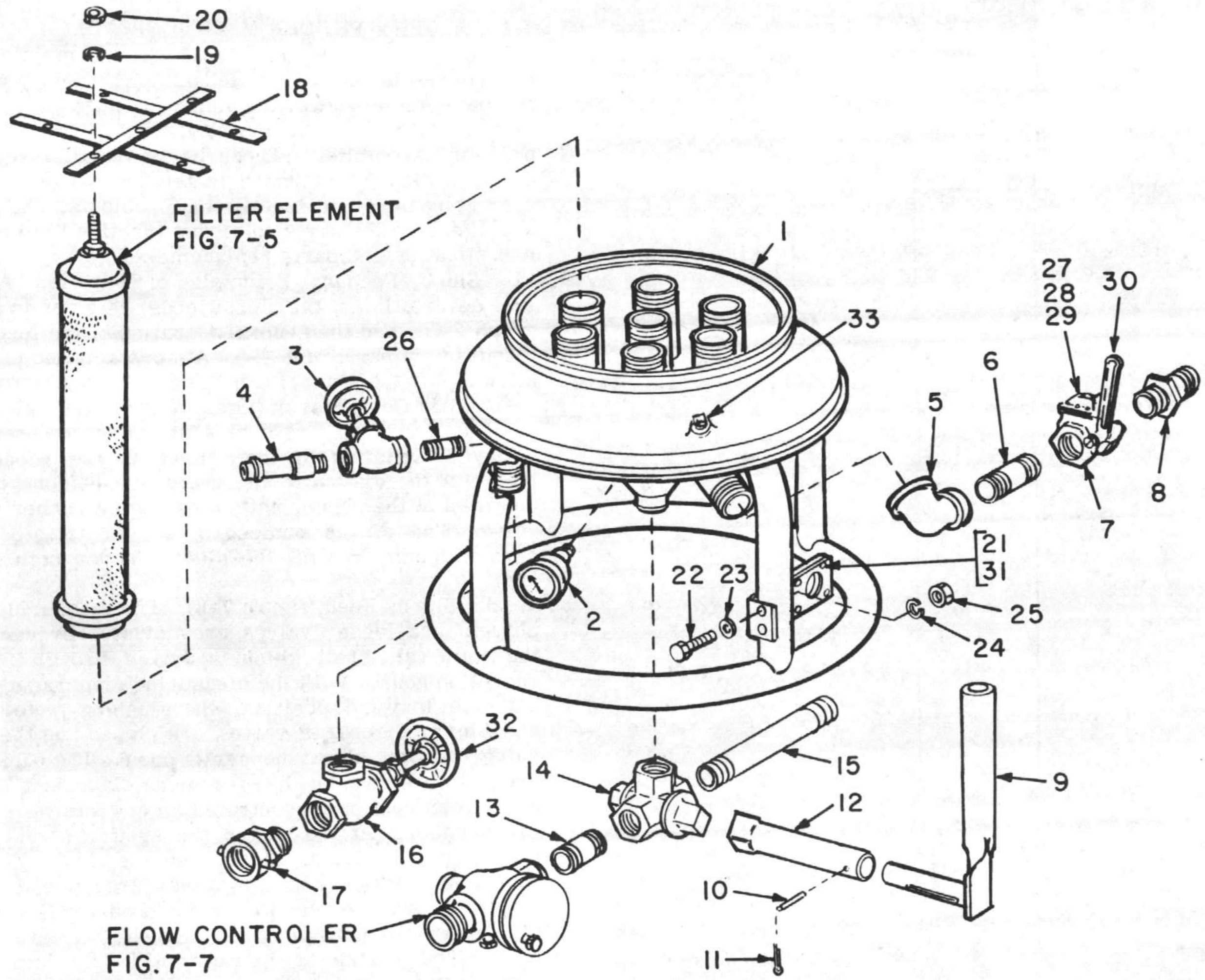
f. Inlet Valve, Drain Valve, 3-Way Filter Valve, and Sampling Valve (figure 7-4). The inlet valve (16), drain valve (7), 3-way valve (14), and the sampling valve (3), are standard commercial units that require no special maintenance. If a valve is hard to turn, remove the valve nut, clean out the inside of the valve and lubricate. Replace valve nut and tighten it until snug and valve does not leak.

g. Filter Base (figure 7-4). Examine the filter base for leaks around the nipples welded in the bottom portion. Repair leaks by filling in with welding rod, or by brazing. Keep mating parts of filter base and fil-



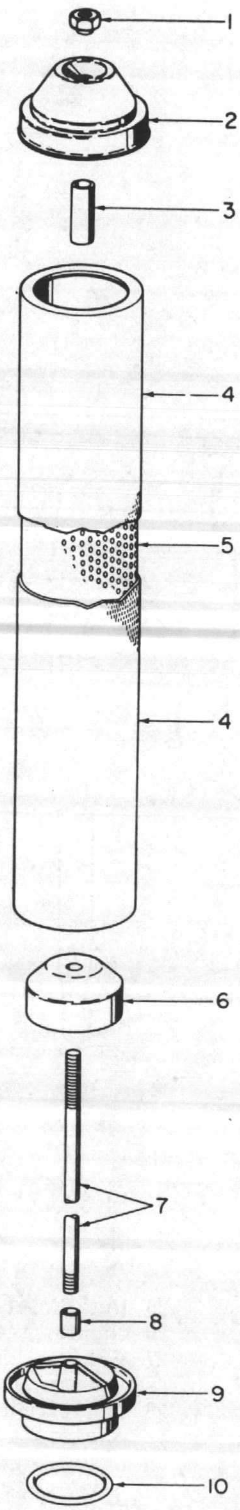
1 Shell, filter	8 Strip, backing (long) (2)	16 Pin, cotter, 3/32 x 3/4 in. long (4)	24 Instruction plate, bleed valve
2 Tank, precoat and recirculating	9 Strip, backing (short) (2)	17 Spring, clamp (4)	25 Instruction plate, air release valve
3 Gasket	10 Gasket, window (inside)	18 Nut, No. 1/4-20 (16)	26 Screw, drive, instruction plate (8)
4 Nut, No. 5/8-18 (2)	11 Window, plastic	19 Gauge, 1/4 in. pressure, water inlet	
5 Instruction plate, backwash	12 Gasket, window (outside)	20 Tee, 1/4 in. brass	
6 Screw, No. 5/8-18 x 6 in. long (2)	13 Screw, No. 5/16-18 (4)	21 Nipple, 1/4 in. close	
7 Ring, clamping	14 Washer, 5/16 in. (4)	22 Valve, 1/4 in. angle	
	15 Clamp (4)	23 Connection, 1/2 in. hose	

Figure 7-3. Upper Half of Filter Section - Exploded



1 Base, filter
2 Gauge, 1/4 in. pressure, water outlet
3 Valve, 1/4 in. globe
4 Connection, 1/2 in. hose
5 Elbow, 2-1/2 in. x 2 in. reducing
6 Nipple, 2 in. x 2-1/2 in. long
7 Valve, 2 in. drain, quick-opening
8 Nipple, 2 in. male hose
9 Handle, wrench
10 Pin, handle
11 Pin, cotter, 3/32 x 3/4 in. long (2)
12 Wrench barrel
13 Nipple, 2 in. x 3 in. long
14 Valve, 2 in. plug, 3 way
15 Orifice nipple
16 Valve, inlet, 2 in. angle
17 Coupling, 2 in. hose, male and female
18 Brace, filter element
19 Lockwasher, 3/8 in. (7)
20 Nut, No. 3/8-16 (7)
21 Bracket, handle
22 Screw, No. 1/4-20 x 1-3/4 in. long (2)
23 Washer, 1/4 in. flat (2)
24 Lockwasher, 1/4 in. (2)
25 Nut, No. 1/4-20 (2)
26 Nipple, 1/4 in. close
27 Bracket, drain valve instruction plate
28 Instruction plate, drain valve
29 Screw, drive, instruction plate (6)
30 Handle, drain valve
31 Instruction plate, filter outlet
32 Instruction plate, inlet valve
33 Plug 3/8 in. NPT

Figure 7-4. Lower Half of Filter Section - Exploded



1 Nut	6 Cup, plastic (12)
2 Dome	7 Tie rod
3 Spacer tube-top	8 Spacer tube-bottom
4 Sleeve, plastic	9 Base, filter element
5 Perforated tube, stainless steel	10 "O" ring

Figure 7-5. Plastic Filter Element - Exploded

ter shell clean and maintain the same relative positions of the filter base and shell.

7-6. SLURRY FEEDER MAINTENANCE.

a. General. This paragraph gives maintenance procedures for the slurry feeder. The slurry feeder is made up of several component assemblies: the mixing and valve chamber, gear box, and air compressor assemblies. These parts are all assembled or connected by standard fasteners and present no special removal or installation problems. All parts are listed in the parts catalogue (Section 8) to enable identification and parts replacement.

b. Slurry Feeder - Principles of Operation. A general description of the slurry feeder is given in paragraph 2-7d. and the general operation of the feeder is discussed in paragraph 4-5. A more detailed explanation of how the slurry feeder operates is given below:

(1). Air Compressor (figure 7-8). The high speed shaft is driven at 1/4 engine speed by a V-belt and pulleys. Agitation of the slurry in the hopper to maintain the diatomite in suspension is done by air admitted at the hopper bottom through a rubber check valve. The air is pumped by a cam-actuated diaphragm pump run off the slurry feeder high speed shaft.

(2). Slurry Feed (figure 7-8). The measuring diaphragm and feeder valves are actuated by cams on the main cam shaft which is driven through a worm reduction gear. With the measuring diaphragm in its extreme forward position, the flushing water inlet and slurry discharge valves are closed and the inlet valve from the slurry hopper is open. The backward or suction stroke of the measuring diaphragm draws a small amount of concentrated slurry into the pumping chamber. At the end of the suction stroke, the slurry inlet valve is closed and the flushing water inlet and slurry discharge valves are opened. The diaphragm then moves forward and during the period of forward diaphragm travel, these valves remain open. The restrictor (paragraph 2-7f.) located in the raw water pump discharge line produces a 2 psi differential and causes a flow of water through the feed chamber which dilutes the charge of slurry drawn from the hopper and flushes it into the main water stream. When the measuring diaphragm again reaches its forward limit of travel, there is a short dwell period during which the flushing water inlet and slurry discharge valves close and the inlet valve from the hopper opens to allow slurry to be drawn from the hopper by the suction stroke of the diaphragm. The rate of slurry feed is not materially affected by the pressure of the line into which it feeds because the diaphragm does not act as a pump, but only as a metering device. This is accomplished by causing all valve operation to occur during periods of no diaphragm motion, and when there is no pressure on the diaphragm. Valves are either fully open or fully closed so that filteraid will not foul the seats and flushing water flow is liberal to scavenge the feeder body at the end of each stroke. The rate of slurry feed is determined by the diaphragm stroke adjuster cam which has a dial graduated from 0 to 10. This adjustment controls the diatomite slurry feed by limiting the suction stroke of the diaphragm (par. 4-5).

c. Disassemble and Repair Slurry Feeder.

(1). General. Most adjustments and repairs required for the slurry feeder can be made without disassembling the entire feeder. The trouble experienced will determine the amount of disassembly work needed. The following paragraphs, covering the complete assembly and each major sub-assembly, give detailed adjustment and repair information.

WARNING

Never make adjustments or work on the slurry feeder without first removing either the drive belt or the ignition cable from the spark plug. Turning the feeder over by hand with the drive belt in place during the adjusting might start the engine and cause serious injury to the operator.

(a). Drain and Filling Plugs. There are two plugs (3) (figure 7-10) in the mixing and valve chamber to drain water and slurry from the valve chamber. FLUSHING WATER VALVES MUST BE IN OPEN POSITION TO COMPLETELY DRAIN THE VALVE CHAMBER. Plug (16) (figure 7-11) drains slurry from the slurry hopper and mixing chamber. There is a filling plug (27) (figure 7-12) and an oil drain plug (44) in the gear box assembly. Water and slurry must be completely drained from the valve chamber during freezing weather (see par. 6-11.)

(b). Remove Major Components (figure 7-9). Remove sheave and hopper from slurry feeder. Disconnect hoses. Remove three cap screws (1) and lockwashers (2) to separate mixing and valve chamber assembly from the slurry feeder gear box. See paragraphs (2) and (3) below for disassembly and repair instructions on the mixing and valve chamber assembly. See paragraph (4) below for disassembly and repair of the gear box. Remove gear box from frame, when necessary, to facilitate disassembly and repair.

(c). Install Major Components (figure 7-9). Attach slurry feeder gear box to frame. Position mixing and valve chamber assembly on the gear box and secure with three lockwashers (2) and cap screws (1). Connect hoses. Install sheave and hopper on slurry feeder.

(d). Adjust Major Components. With the dial on the diaphragm cap control set at 10, turn the slurry feeder shaft until the diaphragm is at the end of the suction stroke and at the start of the pumping stroke.

Key to Figure 7-6

1	Nut, No. 1/4-20	11	Disc, rubber
2	Handle, release	12	Ring, clip
3	Lockwasher, 1/2 in. (2)	13	Spring
4	Screw, pivot (2)	14	Gasket
5	Shaft, eccentric	15	Base
6	Body	16	Lockwasher, 3/8 in. (6)
7	Nut, No. 3/8-24 elastic stop	17	Screw, No. 3/8-16 x 1-1/4 in. long
8	Disc (2)	18	Roller
9	Spacer (As Required)	19	Spacer (4)
10	Stem		

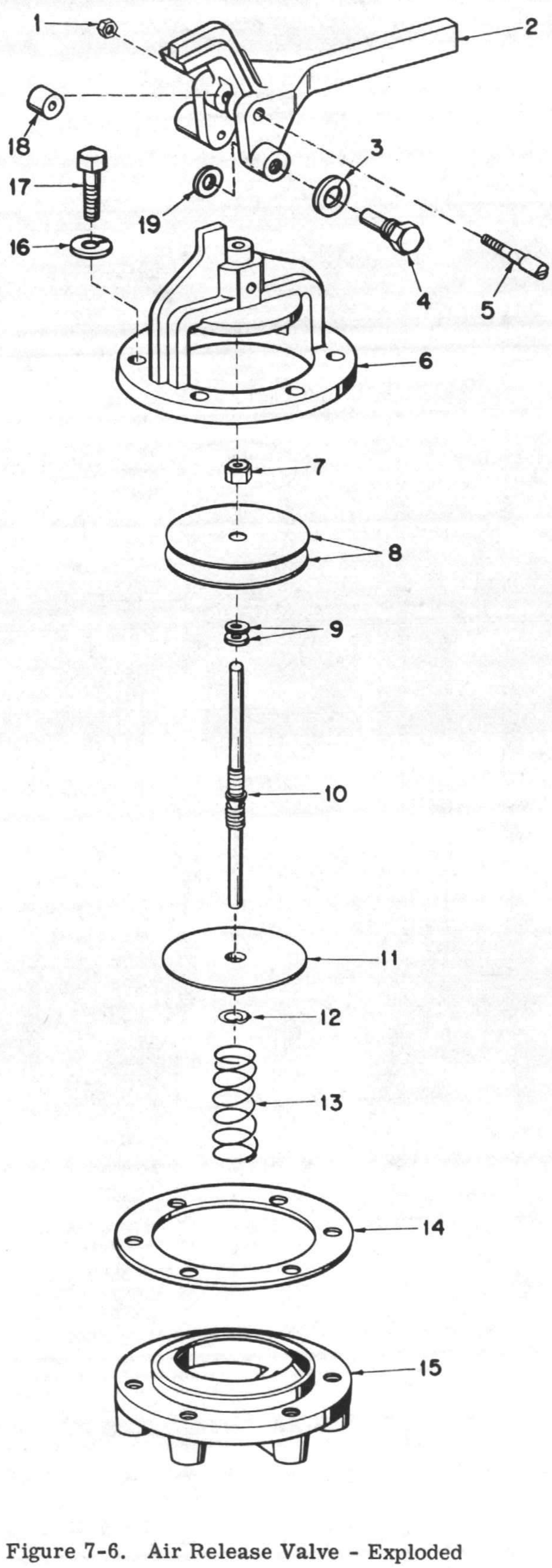


Figure 7-6. Air Release Valve - Exploded

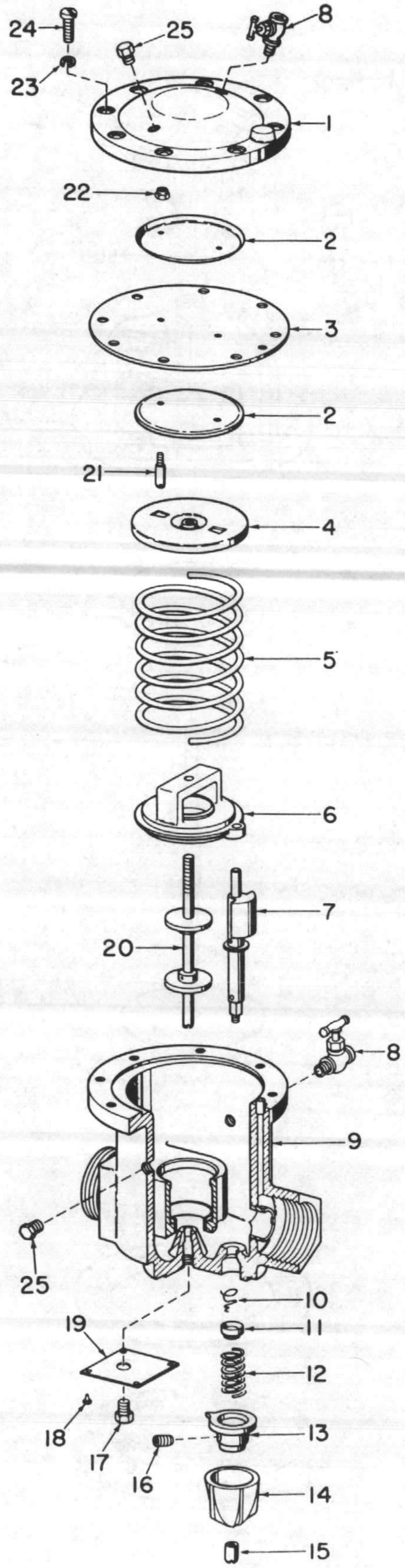


Figure 7-7. Adjustable Flow Control Valve - Exploded

1. Cover
2. Plate, backing (2)
3. Diaphragm
4. Seat, spring
5. Spring
6. Orifice
7. Gate
8. Petcock (2)
9. Body
10. Packing, asbestos cord
11. Gland, packing
12. Spring
13. Pointer
14. Knob
15. Nut
16. Screw, set, No. 1/4-20 x 1/4 in. long
17. Plug, 1/8 in. pipe
18. Screw, drive (4)
19. Dial and nameplate
20. Disc, valve
21. Pin, guide (2)
22. Nut, elastic stop, No. 10-32
23. Lockwasher, 5/16 in. (8)
24. Screw, machine, No. 5/16-18 x 1 in. long (8)
25. Plug, 1/8 in. pipe, (2)

A slight clearance of about 0.005 to 0.010 inches should be left between adjusting screw (6) (figure 7-9) and the end of the yoke (17) (figure 7-12) of the gear box. Lock screw (6) (figure 7-9) in place with nut (7). The shorter of the trip arms on the outside of the gear box assembly opens the slurry inlet valve, the longer trip arm opens the two flushing valves. Adjustments must be made in the trip arm positions for proper valve operation and this adjustment is explained in paragraph (4) (b) below.

(2). Disassemble and Repair Diaphragm End.

(a). Disassemble Diaphragm and Diaphragm Cap. It will not be necessary to disassemble the diaphragm and diaphragm cap unless diaphragm (20) (figure 7-10) leaks, as indicated by slurry dripping from the hole in the bottom of cap (9). To disassemble, loosen two set screws (8) (figure 7-9) and remove diaphragm lever shaft (4) and diaphragm lever (5). Remove screw (15) (figure 7-10), press on exposed end of push rod (4) and lift off cam (13). Remove four screws (11) and lockwashers (12). Lift cap (9) from mixing and valve chamber. Push rod (4) and associated parts will come off with cap unless diaphragm (20) is stuck to mixing and valve chamber. Remove push rod (4) and associated parts from cap or chamber, as necessary. If diaphragm (20) is stuck to chamber, loosen edge at one point and peel with care to avoid damage to diaphragm. Compress spring (7) by pushing on spring seat (8) and remove pin (19). Release spring (7) slowly and lift off seat (8), spring (7), and seat (5). Unscrew diaphragm (20) from rod (4). Remove backing gasket (21) from rod (4). Do not remove bearing (10) unless it must be replaced.

(b). Reassemble Diaphragm and Diaphragm Cap. Stretch backing gasket (21) (figure 7-10) over end of rod (4) and slip it into the groove. Screw diaphragm (20) onto rod (4). Slip seat (5) over rod (4) so that the pin in the rod passes through the hole in the seat. Place spring (7) and seat (8) over rod (4). Compress spring (7) with seat (8) until pin (19) can be pushed into place and be retained by seat (8). Insert rod (4) out through bearing (10) in cap (9) and engage seat (5) with pin (6). Position cap with parts on mixing and valve chamber and secure with four screws (11) and

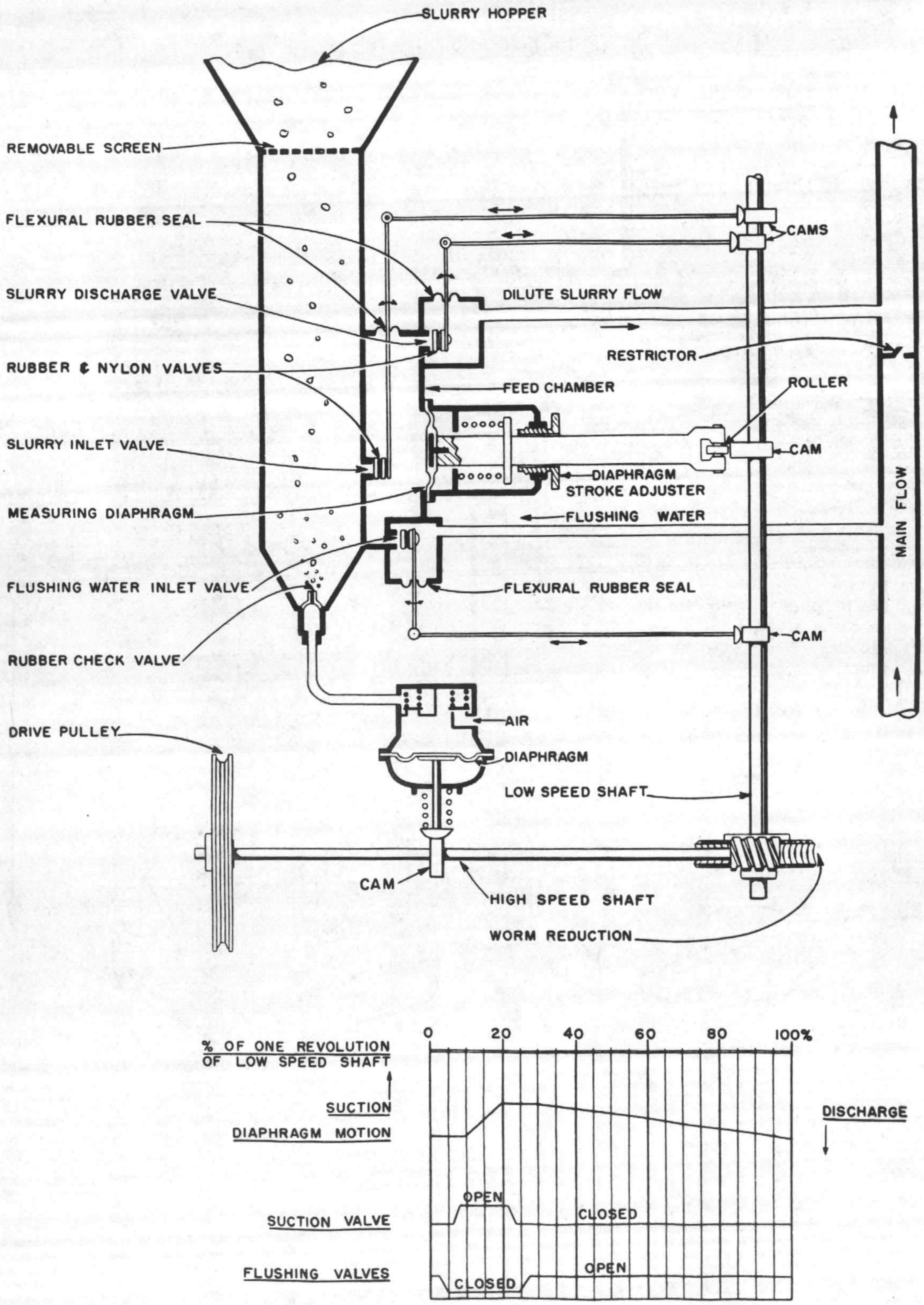
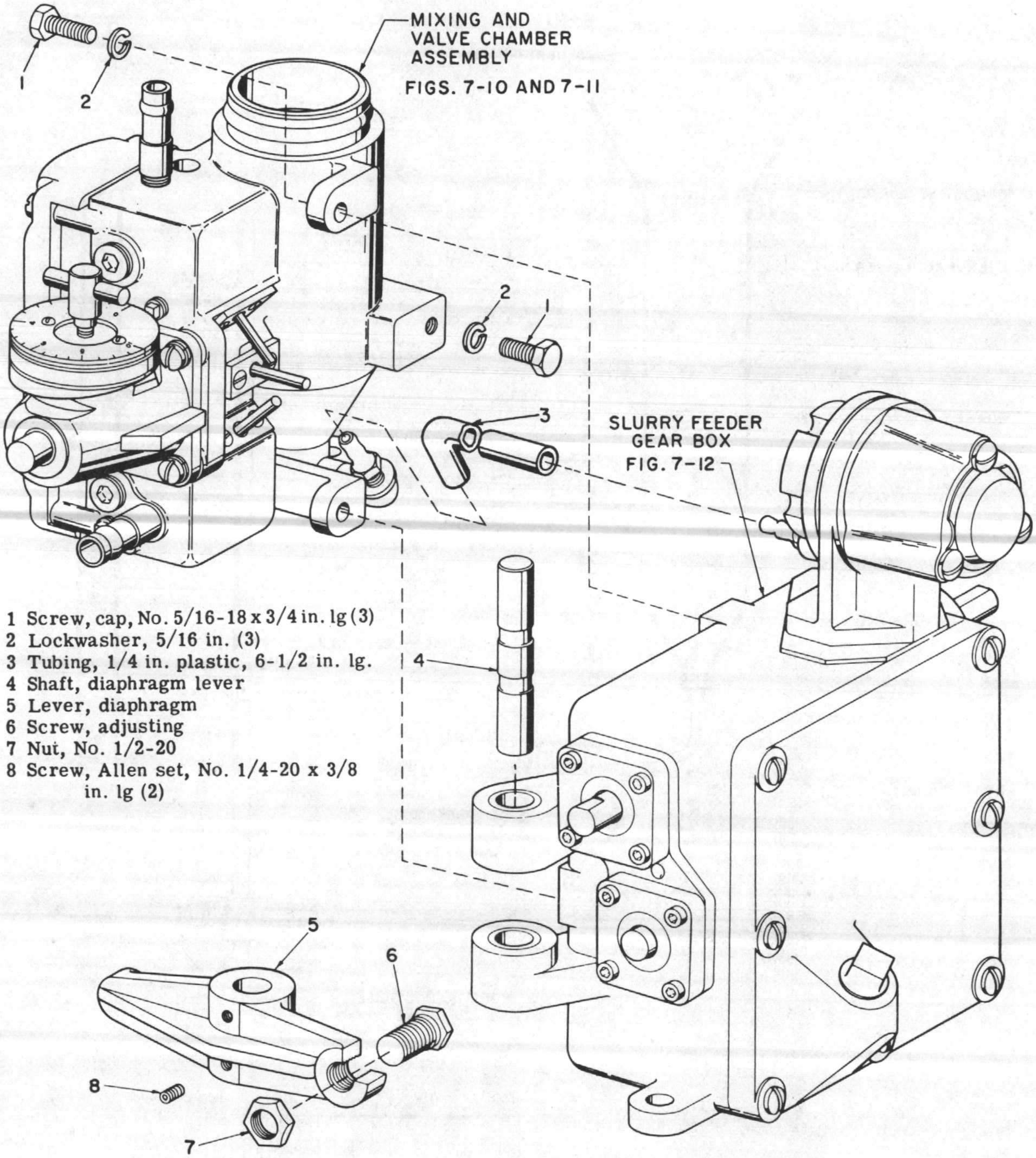


Figure 7-8. Slurry Feeder Operation - Schematic and Sequence Diagram



1 Screw, cap, No. 5/16-18 x 3/4 in. lg (3)
2 Lockwasher, 5/16 in. (3)
3 Tubing, 1/4 in. plastic, 6-1/2 in. lg.
4 Shaft, diaphragm lever
5 Lever, diaphragm
6 Screw, adjusting
7 Nut, No. 1/2-20
8 Screw, Allen set, No. 1/4-20 x 3/8 in. lg (2)

Figure 7-9. Slurry Feeder - Exploded

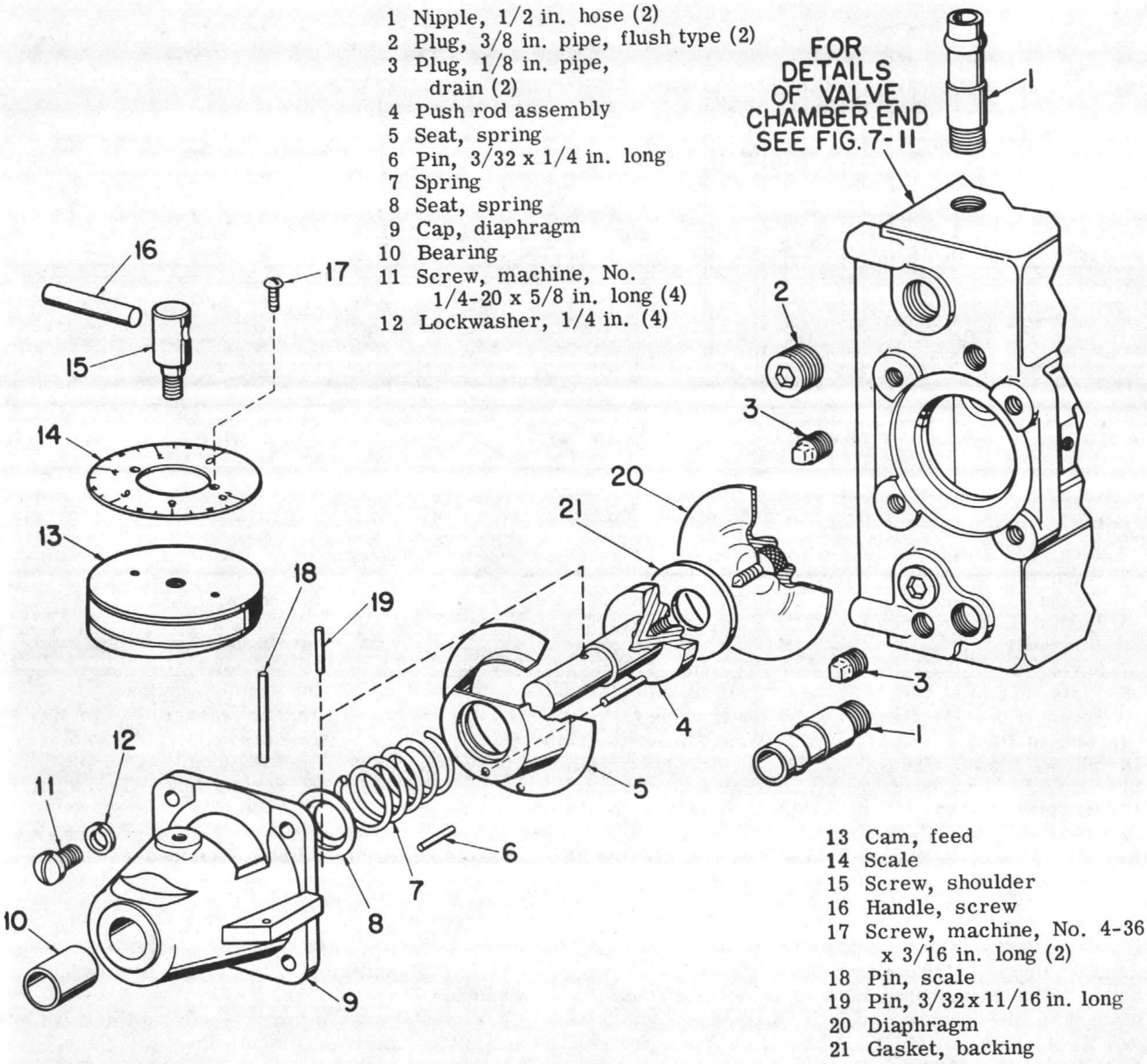


Figure 7-10. Mixing and Valve Chamber-Diaphragm End - Exploded

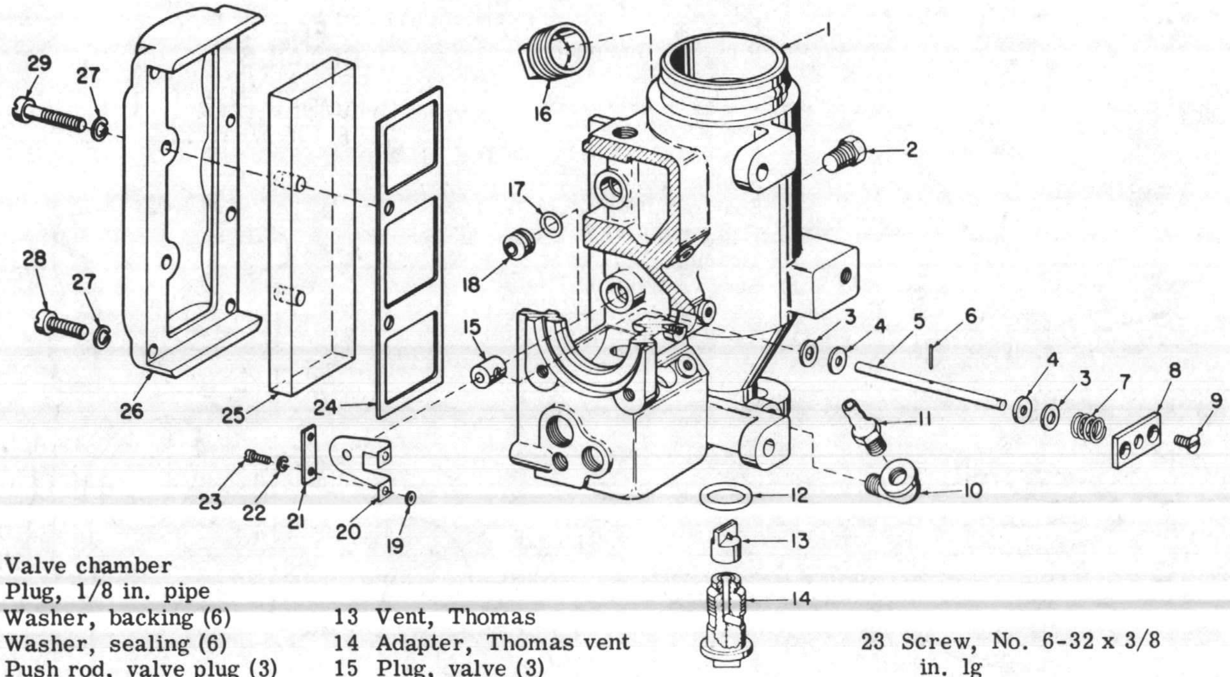
lockwashers (12). Push on exposed end of rod (4) and drop cam (13) in position with ten on scale (14) opposite pin (18). Install screw (15) but do not tighten. Place one drop of oil on bearing (10). Press on end of rod (4) and rotate cam (13) to zero. Install diaphragm lever (5) (figure 7-9), diaphragm lever shaft (4) and tighten set screws (8).

(3). Operation, Disassembly, and Repair of Mixing and Valve Chamber.

(a). General. One valve mechanism is assembled in each of the three valve compartments of the mixing and valve chamber (1) (figure 7-11), however, only the center mechanism is exploded in figure 7-11.

(b). Operation of Valve Chamber. Window (25) in valve chamber is transparent and the operation of the valves may be observed with the slurry feeder installed in the machinery section. During normal operation a white charge of filteraid slurry enters the slurry (center) compartment on the suction stroke of the diaphragm and is discharged on the pumping stroke when the flushing water inlet (lower) and outlet (upper) valves are open. Valves must open from 1/16 to 3/32 inches. If the slurry valve in the center compartment does not open, no white charge will be seen. If the inlet or both flushing valves do not open the white charge will not move out of the chamber and filteraid will collect in the bottom of the chamber. If the outlet flushing valve does not open the white charge will collect and settle in the valve chamber. If the slurry valve leaks and does not seat, a white ring of filteraid will form at the base of the valve during flushing. If either flushing valve leaks, no white charge will enter the slurry chamber on the suction stroke. For valve adjustments that can be made prior to disassembly, see paragraph (4) (b) below.

(c). Disassemble Mixing and Valve Chamber. Remove Thomas vent adapter (14), Thomas vent (13) and "O" ring (12) from bottom of mixing chamber.



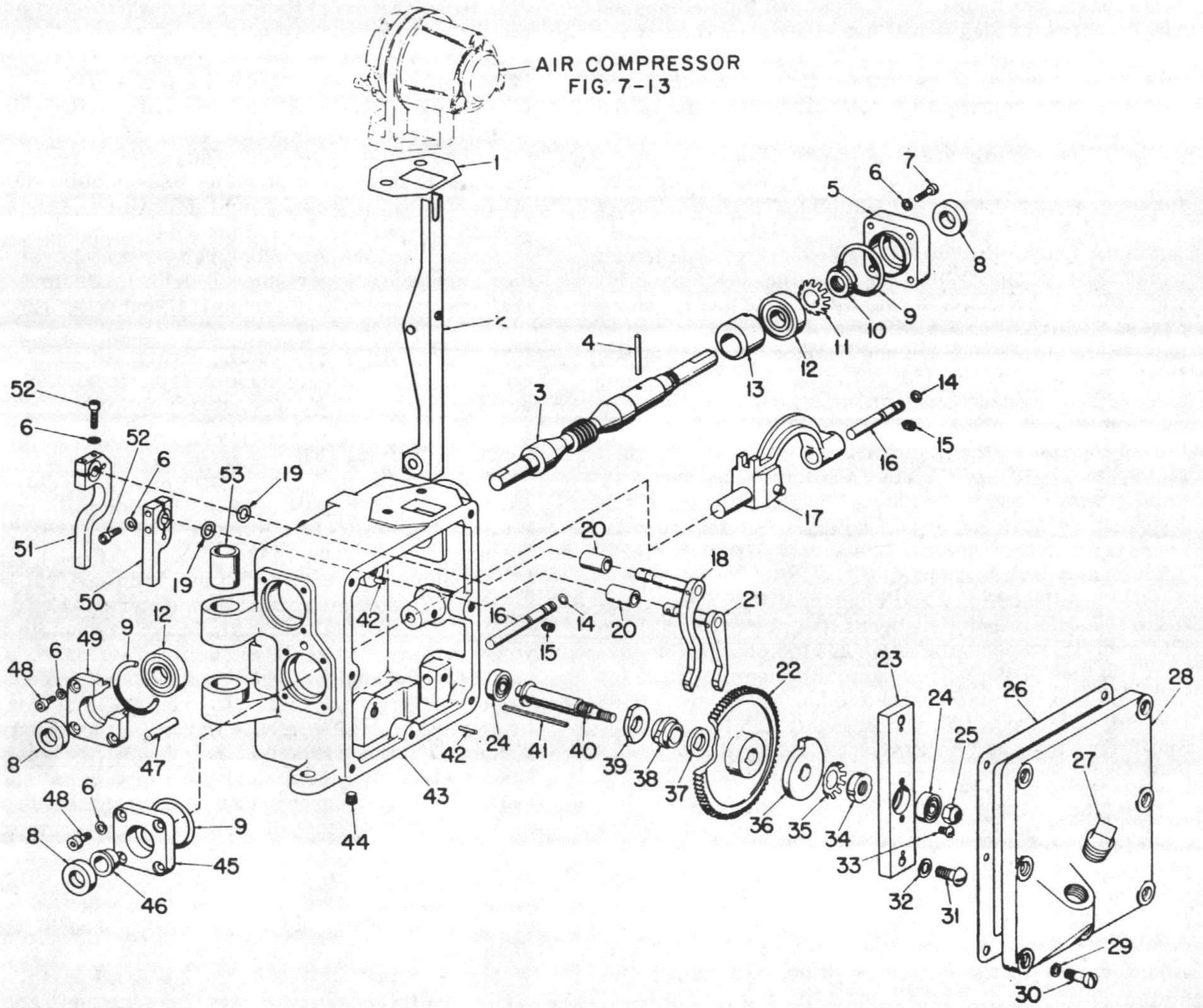
1 Valve chamber
2 Plug, 1/8 in. pipe
3 Washer, backing (6)
4 Washer, sealing (6)
5 Push rod, valve plug (3)
6 Pin, swivel (3)
7 Spring (3)
8 Plate, clamping (3)
9 Screw, No. 8-32 x 3/8 in. long
10 Elbow, 1/8 in. street
11 Nipple, 1/4 in. hose
12 "O" ring, 3/4 in. x 1 in.
13 Vent, Thomas
14 Adapter, Thomas vent
15 Plug, valve (3)
16 Plug, 3/4 in. pipe
17 "O" ring, 1/2 in. x 3/8 in. (3)
18 Seat, valve (3)
19 Washer, screw retaining (6)
20 Spring, inner (6)
21 Plate, clamping (3)
22 Lockwasher, No. 6 (6)
23 Screw, No. 6-32 x 3/8 in. lg
24 Gasket
25 Window
26 Frame, window
27 Lockwasher, 1/4 in. (8)
28 Screw, No. 1/4-20 x 3/4 in. long (6)
29 Screw, No. 1/4-20 x 1-1/4 in. long (2)

Figure 7-11. Mixing and Valve Chamber - Valve Chamber End - Exploded

Remove nipple (11) and elbow (10). If the valves cannot be adjusted for proper operation as descrbied in paragraph (4)(b) below, or if a valve leaks, disassemble the valve chamber and any of the three valves as follows: Remove the six screws (28), two screws (29), eight lockwashers (27), the window frame (26), and the window (25). Be careful not to damage the gasket (24). Remove two screws (9) and the clamping plate (8) and spring (7). Pull out rod (5), pin (6), two washers (3) and two seals (4) as a unit. Remove two screws (23), lockwashers (22), clamping plate (21), spring (20) and washers (19). Withdraw valve plug (15). Use a hooked wire to remove valve seat (18) and "O" ring (17).

(d). Inspect and Clean Parts. Thomas vent (13) acts as a check valve. It permits air from the gear box air compressor to bubble up through the mixing chamber (1), but prevents slurry from backing up into the air line (3) (figure 7-9) and the air compressor. The vent must be soft and pliable and the slot in the top must close off. Test the vent by blowing in the reverse direction to see if it is tight. Check the seating surface of the valve seats (18) (figure 7-11). Seating surfaces must be smooth, clean, and free of nicks. Wash filteraid slurry out of valve compartments and out of mixing chamber.

(e). Reassemble and Adjust Mixing and Valve Chamber.
Care must be taken in reassembling the valve mechanisms. The compartments must be clean, and all seating and gasket surfaces must be smooth. Replace seals (4) (figure 7-11) and rings (12 and 17) if damaged. Replace valve plug (15) and seat (18) if seating surfaces are not in good condition. To reassemble, lubricate valve seat (18) and "O" ring (17) with glycerine and water, slip ring onto seat and carefully press into mixing and valve chamber (1). Insert valve plug (15) over valve seat (18) with button end out and secure with inner spring (20), washers (19), clamping plate (21), lockwashers (22) and cap screws (23). Assemble pin (6), rod (5), two seals (4) and two washers (3) and insert as a unit through hole in valve compartment. HOLE IN THE PROTRUDING END OF ROD (5) AND THE PIN (6) MUST BE PARALLEL TO THE LONG DIMENSION OF THE CHAMBER. Solid end of rod (5) should slide into hole in valve plug (15). Secure parts with spring (7), clamping plate (8), and two cap screws (9). Loosen screws (23), press down gently on springs (20) while retightening screws (23) to obtain the proper spring load on the valve seat. For valve adjustment see paragraph (4)(b) below. Install gasket (24), window (25), window frame (26) and secure with two



1 Gasket
2 Lever, compressor diaphragm
3 Shaft, drive
4 Pin, shaft
5 Retainer, bearing
6 Lockwasher No. 10 (16)
7 Screw, No. 10-32 x 3/4 in. long (4)
8 Seal, oil (3)
9 Ring (3)
10 Locknut
11 Lockwasher
12 Bearing, ball (2)
13 Cam, compressor
14 Ring (2)
15 Screw, No. 1/4-20 x 1/4 in. long, Allen (2)
16 Pin, guide
17 Yoke
18 Follower (flushing water)
19 "O" ring (2)
20 Bushing (2)
21 Follower (slurry feed)
22 Gear, worm
23 Bar, bearing
24 Bearing, ball (2)
25 Nut, No. 1/4-20
26 Gasket
27 Plug, 1/2 in. pipe
28 Cover
29 Lockwasher, 1/4 in. (7)
30 Screw, No. 1/4-20 x 3/4 in. long (7)
31 Screw, No. 5/16-18 x 3/4 in. long (2)
32 Lockwasher, 5/16 in. (2)
33 Screw, No. 10-32 x 1/4 in. long (2)
34 Locknut
35 Lockwasher
36 Cam, diaphragm
37 Spacer
38 Cam (slurry feed)
39 Cam (flushing water)
40 Shaft, cam
41 Key
42 Pin, 1/8 x 3/4 in. long (2)
43 Box, gear
44 Plug, drain, 1/8 in. pipe
45 Cap, bearing
46 Bushing, 5/16 in. x 7/16 in. x 3/8 in.
47 Pin, 1/4 x 1-1/4 in. long, dowel
48 Screw, No. 10-32 x 1/2 in. long (8)
49 Cap, oil seal
50 Arm, trip (short-slurry feed)
51 Arm, trip (long-flushing water)
52 Screw, No. 10-32 x 3/4 in. long (4)
53 Bushing, 5/16 in. x 7/8 in. x 1 in. (2)

Figure 7-12. Slurry Feeder Gear Box - Exploded screws (29), six screws (28), and lockwashers (27). Draw parts down evenly. Gasket and pipe compound should not be needed, but if used they should be of the non-hardening type. Install "O" ring (12), Thomas vent (13), Thomas Vent adapter (14), elbow (10) and nipple (11) to complete reassembly of the mixing and valve chamber.

(4). Disassemble and Repair Gear Box.

(a). General. A minimum of repairs is required for the gear box. Cams (38) and (39) (figure 7-12) may wear and affect valve chamber operation beyond adjustment (par. (4)(b) below). Wear in cam (36) can usually be compensated for by adjusting screw (6) (figure 7-9) (par. (1)(d) above). Repair of the air compressor (which is part of the gear box) is explained in par. (5) below. Bushings and bearings are press fit, flush or against a shoulder. Grease is not required, however, it is necessary to maintain the oil level in the crankcase to the top of the oil filler plug. Direction of rotation of the slurry feeder is clockwise when facing the drive end of the shaft (3) (figure 7-12). Starting with par. (c) below, disassembly steps are listed in logical sequence, however, it may not be necessary to remove all previously listed parts to replace any particular part.

(b). Adjust Slurry and Flushing Water Trip Arms (figure 7-12). Arm (50) opens the slurry feed valve and arm (51) opens the inlet and discharge flushing water valves of the valve chamber assembly (par. (3) above). The action of cam (38) on follower (21) is transferred to arm (50) which opens the slurry valve. Similarly cam (39), follower (18) and arm (51) opens both flushing water valves. Valves are closed by the two springs inside each valve compartment of the valve chamber. The position of cams (38) and (39) on shaft (40) is fixed by key (41). Therefore, valve opening can only be adjusted by loosening screws (52) and moving arms (50) and (51). These arms are outside gear box (43) and adjustment can be made without removing or disassembling the slurry feeder. Always adjust valves in the closed position. To adjust the slurry valve: turn shaft (3) until the diaphragm (par. (2) above) is at the pumping stroke and the slurry valve is in closed position. With a 3/32-inch Allen set screw wrench loosen two screws (52) which lock arm (50) to follower (21). Insert a wire or nail in the hole in the end of follower (21) and turn counterclockwise to press follower (21) against cam (38). Holding follower in this position, press arm (50) against the push rod of the slurry valve and tighten two screws (52). Turn shaft (3) by hand and check by observation to make sure the valve opens and closes. To adjust the two flushing water valves turn shaft (3) until the diaphragm is at the suction stroke and the flushing valves are in closed position. Loosen two screws (52) which lock arm (51) to follower (18). With wire or nail in hole of follower (18) turn counterclockwise to press follower against cam (39). Hold follower in this position, press arm (51) against the two push rods of the flushing water valves and tighten two screws (52). Check valve operation by observation. Valves must open from 1/16 in. to 3/32 in.

(c). Disassemble Gear Box (figure 7-12.)

1. Remove Yoke and Worm Gear. Remove plug (44) and drain out oil. Remove seven screws (30), washers (29) and lift cover (28) from box (43). Do not damage gasket (26). Remove nut (25), two screws (31), two screws (33) and lift out bar (23). Press bearing (24) from the bar. Remove screw (15) and pull out pin (16) and ring (14) which hold yoke (17) in place. Remove four screws (48) and lift off seal (8), bushing (46), cap (45) and ring (9) as a unit. Drive out pin (47) if yoke (17) cannot be lifted out. Lift out locknut (34), lockwasher (35), cam (36), gear (22), spacer (37), cam (38), cam (39), shaft (40), key (41) and bearing (24) as a unit. To disassemble this unit straighten lug on lockwasher (35), remove locknut (34) and lift the parts from the shaft (40).

2. Remove Air Compressor and Lever. Remove air compressor (see (5) below). Remove screw (15) and lift out pin(16), ring (14) and lever (2).

3. Remove Drive Shaft. Remove seal (8), cap (49) and ring (9) as a unit. Straighten lug on lockwasher (11). Remove locknut (10), lockwasher (11), bearing (12), and slide shaft (3) out of box (43) from right to left. Remove pin (4) to release cam (13). Drive off bearing (12).

4. Remove Valve Followers. Remove two screws (52) and pull arm (51) from follower (18). Withdraw follower (18). Remove "O" ring (19). Press bushing (20) from box (43), if necessary. In a similar manner remove arm (50) and follower (21).

(d). Reassemble Gear Box (figure 7-12.)

1. Install Valve Followers. Reassemble in reverse order of the disassembly procedure. Check parts for damage or wear and replace if necessary. Press bushings (20) flush to the inside of box (43). Insert follower (21) in hole in box (43) as illustrated. Place "O" ring (19) on follower (21) and push into space in bore outside bushing (20) to make satisfactory seal. With two screws (52) and washers (6) attach arm (50) loosely to follower (21). The arm must be adjusted later (see (b) above). The screws must engage in the groove of the follower. This will automatically position the arm. Similarly, install follower (18), ring (19), and arm (51) with screws (52) and washers (6).

2. Install Drive Shaft. Check all parts, especially shaft (3) and cam (13) for wear and replace if necessary. Press bearing (12) on left (short) end of shaft (3). Slide cam (13) on shaft (3) and lock in place with pin (4). Slide shaft through box (43) from left to right. Slide bearing (12) on right end of shaft, install lockwasher (11) and locknut (10). Tighten locknut (10) to the nearest lug on lockwasher (11). Lock in place. Assemble retainer (5), seal (8) and ring (9) as a unit, and install on box (43) with four washers (6) and screws (7). Assemble seal (8), ring (9) and cap (49) as a unit, and install on box (43) with four washers (6) and screws (48).

3. Install Air Compressor and Lever. Attach lever (2) to box (43) with pin (16), ring (14) and screw (15). The screw must fit in the groove of the pin which automatically positions the pin. Place gasket (1) on box (43) and install air compressor as explained in paragraph (5) below.

4. Install Worm Gear and Yoke. Inspect all parts, especially cams (36), (37), and (38), for wear and replace if necessary. Press bearing (24) on left end of shaft (40). Place key (41) in shaft (40) and stack cam (39), cam (38), spacer (37), gear (22), cam (36), and lockwasher (35) on shaft (40). Tighten locknut (34) to nearest lug on lockwasher (35). Lock in place. Push followers (18) and (21) out of the way

to the right and place shaft assembly in box (43). The low point of cam (36) should be to the left and gear (22) must mesh with worm of shaft (3). Place yoke (17) in box (43). Press pin (47) flush to outside of box (43), with the beveled end of the pin inside the box and engaging the lugs of yoke (17). Assemble ring (9), cap (45), bushing (46) and seal (8) as a unit and attach to box (43) with four washers (6) and screws (48). Install pin (16) and ring (14) in yoke (17). Screw (15) must engage the groove in pin (16) which automatically positions the pin. Press two pins (42) and bearing (24) in bar (23). The bearing seats on the shoulder of the bar and the pins are flush with the bearing side of the bar. Install two screws (33) to hold bearing (24). Place bar (23), with bearing out and the longer end to the top, on shaft (40) and secure with nut (25), two washers (32) and screws (31).

(e). Inspect and Test the Gear Box (figure 7-12). Turn shaft (3) by hand and make certain that no parts bind, that gears mesh and that cams operate properly. Install drain plug (44), gasket (26), cover (28), fill with oil to the level of the oil filling opening and install plug (27). Arms (50) and (51) are to be adjusted after the valve chamber assembly has been installed on the feeder and the complete unit is to be tested after assembly in the machinery section by operating the equipment.

(5). Operation and Disassembly of Air Compressor (figure 7-13).

(a). Operation of Air Compressor. The action of the air compressor lever compresses spring (6) and pulls back on diaphragm (14) which creates a suction in front of the diaphragm and draws air through strainer (24) into cap (15). On the pressure stroke the spring pushes out on the diaphragm and forces the air out of cap (15) through nipple (16) to the slurry hopper. Valve cages (3) serve as check valves. Felt strainer (24) screens out dirt that may clog the valves and, depending on the cleanliness of air entering the compressor, will have to be replaced periodically. If a new strainer is not available, make one from several thicknesses of cloth such as a handkerchief. If the diaphragm leaks or if the strainer or valves clog no air will bubble up in the slurry hopper. The air compressor need only be disassembled to replace a part, or partially disassembled to install the compressor on the gear box housing.

(b). Air Compressor Removal and Disassembly.

1. Remove Body. Loosen three screws (8), twist cup (9) and remove the cup. Take care that spring (6) does not fly out when the cup is removed. Remove screw (10), lockwasher (11) and washer (12). Remove two screws (13), washers (11) and lift body (5) from gear case housing and the lever arm.

2. Remove Strainer and Diaphragm. Remove three screws (20), lockwashers (21) and washers (22). Lift off disc (23), strainer (24), and disc (17). Remove two screws (19), four screws (25), six washers (18) and lift off cap (15) and diaphragm (14). Remove four screws (1) to remove two cages (3).

(c). Air Compressor Reassembly and Installation. Check strainer for dirt, inspect diaphragm for holes or cracks and blow and suck through valves to test operation. Assemble four screws (1), washers (2), two gaskets (4), cages (3), nipple (16), disc (17), strainer (24), disc (23), three screws (20), lockwashers (21) and washers (20) on cap (15). Install body (5) on gear box housing using two screws (13) and washers (11). The small end of body (5) must face the open end of the gear box housing. To increase pumping rate, move the body as far as possible toward the open end of the gear box. Install cap assembly (15) and diaphragm (14) loosely on body (5). Only take three to four turns on screws (25) and (19). Install washer (12), lockwasher (11) and screw (10) in diaphragm (14). The metal adapter of the diaphragm must be between the lugs of the actuating lever. Turn the drive shaft of the gear box until the lever is at a point farthest away from the open end of the gear box housing. Install three washers (7) and screws (8) loosely in body (5), place cup (9) on large end of spring (6) and insert other end of spring in body (5). Press in on cup (9) and twist to lock in place. Tighten three screws (8), four screws (25) and two screws (19). Screws (25) and (19) must be tight or the diaphragm will leak and the compressor will not pump air.

7-7. RESTRICTOR MAINTENANCE.

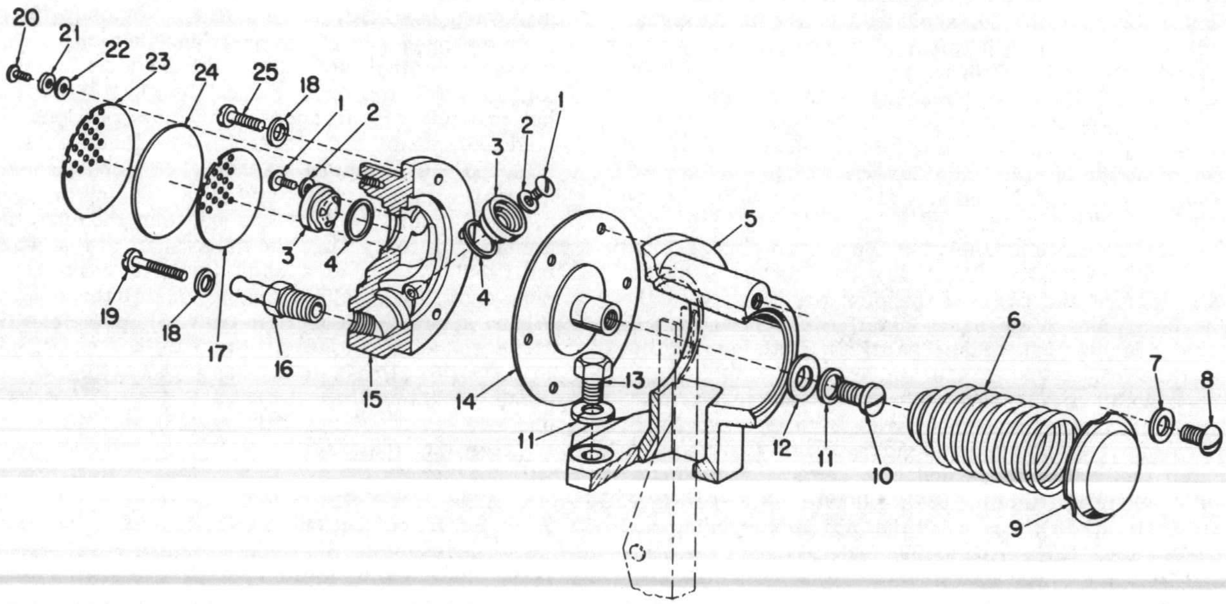
a. Disassemble Restrictor (figure 7-14). Plug (1) is the priming plug for the pump. The restrictor need not be disassembled except to clean it out or to replace the combination gasket and flap valve (5). Remove two screws (9), two screws (8) and remove body (7) and gasket assembly (5). Remove three screws (11), washer (10) and separate plate (4) and weight (6) from gasket (5). Bushing (3) is press fit into body (2).

b. Reassemble Restrictor. Reassemble the restrictor in the reverse order of the disassembly procedure. Gasket (5) must be flexible and the hinged flap intact. Weight (6) must be toward body (7).

7-8. HYPOCHLORINATOR MAINTENANCE.

a. Description and Operation (figure 7-15). The hypochlorinator is a diaphragm pump with gears, bearings and cams running in oil and enclosed in a cast iron housing. On the suction stroke, the vacuum created by the backward motion of diaphragm (17) closes the discharge (upper) poppet valve (20), opens the suction (lower) poppet valve (20) and pulls hypochlorite solution from the hypochlorite reservoir, through a strainer (inside the reservoir) and sight glass into the space between the diaphragm (17) and body (25). On the forward or discharge stroke, the pressure created by the forward movement of the diaphragm closes the suction poppet valve, opens the discharge poppet valve, and discharges the solution through a hose connection into the restrictor in the pump discharge line. Shaft (11) is directly connected to the diaphragm and is actuated by rocker arm (10) which in turn is moved by cam (48) driven through suitable gearing from the main drive shaft (51). As cam follower bearing (54) on the lower end of rocker arm (10) follows the rise on cam (48), the upper end of the rocker arm pushes shaft (11) forward. When the cam follower bearing (54) passes the tip of the cam, spring (13) accomplishes the backward or suction stroke. A variable lever fulcrum roller (58) moves up and down as handle (1) is turned to effect changes in the length of the pumping stroke, causing proportionate changes in the amount of solution pumped.

b. Pumping Body Assembly. Repairs to the hypochlorinator may be made without removing the unit



1 Screw, No. 6-32 x 3/16 in. long (4)	8 Screw, No. 1/4-20 x 1/2 in. long (3)	14 Diaphragm	20 Screw, No. 8-32 x 1/4 in. long (3)
2 Washer, No. 6 (4)	9 Cup, spring	15 Cap, pump	21 Lockwasher, No. 8 (3)
3 Cage, valve (2)	10 Screw, No. 5/16-18 x 1/2 in. long	16 Nipple, 1/4 in. hose	22 Washer, No. 8 (3)
4 Gasket, valve (2)	11 Lockwasher, 5/16 in. (3)	17 Disc, inner	23 Disc, outer
5 Body	12 Washer, 5/16 in.	18 Lockwasher, No. 10 (6)	24 Strainer, felt
6 Spring	13 Screw, No. 5/16-18 x 1/2 in. long (2)	19 Screw, No. 8-32 x 1 in. long (2)	25 Screw, No. 10-32 x 5/8 in. long (4)
7 Lockwasher, 1/4 in. (3)			

Figure 7-13. Gear Box Air Compressor - Exploded

from the machinery section. If it is necessary to disassemble the pumping portion of the hypochlorinator for draining or repair proceed as follows:

(1). Remove Pumping Body Assembly. Loosen screw (31) sufficiently to relieve pressure on nuts (29) and remove four nuts (29) and washers (28). Pull plate (27) and clamping disc (26) from studs (16). Remove screw (23), yoke (24), valve bodies (21) and lift out valves (20) and seats (19). Lift pump body (25) from studs to expose diaphragm (17). Diaphragm (17) screws onto shaft (11). Do not remove the diaphragm unless it must be replaced or adjusted.

(2). Clean and Examine Parts. Examine valves (20), seats (19), valve bodies (21), diaphragm (17) and pump body (25) for damage, cracks, leaks, or breaks. Clean any hard water deposit from parts. The formation of a white coating on diaphragm (17), poppet valves (20), or valve seats (19), is an indication of hard water and may bring about improper operation of the hypochlorinator. The coating can be easily removed by soaking the parts in 5% hydrochloric acid. The commercial form of hydrochloric acid, known as muriatic acid, is quite acceptable. Where hard water exists, deposits may form also on the inside of the tube on the restrictor through which the hypochlorite solution is fed into the water. Inspect this tube at regular intervals and clean out if necessary.

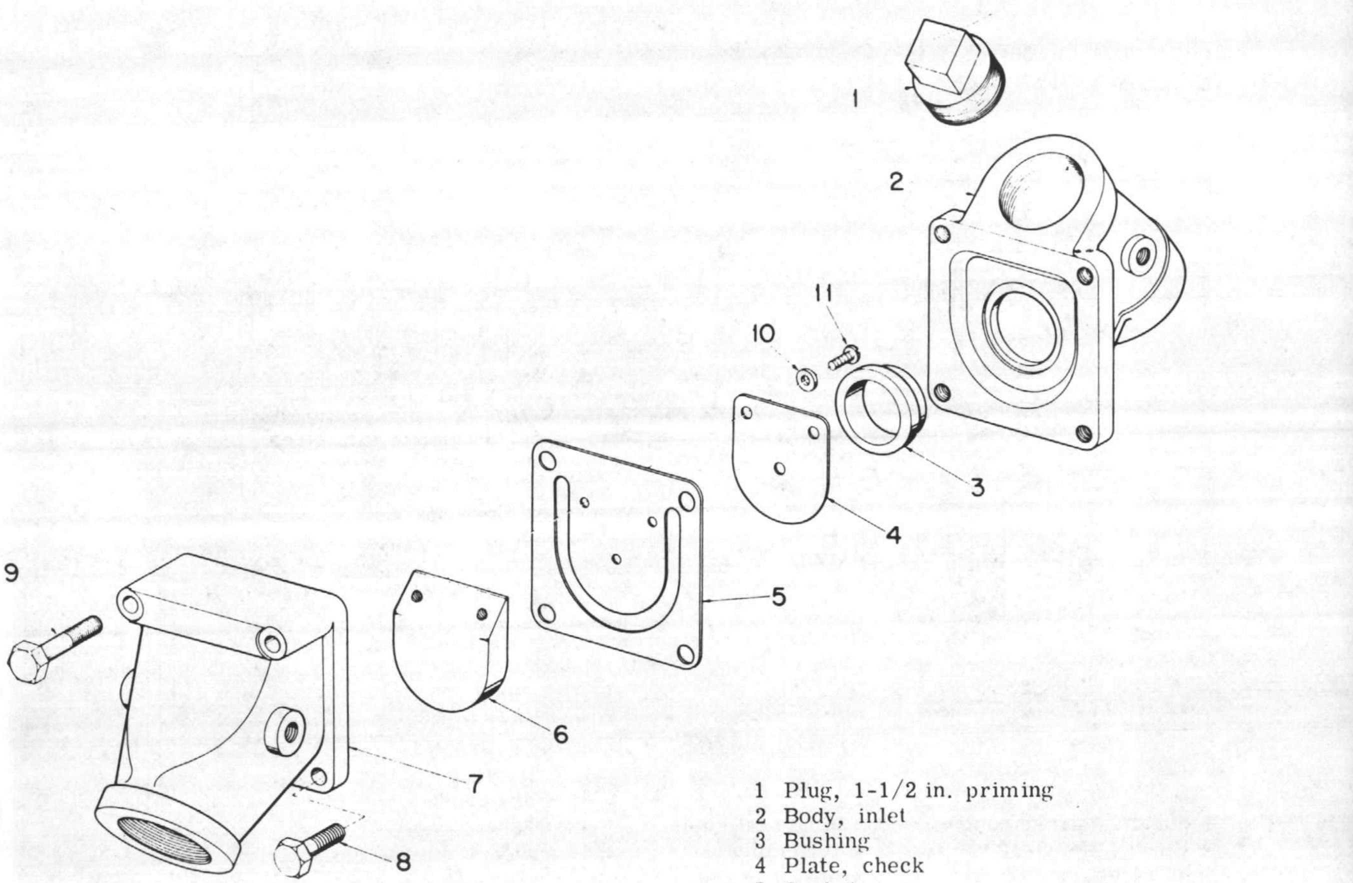
(3). Adjust Diaphragm. The hypochlorinator is designed so that when the stroke control handle (1) is set at 10 on the calibrated dial (72) the pump shaft (11) and diaphragm (17) move one-quarter of an inch. This setting represents the maximum length of stroke. For long life of the diaphragm and for correct pumping rates, it is essential that the diaphragm be set so that it flexes an equal distance backwards and forwards from its normal position. To accomplish this setting, the following procedure should be followed:

(a). Set the stroke control handle (1) on the hypochlorinator at a reading of 10 on the dial (72).

(b). Rotate the pulley on the slurry feeder clockwise until the pump shaft (11) is at the extreme end of the suction stroke.

WARNING

Never make adjustments or work on the hypochlorinator without first removing either the drive belt or the ignition cable from the spark plug. Turning the feeder shaft over by hand with the drive belt in place during adjusting might start the engine and cause serious injury to the operator.



1 Plug, 1-1/2 in. priming
2 Body, inlet
3 Bushing
4 Plate, check
5 Gasket
6 Weight
7 Body, outlet
8 Screw, No. 3/8-16 x 1-14 in. long (2)
9 Screw, No. 3/8-16 x 2-1/4 in. long (2)
10 Washer, No. 10 (3)
11 Screw, No. 10-32 x 1/8 in. long (3)

Figure 7-14. Restrictor - Exploded

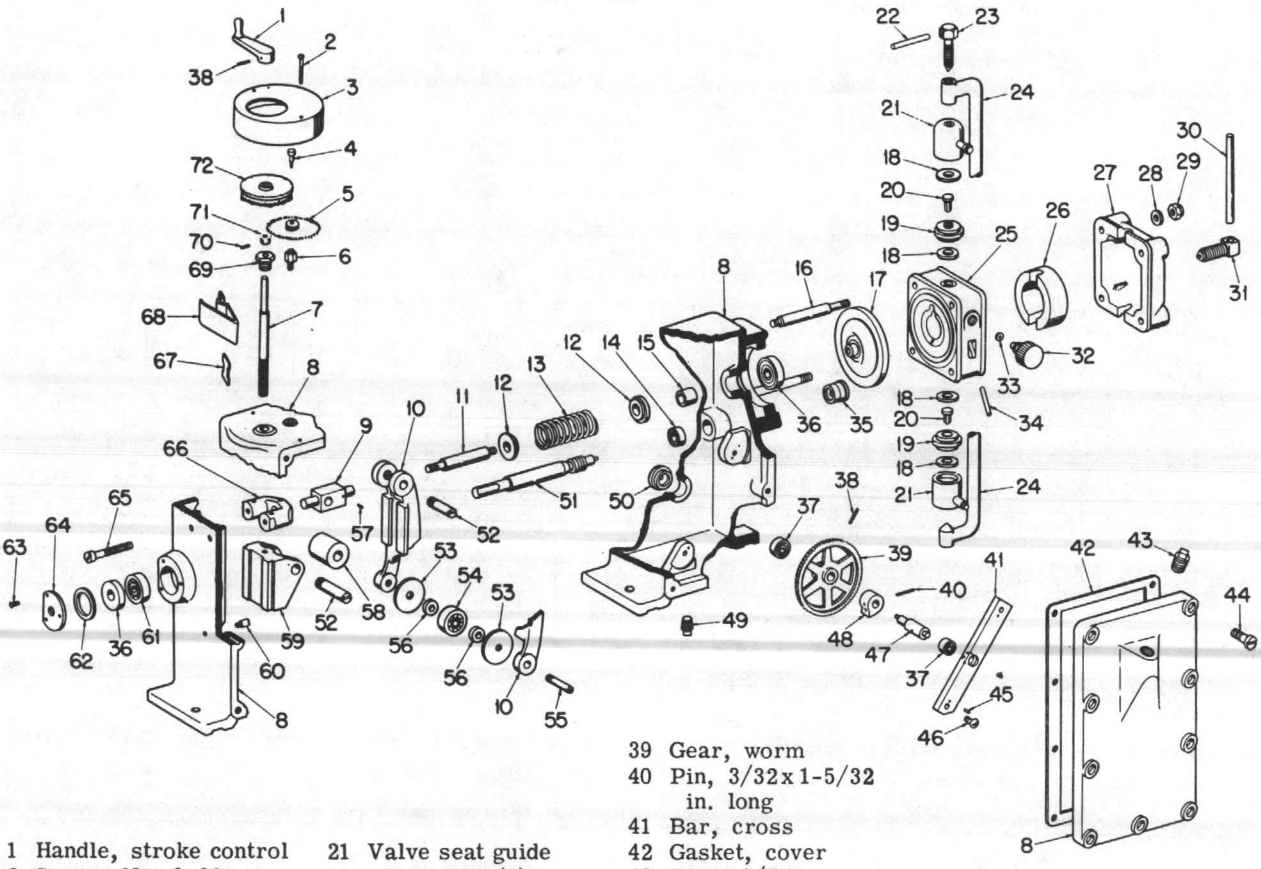
This point can be most readily determined by removing the diaphragm (17) altogether and observing the movement of the pump shaft. If visual inspection is not feasible, the correct position may be determined by holding the thread end of the pump shaft lightly with the fingers.

(c). Screw the diaphragm on the pump shaft and place a straight edge across the face of the diaphragm as shown in figure 7-16. Adjust the diaphragm on the shaft as required to obtain a clearance of 1/8" between the flat position of the diaphragm and the edge of the straight edge.

(4). Reassemble Pumping Body Assembly (figure 7-15). Reassemble in reverse of the removal procedure. Care should be exercised to insure that all gaskets are in place and that the poppet valves (20) are in the positions shown on figure 7-16. When disc (26) and plate (27) are installed, nuts (29) should be turned up finger-tight. The assembly may then be made secure by tightening screw (31). This method insures an equal distribution of forces over the face of the hard rubber pumping block and tends to eliminate damage to the block.

c. Cam Shaft Assembly (figure 7-15). This assembly consists of two bearings (37), pin (38), gear (39), pin (40), bar (41), two pins (45), shaft (47) and cam (48). Bearings (37) are force fit against shoulders of shaft (47). Gear (39) is force fit against a shoulder and attached to the shaft with pin (38). Pin (40) holds cam (48) to shaft (47). To install a new cam (48) pull outside bearing (37) from the shaft, drive pin (40) out of cam (48) and remove the cam. Place the new cam in position as illustrated so that with counterclockwise rotation of gear (39) bearing (54) will follow the rise of the cam and drop to the low point of the cam. Clearance between cam (48) and bearing (37) must be 37/64 inches. Use drill holes in one side of the cam and in the shaft as a guide and drill through the other side of the cam with number 42 (.093") drill. Force fit pin (40) in place. Where a new shaft (47) is used it will be necessary to drill the shaft for the pin. Pins (45) are force fit into bar (41) with 1/8-inch protruding outside the bar.

d. Stroke Adjusting Shaft Assembly (figure 7-15). This assembly consists of handle (1), shaft (7), bushing (69), pin (70), pinion (71), dial (72) and pin (38).



1 Handle, stroke control
2 Screw, No. 8-32 x 1/4 in. long (2)
3 Cover, dial
4 Screw, idler gear
5 Gear, idler
6 Stud, idler gear
7 Shaft, stroke adjusting
8 Housing
9 Block, pivot
10 Arm, actuating (rocker)
11 Shaft, pump
12 Retainer, spring (2)
13 Spring
14 Bearing
15 Bushing, pump shaft
16 Stud (4)
17 Diaphragm
18 Gasket (4)
19 Seat, valve (2)
20 Poppet, valve (2)
21 Valve seat guide assembly (2)
22 Pin, 1/4 x 2 in. long
23 Screw, clamping
24 Yoke, clamping
25 Body, pump
26 Disc, clamping
27 Plate, end, clamping
28 Washer (4)
29 Nut, No. 3/8-16 (4)
30 Pin, 3/8 x 4 in. long
31 Screw, body clamping
32 Plug, priming
33 Gasket
34 Tube, air vent
35 Retainer
36 Seal, oil (2)
37 Bearing
38 Pin, 3/32 x 3/4 in. long
39 Gear, worm
40 Pin, 3/32 x 1-5/32 in. long
41 Bar, cross
42 Gasket, cover
43 Plug, 1/2 in.
44 Screw, No. 1/4-20 x 1 in. long (9)
45 Pin, 1/8 x 3/4 in. long (2)
46 Screw, No. 1/4-20 x 3/4 in. long
47 Shaft, cam
48 Cam
49 Plug, 1/4 in. drain
50 Retainer, bearing
51 Shaft, drive
52 Pin, fulcrum (2)
53 Washer (2)
54 Bearing, cam follower
55 Shaft, cam follower
56 Spacer
57 Screw, No. 10-32 x 1/4 in. long, set
58 Roller, fulcrum
59 Bracket, fulcrum roller
60 Pin, stop
61 Bearing
62 Gasket
63 Screw, No. 8-32 x 1/4 in. long (3)
64 Retainer
65 Screw, No. 5/16 x 1 in. long (2)
66 Block, bearing, pivot block guide
67 Pad, friction
68 Spring, fulcrum
69 Bushing
70 Pin, 3/32 x 1/2 in. long
71 Pinion
72 Dial
73 Decal, arrow
74 Nameplate

Figure 7-15. Hypochlorinator - Exploded

Handle (1) and pinion (71) are pinned to shaft (7) by tapered pins (38) and (70). Bushing (69) and dial (72) are free to rotate on the shaft.

(1). Remove Stroke Adjusting Shaft Assembly. Remove two screws (2) and lift off cover (3). Remove screw (4) and gear (5). Remove pin (60) and screw shaft (7) until it is disengaged from support (59). Unscrew bushing (69) and lift out the assembly.

(2). Install Stroke Adjusting Shaft Assembly. When the assembly is installed, gears must be meshed properly. Insert the shaft assembly through the hole in case (8) and through the hole in guide (66). Tighten bushing (69). Place support (59) in position and engage shaft (7) in support (59). Install pin (60). Turn shaft (7) until support (59) hits pin (60). Turn dial (72) so that number 10 is centered over the hole in stud (6). Maintain this setting and install gear (5), screw (4) and mesh the gears. Install cover (3). If the gear setting is correct, the index mark on cover (3) will coincide with 10 on dial (72) when support (59) is against pin (60).

e. Replace Main Spring (figure 7-15). To replace spring (13) remove pump body (25) and diaphragm (17) (see b (1) above). Loosen screw (57) and unscrew

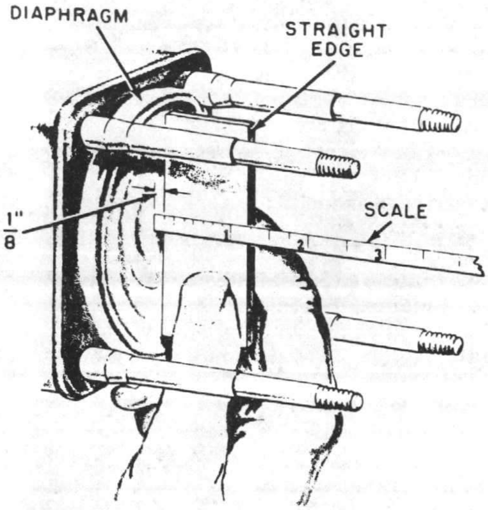


Figure 7-16. Hypochlorinator Diaphragm Adjustment

shaft (11) from block (9). Lift out spring (13) and retainers (12). To reinstall, slide on retainer (12) over the shoulder of block (9). Compress replacement spring (13) and tie it in compressed position with strong cord or string. Install the compressed spring and second retainer (12) on shaft (11). Tighten shaft in block (9) and tighten screw (57). Cut and remove string. Adjust diaphragm and replace pumping body assembly (see b. (4) above).

f. Sight Glass (figure 7-17). The sight glass need only be disassembled to remove any hard water deposit, to stop a leak, or to replace a broken glass. Remove two nuts (6) and washers (7). Replace glass (3) and gaskets (2) if necessary. Reassemble in reverse of the disassembly procedure.

g. Removal and Installation of Hypochlorite Reservoir Cover (figure 7-18). To remove the cover turn the two locking knobs (34) until flat side of knobs are faced in and edge of cover is free. Lift freed edge of cover and slide out from under the opposite cover clips (33). To install the cover, slide one edge under cover clips (33), press it flat on top of the hypochlorite reservoir and lock in place by turning the locking knobs (34) until their curved sides bind the rim of the cover. The drain tube (5) when not in use is clamped to the reservoir (2) to prevent unwanted drainage.

7-9. PUMP AND ENGINE ASSEMBLY MAINTENANCE.

a. General. The pump and engine assembly consists of a close-coupled Wisconsin Model ACND single cylinder, four-cycle, air-cooled, rope-started, gasoline engine; and a Carter Model 8T-2 self priming centrifugal pump.

b. Removal. Remove the engine and pump as a unit mounted on the engine and pump mounting base (13) (figure 7-19).

(1). Remove pulley guard (17) (figure 7-18), and screws and washers (18). Pull idler arm (8) (figure 7-19) downward away from V-belt (3) and remove belt from starting pulley (2) and sheave (1).

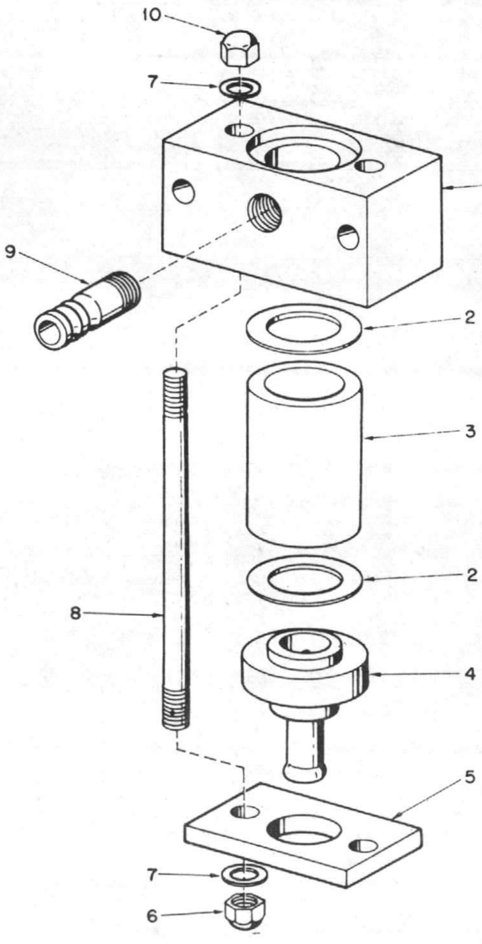
(2). Drain pump by removing drain plug (3) (figure 7-20) and priming plug (1) (figure 7-14). Remove nipple and reducing bushing (38) (figure 7-18), and valve (26) from pump inlet elbow (4) (figure 7-20). Remove nipple (2) (figure 7-20) and restrictor assembly (1) from pump housing (25).

(3). Remove cap screws, nuts and washers (12) (figure 7-19); then lift pump and engine mounting base (13) from mounts (11) and remove from machinery section frame (25) (figure 7-18).

c. Separate Pump and Engine.

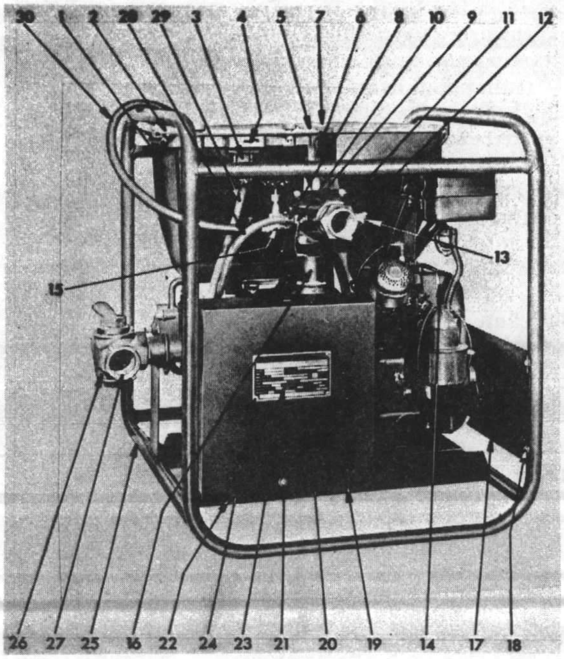
(1). Remove hardware (figure 2-9) securing pump and engine to mounting base (13) (figure 7-19).

(2). Remove pump housing cover (14) (figure 7-20), gasket (15), and nuts (13). Disconnect the ignition cable from the spark plug on the engine before attempting to remove the impeller. Hold the starter rope



1 Block, mounting
2 Gasket (2)
3 Glass
4 Connection, 3/8 in. hose
5 Plate, clamping
6 Nut, No. 10-32 elastic stop (2)
7 Washer, No. 10 (4)
8 Rod, tie (2)
9 Nipple, 3/8 in. hose
10 Nut, No. 10-32, acorn (2)

Figure 7-17. Hypochlorinator Sight Glass - Exploded



1 Screw, cap, No. 1/4-20 x 3/4 in. lg (4) (with nuts and washers)
2 Hypochlorite reservoir, cover, and strainer
3 Sight glass assembly
4 Screw, machine, No. 10-32 x 1-5/8 in. lg (2) (with nuts and washers)
5 Drain tube
6 Drain tube clamp
7 Slurry tank, cover, and strainer
8 Hose clamp, 3/8 in. (4)
9 Restrictor assembly
10 Connection to main
11 Adapter, 2-in. to 2-in. hose
12 Connector and street elbow (2)
13 Hose clamp, 1/2 in. (2)
14 Pump and engine unit assembly
15 Valve, globe, 1/4 in., nipple, hose connector, and clamp
16 Nipple, 2 x 4 in. lg
17 Pulley guard
18 Screw, self-tapping, No. 14 x 1/2 in. lg (4) (with washers)
19 Tool box
20 Instruction plate
21 Screw, machine, No. 4-36 x 1/4 in. lg (2) (with nuts, washers, and lockwashers)
22 Screw, cap, No. 1/4-20 x 5/8 in. lg (2) (with nuts, washers, and lockwashers)
23 Identification plate
24 Rivet, brass, 3/16 x 1/4 in. lg (4)
25 Chassis (frame)
26 Valve, 3-way, 2-position
27 Union, 2 in. (2)
28 Hose, 3/8 ID x 24 in. lg
29 Hose, 3/8 ID x 30 in. lg
30 Hose, 1/2 ID x 48 in. lg
31 Screw, cap, No. 1/4-20 x 5/8 in. lg (3) (with nuts, washers, and lockwashers)
32 Tape, plastic, 3/4 x 12 in. lg
33 Clip (2) (with screws and nuts)
34 Knob, locking (2) (with 4 spring washers, 2 screws, and 2 nuts)
35 Hose clamp, 3/8 in.
36 Nipple, adapter
37 Screw, cap, No. 1/4-20 x 5/8 in. lg (with nuts, washer, and lockwasher)
38 Nipple, 2 NPT x 12 in. lg, with reducing bushing
39 Hypochlorite feeder assembly
40 Screw, cap, No. 1/2 x 13 x 1-1/4 in. lg (2) (with nuts and lockwashers)
41 Coupling
42 Hose, 1/2 ID x 30 in. lg (2)
43 Hose clamp, 1/2 in. (2)
44 Slurry feeder assembly
45 Screw, cap, No. 3/8-16 x 1-1/4 in. lg (3) (with nuts, washers, and lockwashers)
46 Hose sleeve, slurry feeder inlet
47 Hose clamp (2)
48 U-Bolt 3/4-16 nuts and washers

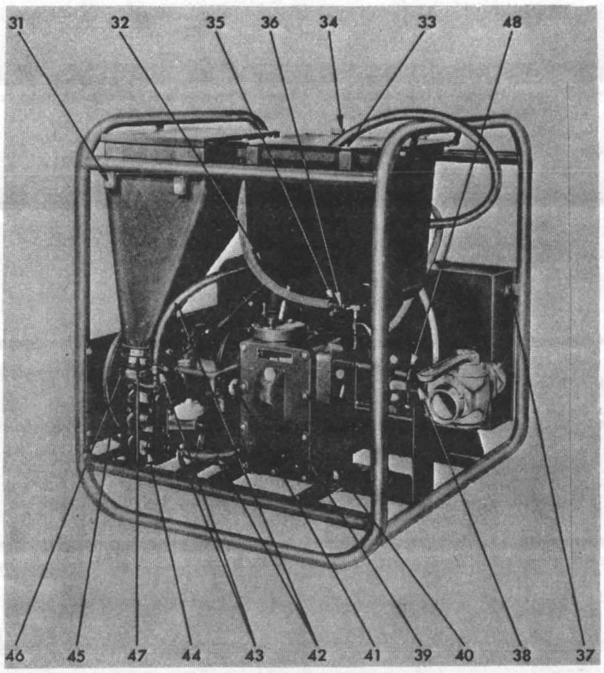
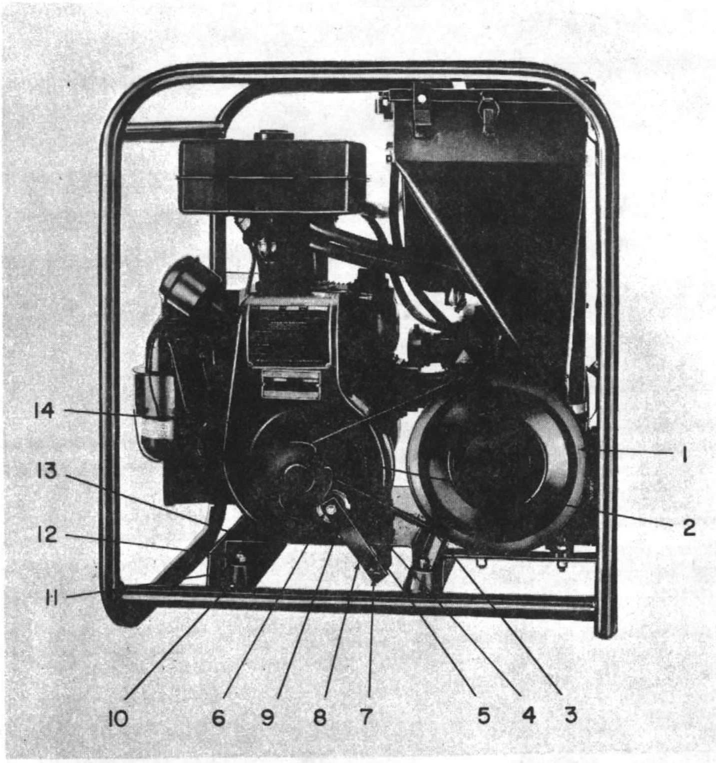


Figure 7-18. Machinery Section Assembly



1 Sheave
2 Pulley and sheave
3 Belt, "V"
4 Pulley assembly, tension
5 Spacer
6 Screw, No. 3/8-16 x 1-3/4 in. lg (with nut)
7 Pin, cotter, 3/32 x 1 in. lg (2)
8 Idler arm
9 Spring, torsion
10 Screws, cap, No. 5/16-18 x 3/4 in. lg (8) (with nuts and lockwashers)
11 Mount, engine and pump (4)
12 Screw, cap, No. 3/8-16 x 2-1/4 in. lg (4) (with nuts and washers)
13 Base, mounting
14 Pump and engine assembly

Figure 7-19. Machinery Section with Pulley Guard Removed

pulley and unscrew the impeller locknut (16) and the impeller (17) by turning counterclockwise off the engine shaft (23). Use a block of hard wood and a hammer to loosen the impeller. Do not damage the impeller vanes.

(3). Remove nuts (21) and separate pump housing from engine housing.

d. Installation.

(1). Reassemble pump and engine as described in paragraph 7-10. d, through f.

(2). Complete installation by reversing removal procedure (7-9. (b). above).

7-10. PUMP MAINTENANCE.

a. General.

(1). Description and Operation. Refer to paragraph 2-7b for a detailed discussion of the internal features of the pump. Operation of the pump is simple. As the impeller (12) (figure 2-10) turns with the engine crankshaft, water is sucked through the suction line and fitting (9) to the center of the impeller. The vanes on the impeller whirl the water from the center out, building up a positive pressure inside the pump housing (6). The housing is designed to collect the water as it is whirled off the impeller and direct the flow out through the pump discharge nipple (1) into the restrictor (3) and then into the discharge line.

(2). Cleaning and Draining. Solid particles must be kept out of the pump as they will clog the passages and the impeller vanes, keep the check valve (8) from closing properly, and possibly cause internal damage. If it is necessary to clean out accumulated muck and debris without disassembling the pump, remove the drain plug (7), priming plug (2), clean-out plug (19), and suction check valve assembly (8). Flush out housing (6) with clean water. Clean passages and impeller vanes. When necessary to drain the pump, remove the drain plug (7) and priming plug (2) to be sure all water flows out of the housing (6). Be sure to drain the pump after use in freezing weather as ice formation inside the pump housing can cause trouble.

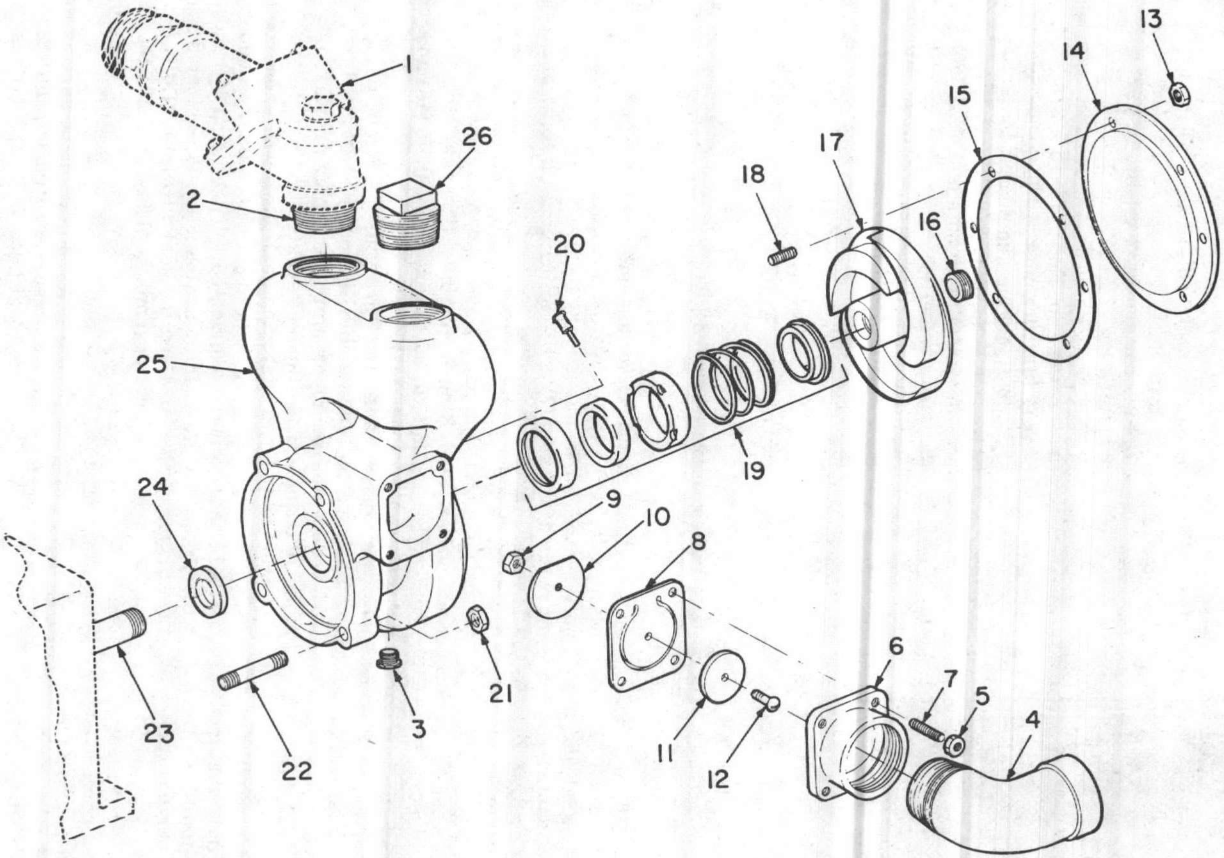
(3). Shaft Seal Ring Assembly. The seal ring assembly (14) mounts on the engine crankshaft (16) and prevents water from leaking from the pump housing into the engine, and also prevents air from being sucked from the engine into the pump. An air leak will reduce the pump capacity, and may prevent or delay priming. The slightest scratch on the polished surfaces of the two matching seal rings will cause a leak. Be careful when handling these parts. Keep the polished surfaces lubricated. If the pump is run without water in it, or if the seal is not well lubricated, the surfaces will score and the seal will leak. Do not replace part of a seal assembly, always replace the complete seal assembly.

b. Removal and Disassembly.

(1). Remove the pump from the machinery section and separate from engine as described in paragraph 7-9.

(2). Remove four nuts (5) (figure 7-20) from studs (7). Pry suction fitting (6) off housing (25). Remove check valve flapper (31) assembly. Remove nut (9) and separate check valve flapper (8), weight (10), washer (11) and bolt (12). Do not remove the studs (7) unless they must be replaced, since it is difficult to remove them without damaging the threads. Remove clean-out plug (26) and drain plug (3).

(3). Remove seal ring assembly (19) from housing (25) using a suitable punch. Turn housing over and



1 Restrictor assembly
2 Nipple, pump outlet
3 Drain plug, 1/4 in. NPT
4 Elbow, street, 2 in. NPT
5 Nut, hex, steel, No. 5/16-18
6 Suction fitting
7 Stud, steel, No. 5/16-18 x 1-1/4 in. lg
8 Flapper, check valve
9 Nut, No. 1/4-20
10 Weight, check valve
11 Washer, check valve
12 Screw, machine, No. 1/4-20 x 1 in. lg
13 Nut, hex, steel, No. 5/16-18
14 Cover, pump housing (volute)
15 Gasket, volute
16 Lockscrew, impeller
17 Impeller
18 Stud, steel, No. 5/16-18 x 1 in. lg
19 Seal ring assembly
20 Cup, oil
21 Nut, hex, steel, No. 7/16-14
22 Stud, steel, No. 7/16-14 x 2-3/4 in. lg
23 Crankshaft, engine
24 Seal, oil
25 Housing (volute)
26 Clean out plug

Figure 7-20. Pump and Engine Assembly - Exploded punch out oil seal (24). Unscrew oil cup (20) from housing (25). Carefully press out seal ring assembly parts (1 through 5) (figure 7-21).

c. Inspection and Repair.

(1). Pump Housing and Check Valve. Thoroughly scrub and flush out the passages inside the housing (25). Clean the impeller (17), remove all dirt and debris from between the impeller vanes. Inspect all parts, gaskets, and the check valve for wear or damage and replace if necessary. The check valve flapper (8) must seal the housing (25) when the pump is shut off or the priming charge will siphon out and be lost. Make sure all gaskets and seals are sound; use new ones if in doubt. Before installing the seal assembly (19), thoroughly clean the engine crankshaft (23) of all foreign matter and oil the shaft so the seal parts will slide on easily.

(2). Impeller. Inspect the open face of the impeller to determine the extent of wear. (See figure 7-22.) Place a straight edge across impeller face at several locations and note if face is worn uniformly. If the face of the vanes have worn such that there is a difference of 1/32 to 3/64 between the face near the tip and the face near the hub or if the leading edges of the vanes have been rounded to a 1/8 radius, the impeller should be replaced.

d. Reassembly of Seal Ring Assembly.

(1). Reassemble Stationary Seal. Install stationary seal (4) (figure 7-21) and vibration ring (5) in housing (25) (figure 7-20) and carefully tap into place. Cover the synthetic rubber vibration ring (5) (figure 7-21) with grease or permatex to facilitate installation. Make sure ceramic face of stationary seal faces outward to make contact with rotating seal (3).

(2). Reassembly Engine and Pump Housings. Install oil seal (6) into housing (25) (figure 7-20). Wipe engine shaft (23) clean and then cover with oil or grease so that rotating seal assembly parts (1, 2, and 3) (figure 7-21) may later be slipped on easily. Join engine housing and pump housing (25) using studs (22) and nuts (21).

(3). Reassemble Rotating Ring Seal. Slide rotating seal (3) (figure 7-21) onto engine shaft so that rotating seal carbon face is in contact with the stationary seal (4) ceramic face. Install spring (2) and spring holder (1). Hold seal ring assembly in place until impeller (17) (figure 7-20) is started on crankshaft threads.

e. Installation and Adjustment of Impeller.

(1). Turn the impeller (17) (figure 7-20) clockwise on the shaft (23) three or four complete revolutions.

(2). Push the impeller toward the engine. This will eliminate the affect on the adjustment of any end play of the crankshaft.

(3). Slowly rotate impeller (17) clockwise until a slight drag is felt between the housing (25) and impeller. Back off the impeller from this point 1/8 of a revolution.

(4). Install the impeller lockscrew (16) and lock it by striking the hex wrench with a mallet.

f. Reassemble Cover. Install gasket (15), and housing cover (14) on housing (25) using nuts (13).

g. Installation.

(1). Secure assembled pump and engine to mounting base (13) (figure 7-19) as shown in figure 2-9.

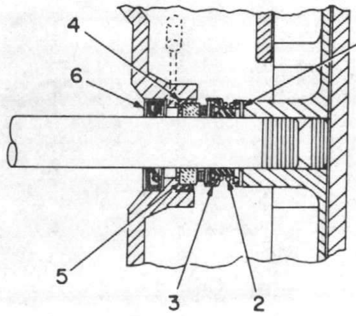
(2). Complete installation by reversing removal procedure 7-9. (b).

7-11. ENGINE MAINTENANCE.

a. General. When extensive repairs are necessary, remove the engine from the machinery section and separate from pump as described in paragraph 7-9. It is not necessary to remove the engine when performing tune-ups and other minor repairs.

b. Maintenance and Repairs. Refer to Wisconsin Motor Corporation Instruction Manual Issue MM-270-E, shipped with this equipment, for a complete description of repair and maintenance procedures.

1 Spring holder
2 Spring
3 Rotating seal
4 Stationary seal
5 Vibration ring
6 Oil seal



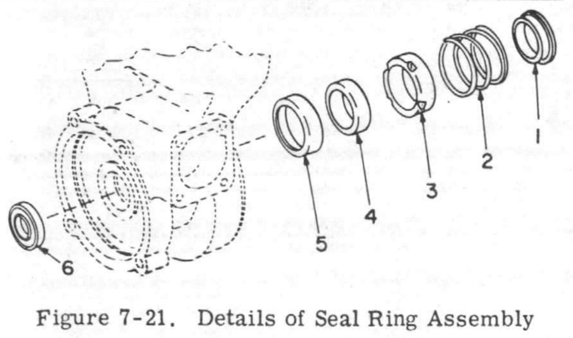


Figure 7-21. Details of Seal Ring Assembly

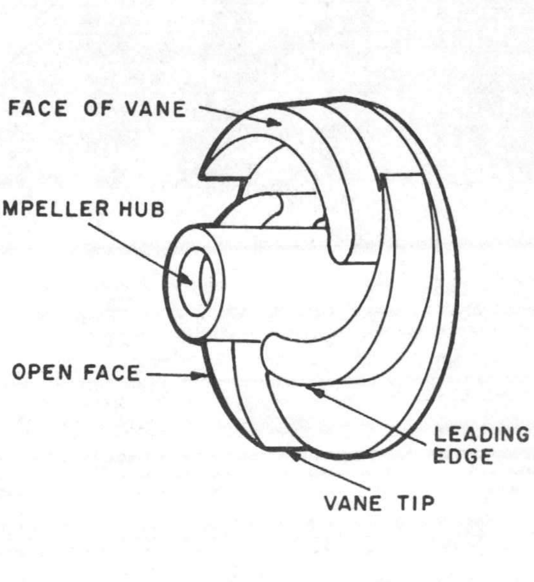


Figure 7-22. Pump Impeller Inspection

SECTION 8

PARTS CATALOG

8-1. INTRODUCTION.

a. General. This catalog lists and describes the parts for the 10-40 gpm, frame-mounted, diatomite type, water purification unit manufactured by Wallace & Tiernan Div. Pennwalt Corp., Belleville, New Jersey. Parts are listed in the Group Assembly Parts List (par. 8-2) according to functional groups and assemblies (See e. below). Parts are listed in the Numerical Parts List (par. 8-3) in alphabetical-numerical order.

b. Explanation of Columns of Group Assembly Parts List.

(1). Figure Number Column. The number of the illustration on which the part is shown in relation to adjoining parts is listed in the figure number column.

(2). Index Number Column. The number assigned the part on the illustration is listed in the index number column. Where no index number is given, the part listed is either an assembly of detail parts shown in the illustration, or is a part that is related to the assembly but is not illustrated.

(3). Part Number Column. The part number shown is the number assigned the part by the manufacturer listed in the manufacturer column. Parts can be obtained either from that manufacturer, or from Wallace & Tiernan

(4). Manufacturer Column. The prime manufacturer of the part is listed in the manufacturer column. To conserve space, the following codes are used to designate the manufacturers of parts used in the water purification unit:

MFR CODE	MANUFACTURER'S NAME AND ADDRESS
CK	Champion Spark Plug Co Toledo Ohio
CRF	Ralph B Carter Co Hackensack NJ
FAMO	Fairbanks Morse and Co Magneto Div Beloit Wis
MSC	Marvel-Schebler Carburetor Div Borg-Warner Corp Flint Mich
TMC	Tillotson Mfg Co Toledo Ohio
USC	United Specialties Co Chicago Ill
WIS	Wisconsin Motor Corp Milwaukee Wis
WT	Wallace & Tiernan Div. Pennwalt Corp. Belleville NJ

(5). Part Name Column. The name given the part by the manufacturer, and any clarifying modifiers, is shown in the part name column. If there is a discrepancy between the part name shown in the parts list, and the nomenclature given the part in the text, use the part name in the parts list when ordering the part.

(6). Number Required Column. The number of identical parts used in the assembly shown in the figure referenced is listed in the number required column.

c. Numerical Parts List. Parts are listed in the numerical parts list in alphabetical-numerical sequence. The listing of parts starts at the left-hand column with letters A-Z, then numbers 1-9. Second and succeeding position order is numbers 1-9, followed by letters A-Z. Whenever the number "0" appears in either first or second positions as the first number appearing in the part number, it is treated as an alphabetical "O" and listed accordingly. For reference, when a part number is known and it is desired to locate it in the assembly, refer to the numerical parts list. Opposite the part number will be found the figure No. and the page on which the part is listed in the Group Assembly Part List.

d. Ordering Parts. When ordering a part, give the part number, part name, the assembly it is used in, and the number desired. The model and serial number of the water purification unit should also be given to be sure of obtaining a satisfactory replacement part. Equipment furnished under this contract is painted color, Marine Corps Green No. 23. When ordering replacement parts for equipment furnished under this contract the order must definitely state the color desired, namely, Marine Corps Green No. 23.

e. Functional Group Index. Assemblies and functional groups are listed in the Group Assembly Parts List (par. 8-2) in the following order:

FUNCTIONAL GROUP INDEX

	Page
Water Purification Unit	8-3
Comparator and Accessories Assembly No. U20487	8-3
Comparator Housing Assembly No. U18935	8-3
Filter Section Assembly No. A694020	8-3
Filter Element Assembly No. U14990	8-5
Air Release Valve Assembly No. U14071	8-5
Flow Controller Assembly No. U15005	8-5
Machinery Section Assembly No. A695020	8-6
Restrictor Assembly No. U13412	8-8
Slurry Feeder Assembly No. A665013	8-8
Mixing and Valve Chamber Assembly No. U15680	8-8
Slurry Feeder Gear Box Assembly No. U13404	8-9
Hypochlorinator Assembly No. UXA15182	8-11
Sight Glass Assembly No. U13919	8-12
Pump and Engine Unit Assembly No. UXA21410	8-12
Carter Centrifugal Pump Model 8T-2	8-12
"O" Kit No. U21789	8-13
Strainer Assembly No. UI5047	8-13

8-2. GROUP ASSEMBLY PARTS LIST.

10

WATER PURIFICATION UNIT ASSEMBLY U22446

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
1-1	--	A694020	WT	Filter section assembly (See page 8-3). . . .	1
1-1	--	A695020	WT	Machinery section assembly (See page 8-6).	1
1-1	--	U20487	WT	Comparator and accessories (See page 8-3) . .	1
1-1	--	U22447	WT	Tools and Accessories (See page 8-3).	1
1-1	--	U22455	WT	Hose Suction.	6
1-1	--	U22456	WT	Hose Fire	3
1-1	--	P47631	WT	Wrench Spanner.	3

TOOLS AND ACCESSORIES

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
1-1	--	U15384	WT	Wrench, 15/16-inch socket, T-handle	1
--	--	U21791	WT	Allen Key set	1
1-1	--	U7787	WT	500 cc bottle of orthotolidine solution . . .	2
1-1	--	U7788	WT	500 cc bottle of bromthymol blue solution . .	2
1-1	--	A528092	WT	500 cc bottle of bromcresol purple-green solution.	2
1-1	--	U14996	WT	2-inch hose cap	1
1-1	--	U15047	WT	Strainer assembly, 2-inch suction hose (See page 8-13)	1
1-1	--	P31035	WT	"O" ring, filter element (spare).	7
1-1	--	WAAJ83459	WT	Instruction book.	2
1-1	--	P32486	WT	Cup, 5-ounce polyethylene	1
1-1	--	P32487	WT	Container, 2-quart polyethylene	1

COMPARATOR AND ACCESSORIES ASSEMBLY NO. U20487

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
2-12	--	U3160	WT	Prism	1
2-12	--	U3145	WT	Disc, indicator, bromthymol blue, 6.0-7.6 pH.	1
2-12	--	U8491	WT	Disc, indicator, bromcresol purple-green, 4.4-6.0 pH.	1
2-12	--	U11204	WT	Disc, indicator, orthotolidine, 0.1-5.0 ppm chlorine residual	1
2-12	--	U20490	WT	Case.	1
2-12	--	U8579	WT	Bottle, reagent dropping, pH.	2
2-12	--	U10597	WT	Bottle, reagent dropping, orthotolidine . . .	1
2-12	--	U18935	WT	Comparator housing assembly (See page 8-3). .	1
2-12	--	P7201	WT	Cell, sample.	4

COMPARATOR HOUSING ASSEMBLY NO. U18935 (Part of U20487)

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
7-2	2	P7215	WT	Screw, bakelite	4
7-2	3	P7212	WT	Cover, front.	1
7-2	5	P7211	WT	Body.	1
7-2	6	P7216	WT	Spring.	1
7-2	7	P7202	WT	Glass, milk	1
7-2	8	P7213	WT	Cover, back	1
7-2	9	PD701	WT	Screw, machine, No. 2-56x5/16 in. lg.	8

FILTER SECTION ASSEMBLY NO. A694020

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
7-3	--	U14071	WT	Air release valve assembly (See page 8-5) . .	1
7-3	1	UXA15000	WT	Shell, filter	1
7-3	2	P32344	WT	Tank, pre-coat . . .	1
7-3	3	P32345	WT	Gasket	1

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
				FILTER SECTION ASSEMBLY NO. A694020 (cont)	
7-3	4	P32358	WT	Nut, No. 5/8-18	2
7-3	5	P32363	WT	Identification plate, backwash instruction.	1
7-3	6	P30171	WT	Screw, No.5/8-18 x 6 in.long.	2
7-3	7	U15008	WT	Ring, clamping.	1
7-3	8	UXA15002	WT	Strip, window backing (long)	2
7-3	9	UXA15001	WT	Strip, window backing (short)	2
7-3	10	PXA33204	WT	Gasket, window (inside)	1
7-3	11	PXA32382	WT	Window.	1
7-3	12	PXA32366	WT	Gasket, window (outside).	1
7-3	13	P32357	WT	Screw, clamp, No.5/16-18	4
7-3	14	PC2475	WT	Washer,5/16 in. brass	4
7-3	15	R30837	WT	Clamp	4
7-3	16	PC2246	WT	Pin,cotter, 3/32x3/4 in.long.	4
7-3	17	P32346	WT	Spring,clamp.	4
7-3	18	PN886	WT	Nut,hex,No. 1/4-20.	16
7-3	19	U13442	WT	Gauge,pressure, 60 lb.	1
7-3	20	P695	WT	Tee,1/4in. NPT brass	1
7-3	21	P629	WT	Nipple, 1/4 in. NPT close	1
7-3	22	U20980	WT	Valve, 1/4 in. NPT angle	1
7-3	23	PC3312	WT	Nipple,1/2in. hose connection	1
7-3	24	P32360	WT	Identification plate, air bleed valve . . .	1
7-3	25	P32361	WT	Identification plate, air release valve . .	1
7-3	26	P33588	WT	Screw,drive,identification plate,No.0x3/16in.lg	8
7-4	--	U14990	WT	Filter element assembly (See page 8-5) . .	7
7-4	--	U15005	WT	Flow controller assembly (See page 8-5) . .	1
7-4	1	U14999	WT	Base, filter	1
7-4	2	U13442	WT	Gauge,pressure, 601b.	1
7-4	3	U608	WT	Valve, globe, 1/4 in. NPT	1
7-4	4	PC3312	WT	Nipple, 1/2 in. hose connection	1
7-4	5	P32351	WT	Elbow, reducing, 2-1/2x2in. NPT.	1
7-4	6	P15402	WT	Nipple, 2in. NPT x 2-1/2in. lg	1
7-4	7	U15677	WT	Valve,drain,quick action, 2in. NPT	1
7-4	8	P15425	WT	Nipple,hose, 2 in. NPT x 2in.lg	1
7-4	9	U15003	WT	Handle, wrench	1
7-4	10	P32350	WT	Pin, handle	1
7-4	11	PC2246	WT	Pin,cotter, 3/32 x 3/4in. long	2
7-4	12	P32365	WT	Wrench	1
7-4	13	P6122	WT	Nipple, 2 in. NPT close	1
7-4	14	U15033	WT	Valve, plug cock, 3-way, 2in.	1
7-4	15	U15006	WT	Nipple, orifice	1
7-4	16	U15698	WT	Valve, inlet, 2 in. NPT angle	1
7-4	17	U9421	WT	Coupling, 2in. hose x 2in. NPT . .	1
7-4	18	U15009	WT	Brace, filter element	1
7-4	19	P16509	WT	Lockwasher, 3/8 in.	7
7-4	20	P18644	WT	Nut, No. 3/8-16	7
7-4	21	P32388	WT	Bracket, handle	1
7-4	22	PC2844	WT	Screw, machine,No. 1/4-20x1-3/4in. long . .	2
7-4	23	PC1089	WT	Washer, 1/4in.	2
7-4	24	PC6337	WT	Lockwasher, 1/4 in.	2
7-4	25	PN886	WT	Nut, No. 1/4-20	2
7-4	26	P629	WT	Nipple, 1/4in. NPT close.	1
7-4	27	P33574	WT	Bracket, identification plate,drain valve .	1
7-4	28	P33575	WT	Identification plate,drain valve.	1
7-4	29	P33588	WT	Screw,drive,identification plate,No.0x3/16in.lg	6
7-4	30	P33572	WT	Handle, drain valve	1

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
				FILTER SECTION ASSEMBLY NO. A694020 (cont)	
7-4	31	P32362	WT	Identification plate, filter outlet	1
7-4	32	P32359	WT	Instruction plate, inlet valve.	1
7-4	33	P994	WT	Plug, 3/8 in. NPT	1
				FILTER ELEMENT ASSEMBLY NO. U14990 (Part of A694020)	
7-5	1	P32330	WT	Nut	1
7-5	2	P32316	WT	Dome	1
7-5	3	P32319	WT	Spacer, tube-top	1
7-5	4	P32320	WT	Sleeve, plastic	1
7-5	5	U14989	WT	Perforated tube assembly, stainless steel .	1
7-5	6	P32321	WT	Cup, plastic	12
7-5	7	P32317	WT	Tie rod	1
7-5	8	P32318	WT	Spacer, tube-bottom	1
7-5	9	P32315	WT	Base,septum,filter element	1
7-5	10	P31035	WT	"O" ring	1
				AIR RELEASE VALVE ASSEMBLY NO. U14071 (Part of A694020)	
7-6	1	PC10946	WT	Nut, No. 1/4-20	1
7-6	2	P30478	WT	Handle, release	1
7-6	3	P14636	WT	Lockwasher, 1/2 in.	2
7-6	4	P30475	WT	Screw, pivot	2
7-6	5	P30469	WT	Shaft, eccentric	1
7-6	6	P30479	WT	Body.	1
7-6	7	P30175	WT	Nut, elastic stop, No. 3/8-24	1
7-6	8	P32354	WT	Disc.	2
7-6	9	P30474	WT	Spacer	2
7-6	10	P30472	WT	Stem	1
7-6	11	P30471	WT	Disc, rubber	1
7-6	12	P30470	WT	Ring, clip	1
7-6	13	P30476	WT	Spring	1
7-6	14	P30473	WT	Gasket	1
7-6	15	P30477	WT	Base.	1
7-6	16	P16509	WT	Lockwasher, 3/8 in.	6
7-6	17	PC9606	WT	Screw,cap, No.3/8-16x1-1/4 in.lg	6
7-6	18	P30468	WT	Roller.	1
7-6	19	P11149	WT	Spacer	4
				ADJUSTABLE FLOW CONTROL VALVE ASSEMBLY NO. U15005 (Part of A694020)	
7-7	1	P30672	WT	Cover	1
7-7	2	P30671	WT	Plate, backing	2
7-7	3	P30669	WT	Diaphragm	1
7-7	4	U14178	WT	Seat, spring	1
7-7	5	P30674	WT	Spring.	1
7-7	6	U14179	WT	Orifice	1
7-7	7	U14180	WT	Gate.	1
7-7	8	UC648	WT	Petcock	2
7-7	9	U15004	WT	Body	1
7-7	10	P538	WT	Packing,asbestos cord, as required	--
7-7	11	P11516	WT	Gland, packing.	1

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
				FLOW CONTROLLER ASSEMBLY NO. U15005 (Pait of A694020 (cont)	
7-7	12	P11518	WT	Spring.	1
7-7	13	PXC12556	WT	Pointer	1
7-7	14	PXD12555	WT	Knob	1
7-7	15	PC12557	WT	Nut	1
7-7	16	PC17854	WT	Screw,set,No. 1/4-20 x 1/4 in.lg	1
7-7	17	PC288	WT	Plug, 1/8 in. pipe	1
7-7	18	PC3689	WT	Screw, drive	4
7-7	19	P32485	WT	Dial and name plate	1
7-7	20	U14177	WT	Disc, valve	1
7-7	21	P30670	WT	Pin, guide	2
7-7	22	P8863	WT	Nut, elastic stop, No. 10-32	2
7-7	23	P15363	WT	Lockwasher, 5/16 in.	8
7-7	24	PC9508	WT	Screw,machine,No. 5/16-18 x 1 in. lg . . .	8
7-7	25	PC288	WT	Plug, 1/8 in. pipe	2
				MACHINERY SECTION ASSEMBLY NO. A695020	
7-18	1	PC8864	WT	Nut, elastic stop, No. 1/4-20	4
7-18	1	PC1089	WT	Washer, 1/4 in.	4
7-18	1	PC34088	WT	Screw,cap, 1/4-20 x 3/4 in. lg	4
7-18	2	U15018	WT	Reservoir, hypochloriet	1
7-18	2	P33183	WT	Cover, reservoir, hypochlorite	1
7-18	2	U11856	WT	Strainer, hypochlorite	1
7-18	2	P17500	WT	Hose,rubber,3/8ID-5/8 OD x 16in. lg (hypochlorite strainer to sight glass). .	1
7-18	3	U13919	WT	Sight glass assembly (see page 8-12) . . .	1
7-18	4	PC8863	WT	Nut, elastic stop, No. 10-32	2
7-18	4	PC5663	WT	Washer, flat, No. 10	2
7-18	4	PC20607	WT	Screw,machine,No. 10-32 x 1-5/8 in. lg . .	2
7-18	5	RP52-4534	WT	Tube,drain, PVC, 1/2 ID-1/8 wall x 22 in. lg 1/2 in. ID, 3/4 in. OD, 22 in. lg . .	1
7-18	6	P32396	WT	Clamp, drain tube	1
7-18	7	U14229	WT	Slurry tank and cover	1
7-18	7	U13632	WT	Strainer, slurry tank	1
7-18	8	U10118	WT	Clamp, hose, 3/8 in.	4
7-18	9	U13412	WT	Restrictor assembly (see page 8-8	1
7-18	10	U3758	WT	Connection to main	1
7-18	11	P15425	WT	Adapter, 2 in. NPT to 2 in. hose	1
7-18	12	PC698	WT	Elbow, street, 1/4 in.	2
7-18	12	PC3312	WT	Connector, hose, 1/2 in.	2
7-18	13	U10119	WT	Clamp, hose, 1/2 in.	2
7-18	14	UXA21410	WT	Pump and engine unit assembly (see page 8-12)	1
7-18	15	U608	WT	Valve, globe, 1/4in.	1
7-18	15	PC629	WT	Nipple, close, 1/4 in.	1
7-18	15	PC3312	WT	Connector, hose, 1/2 in.	1
7-18	15	U10119	WT	Clamp, hose, 1/2 in.	1
7-18	16	P17723	WT	Nipple, 2 in. x 4 in. lg	1
7-18	17	P36490	WT	Guard, pulley	1
7-18	18	P23136	WT	Screw,sheet metal,No.14 x 1/2 in. lg	4
7-18	18	PC657	WT	Washer,brass, 5/8 in. ODx0.280 in. ID	4
7-18	19	UXA15022	WT	Box, tool	1
7-18	20	P47808	WT	Instruction plate, flow diagram	1
7-18	21	PC3542	WT	Screw,machine bolt, No. 4-36x1/4 in. lg . .	2
7-18	21	PC3638	WT	Nut, No. 4-36	2
7-18	21	PC5662	WT	Washer, flat, No. 4	2
7-18	21	PC17244	WT	Lockwasher, No. 4	2
7-18	22	PC16533	WT	Screw,cap,1/4-20 x 5/8 in. lg	2
7-18	22	PC886	WT	Nut, 1/4-20	2
7-18	22	PC1089	WT	Washer, 1/4 in.	2
7-18	22	PC6337	WT	Lockwasher, 1/4 in.	2
7-18	23	PA7574	WT	Identification plate	1
7-18	24	P35628	WT	Rivet,brass,identification plate,3/16x1/4in.lg	4
7-18	25	U15019	WT	Chassis (frame)	1
7-18	26	U13504	WT	Valve,plug cock,3-way 2-position, 2 in. . .	1

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
				MACHINERY SECTION ASSEMBLY NO. A695020 (cont)	
7-18	27	U9421	WT	Union, brass, 2 in. NPT x 2 in. hose swivel connection	2
7-18	28	P17500	WT	Hose, rubber, 3/8 ID-5/8 OD x 24 in. lg (hypochlorite feeder outlet to restrictor)	1
7-18	29	P17500	WT	Hose, rubber, 3/8 ID-5/8 OD x 30 in.lg (sight glass to hypochlorite feeder inlet) . . .	1
7-18	30	P5176	WT	Hose,utility,rubber, 1/2 ID-31/32 OD x48in.lg	1
7-18	31	PC16533	WT	Screw,cap,1/4-20x5/8in.lg	3
7-18	31	PC886	WT	Nut, 1/4-20	3
7-18	31	PC1089	WT	Washer, 1/4 in.	3
7-18	31	PC6337	WT	Lockwasher, 1/4 in.	3
7-18	32	E574	WT	Tape,plastic electrical, 3/4x12in.	1
7-18	33	P33181	WT	Clip	2
7-18	33	PC34088	WT	Screw,cap, 1/4-20x3/4 in. lg	2
7-18	33	PC8864	WT	Nut,elastic stop, 1/4-20	2
7-18	34	P33182	WT	Knob, locking	2
7-18	34	P33184	WT	Washer, spring	4
7-18	34	PC2844	WT	Screw,cap, 1/4-20x1-3/4 in. lg	2
7-18	34	PC8864	WT	Nut,elastic stop, 1/4-20	2
7-18	35	U10118	WT	Clamp,hose, 3/8 in.	1
7-18	36	P32397	WT	Nipple, adapter	1
7-18	37	PC16533	WT	Screw,cap,1/4-20x5/8 in. lg	1
7-18	37	PC886	WT	Nut, 1/4-20	1
7-18	37	PC1089	WT	Washer, 1/4in.	1
7-18	37	PC6337	WT	Lockwasher, 1/4 in.	1
7-18	38	P21012	WT	Nipple, 2 NPT x 12 in. lg	1
7-18	39	UXA15182	WT	Hypochlorinator feeder assembly(see Pg8-11)	1
7-18	40	PC855	WT	Screw,cap, 1/2-13x1-1/4 in.lg	2
7-18	40	PC889	WT	Nut, 1/2-13	2
7-18	40	PC12230	WT	Lockwasher, 1/2 in.	2
7-18	41	U13444	WT	Coupling	1
7-18	42	P5176	WT	Hose,rubber,1/2 ID-31/32 ODx30 in. lg (Slurry feeder to restrictor)	2
7-18	43	U10119	WT	Clamp,hose, 1/2 in.	2
7-18	44	A665013	WT	Slurry feeder assembly.(see pg 8-8)	1
7-18	45	PC2758	WT	Screw,cap, 3/8-16x1-1/4in.lg	3
7-18	45	PC888	WT	Nut, 3/8-16	5
7-18	45	PC1090	WT	Washer, 3/8 in.	3
7-18	45	PC8334	WT	Lockwasher, 3/8 in.	5
7-18	46	P29371	WT	Hose sleeve,slurry feeder inlet	1
7-18	47	U14417	WT	Clamp,hose sleeve,slurry feeder inlet . . .	2
7-18	48	P47807	WT	U-Bolt	1
7-19	1	P29372	WT	Sheave	1
7-19	2	2S-308-C	CRF	Pulley and sheave,special starting	1
7-19	3	P36691	WT	Belt, "V"	1
7-19	4	U13446	WT	Pulley assembly, tension	1
7-19	5	P29364	WT	Spacer	1
7-19	6	PC6171	WT	Screw, 3/8-16 x 1-3/4 in. lg	1
7-19	6	PC888	WT	Nut, 3/8-16	1
7-19	7	PC4731	WT	Pin,cotter, 3/32 x 1 in.	2
7-19	8	U15014	WT	Arm, idler	1
7-19	9	P30849	WT	Spring, torsion	1
7-19	10	PC873	WT	Screw, cap, 5/16-18 x 3/4 in. lg	8
7-19	10	PC887	WT	Nut, 5/16-18	8
7-19	10	PC4763	WT	Lockwasher, 5/16 in.	8
7-19	11	U13471	WT	Mount,engine and pump	4
7-19	12	PC33975	WT	Screw,cap, 3/8-16 x 2-1/4 in. lg	4
7-19	12	PC17308	WT	Nut, elastic stop, 3/8-16	4
7-19	12	PC1090	WT	Washer, 3/8 in.	4

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
				MACHINERY SECTION ASSEMBLY NO. A695020 (cont)	
7-19	13	P45509	WT	Base, mounting, pump and engine	1
1-1	--	U15020	WT	Cover, canvas, machinery section	1
				RESTRICTOR ASSEMBLY NO. U13412 (Part of A695020)	
7-14	1	P14847	WT	Plug, 1-1/2 in. pipe	1
7-14	2	P29374	WT	Body, inlet	1
7-14	3	P29377	WT	Bushing orifice	1
7-14	4	P29388	WT	Plate, check	1
7-14	5	P29400	WT	Gasket	1
7-14	6	P29387	WT	Weight	1
7-14	7	P29386	WT	Body, outlet	1
7-14	8	PC2758	WT	Screw, cap, No. 3/8-16 x 1-1/4 in. lg	2
7-14	9	PC6107	WT	Screw, cap, No. 3/8-16 x 2-1/4 in. lg	2
7-14	10	PC5663	WT	Washer, flat, No. 10	3
7-14	11	PC746	WT	Screw, No. 10-32 x 3/8 in. lg	3
				SLURRY FEEDER ASSEMBLY NO. A665013 (Part of A695020)	
7-9	--	U15680	WT	Mixing and valve chamber assembly (see page 8-8) .	1
7-9	--	U13404	WT	Slurry feeder gear box assembly (see page 8-9) . . .	1
7-9	1	PC8427	WT	Screw, cap, No. 5/16-18 x 3/4 in. lg	3
7-9	2	P15363	WT	Lockwasher. 5/16 in.	3
7-9	3	RP52-4464	WT	Tube, PVC, translucent, 1/4 ID-1/16 wall x6-1/2 in. lg	1
7-9	4	P29324	WT	Shaft, diaphragm lever	1
7-9	5	U14081	WT	Lever, diaphragm	1
7-9	6	P29348	WT	Screw, adjusting	1
7-9	7	P3905	WT	Nut, No. 1/2-20	1
7-9	8	PC5804	WT	Screw, Allen set, No. 1/4-20 in. lg	2
7-9	--	P12053	WT	Tag, oil	1
				MIXING AND VALVE CHAMBER ASSEMBLY NO. U15680 (Part of A665013)	
7-10	1	PC3312	WT	Nipple, 1/2 in. hose	2
7-10	2	PC27373	WT	Plug, 3/8 in. pipe, flush type	2
7-10	3	PC34365	WT	Plug, 1/8 in. pipe	2
7-10	4	U13607	WT	Push rod assembly	1
7-10	5	P29319	WT	Seat, spring	1
7-10	6	P20222	WT	Pin, 3/32 in. dia. x 1/4 in. lg	1
7-10	7	P24697	WT	Spring	1
7-10	8	P29323	WT	Seat, spring	1
7-10	9	P29316	WT	Cap, diaphragm	1
7-10	10	P22295	WT	Bearing	1
7-10	11	PC11559	WT	Screw, machine, No. 1/4-20 x 5/8 in. lg	4
7-10	12	P14635	WT	Lockwasher, 1/4 in.	4
7-10	13	P29320	WT	Cam, feed	1
7-10	14	P29579	WT	Scale	1
7-10	15	P30319	WT	Screw, shoulder	1
7-10	16	P21596	WT	Handle, screw, groove pin, 1/4 x 1-1/2 in. lg . . .	1
7-10	17	PC6113	WT	Screw, machine, No. 4-36 x 3/16 in. lg	2

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
				MIXING AND VALVE CHAMBER ASSEMBLY NO. U15680 (Part of A665013) (cont)	
7-10	18	P30318	WT	Pin, scale	1
7-10	19	FP5407	WT	Pin, monel, 3/32 in. dia x 11/16 in. lg	1
7-10	20	U13403	WT	Diaphragm	1
7-10	21	P31191	WT	Gasket, diaphragm backing	1
7-11	1	U15812	WT	Chamber, valve	1
7-11	2	PC288	WT	Plug, 1/8 in. pipe	1
7-11	3	P29309	WT	Washer, backing	6
7-11	4	P29310	WT	Washer, sealing	6
7-11	5	P29307	WT	Push rod, valve plug	3
7-11	6	P29308	WT	Pin, swivel	3
7-11	7	P33764	WT	Spring	3
7-11	8	P33567	WT	Plate, clamping	3
7-11	9	PC3774	WT	Screw, machine, No. 8-32 x 3/8 in. lg	6
7-11	10	PC697	WT	Elbow, 1/8 in. street	1
7-11	11	PC500	WT	Nipple, 1/4 in. hose	1
7-11	12	P26822	WT	"O" ring, 3/4 in. x 1 in.	1
7-11	13	SP42	WT	Vent, Thomas	1
7-11	14	P29326	WT	Adapter, Thomas vent	1
7-11	15	P29306	WT	Plug, valve	3
7-11	16	PC12262	WT	Plug, 3/4 in. pipe	1
7-11	17	P26482	WT	"O" ring, 1/2 in. x 3/8 in.	3
7-11	18	P29313	WT	Seat, valve	3
7-11	19	P33569	WT	Washer, screw retaining	6
7-11	20	P29304	WT	Spring, inner	6
7-11	21	P33584	WT	Plate, clamping	3
7-11	22	P13662	WT	Lockwasher, No. 6	6
7-11	23	PC16058	WT	Screw, machine, No. 6-32 x 3/8 in. lg	6
7-11	24	P33566	WT	Gasket	1
7-11	25	P33565	WT	Window	1
7-11	26	P33521	WT	Frame, window	1
7-11	27	P14635	WT	Lockwasher, 1/4 in.	8
7-11	28	PC14289	WT	Screw, machine, No. 1/4-20 x 3/4 in. lg	6
7-11	29	PC16105	WT	Screw, machine, No. 1/4-20 x 1-1/4 in. lg	2
				SLURRY FEEDER GEAR BOX ASSEMBLY NO. U13404 (Part of A665013)	
7-12	1	P29594	WT	Gasket	1
7-12	2	U13994	WT	Lever, compressor diaphragm	1
7-12	3	P29330	WT	Shaft, drive	1
7-12	4	P30339	WT	Pin, 1/8 in. dia. x 1-1/8 in. lg	1
7-12	5	P30325	WT	Retainer, bearing	1
7-12	6	P13619	WT	Lockwasher, No. 10	16
7-12	7	PC18546	WT	Screw, No. 10-32 x 3/4 in.	4
7-12	8	P27238	WT	Seal, oil	3
7-12	9	P39952	WT	"O" ring, 1-3/8 in. ID x 1-5/8 in. OD	3
7-12	10	PC12668	WT	Locknut	1
7-12	11	P12667	WT	Lockwasher	1
7-12	12	U5889	WT	Bearing, ball	2
7-12	13	P29331	WT	Cam, compressor	1
7-12	14	P30343	WT	"O" ring, 3/16 in. ID x 5/16 in. OD	2
7-12	15	PC17854	WT	Screw, Allen set, No. 1/4-20 x 1/4 in. lg	2
7-12	16	P30340	WT	Pin, guide	2
7-12	17	U13996	WT	Yoke assembly	1
7-12	18	U13985	WT	Lever, cam follower (flushing water)	2
7-12	19	P26234	WT	"O" ring, 5/16 in. ID x 7/16 in. OD	2
7-12	20	P29276	WT	Bushing, 5/16 in. ID x 7/16 in. OD x 3/4 in. lg	2
7-12	21	U13986	WT	Lever, cam follower (slurry)	1

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
				SLURRY FEEDER GEAR BOX ASSEMBLY NO. U13404 (Part of A665013) (cont)	
7-12	22	P29334	WT	Gear, worm	1
7-12	23	P29332	WT	Bar, bearing	1
7-12	24	U3840	WT	Bearing, ball	2
7-12	25	PC8864	WT	Nut, elastic stop, No. 1/4-20	1
7-12	26	P29328	WT	Gasket	1
7-12	27	PC634	WT	Plug, 1/2 in. pipe	1
7-12	28	P29329	WT	Cover	1
7-12	29	P14635	WT	Lockwasher, 1/4 in.	7
7-12	30	PC14289	WT	Screw, machine, No. 1/4-20 x 3/4 in. lg	7
7-12	31	PC5594	WT	Screw, machine, No. 5/16-18 x 3/4 in. lg	2
7-12	32	P15363	WT	Lockwasher, 5/16 in.	2
7-12	33	PC29546	WT	Screw, No. 10-32 x 1/4 in. lg	2
7-12	34	P21160	WT	Locknut	1
7-12	35	P21159	WT	Lockwasher	1
7-12	36	P29335	WT	Cam, diaphragm	1
7-12	37	P30320	WT	Spacer	1
7-12	38	P30321	WT	Cam (slurry)	1
7-12	39	P30322	WT	Cam (flushing water)	1
7-12	40	P29333	WT	Shaft, cam	1
7-12	41	P30323	WT	Key	1
7-12	42	P11008	WT	Pin, groove, 1/8 in. dia x 3/4 in. lg	2
7-12	43	P29327	WT	Box, gear	1
7-12	44	PC18224	WT	Plug, 1/8 in. pipe	1
7-12	45	P30327	WT	Cap, bearing	1
7-12	46	P29273	WT	Bushing, 5/16 x 7/16 x 3/8 in.	1
7-12	47	P21415	WT	Pin, dowel, 1/4 in. dia x 1-1/4 in. lg	1
7-12	48	PC999	WT	Screw, machine, No. 10-32 x 1/2 in. lg	8
7-12	49	P30326	WT	Cap, oil seal	1
7-12	50	P29345	WT	Arm, trip (short-slurry feed)	1
7-12	51	P30324	WT	Arm, trip (long-flushing water)	1
7-12	52	P21775	WT	Screw, No. 10-32 x 3/4 in.	4
7-12	53	P29360	WT	Bushing, 5/8 in. ID x 7/8 in. OD x 1 in. lg	2
7-12	--	------	WT	Air compressor (part of U13404, not available as an assembly, parts listed below)	--
7-13	1	PC15361	WT	Screw, No. 6-32 x 3/16 in	4
7-13	2	PC6456	WT	Washer, flat, No. 6	4
7-13	3	U13988	WT	Cage, valve	2
7-13	4	P29593	WT	Gasket, valve	2
7-13	5	P30337	WT	Body, air compressor	1
7-13	6	P29575	WT	Spring	1
7-13	7	P14635	WT	Lockwasher	3
7-13	8	PC7778	WT	Screw, No. 1/4-20 x 1/2 in. lg	3
7-13	9	P30338	WT	Cup, spring	1
7-13	10	PC15340	WT	Screw, machine, No. 5/16-18 x 1/2 in.	1
7-13	11	P15363	WT	Lockwasher	3
7-13	12	PC2475	WT	Washer, flat, 5/16 in.	1
7-13	13	PC872	WT	Screw, cap, No. 5/16-18 x 5/8 in. lg	2
7-13	14	U13987	WT	Diaphragm	1
7-13	15	P29351	WT	Cap, pump	1
7-13	16	PC500	WT	Nipple, 1/4 in. hose	1
7-13	17	P29586	WT	Disc, inner	1
7-13	18	P13619	WT	Lockwasher	6
7-13	19	PC23986	WT	Screw, No. 10-32 x 1 in. lg	2
7-13	20	PC6224	WT	Screw, No. 8-32 x 1/4 in. lg	3
7-13	21	P12850	WT	Lockwasher, No. 8	3
7-13	22	PC9581	WT	Washer, No. 8	3
7-13	23	P29355	WT	Disc, outer	1
7-13	24	P29354	WT	Strainer, felt	1
7-13	25	PC10945	WT	Screw, machine, No. 10-32 x 5/8 in. lg	4

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
				HYPOCHLORINATOR ASSEMBLY NO. UXA15182 (Part of A695020)	
7-15	1	P15178	WT	Handle, stroke control	1
7-15	2	PC5338	WT	Screw, machine, No. 8-32 x 1/4 in. lg	2
7-15	3	P14589	WT	Cover, dial	1
7-15	4	P15188	WT	Screw, idler gear	1
7-15	5	U15179	WT	Idler gear assembly	1
7-15	6	P15171	WT	Stud, idler gear	1
7-15	7	P32696	WT	Shaft, stroke adjusting	1
7-15	8	U14206	WT	Housing	1
7-15	9	P14675	WT	Block, pivot	1
7-15	10	P15179	WT	Arm, actuating	1
7-15	11	P15186	WT	Rod, push	1
7-15	12	P14689	WT	Retainer, spring	2
7-15	13	P15386	WT	Spring	1
7-15	14	U4928	WT	Bearing	1
7-15	15	P14657	WT	Bushing, pump shaft	1
7-15	16	PXA12599	WT	Stud	4
7-15	17	UXA5886	WT	Diaphragm	1
7-15	18	PXB12601	WT	Gasket	4
7-15	19	P12600	WT	Seat, valve	2
7-15	20	PXA12638	WT	Poppet, valve	2
7-15	21	U5334	WT	Valve seat guide assembly	2
7-15	22	P11020	WT	Pin, groove, 1/4 in. dia. x 2 in. lg	1
7-15	23	PXA12598	WT	Screw, clamping	1
7-15	24	PXA12585	WT	Yoke, clamping	1
7-15	25	P12582	WT	Body, pump, hard rubber	1
7-15	26	PXE12583	WT	Clamping disc	1
7-15	27	PXA12584	WT	Plate, end, clamping	1
7-15	28	PC2247	WT	Washer	4
7-15	29	PC6145	WT	Nut, No. 3/8-16	4
7-15	30	P11901	WT	Pin groove, 3/8 in. dia. x 4 in. lg	1
7-15	31	PXA11890	WT	Screw, body clamping	1
7-15	32	P12587	WT	Plug, priming	1
7-15	33	P12588	WT	Gasket	1
7-15	34	P12592	WT	Tube, air vent	1
7-15	35	P15164	WT	Retainer, bearing, drive worm shaft	1
7-15	36	U5888	WT	Seal, oil	2
7-15	37	U3840	WT	Bearing	2
7-15	38	P11004	WT	Pin, groove, 3/32 in. dia x 3/4 in. lg	2
7-15	39	P14692	WT	Gear, worm	1
7-15	40	P14661	WT	Pin, cam, 3/32 in. dia x 1-5/32 in. lg	1
7-15	41	P15165	WT	Bar, cross	1
7-15	42	P14684	WT	Gasket, cover	1
7-15	43	PC634	WT	Plug, 1/2 in. pipe	1
7-15	44	PC2509	WT	Screw, machine, No. 1/4-20 x 1 in. lg	9
7-15	45	P11008	WT	Pin, groove, 1/8 in. dia x 3/4 in. lg	2
7-15	46	PC10381	WT	Screw, machine, No. 1/2-20 x 3/4 in. lg	2
7-15	47	P14670	WT	Shaft, cam	1
7-15	48	P32697	WT	Cam	1
7-15	49	P18224	WT	Plug, 1/4 in.	1
7-15	50	P15163	WT	Retainer, cam shaft bearing	1
7-15	51	P28524	WT	Shaft, worm, drive	1
7-15	52	P15180	WT	Pin, fulcrum	2
7-15	53	P15182	WT	Washer	2
7-15	54	U3843	WT	Bearing	1
7-15	55	P15184	WT	Roller shaft	1
7-15	56	P14671	WT	Spacer	2
7-15	57	P9877	WT	Screw, set, No. 10-32 x 1/4 in. lg	1
7-15	58	P15183	WT	Roller, fulcrum	1
7-15	59	P32698	WT	Bracket, roller, fulcrum	1

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.

HYPOCHLORINATOR ASSEMBLY NO. UXA15182 (Part of A695020) (cont)

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
7-15	60	P15187	WT	Pin, stop	1
7-15	61	U5889	WT	Bearing	1
7-15	62	P15289	WT	Gasket	1
7-15	63	PC743	WT	Screw, machine, No. 8-32 x 3/8 in. lg	3
7-15	64	P15290	WT	Retainer, seal	1
7-15	65	PC9508	WT	Screw, machine, No. 5/16-18 x 1 in. lg	2
7-15	66	P32699	WT	Block, bearing	1
7-15	67	P18092	WT	Pad, friction	1
7-15	68	P18091	WHT	Spring, friction	1
7-15	69	P14666	WT	Bushing, adjusting rod	1
7-15	70	P11012	WT	Pin, groove, 3/32 in. dia x 1/2 in. lg	1
7-15	71	P32685	WT	Pinion, adjusting shaft	1
7-15	72	U15178	WT	Dial	1
7-15	73	P27650	WT	Decal, arrow	1
7-15	74	P5781	WT	Nameplate	1
7-15	--	P12053	WT	Tag oil	1

SIGHT GLASS ASSEMBLY NO. U13919 (Part of A695020)

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
7-17	1	P30144	WT	Block, mounting	1
7-17	2	P5536	WT	Gasket	2
7-17	3	P30140	WT	Glass	1
7-17	4	P30143	WT	Connection, 3/8 in. hose	1
7-17	5	P30141	WT	Plate, clamping	1
7-17	6	PC8863	WT	Nut, elastic stop, No. 10-32	2
7-17	7	PC5663	WT	Washer, flat, No. 10	4
7-17	8	P30142	WT	Rod, tie	2
7-17	9	P16590	WT	Nipple, 3/8 in. hose	1
7-17	10	PC16558	WT	Nut, acorn, No. 10-32	2

PUMP AND ENGINE UNIT ASSEMBLY NO. UXA21410 (Part of A695020)

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
2-9	--	ACND	WIS	Engine, 1 cylinder, air cooled (Refer to Wisconsin Issue MM-270-E Instruction Book and Parts List Manual for complete engine breakdown)	1
2-9	--	8T-2	CRF	Pump, centrifugal (see page 8-12)	1
2-9	--	2S-308-C	CRF	Pulley and sheave, special starting	1
2-9	--	2S-432	CRF	Bracket, gas tank	1
2-9	--	2S-433	CRF	Bracket, guy, gas tank	1
2-9	--	2S-434	CRF	Spacer, bracket, gas tank	1
2-9	--	XK-2A	WIS	Drain plug, magnetic, engine crankcase	1
2-9	--	2S-435	CRF	Fuel line	1
2-9	--	XK-73	WIS	Elbow, street, 2 in. NPT (muffler mounting)	1

CARTER CENTRIFUGAL PUMP MODEL 8T-2 (Part of UXA21410)

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
7-20	3	------	CRF	Drain plug, 1/4 in. IPT	1
7-20	4	------	CRF	Elbow, street, 2 in. NPT	1
7-20	5	------	CRF	Nut, hex, steel, No. 5/16-18	4
7-20	6	2S-293	CRF	Suction fitting	1
7-20	7	------	CRF	Stud, steel, 5/16-18 x 1-1/4 in. lg	4
7-20	8	2S-296	CRF	Flapper, check valve	1
7-20	9	------	CRF	Nut, No. 1/4-20	1
7-20	10	2S-154	CRF	Weight, check valve	1

Figure No.	Index No.	Part No.	Mfr.	Part Name	No. Reqd.
				CARTER CENTRIFUGAL PUMP MODEL 8T-2 (Part of UXA21410) (cont)	
7-20	11	2S-108	CRF	Washer, check valve	1
7-20	12	------	CRF	Screw, machine, 1/4-20 x 1 in. lg	1
7-20	13	------	CRF	Nut, hex, steel, No. 5/16-18	6
7-20	14	2S-291	CRF	Cover, pump housing (volute)	1
7-20	15	2S-292	CRF	Gasket, volute	1
7-20	16	2S-318	CRF	Lockscrew, impeller	1
7-20	17	2S-294	CRF	Impeller	1
7-20	18	------	CRF	Stud, steel, 5/16-18 x 1 in. lg	6
7-20	19	2S-5119	CRF	Seal ring assembly	1
7-20	20	1S-101	CRF	Cup, oil	1
7-20	21	------	CRF	Nut, hex, steel, No. 7/16-14	4
7-20	22	------	CRF	Stud, steel, 7/16-14 x 2-3/4 in. lg	4
7-20	24	2S-297	CRF	Seal, oil	1
7-20	25	2S-290	CRF	Housing (volute)	1
7-20	26	------	CRF	Plug, 2 in. IPT	1
				"O" KIT NO. U21789 (Part of A695020)	
7-21	--	U21783	WT	Packing set, pump (consists of one each of CRF PN 2S-5119, 2S-292, and 2S-296)	1
--	--	U21784	WT	Coil, magneto (WIS PN S-2477C)	1
--	--	U21785	WT	Condenser (WIS PN AX-M-R2433)	1
--	--	U21786	WT	Breaker arm, support bracket and points (WIS PN A-2437A)	1
2-11	1	U21787	WT	Spark plug (2 supplied in Kit No. U21789) (WIS PN YD-6-S1; Champion PN D-16-J; A.C. PN C86 Commercial)	1
				STRAINER ASSEMBLY NO. U15047	
--	--	U15046	WT	Strainer and foot valve	1
--	--	P15425	WT	Adapter, 2 in. NPT x 2 in. hose	1

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DETAILED OUTLINE

ROUTINE CONTROL TESTS

INTRODUCTION:

(ON TP #1) (___ MIN)

1. GAIN ATTENTION: During the previous period of instruction we learned that water in its natural state will contain many disease producing organisms, silt, and poisons, but have you ever considered what kinds of tests must be performed in order to render the water safe for human consumption?

2. PURPOSE: The purpose of this period of instruction is to provide you with the knowledge and skills necessary to perform the required routine control tests when working with water.

3. INTRODUCE LEARNING OBJECTIVE(S): (___ MIN)

a. TERMINAL LEARNING OBJECTIVE(S):

(1) Provided with a water source and a color comparator:

(a) perform a pH determination test (1.3.1)

(b) perform a chlorine residual test (1.3.2) on the water in accordance with TM 5-700, Chapter 6.

(2) Provided with a water source, two 1 gallon jugs, five 8 ounce jars, two stopper bottles, a color comparator, alum, soda ash, and two eyedroppers, perform a coagulation jar test on the water in accordance with TM 5-700, Chapter 6. (1.3.3)

(3) Provided with a color comparator, two canteens, HTH, and a water source, perform a chlorine demand test on the water in accordance with TM 5-700, Chapter 6. (1.3.4)

b. ENABLING LEARNING OBJECTIVE(S):

(1) Provided with a color comparator:

(a) point out the components of the color comparator. (1.3.1g)

(b) assemble the color comparator. (1.3.1h)

in accordance with TM 5-700, Chapter 6.

(2) Provided with a water source and a color comparator:

(a) prepare a water sample for a pH determination test (1.3.1i)

(b) prepare a water sample for a chlorine residual test (1.3.2a)

in accordance with TM 5-700, Chapter 6.

(3) Provided with a list of step numbers and a list of steps for making a standard solution, match each step for making the solution to its step number in accordance with TM 5-700, Chapter 6. (1.3.3a)

(4) Without the aid of notes or references, list the materials necessary to perform a coagulation jar test in accordance with TM 5-700, Chapter 6. (1.3.3b)

(5) Provided with a list of step numbers and a list of steps for performing a coagulation jar test, match each step for performing a coagulation jar test to its step number in accordance with TM 5-700, Chapter 6. (1.3.3c)

(6) Without the aid of notes or references, write the coagulation formula in accordance with TM 5-700, Chapter 6. (1.3.3d)

(7) Provided with the dosage of alum required to floc a sample of water and the coagulation formula, calculate the amount of alum required to floc 3000 gallons of water in accordance with TM 5-700, Chapter 6. (1.3.3e)

(8) Provided with the dosage of soda ash required to floc a sample of water and the coagulation formula, calculate the amount of soda ash required to floc 3000 gallons of water in accordance with TM 5-700, Chapter 6. (1.3.3f)

(9) Without the aid of notes or references, list the materials necessary to perform a chlorine demand test in accordance with TM 5-700, Chapter 6. (1.3.4a)

(10) Provided with a list of step numbers and a list of steps for performing a chlorine demand test, match each step for performing a chlorine demand test to its step number in accordance with TM 5-700, Chapter 6. (1.3.4b)

(11) Without the aid of notes or references, write the chlorine demand formula in accordance with TM 5-700, Chapter 6. (1.3.4c)

(12) Provided with a pH factor, a chlorine residual requested by the Medical Department, and a chlorine residual from the raw water canteen, compute the amount of chlorine required to treat 3000 gallons of water in accordance with TM 5-700, Chapter 6. (1.3.4d)

TRANSITION: Now that we know what the learning objectives are, let's begin with some general information about the tests.

(OFF TP #1)

BODY:

1. pH - What do we mean by the term pH? (___ MIN)

a. The term pH is a chemical term for measuring the amounts of acid or alkaline in solution.

b. pH stands for "potential of electricity for positive hydrogen ions". pH measures the quantity of free hydrogen ions, which are the foundation for all acids that are present in a known solution.

(ON TP #2)

c. pH is based on a scale ranging from 0 which is the maximum acid, to 14 which is the maximum alkalinity.

d. 7.0 on the scale indicates neutral water - acid and alkaline are balanced but this does not mean that the water is free from germs.

TRANSITION: As water travels over or through the soil, it picks up many impurities. These fall into two groups, either acidic, similar to vinegar or alkaline like lye. It is important for us to know which one is the most prominent in water for this will affect the purification processes of coagulation and sedimentation.

e. The pH value is a measure of the strength of acid or alkalinity expressed as a number. It can be used to determine the following:

(1) The amount of chemicals needed for adequate coagulation.

(2) The amount of chemical needed for controlling corrosion.

(3) If there are poisons present in the water.

(4) The effects chlorine has on germs.

f. The pH can be maintained at the desired level by the addition of:

(1) Soda ash (sodium carbonate) - will raise the pH of the water.

(2) Aluminum sulfate - will lower the pH.

(OFF TP #2)

g. Neutral water is seldom found in nature and is not necessary. As water goes through its hydrologic cycle, it will pick up acids from either industrial wastes such as sulfuric acid, hydrochloric acid, carbon dioxide or other dissolved gases which will give the water a high acid base which will lower the pH.

h. The alkaline contents in the water may be caused by carbonates or bicarbonates. When water comes into contact with limestone, the water will have a high pH.

i. When both alum and soda ash are added to the water in the same amounts, the pH will not be affected.

(ON TP #3)

(___ MIN)

2. pH DETERMINATION TEST: There are basically six reasons why we must perform

a. Chlorine is less effective in water having a high pH.

b. A pH of 6.0 or less could be an indication that the water may have some type of poison, such as chemical warfare agents.

NOTE: There will be times when you will encounter water with a low pH which is not poisoned. However, in a tactical situation, oftentimes the enemy will poison a water source to keep you from using it. If at any time you find a water source with a pH of 6.0 or less you should have the medical department run a laboratory analysis to find out what type of poison is in the water.

c. A sudden change of one or two points on the pH scale is an indication that some type of harmful contamination could have gotten into the water.

d. We need to know the optimum pH (pH where the floc forms the heaviest in the least amount of time).

e. We need to know the optimum pH (pH where the floc forms the heaviest in the least amount of time).

f. Water with a pH of 7.0 or less has corrosive effect inside cooling systems of equipment.

(OFF TP #3)

OPPORTUNITY FOR QUESTIONS:

1. Questions from the class:

2. Questions to the class: No questions are required at the time.

SUMMARY: (___ MIN)

During the past hour we discussed pH and pH determination test.

BREAK: (10 MIN)

INTRODUCTORY TRANSITION: In order to perform a pH determination test we must first know about the required tools or equipment, the first being a color comparator which is also used for performing a chlorine residual test.

NOTE: At this time the instructor or assistant instructor will issue out all available color comparators to the students.

BODY:

(ON TP #4)

3. NOMENCLATURE OF THE COLOR COMPARATOR (___ MIN)

a. A color comparator is used for performing two tests, the pH determination test and the chlorine residual test.

b. Comparator Body - a box-like configuration with two viewing holes in the front, one in the center to view the color of the test tube and one on the right to view the color of the color disc. It also has an opaque lens in the back to distort the direct rays of the sun. On the top, there are three slots; two narrow slots for the two test tubes and one wide slot for storing the reagent bottle. The two narrow slots have metal springs to hold the test tubes securely.

c. Face Plate - a flat piece which fits over the front of the comparator body. The face plate also has two viewing holes on the front which are in the same place as the two viewing holes on the comparator body. It also has two holes for the hold down screws; one in the upper right hand corner and the other in the lower left hand corner.

d. Hold Down Screws - there are two hold down screws used to secure the face plate to the comparator body.

e. Eyepiece - a prism type lens which draws two objects closer together. In our case, it will make the colors of the two viewing holes appear to overlap making the comparison of the two colors easier to match.

f. Two test tubes with a capacity of 26 ml and marked at 15 ml.

g. Two eyedroppers.

h. Orthotoluidine - a reagent used to determine how much chlorine is present in the water.

i. DPD tablets - put 2 tablets into 15 ml of water to be tested.

j. Wide range reagent - a reagent used to determine the pH of the water any where on the pH scale.

k. Orthotoluidine disc - ranges from 0.1 to 5.0.

l. DPD disc - ranges from 0.1 to 10.0.

m. Wide range disc - ranges from 3.0 to 11.0.

n. A carrying case to store the components of the color comparator.

(OFF TP#4)

TRANSITION: Now that we know what the components of the color comparator are, let's take a look at how to assemble it. Since the first test is going to be the pH determination test, let's assemble the color comparator.

4. ASSEMBLING THE COLOR COMPARATOR

a. The first thing you need is the comparator body. Inspect it for damages.

b. Take the disc marked wide range from the case and place it on the front of the comparator body with the numbers facing you.

c. Install the face plate over the color disc. The face plate can be installed either right side up or upside down, so be sure that the viewing holes in the face plate are aligned with the viewing holes in the comparator body.

d. Install the two hold down screws to secure the face plate to the comparator body.

e. Install the eyepiece on the front of the face plate covering both of the viewing holes.

TRANSITION: The color comparator is now assembled and ready to go, except now we need some water to test.

5. PERFORM A pH DETERMINATION TEST: (___ MIN)

a. As with all tests performed with the color comparator, you must clean the test tubes thoroughly.

b. Fill both test tubes to the 15 ml mark. Make certain that both test tubes are filled from the same source.

c. Insert one test tube completely into the narrow slot on the right of the comparator body.

d. Insert the other test tube partially into the center slot of the comparator body just to have a place to rest it and to keep from knocking it over.

e. Put .5 ml of the wide range pH reagent into the test tube in the center slot of the comparator body. There is an eyedropper in the reagent bottle marked at .5 ml.

f. Take the test tube out of the center slot and agitate it so the pH reagent will mix thoroughly in the water.

g. Insert this test tube partially back into the center slot of the comparator body and using the pH reagent bottle, push the test tube all the way down into the comparator body.

CAUTION: Do not use your fingers to push the test tube into the comparator body or place your finger over the test tube to shake it to mix the pH reagent with the water. The oils from your skin will get into the water and change the pH giving you an erroneous reading.

TRANSITION: Now that we have the water ready for testing, let's determine what the pH value of the water is.

h. Take the color comparator and put the eyepiece close to your eye.

i. Turn the color disc until the color on the disc matches the color in the test tube.

j. The number appearing in the upper left hand corner of the comparator indicates the pH of the water.

NOTE: If the color of the water being tested is darker than the disc, give the pH value an additional .6 value.

Example: Instructor will explain.

k. Once you have found the pH of the water, record it for future use.

TRANSITION: Now that we have completed the first test with the color comparator, let's begin with the second test - the chlorine residual test.

6. PERFORM A CHLORINE RESIDUAL TEST (___ MIN)

a. The purpose of the chlorine residual test is to find out how much chlorine is present in the water. The chlorine residual test is performed in very much the same way the pH determination test is conducted.

b. Remove the pH color disc from the comparator body and install the chlorine disc.

c. Rinse thoroughly and fill the two test tubes to the 15 ml mark with the water to be tested.

d. Hold the test tube that is going into the center slot of the comparator body in your hand for about one minute. This will warm the water a little. Orthotoluidine works best when the water is approximately 70 degrees.

e. Performing this test in the same sequence as the pH determination test, use .5 ml of Orthotoluidine in the test tube in the center slot. Orthotoluidine is clear and depending on the amount of chlorine in the water, will change color anywhere from light yellow to red. When using 2 DPD tablets the water will turn pink to dark red depending on the amount of chlorine in the water.

f. If you get a reading, record it for future use. If the color in the test tube is less than 0.1, it is considered to have no chlorine residual.

TRANSITION: Now that we know the procedures for using the comparator, let us go out and perform both tests.

PRACTICAL APPLICATION: (___ MIN)

1. Students will be broken down into teams.

2. At this time the instructor and assistant will take students to Camp Sweat where every member of each team will get a chance to use the color comparator for performing a pH determination test and a chlorine residual test.

3. The instructor and assistant instructor will remain with the students to assist them with the tests being conducted and answer any questions the student may have.

4. Upon completion of the tests the students will take a break before returning to classroom.

BREAK: (10 MIN)

INTRODUCTORY TRANSITION: Now that we know how to use the color comparator and conduct a pH determination test and a chlorine residual test, let's talk about the coagulation of water.

BODY:

7. COAGULATION: (___ MIN)

a. Coagulation is the process of adding a chemical to water to gather the suspended impurities into particles large enough to settle rapidly.

b. Plain sedimentation is the process of allowing the suspended impurities to settle by themselves, which is a very slow process. Military water supply demands are so great that we must accelerate the settling process by artificial means.

c. Chemical treatment not only hastens the natural sedimentation of suspended impurities which are too finely divided to settle at normal periods of time, but hastens the natural settling of regular suspended impurities.

d. Coagulants - There are five coagulating agents used in the Marine Corps today, however, at this time we will only be discussing two of them.

(1) Aluminum sulfate - when hydrolized by the alkalinity of most waters, will produce a flocculant precipitate of aluminum hydroxide.

(a) The precipitate or "FLOC" is a jelly like substance which absorbs suspended silt and disease organisms and cause them to settle out.

(b) The turbidity in the water will also cause the FLOC to become very heavy and will settle to the bottom of the pretreatment tank.

(c) Some of the FLOC will remain in suspension but will be easily removed by the filtration cycle.

(2) Sodium carbonate (soda ash) - whenever there is not enough natural alkalinity in the water to react with the coagulant, it will be necessary to add a coagulant aid such as soda ash. This coagulant aid will do basically two things:

(a) Cause the Floc to become heavy for faster sedimentation.

(b) Adjust the pH in the water to make it thirst quenching.

TRANSITION: Now let us take a look at some of the factors which will affect the coagulation process.

(ON TP #5)

8. SIX FACTORS AFFECTING COAGULATION: (___ MIN)

The formation of an acceptable FLOC depends on six factors. Flocculation

itself is only one step in the coagulation process which of course is the addition of chemicals. The other factors affecting coagulation are:

a. pH value - also known as the optimum pH. This is the pH value on the pH scale where the FLOC will form the heaviest and in the least amount of time.

(1) The optimum pH values fall between 4.5 to 7.5, depending on impurities present in the water.

(2) Colored water containing only a small amount of dissolved minerals generally FLOCS best between a pH of 4.5 and 6.0.

(3) Turbid water with a considerable amount of natural alkalinity, FLOCS best at pH values between 6.0 and 8.0.

NOTE: These values are only indicators. Remember that there is only one optimum pH for any given water. The optimum pH will vary with rainfall, seasonal changes, etc. Now lets continue with the second factor.

b. Turbidity - the presence of a certain amount of turbidity oftentimes is necessary in order to produce a large FLOC which will settle out rapidly.

(1) Without particles to weight the FLOC down, it will hang in suspension in the water for a considerable amount of time.

(2) Turbidity - is a muddy unclear condition caused by dirt particles which usually have entrapped disease organisms and bacteria. It is not really desirable. Therefore, in order for the FLOC to be heavy enough when working

with clear water, a larger amount of chemicals must be added to the water to compensate for the absence of turbidity.

c. Temperature - is the third factor.

(1) Temperature is actually a measurement of molecular activity of a substance.

(2) In warm water, the molecules are in relatively high motion, the probability of collision of the aluminum ions and hydroxyl ions is increased, and the result is that the FLOC forms faster.

(3) In cold water the molecular activity is less active, therefore the formation of the FLOC will be slower.

d. Agitation - In order to obtain the best FLOC in the least amount of time (especially in cold water) it is necessary to agitate or stir the water and chemicals in order to accelerate the flocculation process.

(1) Agitation is best accomplished by directing the stream of water along the side of the tank as the 3,000 gallon tank is being filled.

(2) Use of wooden paddles (tank staves) can also aid the agitation process.

e. Amounts of chemicals added - The amount of alum added to the water will determine the amount of FLOC that is produced.

(1) Alum and soda ash (sodium carbonate) are added in proportion in order to:

(a) Form the necessary FLOC.

(b) Provide a means of controlling the pH value in the water.

(2) Alum is added to the tank when the tank is filled one fourth to one half from the bottom.

(3) Soda ash (sodium carbonate) is added when the tank is filled three quarters full.

NOTE: The chemicals must be added to the tank as stated. Never! add soda ash before alum. The introduction of soda ash before alum will set the true color. Once the color is set, it cannot be removed.

f. Color - Generally color can be removed by the FLOC by coagulating on the acid side of the scale.

(1) Color is caused by organic substances which are negatively charged while FLOC formed at a low pH is positively charged.

(2) Color, being a negative charge will be attracted by the positive charges forming the FLOC and will settle very easily.

(3) If the pH value is increased later, the color may re-appear to some extent. Therefore if soda ash is added to the water before alum, the color may be fixed and can never be removed.

(OFF TP #5)

OPPORTUNITY FOR QUESTION: (___ MIN)

1. Questions from the class:

2. Questions to the class:

a. Define Coagulation process.

A. The adding of chemicals to the water to gather the suspended impurities into particles large enough to settle rapidly.

b. What are the two coagulating agents which were discussed during this hour?

A. Aluminum sulfate and sodium carbonate (soda ash).

c. What are the six factors that will affect the coagulation process?

A. pH value, turbidity, temperature, agitation, amounts of chemicals added and color.

SUMMARY: During the last period of instruction I covered: (___ MIN)

1. Coagulation process.

2. Six factors affecting coagulation.

BREAK: (10 MIN)

INTRODUCTORY TRANSITION: Now that we know what coagulation is and the six factors which will affect it, let's talk about the coagulation jar test.

(ON TP #6)

BODY: (___ MIN)

9. COAGULATION JAR TEST: The coagulation jar test is performed to find the optimum dosage and the optimum pH of a sample of water. Therefore, we can say that there are two reasons for performing the coagulation jar test.

a. Optimum dosage - is the amount of chemicals in grains per gallon (gpg) that will form the best FLOC in the shortest time. The optimum dosage is the cumulative total amount of alum and soda ash (sodium carbonate) to be added to a sample of water.

b. Optimum pH - is the pH at which the FLOC will be the heaviest for that sample of water.

NOTE: The heaviest FLOC does not necessarily have to be the largest particles of FLOC, or the smallest particles.

(1) The FLOC of the jar test is satisfactory if it has attracted all of the suspended materials and caused them to settle to the bottom of the jar.

(2) The FLOC should be visible to the eye within two minutes once the water has been agitated.

(3) In some instances where the FLOC is not obtained during the first test, it is due to the lack of alkalinity in the water and an additional test must be performed.

c. The dosages are added to the jars by using an eyedropper which must be calibrated in milliliters.

(1) One milliliter is the same as one cubic centimeter or 20 drops of water.

(2) When one milliliter of any of the two coagulants is added to the water, the pH of the water will have a change from 0.2 to 0.3 on the pH scale.

(3) The dosage is defined as the quantity of chemicals necessary to obtain the desired results. Dosages of coagulating chemicals are represented in grains per gallon (gpg). Since one pound is equal to 7,000 grains, the dosage can be determined by using the coagulation formula which we will cover later in this block of instruction.

d. In the coagulation jar test, the amounts of chemicals added to the water are in such a small amount, grains are used to express weights rather than pounds or ounces. Therefore we can say that the quantity is expressed in grains per gallon.

e. The four units of measurement that we will be using with the coagulation jar test are:

(1) Pounds of chemicals - The final results once the jar test has been completed - this result is the amount of each chemical that must be added to a 3,000 gallon tank.

(2) Gallons of water - Quantity of water that we will be treating at one time, usually 3,000 gallons.

(3) Grains per gallon (gpg).

(a) Dosage is added to the jars in grains per gallon.

(b) One milliliter represents 2 grains per gallon.

(4) Grains per pound - number of grains in a pound, which is 7,000 grains to a pound.

f. The formula which we use for figuring the amount of chemical solutions into the jars is this:

(OFF TP #6)

$$\text{POUNDS OF CHEMICALS} = \frac{\text{Gallons of water x Dosage (gpg) x 2}}{7{,}000}$$

Example: Let's take for example, that we are going to coagulate 3,000 gallons of water. To find out how many pounds of alum we need, let us suppose that we put 8 milliliters of alum solution into the jar we decided had the best FLOC. Then we would:

Multiply 3,000 times 16. Why 16? We said that 1 milliliter = 2 gpg. This will give you 48,000 grains.

Divide 48,000 grains by 7,000 (which is the number of grains per pound). The result will be 6.85 or if you round it off, it will be 7.0 pounds of alum.

When the number to the right of the decimal point is 5 or greater then the whole number will be rounded off to the next higher number.

INSTRUCTORS NOTE: Have all necessary equipment and materials readily available before going into the next topic.

TRANSITION: Now that have the basic foundation of what the coagulation jar test is about, including the formula, let us talk about the materials needed in order to perform the coagulation jar test.

10. EQUIPMENT AND MATERIALS: (SHOW EQUIPMENT AND MATERIALS) (___ MIN)

The two main reasons we perform a coagulation jar test are to find the optimum pH and to determine how much chemicals are required to a 3,000 gallon tank. Before you can perform this test, however, you must have the proper materials. These materials are:

a. 2 one gallon containers

b. 2 stopper bottles

c. 5 eight ounce jars

d. Color comparator

e. Soda ash (pulverized)

f. Alum (pulverized)

g. 2 eyedroppers

OPPORTUNITY FOR QUESTIONS: (___ MIN)

1. Questions from the class:

2. Questions to the class:

   a. What are the two reasons for performing a coagulation jar test?

      A. To find out the optimum dosage and the optimum pH.

   b. How many drops of water are there in 1 milliliter?

      A. 20 drops.

SUMMARY: During the last hour I covered. (___ MIN)

1. Coagulation jar test.

2. Equipment and materials.

BREAK: (10 MIN)

INTRODUCTORY TRANSITION: Now that we know what kinds of equipment and materials are needed to perform the coagulation jar test let's continue. The next thing that we are going to do is to make up the standard chemical solutions.

BODY:

NOTE: INSTRUCTOR WILL ACTUALLY PERFORM THE TEST.

11. PREPARATION OF CHEMICAL SOLUTIONS: (___ MIN)

a. The first step that must be done before we can start the test is to procure some water.

b. Rinse containers thoroughly and fill the two one gallon containers with the best water available, preferably distilled water. If no distilled water is available, use regular tap water or water used for consumption.

c. Mark one of the one gallon containers 'Alum' and the other 'Soda Ash'.

d. Using the two test tubes from the color comparator, fill one test tube completely full and the other half way full of alum.

e. Pour these one and a half test tubes of alum into the one gallon container marked 'Alum'.

f. Tighten the cap on the one gallon container securely and shake it vigorously for about one minute. This dissolves as much of the alum the water can take. This process is called saturation.

g. Using one test tube from the color comparator, fill it completely full of soda ash.

h. Pour the soda ash into the one gallon container marked 'Soda Ash'.

i. Tighten the cap on the one gallon container securely and shake it vigorously for about one minute thereby saturating the water with soda ash.

j. Fill the two stopper bottles, one with soda ash and the other with alum.

k. Mark the two stopper bottles appropriately.

TRANSITION: We have just made our chemical solutions. Now let's perform the coagulation jar test.

12. PERFORM COAGULATION JAR TEST: (___ MIN)

a. Make up a chart to show how much alum and soda ash you have put into each of the five jars. It should look something like this:

Jar	1	2	3	4	5
A					
SA					

b. Rinse and fill the five eight ounce jars with the raw water to be tested. Fill these jars up to the neck of the bottle.

c. Take the two eyedroppers from the color comparator and calibrate them at one milliliter. This can be done by taking the rubber cap off one eyedropper, placing your finger over the small orifice at the bottom, and using the other eyedropper, count twenty drops into the eyedropper. Mark it off so it will be calibrated and replace the rubber cap. Do the same to the other eyedropper.

d. Using a two to one ratio (2 ml of alum to 1 ml of soda ash), begin adding your dosages of solutions to the jars. The alum is the coagulant, so it should be added first to start the FLOC. The soda ash adds weight to the FLOC making it sink to the bottom of the jars. Record these dosages on your chart. An example would look something like this:

Jar	1	2	3	4	5
A	2	4	8	12	16
SA	1	2	8	12	16

e. When all of the dosages have been added, take the jars and move them in a circular motion causing the water in the jars to swirl. This will agitate the alum, speeding up the flocculation process. The jar that flocs and settles the fastest is the jar with the optimum pH.

f. Take a pH test of that jar to see if the pH is within the 7.2 to 7.6 range. If not, an adjustment in dosages is needed. Keep in mind that for every milliliter of alum the pH will be lowered by .3 and for every milliliter of soda ash the pH will be raised by .3.

TRANSITION: We have selected the jar with the optimum pH and have the dosages of that jar recorded; however, this is only an eight ounce jar and we need to figure out how much chemicals are required to treat a 3,000 gallon tank.

13. CALCULATING CHEMICAL REQUIREMENTS: (___ MIN)

a. Using the dosages from our selected jar, we can figure out the required chemicals for 3,000 gallons of water with the following formula:

$$\frac{\text{Gallons of water X Dosage X 2}}{7{,}000}$$

The amount of water may change. However, for our purposes it will be 3,000 gallons.

b. The dosages are from the chart in reference to the jar that was selected.

c. The dosages in the chart are in milliliters and the formula is in grains per gallon (gpg). One milliliter is equal to two gpg so you have to multiply these dosages times two.

d. Since the formula is in gpg and you want to know how many pounds of chemicals you need, you have to divide all of this by 7,000. There are 7,000 grains in a pound.

e. Figure this formula once for the alum and again for the soda ash.

NOTE: Instructor will work out one or more problems on the chalkboard - explaining each step and reasons why.

OPPORTUNITY FOR QUESTIONS: (___ MIN)

1. Questions from the class:

2. Questions to the class:

a. How many milliliters do you calibrate your eyedroppers?

A. 1 ml.

b. Why do we multiply our dosages times two?

A. Because one milliliter of solution is equal to two gpg.

SUMMARY: During the last period of instruction I covered: (___ MIN)

1. Preparation of chemical solutions

2. Performing the coagulation jar test

3. Calculating chemical requirements

BREAK: (10 MIN)

INTRODUCTORY TRANSITION: At this time we will solve problems using the coagulation formula.

PRACTICAL APPLICATION FOR PRACTICING THE COAGULATION FORMULA: (___ MIN)

1. At this time, I want everybody to take out some paper so we can figure a few practice problems.

2. I am going to put some dosages on the chalkboard and I want you to tell me how many pounds of each chemical you will need for 3,000 gallons of water.

3. When figuring your problems, figure it to the nearest tenth of a pound.

TRANSITION: The next test which we will talk about is very important because from this test, we can determine the amount of disinfectant required to purify a certain amount of water and still have a satisfactory residual in it to make it safe for drinking.

BODY:

14. CHLORINE TEST: (___ MIN)

a. The most widely used disinfectant used in water today is chlorine. This chlorine can either be in the form of liquid, granular or gas. Chlorine is added to the water to kill or destroy all disease producing organisms, organic substances and parasites and to maintain a desired chlorine residual in the water in order to maintain the water germ free.

(1) The most common form of chlorine used in the military is a dry granulated or what is referred to as "solid form", called calcium hypochlorite, the trade name is high test hypochlorite (HTH).

(2) HTH has 70% free chlorine in it.

(3) It also has 30% calcium which entraps the chlorine to keep it from evaporating.

TRANSITION: Before we can perform the chlorine demand test, there is some terminology which we must define.

b. Contact time: is the length of time that chlorine must remain in the water to kill or satisfy all of the chlorine consuming agents present in the water. The contact time is a variable, depending on several conditions.

(1) The form of chlorine used. It is readily apparent that gaseous chlorine will have a somewhat shorter contact time.

(2) The amount of organic matter in the water. All organic matter in the water affects the chlorine consuming ability of the water, and not just

disease causing organisms. Also any dissolved chemicals or minerals in the water will consume chlorine.

(3) Mineral content - chlorine may be absorbed by certain mineral materials. Super chlorination, or adding chlorine in excess of 10 ppm is used by municipal plants to remove iron and manganese from water.

(4) pH of the water - will affect chlorine. The effectiveness of chlorine is higher in water with a low pH.

(a) A pH of 8.0, chlorine is about one half as effective as it is at a pH of 7.0.

(b) For the pH, a factor of 1.0 ppm of chlorine shall be used since the pH will be maintained at 7.0 to 7.6.

(5) Temperature of the water - chlorination is most effective at 70° degree F. At 35° F chlorine is only one half as effective as it is at 70° F.

(6) Most organisms in the water will be killed off within ten minutes of contact time. (Nonchlorine resistant)

(7) Chlorine resistant parasites will resist 2.0 ppm chlorine for thirty minutes. These are:

(a) Schistosomiasis

(b) Amoebic cyst

(8) The contact time can be defined as a 30 minute period required for disinfection of the water before it is considered safe for drinking.

c. Chlorine demand - The chlorine demand is the amount of chlorine that is neutralized by the chlorine consuming agents in the water. By consuming agents we merely mean the:

(1) Amount of organisms in the water

(2) Amount of mineral contents

(3) Most natural surface waters have a demand ranging from 1.5 ppm to about 4.5 ppm. Ground water will vary but not more than 2.5 ppm.

(4) If the chlorine demand is greater than 5.0 ppm. it should be reported to the medical department. 5.0 ppm or greater is an indication that the water may be poisoned or has a high concentration of harmful contaminates.

d. Chlorine residual - The chlorine residual is the amount of chlorine left in the water after all of the chlorine consuming agents have been satisfied. The purpose for the chlorine residual is twofold:

(1) First it is an insurance that all harmful organisms have been destroyed.

(2) It is an insurance that the water will be safe for drinking, and to prevent the water from becoming recontaminated.

(3) The minimum required chlorine residual is as follows:

(a) If the optimum pH is 6.5 or less the required residual is 2.0 ppm.

(b) Optimum pH between 6.5 - 7.0 minimum is 2.2 ppm

(c) Optimum pH of 7.0 - 9.0 minimum will be 3.0 ppm

(d) The minimum residual required at point of consumption is 1.0 ppm

NOTE: The above residuals were decided at a symposium of medical officers in 1958. However, the medical department will dictate what the residual shall be for all areas of operation.

e. Chlorine Dosage - is determined by two factors:

(1) First, is the chlorine demand - which is nothing more than the amount needed to satisfy the chlorine consuming agent.

(2) Second, is the chlorine residual we want left in the water once the demand has been satisfied. So you can see, that the chlorine dosage is the amount of chlorine that is to be added to the water.

TRANSITION: If you recall, we have already had the opportunity to perform a chlorine residual test, which of course was nothing more than testing the water to see if there was any chlorine in it. Naturally, surface water would not have any chlorine in it but the procedure is the same when testing water that has already been treated

BODY:

15. PERFORM A CHLORINE DEMAND TEST: (___ MIN)

The chlorine demand test consists of adding a known dosage of chlorine to a known quantity of water and waiting thirty minutes before testing it.

a. Before we can perform this test, however, you must have the proper materials.

(1) Two canteens

(2) Color comparator

(3) 7.14 grams of HTH

b. Rinse thoroughly and fill one of the canteens with the best water available.

c. Mark this canteen 'Best'.

d. Rinse thoroughly and fill the other canteen with the raw water to be tested.

e. Mark this canteen 'Raw'. It is very important that you do not confuse these two canteens.

f. Pour the 7.14 grams of HTH into the 'Best' canteen.

g. Tighten the cap securely and shake it vigorously for about one minute. This will give you 5,000 ppm.

h. Let the 'Best' canteen sit for 30 minutes contact time. This is your HTH solution.

i. After the 30 minutes contact time of the HTH solution, take one milliliter of the HTH solution and put it into the 'Raw' canteen.

j. Tighten the cap on the 'Raw' canteen securely and shake it vigorously for about one minute. This will give you 5.0 ppm. Record this figure for future use.

k. Let the 'Raw' canteen sit for 30 minutes contact time.

l. After the 30 minutes contact time of the 'Raw' canteen, take a chlorine residual of the 'Raw' canteen. Record any reading of chlorine residual for future use.

OPPORTUNITY FOR QUESTIONS: (___ MIN)

1. Questions from the class:

2. Questions to the class:
None are required.

SUMMARY: During the last period of instruction I covered: (___ MIN)

1. Chlorine test

a. Contact time

b. Chlorine demand

c. Chlorine residual

d. Chlorine dosage

2. Perform a chlorine demand test.

BREAK: (10 MIN)

INTRODUCTORY TRANSITION: We are now ready to figure out how many ounces of HTH we will need to batch chlorinate 3,000 gallons of water.

BODY:

16. DETERMINE CHEMICAL REQUIREMENTS: (___ MIN)

a. Using the following, we can see how all of the figures we recorded for future use will tie together:

(1) Chlorine dosage minus:

(2) Chlorine residual plus:

(3) pH factor plus:

(4) Safety factor plus

(5) Chlorine dosage = chlorine demand.

NOTE: Instructor will explain step by step each item in detail.

b. Notice I mentioned a pH factor. The following chart will tell you how much chlorine residual to maintain with a given pH value:

pH	Cl. Res.
5.0-6.9	.75
7.0	1.0
8.0	3.0
9.0-10.9	5.0

c. I also mentioned a safety factor. The safety is to disinfect the holding tank, distribution tank, consumers containers, and distribution lines. The safety is 1.0.

d. A breakdown of this formula is as follows:

(1) CL_2 Dos. - Chlorine Dosage. This is the one milliliter of HTH solution you took from your 'Best' canteen and put into your 'Raw' canteen. The chlorine dosage is 5.0.

(2) Chlorine residual - Chlorine residual of your 'Raw' canteen. This chlorine is taken after the 30 minutes contact time. Subtract this from your chlorine dosage and you will get, chlorine demand in ppm; however, you must still add two other factors. These are:

(a) pH Factor - as stated in the Introduction to Military Water Supply class, chlorine is less effective in water with a high pH; therefore, the higher the pH the higher the chlorine residual you must maintain. This factor will be absorbed by the pH of the water.

(b) Safety Factor - mentioned a few minutes ago that it is 1.0 and it is absorbed by the holding tank, distribution tank, consumers containers, and the distribution lines.

(3) Chlorine dosage - Since the pH factor and the safety factor is being absorbed, you have to add the chlorine dosage back into the formula to get your total chlorine demand in ppm.

(4) Chlorine demand - Chlorine Demand in ppm. This is your final answer. Record this figure for future use to use in the formula to find out how much HTH is needed to batch chlorine 3,000 gallons of water.

e. The following formula is actually two parts. The first part will give the pounds of chlorine and the second part will convert the pounds of chlorine to ounces of HTH:

$$\text{lbs. of } CL_2 = \frac{\text{Gals. of water X Weight of water X Dosage (ppm)}}{1{,}000{,}000}$$

(1) Again, the gallons of water may change, however, for our purposes we will use 3,000 gallons. Multiply this times the number of pounds in a gallon of water which is 8.34. Multiply this times your chlorine demand in ppm. This is what you just figured out with the previous formula. Divide all of this by 1,000,000 converting your ppm to pounds.

(2) Converting your pounds of chlorine to ounces of HTH, simply multiply the pounds of chlorine times 16 because there are 16 ounces in a pound. Divide this by .7 because we want to know how much HTH to use and HTH is only 70% chlorine. This will give us the full strength of chlorine that we need. (Give some examples).

<u>OPPORTUNITY FOR QUESTIONS:</u>

1. <u>Questions from the class:</u>

2. <u>Questions to the class:</u>

a. How long is the contact time for the two canteens?

A. 30 minutes.

b. How many pounds does one gallon of water weigh?

A. 8.34 pounds.

<u>SUMMARY</u>: During the past hour I covered. (___ MIN)

1. Determine chemical requirements

a. Chlorine dosage

b. Chlorine residual

c. pH factor

d. Safety factor

e. Chlorine dosage

f. Formula

BREAK: (10 MIN)

INTRODUCTORY TRANSITION: Now that you know the chlorine demand formula, let us see how well we can use it.

PRACTICAL APPLICATION FOR PRACTICING THE FORMULA: (___ MIN)

1. At this time, I want everybody to take out some more paper so we can figure a few practice problems.

2. I am going to put a pH of the raw water and a chlorine residual on the chalkboard. This chlorine residual is from the "raw" water canteen, after the one milliliter of HTH solution was put in and it has sat for its 30 minute contact time.

3. When figuring your problems, figure it to the nearest tenth of an ounce of HTH.

TRANSITION: Now that we had the opportunity to see how the coagulation jar test, chlorine demand test and how to figure out the chemical requirements using the formulas, let us now go to Camp Sweat and practice what we have learned.

NOTE: The instructor or assistant instructor will break down the class into teams of four men to a team. Upon arrival at Camp Sweat the instructor will designate which teams will perform the coagulation jar test, chlorine demand test.

PRACTICAL APPLICATION OF ROUTINE CONTROL TESTS: (___ MIN)

1. The primary instructor will monitor half of the class on the following in order to perform the coagulation jar test:

a. Procurement of equipment and materials.

b. Preparation of standard chemical solutions.

c. Washing out 8 ounce jars and filling them.

d. Making a chart.

e. Calibration of eyedroppers.

f. Perform pH determination test of the raw water.

g. Introduce chemical solution to 8 ounce jars.

h. Selecting best jars.

i. Using formula, determine chemical requirements.

2. The assistant instructor will monitor the other half of the class on the following in order to perform the chlorine demand test.

a. Select necessary materials.

b. Preparation of the standard chlorine solution.

c. Applying solution to "Raw" water canteen.

d. Waiting 30 minutes for contact time.

e. Perform a chlorine residual test

f. Using formula, determine amount of chlorine needed.

NOTE: Once the students have mastered one of the two tests, they will perform the other test. During the practical application phase the instructor and assistant instructor will remain with the students to answer any questions they may have.

SUMMARY: During the past few days, we have discussed:

1. Perform a pH determination test and a chlorine residual test.

a. Studying the nomenclature of the color comparator.

b. Assembling the color comparator.

c. Preparing the water for testing.

d. Determining the pH value of the water.

e. Using the same procedures as the pH determination test, perform the chlorine residual test.

2. Perform a coagulation jar test.

a. Preparing the chemical solutions.

b. Preparing the water for testing.

c. Testing the water.

d. Determining the required chemicals.

3. Perform a chlorine demand test.

a. Preparing the chlorine demand test.

b. Testing the water.

c. Determining the required chemicals.

BREAK:

ADMINISTER THE TEST:

1. Each student will clear his or her desk completely with the exception of a writing utensil. All necessary test forms, answer sheets will be provided.

2. Upon completion of the test, we will have a critique.

BREAK: (10 MIN)

LIST OF SUPPORTING PAPERS:

1. TP #1 Routine Control Tests.
2. TP #2 pH Chart.
3. TP #3 Six reasons for pH determination test.
4. TP #4 The Color comparator.
5. ____ Color comparator.
6. TP #5 Six factors affecting the coagulation process.
7. TP #6 Two reasons for coagulation test.
8. Coagulation jars.
9. Two canteens.
10. Advance Sheet/Student Outline.
11. Student handout - #1 and #2.
12. Two one gallon containers.
13. 1-1/2 test tube of alum.
14. 1 test tube of soda ash.
15. 2 stopper jars.
16. 7.14 grams of chlorine.
17. Water to be tested.

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U-10C04
OCT 1984
(D-539) gvf

ADVANCE SHEET/STUDENT OUTLINE

WATER SUPPLY RECORDS AND FORMS

PURPOSE: To familiarize the student with the information required to complete water supply records and forms.

STUDENT REFERENCE(S): TM 5-700, Chapter 2.

ASSIGNMENT: None.

OUTLINE

1. WATER SUPPLY RECORDS

a. Types

(1) Daily kept by operator.

(2) Inspection Reports to monitor conditions at water point.

(3) Headquarters Summary

b. Objectives

(1) Coordinate operation.

(2) Safeguard water quality.

(3) Improve efficiency.

(4) Decrease equipment maintenance.

(5) Prevent unequal distribution.

(6) Furnish supply data.

2. DAILY WATER POINT REPORTS

a. DA Form 1713R. Daily Water Production Log

(1) Water point number

(2) NCOIC

(3) Date

(4) Time tanks coagulated

(5) Number of tanks coagulated

(6) ph before purification

(7) ph after purification

(8) Chlorine residual after purification

(9) Chemicals expended

(a) Alum

(b) Soda ash

(c) Calcium hypochlorite (HTH)

(d) Diatomaceous earth

(10) Total chemicals for each day

(11) Total each chemical each day

(12) Petroleum used

(a) Oil

(b) Grease

(13) Petroleum on hand

(a) Gas

(b) Oil

(c) Grease

b. Water Point Report (continuous flow) DA Form 1713.

(1) Water point number

(2) Capacity of production

(3) NCOIC and date

(4) Time

(5) Hours of operation

(6) Gallons per minute

(7) Chlorine residual after purification

(8) Chemicals used

(a) Ferric chloride

(b) Limestone

(c) Diatomaceous earth

(d) Hypochlorite

(e) Remarks

(9) Chemicals used for one day operation

(10) Total amount of chemicals on hand

(11) POL used

(a) Gas/Diesel

(b) Oil

(c) Grease

(12) POL on hand

(a) Gas/Diesel

(b) Oil

(c) Grease

c. Daily Water Distribution Log, DA Form 1714R.

(1) Water point number

(2) NCOIC

(3) Date

(4) Time of distribution

(5) Amount of gallons

(6) Using unit

(7) Total gallons distributed

3. WATER POINT INSPECTION REPORT, DA FORM 1715R.

a. Date

b. To

c. From

d. Water point number

e. Inspection rating

f. Location of water point

g. Name of map

h. Inspecting official

i. Chlorine residual at unit outlet

j. Chlorine residual at nozzle

k. Overall condition of water point

l. Deficiencies and recommended improvements

m. Condition of equipment

n. Personal hygiene of personnel

o. Sanitation condition

p. Inspecting official

q. Signature

4. HEADQUARTERS SUMMARIES

a. Water Point Daily Production Summary, DA Form 1716R.

(1) Date

(2) Originates at utilities section

(3) To G-4 or higher headquarters

(4) Water Point Number

(5) Total hours operation

(6) Total gallons water produced

(7) Total gallons gas used

(8) Total quarts oil used

(9) Chemical used

(a) Calcium hypochlorite

(b) Activated carbon

(c) Alum

(d) Soda ash

(10) Cumulative totals for all water points

(a) Total hours

(b) Amount of water

(c) Gallons of gas

(d) Quarts of oil

(e) Ounces of calcium hypochlorite

(f) Pounds of activated carbon

(g) Pounds of alum

(h) Pounds of soda ash

(i) Responsible officer

(j) Signature

b. Water Point Daily Distribution Summary, DA Form 1717R.

(1) Date

(2) To S-4 of engineer group

(3) From S-4 of using battalion

(4) Water received

(5) Water point numbers

(6) Amount from each water point

(7) Amount required per man per day

(8) Originator

(9) Signature

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DETAILED OUTLINE

WATER SUPPLY RECORDS AND FORMS

INTRODUCTION (ON TP #1)
(2 MIN)

1. GAIN ATTENTION: You are the operator of a water point, one of many in your unit. How are you going to keep your OIC and/or NCOIC informed of how much chemicals and POL products (gas, oil, and grease) you require and how often your point needs to be resupplied? What do you have within your reach that you can use in doing this?

2. PURPOSE: To familiarize the student with the information required to complete water supply records and forms.

3. INTRODUCE LEARNING OBJECTIVE(S): Learning objectives are neither specified nor measured during the lesson.

INTRODUCTORY TRANSITION: Keeping records is a must in order to have an open line of communications with the engineer unit for the necessary support.

BODY (43 MIN)
(ON TP #2)

1. WATER SUPPLY RECORDS

a. Types of water supply records

(1) Daily - these are records kept by the operator.

(2) Inspection Reports - used to monitor the conditions at the water point(s).

(3) Headquarters Summary - submitted by the Utilities Officer via S-4 and up to the G-4 section on a monthly or quarterly basis.

(ON TP #3)

b. The keeping of records must meet one of the following objectives.

(1) Coordinate the operation of widely separated water points.

(2) Safeguard water quality.

(3) Improve efficiency of water treatment and distribution.

(4) Decrease equipment maintenance

(5) Prevent unequal distribution of treated water.

(6) Furnish supply data to higher headquarters.

TRANSITION: Now let's look at the various reports.

(ON TP #4)

2. DAILY WATER POINT REPORTS

a. DA Form 1713R. Daily Water Production Log - used for recording pertinent information.

(1) Water point number

(2) NCOIC of water point

(3) Date operated

(4) Time of day tanks are coagulated

(5) Number of 3,000 gallon tanks coagulated

(6) ph of water before purification

(7) ph of water after purification

(8) Chlorine residual after purification

(9) Chemicals expended

(a) Alum, pounds per 3,000 gallons of water

(b) Soda ash, pounds per 3,000 gallons of water

(c) Calcium hypochlorite (HTH), ounces per 3,000 gallon tank

(d) Diatomaceous earth per tank

(10) Total amount of chemicals in pounds for each operating day.

(11) Total each chemical in pounds after each days operation.

(12) Petroleum used:

(a) Oil, quarts used per day

(b) Grease, in pounds used per day

(13) Petroleum on hand

(a) Gas, in gallons on hand

(b) Oil, in quarts on hand

(c) Grease, in pounds on hand

b. Water Point Report (continuous flow) DA Form 1713. (ON TP #5)

(1) Water point number

(2) Capacity of production in gallons

(3) Name of NCOIC and date

(4) Time of day

(5) Time in hours of operation

(6) Gallons per minute during operation

(7) Chlorine residual in ppm after purification

(8) Chemicals used

(a) Ferric chloride in pounds

(b) Limestone in pounds

(c) Diatomaceous earth in pounds

(d) Hypochlorite in pounds

(e) Remarks during operation of unit

(9) Chemicals used for one day operation (totals)

(10) Total amount of chemicals on hand

(11) POL used during operation

(a) Gas/Diesel

(b) Oil

(c) Grease

(12) POL on hand after operation

(a) Gas/Diesel

(b) Oil

(c) Grease

(ON TP #6)

c. Daily Water Distribution Log, DA Form 1714R is used for recording the quantity of water issued to the using units.

(1) Water point number

(2) Name of NCOIC

(3) Date

(4) Time of distribution

(5) Amount of gallons

(6) Identification of using unit

(7) Total gallons of water distributed

TRANSITION: Now let's look at the second group, the inspection reports.

(ON TP #7)

3. WATER POINT INSPECTION REPORT, DA FORM 1715R - Is used by the medical department, utilities officer, or his representative.

a. Date of inspection

b. To responsible officer

c. From medical unit

d. Water point number

e. Inspection rating

f. Location of water point grid coordinate

g. Name of map

h. Name of inspecting official, rank

i. Chlorine residual of the water at unit outlet

j. Chlorine residual at nozzle

k. Overall condition of water point area

l. Deficiencies and recommended improvements

m. Condition of equipment

n. Personal hygiene of personnel

o. Sanitation condition

p. Name and rank of inspecting official

q. Signature of inspecting official

TRANSITION: Now that you know how to correctly fill out the Water Point Inspection Report, let us talk about the last two forms which must be submitted to higher echelon.

(ON TP #8)

4. HEADQUARTERS SUMMARIES - Are used to forward the information to higher echelon via the chain of command.

a. Water Point Daily Production Summary, DA Form 1716R is used to keep headquarters informed on the amount of water produced.

(1) Date

(2) The report originates at the utilities section and is forwarded to the S-4 section at the engineer battalion who will in turn submit it up the chain.

(3) To G-4 or higher headquarters

(4) Water Point Number

(5) Total hours operation

(6) Total gallons water produced

(7) Total gallons gas used

(8) Total quarts oil used

(9) Chemical used for each type of water purification equipment. Example:

(a) Calcium hypochlorite in ounces

(b) Activated carbon in ounces

(c) Pounds of alum

(d) Pounds of soda ash

(10) Cumulative totals for all the water points

(a) Total hours of operation

(b) Amount of water produced

(c) Gallons of gas used

(d) Quarts of oil used

(e) Ounces of calcium hypochlorite used

(f) Pounds of activated carbon

(g) Pounds of alum

(h) Pounds of soda ash

(i) Full name and grade of responsible officer

(j) Signature

(ON TP #9)

b. Water Point Daily Distribution Summary, DA Form 1717R - Keeps higher headquarters on how much water was issued by all the water points.

(1) Date

(2) To S-4 of engineer group

(3) From S-4 of using battalion

(4) Water received by consuming units

(5) Water point numbers

(6) Amount of water received from each water point

(7) Amount of water required per man per day

(8) Name and rank of originator

(9) Signature of originator

OPPORTUNITY FOR QUESTIONS (5 MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. What is the daily water production log used for?

A. Record amount of water produced.

b. Who conducts the inspections of a water point?

A. Medical department, utilities officer, or his representative.

SUMMARY: During the last hour we have covered the records and forms used in water supply; daily reports, inspection reports, and headquarters summaries.

BREAK (10 MIN)

LIST OF SUPPORTING PAPERS

1. TP # 1 Water Supply Records
2. TP # 2 Types of Records
3. TP # 3 Objectives
4. TP # 4 Water Point Log 1713
5. TP # 5 Daily Water Production Log 1713R
6. TP # 6 Daily Water Distribution Log 1714R
7. TP # 7 Water Point Inspection Report 1715R
8. TP # 8 Water Point Daily Production Summary 1716R
9. TP # 9 Water Point Daily Distribution Summary 1717R
10. Advance Sheet/Student Outline
11. Student Handout

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STUDENT HANDOUT

WATER SUPPLY RECORDS

WATER POINT DAILY PRODUCTION SUMMARY
(TM 5-700)

DATE:

TO:

FROM: (Organization)

Water Point	Hours Operation	Production gal.	Gascline gal.	Oil qts.	Lime stone	Soda Ash	Alum	Ferric Chlor	HTH	A/C

Type or Print Name & Grade

Signature

DA FORM 1716 R

WATER POINT DAILY DISTRIBUTION SUMMARY	DATE:
To.	From: (Organization)

Consuming Units	WATER POINTS							TOTAL	Gal. per man

Typed or Printed Name & Grade	Signature

DA FORM 1717 R

DAILY WATER PRODUCTION LOG {CONTINUOUS FLOW - QUIP}
{TM-5-700}

Point No.	NCO in charge	Date

Time		Rate	C12 Residual	Ferric Chloride	Limestone	Diatomite 1b		Acti-	
On	Off	gpm	ppm	1b			(1bs)	Carbon	Remarks:
Chemicals used									
Chemicals on hand									

POL used			POL on hand		
	Gasoline gal.			Gasoline gal.	
	Oil qt.			Oil qt.	
	Grease 1b			Grease 1b	

Remarks

DA FORM 1713 R

DAILY WATER PRODUCTION LOG {TM 5-700}		SET NO.
Point No.	NCO in charge	Date

Time	No. of Tanks Coagulated	ph Source	ph Filter	C12 Residual	Alum (1bs)	Soda Ash (lbs)	C12 (oz)	Activated Carbon	Diatomite (1bs)
Chemicals used									
Chemicals on hand									

Pol used			Pol on hand		
	Gasoline gal.			Gasoline gal	
	Oil qt.			Oil qt.	
	Grease 1b.			Grease 1b.	

Remarks:

DA FORM 1713 R

WATER POINT INSPECTION REPORT (TM 5-700)	DATE:

TO:	FROM:

WATER POINT INSPECTION	WATER POINT	INSPECTION RATING

Name of map cöordinates	DATE:	INSPECTOR

RESIDUAL CHLORINE

FILTER OUTLET {ppm}	DISTRIBUTING NOZZLE {ppm}

Condition of

1. WATER POINT({List defects and improvements of layout}

2. EQUIPMENT {tanks, hose, nozzles, etc}

3. ENGINES {List numbers, of those needing repairs}

4. PERSONNEL {Note sanitation, personal equipment}

REMARKS

TYPED OR PRINTED NAME & GRADE	SIGNATURE

DA Form FORM 1715R

(TM 5-700)

DAILY WATER DISTRIBUTION LOG

POINT NO.	NCO in charge	DATE

TIME	AMOUNT GALLONS	PICKED UP BY {using unit}
		Total Gallons ________

Remarks:

DA FORM 1714R

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WATER RECONNAISSANCE

CHECK LIST

Reconnaissance reports must be prepared carefully and delivered on time. They must be clear, complete and concise.

Advance Reconnaissance.

Advance reconnaissance reports need merely be good reconnaissance field notes. The work estimate must include the men, equipment and materials required to put the water point in operation. If time permits an estimate of the work necessary to develop the point is included.

Higher Echelon Reconnaissance.

Higher echelon water reconnaissance reports must be detailed as they become part of engineer planning data.

Check List for Water Reconnaissance.

Information on the following items must be obtained and recorded:

1. Quantity available.

2. Quality.

   a. Color.

   b. Odor.

   c. Turbidity.

   d. Taste.

   e. Possible sources of pollution.

   f. Condition of vegetation.

   g. pH value.

   h. Chlorine demand.

   i. Tests for chemical warfare agents.

3. Communications.

   a. Condition of roads.

   b. Extent of road net.

   c. Traffic circulation.

4. Site conditions.

   a. Cover and concealment.

   b. Possible aerial and artillery targets.

   c. Drainage.

   d. Bank conditions.

   e. Access roads and parking area.

   f. Bivouac area for operators.

5. Work estimate.

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U-10C05
Oct 1984
(D-551) gvf

DETAILED OUTLINE

DEVELOP A WATER SOURCE

INTRODUCTION (3 MIN)

1. GAIN ATTENTION: You as a Hygiene Equipment Operator will be required to provide support to a unit out in the field. During the water reconnaissance, you selected a water source which you thought would meet the demands, however upon arrival at the preselected site, you found out that the quantity of available water was not adequate as before! Yet you must still provide that unit with enough water for all their needs. What can you do to that source to improve the quantity and quality?

2. PURPOSE: To provide the student with the knowledge and skills necessary to develop a water source.

3. INTRODUCE LEARNING OBJECTIVE(S)

a. ENABLING LEARNING OBJECTIVE(S): Provided with a list of types of water source development and a list of purposes of types of water source development, match each type of water source development to its purpose in accordance with TM 5-700, Chapter 4. (1.3.5a)

b. I will do this by lecture.

c. A post test will be administered upon completion of the lecture.

TRANSITION: The development of a source includes all work which increases the quantity and improves the quality of the water, however elaborate developments should be avoided; simplicity brings more rapid results. With this in mind let's take a look at the first type of source.

BODY (33 MIN)

(ON TP #1, INLAND SOURCE)

1. Inland Surface Water Sources. Surface water sources are the most accessible type, in that this source lends itself readily to the purification equipment common to most engineer units. The methods of constructing intake points are:

a. Rocks and stakes

(1) If stream is not too swift and water is sufficiently deep, an expedient intake may be prepared by placing the strainer on a rock to prevent clogging of the strainer by the silt normally found at the bottom of the streambed.

(2) If the source is a small stream or shallow lake, the intake house can be secured to a post or stake driven down deep enough to withstand the weight of the hose.

(3) These two methods will keep strainers from becoming clogged and prevent the suction of air by the intake hose.

(OFF TP #1)

(ON TP #2, PITS)

b. Pits

(1) When a stream is so shallow that the intake strainer is not covered by at least 4 inches of water this method may be used.

(2) May be dug in streams with clay or silt, but bottom must be lined with gravel to prevent strainer from picking up the fine materials.

(3) Entire pit must be filled with gravel and embed strainer within the medium. This method will:

(a) Prevent the sides of pit from collapsing.

(b) Shield the screen from damage by large floating objects.

(c) Act as a filter medium.

(d) Enlarge the voids or pore space of the medium and increase the quantity of water.

(4) Bucket may also be used in conjunction with the pit. This method will:

(a) Increase the volume of water.

(b) Prevent strainer from picking up fine medium.

(OFF TP #2)

(ON TP #3, DAM)

c. Dams

(1) The level of water can be raised by building a dam.

(2) Dam must be constructed at a narrow part of the stream having stable banks.

(3) Dams may be constructed of log, dirt or any available natural material.

(4) Dams may be constructed of concrete and steel reinforcements if cost effective.

(5) Dams may be constructed of sand bags filled with sand or dirt or a combination of various materials depending on availability. (OFF TP #3)

(ON TP #4, BAFFLE DAM)

d. Baffle or Wing Dam

(1) Used in a swiftly flowing stream having a high turbidity content or floating debris.

(2) Baffle dam may be constructed of sand bags, perforated wooden box or a combination of the two.

(3) Bottom of baffle dam may be lined with gravel which will act as a filter medium. This method will:

(a) Improve quality of the water.

(b) Increase quantity if constructed to tap the water table.

(OFF TP #4)

(ON TP #5, FLOATS)

e. Floats

(1) Used for keeping the suction hose off the bottom of the source.

(2) Floats may be constructed of logs, lumber, sealed cans, empty fuel drums, or be manufactured floats.

(3) Floats are used in large streams where the quality of water varies across its width or where water is not deep enough near the banks to cover the suction strainer.

(4) Floats must be anchored to prevent suction strainer float from going back to shore.

(5) Secure hose to float so that suction strainer will be submerged under water at least 4 inches.

(6) The anchor support line should have adequate slack in order to allow the suction strainer to remain under water at all times if there is a change in the water level.

(OFF TP #5)

(ON TP #6, GALLERY)

f. Gallery

(1) Used to improve the quality of water having a muddy or extremely turbid condition.

(2) Construction of a gallery should be accomplished by digging the intake point along the banks.

(3) A trench is dug along the stream bank deep enough to allow water from the stream to percolate into it and also intercept ground water.

(4) Once the trench has been dug, fill with gravel to prevent sides from collapsing.

(5) The amount of work required to produce the gallery is justified by a reduction in the amount of chemicals needed to coagulate the water.

(6) Suction strainer must be placed in the gravel below the water line. Work required to produce a gallery is justified by reduction of chemicals needed to coagulate the water.

(7) A drive point (well point) may be used in place of the strainer, however the trench must be deep enough to accommodate the length of the point which is 54 inches long.

(OFF TP #6)

TRANSITION: Surface water sources are what we normally depend on. However, there are areas in parts of the world where these sources are not readily available. Therefore, we must consider the next type of source which is ground water.

(ON TP #7, SPRINGS)

2. Ground Water Sources - includes springs and wells.

a. Springs

(1) Can be used as a water source if the spring yields 20 gallosn per minute or more.

(2) Developing a spring is accomplished by enlarging the outlet with picks and shovel. (NEVER USE EXPLOSIVES).

(3) Once developed, water must be channeled into a storage basin such as boxes or basins of wood, tile, or concrete.

(4) Collecting box should be large enough to impound most of the flow.

(5) Should be placed below ground level, top protruding above ground level.

(6) Box should be covered to prevent contamination of the source.

(OFF TP #7)

(ON TP #8, WELLS)

b. Wells

(1) If wells are to be used, some of the considerations to be observed to determine whether or not a well can be used as a water source are:

(a) Type and depth - will determine what kind of equipment must be used to pump the water.

(b) Static water level - at what level the water stands in the casing.

(c) Drawdown level - how far down the water level will drop when pumped at a given rate.

(d) Recovery time - how long it takes for the water to recover to the static water level.

(2) Development of wells may be done by:

(a) Removal of sediments by the use of the reverse flow. Pumping of water into the well to dislodge materials, keeping them agitated for easier removal by reversing the flow.

(b) Whenever the well casing is large enough for a man to go down, the task is accomplished easily by digging out by hand and bailing out the materials.

(OFF TP #8)

OPPORTUNITY FOR QUESTIONS (4 MIN)

1. Questions from the class

2. Questions to the class

a. What is the purpose for developing a water source?

A. To improve the quantity and quality

b. How deep must the suction strainer be in water?

A. Suction strainer must be at least 4 inches in water

c. Where should a dam be constructed in relation to a stream?

A. At the narrow portion of the stream

d. What is the purpose of a float?

A. To keep the suction strainer or hose from sucking sand, rocks, or silt from the bottom

e. How much water must a spring yield before it can be used as a water source?

A. 20 GPM

SUMMARY: During the past hour I covered:

1. Inland water sources
2. Pits
3. Dams
4. Floats
5. Galleries
6. Ground water

POST TEST (10 MIN)

BREAK (10 MIN)

LIST OF SUPPORTING PAPERS

1. TP # 1 Inland Sources
2. TP # 2 Pits
3. TP # 3 Dam
4. TP # 4 Baffle Dam
5. TP # 5 Floats
6. TP # 6 Gallery
7. TP # 7 Springs
8. TP # 8 Wells
9. Advance Sheet/Student Outline

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DETAILED OUTLINE

DEVELOP A WATER POINT

INTRODUCTION (5 MIN)
(ON TP#1)

1. GAIN ATTENTION: You are informed that you must develop a water point because you are going to be there for an indefinite period of time. What are you going to do?

2. PURPOSE: To provide the student with the knowledge and skills necessary to develop a water point.

3. INTRODUCE LEARNING OBJECTIVE(S)

a. ENABLING LEARNING OBJECTIVE(S): Provided with a list of types of water point development and a list of the purposes of each type of water point development, match each type of water point development to its purpose in accordance with TM 5-700, Chapter 4. (1.3.5b)

b. I will do this by lecture.

c. At the end of this lesson there will be a written post test.

INTRODUCTORY TRANSITION: The development of a water point is the gradual improvement of the point to increase the quality and quantity of the water. Let us see what these developments are.

(OFF TP#1)

BODY (40 MIN)

(ON TP#2)

1. OBJECTIVES: The following objectives should be kept in mind. All developments can be justified if that work accomplishes one or more of the following objectives.

a. Increase the quantity of potable water available.

b. Improve the quality of the water produced.

c. Improve distribution.

d. Decrease maintenance of site.

e. Improve security.

f. Improve living conditions of water point personnel.

(OFF TP#2)

TRANSITION: Let us take a look at the planning aspects.

(ON TP#3)

2. PLANNING: Proper planning is essential to the orderly development and should be foremost in the minds of reconnaissance and supervisory personnel. The following items must be considered.

a. Tactical situation will determine the order in which improvements are to be made at a water point.

b. Location of water point within the area of operation

(1) Frontline Installation - developement is to be held down to a minimum.

(2) Rear Areas - developement varies with the size of the water point and problems to be overcome.

c. Cost effectiveness

(1) Time - how long will the water point be in operation?

(2) Labor - how many manhours must be spent in making the improvements?

(3) Troops - How many men will be needd to make the improvements?

(4) Materials - are materials needed to accomplish the task readily available or must materials be procured?

(OFF TP#3)

OPPORTUNITY FOR QUESTIONS (5 MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS: No questions are required at this time.

SUMMARY

1. Objectives

2. Planning

BREAK (10 MIN)

INTRODUCTORY TRANSITION: Now that we have discussed the purpose for developing a water point and the planning aspects, let us direct our attention to the kinds of development which must be considered.

BODY (35 MIN)

3. DEVELOPMENT

a. Drainage - poor drainage may cause area to be so muddy that it may cause water point to become inoperable. This problem can be overcome by:

(1) Selecting a site on a high level area.

(2) Dig drainage lines to carry waste water away from the site.

(3) Take care of any loose connections on the equipment.

(ON TP#4)

b. Platforms - should be used if time permits.

(1) Low platforms are used to keep tanks out of the mud thus:

(a) Allow air to recirculate underneath tank to prevent tank from rotting.

(b) Prevent tanks from being punctured by rocks or sharp objects.

(OFF TP#4)
(ON TP#5)

(2) Elevated platforms - can be best used in rear area water point for:

(a) Distribution of water using the gravity flow method.

(b) Eliminating the use of additional equipment for distribution purposes.

(OFF TP#5)

(3) Operating platforms - can be used in a poorly drained water point. These platforms may be constructed of:

(a) Beach matting.

(b) Duckboards.

(c) Any suitable material available.

c. Storage facilities - large enough to meet daily peak demand will increase efficiency by eliminating long waits at the water point. The storage facilities can be improved by the use of the following storage containers:

(1) Wood storage tanks.

(2) Bolted steel tanks.

(3) Existing facilities may be used if available.

(4) Expedient method by lining an excavation with a tarpaulin.

(ON TP#6)
(INSTRUCTOR EXPLAIN)
(ON TP#7)

(5) Utilizing the tactical water distribution system or what is commonly referred to as the TWDS.

d. Traffic Flow Improvements

(1) Turnout and Turnarounds - may be widened section of the main road or a new one-way road constructed for eliminating interference with normal traffic.

(OFF TP#7)
(ON TP#8

(2) Traffic Signs - the route to the water point should be clearly marked by signs.

(a) Posted at all critical points such as:

1. Side roads.

2. Crossroads.

3. Forks in the road.

(b) Posted within a 2-mile radius of the water point.

(OFF TP#8)

e. Distribution - can be improved by the use of:

(ON TP#9)
(ON TP#10)

(1) Standpipes.

(2) Elevated platform and standpipe combination.

f. Camouflage - misleads the enemy by misrepresenting the true identity of an installation.

(1) Water point should have good cover and concealment if possible.

(2) Camouflage nets should be used to a maximum.

(a) Purification equipment must be camouflaged if located in the open.

(b) Turnouts and turnarounds should be provided with overhead concealment at all times.

g. Bivouac Areas - when selecting a bivouac area, the factors considered should be:

(1) Security - at a water point is a must. Lack of security could result in complete loss of a water point or enable an enemy to contaminate potable water storage facilities.

(2) Facilities - bivouac site should be conveniently located with respect to the water point. Such a location will facilitate the arrange of "shifts" and make personnel readily available in case of emergency.

(3) Sanitation facilities - area should be located at least 100 feet away and downstream from the water source.

OPPORTUNITY FOR QUESTIONS (5 MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

SUMMARY: During the past two hours two hours we have discussed the items which must be considered when developing a water point.

POST TEST (10 MIN)

BREAK (10 MIN)

LIST OF SUPPORTING PAPERS

1. TP # 1 Develop a Water Point

2. TP # 2 Objectives

3. TP # 3 Planning

4. TP # 4 Low Platform

5. TP # 5 Elevated Platform
   TP # 5a Dry Point

6. TP # 6 Expedient Storage

7. TP # 7 Turnouts

8. TP # 8 Traffic Signs

9. TP # 9 Standpipes

10. TP # 10 Standpipe Illustration

11. Advance Sheet/Student Outline

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Marine Corps Engineer School
Marine Corps Base
Camp Lejeune, North Carolina 28542

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DETAILED OUTLINE

WATER RECONNAISSANCE

INTRODUCTION (ON TP#1)

(2 MIN)

1. GAIN ATTENTION: It was once said; "Deny man food and his body can sustain life for days. But deny him water and death must come within hours. Lacking enough water to maintain body processes, man loses his appetite, becomes undernourished, then incapacitated until finally death ends his suffering."

What good is all the water supply equipment that we have, if there is no water source available for us to purify?

In the past few weeks you have acquired the knowledge of the equipment that is normally found in the water supply field. This equipment and your knowledge of it would be useless unless you have an adequate water source that would yield enough water in a field environment.

To determine which water source is best, a water reconnaissance must be conducted in order for you to gather the necessary information about a particular source for later development.

Once a water reconnaissance has been conducted and all the information has been compiled, we can determine which water purification unit can be utilized to render the water safe for human consumption.

2. PURPOSE: The purpose of this period of instruction is to provide you with the knowledge and skills required for performing a water reconnaissance.

3. INTRODUCE LEARNING OBJECTIVE(S) (3 MIN)

a. TERMINAL LEARNING OBJECTIVE(S): Provided with a map, a proposed water source to be reconnoitered, DA form 1711R, DA form 1712R, and materials for the routine control tests, perform a water reconnaissance in accordance with TM 5-700, Chapter 3. (1.3.5)

b. ENABLING LEARNING OBJECTIVE(S)

(1) Provided with a map and grid coordinates of a proposed water source:

(a) Mark on the map a route to the water source. (1.3.5c)

(b) Make a written estimate of the time needed to march to the water source.

in accordance with TM 5-700, Chapter 3.

(2) Provided with reconnaissance report forms 1711R and DA 1712R, and a water source, complete each form in accordance with TM 5-700, Chapter 3. (1.3.5e)

TRANSITION: The first thing we are going to discuss is the purpose of a water reconnaissance and who shares the responsibility to make sure that a reconnaissance is performed.

(OFF TP#1)

BODY (5 MIN)

1. Water reconnaissance Purpose and Responsibilities

a. Special engineer reconnaissance conducted to gather information about water sources.

(ON TP#2)

b. The unit commander is responsible to make sure that his men have an adequate amount of water for all purposes.

(ON TP#3)

c. The primary responsibility for water supply is vested in the S-4 who coordinates reconnaissance activities with the S-2.

(ON TP#4)

d. The engineer unit leader is tasked with locating water sources.

(ON TP#5)

e. Medical Department. Inspects quality of the water and makes recommendations on improvement of water point.

TRANSITION: Now that you know the purpose and responsibilities let's look into selecting a water source.

2. Selecting a Water Source (MIN)

a. A satisfactory water source in one of sufficient quantity to meet troop needs.

b. A source developed for military use is called a water point.

c. Water classifications

(1) Surface water: lakes, streams, rivers

(2) Ground water: wells and springs

(3) Sea water: salt water and brackish water

(4) Minor sources: rain, snow, and ice

(ON TP#7)

d. Types found in various regions

(1) Arctic and sub-arctic regions

(a) Lakes

(b) Muskeg areas - Grassy bogs

(2) During the winter months the only source to be found are

(a) Very deep lakes

(b) Some wells

(c) Ice and snow are plentiful. However, because of the unavailability of devices to melt snow or ice, they are the least desireable water sources.

(3) Humid regions

(a) Lakes very in sizes and depths

(b) Streams may contain an adequate supply of fresh water to support any troop need.

(c) Ponds are a common source. However, the water may be stagnant or may contain algae.

(4) Tropical regions may contain some underground water, but may only be found as a lens or small amount floating on top of the salt water.

(a) Due to the amount of rain fall one may find runoffs in the form of streams.

(b) Due to the elevation of such areas the possibility of locating a large source is slim.

(ON TP#8)

(5) Desert regions are known to be sub-divided into three principal areas.

(a) Mountain ranges - will have runoff but very little surface sources.

(b) Upper alluvial slopes may only contain ground water at great depths.

(c) The valley fill at lower parts of the basin contains most of the ground water.

OPPORTUNITY FOR QUESTIONS

!. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS: None at this time

SUMMARY: During this period we have discussed:

1. Purpose and responsibilities of a water reconnaissance.

2. Selecting a water source.

BREAK (10 MIN)

INTRODUCTORY TRANSITION: Now that we know what kinds of water are normally found in various regions of the world, let's look at the phases involved in a water reconnaissance.

3. First Phase or the Preliminary Planning (MIN)

(ON TP#9 THREE PHASES)

a. Field reports are most important and reliable source of information. The G-2 section may provide information which has been gathered from the local inhabitants or from interogation of POW's.

b. Map studies should be taken into consideration. Also aireal photos of the area should be studied before the actual ground reconnaissance. The information obtained from maps are:

(1) Drainage lines can be identified which are an indication where no streams are indicated.

(2) Water sources down stream of human habitations are subject to contamination. If possible, water points should be located upstream from a village whether inhabited or abandoned.

(3) Road nets are best shown on maps, although the credibility of the information obtained from the map study will depend largely on the date of the map being used.

(4) Fundamentals of map reading

(a) The map is laid out with the name at the top and the sheet number at the upper right hand corner; the legend is located at the bottom left hand corner of the map.

Note: The legend indicates what the different colors mean on the map and how certain terrain features, e.g. roads, contour lines, are represented on the map.

(b) Colors of the map

1. Red is used for primary roads.

2. Green is used to designate woods, orchards, etc.

3. Blue is used to designate rivers, streams and lakes.

4. Brown lines on the map are contour lines and they show elevation.

5. Black shows secondary roads and manmade objects.

(c) Scale of the map is located near the bottom center.

Note: It the scale on the map is 1:25,000 it means that any increment of 1 on the map = 25,000 on the ground, e.g. 1 inch is = 25,000 inches.

(d) the direction of true north and magnetic north is located on the bottom of the map.

(e) Reading grid coordinates

1. Longitude lines run north and south.

2. Latitude lines run east and west

3. These lines are called grid lines.

Note: Instructor will give an example on how a city map the streets run north and south and east and west just as the grid lines do on a military map.

4. To read a grid coordinate you read right then up.

Note: Show students an example on the map. Instructor will show the students how to break up the grid coordinate down into six-digits.

(30 MIN)

PRACTICAL APPLICATION: The instructor will give the students several grid coordinates to look up on the New River map:

1. 832295 BB49

2. 799287 Drawbridge

3. 890320 Road intersection

4. 932442 Reservoir

5. 852439 Camp Lejeune School

6. 878346 French Creek & Jumping Run

INTRODUCTORY TRANSITION: Now let's look into measuring distance on a map.

(f) Measuring distance by using graphic (Bar) scales located at the center bottom of the map.

1. Straight line distance is measured by using edge of a piece of paper, putting a tick mark at the two points you are measuring and move down to the graphic scale and read the distance.

2. Curved line distance is measures by placing a tick mark at the start of the road or stream and make a tick mark at the end of the straight section. Then rotate the piece of paper keeping the second tick mark in place and make another tick mark at the end of the next straight section of the road and so on, then move the piece of paper down to the graphic scale and read the distance.

(15 MIN)

PRACTICAL APPLICATION: The instructor will give the students 4 distances to find by using grid coordinates below.

1. Straight 835297 to 799287 2.3 miles

2. Straight 835297 to 878346 3.8 miles

3. Curved 835297 to 799287 By the road 4 miles

4. Curved 835297 to 878346 4.8 miles

Note: During this class use 3 miles per hour to calculate the time.

c. Personnel and equipment

(1) Personnel selected to perform a water reconnaissance should include at least one qualified water supply specialist. He should be thoroughly familiar with water treatment processes and know how to produce potable water with available equipment.

(2) The reconnaissance team should be accompanied by a representative of the medical department.

d. Route and time schedule should be established. This is begun by determining from a map study or other sources of information about possible water sources to be reconnoitered. Then with a map at hand, time should be alloted for travel to and from the sites as well as additional time for any unforseen events and for preparing and submitting of the report.

OPPORTUNITY FOR QUESTIONS (MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS: None at this time

(OFF TP#9)

SUMMARY: During the last period of instruction I covered: (MIN)

1. Purpose and responsibilities

2. Selecting a water source

3. Water classification

4. Types of water found in various regions

5. The first phase or preliminary planning of water reconnaissance

BREAK (10 MIN)

INTRODUCTORY TRANSITION: During the next period of instruction, I will cover the second and third phases of the water reconnaissance.

(ON TP#9)

BODY (MIN)

4. Second Phase - Air and Ground Reconnaissance

a. Aid reconnaissance may be utilized if aircraft are available. An air reconnaissance is generally a reliable means for rapidly securing information about water sources over a large area.

(1) If a helicopter is used, the air and ground reconnaissance can be conducted as one.

(2) The use of aircraft for reconnaissance is limited by adverse weather conditions and security considerations.

b. Ground reconnaissance is the only positive way of getting accurate information from which to select a water point. The factors to be considered during the ground reconnaissance are:

(1) Quantity of water (Instructor will ad-lib)

(ON TP#10)

(2) Quality of water - the water should be of such quality that it can be approved for use or readily purified with normal field equipment. By the use of test kits, the pH can be determined.

(Instructor will explain pH Chart at this point.)

(ON TP#11)

Valuable information can be obtained by close observation and common sense in the following quality characteristics:

(a) Color of the water (Instructor explain colors)

(b) Tubidity - (explain)

(c) Odor - (explain

(d) Taste - use caution when tasting water by insuring that no water is swallowed.

(e) Check for possible sources of pollution

(f) Condition of vegetation around sources; dead or mottled vegetation may indicate the presence of chemical agent

(g) Presence of dead fish, frogs, etc may also indicate the presence of some type of poisons

(ON TP#9)

(3) Routes of communications. A satisfactory water point must be accessible to both vehicles and personnel.

(ON TP#12)

(4) Site conditions (Instructor explain in detail - all three things being covered)

(a) Drainage

(b) Security

(c) Bivouac area for personnel

(OFF TP#12)

OPPORTUNITY FOR QUESTIONS (MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS: None at this time

SUMMARY: During the last period of instruction I covered the:

1. The second phase of air and ground reconnaissance

2. Quantity of water

3. Quality of water

4. Routes and communication

5. The site conditions

BREAK (10 MIN)

INTRODUCTORY TRANSITION: Now that we have the foundation for conducting a water reconnaissance, let's take a look at the most important phase of the three phases of water reconnaissance.

BODY (MIN)

5. Third Phase - Reports

(ON TP#13, ENGINEER REPORT)

a. Engineer Report - front page (Instructor will explain step by step) have students fill out by T.P. for example.

b. Back page of engineer report - have students fill out by T.P. for example

c. Water reconnaissance report - have students fill out by T.P. for example

(ON TP#14, WATER RECONNAISSANCE REPORT)

PRACTICE: At this time the instructor and assistant instructor guide the students in completing an engineer reconnaissance report.

(OFF TP#14)

OPPORTUNITY FOR QUESTIONS (MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS: None at this time

SUMMARY: During this last period of instruction I covered:

1. The Engineer reconnaissance report

2. Backside of the report

3. Conducted a practice on how to complete the report

BREAK (10 MIN)

INSTRUCTORS NOTE: At this time pass out the programed instruction and have the students complete during the night and return the next working day to the instructor.

PRACTICAL APPLICATION: The instructor will assign himself and 3 other instructors a point on the map to be reconnoitered by the students. The class will be split into 4 teams and assigned a particular site to reconnoiter, students will be provided on an area map, engineer reconnaissance report, water reconnaissance report and water reconnaissance checklist.

1. At this time the teams will plan their route, time schedule, and assemble all material to do the required test at the site to be reconnoitered.

2. The team leader will give the instructor his route, time schedule and a list of students in his/her team.

3. The team leader will be instructed to return to CHB area by no later that 1445.

4. The students will clean and secure all materials used.

The instructor will issue exam the following morning (U-10C08)

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ADVANCE SHEET/STUDENT OUTLINE

1500 GPH WATER PURIFICATION UNIT

PURPOSE: The purpose of this period of instruction is to provide you with the knowledge and skills necessary to operate the 1500 GPH Erdlator.

TERMINAL LEARNING OBJECTIVE: Provided with a 1500 GPH Water Purification Unit (Erdlator), chemicals, two 3 gallon buckets, power supply, and water supply, purify water in accordance with TM-04461A-15, Chapter 2. (1.4.3)

ENABLING LEARNING OBJECTIVES: Provided with a 1500 GPH Water Purification Unit (Erdlator), chemicals, power supply, water supply, and two 3 gallon buckets

1. Point out each major component of the unit (1.4.3a)

2. Install the unit (1.4.3b)

3. Perform before operation maintenance on the unit (1.4.3c)

4. Prepare the required chemicals (1.4.3d)

5. Start the unit (1.4.3e)

6. Perform operational adjustments (1.4.3f)

7. Shut the unit down (1.4.3g)

8. Perform after operation maintenance on the unit (1.4.3h)

in accordance with TM-04461A-15, Chapter 2.

STUDENT REFERENCE(S): TM-04461A-15

ASSIGNMENT: Review Chapter 2, Section II, pp. 2-25 to 2-32 in SRT-UT-P02 (Student Reference Text Field Water Supply and Water Purification Equipment)

OUTLINE:

1. NOMENCLATURE

a. Van type body mounted water purification unit.

b. Erdlator assembly.

(1) Erdlator tank.

(2) Agitator shaft with circular disks.

(3) Sludge concentrator tank.

(4) Wet well tank.

(5) Influent launder.

(6) Aspirators.

(7) Agitator drive motor.

(8) Speed reducer.

(9) Filter section.

c. Chemical feed equipment.

(1) Slurry feeder.

(2) Chemical solution feeder assembly.

d. Supporting equipment.

(1) Electric pumps.

(2) Auxiliary pump.

(3) Water storage tanks.

(4) Personnel heater.

(5) M-64 set.

2. INSTALLATION:

a. Set up unit as close to source as possible on level terrain.

b. Leveling jacks.

c. Check levels.

d. Open side panel doors.

e. Unload supporting equipment.

f. Preoperation valve settings - (REFER TO STUDENT HANDOUT).

g. Setting of controls (REFER TO STUDENT HANDOUT).

h. Trailer mounted generator set.

(1) Not more than 50 feet away from unit.

(2) Preoperation maintenance check.

(3) Safety check.

(a) Units grounded.

(b) Loose or frayed wires.

(c) Breakers off.

(4) Connect power cable.

i. Raw water pump.

j. Hoses.

(1) 1-1/2 inch, 25 foot discharge hose to pump discharge.

(2) 1-1/2 inch, 10 foot suction hose to suction side of pump.

(3) 1-1/2 inch, 25 foot discharge hose to female hose connection.

(4) 2 inch, 20 foot suction hose to erdlator drain.

(5) 2 inch, 20 foot suction hose to filter drain.

k. Set up storage tanks.

l. Set up distribution pump.

3. <u>LUBRICATION INTERVALS AND LUBRICANTS</u>

a. Lubrication intervals according to lubrication instructions.

b. Lubrication Points.

(1) Agitator.

(a) Agitator drive shaft bearings.

(b) Agitator gear assembly.

(c) Agitator shaft bearing.

(d) Agitator gear assembly.

(2) Filter section plug valves.

(3) Chemical slurry feed equipment.

(a) Slip clutch and slurry feeder bearings.

(b) Slurry feeder chain tightener.

(c) Slurry feeder gear assembly speed reducer.

(4) Chemical solution feeder assembly.

4. CHEMICAL REQUIREMENTS

a. Ferric chloride.

b. Calcium hypochloride.

c. Pulverized limestone.

d. Diatomatious earth.

e. Activated carbon.

5. STARTING

a. Prime and start raw water pump.

b. Chemical solution feeder.

c. Chemical slurry feeder.

(1) Adjust valve CV-8.

(2) Set FEI-6.

(3) Charge limestone hopper.

d. Agitator.

e. Bleed raw water flow indicator.

f. Adjust CV-9.

g. Drain off foreign material.

h. Level effluent launder.

i. Partially open CV-14.

j. Open CV-16.

k. Open CV-14.

l. Open CV-17.

m. Adjust chemical solution feeder.

n. Close DV-25.

6. OPERATIONAL ADJUSTMENTS

a. Precoat cycle.

(1) Preposition valves.

(a) Close CV-32.

(b) Close CV-33.

(c) Set CV-36.

(d) Close CV-37.

(e) Open CV-38.

(f) Close DC-39.

(g) Open CV-40.

(h) Open DC-41.

(i) Close DC-42.

(j) Open DC-43.

(k) Close DC-44.

(l) Adjust CV-45.

(m) Set CV-46 on recirculate.

(n) Close DV-47.

(o) Close DC-48.

(p) Set ARV-49 to filter.

(q) Close CV-50.

(2) Mix D.E.

(3) Open CV-37.

(4) Close CV-37.

(5) Open CV-34.

(6) Start filter pump.

(7) Close CV-38.

(8) Precoat.

b. Filter cycle.

(1) CV-46 to filter.

(2) Open CV-50.

(3) Prepare D.E. for slurry hopper.

(4) Open CV-33.

(5) Close CV-33.

(6) Open CV-32.

(7) Add D.E. to compartment.

(8) Set FEI-5.

(9) Close CV-32.

(10) Filter cycle lasts 10 minutes to 10 hours.

c. Backwash.

(1) Four reasons for backwash.

(2) To go into backwash.

(a) Close CV-40 and CV-50.

(b) Let pressure gauges equalize.

(c) Shut down filter pump.

(d) Close CV-34.

(e) Close DV-23.

(f) Turn ARV-49 to backwash and open DV-47.

(g) Open CV-38.

(h) Allow filter to drain.

d. Wash cycle valve adjustment.

(1) CV-36 to wash.

(2) Open CV-34.

(3) Start filter pump.

(4) Wash.

(5) Stop filter pump.

(6) Close CV-34.

(7) Drain.

7. SHUTDOWN

a. If operation of the unit will be within 24 hours.

b. Close.

c. Open drain valves DV-26 and DV-27.

d. Turn off slurry feeder drive.

e. Remove chemical hoses.

f. Empty solution trays.

g. Stop solution feeder.

h. Stop agitator drive.

i. Open valves and draincocks.

j. Stop raw water pump.

k. Open petcock valve on raw water pump.

l. Disconnect hoses.

m. Shut down generator.

8. POST-OPERATION MAINTENANCE

a. After every operating period.

b. General.

(1) Inspect unit.

(2) Keep work area clean.

c. Lubrication.

d. Check for leaks.

e. Personnel heater.

f. Clean equipment.

g. Clean chemical hoppers and trays.

h. Clean tools and support equipment.

i. Secure side panels and doors.

j. If unit is not going to be used again, disconnect.

(1) Electrical cable.

(2) Leveling jacks.

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U-10D07/U-22E04
JUNE 1985
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STUDENT HANDOUT #1

WATER PURIFICATION UNIT 600 GPH

1. Prepositioning of valves

NUMBER	NAME	POSITION
FCV1	Raw water restrictor valve	10 GPM
LLCV1	Raw water by-pass valve	Open
BV1	Raw water inlet valve	Open
CV2	Limestone slurry feed valve	Partially open
DV3	Complete drain valve	Closed
DV4	Partial drain valve	Closed
CV5	Solution make-up valve	Closed
BV6	Weir box outlet valve	Open
CV7	Liquid level control valve	Closed
CV8	Sludge control valve	Open to first notch
CV9	Sludge drain valve	Closed
DV10	Wet well drain valve	Open
CV11	Diatomite slurry feed valve	Closed
BV12	Filter pump discharge valve	Closed
CV13	Filter input valve	2 Position valve, wash and filter, set on filter
VV14	Vent valve	Open
CV15	Precoat feed valve	Closed
DV16	Filter drain valve	Closed
ARV17	Air release valve	2 Position, filter & backwash setting on filter
BV18	Filter discharge valve	Open
DC19	Drain cock	Closed
CV20	Flow control valve	Set at 10 GPM
DC21	Drain cock	Closed
DC22	Drain cock	Closed
CV23	Filter output valve	2 positions, filter & recirculate set on recir.
CV24	Air control valve	Partially open
DV25	Raw water pump drain plug	Installed
DV26	Filter pump drain plug	Installed

2. Chemical Requirements

a. Ferric chloride is a coagulant - it takes 1 pound of ferric chloride to 3 gallons of water mixed in 1 of the 3 gallon pails. The scale setting on the solution feeder on the ferric chloride side is 1.2.

b. Pulverized limestone is a coagulant aid. It takes 120 PPM of limestone in the slurry hopper. The limestone slurry hopper is recharged every hour of operation.

c. Calcium hypochlorite is a disinfectant. It takes .15 pounds of calcium hypochlorite in 3 gallons of water. The scale setting on the solution feeder for the calcium hypochlorite is 5.0, until your erdlator tank is full of water, and then the scale setting is reduced to 1.2.

d. Diatomaceous earth is a filter aid. It takes 0.4 pounds of D.E. in the precoat funnel for each precoat cycle. D.E. is also used in a diatomite slurry hopper. It's required amount is .10 pounds to each hour of operation.

e. Activated carbon is the absorbent. It takes .25 pounds of activated carbon added to your limestone slurry hopper if there is an unpleasant odor or taste in the water that you are about to purify.

f. <u>CAUTION</u>: Do not mix ferric chloride and calcium hypochlorite together in any large quantities. When these two chemicals are mixed together they will form chlorine gas which is very dangerous.

3. Chemical Adjustment.

a. FERRIC CHLORIDE

(1) If water in the erdlator tank is cloudy in color the adjustment to be made would be to increase the ferric chloride.

(2) If the water is red in color you would reduce the ferric chloride.

b. LIMESTONE

(1) If the flock in the erdlator tank should appear to be light and rising you would increase the pulverized limestone.

(2) If the flock appears heavy and rolling you would decrease the amount of pulverized limestone.

c. ACTIVATED CARBON

(1) If there should be any unpleasant odor or taste to the water that is purify you would add activated carbon to the limestone side of the slurry hopper.

d. ROTATING ADJUSTMENT

(1) When the blanket in the erdlator tank is banking and slushing against the sides decrease the speed on the agitator speed reducer.

(2) If there is little or no movement in the blanket you would increase the speed on the agitator speed reducer.

MAINTENANCE INSTRUCTIONS

1. SOLUTION FEEDER:

a. Solution feeder drive arm bearings are lubricated every 250 hours of operation.

b. Solution feeder drive arms are oiled every 50 hours of operation.

c. Solution feeder lever arms are lubricated every 50 hours of operation.

d. Solution feeder oil is checked before operation and 10 hours of operation thereafter. The oil is changed every 500 hours of operation. It takes a special purpose electrical insulated oil.

2. AGITATOR SPEED REDUCER:

a. Agitator speed reduction gear is lubricated every 50 hours of operation.

b. Upper agitator shaft bearing is lubricated every 50 hours of operation.

c. The oil in the agitator speed reducer is checked before operation and every 10 hours thereafter. It is changed every 1,000 hours of operation. It takes 1/4 pounds of GAA grease.

3. TRAILERS LEVELING JACKS

a. The trailers leveling jacks are lubricated every 250 hours.

OPERATION OF WATER PURIFICATION UNIT AND FILTER ASSEMBLY

1. Make maintenance check on generator and erdlator assembly.

2. Safety check:

a. Make sure there are no loose or frayed wires.

b. Make sure all breakers are "OFF" in the control box.

c. Make sure both units are grounded.

3. Mix chemicals in 3 gallon pails

a. Ferric chloride (1 pound to 3 gallons of water)
b. Calcium hypochlorite (.15 pounds to 3 gallons of water)

4. Install poppit valves, rubber washers and plastic disc in solution feeder pump.

a. Set ferric chloride side at 1.2

b. Set calcium hypochlorite at 5.0

5. Set valves in preliminary position.

6. Install hoses in proper positions:

a. 1" x 25' discharge hose on 90° elbow at CV23 to storage tank.

b. 1" x 25' discharge hose from raw water pump to water inlet pipe.

c. 1" x 10' suction hose with strainer on end to raw water source to the suction side of raw water pump.

d. 1" x 10' suction hose from CV23 on 45° elbow to the wet well tank.

e. 1" x 10' suction hose on CV13 to BV12.

f. 1 1/4" x 10' suction hose on DV3 to drain.

g. 1 1/4 x 10' suction hose on DV16 to drain.

7. Prime raw water pump and start pump.

8. Start solution feeder as soon as you have water in your influent launder.

9. As soon as there is 1' of water in the erdlator tank, start the agitator.

10. Fill the limestone slurry hopper with raw water and add 120 PPM of pulverized limestone.

11. Wait until erdlator tank is full of water.

12. When erdlator tank is full of water, lower one side of the effluent launder and let trash and dirt drain off the top of the erdlator tank into the effluent launder and into the wet well and out to waste.

13. Close DV10

14. Crack CV9 and level water in the sludge concentrator tank.

15. Then level effluent launder so water enters hose evenly all the way around

16. Reduce the scale setting on the solution feeder calcium hypochlorite side from 5.0 to 1.2

17. Take clean bucket and fill precoat feed funnel on filter assembly 2/3 full of precoat water.

FOUR CYCLE OPERATION

There are four cycles of operation:

1. PRECOAT

a. Take 0.4 pounds of D.E. and mix it with your hand, open CV15 and let drain into your filter.

b. Close CV15

c. Open DV12

d. Start filter pump

e. Precoat from 4 to 6 minutes or until the water is clear in the observation window in the filter assembly or you can see a good coat of D.E. on the filter sleeves.

f. Flow of water during precoat cycle - the water leaves the wet well through a yellow pipe into the filter pump. It travels through BV12 through the 10' piece of suction hose in CV13. It drops down through CV13 into the bottom of the filter section. It rises on the inside of the filter housing out on the outside of the filter sleeves, until it reaches the top of the housing. The water is then forced through the filter sleeves and elements leaving a cake of D.E. on the outside of the filter sleeves. Water then drops down through the filter element out the false bottom of the filter housing into BV18, CV20, into CV23 out of the 45 degree elbow through a 10' piece of suction hose and into th wet well tank.

2. FILTER CYCLE

a. Fill D. E. hopper with coagulated water and add 10 lbs. of E. E. to the hopper.

b. In order to go into the filter cycle change CV23 from recirculate to filter and crack CV11 to where there is a small amount of D.E.

c. This small amount of D.E. will repair any pinholes or cracks in your filter sleeves that you may develop during your filter cycle.

d. The filter cycle may run from 10 minutes to 10 hours.

3. BACKWASH

a. There are 4 times you have to backwash

(1) When your source is dry

(2) When your storage tanks are full

(3) If you have an interruption in your operation

(4) If the effluent pressure gauge drops to 5 PSI

b. The way to go into a backwash cycle is

(1) Close BV18

(2) Close CV11

(3) Wait until the pressure equalizes

(4) Shut off your filter pump

(5) Close BV12

(6) Change ARV17 from filter to backwash and open DV16

(7) Open VV14 and let filter drain completely

4. WASH CYCLE

a. The wash cylce lasts for one minute

(1) Change CV13 from filter to wash

(2) Open BV12

(3) Start filter pump and wash for one minute

(4) Cut off your filter pump

(5) Close BV12

(6) Let filter assembly drain completely

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U-02F14/U-05F14
U-10C07/U-22D06
APR 1984
(D-1042)brw

WATER RECONNAISSANCE

CHECK LIST

Reconnaissance reports must be prepared carefully and delivered on time. They must be clear, complete and concise.

Advance Reconnaissance.

Advance reconnaissance reports need merely be good reconnaissance field notes. The work estimate must include the men, equipment and materials required to put the water point in operation. If time permits an estimate of the work necessary to develop the point is included.

Higher Echelon Reconnaissance.

Higher echelon water reconnaissance reports must be detailed as they become part of engineer planning data.

Check List for Water Reconnaissance.

Information on the following items must be obtained and recorded:

1. Quantity available.

2. Quality.

    a. Color.

    b. Odor.

    c. Turbidity.

    d. Taste.

    e. Possible sources of pollution.

    f. Condition of vegetation.

    g. pH value.

    h. Chlorine demand.

    i. Tests for chemical warfare agents.

3. Communications.

   a. Condition of roads.

   b. Extent of road net.

   c. Traffic circulation.

4. Site conditions.

   a. Cover and concealment.

   b. Possible aerial and artillery targets.

   c. Drainage.

   d. Bank conditions.

   e. Access roads and parking area.

   f. Bivouac area for operators.

5. Work estimate.

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U-10C02/U-22C01
Feb 1984
(D-1003)ed

STUDENT HANDOUT # 1

COAGULATION JAR TEST

In order to conduct the coagulation jar test you must have a standard alum and a standard soda ash solution. To make this solution you must have the following:

1. Pulverized alum
2. Pulverized soda ash
3. Two, 1 gallon containers
4. Stopper jars: One marked alum and one marked soda ash
5. Test tubes from comparator

STEP 1: Fill the two, 1 gallon jugs with best water available. Mark each jug (one alum and one soda ash).

STEP 2: Make alum solution by filling test tubes with pulverized alum (1 1/2 tubes) and then add to gallon jug marked alum.

STEP 3: Make soda ash solution by filling test tube with pulverized soda ash (1 tube) and then add to gallon jug marked soda ash.

STEP 4: Shake both jugs until chemicals are dissolved and then fill small stopper bottles.

Now that you have prepared the solutions you are ready to start the coagulation jar test. To do this you must have the following:

1. Standard alum solution
2. Standard soda ash solution
3. Five, 8 ounce jars
4. Two eyedroppers graduated in mililiters
5. 40 ounces of water to be tested (only if not near source)

STEP 1: Take a PH determination test of the water to be tested.

STEP 2: Make chart and add dosages according to the PH of the water to be tested.

JARS	1	2	3	4	5
ALUM					
S.A.					

STEP 3: Wash out and fill the 8 ounce sample water jars with the water to be tested.

STEP 4: Add the dosage from the chart to sample jugs by using eyedroppers.

STEP 5: After chemicals have been added the jars must be agitated to ensure that the chemicals are thoroughly mixed and promote faster formation of the floc.

STEP 6: Observe to determine which jars produce the best floc in the least amount of time, and which settles the fastest.

STEP 7: Select two of the jars which have the best floc and a take a PH test to find Optimum PH.

STEP 8: After finding the jar with the Optimum PH, take the corresponding dosage from the chart and work the formula to find how many pounds of alum and soda ash it will take to coagulate a 3000 gallon tank of water. Note: You must work the formula twice, once for alum and once for soda ash.

$$\frac{\text{GALLONS OF WATER TO BE TREATED X DOSAGE IN GRAINS PER GALLON}}{7000}$$

(REMEMBER: Dosages in chart are in P.P.M. and the dosage in the formula are in G.P.M. One PPM is equal to two GPG.)

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STUDENT HANDOUT # 2

CHLORINE DEMAND TEST

The chlorine demand test is used as a guide in determining how much chlorine is needed to treat a given water. Briefly, the test consists of: preparing a measured test dosage of chlorine, adding it to a sample of the water to be treated, and reading the resultant residual after 30 minutes contact time. Required dosage is then computed; it is the chlorine needed to equal the sum of the demand plus the minimum required residual.

In order to conduct the chlorine demand test, you MUST have the following equipment.

1. Color comparator with eyedropper graduated in mililiters
2. One packet of chlorine (7.14 grams)
3. Two canteens

STEP 1: Fill two canteens, one with the best available water and the other with the water to be tested.

STEP 2: The canteen with the best available water is used to make a standard chlorine solution. To make this solution add 7.14 grams of chlorine to canteen containing best water. NOTE: This will give the solution a strength of 5000 PPM.

STEP 3: After adding chlorine, shake canteen vigorously to dissolve chlorine, then let it sit for 30 minutes.

STEP 4: After 30 minutes take one mililiter of this chlorine solution and add it to the canteen containing water to be tested. NOTE: This will give the water in this canteen a strength of 5.0. This will be considered the dosage.

STEP 5: Shake this canteen vigorously and let it set for 30 minutes.

STEP 6: After 30 minutes take a chlorine residual test on the water being tested. Subtract the residual from the dosage and the answer will be the chlorine demand. The chlorine demand is the result we are looking for.

CHLORINE DOSAGE - CHLORINE RESIDUAL = CHLORINE DEMAND

STEP 7: After you find the chlorine demand you will be told by the medical department what chlorine residual to maintain in the 3000 gal water tank. Add the chlorine demand and depending on the PH of the water which you must take from the chart that was given to you in our previous class, determine dosage that will be used to disinfect 3000 gallons of water.

$$\text{POUNDS OF CHLORINE} = \frac{\text{GALLONS OF WATER} \times 8.34 \times \text{DOSAGE OF CHLORINE IN PPM}}{1{,}000{,}000}$$

$$\text{DOSAGE IN OUNCES} = \frac{\text{POUNDS OF CHLORINE} \times 16}{0.7}$$

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WATER RECONNAISSANCE REPORT DATE PAGE OF PAGES

TITLE NUMBER	REPORT NUMBER	REPORTED BY (Name-Grade-Organization

FORWARDED TO

1. Location of Water Source

MAP COORDINATES

2. TYPE OF SOURCE (Check one) ( ) Stream ( ) Lake ( ) Pond ( ) Spring ( ) Well ( ) Reservoir	LOCAL NAME OF SOURCE

3. DATE AND HOUR INSPECTED	YIELD		
	IMMEDIATE (gpm)	ULTIMATE (gpm)	(Give work estimate

5. Quality

COLOR	ODOR	TASTE

TURBIDITY (estimate ppm)	pH TEST	CHLORINE DEMAND TEST (ppm)

POSSIBLE SOURCE OF POLLUTION

6. Communication

DISTANCE TO CONSUMERS	ROADS	RAILROADS	BRIDGES

7. Site conditions (if municipal system use item 9 & 10)

SECURITY

DRAINAGE

BANKS (if surface source)

DISTRIBUTION FACILITIES (existing)

8. SKETCH OF AREA (show road net and traffic circulation) (use reverse side for additional sketches, if necessary)

9. SKETCH OF WATER POINT. (Show proposed set up for immediate operation, if water point is a municipal system, include sketch of system) (Use reverse side for additional sketches, if necessary).

10. DESCRIPTION AND SKETCH OF PROPOSED DEVELOPMENTS. (If municipal system, include survey) (Use reverse side for additional sketches, if necessary).

11. WORK ESTIMATES

FOR IMMEDIATE OPERATION

TASK	MAN HOURS	EQUIPMENT	MATERIALS

FOR DEVELOPMENT

TASK	MAN HOURS	EQUIPMENT	MATERIALS

TYPED NAME AND GRADE SIGNATURE

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ENGINEER RECONNAISSANCE REPORT			PAGE OF PAGES
TO:		FROM:	
FILE NO.	PARTY LEADER: (Name, Rank, Organization)	PLACE HOUR DATE	
MAPS:			
DELIVER TO: (Organization, Place, Hour, Date)			

KEY	OBJECT	TIME OBSERVED	WORK ESTIMATE	ADDITIONAL REMARKS AND SKETCH
				ENGINEER WORK ESTIMATE ON OTHER SIDE

TYPED NAME, RANK & ORGANIZATION	SIGNATURE

ENGINEER WORK ESTIMATE

LOC KEY	DESCRIPTION OF WORK	UNIT REQ'D	HOUR	EQUIPMENT			MATERIALS		
				TYPE	NO.	HOURS	TYPE	UNIT	QTY

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FIELD WATER SUPPLY
AND
WATER PURIFICATION
EQUIPMENT

SR-UT-P02

MARINE CORPS ENGINEER SCHOOL

MARINE CORPS BASE

CAMP LEJEUNE, NORTH CAROLINA

PREFACE

Field Water Supply is designed to supplement OJT for sergeants and below in MOS's 1121 and 1122. It includes a study of the characteristics and sources of water, recognized methods of purifying water, and various water supply equipment used by the Marine Corps.

A water-supply man will be able to do such things as treat, test, and distribute water; install and operate water purification and distillation units; and perform operator's maintenance on the equipment required for his job.

SOURCE MATERIALS

TM 5-700	Field Water Supply, Jul 67 w/Ch 1 dtd Nov 70
TM-01056C-14	Water Purification Unit, Model U22446, Operations and Maintenance, Aug 71
TM-01274D-14	Distillation Unit, Water, PD200LP, Operation and Maintenance, Feb 1975
TM-03957A-15	Water Purification Unit, Trailer-Mounted, Model A800011, Oct 64
TM-04461A-15	Water Purification Equipment Set, Mobile Erdlator-Type Clarifier' Diatomite-Type Filter, 1500-GPH, Operation and Maintenance, Aug 1967
TM 5-4320-200-15	Pump, Centrifugal, Frame-Mounted, Barnes Model 17570, Nov 1968 w/Ch 1 & 2
TM 5-4320-251-14	Pump, Reciprocating, Gas-Driven, Wheel-Mounted 100-GPM, Gorman Rupp Model 4D-2A016, Operation, Mar 1971
TM 5-4320-251-24P	Pump, Reciprocating, Gas-Driven, Wheel-Mounted, 100-GPM, Gorman Rupp Model 4D-2A16, Organizational, Oct 1971
TM 5-4320-252-14	Pump, Reciprocating Diaphagm, 100-GPM, Rex Chainbelt Model 4DG, Dec 1968
TM 5-2805-256-14	Military Standard Model Gasoline Engines, 1 1/2 HP, Sep 68 w/Ch 1 & 2
TM 5-2805-257-14	Military Standard Gasoline Engines, 3 HP, Sep 68, w/Ch 1 2, & 3
SL-3-00970A	Pump, Centrifugal, May 1970
Manufacturer's Manual	Pumping Assembly, Deep-Well, Gasoline-Engine and Electric-Motor-Driven, Enclosed Impeller Turbine (Worthington)
TM 00848D-15	Bath Unit, Trailer Mounted Model EC-8B-64 Operation and Maintenance

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CHAPTER 1

GENERAL WATER SUPPLY

1-1. INTRODUCTION TO WATER SUPPLY

Today in the Marine Corps, you as a hygiene equipment operator can contribute greatly toward the successful completion of the mission of your unit since one of the most important supplies for combat Marines is safe water. The water requirements for the Marine infantry battalion are great; therefore, water points are established as close to the front lines as possible. On occasion, water points have been established in front of the FEBA (Forward Edge of the Battle Area). As you can see, hygiene equipment operators must be able to purify water under any and all conditions. You must be able to detect contaminated water and know the treatment for it. You must know how to set up distribution facilities to speed purified water to the troops. In camps, your job is even more complex. You must know how to run water and sewage systems, and be able to perform maintenance on these systems.

The MOS of a hygiene equipment operator is 1171. 1171 covers all the MOS qualifications necessary to install, operate, maintain, and repair plumbing, heating, sewage, and water supply equipment and accessory materials. MOS 1171 is only one MOS found in the occupational field in (OF11). The Electrician's MOS is 1141 and 1142 is an Electrical Equipment Repairman. MOS 1161 covers Refrigeration Machanics. People assigned these MOS's advance in rank until they reach the rank of staff sergeant, after which they must qualify as a Utilities Chief (1169) for futher promotion.

a. Importance. The lack of water affects a Marine's health, welfare, moral, and the accomplishment of his mission. Without water, a Marine's capacity to carry out his mission is about 2 days. In extreme heat or when undergoing extreme physical exertion, it is less than a day. The water a Marine drinks must be safe and available in sufficient quantities at all times; therefore, the equipment and the operator must be highly efficient and mobile. The Marine Corps requires large amounts of water free from disease-producing organisms, color, odor, and taste. Figure 1-1 shows the daily minimum water requirements for Marines and vehicles.

Unit consumer	Conditions of use	Gallons per unit consumer per day	Remarks
Man	In combat: Minimum	1/2-1	For periods not exceeding 3 days, when operational rations are used
		2	When field rations are used
	Normal	3	Drinking plus small amount for cooking or personal hygiene
	March or bivouac	2	Minimum for all purposes
	Temporary camp	5	Desirable for all purposes (does not include bathing)
	Temporary camp with bathing facilities	15	
	Semipermanent camp	30-60	Includes allowance for water borne sewage system
	Permanent camp	60-100	
Vehicle	Level and rolling country	1/8 to 1/2	Depending on size of vehicle
	Mountainous country	1/4 to 1	Depending on size of vehicle
Hospital	Drinking and cooking	10 per bed	Minimum, does not include bathing or water for flushing
	With waterborne sewage	50 per bed	

Fig 1-1. Daily water requirements in temperature zone.

b. Responsibilities.

(1) Commanding officer or officer in charge. He is responsible for supplying safe drinking water to all individuals under his command. Accordingly, he directs the establishment of the water supply system and the rules governing its operation. In addition he promulgates water-discipline rules and is vested with full authority to enforce them.

(2) Medical officer. The medical officer, who is responsible to the commanding officer or the officer in charge, closely supervises the testing and treating of all contaminated water.

1-2. WATER RECONNAISSANCE

a. Sources of water. A satisfactory water source is one with a natural supply of water of sufficient quantity to supply all needs of using units and of such quality that it can be readily purified with available equipment. A water source developed for military use is called a water point.

(1) Types of water sources.

(a) Surface water. Streams, lakes, and rivers.

(b) Ground water. Wells and springs.

(c) Seawater.

(d) Snow and ice.

(e) Minor sources. Sources such as rain and vegetation.

(2) Types of water sources found in various climates.

(a) Humid temperate climate. Surface and ground water.

(b) Tropical climate. Surface water, ground water, and minor sources.

(c) Arid climate. Ground water and minor sources.

(d) Coral islands. Ground and sea water.

(e) Arctic climate. Surface water, ice, and snow.

b. Planning.

(1) Field reports. The most important and reliable sources of information on water resources in an area are field reports which contain summaries based on recent observations. In the engineer battalion, the S-2 is the source of this information.

(2) Map studies. Maps and aerial photographs of the area of operation should be studied before the actual ground reconnaissance is made. In the use of maps, it should be understood that military maps are frequently incomplete and inaccurate; therefore, heavy reliance should not be placed on them. There are a few fundamentals which must be understood to correctly read a map. When the map is laid out with the name at top center and the sheet number at the upper right hand corner, the legend will appear at the bottom left hand corner of the map. This legend will tell you what the different colors mean on the map and how certain features will be represented on the map. For example, the color red is used for primary highways. Green is used to designate woods, orchards, etc. (but not fields) Blue is used to designate rivers, streams and lakes. The brown lines on a map are contour lines and they show elevation. Black shows secondary roads and manmade objects. Near the bottom center you will also find the scale of the map. A map with a scale of 1:25,000 means that any increment of 1 on the map = 25,000 of these increments on the ground, e.g., 1 inch = 25,000 inches. You will also find the direction of true north or magnetic north on the bottom of the map. Most important in your work is reading grid coordinates. You will find numbers

on the margin around your map. To read a given coordinate, remember to read RIGHT first then UP. That is to say you would read the north and south lines first and then the east and west lines. Read only the larger numbers of these coordinates. The smaller numbers are used to break down the grid square even further. If you have to break up a grid square to give exact coordinates for a feature, then imagine each line in that square to be broken up in ten even increments. Example in figure 1-2 is shown as a grid square. If you were to read this grid square, you would read right or 98 and then up or 29. The grid square would be numbered 98 29. Now to break it down even further and pinpoint where the dot is circled, you would read 98 and because the dot is on the 8th line of the 10 dividing lines this would now become 98 8 and then reading up it would become 29 2 or the six-digit pinpointed number would be 98 8 29 2. Keeping their limitations in mind, the following information can be obtained from a study of maps.

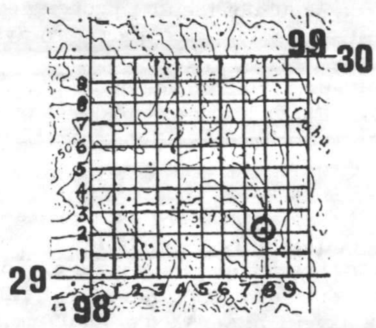


Fig 1-2. Sample grid square.

(a) Locating water sources. Maps are valuable for locating surface-water sources. Places where a road crosses or runs near a stream or pond are always possible water points. A study of contour lines is helpful in areas where no streams are indicated.

(b) Contamination. Water sources downstream of human habitations are subject to contamination. If possible, water points should be selected upstream from villages whether inhabited or not.

(c) Road nets. Road nets are best shown on maps, although the accuracy of the information obtained from the map study will depend on the date of the map being used.

(3) Personnel and equipment. Personnel selected to perform a water reconnaissance should include at least one qualified water-supply man. He should be familiar with water-treatment processes and know how to produce potable water with available equipment. Equipment carried by personnel should include testing equipment necessary for use in determining water characteristics from test samples.

(4) Route and time schedule. Before making a ground reconnaissance, it is important that a route and time schedule be drawn up. This is done by determining the possible water sources to be reconnoitered. Time should be allotted for travel to and from the sites as well as additional time for any unforeseen events, and for preparing and turning in the report. After these considerations, the time remaining is the amount left to be divided for coverage of each site. Once the time schedule is set up, the time of arrival and departure for selected points should be written down and the schedule followed closely.

c. Air reconnaissance. Air reconnaissance, using any type of aircraft, is an effective and generally reliable means for rapidly securing information about water sources over a large area. If used in conjunction with the map study, a visual or photographic air reconnaissance will disclose changes of the terrain not shown on existing maps. While en route to possible sites, the observer should note routes of communications; cover and concealment from enemy observation; and protection from encirclement, infiltration, or attack. The appraisal of the area covered can be confirmed by the ground reconnaissance. If a helicopter is used, the air and ground reconnaissance can be conducted as one. Upon location of a possible site, the helicopter can be landed for closer observation and performance of tests. The use of aircraft for reconnaissance is limited by adverse weather conditions.

d. Ground reconnaissance. Although an air reconnaissance is valuable as a general aid in determining possible water sources and other general information, an actual ground observation is the only positive way of getting accurate information from which to select a water point. During the conduct of the ground reconnaissance, a sketch of the site properly keyed to a map will prove invaluable. Memory alone is not sufficiently reliable; notes should always be taken. The route and time schedule should be followed closely since it is better to make a sketchy report than to be late in submission of a more complete report. Command decisions cannot always be delayed until complete information is obtained. Factors to be considered during the ground reconnaissance are: quantity of water, quality of water, routes of communication, and site conditions.

(1) Quantity of water. Seasonal changes in the water quantity are neglected in making an advanced reconnaissance unless information is readily available from native sources. Ordinarily a report of sufficient or insufficient water is adequate except where rear-area units are required to develop more permanent installations. Refined measurement of flow is seldom possible because gages, meters, and other measuring devices are not generally available. Often less accurate methods of flow measurement must be improvised. One such method of stream flow is to determine the cross-sectional area and the average velocity. This method will prove to be reasonably accurate if care is taken making the measurements.

(a) Formula.

$Q = 6.4 \times A \times V$

Q = quantity of water in gallons per minute.

6.4 = a constant--there are 7.5 gallons of water per cubic foot. However, because of probable error in stream measurements, 7.5 has been reduced to 6.4.

V = the velocity of the stream in feet per minute. This is obtained by noting the time it takes a twig or floating object to travel a known distance.

A = the area of the stream in square feet obtained by multiplying the width of the stream times the average depth of the stream.

(b) Example. A stream has an average depth of 2 ft and a width of 16 ft, and a twig is noted to flow 13.3 ft per minute. How many gallons per minute are flowing in this stream?

$$Q = 6.4 \times A \times V$$
$$= 6.4 \times 2 \times 16 \times 13.3$$
$$= 2,723.84 \text{ gallons per minute}$$

(2) Quality of water. Water should be of such quality that it can be readily purified with normal field equipment. If test kits are available, the pH value, chlorine demand, and the presence of chemical warfare agents can be determined If kits are not available, valuable information can be obtained by close observation and common sense judgment on the following quality characteristics:

(a) Color.

(b) Turbidity.

(c) Odor.

(d) Taste (use with caution).

(e) Possible sources of pollution.

(f) Condition of vegetation around source: dead or mottled vegetation may indicate the presence of chemical warfare agents.

(g) Presence of dead fish, dead frogs, etc.

(3) Routes of communications. A satisfactory water point must be accessible to both vehicles and personnel. A good road net with turnarounds, cover and concealment at the water point, and an adequate parking area are particularly desirable features. The bearing capacity of roads should be sufficient to withstand the heaviest vehicles under all weather conditions. The water point should be located on a through road whenever possible, but main supply routes should be avoided.

(4) Site conditions. Where two or more sites meet the above requirements, selection is based on site conditions. The following considerations are discussed in order of importance:

(a) Drainage. The site should be on high porous ground to prevent its becoming excessively muddy or swampy.

(b) Security. In addition to cover and concealment, the site should be a safe distance from enemy snipers and artillery and aerial targets. Security against ground attacks and sabotage of storage facilities are also important factors to be considered.

(c) Bivouac for personnel. A satisfactory bivouac area should be provided since purification-unit operators must live near the water point. This area should be near enough so operators not on duty are available in emergencies, yet far enough away to maintain proper sanitation of the water source. The bivouac area must be downstream from the water source.

e. Reconnaissance report forms. Reconnaissance data should be reported on DA Forms 1711-R (Engineer Reconnaissance Report) and 1712-R (Water Reconnaissance Report) (figs 1-3 through 1-7). Reconnaissance reports must be carefully prepared and available on time. The information presented must be legible, clear, complete, and concise. All information should be printed. DA Forms 1711-R and 1712-R can be reproduced locally on 8- by 10 1/2-inch paper.

WATER RECONNAISSANCE REPORT | DATE 8 Sep 7_ | PAGE 1 OF 3 PAGES

TITLE NUMBER	REPORT NUMBER	REPORTED BY (Name - Grade - Organization)
	1	Walter J. Newman, SSgt 2d Engr Bn

FORWARDED TO S-4, 2d Engr Bn

1. LOCATION OF WATER SOURCE

MAP	COORDINATES
Ft Belvoir & Vicinity, 1:25000	516723

2. TYPE OF SOURCE (Check one) ☐ Other (specify)

☑ Stream ☐ Lake ☐ Pond ☐ Spring ☐ Well ☐ Reservoir

LOCAL NAME OF SOURCE: ACCOTINK CREEK

3. DATE AND HOUR INSPECTED	4. YIELD IMMEDIATE (gpm)	ULTIMATE (gpm) (Give work estimate)
081400T-	12,500	17,000 108 MAN HOURS

5. QUALITY

COLOR	ODOR	TASTE
CLEAR	NONE	MUDDY

TURBIDITY (estimate)	pH TEST	CHLORINE DEMAND TEST (ppm)
LESS THAN 50	7.5	3.5

POSSIBLE SOURCE OF POLLUTION: ALGAE

6. COMMUNICATIONS

DISTANCE TO CONSUMERS	ROADS	RAILROADS	BRIDGES
10 MI	GOOD	NONE	NONE

7. SITE CONDITIONS (If municipal system, use Items 9 and 10)

SECURITY: OVERHEAD CONCEALMENT GOOD. SECURITY AGAINST GROUND ATTACK MUST BE PROVIDED.

DRAINAGE: GOOD

BANKS (If surface source): STABLE & SLOPING — ABOUT 3' HIGH

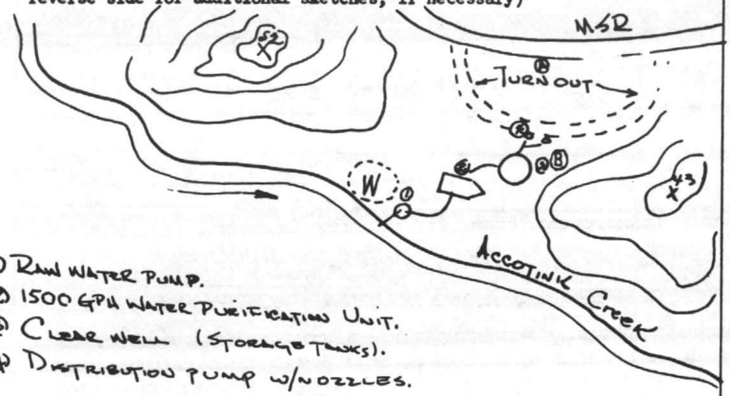
DISTRIBUTION FACILITIES (existing): NONE

8. SKETCH OF AREA (Show road net and traffic circulation) (Use reverse side for additional sketches, if necessary)

SEE REVERSE SIDE.

Fig 1-3. Engineer reconnaissance report form (front).

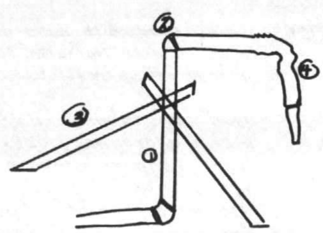
9. SKETCH OF WATER POINT (Show proposed set up for immediate operation. If water point is a municipel system, include sketch of system) (Use reverse side for additional sketches, if necessary)



① Raw water pump.
② 1500 GPH Water Purification Unit.
③ Clear well (Storage tanks).
④ Distribution pump w/nozzles.

10. DESCRIPTION AND SKETCH OF PROPOSED DEVELOPMENTS (If municipal system, include survey) (Use reverse side for additional sketches, if necessary)

Ⓐ Proposed turnout (approx. 75 meters long)
Ⓑ Standpipes for distribution



Note: See materials listed in

Fig 1-4. Engineer reconnaissance report form (back).

ENGINEER RECONNAISSANCE REPORT

PAGE 1 OF 1 PAGES

TO:	FROM:
CO 32nd Engr. Bn	Hq + Hq Co. 32nd Engr. Bn

FILE NO.	PARTY LEADER (Name, Grade, Organization)	PLACE - HOUR - DATE
HS 47	Smith 1st Lt Hq + Hq Co 32nd Eng. Bn	Cq. 187256-070700 OCT.
REPORT NO. 1		

MAPS

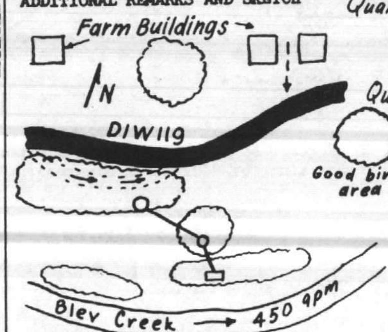
France & Belgium; 1944; 1:50,000 Sheet 3855 IV NW

DELIVER TO (Organization, Place, Hour and Date)

32nd Engr. Bn, St Nicholas, 071100 Oct.

KEY	OBJECT	TIME OBSERVED	WORK ESTIMATE?
1	W	0835	YES

ADDITIONAL REMARKS AND SKETCH



Quantity: A = 2 sq. ft.
V = 30 fpm.
Q = 60 cfm, 450 gpm

Quality: slight turbidity
no odor
possible pollution from nearby farms
pH = 6.8
Chlorine demand = 2 ppm

Communications: 1-way road with good drainage runs to 1st Inf area. Not used for division supplies. Turnout at wp must be constructed.

Site Conditions: good concealment, no targets in vicinity ground slopes gently from road to stream, good drainage banks, 3' high, sodded. Use access road as parking area. Grove of trees or farmhouse can be used as bivouac for w.p. personnel.

Rating: Excellent w.p. for 1st Inf.

ENGINEER WORK ESTIMATE ON OTHER SIDE

TYPED NAME, GRADE AND ORGANIZATION	SIGNATURE
Norman H. Wells Capt. Hq & Hq 32 Eng Bn	Norman H. Wells

Fig 1-5. Reconnaissance report form for higher echelons (1st page).

ENGINEER WORK ESTIMATE								
DESCRIPTION OF WORK	UNIT REQ'D	HOURS	EQUIPMENT			MATERIALS		
			Type	No.	Hours	Type	Unit	Quan
A. Construct Turnout: 1. Light Clearing & grubbing. 2. Spread Gravel.	1 Squad	2 hr.	Squad Pioneer Tool Set	1	2 hr.	bank gravel (on site)	cu. yd.	
B. Set up Equipment.	WP Team	½ hr.	Mobile Water Purification Unit, 1500 GPH	1				

RECONNAISSANCE REPORT ON OTHER SIDE

Fig 1-6. Reconnaissance report form for higher echelons (2d page).

11.	WORK ESTIMATES		
	FOR IMMEDIATE OPERATION		
TASK	**MAN-HOURS**	**EQUIPMENT**	**MATERIAL**
① Construct Turnout 1. Light clearing & grubbing 2- Haul & spread gravel.	96	① Sq pioneer set. ② Case, MC450 Tractor	40 cubic yards of gravel
② Set up equipment.	6	1500GPH Mobile water purification unit.	None
	FOR DEVELOPMENTS		
TASK	**MAN-HOURS**	**EQUIPMENT**	**MATERIAL**
③ Standpipes	6	① Pipe wrenches ② Hammer ③ Saw	① 2" pipe - 1 pc. 8' long and 1 pc 2' long ② 2" 90° Elbow, 2 ea. ③ 2"x4" lumber 6' long - 2 ea ④ 1 length of 2" canvas hose with distribution nozzle. Note: Material for 1 ea stand pipe.
TYPED OR PRINTED NAME AND GRADE Walter J. Newman, Jr.		SIGNATURE Walter J. Newman	

Fig 1-7. Reconnaissance report form for higher echelons (3d page).

1-3. PROPERTIES AND IMPURITIES OF WATER

a. Contaminated, polluted, palatable, and potable water.

(1) Contaminated water. Contaminated water contains disease-producing organisms or poisonous substances which make it hazardous and, therefore, unfit for human consumption or domestic use. Water may be contaminated, but not necessarily polluted.

(2) Polluted water. This is water containing substances such as garbage, industrial waste, or mud which make it objectionable because of appearance, taste, or odor. Polluted water is usually contaminated and may be easily detected.

(3) Palatability of water. This is a term which describes the characteristics of being pleasing to the taste. To be palatable, water should be free from color, turbidity, objectional taste, and odor, and should be cool and aerated. However, palatable water is not always safe to drink.

(4) Potable water. This is water that is free from disease-producing organisms and organic and inorganic poisonous substances and, therefore, safe for human consumption. Although potable water is safe to drink, it may not be palatable.

b. Characteristics of water. Water takes on various characteristics and properties as it passes over and through the earth. They may be classified according to means of detection as physical (detected by one or more of the five senses) and chemical (detected by chemical analysis). The important physical characteristics are turbidity, color, odor, taste, and temperature. The important chemical characteristics are acidity, alkalinity, hardness, and corrosiveness. These two types of characteristics may overlap. For example, iron in water is a dissolved mineral detectable by chemical analysis, yet its color and taste are also physical.

(1) Turbidity. Turbidity is an unclear condition of water caused by particles being held in suspension by the movement of the water. The faster the water moves, the larger the particles. When the water slows down, the larger particles settle out. When water movement stops, the smaller particles settle out. Clay and silt remain suspended the longest because their particles are the smallest. Turbidity should be removed from water because suspended material often contains disease-producing organisms. Removal also improves the quality of the water.

(2) Color. This is caused by colored substances in solution such as dye from decaying vegetable matter, humus, and iron salts. There are two types of color in water, true and apparent. True color is caused from substances in true solution. Apparent color is caused from turbidity.

(3) Odors and taste. Odors and taste found in water are caused by algae (tiny water plants), decomposing organic matter, dissolved gases, industrial wastes, or mineral substances. Chlorination of water can produce odors and tastes of its own and also increases the odors and tastes already there.

(4) Temperature. When the temperature of water is lowered, it tends to suppress odors and tastes, making it more palatable. When drawing water from deep lakes or reservoirs, you should remember that the water temperature near the bottom is cooler than at the top. By shifting the depth of the intake it is possible to draw in cooler water. This should be done whenever possible. However, cool water is difficult to filter and coagulate. Water-treatment rates should be reduced when the water temperature is less than 45° F.

(5) Acidity and alkalinity. The impurities that water picks up are classified as either acid or alkaline. Water can contain both acidic and alkaline materials at the same time. It is necessary to know the quantity of each since these impurities can affect purification processes, such as coagulation and sedimentation. Therefore, we must find the pH value of a water sample which is a measure of its acid or alkaline reaction. The pH values range from 0 to 14, 7 indicating neutrality (fig 1-8). Values less than 7 indicate increasing acidity, and values greater than 7 indicate increasing alkalinity. An apparent "neutral" solution, having a pH value of 7 and reacting neither acid nor alkaline, may yet possess considerable alkalinity and acidity. The pH of water in its natural state varies from 5.5 to 9. Determination of the pH value assists in the control of corrosion, the determination of proper chemical dosages and adequate disinfection, and the detection of contaminants.

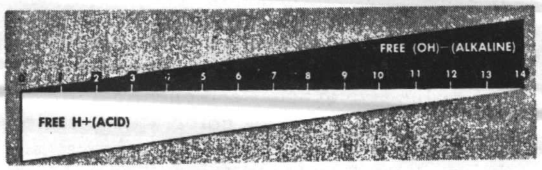


Fig 1-8. pH scale.

(6) Characteristics due to dissolved minerals. The amount of dissolved mineral solids in water depends on the length of time the water is in contact with the various minerals.

(a) Hardness. Hardness is caused by the soluble salts of calcium, magnesium, iron, manganese, sodium, sulfates, chlorides, and nitrates. The degree of hardness depends on the type and on the amount of impurities present in the water. Hardness also depends on the amount of carbon dioxide in solution. Carbon dioxide influences the solubility of the impurities that cause hardness. The hardness caused by carbonates and bicarbonates is called carbonate hardness. The hardness caused by all others (chlorides, sulfates, nitrates) is called non-carbonate hardness. Hardness is undesirable in that it consumes soap, makes water less satisfactory for cooking, and produces scale in boilers and distillation units.

(b) A rusty appearance and objectionable taste. This is caused when iron is present in water. Iron also forms crusts in plumbing and piping. When iron is present in water, bacteria may also be present. These organisms cause taste and odor as well as clogging up pipes.

(c) A gray or black color. This is normally caused by the presence of manganese in water. Manganese, while not encountered as often as iron, is found in both surface and ground water.

(d) Increase in alkalinity. Sodium carbonate (soda ash) and sodium bicarbonate (baking soda) increase the alkalinity of water, thus raising its pH value. In steam boilers, hot-water heaters, and distillation units, these minerals break down and release carbon dioxide which corrodes metal tubes.

(e) Salty taste. Sodium chloride (table salt) in amounts greater than 400 ppm (parts per million) causes a salty taste.

(f) Laxative effect. Sodium sulfate (glauber salts) has a laxative effect when present in drinking water in amounts greater than 500 ppm. In larger amounts it causes foaming in boilers and distillation units.

4

(7) Dissolved gases. The concentration of a gas in water is directly proportional to the concentration, or partial pressure, of the gas in the atmosphere in contact with the water surface. In general, this involves the water temperature, its salinity, and the altitude. The gas of primary interest to you is hydrogen sulfide. In solution, this lends a disagreeable taste and a rotten-egg odor to water. Ground water absorbs sulfides by passing over sulfur-bearing rocks. Hydrogen sulfide is also responsible for the destruction of cement and concrete as well as the corrosion of metals. In small amounts it is unpleasant, but not dangerous. In large amounts it is harmful. Water which smells of hydrogen sulfide should be treated.

c. Sources of water contamination. "Contaminant" is a general term for a harmful impurity which makes water unfit for human consumption or domestic use. Contamination of water may be caused by disease-producing organisms, by industrial wastes, or by chemical, biological, and radiological agents.

(1) Disease-producing organisms. Water is a carrier of many organisms which cause intestinal disease. An epidemic of one of these diseases among military troops can be more devastating than enemy action, and can cause great damage to morale as well as health. A waterborne disease rarely produces symptoms in its victim immediately after he has drunk the contaminated water. A period of time known as the incubation period must pass before the victim comes down with the disease. Types of waterborne diseases include: typhoid fever, paratyphoid fever, cholera, bacillary dysentery, amebic dysentery, common diarrhea, infectious hepatitis, and schistosomiasis. The last-mentioned disease is the result of infection by the larvae (cercariae) of the blood flukes (schistosomes). The snail host of the schistosomes liberates large numbers of the cercariae into the water. When the water dries on the skin of human beings, the cercariae then burrow into the skin and infection occurs. Treatment of water contaminated with schistosomes, and the safeguarding of personnel while they are treating the water are discussed in paragraph 1-4.

(2) Industrial wastes. Toxic metals and chemicals discharged as industrial waste can destroy the biological activity of streams and cause receiving waters to become unfit for further use. Organic chemicals may add their own tastes and odors to the receiving water's tastes and odors, making it almost impossible to remove by water purification. The use of raw water sources containing measurable quantities of industrial wastes should be avoided. However, if such a source must be used, the medical officer will prescribe and supervise water treatment.

(3) Chemical agents. Toxic chemical agents include mustard, nitrogen mustards, lewisite, hydrogen cyanide, and the nerve agents. The blister gases, nerve gases, and agents containing cyanide are most dangerous because they are highly poisonous, are soluble in water, and either are slow to decompose in solution or remain poisonous after decomposition. At the present there is no detecting kit for water-point personnel. However, a low pH reading will indicate that something is wrong with the water. Whenever you have a low pH reading, you should notify the medical officer immediately. He will check the water and prescribe treatment.

(4) Biological agents. Biological warfare, if employed today, can be of major significance, and field water sources would undoubtedly be contaminated. Water-supply personnel must be alert to detect indications of the use of biological warfare. Some of the indications are sick animals or people, dead vegetation, and a low pH reading. If any of these occur, the medical officer should be contacted immediately.

(5) Radiological agents. Although nuclear weapons have been employed in combat, there is no reliable data as to the effect of nuclear explosions on field water supplies. However, available fallout data leaves no doubt that contamination of water supplies by this means must be considered. Radiation is not detectable by human senses. To check for possible contamination of water we rely on the radiac instruments and the medical officer.

d. Detection of impurities. At the present the Marine Corps has two ways of detecting impurities, the comparator and by one or more of the five senses. These are discussed in paragraph 1-4.

1-4. WATER-TREATMENT PROCESS

a. Hydrologic cycle. This is a term used to describe the natural circulation of the water in, on, and above the earth. Figure 1-9 is a simplified illustration showing the steps in the cycle. Water is evaporated from water and land surfaces. It is then condensed to produce cloud formations, and returned to earth as rain, snow, sleet, or hail. A portion of the precipitation evaporates; some flows over the earth as runoff into lakes and streams, and the remainder goes into the soil and from there into underlying rock formations by seepage or infiltration. Eventually the water which has seeped through the earth will find its way to the surface through springs, or will flow through porous media until intercepted by streams, lakes, or the ocean.

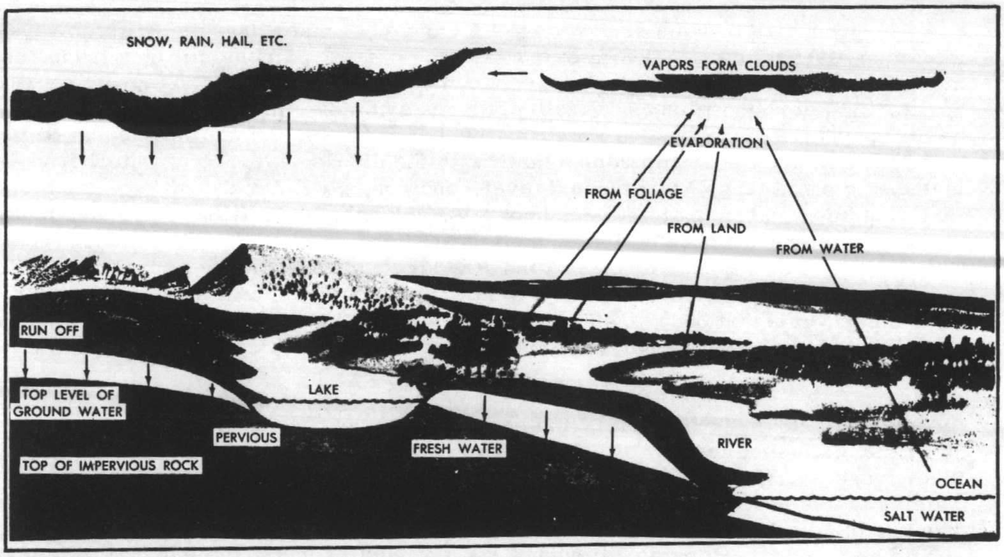


Fig 1-9. Hydrologic cycle.

b. Self-purification. Under favorable conditions, any polluted body of surface water (stream or river, lake or pond) will rid itself of a certain amount of its pollution by means of natural processes.

c. Field water purification.

(1) Equipment. Various pieces of equipment in this paragraph are covered only to the extent needed to cover water-treatment procedures. For a detailed discussion see chapter 2.

(2) Basic steps in treating water. There are five basic steps in treating water. These are sedimentation, coagulation, filtration, disinfection, and demineralization.

(a) Sedimentation. Sedimentation is the natural settling of solids heavier than water without addition of chemical coagulants. Solids heavier than water are held in suspension while in moving water, but gradually settle to the bottom as the water velocity is reduced. Sedimentation is not usually used by the Marine Corps as a separate step in water treatment because the long period required for complete settling would call for an impractical number of settling tanks. However, in emergency situations, such as the necessity of taking water from a swift-moving stream which is heavily silt laden after a rain storm, sedimentation tanks may be set up to ease the load on the coagulation and filtration steps of the water-treatment process.

(b) Coagulation. This is the process of preparing water for rapid sedimentation through the use of chemicals. The 600-gph purification unit uses ferric chloride. This chemical, when added to water, causes the small suspended impurities to gather into larger particles and then settle out or be drawn off more rapidly. The ferric chloride combines with the alkalinity present in the water to form an insoluble jellylike substance called "floc." The chemical process which takes place in the water is called "flocculation." When the water does not have a sufficient amount of natural alkalinity to react in this way with the coagulant, alkalinity is added to stimulate the process. The 600-gph purification unit uses pulverized limestone (calcium carbonate). The floc attracts and traps the suspended silt, disease organisms, and other impurities. The water must be agitated, or kept moving, to cause the floc particles to unite into bigger pieces to rapidly produce a heavy floc. The movement is accomplished mechanically.

(c) Filtration. Filtration consists of passing the water through some porous materials to remove the suspended impurities. The most effective filtration system ever devised and one of the most effective portable systems in existence is the diatomite filter unit. It is capable of removing approximately 90% of the bacteria, as well as producing water with less than 1 ppm of turbidity.

(d) Disinfection. This is necessary because no combination of the other two steps can be relied upon to remove all disease-producing organisms from water, and also there is danger of recontamination during handling before consumption. Residual disinfection utilizing chlorination is the final step in all water-treatment processes. In emergencies for small units or individual Marines, water may be disinfected by boiling. The water must be boiled for at least 15 minutes and then placed in an uncontaminated covered container.

1. Residual chlorine. This is the amount of unreacted chlorine remaining at a specified time after the chlorine compound is added. Chlorine in a concentrated solution is highly unstable. It may change the quantity and the quality under numerous conditions, including the presence of other elements or compounds.

2. Chlorine dosage. Dosage is the amount of chlorine added to water to satisfy the chlorine demand as well as to provide a residual. The dosage is usually stated in terms of parts per million (ppm).

3. Chlorine demand. The chlorine demand of water is the difference between the quantity of chlorine applied in water treatment and the total available residual chlorine present at the end of a specified contact period.

4. Disinfecting time. Chlorine demand in most water is likely to be largely satisfied 10 minutes after chlorine is added. After the first 10 minutes of chlorination, disinfection continues, but at a diminishing rate. A standard period of 30 minutes contact time is used to assure that highly resistant or highly active disease-producing organisms have been destroyed, provided that a large enough dosage has been applied.

(e) Demineralization. This is the removal of most materials that leave a residue on evaporation. Demineralization may be used to soften water, to remove iron and manganese, and to reduce the concentration of fluorides to tolerable or desirable values. It is also used in the military for the removal of radioactive materials from water. Demineralization in the Marine Corps is accomplished by using the distillation unit.

(3) Decontamination treatments.

(a) Activated carbon treatment. This is used when nitrogen mustard gases, sulfur mustard, or lewisite are present. Activated carbon is a relatively pure, finely powdered form of carbon which readily absorbs many substances. The activated carbon is added to a pretreatment tank set up separately from the coagulator assembly. Raw water is pumped into this pretreatment tank from the source, and the activated carbon added; 600 ppm is generally sufficient. The water is allowed to remain in contact with the carbon for 30 minutes or longer. Then it is pumped to the 600-gph purification unit for the usual treatment.

(b) Aeration treatment. This treatment is used with good results in restoring good taste to water, and also for removing some poisons. The water should be warm (above 70° F). Aeration is the simple spraying of water into the air by means of an elevated strainer or nozzle attached to the discharge end of a hose (fig 1-10). As the water is sprayed into the air, impurities will be separated from the water. Distilled water can be restored from its flat taste through the aeration treatment.

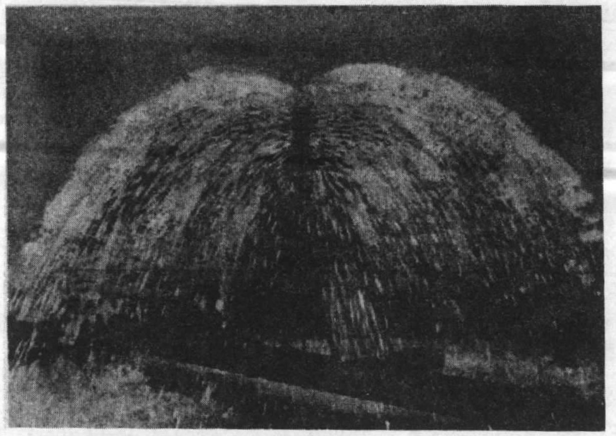


Fig 1-10. Aeration of water.

(c) Superchlorination and dechlorination. In this process, there are two chemicals used, calcium hypochlorite and activated carbon. Calcium hypochlorite is used in disinfection. Activated carbon is an absorbing agent. When hydrogen cyanide is the contaminant, two pretreatment tanks should be used. Raw water is pumped into both tanks and superchlorinated by the addition of 100 ppm available chlorine from high-strength calcium hypochlorite. (The calcium hypochlorite is added to the tanks prior to filling them with raw water.) The water is then dechlorinated by the activated carbon treatment. By the use of two tanks, a continuous quantity of pretreated water can be made available to the coagulator. It is important that the residue of activated carbon in the pretreatment tanks be kept in suspension. Pumps should be used for this purpose if necessary. The carbon is removed by the diatomite filters. After the water has been filtered, the chlorine residual should be checked. If it is inadequate, postchlorination is necessary.

(d) Removal of industrial wastes and other contaminants. Occasionally there is no alternative to using a water source containing certain harmful industrial wastes. If so, advice should be sought from the medical officer. The most common industrial waste products are inorganic acids. These acids will be neutralized by the calcium carbonate (limestone) in the normal purification procedure. Certain materials, such as arsenic, can be entrapped in a freshly prepared ferric hydroxide precipitate (iron floc), and will be eliminated in normal treatment. Water found to contain petroleum products is generally allowed to settle in a pretreatment tank so that the oil will rise to the surface. The water is then drawn off the bottom of the tank, treated with activated carbon if necessary, and then subjected to the normal purification method.

(e) Removal of schistosomes. In areas where schistosomiasis is known to be present (fig 1-11), wells and springs not subject to contamination by drainage and surface run-off should be used. However, in a surface source known to have schistosomes, the standard diatomite filter is capable of removing the cercariae of the schistosome from the water. The medical officer will make changes in the chlorination as needed. All water-point personnel working with this water should wear boots and gloves.

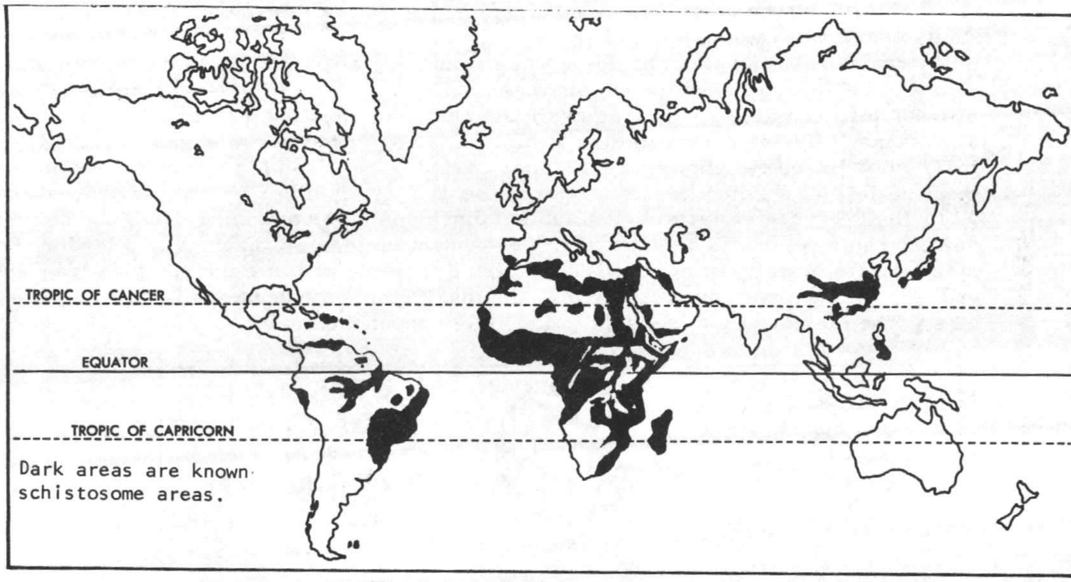


Fig 1-11. Schistosome areas.

(f) Removal of radioactive sludge from tanks. The use of the 600-gph purification unit to remove radioactive materials from water results in a highly radioactive sludge in the erdlator tank. A pit should be dug deep enough to contain the sludge and in a location that will prevent drainage back into the stream. The pit should be marked with tape for protection of personnel. The backwash and the sludge are drained into this pit. The tank is then cleaned with GI soap and trisodium phosphate and flushed into the pit. When the tank is decontaminated, the pit should be covered and marked to show that radioactive sludge has been buried.

(4) Quality control. In the Marine Corps water-supply personnel rely on the comparator for quality control. Any other tests desired are made by the medical officer. The comparator kit (fig 1-12) consists of a case, comparator, prism, three bottles with droppers, four test tubes, two pH discs, and one chlorine disc. To use the comparator, wash the tubes to be used in the water that is to be tested. Then fill a dropper to the graduated mark with the indicator solution; this equals 1/2 ml. Put the solution in one of the tubes; then fill another tube up to the etched mark with the water to be tested. Pour this water into the tube containing the indicator solution, thus mixing the solution and the sample of water. Place both tubes in the comparator with the second tube behind the colored glass disc and the tube containing the indicator behind the viewing hole. The disc is rotated alongside the water sample until the colored glass and the color of the sample match. Then the numerical number reading is taken from the disc.

(a) pH test. Two indicator solutions are supplied for making pH determinations with the comparator. Bromcresol purple-green is used for the pH range from 4.4 to 6.0. Bromthymol blue is used for pH values from 6.1 to 7.6. Standard color discs covering each range are supplied with the indicator. Generally the bromthymol blue indicator is used first since most pH values fall within its range. The readings for pH are made immediately after adding the indicator. It should be kept in mind that colorimetric indicators provide sharp changes in readings over a short span of the pH range, but once the end of this range has been reached, little change in color is noted even though a considerable change in pH takes place. For this reason, readings of 5.8 to 6.0 obtained when using the bromcresol purple-green indicator should be checked by taking a reading with the bromthymol blue.

(b) Residual chlorine test. This test is made to determine the quantity of available chlorine remaining in the water after satisfaction of the chlorine demand and disinfection has occurred. Orthotoluidine is the solution used in making the residual chlorine determination. This solution reacts with the residual chlorine, taking on a color which is matched against a standard color on the chlorine disc. The time required for full development of color by orthotoluidine depends on temperature and the kind of residual chlorine present. Color develops several times faster when water is at 70° F than when it is near the freezing point. For this reason, cold samples should be warmed quickly after mixing with orthotoluidine. This can be accomplished by holding the sample in a closed fist using body heat. For samples containing only free available chlorine, maximum color appears almost instantly and begins to fade after 1 minute. Take the readings at maximum color intensity. However, a longer period is required for full color development of the chloramines which may be present, formed either by natural processes or by the presence of certain chemicals. Since samples containing combined chlorine develop their color at a rate primarily dependent on temperature and to a lesser extent on the quantity of nitrogenous material present, observe the samples frequently and use the maximum value. At 70° F the maximum color develops in about 3 minutes. The maximum color starts to fade after about 1 minute.

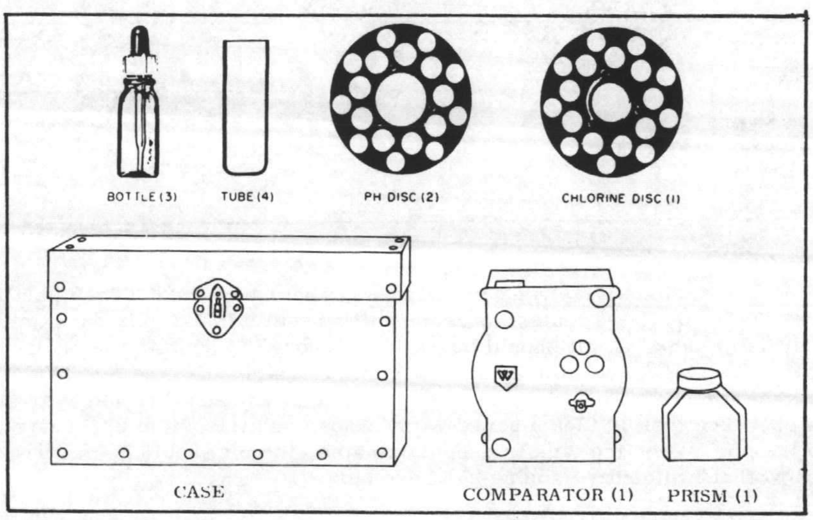


Fig 1-12. Comparator kit.

1-5. DEVELOPMENT OF WATER SOURCES.

a. Surface sources. Development of a water source includes all work which increases the quantity and improves the quality of the water, or makes it more readily available for treatment and distribution.

(1) Streams, rivers, lakes, and ponds. These sources are usually the first sources considered for water points. They require the least amount of development. However, some developments will usually have to be made. The type and extent of these developments will depend on the individual Marine's initiative. A few examples for developments are explained below.

(a) Rocks and stakes. If a stream is not too swift and the water is sufficiently deep (at least 4 in. above the strainer), an expedient intake may be prepared by placing the intake on a rock. This will prevent clogging of the strainer by the streambed and provide enough water overhead to prevent suction of air into the intake hose. If the water source is a small stream or shallow lake, the intake hose can be secured to a post or pile (fig 1-13).

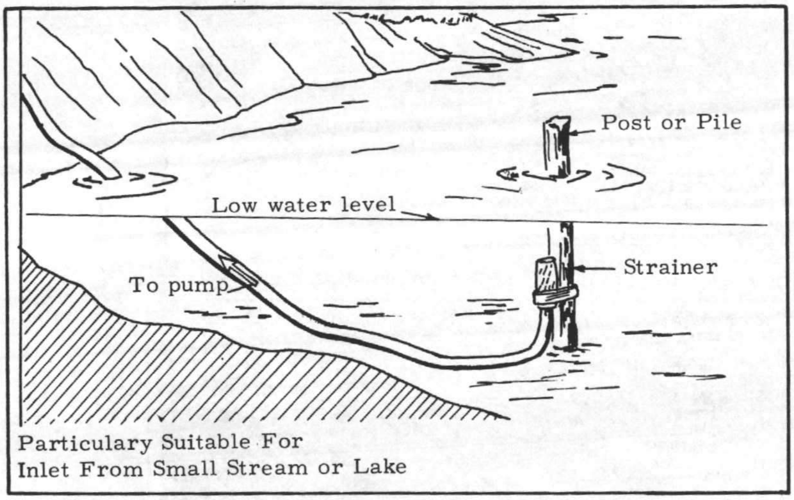


Fig 1-13. Direct intake with hose on bottom of water source.

(b) Pits. If the stream does not provide at least 4 in. of water over the intake strainer, a pit should be dug and the strainer laid on a rock or board placed at the bottom of the pit. Pits dug in streams with clay or silt bottoms should be lined with gravel to prevent dirt from entering the purification equipment (fig 1-14). The screen is surrounded by gravel which prevents the sides of the pit from caving in and shields the strainer from damage by floating objects. A similar method may be used by enclosing the intake strainer.

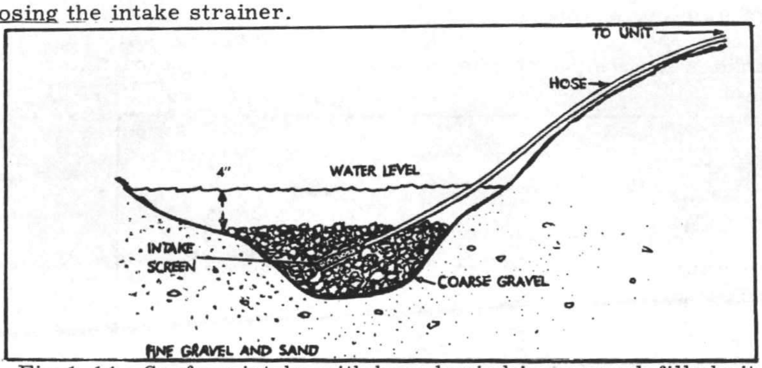


Fig 1-14. Surface intake with hose buried in a gravel-filled pit.

(c) Dams. The level of the water in a stream can be raised by building a dam (fig 1-15). In swift streams, a wing or baffle dam can be constructed to protect the intake strainer without impounding the water (fig 1-16).

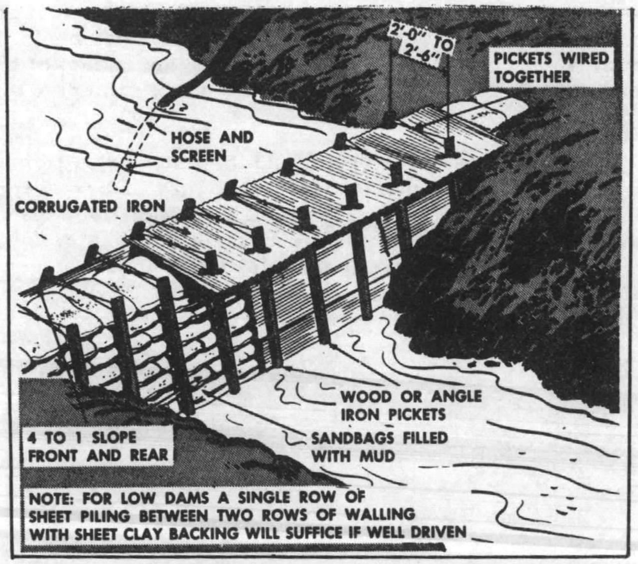


Fig 1-15. Improvised dam for impounding small streams.

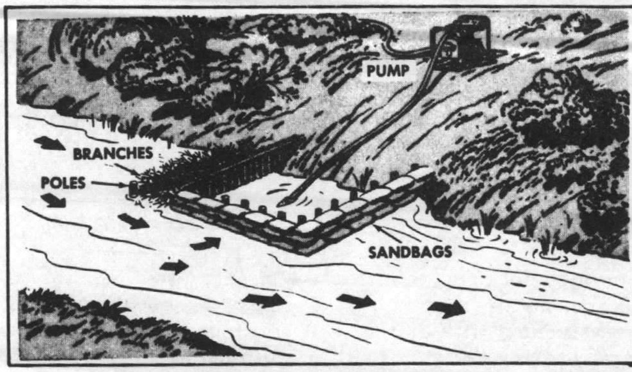


Fig 1-16. Baffle dam for protecting inlet strainer.

(d) Floats (fig 1-17). Floats made of logs, lumber, sealed cans, or empty fuel drums can be used to support the intake strainer in deep water. They are especially useful near the banks of large streams where the water is not deep enough to cover the intake strainer.

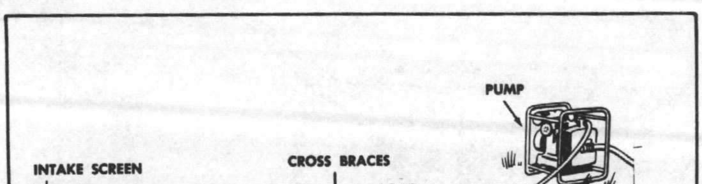


Fig 1-17. Float-type surface intake.

(e) Galleries (fig 1-18). Water from muddy streams can be improved in quality by digging intake galleries along the bank. A trench is dug along the bank deep enough so that water from the stream percolates into it and intercepts ground water flowing to the stream. The trench is filled with gravel to prevent the sides from caving in and the intake strainer is placed in the gravel below the water line.

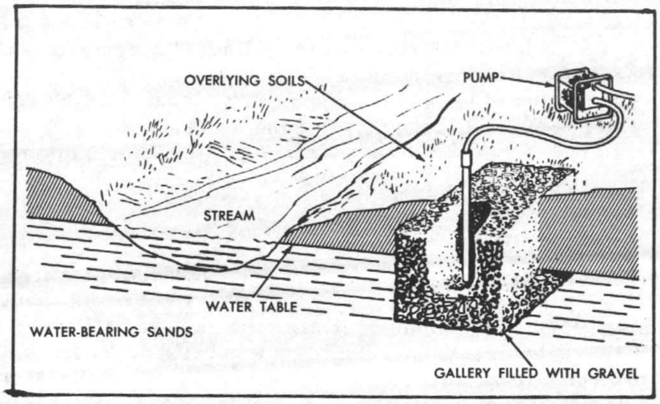


Fig 1-18. Gravel-filled gallery intakes.

(f) Drive points (fig 1-19). Many times it is advantageous to utilize shallow ground water sources or percolated waters adjacent to turbid surface water. Well points have a 2-in. diameter and 54-in. length. A drive cap is placed over the thread and the well point is driven into the ground with a sledge. Successive sections of pipe, each 5 ft long, are added and driven until the screen is well within the water-bearing media. Several well points may be connected in parallel to supply sufficient water to the raw water pump. The pumps issued with field equipment have but 15 ft of practical suction lift. Therefore pumping water from well points from a depth of 20 ft is mechanically impractical.

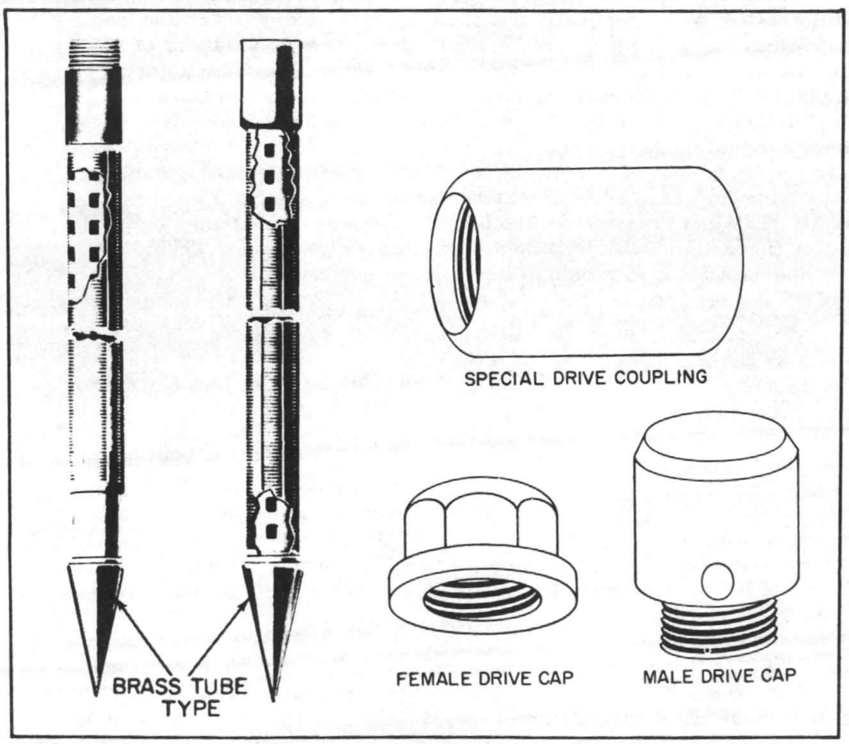


Fig 1-19. Drive points and drive caps.

(2) Springs. Springs yielding 20 gallons per minute or more of water can be used as a field source of water if properly developed. Springs may be developed by enlarging the outlet and reducing loss by damming and conducting water to storage. To reduce possible pollution, springs should be cleared of all debris, undergrowth, top soil, loose rocks, and sand. Digging is a more positive and more economical method of developing a spring than blasting. Blasting in unconsolidated rocks may shift the sand or gravel in such a way as to divert the spring to a different point.

(3) Rainwater. This may be sufficient for small units or limited operations, but it should not be considered if other more reliable sources are available. The collecting surface may be constructed of tarpaulins supported by wood, metal, or concrete, and elevated so the water drains into tanks. After the water has been collected, the tanks should be covered to safeguard the water from further contamination and pollution.

b. Arctic sources.

(1) Summer conditions.

(a) Lakes and streams. During the summer months, the numerous lakes and streams common to the arctic region may be developed as water-supply sources. The intakes must be protected from floating objects, especially after the spring thaw. The streams in arctic areas often contain large amounts of silt which must be removed in the treatment process. The nonflowing sources contain less silt, but require treatment to remove organic materials or other impurities.

(b) Muskeg areas. Muskeg is a resilient soil covered with bog. It has a high water table. Muskeg water can be collected by building galleries or ditches intercepting the water table. This water generally contains a large amount of dissolved organic matter which must be removed in the treatment process.

(2) Winter conditions. During the winter months, surface-water supplies freeze to the bottom unless the water sources are deep. Ice can develop to a thickness of six to eight feet in a single winter season. Dams and reservoirs built to store surface water for use during winter seasons are seldom justified because of the danger of the water thawing the adjacent ground and causing slides, cave-ins, or settling. For this reason wells generally make more satisfactory water sources in arctic areas. Where deep wells cannot be sunk through the thick layers of permafrost, and the surface sources are frozen solid, water must be obtained by melting snow or ice. Ice is preferred to snow because it will yield more water for a given volume. Snow or ice may be contaminated; therefore, all melt produced should be treated prior to drinking. Approximately five cubic feet of snow is required to yield one cubic foot of water. Several models of ice and snow melters are currently available for troop use. In emergencies, personnel can eat small quantities of snow. This snow should be placed in the mouth, rather than being sucked, to prevent chapped or cut lips. Only small quantities of snow should be consumed in this manner because consumption of large quantities will reduce the body temperature.

c. Underground sources.

(1) Wells. The development of wells consists of improving the yield of water and protecting it from contamination.

(a) Improving the yield. The yield of well water can be improved by overpumping or backwashing. Overpumping means pumping the water out faster than it can replace itself. This removes the finer particles from the water-bearing sand or gravel, allowing water to flow more freely. To backwash means to allow water to run down into the well. This pushes the finer particles away from the well point and allows water to flow more freely.

(b) Protection from contamination. Filling the space between the outside of the casing and the inside of the drilled hole with cement grout will prevent seepage of polluted surface water down along the outside of the casing and seal out water of unsuitable chemical quality above the desirable water-bearing formation. Also, extending the well casing one foot above the surface and pouring a concrete platform around it will prevent surface water from contaminating the well.

(2) Basins. Most desert regions throughout the world have a basin and range type of topography. Such regions consist of scattered mountain ranges, separated by basins which are filled with alluvial sediments (materials deposited by running water). The rain that falls on the mountain flows into the basins and is absorbed by the sediments. Wells can be drilled to tap the ground water present in the sediments.

d. Seawater sources. In developing seawater sources, consideration must be given to such factors as surf action, saltwater corrosion, suspended sand and silt in the water, living organisms, surface oil along beaches, and the rise and fall of the water level with tide. Distillation equipment located on sheltered bays, harbors, lagoons, or estuaries can be supplied by intakes constructed in the same way as freshwater surface intakes. On small islands where there is insufficient surface and ground water, and on or near open beaches, intakes for distillation equipment can be constructed.

(1) Saltwater wells. Wells can be dug to tap fresh or salty ground water. This eliminates the problems caused by tides, surf, and shallow water close to shore. Such wells have an added advantage in that they can be constructed back of the shoreline under natural overhead concealment. Driven wells may also be used effectively at beach locations.

(2) Offshore intakes. Offshore intakes are sometimes required because of lack of time, men, or equipment or because of coral conditions which prohibit well construction. Intakes of either the rigid pipe (fig 1-20) or float (fig 1-21) type may be used, but should be located in deep water beyond the surf. They must be positioned vertically and be off the bottom, but still beneath the water surface at low tide. In this way foreign materials in the water which might cause excessive wear on distillation equipment will be kept to a minimum.

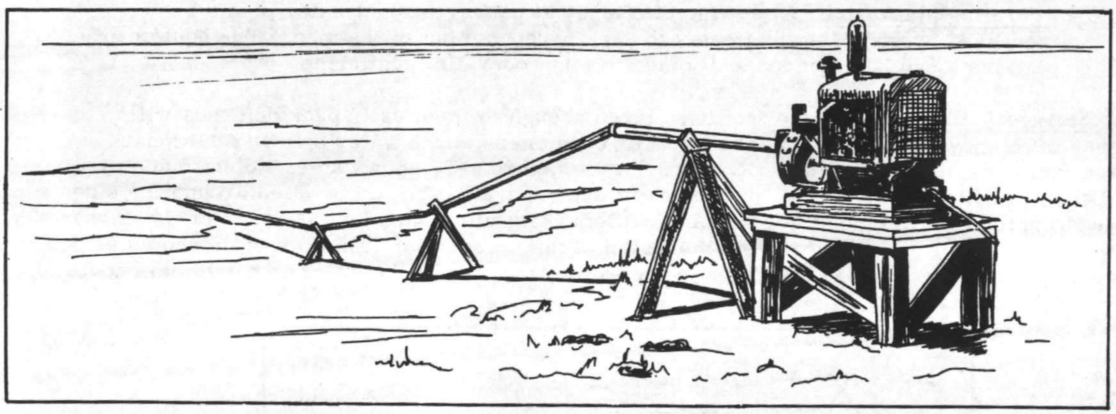


Fig 1-20. Rigid-pipe type seawater intake.

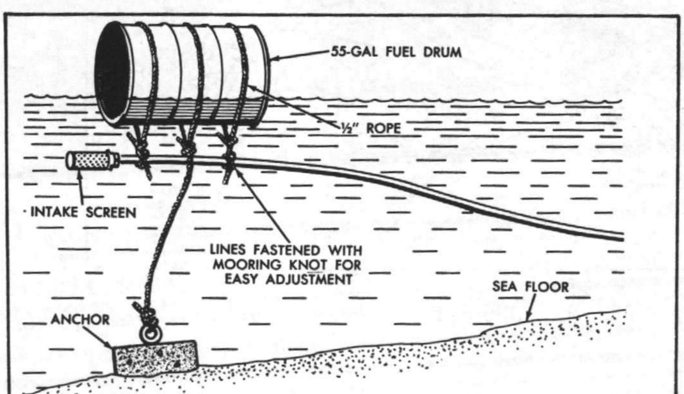


Fig 1-21. Float-type seawater intake.

1-6. DEVELOPMENT OF WATER POINTS

a. Order and extent of development. The extent to which a water point is developed depends primarily on the time, labor, troops, and materials available to do the work. At frontline installations, development is held to a minimum consistent with supplying enough potable water to the troops. However, in rear areas the extent of development varies with the size of the water point, the problems to be overcome, and the permanency of the installation.

b. Drainage. In addition to creating a sanitation problem, poor drainage may cause the area to be so muddy that it becomes inoperable. If vehicles cannot get to the point of distribution, the water point no longer serves its intended purpose. Such conditions can be eliminated by providing adequate drainage.

c. Supports and platforms.

(1) Low platforms. At forward water points, storage tanks should be erected on platforms resting on the ground. These platforms keep the tanks out of the mud, allow circulation of air underneath, and as a result, prevent the tanks from rotting. They also eliminate the possibility of the tanks being punctured by rocks or other sharp objects.

(2) Elevated platforms. If potable-water storage tanks are erected on elevated platforms, distribution can be improved by using gravity feed to standpipes and distributing nozzles. However, such platforms are more suitable for rear areas or permanent installations than for forward areas.

(3) Operating platforms. Operating efficiency at poorly drained water points can be increased by installing platforms to keep personnel out of the mud. The equipment platforms can be extended and joined to form operating platforms.

d. Storage facilities. Storage facilities large enough to meet daily peak demands will increase efficiency by eliminating long waits by consumers at the water point. Additional storage facilities must sometimes be improvised. Figure 1-22 shows an expedient made by lining an excavation with a tarpaulin. Soil from the excavation should be piled around the sides to prevent pollution by surface water. An additional tarpaulin should be placed over the excavation to serve as a protective cover for the water in the excavation. This tarpaulin should be large enough to extend beyond the edges of the excavation so that the water is completely covered.

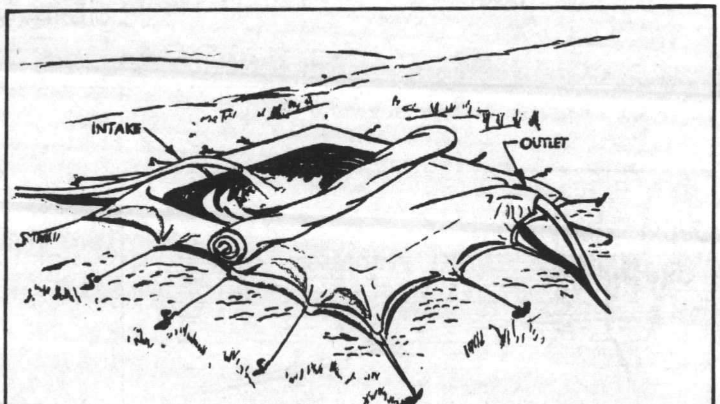


Fig 1-22. Expedient storage basin-tarpaulin.

e. Traffic considerations.

(1) Turnouts and turnarounds (figs 1-23 and 1-24). A turnout may be a widened section of a main road or a new one-way road past the water point, depending on the labor and equipment available. For large installations, a turnaround is more convenient and efficient. Space is provided for the simultaneous distribution of water to more than one truck, thus increasing distribution capability.

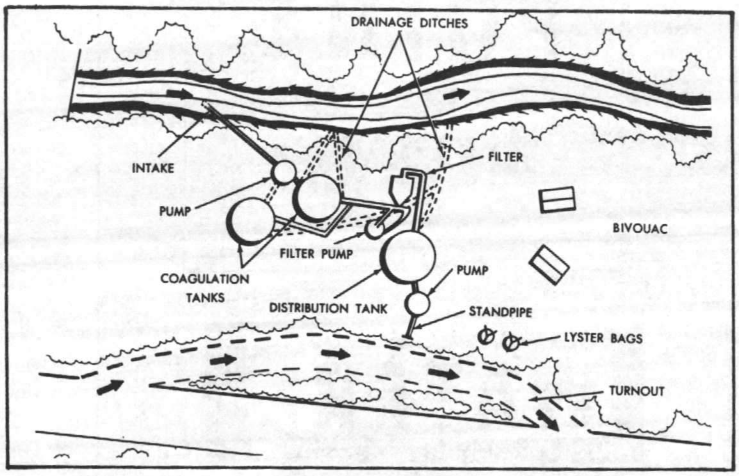


Fig 1-23. Turnout.

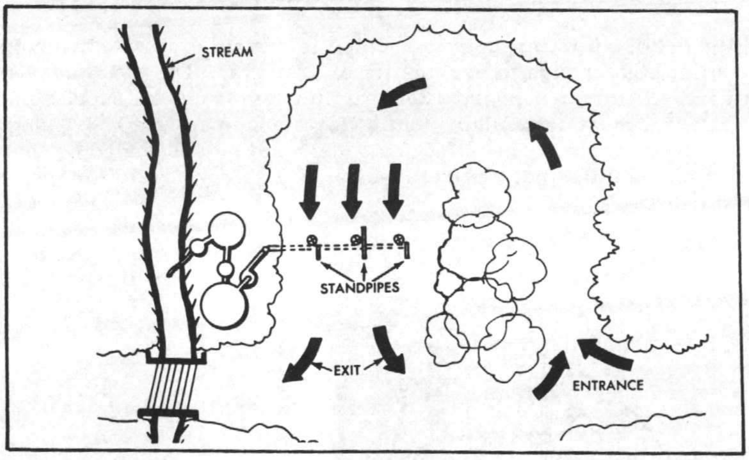


Fig 1-24. Turnaround.

(2) Traffic signs (fig 1-25). The route to the water point should be adequately marked by signs posted by water-supply personnel. The signs should be so posted that they are clearly visible to vehicle drivers and so placed that cross-traffic interference will be kept to a minimum. They should be posted at all critical points such as side roads, crossroads, and forks within a 2-mile radius of the water point. The signs should be prefabricated from metal and stored with the water-purification equipment for field use.

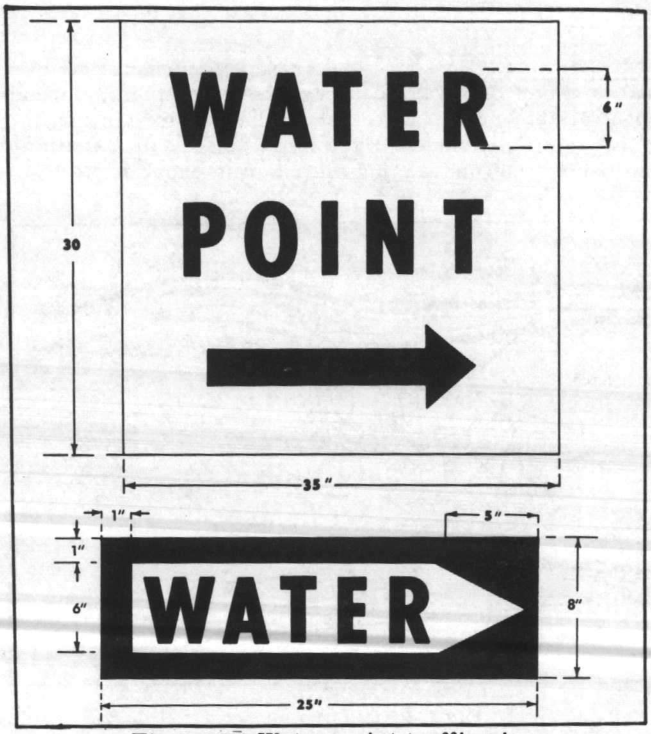


Fig 1-25. Water-point traffic signs.

f. Standpipes (fig 1-26). A water-point standpipe is a rigid pipe which supplies water under pressure from an outlet high enough to service water trailers. The usual construction is a 2-in. pipe fastened to a vertical timber support. Several standpipes can be supplied from a common underground header. The most satisfactory outlet for standpipes is a short length of rubber suction hose with a safety nozzle. The safety nozzle should be suspended so that it cannot touch the ground and become contaminated. In the absence of a safety nozzle for the hose, a valve may be inserted in the standpipe.

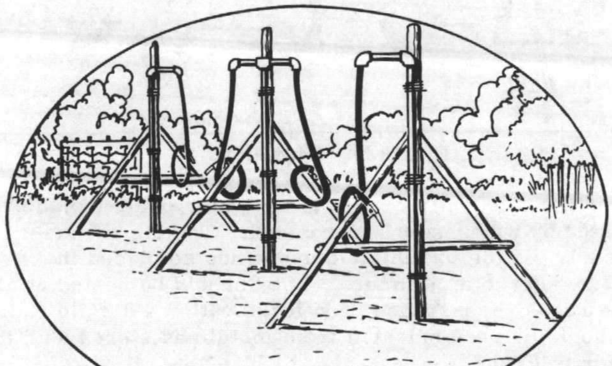


Fig 1-26. Standpipes.

g. Camouflage. The water source may or may not be in the immediate vicinity of friendly forces and, as a result, imposes a special problem of security. The best means of reducing the chances of attack is to deny the enemy any information concerning the location of the water point. This can be done by maximum use of overhead concealment and the use of camouflage nets to distort equipment outlines and shadows. Camouflage nets are particularly applicable for use with the mobile purification unit where overhead concealment is lacking. Whenever possible, parking areas, turnouts and turnarounds, and all distribution facilities should be provided with overhead concealment.

h. Bivouac areas.

(1) Location. The bivouac area should be located at least 100 ft away and downstream from the selected water source.

(2) Heads. Heads should be located at least 100 yd away and downstream from the water source. Heads should not be dug below ground-water level nor in a place where human waste may drain into and contaminate the water source.

i. Methods of preventing freezing.

(1) Draining equipment. The filters, hoses, pumps, and engines must be constantly checked for signs of freezing, and must be drained after use. Immersion-type heaters may be used in the storage tanks or in the clear-well tanks to keep the water from freezing.

(2) Recirculation of water in tanks. Pumps and engine sets available at water sites may be used to prevent freezing by recirculating the water in storage tanks. The number of pumps required and their location depends on the number of storage tanks used.

(3) Intake points, raw water pumps, and hose. Normally, water hoses may be laid directly on the snow as long as water in them is in circulation. When the water pumps are stopped, however, water in the hoses must be drained immediately if freezing is to be avoided. Freezing of the intake point is prevented by constructing a wooden box with insulating material for the cover (fig 1-27). The raw water pump may be protected by covering with an insulated cover or by constructing an insulated box (fig 1-28). All water lines to or from pumping sets should be suitably supported and angled to facilitate rapid drainage when pumping stops.

(4) Water storage. Storage facilities are a necessary part of any water-supply system. They provide a reserve for peak loads and emergencies such as firefighting and breakdown of pumping equipment. Adequate provisions must be made to prevent freezing of the stored water. Small tanks or open basins should be enclosed in a heated building, while elevated or outdoor tanks must be properly insulated.

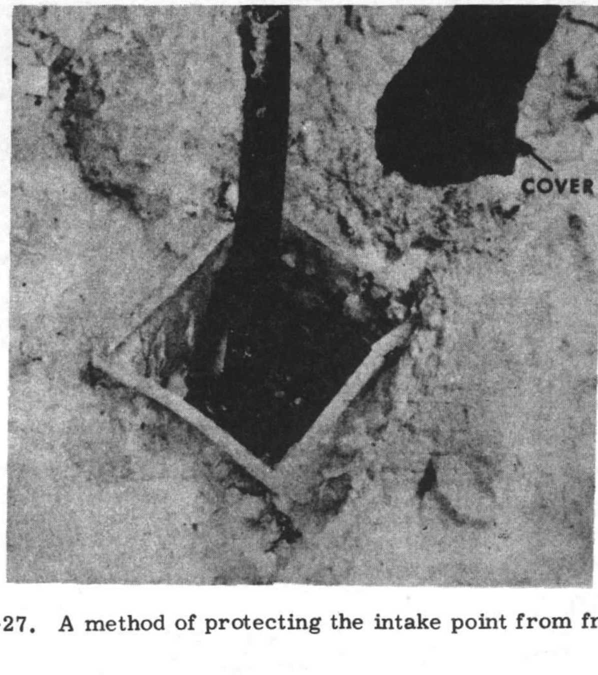


Fig 1-27. A method of protecting the intake point from freezing.

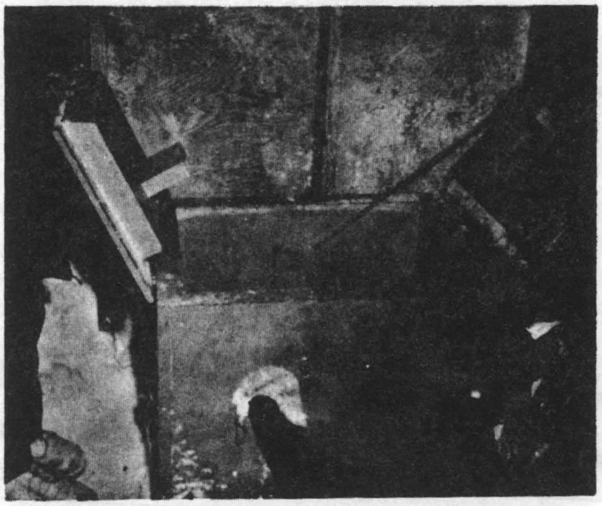


Fig 1-28. Insulated box for raw water pump.

1-7. WATER DISTRIBUTION

a. Water trailers and trucks.

(1) Water trailers. The Marine Corps uses a water trailer commonly known as a water buffalo which holds 400 gal of water. This is the most widely used method of transporting water from the water point to the troops.

(2) Water trucks. The Marine Corps also has a 2 1/2-ton 6 x 6 truck, which hauls a 1,000-gal tank for distributing water. It is generally used to haul water from the water point to a dry point several miles away.

b. Dry points. These are distribution points established for distributing treated water. Water is trucked from the water point to the dry points where distribution facilities can be more conveniently located for consumers.

c. Pipelines. Pipelines are used in conjunction with certain dry points such as hospitals, bakeries, and camps. A typical dry point utilizing pipelines is shown in figure 1-28.

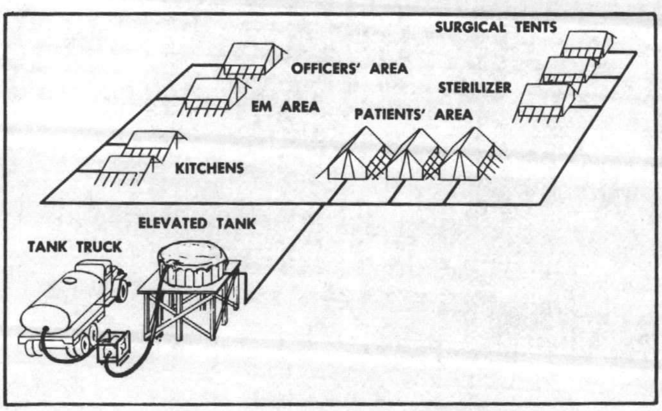


Fig 1-29. Dry point using pipelines.

d. Cleaning emergency water containers. In combat situations it may become necessary to use petroleum containers or other containers to transport potable water. Water-point personnel are responsible for insuring that all such containers have been cleaned properly and are safe before filling them with potable water. In most cases the using unit cleans their containers. However, this should be done under the supervision of a water-supply man. Therefore, every water-supply man should be familiar with the following cleaning procedures.

(1) Gasoline containers. Recommended procedures for cleaning leaded and unleaded gasolines from containers to be used for transporting water are given below:

(a) Five-gallon cans. Use only newer cans with bright interiors. Drain the can thoroughly (10 to 15 minutes), then fill the can one half full with water, add one ounce of powdered soap or three ounces of powdered activated carbon and shake it for 5 minutes. Then rinse the can thoroughly several times, then fill to overflowing and discard the water.

(b) Fifty five-gallon drums. Use only drums with bright interiors. Steam for 1 hour or aerate for 15 minutes with compressed air; then add 10 to 20 gal of water and one lb of powdered soap. Roll the drum for 15 minutes and discard the contents. Add 10 to 20 gal of water and one half pound of activated powdered carbon. Again roll the drum for 15 minutes and discard the contents. Rinse repeatedly if time and supply of water permit; fill the drum to overflowing and discard the contents. Limit storage of water in drums to 1 week; if odors occur, add one pound of powdered activated carbon and shake (by rolling) for 15 minutes.

(c) Tank trucks. First, drain completely and steam for 90 minutes. Then, flush with pressure hose, fill to overflowing, and drain to gage level. If no color or sediment is evident, water transported in tank trucks may be used up to 18 hours after filling. Flush the tank after each refilling.

(d) Tank cars. Steam at least 6 hours. If possible, have interior thoroughly flushed with a pressure hose. Fill to overflowing and drain.

(e) Alternate cleaning method. Where steam is not available, a detergent may be used for removing gasoline. Commercial detergents containing polyphosphates are effective cleaning agents in both hot and cold water.

(2) Other liquid containers. Tanks and containers used to transport juices, oils, and other liquids may be cleaned by opening the drain and flushing with hot water. Then, steam with an emulsifying detergent until the tank is clean. Where steam is not available, circulate the detergent at a temperature of 180° to 210° F, changing the location of the nozzle to keep the interior continuously wet from top to bottom. Return the solution to the supply tank and recirculate until clean. Rinse the tank thoroughly with hot water and drain.

(3) Safety precautions. Tanks large enough to accommodate a man should never be entered without equipment to test for harmful or explosive gasoline vapors, unless the following precautions are observed:

(a) Ventilation. An air-line mask and air-line hose with constantly supplied fresh air should be used.

(b) Sparkproof equipment. Fire or explosion should be guarded against by using sparkproof equipment only and wearing composition-soled shoes free of nails. These precautions must be observed by workers both inside and outside the tank.

(c) Safety belt. The worker should use a safety belt to which a safety line is attached before entering the tank. While in the tank he must be kept constantly under the observation of two other workers who hold the safety line in their hands at all times. They should remove him from the tank at the first sign that he is being affected by the vapors. Artificial respiration should be administered if necessary.

e. Water distribution equipment sets. The Marine Corps has three types. Basically these distribution sets contain the tanks, pumps, testing equipment, hoses, and tools to set up distribution facilities. The M-62, with its equipment, is explained in chapter 2.

1-8. STORAGE AND HANDLING OF WATER-SUPPLY CHEMICALS

a. Handling. When handling soda ash, alum, or limestone there is no special problem other than keeping them dry until ready for use. However, calcium hypochlorite or ferric chloride when mixed with activated carbon will react violently. Care must be taken to keep these two chemicals separated and dry. If calcium hypochlorite or ferric chloride when mixed in a slurry form splashes on your skin, it will cause a burning sensation. You should rinse this area with water. It also acts like an acid if splashed on clothing. To prevent clothing from developing holes, you should use water on the area immediately to dilute the solution.

b. Storage. Water-supply chemicals should be stored where they are protected from the weather and kept dry at all times. If possible, they should be set on pallets to let air circulate around them to help keep the containers from rusting or dry rotting. The containers should be inspected for rust or dry rot at regular intervals. If rust is detected, steps must be taken to prevent the rust from spreading. Painting with a rust inhibitor will help.

c. Detecting overexposure to water-supply chemicals. Calcium hypochlorite when mixed in a slurry form gives off a chlorine gas, although in small amounts. However, if this chemical is being mixed in a building that doesn't have the proper amount of ventilation, the results could be fatal to personnel there. Symptoms of overexposure are irritation of the throat and eyes and coughing. Whenever you note any of the above symptoms, you should immediately get all personnel out of the area and into fresh air. If any of the symptoms continue, see the corpsman at once.

Chapter 2

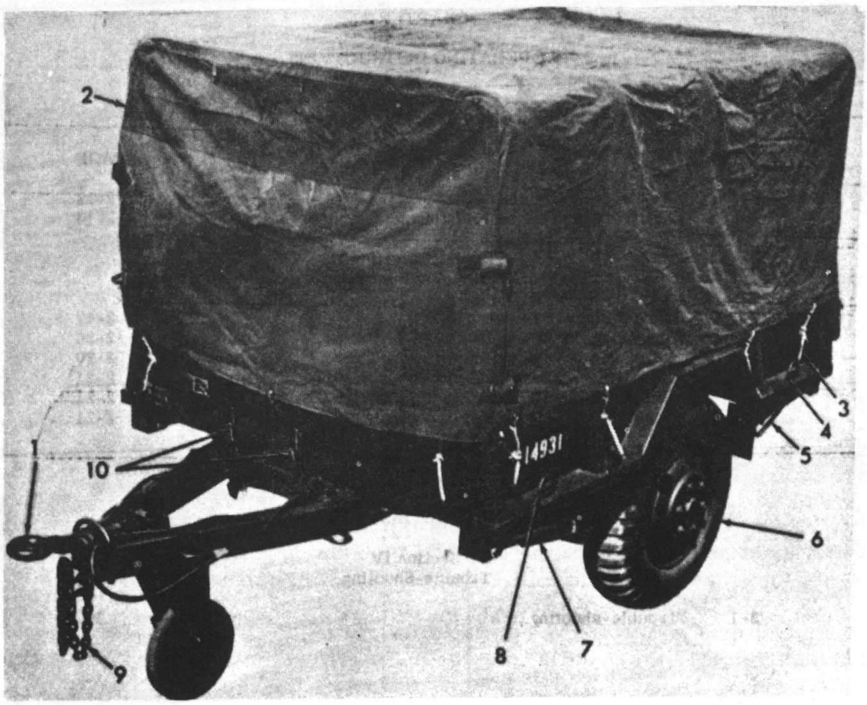
WATER-PURIFICATION AND DISTILLATION EQUIPMENT

Section I. TRAILER-MOUNTED, 600-GPH WATER-PURIFICATION UNIT (ERDLATOR)

2-1. DESCRIPTION

a. General. The 600-gph erdlator, when operated properly, will supply a unit with 600 gph of crystal clear, good tasting, and germ-free water. It is a complex unit with many valves, and some critical procedures must be followed. But at the same time, once all is set and the operator understands the unit, it is a simple unit to operate. In this chapter we are not going to attempt to tell you all there is to know about this unit, but what you need to know to operate it. If you have a need to go deeper into any area we discuss here, then obtain the appropriate TM (TM-03957A-15). This purification unit is furnished on a 2 1/2-ton, 2-wheeled trailer. The erdlator assembly, diatomite filter, filter pump, chemical feed equipment, and the electrical controls are mounted on the trailer and are designed to be operated on the trailer. A 10-kilowatt generator, raw-water pump, distribution pump, chemical storage box, and the M-62 water distribution set are carried on the trailer but are removed when setting up a water point.

b. Trailer (fig 2-1). The trailer is equipped with air-operated hydraulic brakes and an electrical system for the stoplights and taillights. This trailer has four leveling jacks, one located under each corner. It is usually towed by a 2 1/2-ton, 6 x 6 truck.



1 Lunette
2 Paulin
3 Tiedown ropes
4 Rear air drop strap
5 Rear jack
6 Wheel
7 Front jack
8 Front air drop strap
9 Safety chain
10 Parking brake levers

Fig 2-1. Trailer.

c. Erdlator assembly (figs 2-2 and 2-3). This consists primarily of the tank, influent launder, effluent launder, wet well tank, sludge concentrator tank, slurry weir box, downcomer tube, and agitator shaft with discs. Also part of the erdlator assembly are the agitator speed reducer, drive motor, air pump, and bridge rails. The erdlator assembly is mounted on a separate aluminum base equipped with six carrying handles.

(1) Erdlator tank. The erdlator tank serves as a separator which hydraulically separates the slurry blanket from the clear water in the upper section of the tank in what is called the separation zone. It also serves as a clarifier as the coagulated water is deflected at the bottom of the tank and directed in an upward rotating direction into the clarification zone. The erdlator tank is a circular funnel-shaped unit of one-piece aluminum construction with a capacity of approximately 245 gallons. A stub shaft and bearing support for the agitator are mounted in the bottom of the tank. There is a ring near the bottom secured to the tank with a series of short baffles which supports the downcomer tube. A draw-off port is located opposite the weir box and another near the top. The draw-off port located at the top opens into the wet well. There are two drains, an upper one for partial draining and a lower one for complete draining.

(2) Influent launder. This is of one-piece aluminum construction and is attached to the two bridge rails. The raw water is introduced into the influent launder through the aspirators. From the influent launder it overflows into the downcomer tube or mixing zone.

(3) Effluent launder. This is a one-piece hexagon-shaped aluminum trough which surrounds the downcomer tube. It is attached to the bridge rails by three adjustable rods. It collects the clear water from the upper section of the erdlator tank and discharges it into the wet well tank.

(4) Wet well tank. This is made of aluminum and is a triangular-shaped section which is welded to the erdlator tank for the collection of the effluent from the erdlator. It provides for limited storage of the coagulated water and serves as a sump for the suction of the filter pump. The wet well tank contains an overflow pipe to permit operation of the erdlator at rated capacity when the filter is stopped. A drain in the bottom of the wet well permits complete drainage of the tank to waste when water unsuited for filtering is obtained from the erdlator. The wet well tank also contains an alarm which warns the operator when the tank is low on water. It is activated by a float assembly.

(5) Sludge concentrator tank. This tank is welded to the wet well tank. It is a square, funnel-shaped aluminum tank with a shorter circular tank welded to the inside of it. There is an inlet in the side of the main tank near the bottom which permits the flocculent slurry to enter by gravity. The inner tank has an opening in the bottom controlled by a manually operated plug valve to permit intermittent drainage of slurry to waste. There is an outlet near the top of the main tank with a manually operated valve to control the flow of clear coagulated water to the wet well. There is also an outlet in the bottom of the tank for draining.

(6) Slurry weir box. This is a small aluminum tank which is welded to the erdlator. It houses the draw-off port near the top of the erdlator tank and permits gravity flow of flocculent slurry from the erdlator tank to the sludge concentrator tank.

(7) Agitator and downcomer tube. The agitator consists of a tubular shaft with four equally spaced circular discs attached. It is mounted in the center of the erdlator tank on a bearing support. The agitator is surrounded by the downcomer tube and baffle ring to form the mixing zone.

(8) Agitator speed reducer. This is mounted on two spacers attached to the agitator bearing mounting plate. It reduces the speed from the agitator drive motor to the erdlator agitator drive shaft.

(9) Agitator drive motor. This is mounted on a bracket attached to the bridge rails. It is a single-phase totally enclosed motor with oblong mounting holes in the base for use in adjusting the drive belt. The agitator motor also drives the air pump.

(10) Air pump. This is an oilless type pump with an intake filter. It is mounted to the bearing plate and driven off of an extended shaft from the speed reducer. It furnishes air to the duplex chemical slurry feeders.

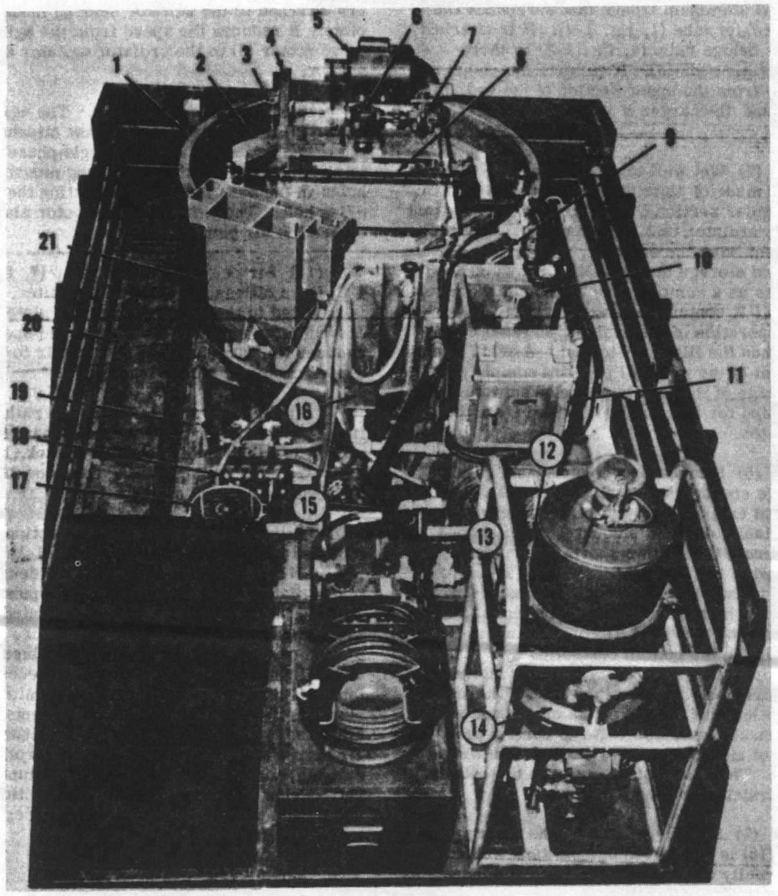
d. Chemical feeders (fig 2-2).

(1) Chemical slurry feeder. This is an aluminum tank mounted to brackets which are welded to the erdlator tank. It has two identical chemical compartments and water collection troughs, and two weirs, one of which contains a float-operated needle valve. One compartment supplies pulverized limestone slurry (coagulant aid) and activated carbon, when needed, to the mixing zone of the erdlator, and the other supplies diatomite slurry to the suction inlet of the filter pump. A dial-indicating timer is mounted on the lower part of the feeder. It is set at 60 minutes when the unit is started. At the end of 60 minutes a bell tone will be heard. This indicates the base charges need recharging.

(2) Chemical solution feeder. The chemical solution feeder, which is constructed of anticorrosive material, is mounted to the erdlator mounting base. It consists of two diaphragm pumps operated from one electric motor by means of a gear reduction mechanism. The chemical solution feeder pumps ferric chloride and calcium hypochlorite solution from two rubber pails into the mixing zone of the erdlator.

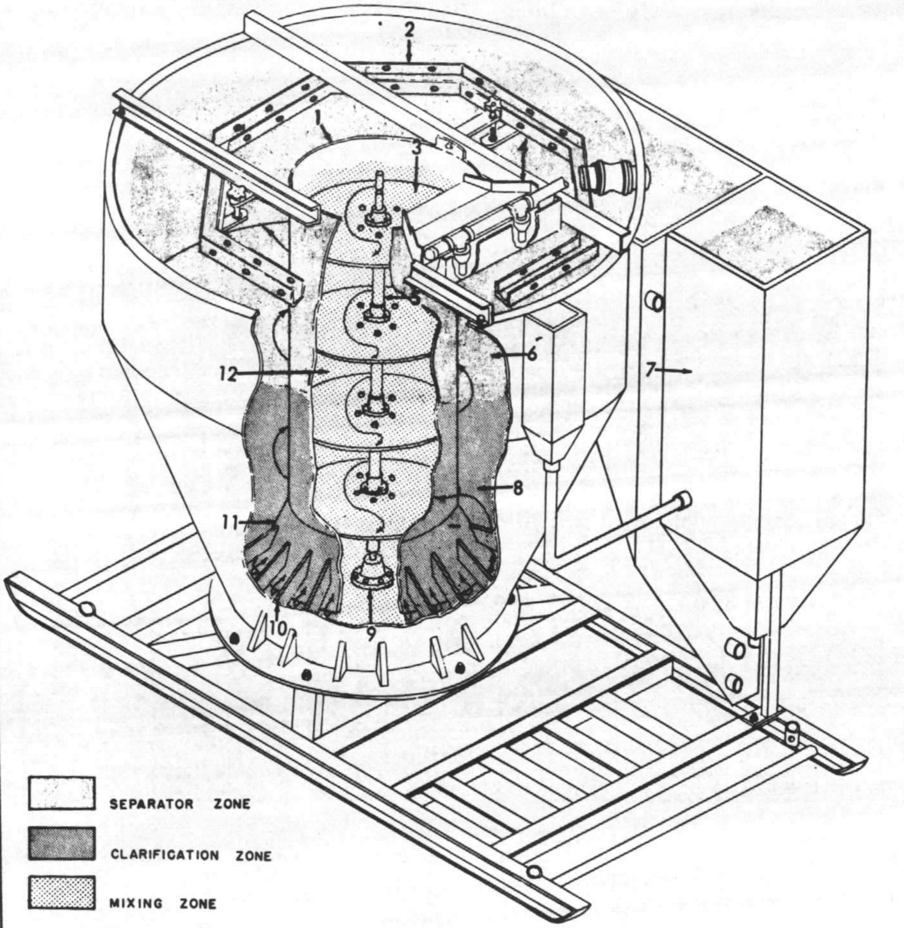
e. Filter section (fig 2-2). This is mounted in a tubular frame and consists of: a filter designed to use diatomaceous earth, a filter pump for pumping the coagulated water through the filter, two pressure gages for indicating the pressure on the effluent and influent sides of the filter, a precoat funnel for adding diatomite slurry for precoating the filter elements, an air-release valve for releasing air trapped in the filter, and a flow-control valve for maintaining a constant rate of flow through the filter.

f. Raw-water and filter pumps (fig 2-2). Both pumps are identical. They are centrifugal, vertical type, powered by a self-contained, integrally built universal motor. The raw-water pump is used for pumping the raw water to the erdlator. It is mounted in a tubular frame designed to mount on the erdlator base when not in use. The filter pump is used for pumping coagulated water from the wet well tank to the filter. It is mounted on the erdlator base.



1 Erdlator tank	8 Influent launder	15 Filter pump
2 Effluent launder	9 Wet well tank	16 Weir box
3 Effluent launder leveling rods	10 Sludge concentrator tank	17 Raw-water pump
4 Bridge rail	11 Electric control box	18 Chemical solution feeder
5 Agitator drive motor	12 Precoat funnel	19 Erdlator mounting base
6 Speed reducer	13 Power cable	20 Storage box
7 Air pump	14 Filter	21 Chemical slurry feeder

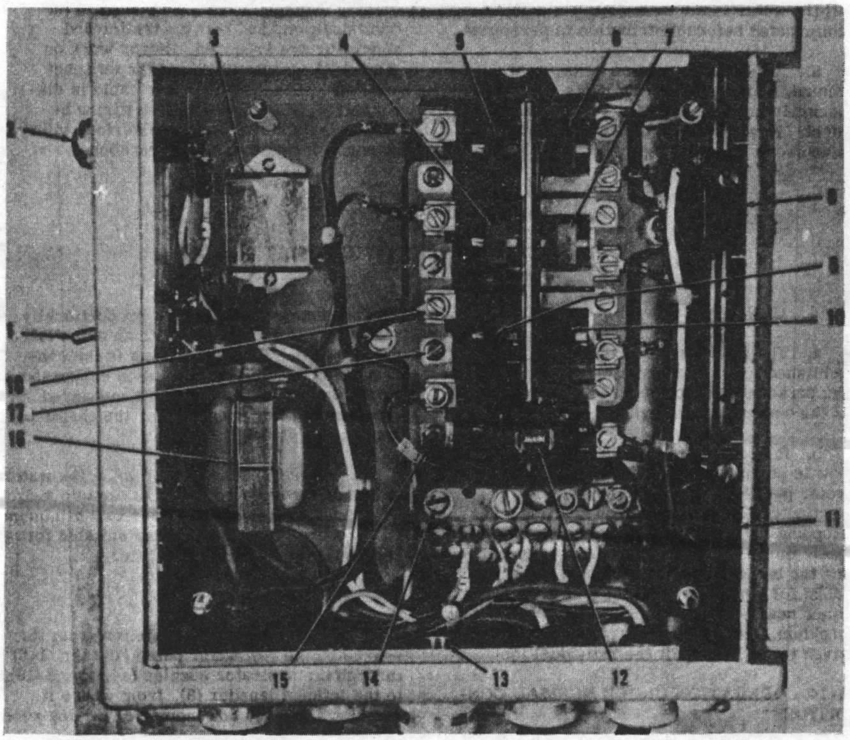
Fig 2-2. Water-purification unit mounted in trailer.



1 Downcomer tube	5 Agitator shaft	9 Bearing support
2 Effluent launder	6 Separation zone	10 Baffle
3 Circular disc	7 Sludge concentrator tank	11 Baffle ring
4 Influent launder	8 Clarification zone	12 Mixing zone

Fig 2-3. Cutaway view of erdlator.

g. Control box (fig 2-4). This is attached to the sludge concentrator tank. It houses the circuit breakers, receptacles, switches, lamp, buzzer, and the necessary wiring to operate the unit.



1 Wet well alarm switch
2 Wet well alarm indicator light
3 Wet well alarm buzzer
4 Solution feeder circuit breaker
5 Wet well alarm circuit breaker
6 Agitator drive motor circuit breaker
7 120 volt outlet circuit breaker
8 120 volt outlet
9 Filter pump circuit breaker
10 Raw-water pump circuit breaker
11 Raw-water pump outlet
12 Master control (MAIN) circuit breaker
13 Generator cable fitting
14 Generator lead terminal 0-WH
15 Generator lead terminal T1-BK
16 Buzzer-alarm transformer
17 Retaining screw
18 Terminal screw

Fig 2-4. Electrical control box components.

h. Distribution set, M-62 (fig 2-5). This set is designed to be used with the 600-gph water-purification unit. However, it also contains enough equipment so that in an emergency it can be used with any purification unit in the Marine Corps.

(1) Adapter pipe to hose. There are two different types of adapters in this set. One has male threads at both ends; one of this type is issued in each set. The other one has a female thread and a male thread; two of this type are issued with each set. These are both 1 1/2 in. fittings.

(2) Bushings. These are not shown in the figure, but there are three issued in each set. Their measurements are 1 in. by 1 1/2 in.

(3) Electrical power cable. This is a 3-strand, 600-volt, rubber-insulated electrical cable. Each set contains 50 ft of this cable.

(4) Comparator. This is not shown in the figure, but each set contains a comparator consisting of the components discussed in chapter 1.

(5) Machinist's hammer. Each set contains one 12-oz ball peen hammer.

(6) Hose, cotton, rubber-lined. This has 1 1/2-in. female and male threads and comes in 25-ft lengths. There are two of these in each set.

(7) Hose, dacron, rubber-lined. This has 1 in. male and female threads and comes in 25-ft lengths. There are two of these in each set.

(8) Hose, assembly, rubber. There are three different hoses. One has 1-in. fittings and comes in 10-ft lengths. Six of these are issued with each set. Another one has 1 1/4-in. fittings and comes in 10-ft lengths. Four of these are in each set. The last one has 1 1/2-in. fittings and comes in 10-ft lengths. There are two of these in each set.

(9) Key set, socket-head screw. This includes 14 L-type keys ranging from .050 to 5/8 in. in size. There is one key set in each distribution set.

(10) Light extension. This has a 100-watt lamp and 25 ft of cord. There is a wire cage around the lamp to prevent it from being broken. There is one light in each set.

(11) Dry chemical measure. There are four measures. Each one is marked as shown in figure 2-5.

(a) Diatomite slurry feed. This measure has a capacity of 0.1 lb. Its smallest graduation is 10 ppm.

(b) Diatomite precoat. This measure holds 0.4 lb when level with the top.

(c) Limestone. This measure holds 3/4 lb. Its smallest graduation is 20 ppm.

(d) Calcium hypochlorite. This has a 0.2-lb capacity and is divided into 0.5-oz measurements.

(12) Pipe nipple. There are three, 1 1/2-in. by 6-in. galvanized nipples in each set.

(13) Nozzle, fuel and oil servicing. Each set has one nozzle for distributing water.

(14) Pliers. There is a 6-in. pair of pliers in each set.

(15) Screwdrivers. The figure shows the two screwdrivers used.

(16) Strainer. There is one strainer with a 1-in. female fitting.

(17) Water tank. This is not shown in the figure, but each distribution set contains one tank with all of its components.

(18) Rubber pail. There are four rubber pails in each set, each with a 3-gal capacity.

(19) Open-end wrenches. There are four open-end wrenches included in this set. Wrench sizes are found in the key to figure 2-5.

(20) Adjustable open-end wrenches. There are two adjustable wrenches in each set: one 8 in., and one 12 in.

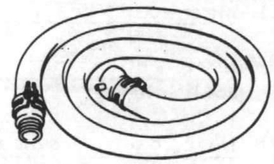
(21) Pipe wrench. Two of these are included in each set: one 14 in., and one 18 in.

(22) Spanner wrench. There are two wrenches in each set for connecting the suction and discharge hoses.

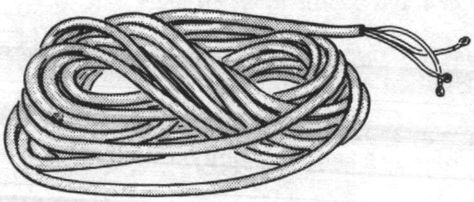
(23) Miscellaneous items. These items are not furnished with the distribution set but must be requisitioned separately and placed in the set. They include 10 lb of calcium hypochlorite, a 5-lb bag of activated carbon, a 50-lb bag of diatomaceous earth, twenty 1-lb bags of ferric chloride, an 80-lb bag of pulverized limestone, a 500-cc bottle of orthotolidine solution, and one dry cell 1.5v battery.

Adapter, pipe to hose (male threads both ends)

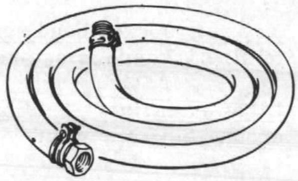
Adapter, pipe to hose (one male and one female threads)



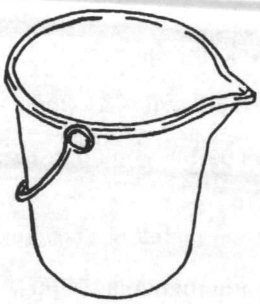
Hose assembly, rubber, 1 1/4-in. fittings



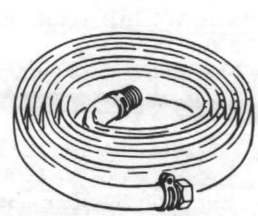
Power cable, electrical



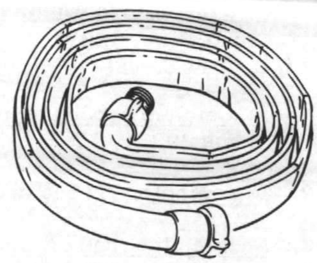
Hose assembly, rubber, 1-in. fittings



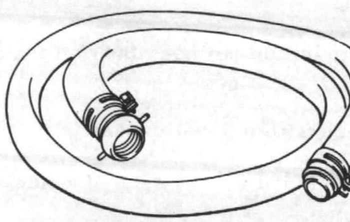
Pail, rubber



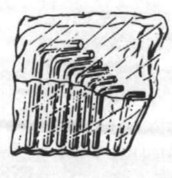
Hose, dacron, rubber-lined, 1-in. fittings



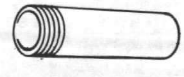
Hose, cotton, rubber-lined, 1 1/2-in. fittings



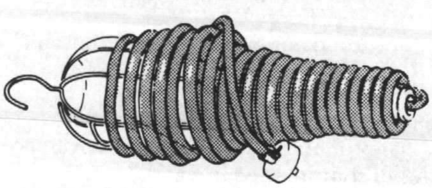
Hose assembly, rubber, 1 1/2-in. fittings



Key set, socket-head screw

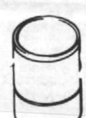


Nipple pipe



Light, extension

Dry chemical measure (calcium hypochlorite)



Dry chemical measure (diatomite slurry feed)

Fig 2-5. Components of water distribution set M-62.

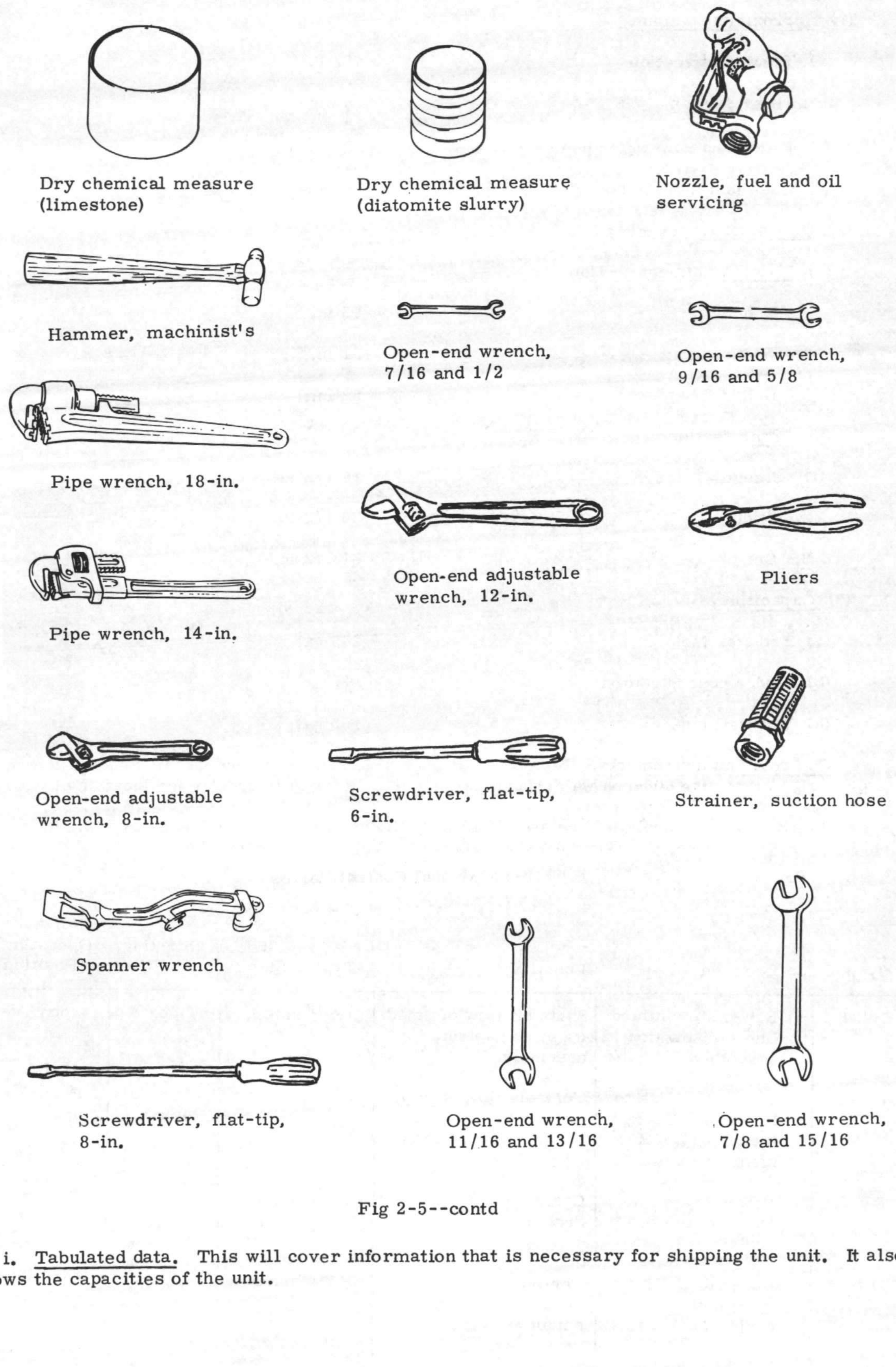


Fig 2-5--contd

i. <u>Tabulated data.</u> This will cover information that is necessary for shipping the unit. It also shows the capacities of the unit.

(1) Approximate weight.

(a) Treatment section 702 lb

(b) Filter section 268 lb

(c) Filter and raw-water pumps 20 lb ea.

(d) Chemical storage box 41 lb

(2) Dimensions.

(a) Water-treatment section.

1. Length 73 in.

2. Width 51 in.

3. Height 53 in.

(b) Filter section.

1. Length 29 1/2 in.

2. Width 23 1/2 in.

3. Height 51 1/2 in.

(3) Capacities.

(a) Erdlator tank 245 gal

(b) Sludge concentrator tank 30 gal

(c) Wet well tank 50 gal

j. Controls and instruments. Tables 2-1 through 2-6 should give the operator enough information to properly operate the 600-gph water-purification unit. Refer to figure 2-6 for location of valves.

The following symbols will be used to identify the manual control valves: ARV-Air Release Valve, BV-Block Valve, CV-Control Valve, DV-Drain Valve, VV-Vent Valve.

Table 2-1. Manual Control Valves

Symbol	Location	Function	Type & Size	Starting Position	Normal Operating Position
BV-1	Raw-water influent line to aspirator assembly	Shuts off flow of raw water to aspirator assembly	1-in. gate	Open	Open
CV-2	Raw-water line to limestone slurry feeder compartment	Controls flow of raw water used for dilution of limestone slurry	1/8-in. globe	Partially open	Partially open
DV-3	Lower drain line from bottom of erdlator	Completely drains erdlator	1 1/4-in. gate	Closed	Closed
DV-4	Upper drain line from bottom of erdlator	Partially drains erdlator for short shutdown	1 1/4-in. gate	Closed	Closed
CV-5	Side of erdlator, near top, between wet well tank & weir box	Supplies coagulated water for mixing chemicals	3/8-in. angle globe	Closed	Closed

Table 2-1. Manual Control Valves--contd

Symbol	Location	Function	Type & Size	Starting Position	Normal Operating Position
BV-6	Coagulated water line from weir box to sludge concentrator tank	Permits slurry withdrawal from erdlator tank to sludge concentrator	1-in. gate	Open	Open
CV-7	Draw-off piping from concentrator tank to wet well tank	Controls flow of coagulated water to wet well	Orifice plug valve (short threaded rod)	Closed	Partially open
CV-8	Draw-off piping in false bottom of concentrator	Permits high rate waste water sludge draw off to waste	Orifice plug valve (long threaded rod)	Closed	Closed
CV-9	Drain line from bottom of concentrator	Drains concentrator, controls amount of slurry thrown to waste	3/4-in. gate	Closed	Partially open
DV-10	Drain line from bottom of wet well tank	Drains wet well tank	3/4-in. gate	Open	Closed
CV-11	Coagulated water line from filter pump to diatomite slurry feeder compartment	Controls flow of coagulated water used for dilution of diatomite slurry	1/4-in. gate	Closed	Partially open
BV-12	Coagulated water line from filter pump to influent side of filter	Shuts off coagulated water to filter	1-in. quick-acting gate	Closed	Open
CV-13	Influent side of filter	Controls direction of flow of coagulated filter influent for either filtering or washing	1-in. plug valve, 3-way, 2-port, 90° turn	Filter Wash	Filter (When filtering) Wash (When backwashing)
VV-14	Air vent line from filter	Vents air from filter as required	1/4-in. angle globe	Open	Closed
CV-15	Feed water line from precoat funnel	Permits flow of filter-aid slurry for precoating filter	1/2-in. globe	Open	Closed
DV-16	Drain line from bottom of filter	Drains filter when backwashing	1-1/4-in. quick-acting gate	Closed	Closed
ARV-17	Top of filter	Releases air trapped in influent side of filter	5-sq in. air-release valve	Closed (Filter) Open (Backwash)	Closed (Filter) Open (Backwash)

Table 2-1. Manual Control Valves--contd.

Symbol	Location	Function	Type & Size	Starting Position	Normal Operating Position
BV-18	Filtered water line from bottom of filter	Shuts off flow of filter effluent	1-in. gate	Closed	Open (When filtering) Closed (When backwash-ing)
DV-19	Filtered water line below flow controller (CV-20)	Drains filtered water line	1/2-in. drain valve	Closed	Closed
CV-20	Filtered water line below 3-way valve	Controls flow of filter effluent	1-in. flow controller	Open	Open
DV-21	Bottom of flange on flow controller valve (CV-20)	Drains water from area between valve diaphragm and flange	1/8-in. drain valve	Closed	Closed
DV-22	Top of flange on flow controller (CV-20)	Permits drainage of water from area between valve diaphragm and flange	1/8-in. drain valve	Closed	Closed
CV-23	Filtered water line	Controls direction of flow of filter effluent for either filtering or re-circulation	1-in. plug valve, 3-way, 2-port, 90° turn	Re-circulate	Filter
CV-24	Top of air pump connected to erdlator drive	Controls flow of air to slurry feeder	1/8-in. needle	Partially open	Partially open
DV-25	Base of raw-water pump	Permits drainage of pump	1/8-in. drain plug	Closed	Closed
DV-26	Base of filter pump	Permits drainage of pump	1/8-in. drain plug	Closed	Closed

The following symbols will be used to identify the flow control valves: FCV-Flow Control Valve, SCV-Swing Check Valve.

Table 2-2. Preset and One-way Flow Control Valves

Symbol	Location	Function	Type & Size	Starting Position	Normal Operating Position
FCV-1	Raw-water line opposite float valve (LLCV-1)	Permits predeter-mined flow of raw water to the aspirators	3/4-in. flow control valve (preset 10 gpm)	Open	Open

Table 2-2. Preset and One-way Flow Control Valves--contd

Symbol	Location	Function	Type & Size	Starting Position	Normal Operating Position
SCV-2	Coagulated water line below 3-way plug valve (CV-13)	Prevents backward flow of coagulated water and holds filter water pressure during backwash	1-in. swing check valve	Closed	Open

The following symbols will be used to identify the mechanically automatic valves and liquid level controls: LLC-Liquid Level Control, LLCV-Liquid Level Control Valve.

Table 2-3. Automatic Valves and Liquid Level Controls

Symbol	Location	Function	Type & Size	Starting Position	Normal Operating Position
LLCV-1	Raw-water bypass. Directly connected to LLC-2	Regulates raw-water flow from min to max bypassing FCV-1 at max flow	1/2-in. lever-actuated valve	Open	Closed
LLC-2	Wet well tank, directly connected to LLCV-1	Controls liquid level in wet well tank	Float chamber mechanically interlocked to lever-actuated valve (LLCV-1)	Down	Up

The following symbols will be used to identify the indicators: TI-Time Indicator, PI-Pressure Indicator.

Table 2-4. Time and Pressure Indicators

Symbol	Location	Function	Type	Range	Normal Operating Range
TI-1	Front of slurry feeder	Indicates time to charge slurry feeder	Dial indicator manually operated, bell signal	0-60 min	0-60 min
PI-2	Upper gage at bottom of filter	Indicates influent pump pressure to filter	Dial indicator	0-100 psi	40-50 psi
PI-3	Lower gage at bottom of filter	Indicates effluent pressure from filter	Dial indicator	0-100 psi	5-50 psi

The following symbol will be used to identify the automatic electric control: SS-Sensitive Switch.

Table 2-5. Automatic Electric Control

Symbol	Location	Function	Type	Normal Setting
SS-1	Top of wet well tank, under lever actuated by the liquid level control (LLC-2)	Operate buzzer and light to warn operator when water in wet well is low, energized by contact with lever actuated by liquid lever control (LLC-2)	Switch, sensitive, single-pole	Open

Table 2-6. Manually Operated Electric Controls

Component Controlled	Control Station	Type of Contact	Location
Wet well warning buzzer and light	On - Off	Toggle Swtich	Left side of control cubicle
Wet well alarm	On - Off	Circuit breaker, single-pole, stationary contact, 15 amps, 120 volts	Inside electric control cubicle
Solution feeder	On - Off	Circuit breaker, single-pole, stationary contact, 15 amps, 120 volts	Inside electric control cubicle
120-volt outlet	On - Off	Circuit breaker, single-pole, stationary contact, 15 amps, 120 volts	Inside electric control cubicle
Filter pump	On - Off	Circuit breaker, single-pole, stationary contact, 20 amps, 120 volts	Inside electric control cubicle
Raw-water pump	On - Off	Circuit breaker, single-pole, stationary contact, 20 amps, 120 volts	Inside electric control cubicle
Agitator motor	On - Off	Circuit breaker, single-pole, stationary contact, 20 amps, 120 volts	Inside electric control cubicle
Master control circuit	On - Off	2 circuit breakers, single-pole, stationary contact, 30 amps each, 120 volts, connected by 2-pole connecting handle	Inside electric control cubicle

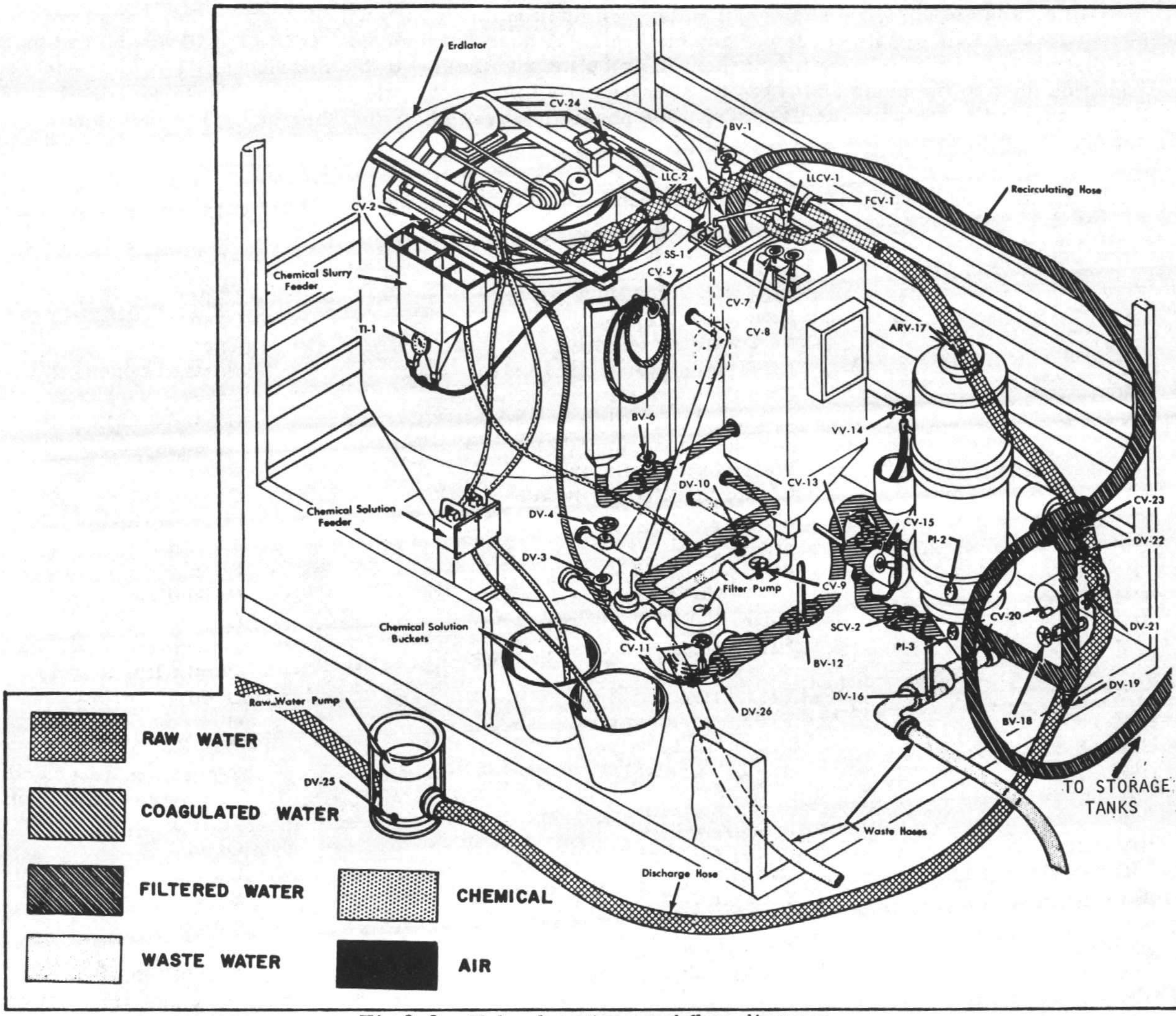


Fig 2-6. Valve locations and flow diagram.

2-2. OPERATION OF PURIFICATION UNIT

a. Preparing unit for operation. Select an operating site as discussed in chapter 1. Once this is done, the unit is towed to it and disconnected from the towing vehicle. The unit, which should be located within 50 ft of the raw-water source, is then leveled by lowering the front and rear leveling jacks and adjusting them. The ground rod and cable stored in the storage box on the trailer is then put in place. It is driven into the ground and a cable is connected from it to the trailer. The main power cable located on the brackets under the control box is then connected to the terminal lugs of the external power source.

Note: Care must be taken when connecting the main power cable to generator terminal lugs. These wires may not be color-coded alike. If you are in doubt as to the right connection, trace the wires to determine the hot lead and so on.

Connect the filter waste water hose and the erdlator tank waste hose and run them to a suitable discharge point where the waste will not be drawn back into the unit. Remove the raw-water pump from the trailer and place it as close to the raw-water source as possible. The suction lift of the raw-water pump should not exceed 10 ft. A 1-in. suction hose and a 1-in. discharge hose are connected to the raw-water pump. Place a strainer on the raw-water suction hose. Connect the raw-water pump discharge hose to the erdlator. The water distribution tanks are removed from the trailer and set up. The number of water distribution tanks used will depend on the amount of purified water that will be needed at any one time. A hose is then connected to the filter and run to the distribution tanks. Place the 65-gpm distribution pump close to the distribution tank and connect a suction hose to the pump and place the other end into the distribution tank. A discharge hose is then connected to the pump and a distribution nozzle is screwed on the other end. The unit is now set up.

b. Prepositioning of valves before putting unit in operation.

NUMBER	NAME	POSITION
FCV-1	Raw-water restrictor valve	10 gpm
LLCV-1	Raw-water bypass valve	Open
BV-1	Raw-water inlet valve	Open
CV-2	Limestone slurry feed valve	Partially open
DV-3	Complete drain valve	Closed
DV-4	Partial drain valve	Closed
CV-5	Solution make-up valve	Closed
BV-6	Weir box outlet valve	Open
CV-7	Liquid level control valve	Closed
CV-8	Sludge control valve	Open to first notch
CV-9	Sludge drain valve	Closed
DV-10	Wet well drain valve	Open
CV-11	Diatomite slurry feed valve	Closed
BV-12	Filter pump discharge valve	Closed
CV-13	Filter input valve	2-position valve, wash and filter setting
VV-14	Vent valve	Open
CV-15	Precoat feed valve	Closed
DV-16	Filter drain valve	Closed
ARV-17	Air release valve	2-position, filter and backwash setting on filter
BV-18	Filter discharge valve	Open
DC-19	Drain cock	Closed
CV-20	Flow control valve	Set at 10 gpm
DC-21	Draincock	Closed
DC-22	Draincock	Closed
CV-23	Filter output valve	2-position, filter and recirculate. Set on recirculate.
CV24	Air control valve	Partially open

c. Chemical requirements.

(1) Ferric chloride is a coagulant. It takes one pound of ferric chloride to three gallons of water mixed in one of the 3-gallon pails. The scale setting on the solution feeder on the ferric chloride side is 1.2.

(2) Pulverized limestone is a coagulant aid. It takes 120 ppm of limestone in the slurry hopper. The limestone slurry hopper is recharged every hour of operation.

(3) Calcium hypochlorite is a disinfectant. It takes .15 pounds of calcium hypochlorite in three gallons of water. The scale setting on the solution feeder for calcium hypochlorite is 5.0 until your erdlator tank is full of water, and then the scale setting is reduced to 1.2.

(4) Diatomaceous earth (D.E.) is a filter aid. It takes 0.4 pounds of D.E. in the precoat funnel for each precoat cycle. D.E. is also used in a diatomite slurry hopper. Its required amount is .10 pounds to each hour of operation.

(5) Activated carbon is the absorbent. It takes .25 pounds of activated carbon added to your limestone slurry hopper if there is an unpleasant odor or taste in the water that you are about to purify.

CAUTION: Do not mix ferric chloride and calcium hypochlorite together in any large quantities. When these two chemicals are mixed together, they will form chlorine gas which is very dangerous.

d. Chemical adjustment.

(1) Ferric chloride.

(a) If the water in the erdlator tank is cloudy in color, the adjustment to be made would be to increase the ferric chloride.

(b) If the water is red in color, you would reduce the ferric chloride.

(2) Limestone.

(a) If the floc in the erdlator tank should appear to be light and rising, you would increase the pulverized limestone.

(b) If the floc appears heavy and rolling, you would decrease the amount of pulverized limestone.

(3) Activated carbon. If there should be any unpleasant odor or taste to the water that is purified, you would add activated carbon to the limestone side of the slurry hopper.

(4) Rotating adjustment.

(a) When the blanket in the erdlator tank is banking and slushing against the sides, decrease the speed on the agitator speed reducer.

(b) If there is little or no movement in the blanket, you would increase the speed on the agitator speed reducer.

e. Procedure.

(1) Make maintenance check on generator and erdlator assembly.

(2) Safety check.

(a) Make sure there are no loose or frayed wires.

(b) Make sure all breakers are "off" in the control box.

(c) Make sure both units are grounded.

(3) Mix chemicals in 3-gallon pails.

(a) Ferric chloride (one pound to three gallons of water).

(b) Calcium hypochlorite (.15 pounds to three gallons of water).

(4) Install poppit valves, rubber washers, and plastic disc in solution feeder pump.

(a) Set ferric chloride side at 1.2.

(b) Set calcium hypochlorite at 5.0.

(5) Set valves in preliminary position.

(6) Install hoses in proper positions:

(a) 25' discharge hose on 90° elbow at CV-23 to storage tank.

(b) 25' discharge hose from raw water pump to raw water inlet pipe.

(c) 10' suction hose with strainer on end to raw water source to the suction side of raw water pump.

(d) 10' suction hose from CV-23 on 45° elbow to the wet well tank.

(e) 10' suction hose on CV-23 to BV-12.

(f) 10' suction hose on DV-3 to drain.

(g) 10' suction hose on DV-16 to drain.

(7) Prime the raw water pump and start it.

(8) Start solution feeder as soon as you have water in your influent launder.

(9) As soon as there is one foot of water in the erdlator tank, start the agitator.

(10) Fill the limestone slurry hopper with raw water and add 120 ppm of pulverized limestone.

(11) Wait until the erdlator tank is full of water.

(12) When the erdlator tank is full of water, lower one side of the effluent launder and let trash and dirt drain off the top of the erdlator tank into the effluent launder and into the wet well and out to waste.

(13) Close DV-10.

(14) Crack CV-9 and level water in the sludge concentrator tank.

(15) Then level effluent launder so water enters hose evenly all the way around.

(16) Reduce the scale setting on the solution feeder calcium hypochlorite side from 5.0 to 1.2.

(17) Take a clean bucket and fill precoat feed funnel on filter assembly 2/3 full of precoat water.

(18) Take a clean bucket and fill the diatomite slurry hopper full of pretreated water and 40 ppm of of D.E.

f. Four cycles of operation.

(1) Precoat.

(a) Take 0.4 pounds of D.E. and mix it with the water in the precoat funnel, open CV-15, and let the solution drain into the filter.

(b) Close CV-15.

(c) Open DV-12.

(d) Start the filter pump.

(e) Precoat from 4 to 6 minutes or until the water is clear in the observation window on the filter assembly or until you can see a good coat or cake of D.E. on the filter sleeves.

(f) Flow of water during precoat cycle: The water leaves the wet well through a yellow pipe into the filter pump. It travels through DV-12 through the 10' piece of suction hose in CV-13. It drops down through CV-13 into the bottom of the filter section. It rises on the inside of the filter housing on the outside of the filter sleeves, until it reaches the top of the housing. The water is then forced through the filter sleeves and elements leaving a cake of D.E. on the outside of the filter sleeves. Water then drops down through the filter element and out the false bottom of the filter housing into BV-18, CV-20, into CV-23. It goes out the 45° elbow and through a 10' piece of suction hose into the wet well tank.

(2) Filter cycle.

(a) In order to go into the filter cycle, change CV-23 from recirculate to filter and crack CV-11 to where there is a small amount of D.E. entering the line behind the filter pump to the filter housing.

(b) This small amount of D.E. will repair any pinholes or cracks in the filter sleeves that may develop during the filter cycle.

(c) The filter cycle may run from 10 minutes to 10 hours.

(3) Backwash.

(a) There are four times you have to backwash:

- When the source is dry.
- When the storage tanks are full.
- If there is an interruption in the operation.
- If the effluent pressure gage drops to 5 psi.

(b) The way to go into a backwash cycle is:

- Close BV-18.
- Close CV-11.
- Wait until the pressure equalizes.
- Shut off the filter pump.
- Close BV-12.
- Change ARV-17 from filter to backwash and open DV-16.
- Open VV-14 and let filter drain completely.

(4) Wash cycle. The wash cycle lasts for one minute:

- Change CV-13 from filter to wash.
- Open BV-12.
- Start filter pump and wash for one minute.
- Cut off the filter pump.
- Close BV-12.
- Let filter assembly drain completely.

g. Shutting down the erdlator. First, push the agitator drive motor circuit breaker off. Then remove the chemical solution feeder suction tubing from the two rubber pails. Allow the solution feeder to pump until all the solution is drawn from the tubing and then push its circuit breaker off. Also push the raw-water pump and wet well alarm circuit breakers off. Push the wet well warning buzzer and light toggle switch breakers off and then secure the main breaker in the off position. Next open upper drain valve DV-14 and lower drain valve DV-3 in the lower section of the erdlator tank.

Note: (If the erdlator is to be shut down for a short period, not to exceed 2 days, and there is no possibility of the water freezing or the unit being moved, do not open lower drain valve DV-3. This will allow the unit to be started without having to form a new floc.) After the water in the erdlator has drained below the inlet to valve CV-5, open the valve and let all the water drain from the hose. Next, open valve CV-11 in the dilution line and drain valve DV-10 in the line from the bottom of the wet well tank and let all the water drain out. Open valves CV-9, CV-7, CV-8, CV-2, BV-1, and CV-4. Then remove the vent plugs from the bottom of the limestone and slurry compartments of the slurry feeder. After all the water has drained from the slurry feeder, replace the two vent plugs. Next open valve BV-12 and remove drain plug DV-26 from the base of the filter pump. Then, change valve CV-13 from wash to filter position and drain all the water from the filter pump discharge hose. After all the water has drained from the filter pump, install drain plug DV-26. Now, drain all the hoses. The raw-water pump is drained in the same manner as the filter pump.

h. Operation under unusual conditions.

(1) Operation in cold weather. In cold water, 40° F or less, the erdlator agitator should be set at its lowest mixing speed. Use warm water to prime the pumps, to thaw possible ice accumulations on the impellers and seals, and to prevent damage. When the equipment is to be stopped or shut down, drain all pumps, hoses, pipes, and tanks quickly. Leave all drain valves open and inspect all equipment to be sure that it has drained completely. To prevent freezing when there is not a continuous water demand, instead of stopping the unit, maintain the flow of water through the equipment. Do not bend wiring insulation in extreme cold; it may crack or break and cause a short circuit. The trailer should be parked on planking to prevent the tires from freezing to the ground. Inflate the tires to their maximum pressure (45 psi).

(2) Operation in extreme heat. The erdlator agitator should be operated at or near its maximum mixing speed. The canvas tarpaulin of the trailer should cover the equipment in the trailer and protect the water from the direct rays of the sun. Sunlight will cause the floc particles to rise to the surface. The insulation of electrical wiring softens in extreme heat and can be easily damaged; therefore, check the wiring often.

(3) Operation in extreme dust and dirt. Place the unit in some type of shelter or windbreak to protect it from dust or dirt being blown into the erdlator. When muddy or sandy water is being pumped, the pump chamber should be drained frequently to prevent sedimentation from plugging the priming hole.

2-3. MAINTENANCE INSTRUCTIONS

a. General. To insure that equipment is ready for operation at all times, it must be inspected systematically and all operator's services must be performed so that defects may be discovered and corrected before they result in serious damage or failure. The necessary preventive maintenance services will be performed before operation. Defects discovered during operation of the unit will be noted for future correction. Stop operation immediately if a deficiency is noted which would damage the equipment. After-operation services will be performed at intervals based on the normal operations of the equipment. Reduce the interval to compensate for abnormal conditions. Defects or unsatisfactory operating characteristics beyond the scope of the operator must be reported at the earliest opportunity to organizational maintenance.

b. Lubrication.

(1) Solution feeder.

(a) Solution feeder drive arm bearings are lubricated every 250 hours of operation.

(b) Solution feeder drive arms are oiled every 50 hours of operation.

(c) Solution feeder lever arms are lubricated every 50 hours of operation.

(d) Solution feeder oil is checked before operation and every 10 hours of operation thereafter. The oil is changed every 500 hours of operation. It takes a special purpose electrical insulated oil.

(2) Agitator speed reducer.

(a) Agitator reduction gear is lubricated every 50 hours of operation.

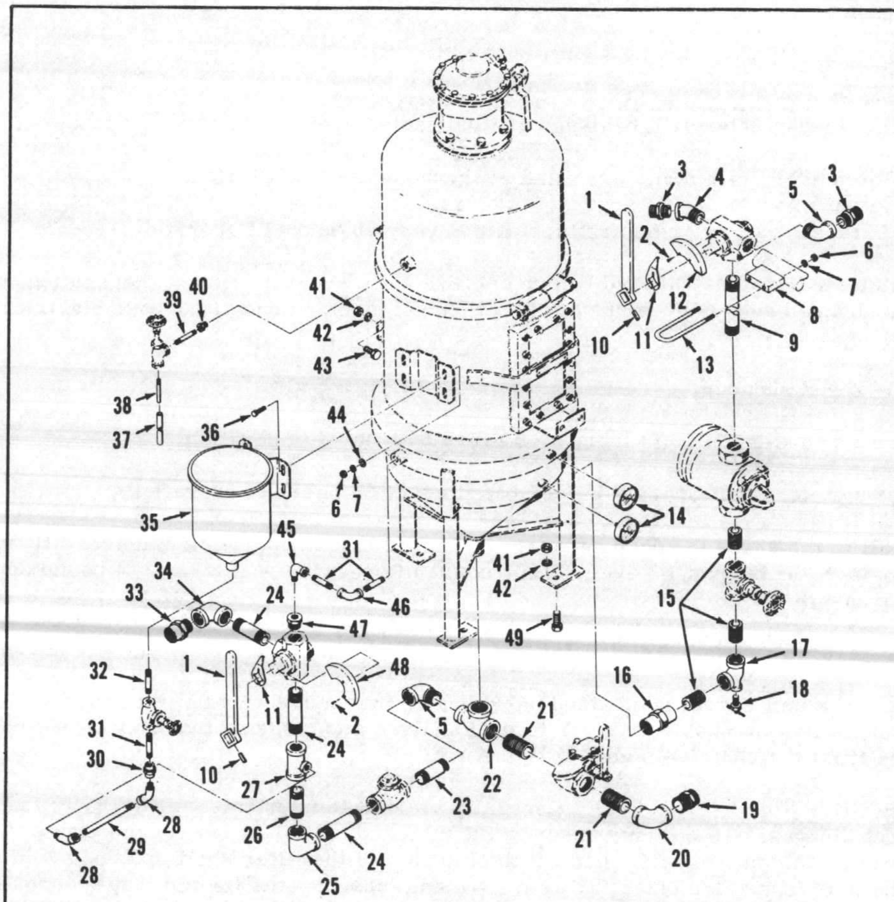
(b) Upper agitator shaft bearing is lubricated every 50 hours of operation.

(c) The oil in the agitator speed reducer is checked before operation and every 10 hours thereafter. It is changed every 1,000 hours of operation. It takes 1/4 pound of 90 wt. GW grease.

(3) Trailer leveling jacks. The trailer leveling jacks are lubricated every 250 hours.

c. Cleaning. The unit should be cleaned periodically (washed down with water and wiped with a cloth). Particular attention should be given to drain valves and plugs so that they do not become clogged or stuck from the chemicals used with the unit.

d. Diatomite filter (figs 2-7 and 2-8). Generally the servicing of this unit is the replacement of the filter element sleeves. To do this, unscrew the nuts and bolts that secure the clamp ring around the filter and take the clamp ring off. Lift off the top part of the filter shell and remove the gasket. This exposes the four filter elements. To remove them, unscrew the tie rod that secures the upper bracket (head) and lift the bracket off. Now lift off the perforated metal tubes which the filter sleeves are on. This exposes the plastic cups. Visually check these plastic cups for cracks, breaks, or chips and replace if necessary. Then remove the plastic sleeve from the perforated metal tube as shown in figure 2-9.



1 Handle	11 Pointer	21 Nipple	31 Nipple	41 Nut
2 Screw	12 Plate	22 Tee	32 Nipple	42 Washer
3 Adapter	13 Bolt	23 Nipple	33 Adapter	43 Screw
4 Elbow	14 Gage	24 Nipple	34 Elbow	44 Washer
5 Elbow	15 Nipple	25 Elbow	35 Funnel	45 Elbow
6 Nut	16 Union	26 Nipple	36 Screw	46 Elbow
7 Washer	17 Tee	27 Tee	37 Tubing	47 Bushing
8 Spacer	18 Cock	28 Elbow	38 Nipple	48 Plate
9 Nipple	19 Adapter	29 Nipple	39 Nipple	49 Screw
10 Pin	20 Elbow	30 Union	40 Bushing	

Fig 2-7. Exploded view of filter unit.

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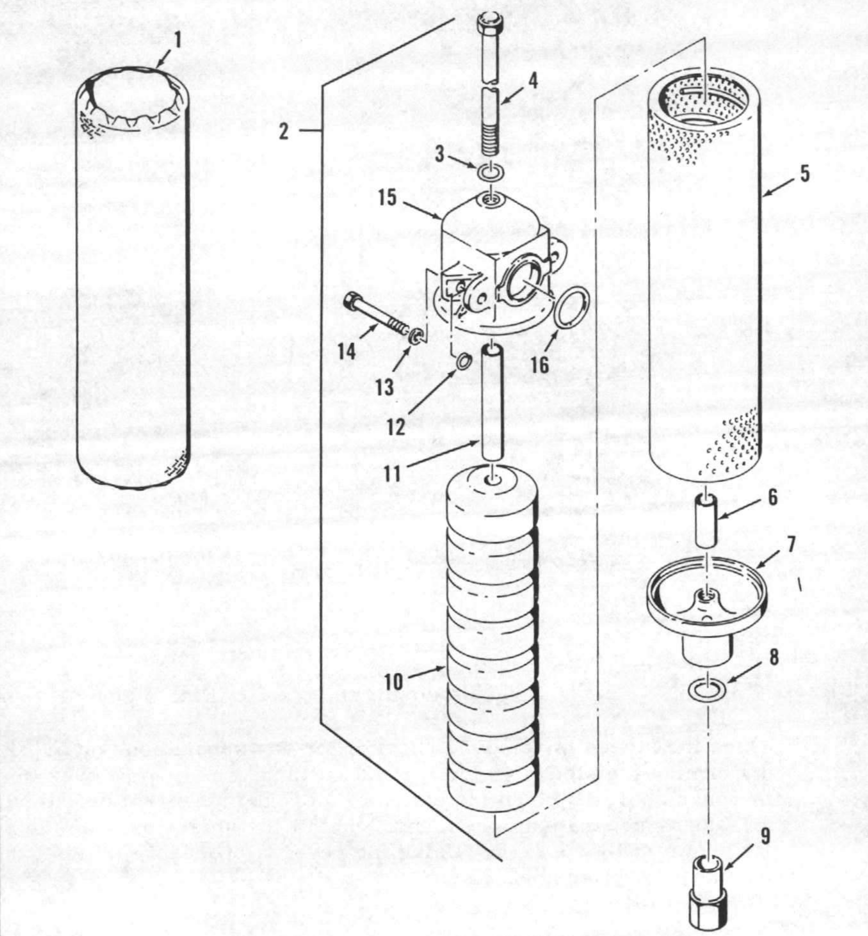
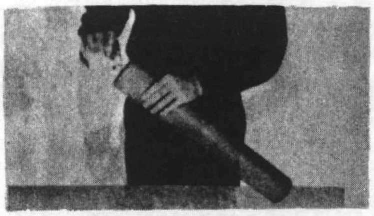
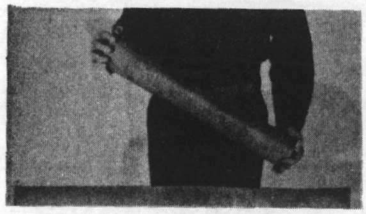


1 Sleeve
2 Element
3 Packing
4 Tierod
5 Tube
6 Spacer
7 Base
8 Packing
9 Adapter
10 Cup
11 Spacer
12 Ring
13 Washer
14 Screw
15 Head
16 Packing

Fig 2-8. Exploded view of filter element.

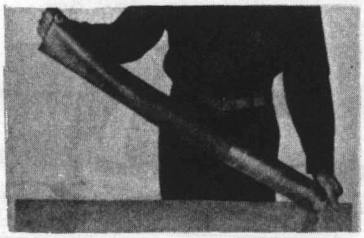


A – Depositing diatomaceous earth in sleeve



B – Distributing diatomaceous earth in tube

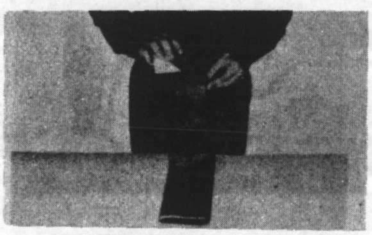
C – Loosening sleeve



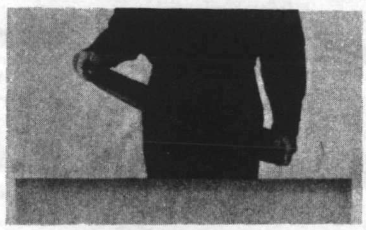
D – Removing sleeve from tube

Fig 2-9. Removing the plastic filter sleeve.

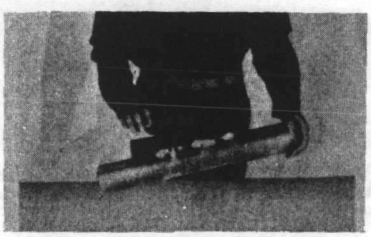
Once the sleeve is removed, check it for any separations or breaks. This can be done by turning the sleeve inside out and running your fingers over the smooth surface. A rough spot will be an indication of a break or separation. Replace the sleeve if any breaks or separations are found. Install the sleeve back on the perforated metal tube as shown in figure 2-10. Using the reverse procedure, install the filter elements and replace the filter shell gasket and shell.



A – Depositing diatomaceous earth in sleeve



B – Distribution of diatomaceous earth in sleeve



C – Dusting perforated tube

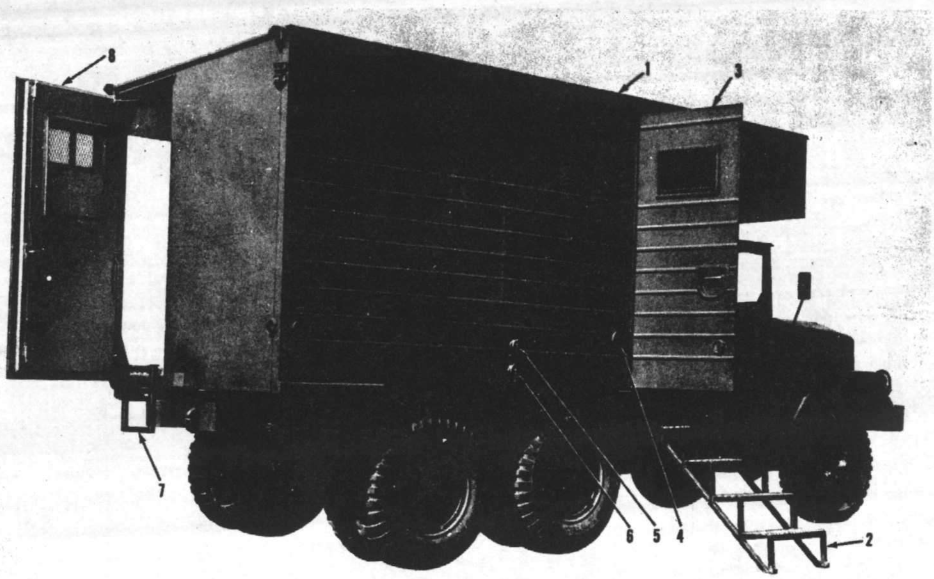
D – Placing tube in sleeve

Fig 2-10. Installing the filter sleeve.

Section II. VAN-MOUNTED 1500-GPH WATER-PURIFICATION UNIT (ERDLATOR)

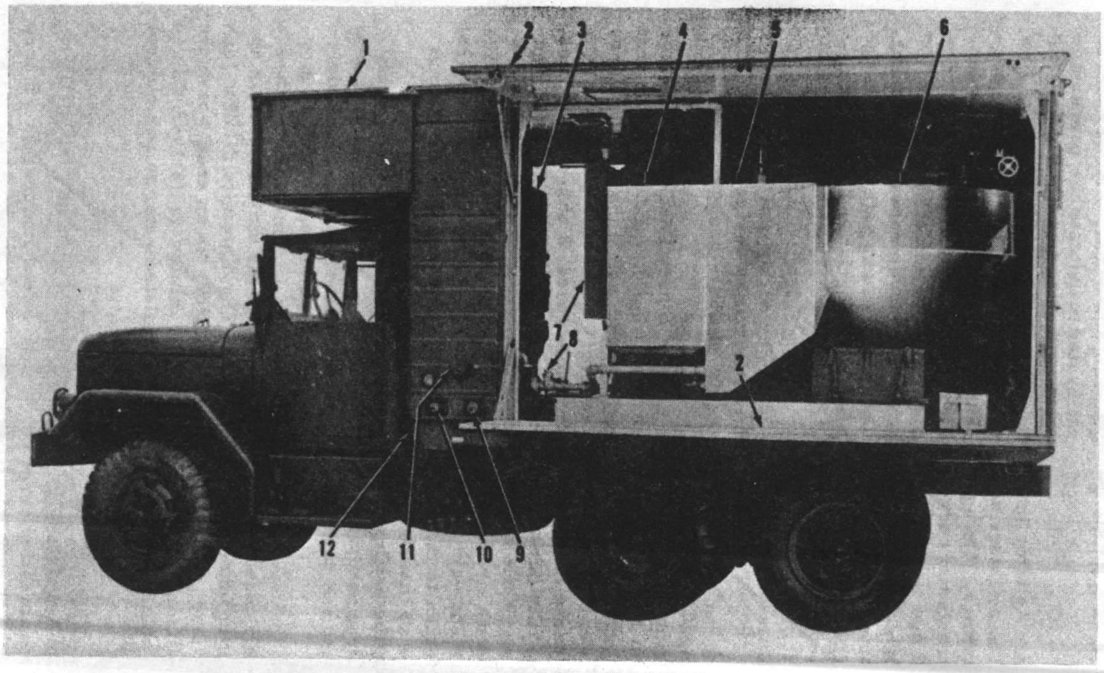
2-4. DESCRIPTION

a. General. This unit is similar in operation to the 600-gph erdlator previously mentioned in this chapter. It is a self-contained, continuous-flow unit capable of purifying 1500 gallons per hour of water. The 1500-gph erdlator is mounted in an enclosed van on the chassis of a 5-ton truck. Figure 2-11 shows a right side view of the van body. Figure 2-12 shows the van body with the left side doors open.



1. Van Body
2. Ladder Assembly
3. Right side door
4. Cable outlet cap
5. Hose cap (raw water inlet)
6. Hose cap (waste water outlet)
7. Ladder assembly
8. Rear door

Fig 2-11. Van body, right view/chassis.



1. Bonnet door (2 rqr)
2. Left side door
3. Diatomite filter assembly
4. Sludge concentrator tank
5. Wet well tank
6. Erdlator tank
7. Control cabinet
8. Filter pump assembly
9. Hose cap (waste water outlet)
10. Hose cap (filtered water outlet)
11. Cable outlet cap
12. Ground stud

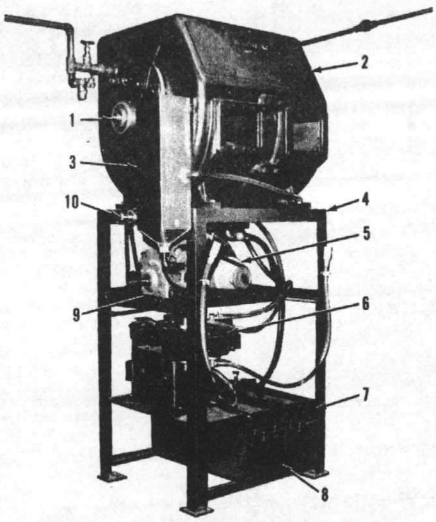
Fig 2-12. Van body, left side with doors open.

The water purifying equipment consists primarily of the water treatment section where the raw water is mixed and treated with chemicals; the filter section; and the necessary valves, piping, and controls to direct the water. The unit was designed to be powered electrically by a 10 kw generator. The water distribution set that is carried by this unit is designated as the M-64 set. The van body has a rear door and a side door. The rear entrance is accessible by a two-step ladder assembly and the side door has a stair-type ladder assembly. The van body is insulated and has a built-in heater. As we did with the 600-gph erdlator, we will attempt to cover here just what the operator needs to know to operate the 1500-gph unit. If detailed explanation is necessary for a given problem, then refer to TM-04461A-15.

b. Chemical feed equipment (fig 2-13). The chemical feed equipment consists of a duplex chemical solution feeder and accessories. The chemical feeders are electric motor driven to provide a continuous feed of chemical.

(1) Slurry feeder. This feeder supplies pulverized limestone slurry to the erdlator tank and a diatomite slurry to the filter. The slurry feeder consists of a tank, agitators, charge regulators, and a safety clutch.

(2) Chemical solution feeder. These tanks are located below the chemical feeder assembly just mentioned above. These rubber-lined metal tanks are used to supply calcium hypochlorite and ferric chloride which are pumped into the erdlator tank.



1. Chemical slurry feeder safety slip clutch
2. Chemical slurry feeder tank assembly
3. Diatomite slurry dilution tank assembly
4. Chemical feed equipment frame
5. Chemical slurry feeder drive motor
6. Chemical solution feeder
7. Ferric chloride solution tank
8. Calcium hypochlorite solution tank
9. Speed reducer
10. Chain tightener

Fig 2-13. Chemical feed equipment.

c. Erdlator assembly. This assembly consists of an erdlator tank, agitator shaft, sludge concentrator tank, wet well tank, influent launder, agitator drive motor, adjustable motor base, speed reducer, effluent launder, and aspirators. Figure 2-14 shows a cutaway view of the erdlator assembly.

LEGEND

1. Aspirator
2. Influent launder
3. Agitator shaft
4. Mixing zone
5. Effluent launder discharge tube
6. Sludge concentrator tank
7. Separator zone
8. Slurry weir box
9. Clarification zone
10. Bearing support
11. Baffle
12. Baffle ring
13. Downcomer tube
14. Circular disk
15. Effluent launder
16. Erdlator tank
17. Wet well tank

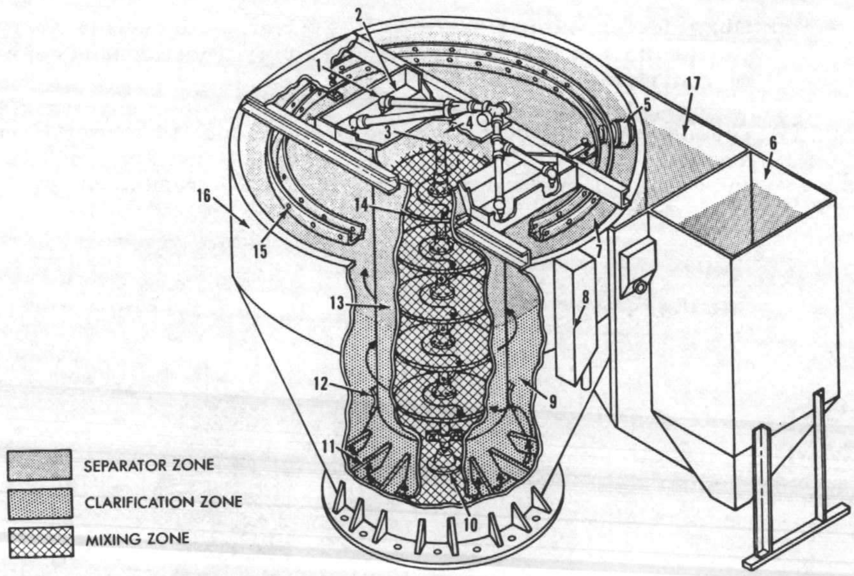


Fig 2-14. Erdlator assembly-cutaway view.

(1) Erdlator tank. This tank has a capacity of 530 gallons and serves as a separator which separates the slurry blanket from the clear water in the upper section of the tank.

(2) Agitator shaft. This consists of a tubular shaft with five equally spaced circular discs attached which is mounted in the center of the erdlator tank.

(3) Sludge concentrator tank. This tank, which is welded to the front of the wet well tank, is used to draw off the floc slurry, thereby always allowing some clear water on the top of the erdlator tank. It has a drain that is used to drain off this floc slurry to waste.

(4) Wet well tank. This tank is welded to the rear of the erdlator tank and provides for a limited storage of coagulated water. It also serves as a sump for the suction filter pumps.

(5) Influent launder. The raw water is first introduced into the influent launders through four aspirators. From the influent launder the raw water overflows into the downcomer tube or mixing zone.

(6) Agitator drive motor. This motor which drives the agitator is mounted on an adjustable sliding base attached to the two bridge rails on top of the erdlator tank.

(7) Adjustable motor base. This iron casting permits approximately nine inches of horizontal adjustment.

(8) Speed reducer. The speed reducer is a worm gear used to reduce the drive speed from the agitator drive motor to the erdlator agitator shaft.

(9) Effluent launder. This is an aluminum trough that surrounds the downcomer tube. It is attached to the bridge rails by three leveling rods. It collects the clear water from the upper section of the erdlator tank and discharges it into the wet well tank.

(10) Aspirators. The four aspirators are located at the ends of the raw water piping above the erdlator tank. They direct the raw water into the influent launder and provide aeration of the raw water.

d. Filter section. The filter section consists of one diatomite filter, one filter pump, pressure gages, a flow controller, a precoat funnel, an air release valve, and the additional valves and piping for operation of the filter. This filter uses diatomaceous earth (D.E.) to filter the water. Figure 2-15 shows the filter section.

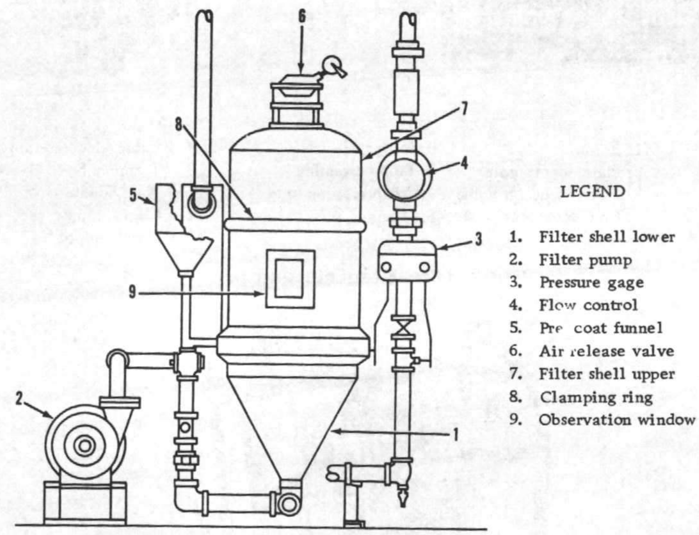


Fig 2-15. Diatomite filter.

(1) Diatomite filter. This is a 2-part, vertical shell containing six filter elements. These filter elements, which use D.E. as a filter aid, remove the fine particles remaining in the coagulated water.

(2) Filter pump. The filter pump is electrically driven and is rated at 25 gpm. This pump draws the coagulated water from the wet well and pumps it through the filter.

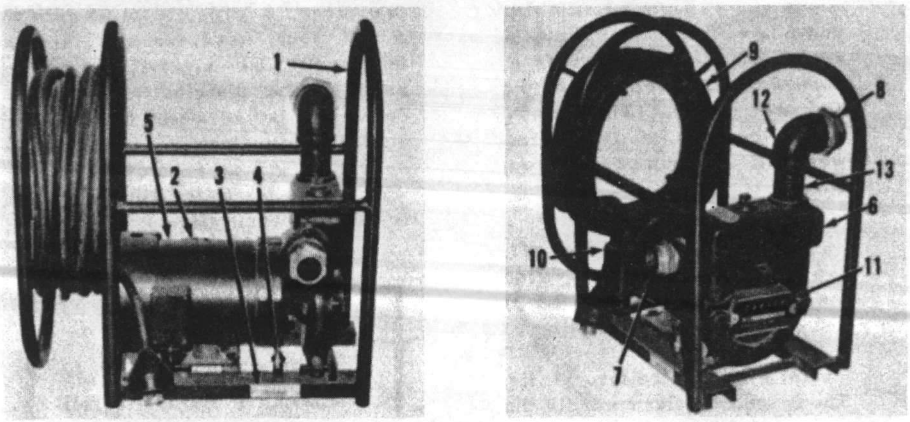
(3) Pressure gages. The pressure gages indicate the amount of pressure on the influent and effluent side of the filter.

(4) Flow controller. This control controls the flow of water through the filter.

(5) Precoat funnel. The precoat funnel is used to add the D. E. slurry when precoating the filter sleeves before going into a normal filter run.

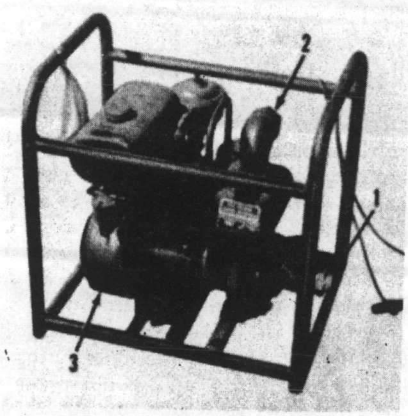
(6) Air-release valve. The air-release valve releases air trapped in the dome of the filter. The sudden release of air has the effect of a blast which knocks the filter cake and foreign matter off the element.

e. Supporting equipment. Two electric pumps (fig 2-16), each with a capacity of 65 gpm, are provided. One pump is used as a raw-water pump and the other is used as a distribution pump. There is a gasoline-engine-driven auxiliary pump (fig 2-17) that can deliver 125 gpm when the two electric pumps are being used in series when pumping raw water.



1. Frame
2. Plate, ident. motor
3. Plate, ident. (ground)
4. Connector plug
5. Motor, electrical
6. Pump assembly
7. Adapter, pipe to hose
8. Adapter, pipe to hose
9. Cable, elec. assembly
10. Terminal box
11. Plate, ident.
12. Elbow, pipe
13. Nipple, pipe

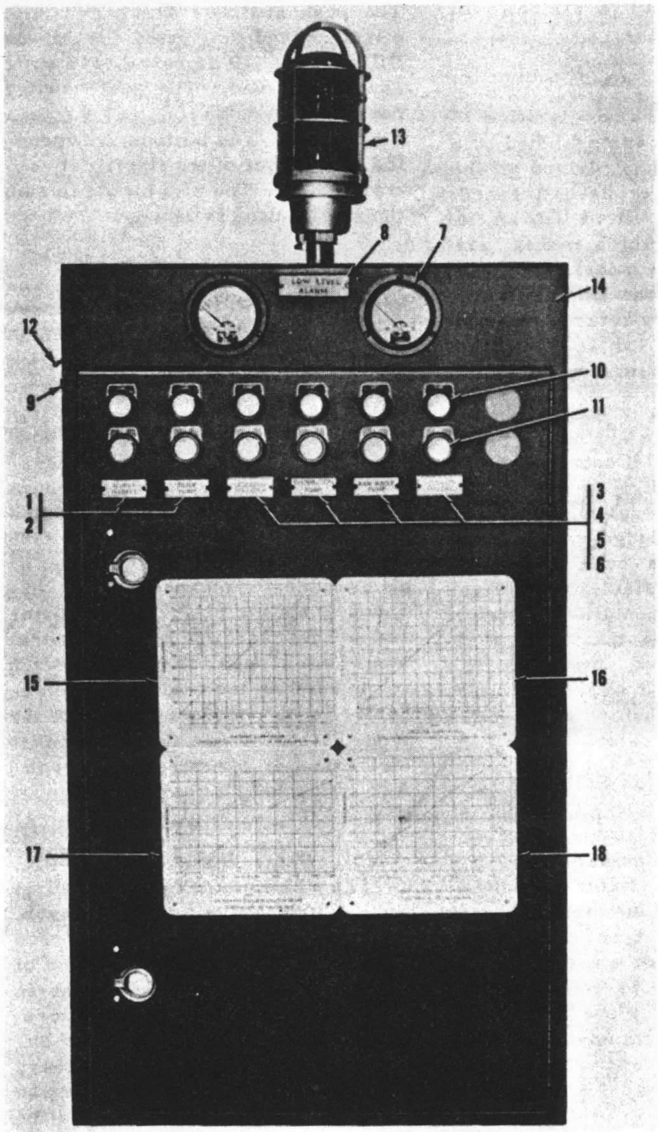
Fig 2-16. Electric pump.



1. Suction intake
2. Distribution outlet
3. Gasoline engine

Fig 2-17. Auxiliary pump--gasoline-engine-driven.

10 f. <u>Electrical control cabinet</u> (fig 2-18). This provides controls for the operation of all electrically operated components.



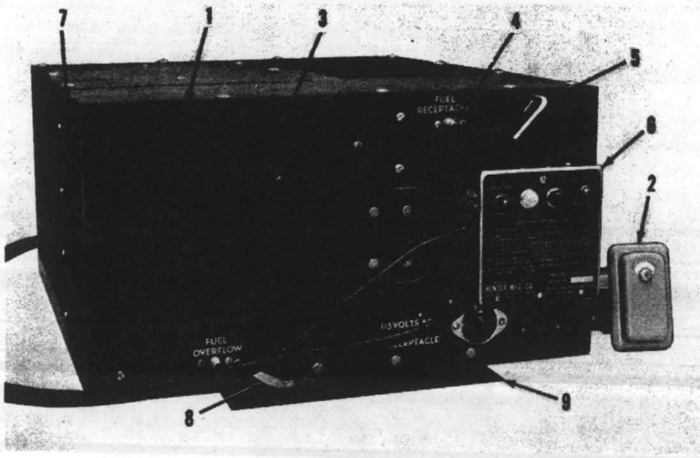
1. Slurry feeder switch ident. plate
2. Filter pump switch ident. plate
3. Erdlator agitator switch ident, plate
4. Distribution pump switch ident. plate
5. Raw water pump switch ident. plate
6. Chemical solution feeder switch ident. plate.
7. Electrical meters, voltage and amperes
8. Low level alarm
9. Alarm silence ident. plate
10. Control cabinet switch, start
11. Control cabinet switch, stop
12. Alarm silence on-off switch
13. Low level alarm light fixture
14. Cabinet,electrical control
15. Slurry feeder calibration chart, Diatomite
16. Slurry feeder calibration chart

L Limestone

17. Solution feeder calibration chart Cal.Hypochorite
18. Solution feeder calibration chart, Ferric Chloride.

Fig 2-18. Electrical control cabinet.

g. Personnel heater (fig 2-19). This is a thermostatically controlled, forced-hot-air, multifuel-burning heater.



1. Heater, Hunter UH-68-2
2. Thermostat, Room
3. Door, Front Access
4. Connector, Fuel
5. Handle, Damper Control
6. Box, Control
7. Panel, Left Side
8. Strap, Ground
9. Bracket, Heater Mounting

Fig 2-19. Heater.

2-5. FUNCTION AND LOCATION OF CONTROLS AND INSTRUMENTS

This paragraph describes, in tables, the function and location of controls and instruments which are necessary to the operation of the 1500-gph erdlator.

Table 2-7 furnishes information on the valves and draincocks. The following symbols are used to identify the valves and draincocks: ARV--Air Release Valve, CV--Control Valve, DV--Drain Valve, VC--Vent Cock, DC--Draincock, BPV--Bypass Valve, FV--Float Valve.

Table 2-7. Valves and Draincocks

Symbol	Location	Function	Type & Size	Startup Position	Normal Operating Position
DC-1	Raw water line flow indicator manifold	Bleeds the air from rate of flow indicator for "0" reading check	"A", 1/4 in. brass drain cock	Closed	Closed
DC-2	Raw water line flow indicator manifold	Bleeds the air from rate of flow indicator for "0" reading check	"A", 1/4 in. brass drain cock	Closed	Closed
BPV-3	Raw water line flow indicator manifold	Bleeds the air from rate of flow indicator for "0" reading check	1/4 in. gate valve	Closed	Closed
CV-4	Raw water line flow indicator manifold	Bleeds the air from rate of flow indicator for "0" reading check	1/4 in. gate valve	Open	Open
CV-5	Raw water line flow indicator manifold	Bleeds the air from rate of flow indicator for "0" reading check	1/4 in. gate valve	Open	Open
CV-6	Raw water line to slurry feeder	Vents raw water line to assist complete drainage	"A", 1/4 in. brass drain cock	Closed	Closed
CV-8	Raw water line to slurry feeder tank	Controls valve for filling limestone slurry tank	1/2 in. gate valve	Open	Partially open
CV-9	Raw water line to manifold aspirator	Main raw water influent valve for filling erdlator tank	2 in. gate valve	Open	Open

Table 2-7. Valves and Draincocks--contd

Symbol	Location	Function	Type & Size	Startup Position	Normal Operating Position
CV-10	Raw water influent line to aspirator	Controls flow of raw water to aspirator	1-1/2 in. gate valve	Open	Open
CV-11	Raw water influent line to aspirator	Controls flow of raw water to aspirator	1-1/2 in. gate valve	Open	Open
BPV-12	Raw water level alarm piping	Controls raw water rate of flow to erdlator tank	1-1/2 in. gate valve	Open	Open
CV-14	Coagulated water line from slurry take-off weir box to sludge	Permits drainage of sludge	1-1/2 in. gate valve	Open	Open
CV-15	Coagulated water line from erdlator tank to diatomite dilution box	Supplies coagulated water for mixing chemicals	1/2 in. angle valve	Closed	Closed
CV-16	False bottom of the concentrator tank	Controls waste sludge draw-off without loss of clear water	Orifice plug valve (long pull rod)	Open	Open
DV-27	Drain line from chemical slurry feeder tank	Drains limestone slurry compartment	3/4 in. gate valve	Closed	Closed
CV-32	Filter water effluent line	Controls flow of filtered water to slurry feeder tank diatomaceous earth compartment	1/2 in. gate valve	Closed	Closed

Table 2-7. Valves and Draincocks--contd

Symbol	Location	Function	Type & Size	Startup Position	Normal Operating Position
CV-33	Slurry feeder filtered water line	Supplies filtered water for mixing chemical	1/2 in. angle globe valve	Closed	Closed
CV-34	Coagulated water line to suction side of filter water pump	Controls flow of coagulated water to filter pump	1-1/2 in. quick-acting gate valve	Open	Open
DV-22	Drain line from con-centrator tank	Drains con-centrator tank completely	1 in. gate valve	Closed	Closed
DV-23	Drain line from waste tank	Drains waste tank	1 in. gate valve	Open	Open
CV-24	Drain line from wet well	Prevents backward flow of contaminated water into settled water of wet well	2 in. hori-zontal swing check valve	Closed	Closed
DV-25	Drain water line from wet well	Drains wet well	2 in. gate	Open	Closed
DV-26	Drain line from chem-ical slurry feeder	Drains dia-tomaceous earth slurry compartment	3/4 in. gate valve	Closed	Closed
DV-27	Drain line from chem-ical slurry feeder tank	Drains lime-stone slurry compartment	3/4 in. gate valve	Closed	Closed

Table 2-7. Valves and Draincocks--contd

Symbol	Location	Function	Type & Size	Startup Position	Normal Operating Position
CV-32	Filter water effluent line	Controls flow of filtered water to slurry feeder tank diatomaceous earth compartment	1/2 in. gate valve	Closed	Closed
CV-33	Slurry feeder filtered water line	Supplies filtered water for mixing chemicals	1/2 in. angle globe valve	Closed	Closed
CV-34	Coagulated water line to suction side of filter water pump	Controls flow of coagulated water to filter pump	1-1/2 in. quick-acting gate valve	Open	Open
CV-35	Coagulated water line from filter pump to influent plug valve	Prevents backward flow of water from filter	1-1/4 in. swing check valve	Closed	Open
CV-36	Coagulated water line from filter pump to influent side of filter	Controls flow of coagulated water for filtering or washing	1-1/2 in. 3-way plug valve 2 port, 90 degree turn	Open Down	Open Down
CV-37	Coagulated water line below precoat funnel filter No. 1	Diatomite slurry filling control valve to filter	3/4 in. gate valve	Open	Closed
CV-38	Air vent line on influent side of filter	Filter air vent	3/8 in. gate valve	Open	Closed
DV-39	Recirculation filter line below gate valve CV-40	Drains recirculation filtered water line	1/2 in. gate valve	Closed	Closed

Table 2-7. Valves and Draincocks--contd

Symbol	Location	Function	Type & Size	Startup Position	Normal Operating Position
CV-40	Recirculation filter line below flow controller valve, CV-45	Starts and stops flow of water from filter	1-1/2 in. gate valve	Closed	Open
DC-41	Influent filter pressure gage line	Cutoff water pressure to influent gate	"E", 1/4 in. brass drain cock	Open	Open
DC-42	Influent filter pressure gage line	Drains filter influent gage and piping	"A", 1/8 in. brass drain cock	Closed	Closed
DC-43	Effluent filter pressure gage line	Cutoff water pressure to effluent gage	"E", 1/4 in. brass drain cock	Open	Open
DC-44	Effluent filter pressure gage line	Drains filter effluent gage and piping	"A", 1/8 in. brass drain cock	Closed	Closed
CV-45	Recirculation filter line below effluent plug valve CV-46	Controls rate of flow of water from filter	1-1/2 in. flow controller valve	Open	Open
CV-46	Recirculation filter line above flow controller valve, CV-45	Controls direction of flow for recirculating or filtering	1-1/2 in. 3 way, 3 port, 90 degrees turn, plug valve	Open and recirculating	Open filter position
DV-47	Drain line from bottom of filter	Drains waste from filter	2 in. quick-acting gate valve	Closed	Closed
DC-48	Base of filter pump	Drains pump volute	1/8 in. cock	Closed	Closed
ARV-49	Top of filter	Releases air trapped in dome of filter and filter elements	Air release valve	Closed	Closed

Table 2-7. Valves and Draincocks--contd

Symbol	Location	Function	Type & Size	Startup Position	Normal Operating Position
CV-50	In back of flow control valve	Controls flow of water out of van	1-1/2 in. gate valve	Closed	Open

Table 2-8 furnishes information pertaining to the flow, feed, and pressure indicators. The following symbols are used to identify the indicators: PI--Pressure Indicator, FEI--Feed Indicator, and FLI--Flow Indicator.

Table 2-8. Pressure Flow and Feed Indicators

Symbol	Location	Function	Type & Size	Startup Position	Normal Operating Position
PI-1	Aspirator manifold	Indicates discharge pressure from raw water aspirator manifold	Dial indicator	0-30 psi	10-15 psi
PI-2	Mounted on recirculation filter line between filter and flow controller	Indicates influent filter pump pressure	Dial indicator	0-100 psi	0-65 psi
PI-3	Mounted on recirculation filter line from filter to flow controller	Indicates effluent filter pump pressure	Dial indicator	0-100 psi	0-65 psi
FLI-4	Mounted on erdlator wet well	Determines rate of raw water influent flow		0-65 gpm	50 gpm
FEI-5	Mounted on left side of slurry tank	Regulates rate of feed for diatomaceous earth slurry		0-100% capacity	50 ppm
FEI-6	Mounted on right side of slurry tank	Regulates rate of feed for limestone slurry		0-100% capacity	50 ppm

11 Table 2-8. Pressure Flow and Feed Indicators--contd

Symbol	Location	Function	Type & Size	Startup Position	Normal Operating Position
FEI-7	Chemical solution feeder	Regulates rate of feed for ferric chloride solution		1/2-2-1/2 gph	30 ppm
FEI-8	Chemical solution feeder	Regulates rate of feed for calcium hypochlorite solution		1/2-2-1/2 gph	6 ppm

Table 2-9 furnishes information pertaining to the manually operated electrical controls. No symbols are used.

Table 2-9. Manually Operated Electrical Controls

Component Controlled	Control Station	Type of Contact	Location	Button and Location
Slurry feeder	Start	Push switch momentary	Inside control cabinet	Black, control cabinet door
Filter pump	Start	Push switch momentary	Inside control cabinet	Black, control cabinet door
Erdlator agitator	Start	Push switch momentary	Inside control cabinet	Black, control cabinet door
Distribution pump	Start	Push switch momentary	Inside control cabinet	Black, control cabinet door
Raw water pump	Start	Push switch momentary	Inside control cabinet	Black, control cabinet door
Blackout lights	Off when doors are open	Micro-switch momentary	At rear right door	Ceiling mounted
Warning buzzer and fixture light	Off-On	Toggle switch	Upper left of control cabinet	
Slurry feeder	Stop	Push switch momentary	Inside control cabinet	Red, control cabinet door
Filter pump	Stop	Push switch momentary	Inside control cabinet	Red, control cabinet door
Erdlator agitator	Stop	Push switch momentary	Inside control cabinet	Red, control cabinet door
Distribution pump	Stop	Push switch momentary	Inside control cabinet	Red, control cabinet door

Table 2-9. Manually Operated Electrical Controls--contd

Component Controlled	Control Station	Type of Contact	Location	Button and Location
Raw water pump	Stop	Push switch momentary	Inside control cabinet	Red, control cabinet door
Solution feeder	Start-Stop	Push switch	Inside control cabinet	Black-start, red-stop, control cabinet door
Ceiling lights, dome	NORMAL OUT BLACKOUT (3-position)	Toggle switch, double	Mounted in roof panel near front door	
Van body lights and heater	On-Off	Circuit breaker	Inside control cabinet	
Personnel heater thermostat			Left rear corner of van body ceiling	
Personnel heater switch	Heater on vent	Toggle switch	Front heater control panel	

Table 2-10 furnishes information pertaining to the sight glass and low level alarm sensitive switch. The following symbols are used to identify them: SG--Sight Glass and SS--Sensitive Switch.

Table 2-10. Sight Glass and Sensitive Switch

Symbol	Location	Purpose	Type & Size
SG-1	Raw water line point of entry to erdlator	Observe water clarity presence of air bubble	Oval glass transparent
SS-1	Mounted on top of erdlator wet well	Closing circuit which operates buzzer and light to warn operator when well is low	BZV-2RN tapped 1/2 in. NPT

2-6. SETTING UP THE UNIT

a. Preparing the unit. When the truck-mounted unit has been positioned at a site as discussed in chapter 1, provide a firm footing for the wheels and jacks by digging ditches and installing blocks or timber under the wheels to prevent settling. The truck's hand brake should be set and the transmission should be in gear. When the spirit levels on the body indicate the unit is level, open the side panels (weather permitting) to provide better access to equipment.

b. Grounding. Electrically ground the van body by driving a long metal ground rod (approx. 8 ft) into the earth near the vehicle. Connect a #6 cable to the ground rod and to the ground connector of the van body. The ground cable should not exceed 6 feet in length.

c. Generator. The generator set should not be more than 50 feet from the purification unit. Insure that the generator is level and ground it in much the same way as discussed for the purification unit.

Note: When connecting the main power cable to the generator lugs, insure that the color-coded wires are connected correctly to the control panel.

L_1 - Black
L_2 - Red
L_3 - Blue
L_0 - White

d. Raw-water pump. Place the electrically driven raw-water pump not more than 50 feet from the erdlator. When the distance requires it, use two raw-water pumps in series. The maximum suction lift is 20 feet for each pump.

e. Hose connections. Install the 2-inch filter waste hose and erdlator tank waste hose and run them to a suitable discharge point where the waste will not be drawn back into the unit. Connect the 1 1/2'' suction and discharge hose to the raw-water pump. Connect the raw-water pump discharge hose to the raw-water intake on the van body. The number of water distribution tanks used will depend on the amount of purified water that will be needed at any one time. A hose is connected to the filter and run to a distribution tank. Place the distribution pump close to the distribution tank and connect a suction hose to the pump and place the other end into the distribution tank. A discharge hose is then connected to the pump with a distribution nozzle screwed on the other end. Connect all electrical cables from the electrically operated units to their power source.

2-7. OPERATION

a. Chemical requirements.

(1) Ferric chloride. Two pounds of ferric chloride are emptied into the rubber pail that is used for this purpose. The pail is filled with water to the 3-gallon mark. The solution is stirred with a wooden paddle to dissolve the chemical.

Note: Protect eyes and skin from direct contact with any chemical and solution mix. Be especially careful when opening chemical containers to avoid inhaling chemical powder.

Pour the three gallons of solution in the ferric chloride solution tank. Then rinse the rubber pail with a gallon of raw water and add this to the solution bringing the total to four gallons of solution.

(2) Calcium hypochlorite solution. Measure eight ounces in the calcium hypochlorite plastic measure that is provided and pour into a rubber pail. Stir in water to the 3-gallon mark and then slowly pour this solution into the calcium hypochlorite solution tank. Then rinse the pail with an additional gallon of water and pour this into the solution tank bringing the total to four gallons of this solution.

(3) Limestone slurry. The limestone compartment is on the right side of the slurry feeder. When the operator has filled this compartment with raw water (14 gal) to the upper mark on the Hi-Low indicator, 14 pounds of limestone are added to this raw water using an aluminum measure made for this purpose.

(4) Diatomaceous earth slurry. The D.E. compartment is on the left side of the slurry feeder. After allowing filtered water (14 gal) into the compartment to the upper mark on the Hi-Low indicator, add seven pounds to the D.E. compartment and mix thoroughly. An aluminum measure is used for measuring the D.E.

(5) Activated carbon. If activated carbon is used for objectionable tastes and odors, add 1.4 pounds to the 14 gallons of water in the limestone compartment of the slurry feeder. A porcelain measure is used to measure the activated carbon.

b. Preliminary positioning of valves. The valves are set as follows before actual starting of the unit.

Note: Below are the codes used for the valves in the sequence that follows.

ARV - Air Release Valve.
CV - Control Valve.
DV - Drain Valve.
VC - Vent Cock.
DC - Drain Cock.
BPV - By-Pass Valve.
FV - Float Valve.

(1)	DC-1	Bleeds air from rate of flow indicator.	Closed
(2)	DC-2	Bleeds air from rate of flow indicator.	Closed
(3)	BPV-3	Bleeds air from rate of flow indicator.	Closed
(4)	CV-4	Bleeds air from rate of flow indicator.	Open
(5)	CV-5	Bleeds air from rate of flow indicator.	Open
(6)	VC-6	Vents raw water line.	Closed
(7)	CV-7	Controls raw-water flow into limestone compartment.	Open
(8)	CV-8	Controls water into limestone slurry tank.	Open
(9)	CV-9	Main raw-water influent valve for erdlator tank.	Open
(10)	CV-10	Controls flow of water to aspirator.	Open
(11)	CV-11	Controls flow of water to aspirator.	Open
(12)	BPV-12	Controls rate of flow to erdlator tank.	Open
(13)	CV-14	Permits drainage of sludge from weir box.	Open
(14)	CV-15	Supplies coagulated water for mixing chemicals.	Closed
(15)	CV-16	Controls waste sludge draw-off without loss of clear water.	Open 1st notch
(16)	CV-17	Controls clear water into wet well from sludge concentrator.	Open
(17)	DV-19	Partial drain valve.	Closed
(18)	DV-20	Complete drain valve.	Closed
(19)	DV-21	Sludge draw-off for concentrator.	Part, Open
(20)	DV-22	Complete drain for sludge concentrator tank.	Closed
(21)	DV-23	Drains waste tank.	Open
(22)	CV-24	Prevents backward flow of contaminated water into settled water of wet well.	Closed
(23)	DV-25	Drains wet well.	Open

(24) DV-26	Drains diatomaceous earth slurry compartment.	Closed
(25) DV-27	Drains limestone compartment.	Closed
(26) CV-34	Controls pretreated water from wet well to filter pump.	Closed

c. Pumps. Prime the feeder pumps and adjust chemical setting.

(1) Ferric chloride - 1.2

(2) Calcium hypochlorite (HTH) - 5.0

d. Starting.

(1) Start raw-water pump.

(2) Bleed all air from lines by opening draincocks. (When water flows out of draincock, close it.)

(3) Adjust CV-8 and set FEI-6 to 50 ppm.

(4) Adjust CV-9 to read 15 psi on gage.

(5) Allow erdlator tank to fill.

(6) Start agitator motor when there is at least one foot of water in erdlator tank.

(7) When erdlator tank is full, drain off any foreign material that could have gotten into the tank by lowering the effluent launder with the leveling rods and draining off to waste. Level effluent launder.

(8) Close DV-25 when water is clear flowing from erdlator tank to wet well.

(9) Adjust calcium hypochlorite setting to 1.2.

(10) Wait for proper floc and adjust chemicals accordingly. When a proper floc is obtained and the water is clear at the top of the erdlator tank, then it is time to precoat the filter elements to prepare the filter for filtering.

e. Prepositioning of filter valves. The preliminary settings on the filter section that must be accomplished before precoating are as follows:

(1) CV-32	Allows filter water to diatomaceous earth slurry compartment.	Closed
(2) CV-33	Solution make-up valve.	Closed
(3) CV-35	Check valve.	Open
(4) CV-36	Controls pretreated water into filter.	Filter
(5) CV-37	Precoat feed funnel drain into filter.	Closed
(6) CV-38	Filter vent valve.	Open
(7) DC-39	Draincock.	Closed
(8) CV-40	Filter outlet valve.	Open
(9) DC-41	Draincock.	Open

(10) DC-42	Draincock.	Closed
(11) DC-43	Draincock.	Open
(12) DC-44	Draincock.	Closed
(13) CV-45	Flow control.	25 gpm
(14) CV-46	Controls direction of flow.	Recirculating
(15) DV-47	Filter drain valve.	Closed
(16) DC-48	Draincock.	Closed
(17) ARV-49	Air release valve.	Filter
(18) CV-50	Controls flow of water out of van.	Closed

f. Precoating.

(1) Mix D.E. in the proper mixture and add to precoat funnel. (1 1/2 lb to one gal water)

(2) Open CV-37 and allow this mixture to drain into the filter.

(3) Close CV-37.

(4) Open CV-34.

(5) Start filter pump.

(6) Close CV-38 when water starts to flow out.

(7) Precoat for:

(a) 4-6 minutes.

(b) until good filter cake is seen.

(c) until water in filter is clear.

Now you are ready to filter.

g. Filtering.

(1) Change CV-46 to filter.

(2) Open CV-50.

(3) Make-up diatomaceous earth for compartment as shown in chemical requirements for slurry.

(4) Open CV-33.

(5) Close CV-33.

(6) Add diatomaceous earth to compartment.

(7) Open CV-32 and adjust for proper flow.

(8) FEI-7 set to 50 ppm.

h. Backwashing. Backwashing the filter is done whenever there is an interruption in the filter cycle, when the storage tanks are full, when the source is exhausted, or when the influent and effluent pressure gages differ by 5 psi.

(1) Close CV-40 and CV-50.

(2) Let pressure gages equalize.

(3) Shut down filter pump.

(4) Close CV-34.

(5) Close CV-23.

(6) Turn ARV-49 to backwash and open DV-47.

(7) Open CV-38.

The unit is now backwashed and by prepositioning the valves again as discussed earlier for precoating, you could go into the precoat cycle and then back to filter. If the unit is to be shut down, then all power to the unit should be shut off and all valves and drains opened. All compartments, tanks, and feeders should be flushed out, using filtered water if possible.

i. Operator maintenance and lubrication. For a complete lubrication chart refer to TM-04461A-15, which covers the operation and maintenance of the 1500-gph erdlator. The van door hinges, latches, and cables should be oiled with OE #10 every 50 hours. All oilcan lubrication points should use #10 OE. Grease points will use GAA grease. Gear oil used will be of 140 weight above 32° F and 90 weight below 32° F.

(1) Solution feeder.

(a) Drive arms - 50 hours.

(b) Lever arms - 50 hours.

(c) Drive arm bearings - 250 hours.

(d) Gear case - Check every 10 hours and change every 500 hours.

(2) Erdlator assembly.

(a) Agitator reduction gear - 50 hours.

(b) Agitator shaft bearings - 50 hours.

(c) Agitator reduction gear case - Check every 10 hours and change every 1000 hours.

Section III. WATER-PURIFICATION UNIT, WALLACE AND TIERNAN MODEL U22446

2-8. DESCRIPTION

a. General. The water purification unit (see figure 2-20) is a frame-mounted, diatomite type unit with an adjustable flow rating of 10 to 40 gallons per minute. This unit is presently in the system of the Marine Corps. This unit is similar to the 600-gph unit in its concept of operation, although there are some differences in its components; these components will be discussed in this section to give you a better understanding of the water-purification unit model U22446.

b. Machinery section. The machinery section (figures 2-21 and 2-22) consists of a pumping unit, tool box, a diatomite slurry feeder, a calcium hypochlorite solution feeder (hypochlorinator), hoppers or reservoirs for slurry and solution, and all necessary valves and fittings for connection to a 2-inch hose. The machinery section should be located close to the filter section and near the settling tanks (figure 2-20) for convenience of operation and to keep hose lines short. A canvas cover is supplied to protect the equipment during inclement weather.

(1) Pumping Unit. The pumping unit consists of a centrifugal pump capable of delivering 55 gpm against a total head of 50 feet including a 15-foot suction lift and a single cylinder, four-cycle, air-cooled gasoline engine. The pump and engine are close coupled, with pump impeller mounted on the end of the engine crankshaft. The engine is capable of operating the pump continuously at rated capacity. By proper manipulation of the pump section valve (figure 2-22) and the valves on the filter section, the unit performs the pumping necessary for precoat, filter, and backwash operations. A power take-off from the engine starting pulley drives the slurry feeder.

(2) Toolbox (fig 2-21). The toolbox has compartments for storing the comparator, tools, and spare parts. Flow diagrams are mounted inside the hinged cover.

(3) Slurry feeder (fig 2-22). The slurry feeder is mounted alongside of the gasoline engine and is driven at approximately one-quarter engine speed by a V-belt and pulleys. A slurry of filteraid and water is made in the slurry hopper. The hopper has

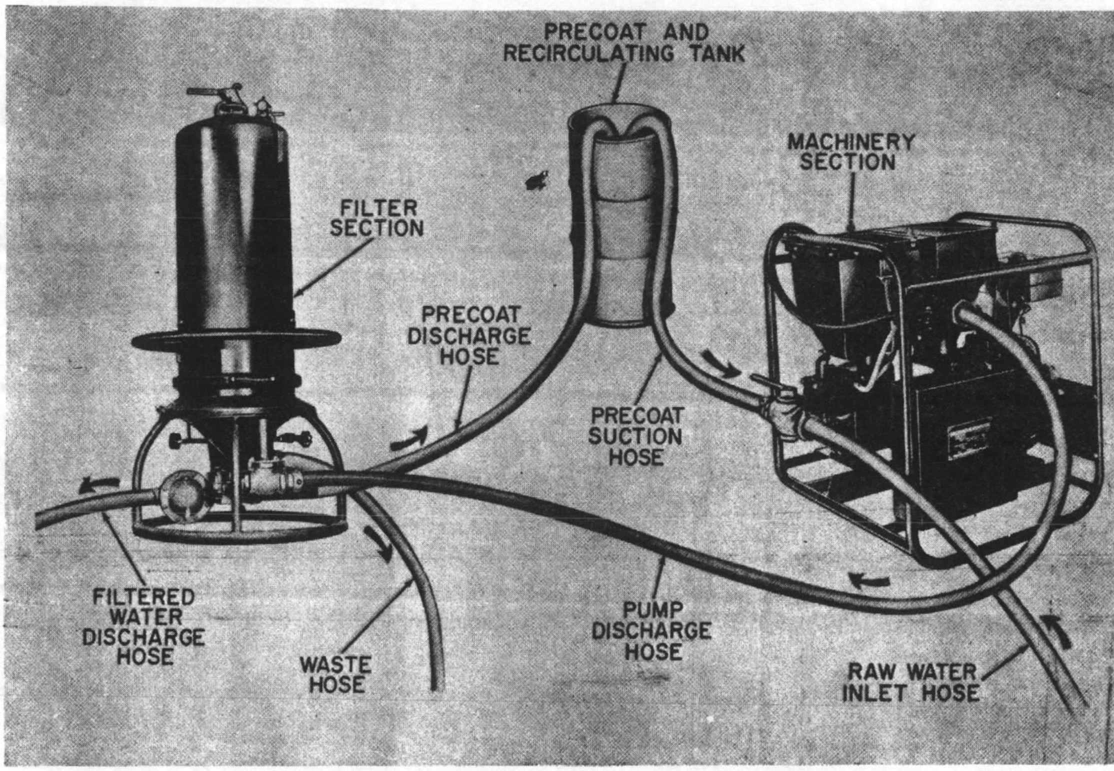


Fig 2-20. Water purification unit in operating position.

12 a strainer (to keep leaves, stones, debris, and other foreign matter from the feeder mechanism) and a clamp-on cover. A diaphragm type air compressor, powered by the slurry feeder shaft, pumps air to the slurry hopper. This air agitates the slurry and keeps the filteraid from settling to the bottom of the hopper. The slurry feeder draws a small amount of slurry from the hopper into the feeder. Flushing water flows to the filter through the slurry feeder, automatically flushing out the slurry change. The flushing action is caused by means of valves in the feeder and the restrictor.

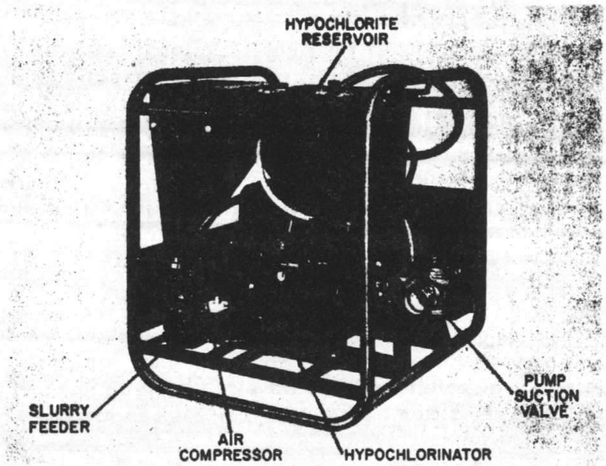


Fig 2-21. Machinery section--front view.

(4) Hypochlorinator (fig 2-22). The hypochlorinator is mounted in line with the slurry feeder and is driven through a flexible coupling from an extension shaft of the slurry feeder. A solution of calcium hypochlorite and water is put in the hypochlorite reservoir. The pumping action of the hypochlorinator draws a small amount of solution from the hypochlorite reservoir through a strainer, hose, and sight glass to the hypochlorinator. The charge of solution is then pumped from the hypchlorinator to the pump discharge. Rate of feed is altered by moving the control handle. The sight glass provides a visual check on the operation of the hypochlorinator.

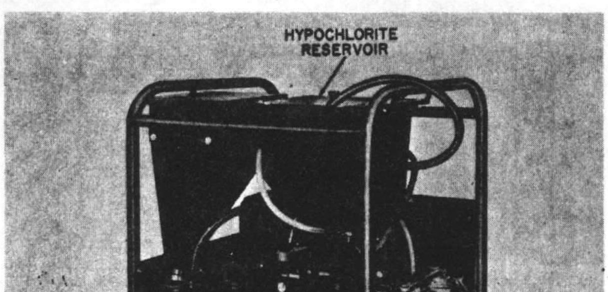


Fig 2-22. Machinery section--rear view.

(5) Restrictor (fig 2-21). The restrictor is located between the pump and the pump discharge hose connection. Water flowing from the pump is restricted by a flap valve and weight inside the restrictor housing. This action produces a small differential in pressure. Water drawn from the restrictor at a point of higher pressure provides flushing water to the slurry feeder. This flushing water dilutes the slurry in the feeder, prevents filteraid from settling in the feeder, and flushes the slurry to the pump discharge. Hose connections on the restrictor housing are provided for filling the slurry hopper and the hypchlorite reservoir, and for discharging from the slurry feed and the hypchlorinator.

c. Filter section (figs 2-23 and 2-24). The filter section is placed close to and between the machinery section and storage tanks for convenience in operation and to keep the hose lines as short as possible. The pressure type filter has a steel shell attached to a steel base in which are mounted seven cylindrical filter elements. Valves, controls, and hose adapters are mounted on the filter section. By proper manipulation of the valves the basic operations of precoating, filtering, and air-bump backwashing are performed. A steel cover protects the top of the filter during transportation and is used as a precoat and recirculating tank during operation. Test samples are withdrawn through a filtered water sampling valve. The adjustable flow controller maintains a constant preset flow during filtering. The air release valve is mounted on top of the filter shell. A window in the filter shell permits visual observation during operation. The filter section is equipped with a tubular pipe ring for protection and ease in handling. The filter is the diatomite type.

(1) Precoat and recirculating tank. When the filter is not in use, the steel precoat and recirculating tank (which is part of filter section) fits over the filter shell and protects the top of the filter from damage. The tank is secured by four clamps. When the filter is in service, the precoat diatomite filteraid slurry (diatamaceous earth) is mixed in the tank and then applied to the filter elements. The tank is also used for recirculating water during filtering.

(2) Filter elements (fig 2-25). Seven identical filter elements are individually mounted on nipples welded to a false bottom of the filter base. The elements extend

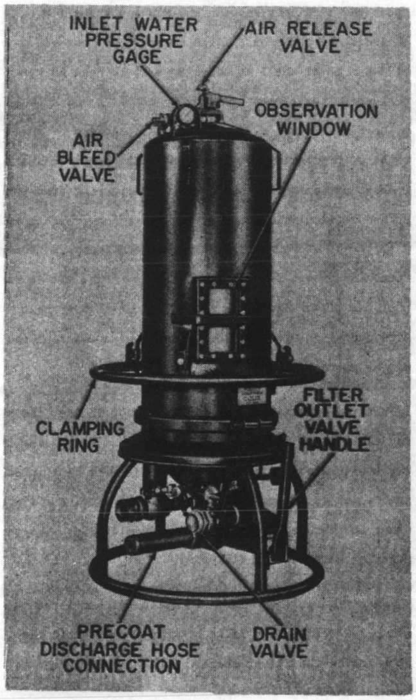


Fig 2-23. Filter section--front view.

vertically inside the filter shell. Each filter element is made up of a plastic sleeve and perforated steel tube assembly, a brass top cap, a tie rod, 12 plastic cups, two spacers, a cast bronze base, and an O-ring gasket. The filter element assembly is essentially a fine strainer which is rigid and strong enough to support a cake of diatomite filteraid.

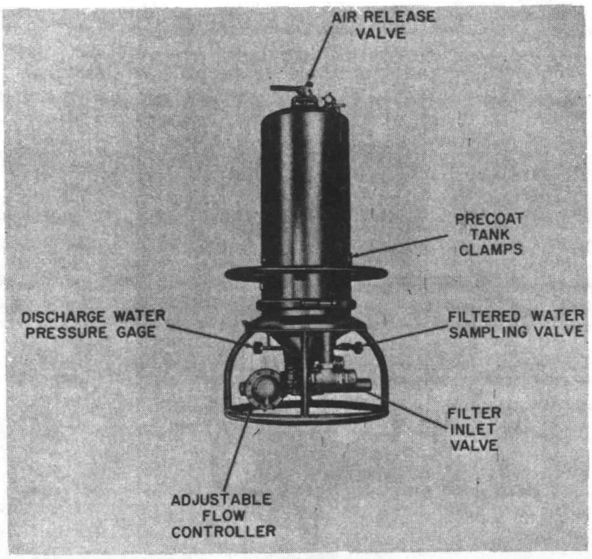


Fig. 2-24. Filter section--rear view.

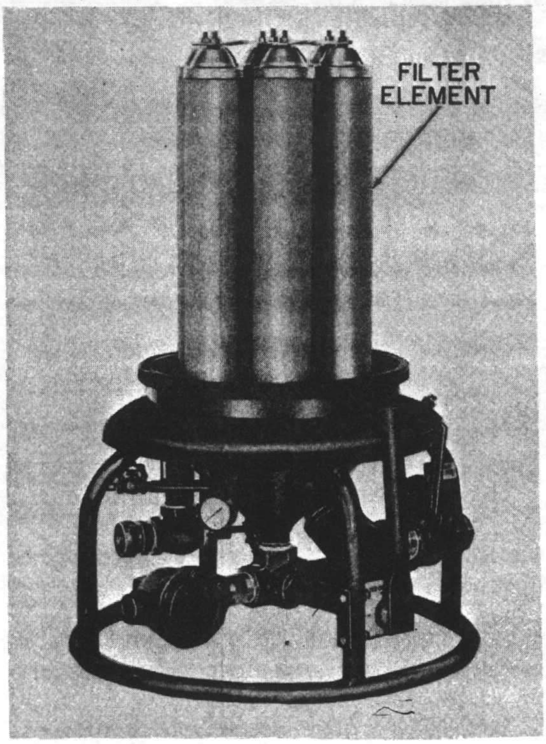


Fig 2-25. Dismantled filter section showing filter elements.

d. Auxiliary equipment. Very clear water need not be coagulated and settled, but may be pumped directly from a raw-water source. For such water sources only, the following auxiliary equipment will generally be required:

- Calcium hypochlorite.

- Filteraid (diatomaceous earth).

- Hose. Two-inch suction (or discharge) hose must be used on connections to any pumping unit.

- Tanks for water storage.

- Distribution equipment. Pumping units, hose, water cans, tanks, etc. are needed for water storage and distribution, depending on the way the treated water is to be utilized.

Turbid water must be coagulated and settled before it is filtered. For such water sources, in addition to auxiliary equipment listed above, the following additional auxiliary equipment will be needed:

- Ground alum (aluminum sulfate).

- Soda ash.

- Chemical baskets.

- Raw-water pumping unit.

- Tanks for the pretreatment of the water.

2-9. FUNCTION OF EQUIPMENT

Impurities and organisms are removed from water by mechanical and chemical means. Suspended matter is removed by filtering; amoebic cysts, endamoeba histolyca, and schistosomes are removed by coagulation, settling, and filtering; most bacteria are killed by addition of calcium hypochlorite to water. Coagulation and settling are accomplished by adding alum and soda ash which coagulate and enmesh (FLOC) most suspended small particles (including living organisms) in the water and carry them to the bottom of the tank. This process is called flocculation. After settling, water is drawn from the top of the tank and filtered. A typical arrangement of water purification equipment is shown in figure 2-26. In this arrangement, raw water is pumped from a source into settling tanks. Chemicals (alum and soda ash) for coagulation are added during filling. Settling is important because suspended matter in the water will quickly clog filter elements. The pump in the machinery section draws water from settling tanks and forces it through the filters in the filter section. Before settled water can be filtered, diatomite filteraid (called slurry) is mixed in the precoat tank and pumped through the filter section where the filteraid is deposited on the filter elements in cake form. This cake passes water but screens out any suspended matter and bacteria. A controlled amount of calcium hypochlorite solution is added to the water by the hypochlorinator contained in the machinery section. When filter elements become clogged, as indicated by the pressure gage and by a reduction in output of filtered water, the filter elements must be backwashed. Air-pump backwashing is used to dislodge the filter cake, with accumulated suspended matter, from the filter elements so it may be easily drained from the filter shell. The filtered water is stored in the filtered water storage tank. The water purification unit described here can purify fresh water, but cannot remove salt or any other dissolved matter from water.

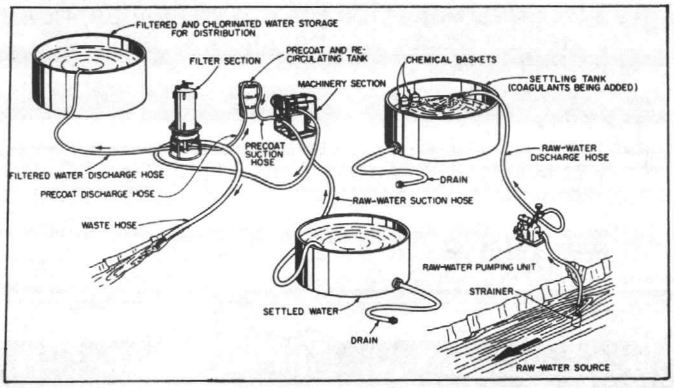


Fig 2-26. Typical arrangement of water-purification equipment.

f. Tabulated data. Equipment characteristics information is provided in table 2-11.

Table 2-11. Tabulated Data

Item	Value
Weights:	
Machinery section	450 pounds
Filter section	325 pounds
Pump capacities:	
System	40 $\pm$4 gpm
Pump	55 gpm
Hypochlorinator at a rate of 600 rpm	0.6 to 2.4 gph
Slurry feeder at a rate of 600 rpm	0.33 to 1.66 gph
Capacities:	
Slurry feeder hopper	3 gallons
Hypochlorite reservoir	5 gallons
Engine fuel tank	1 gallon
Oil capacities:	
Slurry feeder	1 quart
Hypochlorinator case	3.5 quarts
Engine crankcase	2 pints
Engine air cleaner	0.25 pint
Engine:	
Power	4.5 hp
Speed	2600 rpm
Torque	110 pound-inches

Section IV. HYPOCHLORINATION UNIT, WATER-PURIFICATION, FRAME-MOUNTED, WATER-DRIVEN, 100-GPM

2-9. DESCRIPTION

a. General. This unit (fig 2-27) was designed to chlorinate water automatically. The force of the water that is pumped through the unit is what actuates the chlorination mechanism. The unit can chlorinate up to 100 gallons of water per minute. A constant chlorine residual will be held even if the water is fed at different flow rates. The only time the chlorine residual could change is if the water character would change, that is to say, if the water would somehow contain more contaminants at different times.

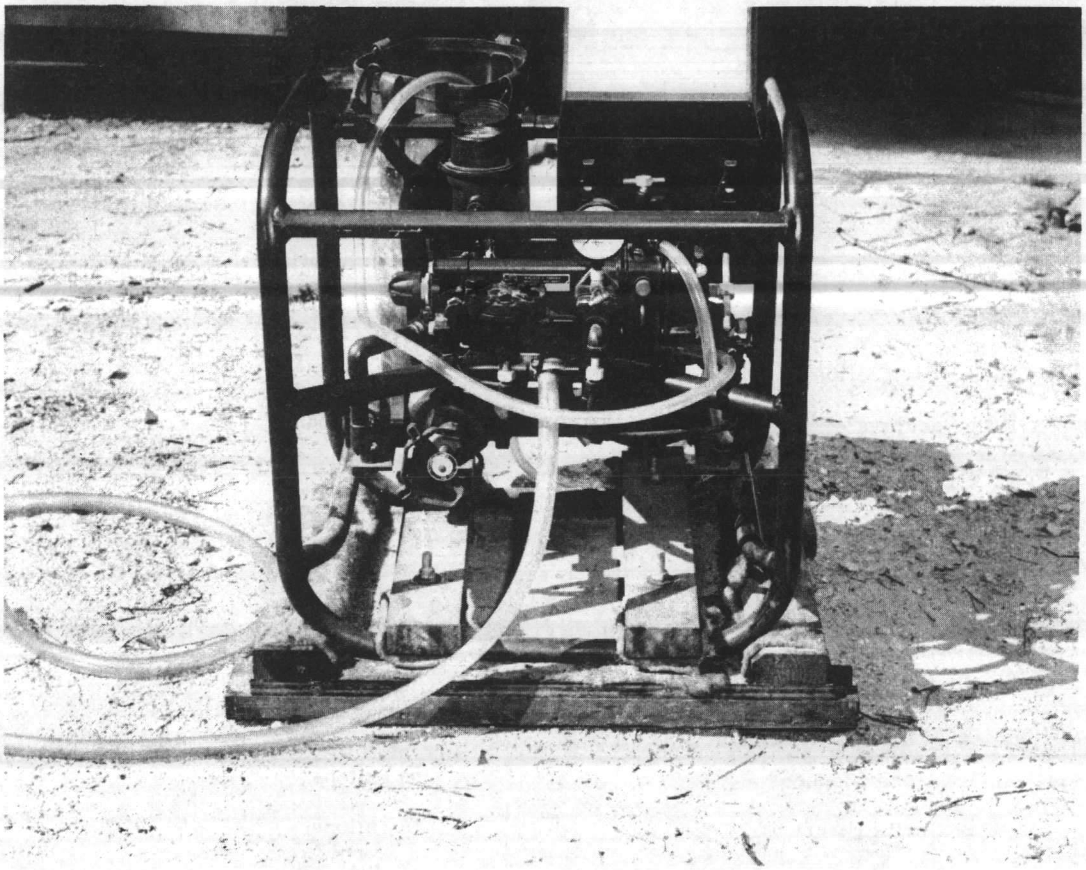


Fig 2-27. Hypochlorinator.

The unit consists primarily of a tubular frame which supports and protects the working parts, a hypochlorinator, a flow control valve, and a 5-gal hypochlorite solution reservoir. The unit is supplied with a canvas cover for protection.

b. Hypochlorinator. The hypochlorinator is a water-operated pump with a diaphragm instead of the usual piston. A controlled flow of water is admitted through a flow controller. The hypochlorinator pumps in direct proportion to the rate of flow of water flowing through it. The hypochlorinator pumps hypochlorite solution into the water flowing through it. This solution is preset. That is, it is mixed according to the length of the stroke of the hypochlorinator. Normally 10 ounces of hypochlorite powder to 5 gallons of water will produce a 1.0 percent solution. The pump shaft and pumping diaphragm move forward to accomplish the pumping stroke. During this process the suction poppet valve is closed, the discharge poppet valve is open, and solution is pumped out of the space between the head diaphragm and pump body. The number of strokes per minute which are accomplished by the hypochlorinator is determined by the speed at which the cam rotates (fig 2-28). The speed at which the cam rotates and the speed at which the hypochlorinator pumps will be in direct proportion to the amount of water passing through the meter.

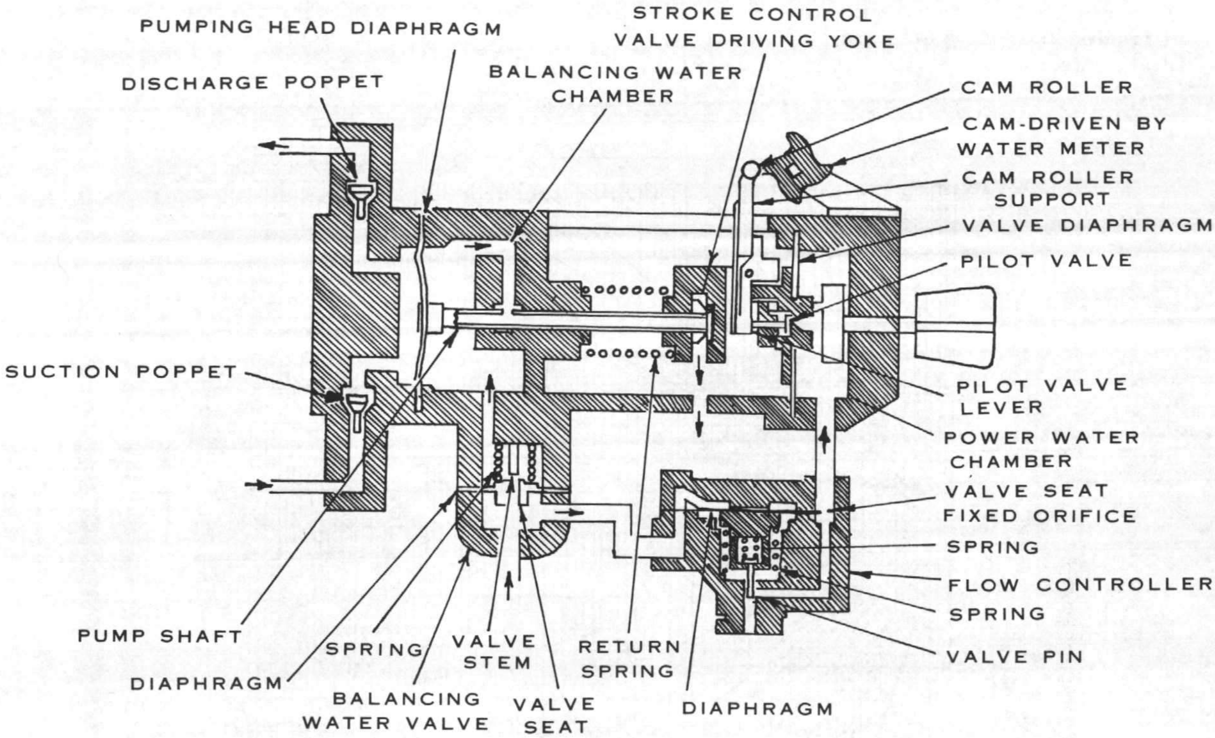


Fig 2-28. Operation of equipment.

c. Balancing water valve. The balancing water valve's main purpose is to allow enough water to pass to maintain a pressure in the balancing chamber about equal to the pressure which exists in the hypochlorinator discharge line. Figure 2-28 shows the internal workings of the equipment.

d. Flow controller (fig 2-28). The main purpose of this valve is as the name states (control the flow of water). At an increase of inlet water flow, the flow controller diaphragm moves the needle valve toward its seat causing a reduction of flow.

e. Water pressure regulating valve (fig 2-28). This valve regulates the water pressure. A valve is held closed by a spring loaded diaphragm until the pressure under the diaphragm is at least 10 psi.

2-10. DETERMINING SOLUTION STRENGTH

In the previous paragraph we mentioned some terms and words used with the hypochlorinator (stroke, solution.) It would not have been proper to go deeper into these terms then, but it is hoped that the following explanation will help you understand their meanings as pertains to the hypochlorinator unit.

Two factors determine the hypochlorite solution strength. One is the volume (gallons) of hypochlorite solution used, and the other is the strength (percent) of the solution.

Sixty (60) gallons of 0.5 per cent hypochlorite solution contain the same amount of chlorine (2.5 pounds) as 30 gallons of 1.0 per cent solution. For field use, 10 ounces of hypochlorite powder added to 5 gallons of water will produce a 1.0 per cent hypochlorite solution. When the stroke control is set at "10" on the dial, the hypochlorinator will make 12 strokes per minute and deliver 60 gallons of solution per day. The hypochlorinator will pump 30 gallons of solution per day when the stroke control dial is set at "5"

Figure 2-29 shows a treatment chart that gives the relationship between the flow of water to be treated and the volume and strength of hypochlorite solution required to produce various chlorine treatments.

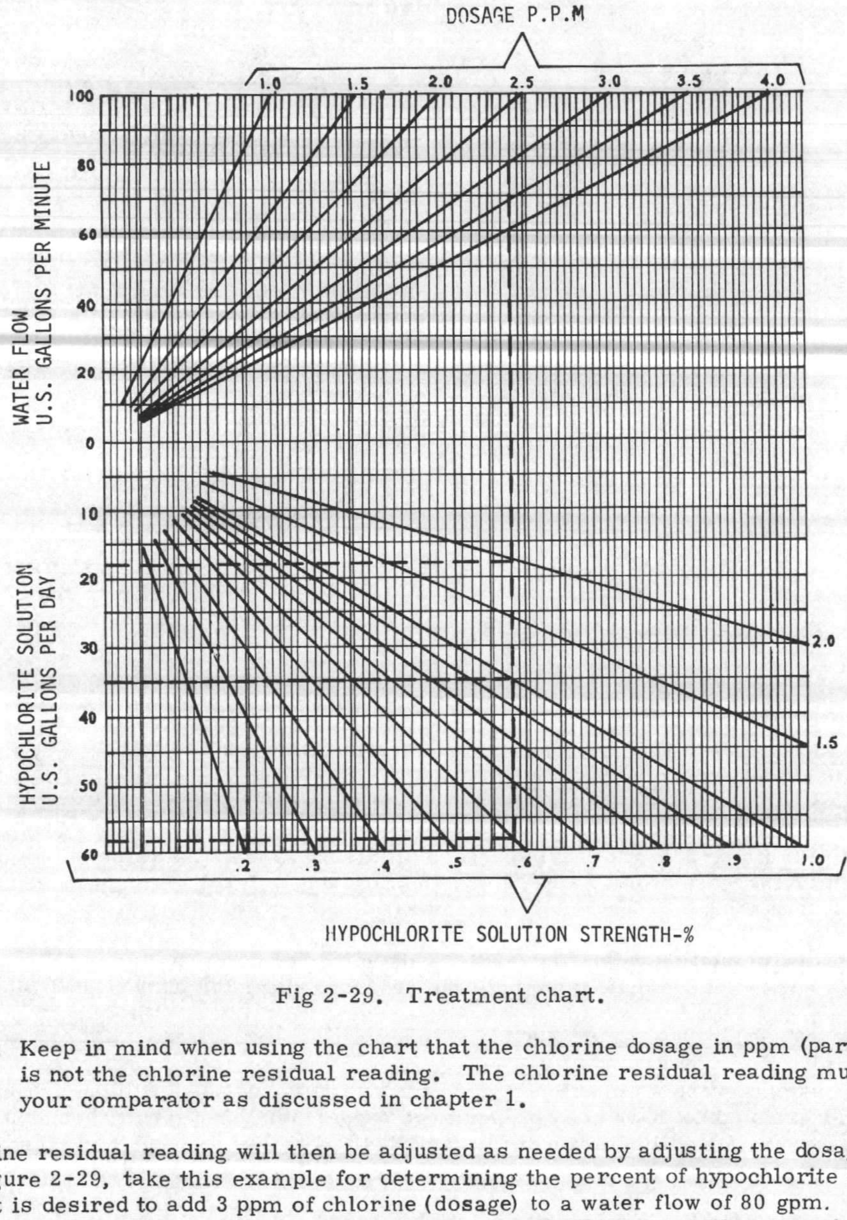


Fig 2-29. Treatment chart.

Note: Keep in mind when using the chart that the chlorine dosage in ppm (parts per million) is not the chlorine residual reading. The chlorine residual reading must be taken with your comparator as discussed in chapter 1.

This chlorine residual reading will then be adjusted as needed by adjusting the dosage. Using the chart in figure 2-29, take this example for determining the percent of hypochlorite solution Suppose that it is desired to add 3 ppm of chlorine (dosage) to a water flow of 80 gpm. On the upper left-hand portion of the chart, we find the line corresponding to 80 gpm. Follow it to the right horizontally to a line coming down diagonally from 3.0 ppm (note dotted line). A vertical line dropped from that intersection to the lower half of the chart gives the volumes of various solutions necessary to

13 get a 3 ppm (dosage) treatment. We find that the treatment can be obtained with about 18 gallons per day of 2-percent solution; 35 gallons per day or 1-percent solution; or with 58 gallons per day of a .6-percent solution.

Section V. WATER DISTILLATION UNIT, 200-GPH

2-11. GENERAL

The Meco water distillation unit, model PD200LP, is a thermocompression-type, trailer-mounted, diesel-engine-driven machine. This unit is capable of producing 200 gallons of potable water per hour from salt or sea water with a salinity of from 2-15 parts per million (ppm). Figure 2-30 shows a front view of the distillation unit with the canvas curtains up. Figure 2-31 shows a side view on the observation window side of the unit. A 10-gallon tank is provided for the fresh water required to fill the exhaust boiler and engine system. The crankcase holds seven quarts of high grade detergent oil (the weight of which depends on temperature). The filter uses the same type oil, and its capacity is half a quart. The compressor takes one and a half quarts of special compressor oil.

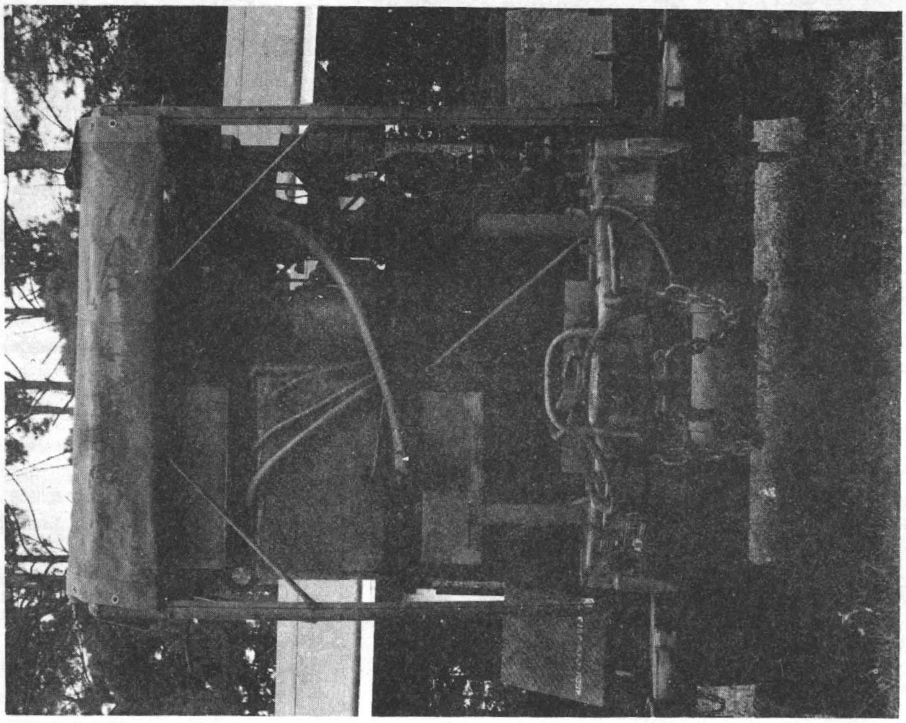


Fig 2-30. Distillation unit, 200-gph--front view.

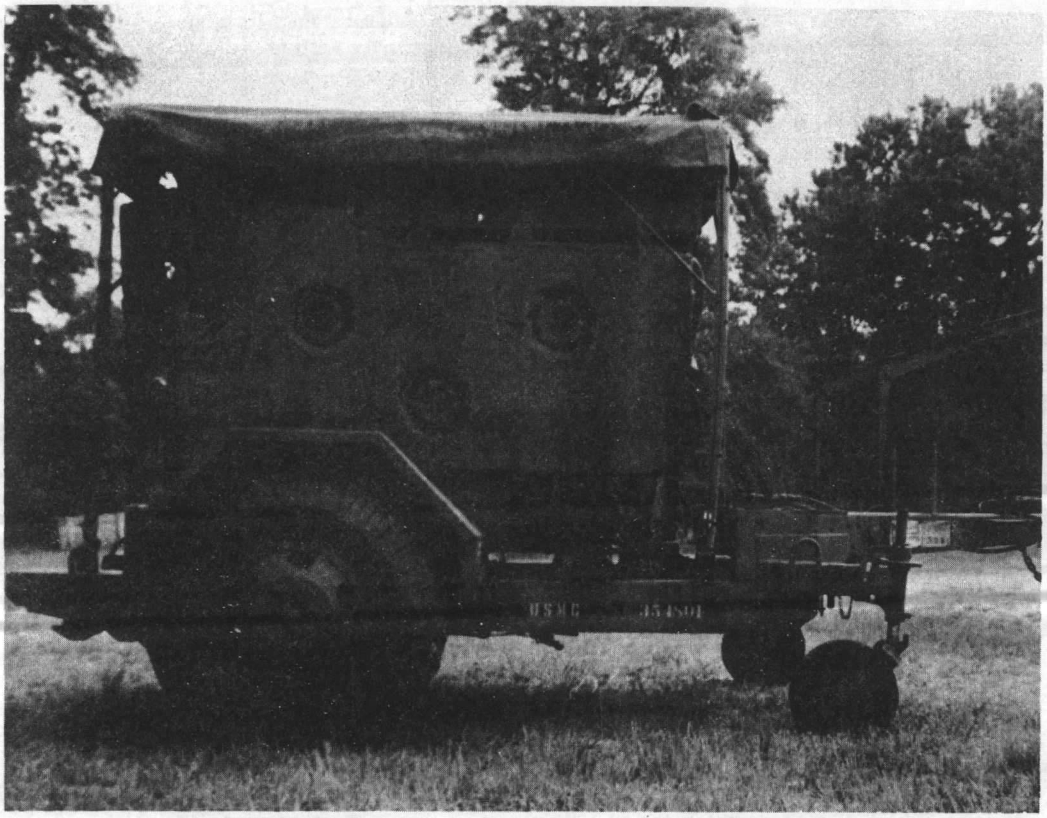


Fig 2-31. Distillation unit, 200-gph--side view.

2-12. INSTALLATION

The trailer-mounted unit should be parked on relatively level ground and the trailer bed should be leveled to within 1/8 inch, particularly from front to rear. Locate the unit as close as possible to the feed water supply (maximum 50 feet). If the terrain is uneven, then an attempt should be made to level the terrain. If it is muddy or sandy, then heavy planking should be used to form a platform for the unit.

2-13. OPERATION

a. Before starting.

(1) Roll up and secure canvas siding (curtains) on operator's side of unit. Figure 2-32 shows operator's side of unit with canvas curtain down.

Fig 2-32. Operator side of unit with curtains down.

(2) Connect the feed water supply to the duplex feed water strainer (fig 2-33). The feed water supply can be gravity flow from a supply tank to the unit, or the feed pump (fig 2-33) can be used to lift the water from the source if the lift does not exceed eight feet.

Note: When the feed pump is used to lift the feed water from the supply source, it will be necessary to use a foot valve on the end of the suction hose and the feed pump will have to be primed. To prime the feed pump, remove the cover from one of the strainer baskets and fill the entire suction line with raw water; replace the strainer cover and tighten clamp. Connect distillate hose to service tank. Insure that fuel tanks are full.

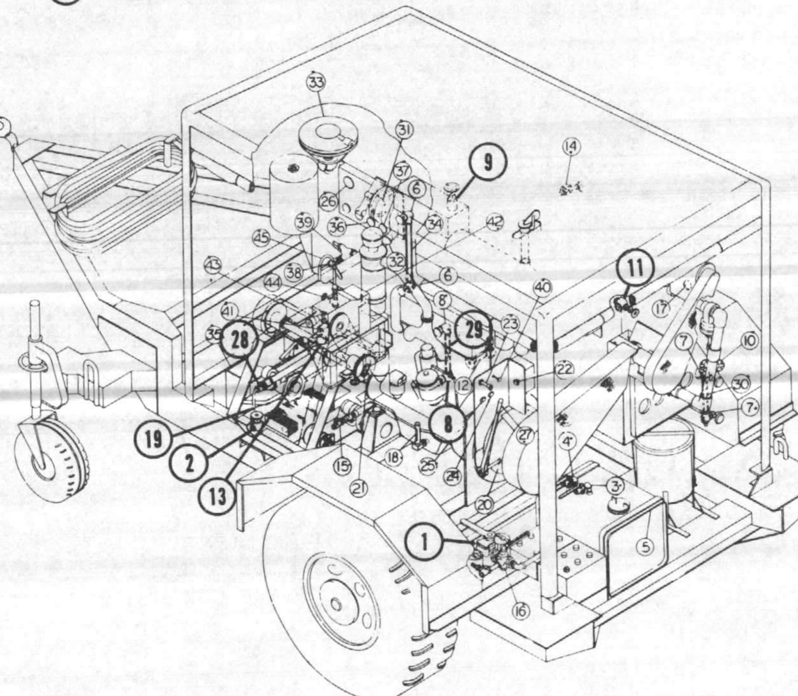
(1) DUPLEX FEED WATER STRAINER

(19) FEED PUMP

(2) DISTILLATE VALVE

(29) (8) EVAPORATOR LEVEL GAGE/VALVES

(9) EXHAUST BOILER WATER FILL



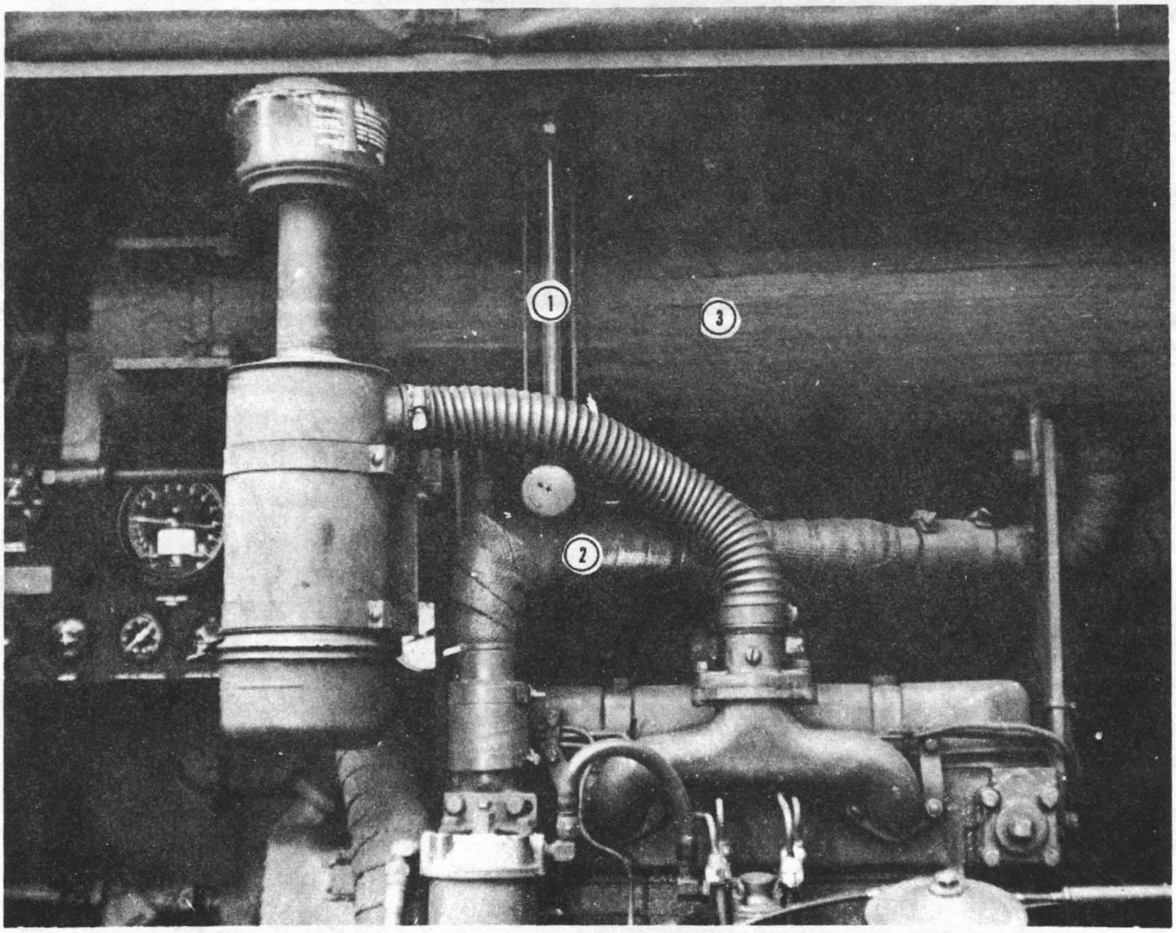
(11) VENT VALVE (AIR)

(28) FEEDLINE PETCOCK

(13) BLOWDOWN VALVE

Fig 2-33. Distillation unit.

(3) Check distilled water level in the exhaust boiler, adding water if necessary. Figure 2-34 shows gage on exhaust boiler.



1. Exhaust boiler gage
2. Engine water return line to exhaust boiler
3. Engine exhaust boiler

Fig 2-34. Exhaust boiler and gage.

(4) Close evaporator drain valve and drain cocks on all gage valves. Make certain the manual blowdown valve is closed along with the distillate valve (fig 2-33).

(5) Open level gage valves on exhaust boiler, evaporator distillate level gage, and evaporator raw-water level gage (fig 2-33).

(6) Check compressor oil level and engine oil level (fig 2-35), adding oil if necessary. See the following subparagraph d for listing of normal water levels and oil levels. Figure 2-36 shows observation glass with proper compressor oil level.

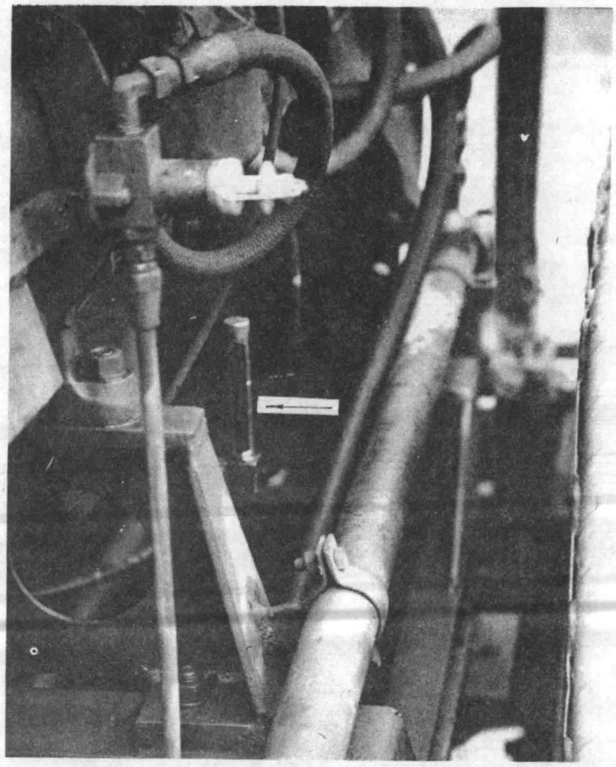


Fig 2-35. Engine oil gage.

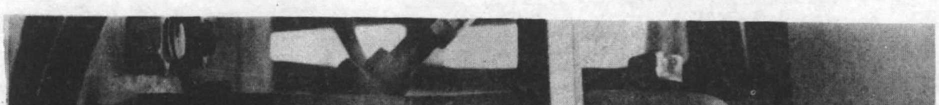


Fig 2-36. Compressor oil sight glass.

b. Safety controls. The safety controls consist of five main assemblies: evaporator high-water-level; engine high-water-temperature; engine low-oil-pressure; engine overspeed-shutdown switch; and compressor low-oil-pressure switch. Each safety control provides a means for stopping the engine by de-energizing the solenoid located in the engine fuel pump. The engine low-oil-pressure switch and high-water-temperature switch is a combination type control that automatically energizes the safety control system when the engine oil pressure increases above the set point of 12 psig. The engine high-water-temperature switch will be actuated if the jacket water temperature exceeds 250° F. The evaporator high-water-level switch will stop the engine if the raw-water level in the evaporator is increased to a point just below the demister pad. The "overspeed" switch, which is built into the tachometer, is set to stop the engine at 1125 rpm. The compressor low-oil-pressure switch is set at 12 psig.

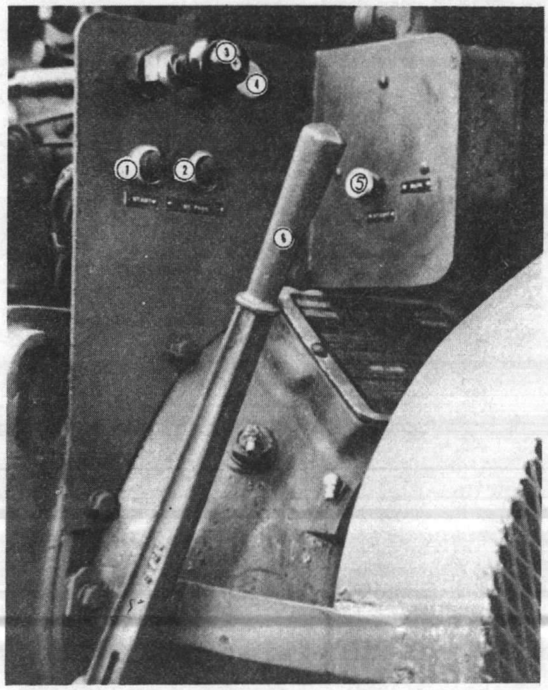
Warning: This trip setting should never be exceeded because the compressor may be severely damaged when operating above normal speed levels. If an overspeed condition is experienced, it will be necessary to push the reset button located on the rear and side of the tachometer in order to restart the engine.

Note: It is recommended that the operation of each safety control device be checked individually at regular intervals not exceeding 60/90 days to be certain that each is in good operating condition and that each is actually "on watch" at all times.

c. Starting procedure.

(1) Prime engine fuel system and vent same (if necessary) through plug on top of the secondary fuel filter (Refer to TM 01274D-14). Position engine safety control knob to START and open throttle about one inch (throttle is a combination push-pull-screw type) (fig 2-37). With clutch disengaged, press compressor low-oil-pressure bypass switch and engine start switch simultaneously to start engine (fig 2-37). Hold bypass switch until engine is operating and compressor oil pressure exceeds 12 psi (fig 2-38). The engine safety control knob will reposition itself to RUN automatically when the engine low-oil-pressure setting of 12 psig is exceeded.

Note: If engine surges on start-up and tachometer indicator exceeds overspeed set point of 1125 rpm, the engine will be shut down. To restart, press overspeed reset button on the rear and side of the tachometer. Screw throttle in slightly and restart engine.



1. Start button
2. Low oil bypass button
3. Throttle twist
4. Stop engine
5. Safety switch
6. Compressor clutch lever

Fig 2-37. Engine operating panel.

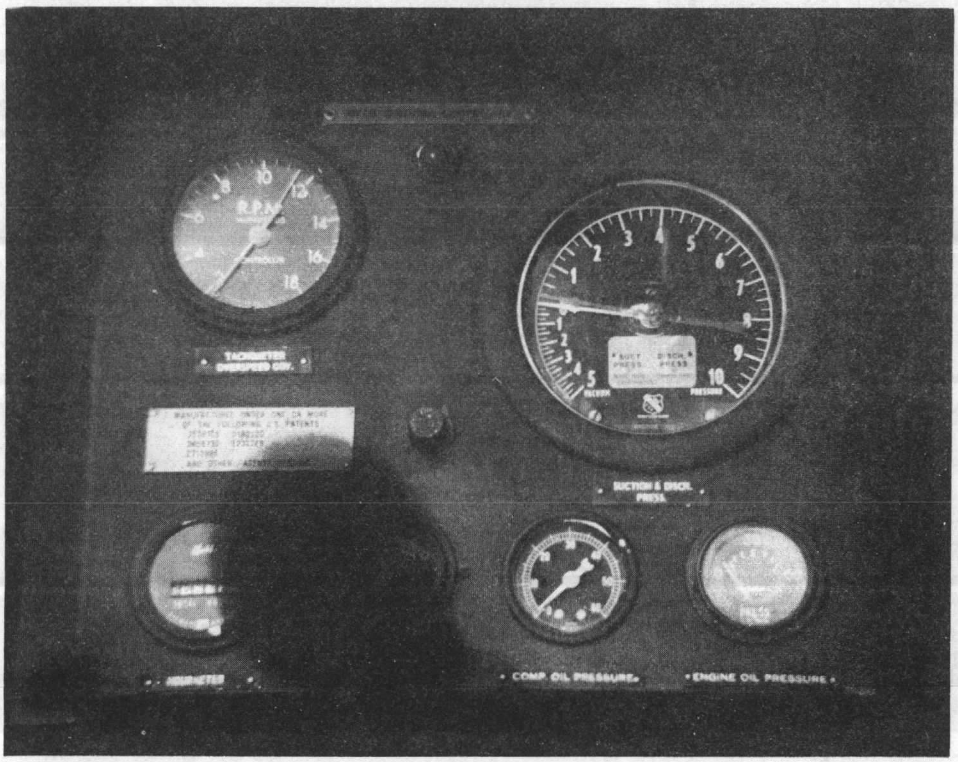


Fig 2-38. Unit control panel.

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(2) Adjust engine speed to 975 rpm (fig 2-38), allowing a 3- to 5-minute warm-up period and permitting raw water feed to enter the evaporator. Slowly engage the clutch by applying a steady force to the clutch operating lever, permitting the compressor to accelerate smoothly without reducing engine speed below approximately 700 rpm. When the compressor inertia load has been overcome and it is operating at near normal speed, the clutch operating lever should then be thrown to the over-center position.

Warning: If the clutch is not engaged slowly, permitting adequate time to allow the compressor inertia load to be overcome before throwing the clutch lever over center, the V-belts may be thrown out of the sheave grooves or the engine will bog down and stop.

Readjust the engine speed to 975 rpm if necessary. Check engine oil pressure which should read between 20 and 45 psig (fig 2-38). The low-oil-pressure switch is set to shut the engine down at 12 psig. Check compressor lube oil pressure which should be 18 psig to 20 psig. The low-oil-pressure switch is set to stop the engine if the compressor oil pressure is reduced to 12 psig.

(3) Open vent valve 1/2 turn (fig 2-33). Open pet cock (fig 2-33) in the feed line permitting feed water to flow through the engine lube oil cooler during the starting period.

(4) The operator should observe the evaporator raw-water level during the starting period. This level is indicated by the water level gage located on the side of the sump on the bottom of the evaporator (fig 2-39). If, during the starting, the operator observes the water level rising to the top of the gage glass, it is an indication of excessive amount of water in the evaporator. The excess water should be pumped out of the evaporator by opening the manual blowdown valve. Should too much feed water enter the evaporator, the high-water-safety control will shut the unit down. It would then be necessary to drain the water out of the evaporator by means of the evaporator drain valve (located at the sump of the evaporator) before restarting. Excess feed water can enter the evaporator only if the feed float valve (fig 2-40) fails to shut off tightly. If this happens, it is usually due to foreign matter under the valve seat which will necessitate removal of the valve assembly to free the valve seat of any debris.

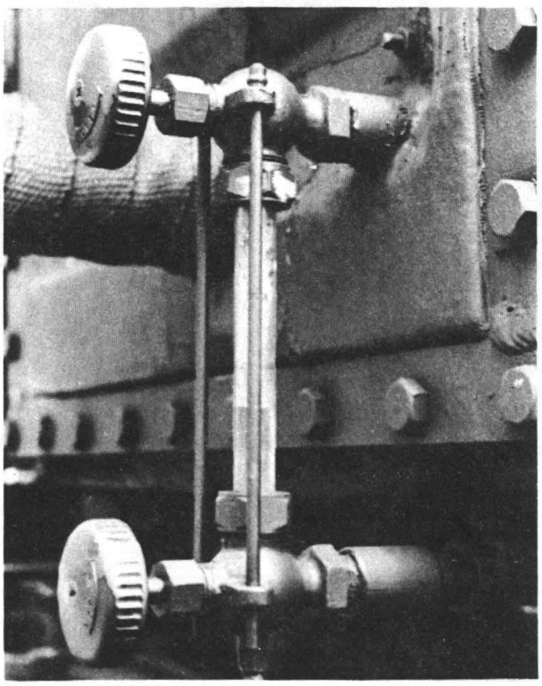


Fig 2-39. Evaporator distillate gage.

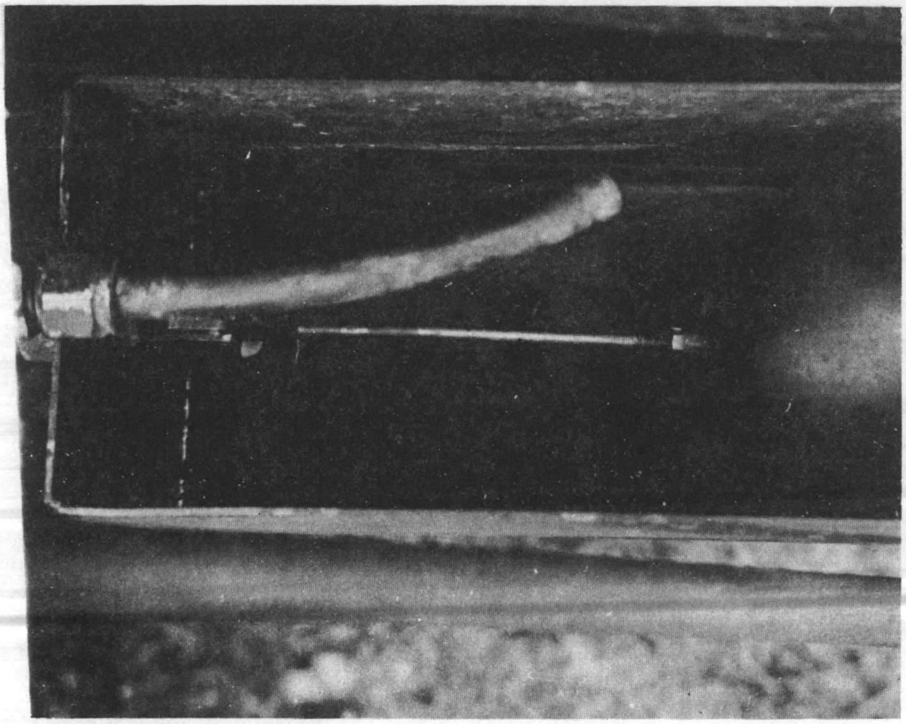


Fig 2-40. Automatic feed float/valve--top view.

(5) As the unit warms up, observe the distillate level in the evaporator gage glass and open the distillate valve as necessary to prevent an increase of distillate level in the evaporator. This should be done slowly in order to prevent losing the charge of distilled water in the exhaust boiler and in the evaporator.

(6) The manual blowdown valve (fig 2-33) can be opened slightly when the suction pressure reaches 1.0 psig. When opening the valve, observe the suction pressure as it will drop rapidly due to the sudden loss of heat. When opening the blowdown valve, attempt to hold the suction pressure to .25 psig minimum with each valve opening increment of approximately one turn on the blowdown valve. Continue to open the blowdown valve until the valve is fully open; the suction pressure will slowly increase after each opening to 1.0 psig.

(7) Open distillate valve fully and adjust air vent valve to emanate a 6- to 10-inch streamer of steam when circulating water temperature reaches 215° F and the suction pressure is 1.0 psig. Close the petcock to the feed line.

(8) When the suction pressure approaches .8 psig, the automatic control valve (fig 2-41) will begin to open, permitting the flow of cold feed water to the evaporator. As the suction pressure increases to 1.0 psig, the cold water bypass rate will maintain 1.0 psig suction pressure.

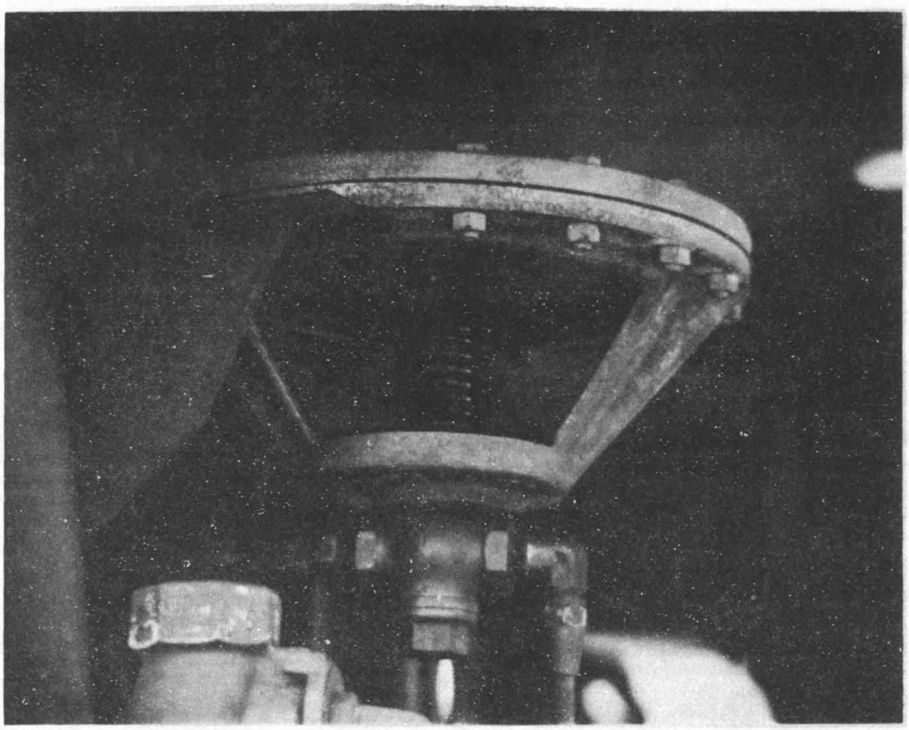


Fig 2-41. Automatic, water-bypass valve

d. Operating procedure. After the starting procedure has been followed through, the system is maintained in balance by the automatic-control, water-bypass valve. Any adjustment to this valve should be made slowly and proper time allowed between adjustments to stabilize. Refer to TM-01274D-14 for details. The automatic-control, water-bypass valve maintains a constant suction pressure by varying the control-water rate, depending upon the feed water and the ambient temperatures. During winter operation the bypass-water rate will be decreased whereas the bypass-water rate will be increased during summer operation. The automatic-control, water-bypass valve should always be adjusted to maintain approximately 1.0 psig suction pressure. Further compression of the valve spring will increase the suction pressure and lessening of the spring compression will reduce the suction pressure.

Observe the raw-water level, distillate level in the evaporator and exhaust boiler, liquid level in the blowdown float tank, compressor oil pressure, engine oil pressure, circulating water temperature, compressor oil level and engine oil level which are as follows:

Raw-water level	2'' to 3'' in gage glass
Distillate level in evaporator.	2'' in gage glass
Distillate level in exhaust boiler.	10'' to full in gage glass
Blowdown float tank level.	3'' to 4'' above bottom of tank
Compressor oil pressure.	15 psi to 20 psi
Engine oil pressure.	20 psi to 45 psi
Circulating water temperature	215° F to 217° F
Compressor oil level.	Middle of glass ±3/16''
Engine oil level.	1-3/4'' to 2-1/4'' in gage glass

Check the duplex feed water strainer frequently, switching the valve from one basket to the other and cleaning the basket as necessary, depending on the feed water conditions, to make certain the unit always has an adequate feed water supply. Always make certain the strainer basket in the "Y" type strainer in the blowdown line is clean, preventing a decrease in blowdown flow rate. Always open the strainer blowdown valve at least once every eight hours, particularly after descaling, to prevent the buildup of scale particles which would plug the strainer and reduce the blowdown flow rate.

During operation in cool or windy weather, it is recommended that the two sides and rear canvas panels remain in the down position and secured to the housing legs. It may be necessary to lower the canvas panel on the operator's side of the unit to keep the unit warm enough for proper operation at approximately 1.0 psig suction pressure. Every day of operation the drain valve in the sump of the evaporator should be fully opened for a few seconds to remove any scale sediment and sludge from the bottom of the evaporator. When operating on normal sea water, the unit will begin to scale and a slight decrease in distillate output will be realized when operating at a constant engine rpm of 975. It is permissible to adjust the throttle setting from 975 to 1060 rpm.

e. Stopping procedure.

(1) If the unit is within two or three hours of the descaling period, the evaporator should be descaled prior to shut down. (Descaling will be discussed later.)

(2) Disengage clutch and close distillate valve.

(3) Continue to operate the unit for approximately 5 minutes with the manual blowdown valve fully open in order to flush the unit. Close manual blowdown valve.

(4) Push throttle all the way in and pull STOP control.

The above procedure reduces the evaporator pressure slowly and therefore gradually reduces the engine system to atmospheric pressure, minimizing flushing of the engine water when the engine is stopped, and rids the evaporator of concentrated sea water.

Caution: Unit must be drained after stopping if freezing weather exists or is apt to exist. For draining instructions see subparagraph f below.

f. After-operation procedure. Unless freezing weather exists, or is apt to exist, allow unit, while idle, to remain full (to normal level) of raw water. When a possibility of freezing weather exists, drain all water from all parts of the unit as follows:

- Evaporator. Open evaporator drain valve on bottom of the sump.
- Engine-exhaust boiler. Open drain cock on block which will drain the engine and exhaust boiler. Remove plug from the engine water pump.
- Feed-water strainer. Remove plug from each basket and valve chamber and place position handle to mid position.
- Pumps. Remove the pipe plug from the bottom of the casing on the feed pump distillate pump and recirculating water pump. Removing the plug in the feed pump will drain the feed water section in the cooler.
- Cooler. Open wide the distillate shut-off valve to drain the distillate section of the cooler. Remove the drain plug in the "T" just ahead of the blowdown float valve in order to drain the blowdown section of the cooler.
- Liquid-level-gage valves. Open petcocks on all liquid level gage valves.
- Acid-injector tank. Open drain valve, fill valve, and acid flow valves.
- Chemical-injector system. Open drain valve, fill valve, and acid flow valves.

g. Operation under abnormal conditions.

(1) Extreme cold weather operation. Difficulty may be experienced when the unit is operated in a cold atmosphere with very cold feed water. This will greatly increase the load on the distillate and blowdown cooler, resulting in less heat being recovered by the feed water, and it will increase the heat lost by radiation. Under these conditions it is essential that

the canvas side panels be lowered and lashed to the housing legs with rope in order to keep the radiation losses to a minimum. Should it be found that 1.0 psig suction pressure cannot be maintained with minimum venting, then the compressor suction pressure should be maintained as high as possible from 0.0 psig to 1.0 psig with minimum venting and no flow through the control-water-bypass valve.

(2) Extreme hot weather operation. Operation in extremely high atmospheric temperatures with very warm raw water should not affect normal operation. Excess heat can be carried away by increasing the flow rate through the control-water-bypass valve (by adjusting the spring tension) and by opening further the air vent valve and, if necessary, the chemical cleaning vent valve.

(3) Extreme quantities of dust or sand in the air. The engine has an air filter to protect the engine from dust. It should be cleaned as often as found necessary in each particular installation.

(4) Unusual feed water supply. The distillation unit is designed and manufactured to give long and satisfactory service under normal operating conditions on average sea water as well as most brackish feed water supplies. To accomplish this, the components are constructed of silicon bronze, 90/10 copper nickel, and bronze. This type of construction has proved quite satisfactory for normal sea water and brackish water supplies; however, it should be noted that feed water containing as little as one ppm to two ppm of hydrogen sulfide will result in an extremely high corrosion rate and relatively rapid deterioration of the equipment. In view of this, it is strongly recommended that feed waters containing hydrogen sulfide not be used, or the water be degassed and all hydrogen sulfide be removed prior to admitting the feed water to the distillation unit.

h. Chemical injection system (M8). The chemical injection system (fig 2-42) consists of a 5-gallon supply tank, a chemical pump with a manual micrometer adjustment knob (fig 2-43), suction and discharge lines, a blow off valve, and a sampling connection to check flow rate.

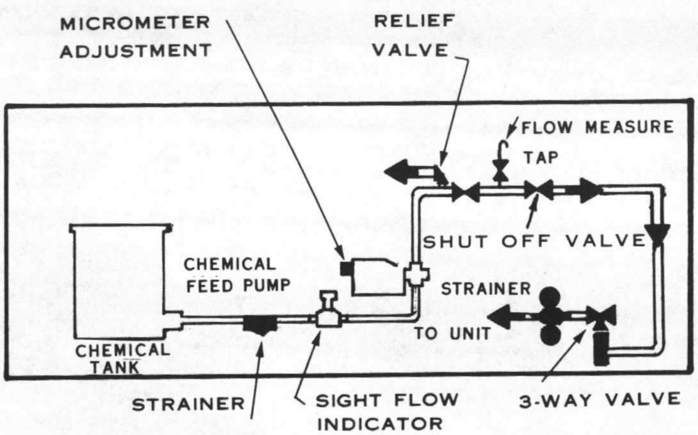


Fig 2-42. Chemical injection system schematic.

This system (also known as the M8 "Nu Tek" system) is used to inject a metered quantity of chemical into the feed water to prevent scale from forming on the heat transfer surfaces. The system is operated as described below.

(1) Mix the chemical solution in the chemical supply tank (fig 2-44). Use 0.5 gallons of NU Tek 30 to 4.5 gallons of water initially. Vary these amounts on a trail basis to determine the minimum amount of chemical needed for the type of feed water.

(2) Open the shutoff valve in the discharge line (fig 2-42 and 2-43).

(3) Using the micrometer adjustment knob, set the stroke adjustment at 25% (figs 2-42 and 2-43).

(4) To check delivery of the chemical injection system, close the shutoff valve and open the sampling valve (flow measure tap, fig 2-42). Using a small plastic medicine cup (graduated in cubic centimeters (cc's), measure the quantity delivered in six minutes and multiply by 10 (the proper rate of delivery is 25cc per hour). Position valves to return flow to system.

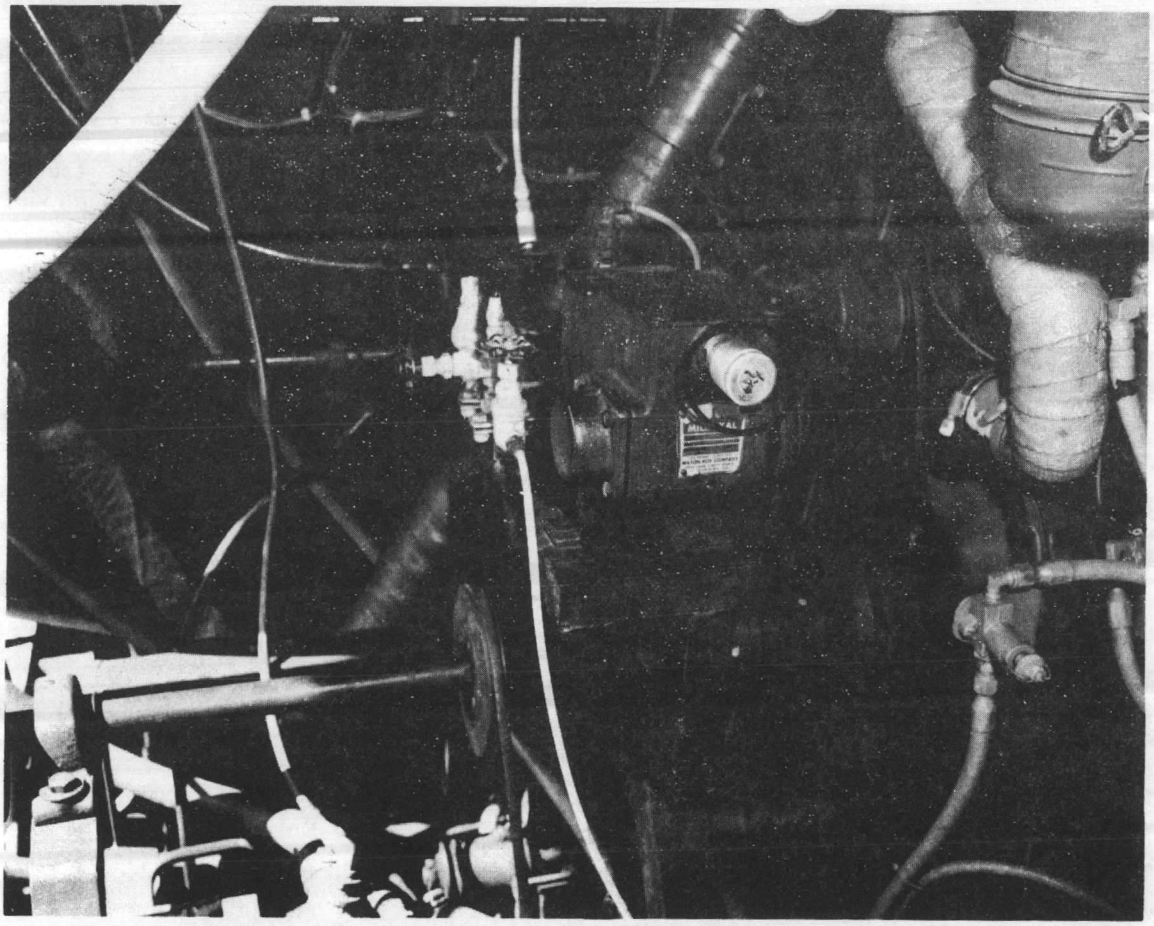


Fig 2-43. Chemical injector, micrometer injector knob.

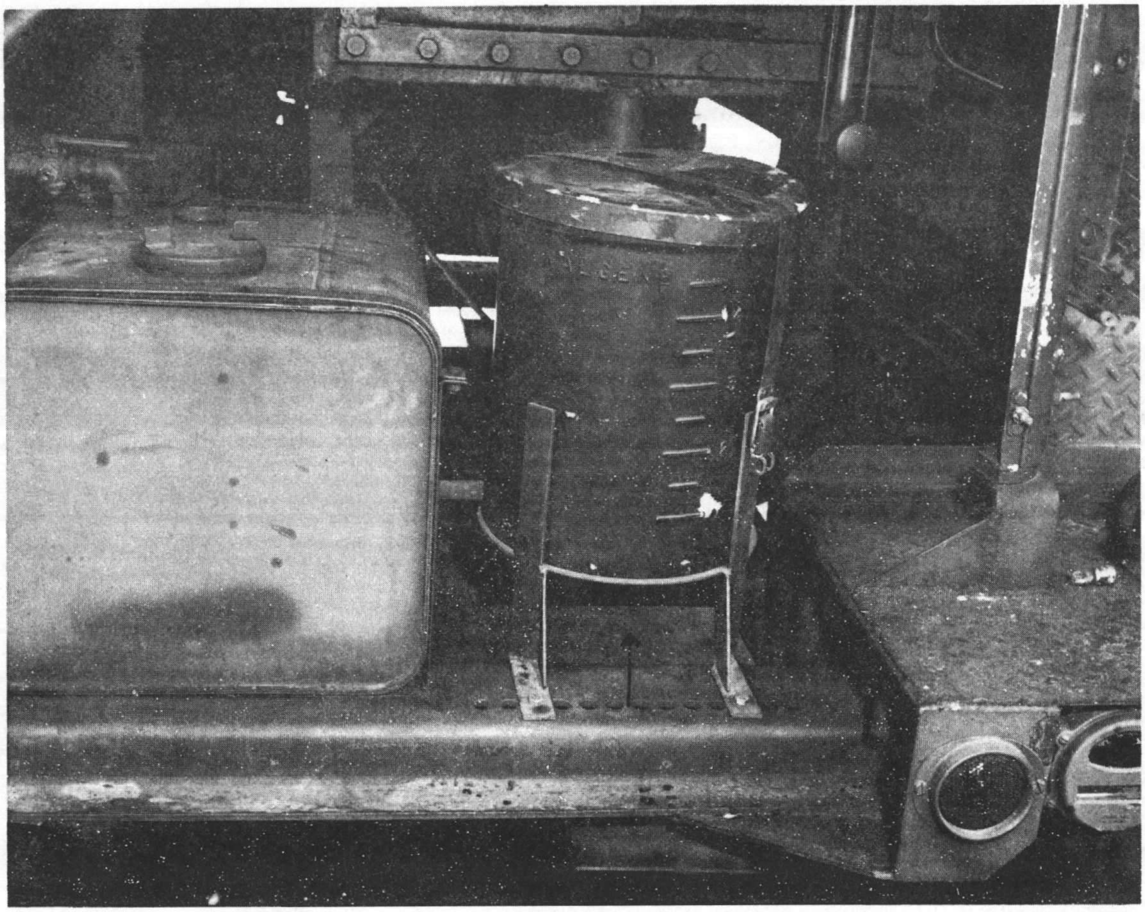


Fig 2-44. Chemical injector, 5-gallon supply tank.

2-14. MAINTENANCE INSTRUCTIONS

a. General. The 200-gph distillation unit is a complicated unit. In our text we try to give you the highlights of the operation and merely try to familiarize you with nomenclature and function. You must rely on TM-01274D-14 for a more detailed explanation. This applies also to the maintenance end of your job as an operator. If there is a need for details on echelons of maintenance up to 4th, then you must refer to the TM mentioned above.

b. Lubrication. There are three different kinds of lubricants used in the 200-gph distillation unit. These lubricants require changing at varying intervals. Below you will find the lubricants described and the intervals listed.

(1) Types.

Lubricant "A" - Series 3, DS MIL-L-45199A
SAE 20 for $+10^{\circ}$ F to $+60^{\circ}$ F ambient
SAE 30 for 60° F and above

Lubricant "B" - Esso Teresso 52 or equal, paraffin base oil with rust and oxidation inhibitors containing an antifoam agent.

Lubricant "C" - No. 1 grease. Calcium complex, water resistant, high temperature. MIL-G-18709A Amendment 3.

(2) Intervals.

Time	Item	Lubricant
Every 24 hours (Daily) DL	1. Add crankcase oil as required.	A
	2. Add compressor gear oil as required	B
	3. Clean air filter if dirty.	
	4. Grease power take-off throw-out collar.	C
Every 50 hours	1. Repeat daily servicing.	
	2. Change oil in crankcase	A
	3. Change lube oil filter element	
Every 100 hours	1. Oil throttle linkage.	A
	2. Change oil in air filter and clean	A
	3. Check water level of batteries.	
	4. Grease pump bearings. (Caution: Use low pressure gun and grease only while pumps are running)	C
	5. Grease clutch shaft bearing, pilot bearing, and operating lever shaft.	C
	6. Grease tachometer angle drive	C
Every 500 hours	1. Repeat daily and weekly servicing.	
	2. Check specific gravity of batteries.	
	3. Change compressor oil	B
	4. Change compressor lube oil filter element.	
	5. Fuel filter elements should be changed as necessary, based on fuel cleanliness.	
	6. Clean crankcase breather.	
	7. Grease pillow block bearings	C

c. Scale removal (using acid pot). Normally when operating on sea water, the unit will scale and a steady decrease in distillate output will occur. For optimum operating results it is recommended that acid cleaning be accomplished every 24 hours. To accomplish this, the unit is equipped with an acid injector pot for injecting acid into the evaporator on a programmed basis without shutting the unit down. The acid injection system is so arranged that when it is desired to introduce acid into the system, the operator can place the prescribed amount of acid into the injector pot (fig 2-45) and simply reposition the handles of the acid flow valves and flush the acid into the evaporator. It has been found that acid injection every 24 hours of operation gives extremely good results in maintaining clean tube condition, resulting in maximum output. The acid is usually more than adequate for scale removal when operating on normal sea water; however, the exact amount of acid required should be determined in the field by trial and error. This is to say that it is preferable for the operator to deviate slightly from the quantities listed, either up or down, in order to use as small an amount as possible to maintain the evaporator at clean tube condition. In this manner the operator can arrive at a regular quantity of acid and inject it into the evaporator on a programmed basis and maintain clean tube condition. The use of acid in excess of the quantity required to remove the scale will result in severe corrosion in the metals of the distillation unit. The amount of chemical required will vary from location to location, depending on the type of feed water as well as the blowdown rate maintained by the operator. It is desirable to maintain maximum blowdown rate as the scale formed under this condition is easier to remove than the scale which forms when the blowdown rate is too low. A low blowdown rate causes high concentration in the evaporator and the scale formed during this time is more difficult to remove; therefore, if it is noticed that continually increasing amount of chemicals are reguired, the rate of blowdown flow should be checked to be sure it is normal. Normal operating pressure should be 1.0 psig suction and the discharge pressure should be approximately 3.6 psig. When scaling occurs, the discharge pressure will be reduced slightly as a result of reduction in production rate; therefore, when the descaling is properly accomplished, the discharge pressure should return to approximately 3.6 psig, accompanied with an increase in production rate to normal output. To properly check the minimum dose of acid for any particular water on any particular time interval basis, it should be understood that to properly attack the scale, sufficient acid must be injected to cause the pH (if measured at the blowdown outlet) to drop initially to slightly less than one. This can be checked with litmus paper or the comparator. It usually takes 15-30 seconds, according to how much acid was put in and how much scale was present. When the pH rises to above two, substantially all attack on the scale has ceased. The following procedure should be carried out to descale the evaporator on a 24-hour operational basis. To repeat, the quantities listed below are considered the normal quantities usually required, but the operator may deviate from these quantities to suit the installation and sea water conditions. It is strongly recommended that a daily written record of the average distillate output be kept so that it can be clearly determined if the unit is being cleaned or is gradually scaling. An acid in liquid form that may be used is sulfuric acid, 66° Baume (Preferred Acid). The quantity used is 1.5 pints per injection per 24 hours. The chemical cleaning procedure is as follows:

- Observe the compressor discharge pressure and record the reading when operating at 1.0 psig suction pressure. The discharge reading should be compared with the reading for clean tube conditions to determine the increase in discharge pressure required to return the evaporator to normal conditions.

- Check the position of the acid flow valves, making certain the recirculating water is bypassing the acid pot. Open the acid fill valve and the acid tank drain valve. Pour the designated quantity of acid into the injector tank and close the fill valve. Reposition the handles of the acid flow valve permitting the recirculating water to flow through the tank and flushing the acid into the evaporator. Discharge the distillate to waste during the acid cleaning period. Open the chemical cleaning vent valve if necessary to maintain approximately 1.0 to 2.0 psig suction pressure.

- Approximately five minutes after the time of acid injection, the evaporator drain valve should be opened for approximately two to three seconds to blow any sludge and scale out of the bottom.

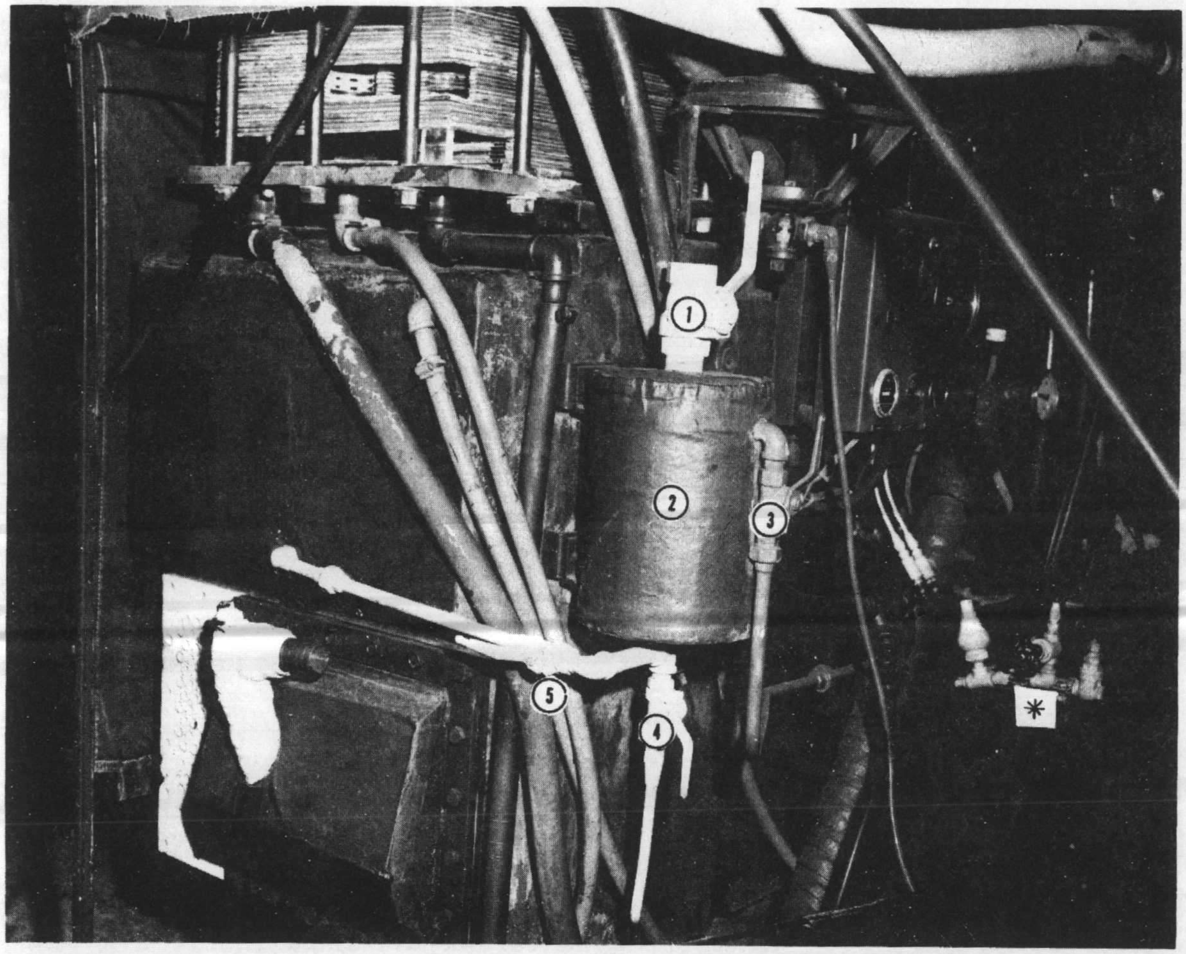
- After 5 to 10 minutes of operation the acid should be "spent" and the discharge pressure should increase to normal as well as the distillate output as indicated by a clean tube condition, if the acid has done the job. Reposition the acid flow valves so that the circulating water will bypass the acid injector pot. Allow the unit to flush itself through normal operation for approximately 15 to 20 minutes before reconnecting the distillate line to the service tank. Total descaling and flushing time should not exceed 30 minutes.

- Approximately every seven days (168 hours) of operation, a small quantity of acid will have to be added to the feed-water strainer to clean the feed section of the cooler. This should be done prior to the acid injection into the evaporator.

- For ease in handling the concentrated sulfuric acid, it is recommended that the acid be diluted with distilled water on a one-to-one basis and the prescribed amount per injection be doubled. Always pour the acid into the distilled water when diluting the acid.

If the liquid acids are not available or are found to be objectionable by some operators, then dry acids such as sodium bisulfate or sulfamic acid may be used. The dry acids may be placed directly in the acid injector pot or first dissolved in water and then poured into the acid pot. If the dry acid is used, trial at the particular location will determine the necessary quantity. Proceed in the same manner as given above for the liquid acid cleaning operation except that, for quantity, use about three pounds of sodium bisulfate per 1,000 gallons of distilled water output by your distilling unit. Do not use more than about six or seven pounds per charge in the pot. The daily record of discharge pressure indicates if more or less acid should be used per day.

As a safety measure, the operator should be equipped with protective clothing such as face shield or goggles, rubber gloves, rubber apron, and rubber pants when handling the acid for descaling. The operator should always remember that water is never to be added to acid; to prevent spattering, always pour the acid into the water. Avoid inhaling acid fumes as much as possible during descaling period. In the event of overexposure to the acid fumes a physician should be consulted.



1. Acid fill valve
2. Acid pot
3. Water flow valve
4. Acid pot drain valve
5. Acid flow valve

* Valves which are part of the automatic descaling system.

Fig 2-45. Acid injection system.

Chapter 3

PUMPS

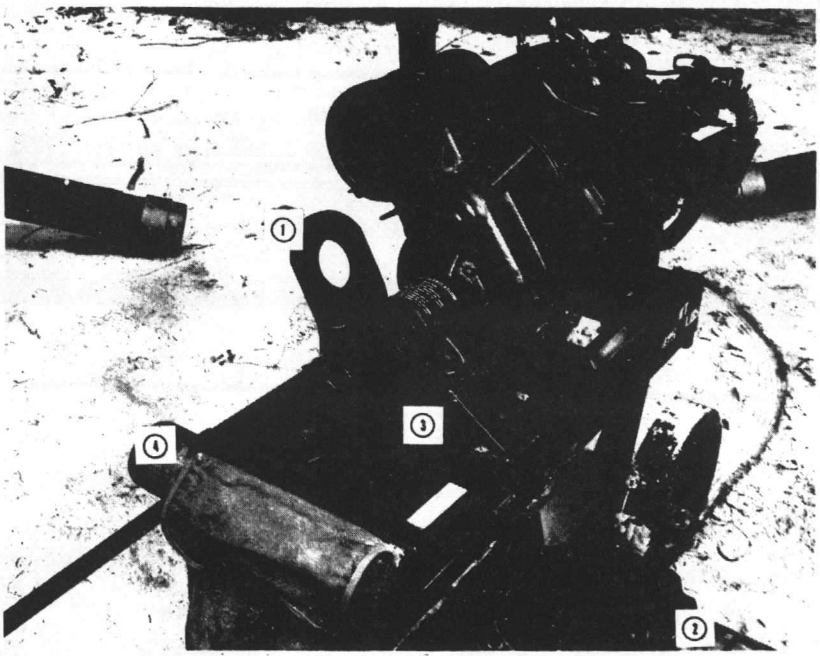
3-1. INTRODUCTION

In this chapter we will discuss the water pumps which are currently in use in the Marine Corps and are available to water supply personnel. These are the 100-gpm, reciprocating, diaphragm pumps (2); the rotary deep-well pump; and the 65-gpm and 55-gpm pumps.

3-2. PUMP, RECIPROCATING, DIAPHRAGM, 100-GPM (REX CHAINBELT MODEL 4DG)

a. General. This pump is a gasoline-engine-driven, positive-displacement, diaphragm-type pump. The engine and pump assembly is mounted on a two-wheel cart. The engine is a military standard 2-cylinder, air-cooled engine. Figure 3-1 shows a front corner view of the unit. This unit weighs 425 pounds and is equipped with two lifting eyes (fig 3-1). This pump was designed to be used where the liquid carries a high percentage of trash, mud, or sand.

Note: A strainer must always be used on the suction hose to prevent stones and heavy trash from entering the pump.

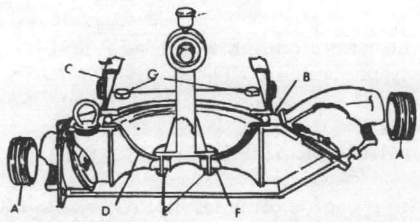


1. Lifting eye
2. Discharge side
3. Diaphragm and pump housing
4. Suction side

Fig 3-1. Pump, reciprocating, 100-gpm.

b. Preparation for use. If the pump is new and you are uncrating it, a visual inspection is necessary to insure that the pump is not damaged. Four 10-foot sections of 4-inch diameter hose with 4-inch diameter close nipples should also be with the unit. These close nipples are screwed into the inlet and outlet valves so that the hoses can be attached. The rubber diaphragm is shipped separately and has to be installed before operation. Figure 3-1 shows a view of the rubber diaphragm housing. Figure 3-2 shows the pump body and adjacent parts. The pump should not be placed more than 25 feet above the water level. The pump should be level and placed as close to the source as possible. The wheels of the pump unit should be chocked to prevent movement.

The 4-inch suction hose is of the rigid type. This is the only type which should be used on the suction side. The discharge side of the pump can use a collapsible type hose.



A. 4" close nipples
B. Pump body
C. Frame
D. Rubber diaphragm
E. 5/8" brass nuts
F. Diaphragm flange
G. Bolts and nuts

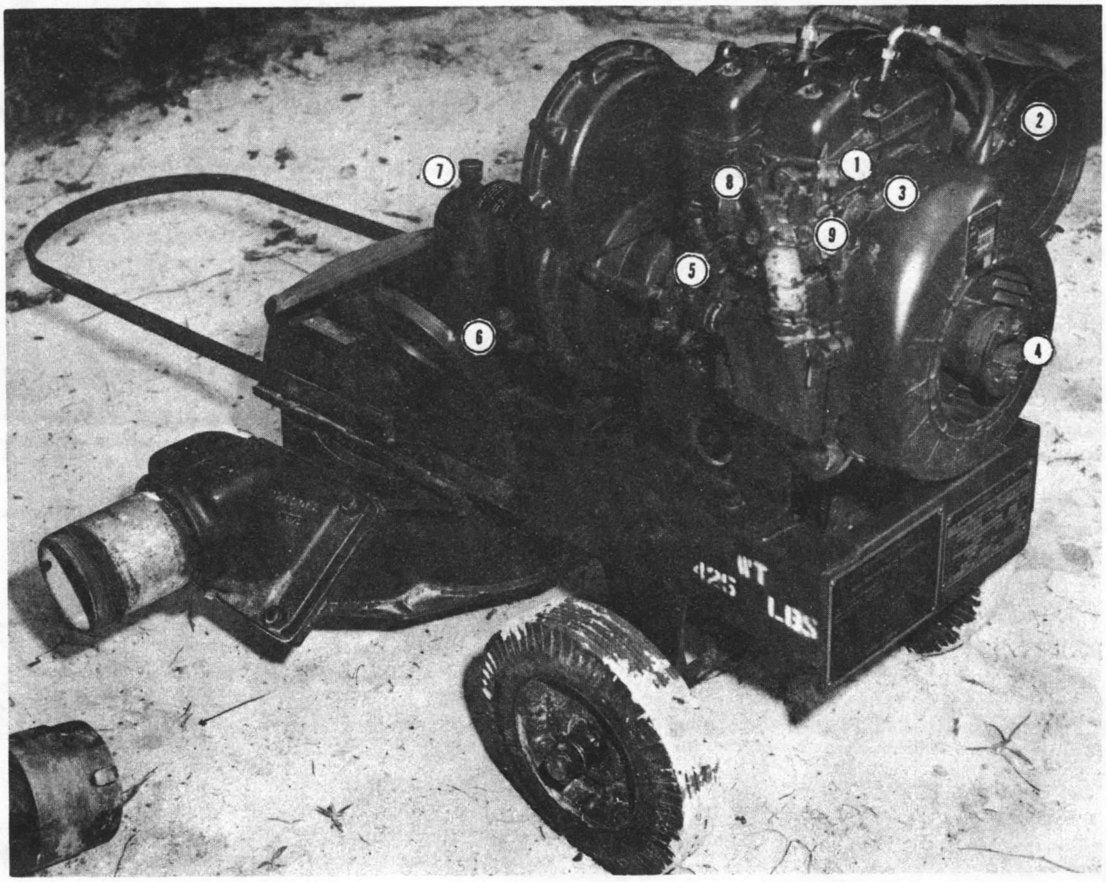
Fig 3-2. Pump body and adjacent parts--cutaway.

c. Operating instructions.

(1) Starting. Follow the procedure described below: (the (F) refers to fig 3-3).

- Fill the engine fuel tank (1.5 gallons) (F) with regular gasoline.
- Check the engine crankcase oil level by removing the dipstick (F). Observe the level indicated. Add oil if necessary. Lubrication will be discussed later.
- Check the oil level in the pump reduction gearcase. Remove the oil level plug (F). Oil should be to this level. Add oil if necessary.
- Hand turn down the grease cup cap (F) slightly on top of the connecting rod needle bearing to force grease to the bearing.
- Connect the suction hose to the pump and place the inlet end of the hose in the liquid to be pumped.
- Connect the discharge hose and place it in the required position.
- Remove the pump body priming cap and fill the pump body with liquid (fig 3-4).
- Replace the priming cap tightly on the pump body.
- Flip the engine on-off switch to the ON position (F).
- Close the choke valve (F).
- Start the engine with the engine starter rope (F).
- Open the choke valve slowly to obtain smooth engine operation.

(2) Stopping. Shut off the engine by flipping the on-off switch to the OFF position. If the pump is to remain in its present location, engine need only be shut off.



1. Engine speed knob
2. Engine fuel tank
3. Engine "ON" "OFF" switch
4. Engine starting rope flange
5. Engine oil dipstick
6. Gear case oil level
7. Pump shaft grease cup
8. Engine governor
9. Choke control

Fig 3-3. Engine components.

(3) Normal operation. The operation of the pump is dependent on the volume or supply of liquid to be pumped. When shallow suction lifts with the little liquid to be pumped are encountered, reduce engine speed. To govern the engine speed, loosen the spring-loaded knurled knob (F). Actuate knob forward or back in slotted hole to gain the desired engine speed. This will reduce the load on the engine resulting in reduced fuel consumption. On high suction lifts it will be necessary to keep the engine speed higher.

(4) Cold weather operation. Cold or freezing weather should not affect the operation of the pump as long as water is being drawn into and passed through the pump body. However, at the close of pumping operations, the pump body should be thoroughly drained by removing the pump body and discharge valve drain plugs (fig 3-4). Leave drain plugs out if pump is to be left outside. Replace plugs before starting operation. If hi-solid content water has been pumped, remove the clean-out door (fig 3-4) and flush out pump with clear water.

(5) Pump body clean-out door (fig 3-4). A clean-out door is provided for quick inspection and clean-out. After pumping of muddy sludge water or water containing chemicals harmful to rubber, the pump body should be flushed out with clean water. Access to the inside of the pump body is made by removing four wing nuts holding the clean-out door to the pump body and removing the door. Replace the door and the rubber gasket. Turn the wing nuts down tightly.

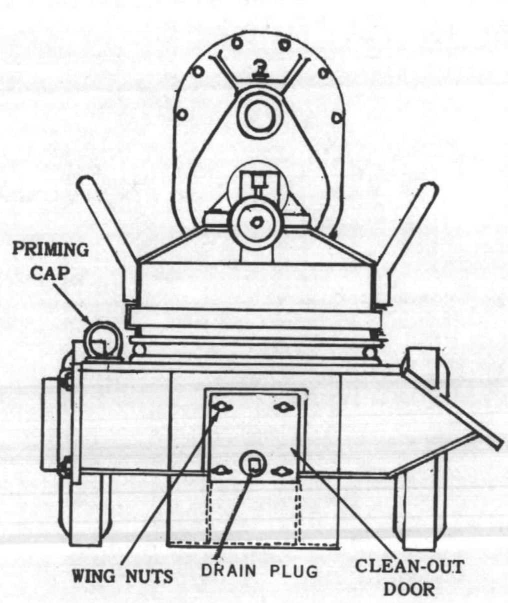
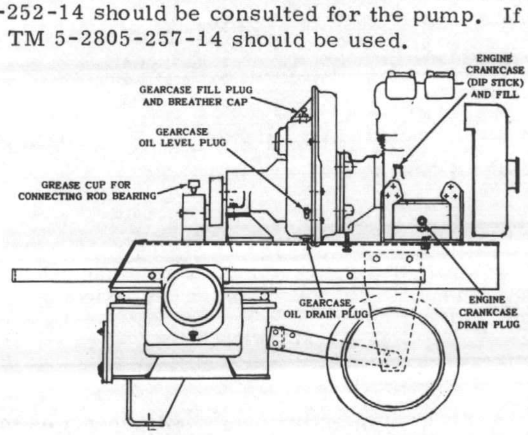


Fig 3-4. Pump body clean-out door.

d. Maintenance. As with all pieces of machinery, proper maintenance will extend the life of the pump. Below is a listing of the things required on the daily maintenance of the pump. Also, figure 3-6 will show you the lubrication points. If there is need for more information on maintenance, then TM 5-4320-252-14 should be consulted for the pump. If there is a need for futher engine maintenance, then TM 5-2805-257-14 should be used.



Engine Crankcase - Consult "Engine Manual" (TM 5-2850-257-14).

Connecting rod bearing grease cup - Hand fill as required.

MIL-G-10924A-GAA

Pump Reduction Gearcase - Check oil level daily - drain, flush, and refill case to level plug every 1,000 running hours.

EP90-140 (MIL-L-2105, Grade 90)

Wheel Bearings - Sealed type ball bearing, no lubrication required.

Fig 3-5. Lubrication chart.

(1) Daily. Follow the steps outlined below:

- Fill the engine fuel tank if necessary.
- Check the engine crankcase oil level every 5 hours and change the oil every 25 hours of operation. Add oil if necessary when checking oil.
- Check the pump gearcase oil level. Remove the oil level plug on the side of the gearcase. Add oil if necessary.
- Check the connecting rod bearing grease cup. To lubricate the bearing, hand turn down the grease cup cap one quarter turn, twice daily. Fill cup as required.
- Flush out the pump body with clean water.
- During freezing weather, make sure the pump body is drained after pumping. Remove the suction line from the liquid.

(2) Troubleshooting.

(a) Priming. Failure to prime initially may be due to:

- Suction left too high - Total lift must be no greater than 25 feet.
- Suction leak - Check the hose connections, check valve and seat gasket, check diaphragm for cracks and make sure that the inlet end of the suction hose is submerged in liquid but not buried in mud and/or foreign matter.
- Valve leak - Check for proper seating and easy operation.

(b) Loss of prime. This may be due to the same conditions as noted above.

(c) Low pumping rate. Failure to deliver at rated capacity may be due to any of the following causes:

- Suction lift too high - Reposition the pump as required.
- Discharge point too high - Change the discharge system as required.
- Suction leaks - Check as indicated under priming.
- Collapsed suction line - Make sure that the suction hose lining is not damaged or that the line is not crimped.
- Clogged suction - Clean the suction inlet.
- Reduced engine speed - Make sure engine is properly serviced and adjusted. (Connecting rod should operate at approximately 60 strokes per minute.)

3-3. PUMP, RECIPROCATING, DIAPHRAGM, 100-GPM (GORMAN RUPP MODEL 4D2A016)

a. General. This pump is basically similar to the 100-gpm pump just discussed in paragraph 3-2. The engines are identical; therefore, the engine on this pump will not be discussed in this paragraph. The pump itself is slightly different in design so we will be discussing it. The engine and pump are mounted on a two-wheel, hand-drawn cart, differing from the other cart in the shape of the drawbar and strength. Figure 3-6 shows a view of the pump from the discharge side. Figure 3-7 shows an exploded view of the cart.

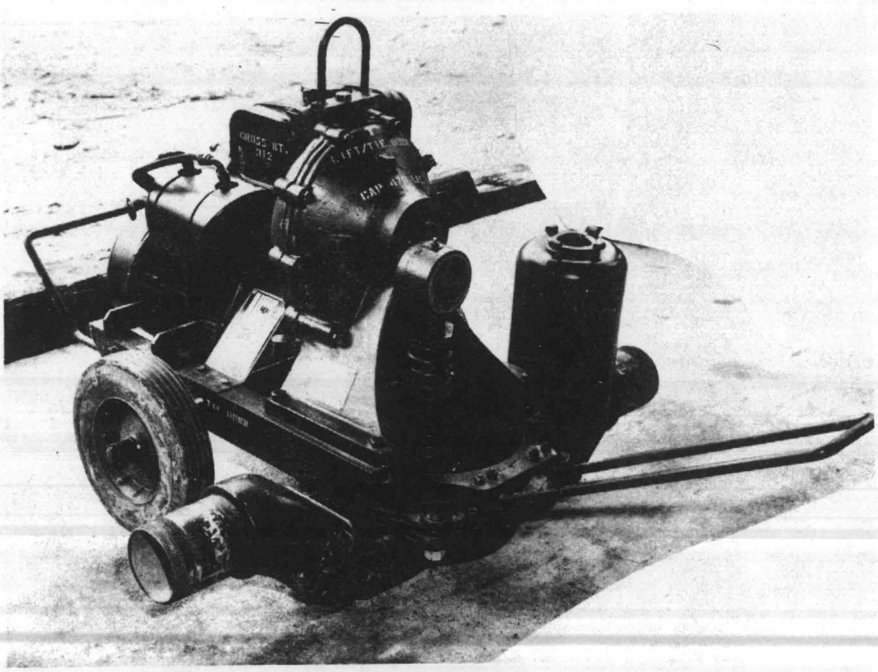
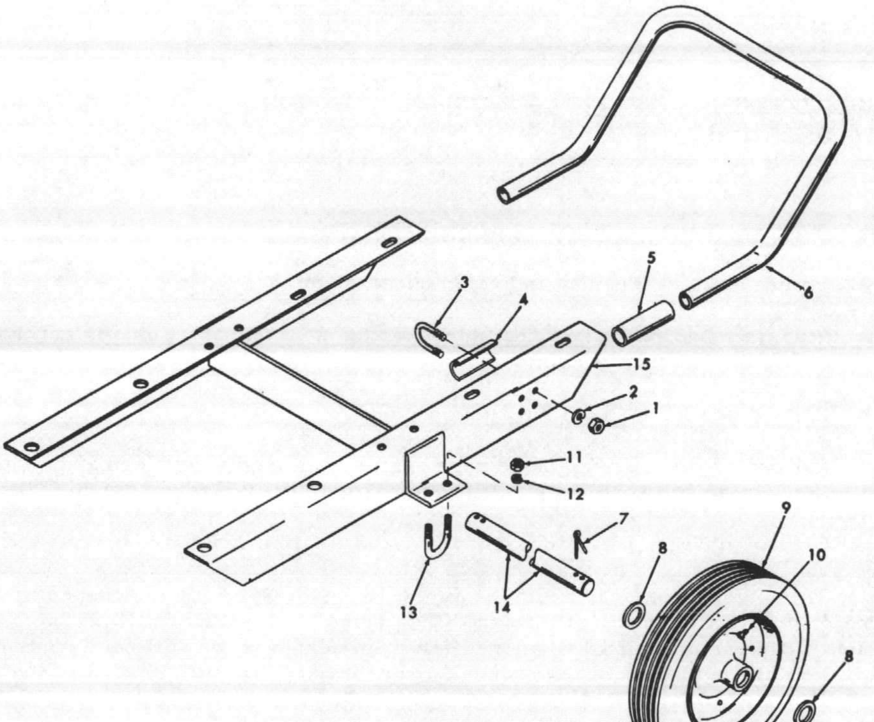


Fig 3-6. Pump, reciprocating, 100-gpm (Gorman - Rupp).



1. Nut
2. Lock washer
3. U-bolt
4. Clamp
5. Hose
6. Engine guard
7. Cotter pin
8. Washer
9. Wheel
10. Lube fitting
11. Nut
12. Lock washer
13. U-bolt
14. Axle
15. Base

Fig 3-7. Pump, cart.

The Gorman - Rupp pump is also rated at 100 gallons per minute against a 25-foot head (maximum suction lift of 25 feet). This pump unit weighs only 312 pounds as opposed to the 425 pounds of the Rex Chainbelt model. Since the procedures of preparing the units for use and installation are the same, we will not repeat them here but merely refer you back to paragraph 3-2 to refresh your memory. When the unit is being transported, the wheels should be chocked to prevent movement. The tiedowns provide additional security.

b. Pump. The pump uses a diaphragm and plunger assembly. The diaphragm is a tough, flexible, rubber ring which is mounted between the diaphragm pot and the diaphragm ring which is secured to the frame. Figure 3-8 shows these components.

KEY

1. Plug
2. Nut
3. Lock washer
4. U-bolt
5. Drawbar
6. Nut
7. Lock washer
8. Ribbed bolt
9. Diaphragm pot
10. Nut
11. Lower diaphragm plate
12. Diaphragm
13. Plunger rod
14. Plunger nut
15. Spring
16. Spring washer
17. Lubrication fitting
18. Upper diaphragm plate
19. Cap screw
20. Diaphragm ring
21. Protective cap
22. Retaining ring
23. Retaining ring
24. Roller bearing
25. Lubrication fitting
26. Bearing housing

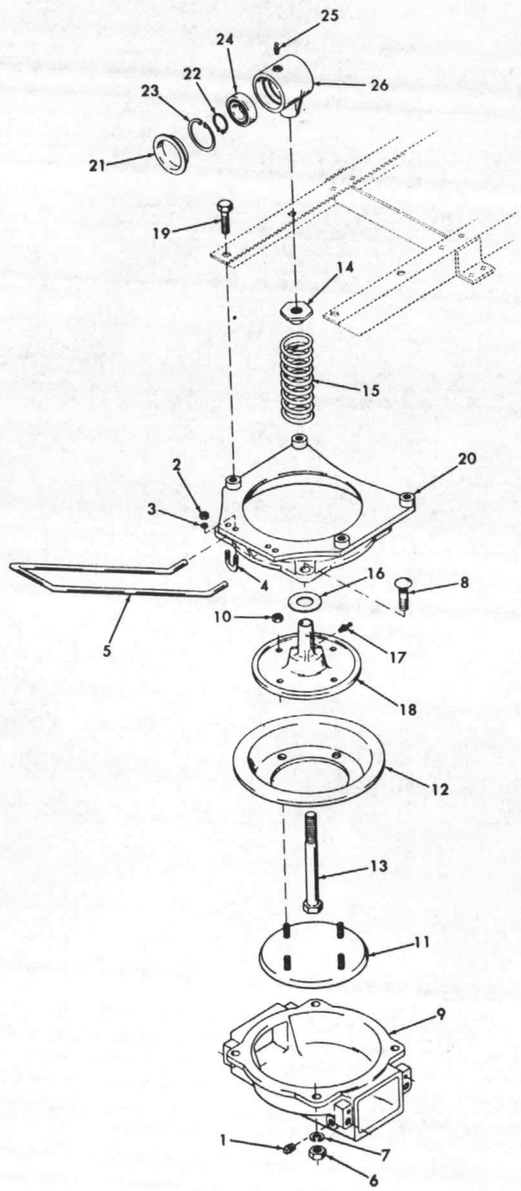
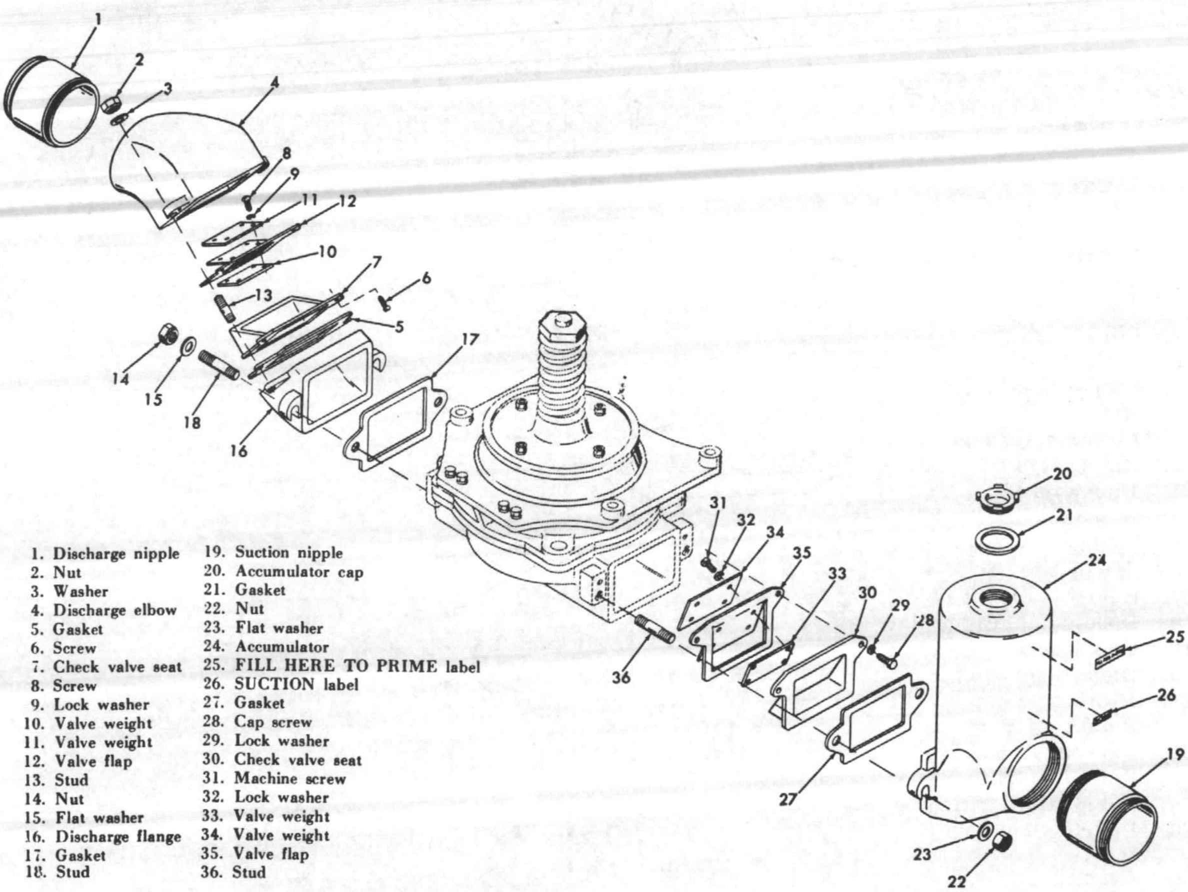


Fig 3-8. Diaphragm and plunger assembly.

The plunger assembly is powered by the crankshaft of the pump gearcase. The plunger assembly has an up and down reciprocating motion. On the upward stroke the plunger rod pulls the upper diaphragm plate and the diaphragm up. On the downward stroke the heavy plunger spring pushes the diaphragm plate downward (this is one of the major differences between the two pumps). This spring loading of the downward stroke minimizes damage to the pump. Figure 3-9 shows the suction and discharge sides of the pump assembly. An accumulator (the other major difference) is mounted on the suction check valve housing. This accumulator reduces the surging of fluid as the pump diaphragm changes stroke direction. At the end of the intake part of the pump cycle, a column of fluid in the suction line is in movement toward the pump. As the diaphragm reverses its stroke, the column of fluid is suddenly stopped. This would normally result in a surge in the suction line. This surge is minimized because the shock is absorbed by the cushion of air in the accumulator. Figure 3-10 shows the accumulator plus the position of the valves during intake and discharge.



1. Discharge nipple
2. Nut
3. Washer
4. Discharge elbow
5. Gasket
6. Screw
7. Check valve seat
8. Screw
9. Lock washer
10. Valve weight
11. Valve weight
12. Valve flap
13. Stud
14. Nut
15. Flat washer
16. Discharge flange
17. Gasket
18. Stud
19. Suction nipple
20. Accumulator cap
21. Gasket
22. Nut
23. Flat washer
24. Accumulator
25. FILL HERE TO PRIME label
26. SUCTION label
27. Gasket
28. Cap screw
29. Lock washer
30. Check valve seat
31. Machine screw
32. Lock washer
33. Valve weight
34. Valve weight
35. Valve flap
36. Stud

Fig 3-9. Pump assembly (suction and discharge sides).

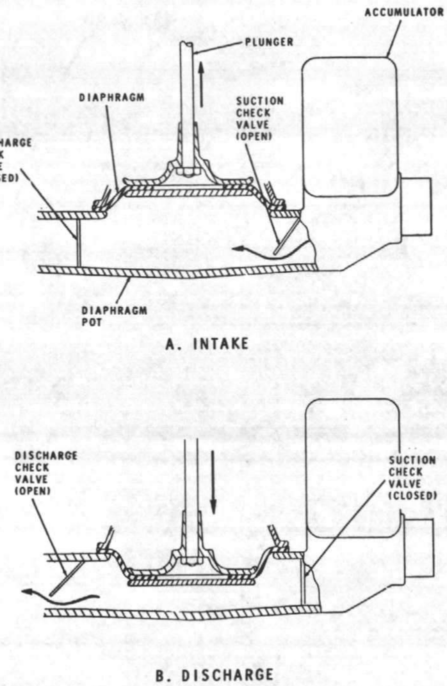
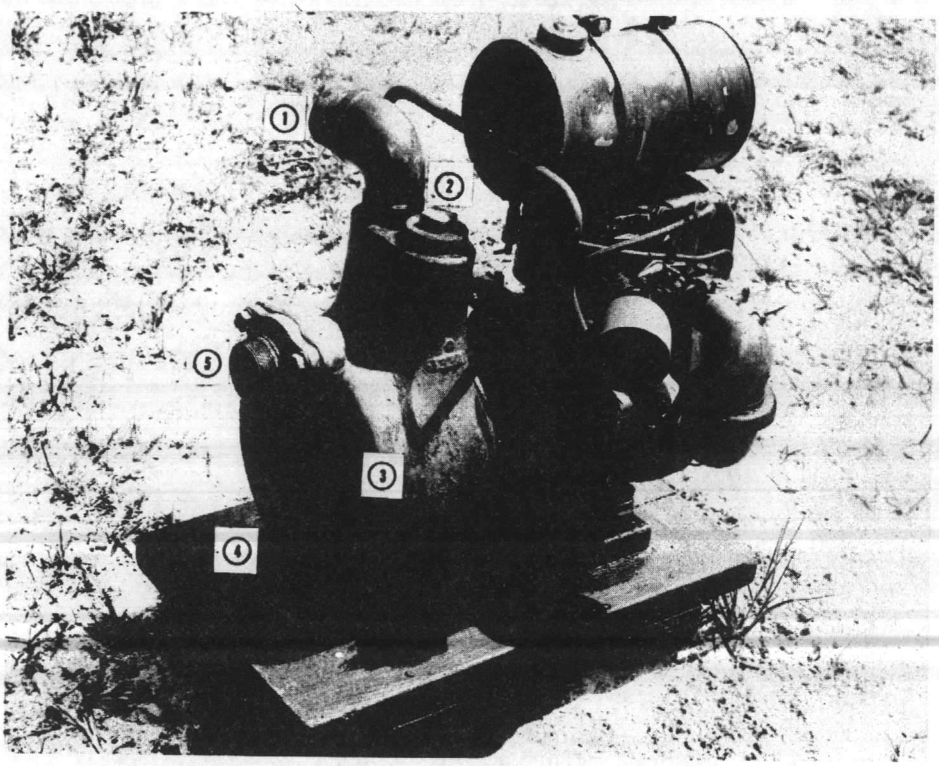


Fig 3-10. Pump valve positions.

c. Maintenance and troubleshooting. Refer to paragraph 3-2 for information and discussion. Although the pumps are not exactly alike, the maintenance and troubleshooting procedures are the same.

3-4. PUMP, CENTRIFUGAL, GASOLINE-ENGINE-DRIVEN, 55-GPM

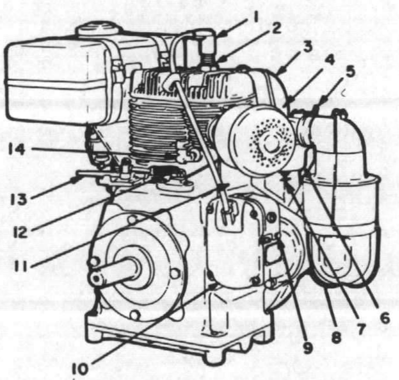
a. General. The 55-gpm pump is one of the oldest items of engineer equipment used by the water supply man. The pump can be used as a raw-water pump, distribution pump, or wherever there is a need to pump water that does not have a high percentage of trash or sand. These pumps have proved themselves in many wars and lands. With new equipment now being used in the Marine Corps and with more emphasis being placed on electrical pumps, the 55-gpm pump is probably not used as much anymore. But it is still in the system, and a water supply man should acquaint himself with this pump. This unit, which is portable and base-mounted, can pump 55 gallons per minute of water with a maximum suction lift of 15 feet. The pump is powered by a one-cylinder, four-cycle, air-cooled, gasoline-operated Wisconsin engine. The engine is directly coupled to a centrifugal pump. Figure 3-11 shows the 55-gpm pump.



1. Pump discharge
2. Priming plug
3. Pump body
4. Drain plug
5. Pump suction

Fig 3-11. 55-gpm pump.

b. Engine (fig 3-12). The engine is started by winding a starting rope clockwise around the crankshaft starting sheave and pulling hard on the rope thereby turning over the engine. The magneto (10, fig 3-12) supplies electricity to the spark plug. The gasoline is gravity fed from the gasoline tank to the carburetor (6, fig 3-12). The carburetor has a choke (5, fig 3-12) which should be closed when initially starting the engine in cold weather. The engine has a governor (13, fig 3-12) which will compensate the speed of the engine under differing loads.



1. Ignition cable
2. Spark plug
3. Flywheel shroud
4. Muffler
5. Choke lever
6. Carburetor
7. Needle valve
8. Oil bath air cleaner
9. Magneto stop switch
10. Magneto breaker cover
11. Valve tappet inspection plate
12. Governor spring
13. Governor control
14. Breather

Fig 3-12. Pump engine.

c. Water pump. The water pump is directly coupled to the engine and the impeller (fig 3-13) turns at the same rate as the engine.

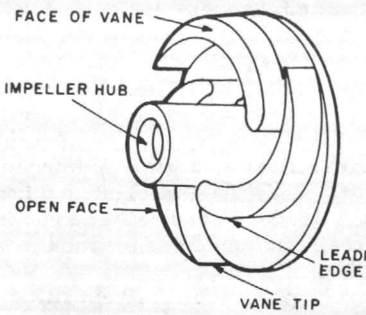


Fig 3-13. Pump impeller.

This impeller, which is located inside the pump body (fig 3-12), creates the difference in pressure to allow water to enter the suction side of the pump and forces it out of the discharge port.

(1) Pump priming. The pump must be primed prior to operating the engine. Operating the engine without having water in the pump body can damage the pump. To prime the pump, the drain plug (fig 3-11) must be inserted into the drain plug opening and tightened with a wrench. Then, clean water is poured into the priming plug (fig 3-11) port until filled. The priming plug is then inserted into the priming plug opening and tightened. Ideally, the suction hose should also be filled with water after it is connected to the pump to help in the priming process.

(2) Hoses. There are two types of hoses (rigid and collapsible) used with the pumping unit. Both types are two inches in diameter. The rigid, rubber-lined type must be used on the suction side and the collapsible canvas hose is used on the discharge side. The rigid hose can also be used on the discharge side if needed.

(a) Rigid. The suction side of the water pump must use the rigid type hose so the suction force does not collapse the hose and block water flow. These 10-foot sections of 2-inch hose can be coupled together for a longer suction lift but it must be remembered that a washer or gasket must be used to insure a tight fit at the coupling. There can be no air leaks on the suction side of the pump. The pump will lose or not attain a prime if a leak develops. A strainer with foot valve should be used on the suction hose.

(b) Collapsible. These 2-inch canvas hoses come in 25-foot lengths. Tight fit is not critical on the discharge side, but the hoses should be as free of leaks as possible at the fittings to prevent water from spraying over equipment or muddying up the area.

d. Installation. The 55-gpm pump should be located on a level area. The maximum height which the pump should be placed above the water source is 15 feet. Any height above this will cause the pump to decrease in efficiency and probably not pump. Connect the suction and discharge hoses to their proper fittings. Remember to use a strainer equipped with a foot valve on the end of the suction hose. This foot valve on the strainer allows water to travel in just one direction and that is into the pump, not out of it. On shutdown, the foot valve will close and prevent the hose from emptying thereby losing its prime on start-up. If the water source is shallow, the suction end of the hose should be tied to a floating device in such a way that it does not suck up mud or sand, but just hangs below the water surface. The pump should be primed as discussed earlier.

e. Operation. Start the engine and bring up to speed using the throttle control after a short warmup. The pump should start to pump water in a few seconds. If the unit fails to pump water after a reasonable time, check for air leaks or restriction on the suction side. All that is needed when shutting down the unit for short periods is to throttle down the engine for a short period (30 seconds) to cool the engine somewhat and then stop the engine using the magneto stop button (fig 3-12). In freezing weather and during prolonged shutdowns, insure that all parts of the system are drained completely. This includes pulling the suction hose from the water source and draining all hoses. Also remove the drain plug from pump body and allow the pump body to drain. Cover the pumping unit with a suitable cover to protect it from the weather.

f. Maintenance and service. As with all units, a good maintenance program will insure a long and troublefree life for the pumping unit. Keep the unit clean and keep your eyes and ears open for unusual part movement and sounds. Use high grade oil and gas in the unit. Make sure that the fuel and lubricants are clean and free from any contaminants.

(1) Engine service. The engine crankcase should be kept filled with oil during operation. Check the engine oil at every start up and after every 8 hours of continuous operation and add oil if needed. To check the oil, remove the filler plug (fig 3-14) and visually check it by looking into the filler opening. The oil should be up into the threads in the filler opening. The unit must be level to do this. After 50 hours of operation, drain the oil from the crankcase while the unit is hot after operation. To drain the crankcase oil, simply remove the crankcase drain plug (fig 3-14) and allow the oil to drain. Replace the drain plug and refill the crankcase through the filler opening. Replace the filler plug.

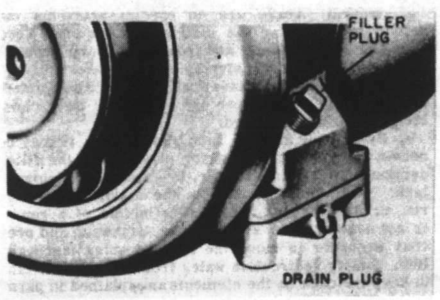


Fig 3-14. Engine oil filler and drain plugs.

(a) Oil bath air cleaner. After every 8 hours of operation, remove the oil bowl from the filter unit, remove the dirty oil, clean the bowl, and replace with clean oil. There is an indicator line on the bowl for correct oil level. Every 50 hours, completely disassemble the filter and wash it in a suitable solvent. This will clean the wire mesh portion of the filter. Reassemble, add oil to bowl, and reinstall on the carburetor opening.

(b) Lubricants. Use a high grade of oil and grease. In temperatures above 40° F, use 30 weight oil in engine and air cleaner. Below 40° F, use 10 weight oil.

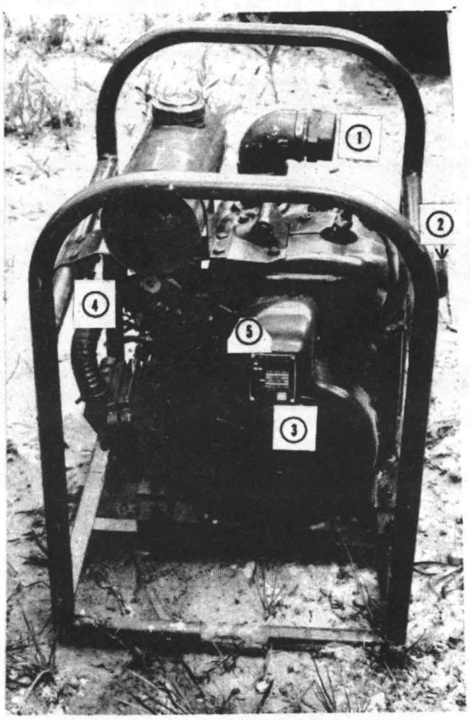
(c) Spark plug. Use a grade of gasoline with an octane rating of at least 90 to prevent excessive plug fouling. The spark plug should be removed and cleaned every 250 hours. Regapping should be accomplished at this time at .030 inch gap setting.

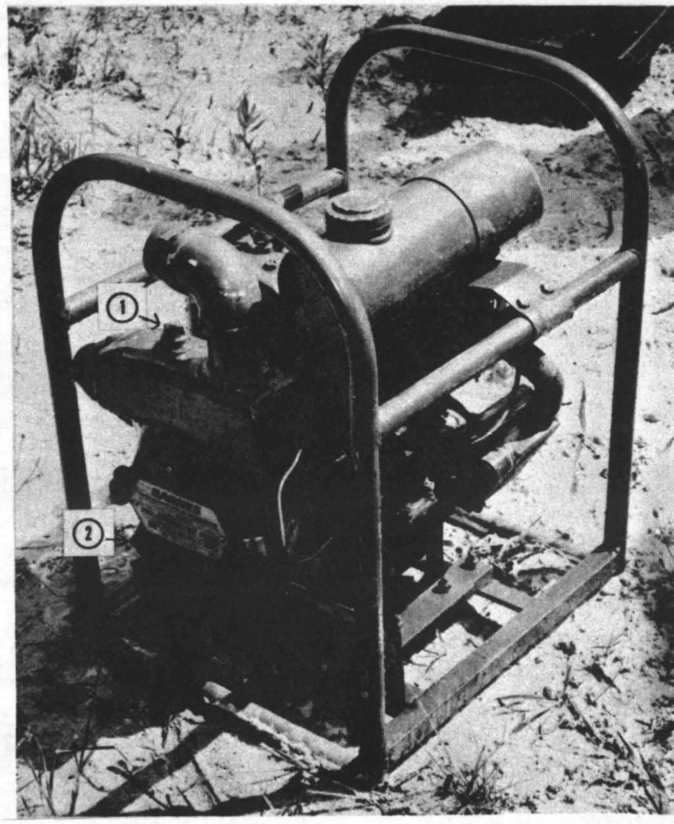
(d) Gasoline settling bowl. If the unit has a settling bowl on the carburetor inlet, this bowl should be inspected daily to insure that water or any other contaminants do not reach the level in the bowl that will impair the operation of the unit. The bowl should be removed using the knurled knob on the wire holder and cleaned as needed or after every 8 hours of operation.

(2) Pump shaft seal. Insure that the grease cup is filled with clean grease (use GAA grease). Screw down the grease cup cover one half turn after every 8 hours of operation. Do not overgrease the pump shaft seal.

3-5. PUMP, CENTRIFUGAL, FRAME-MOUNTED, 65-GPM, 1 1/2 - INCH (BARNES MODEL 17570)

a. General. This pump is being seen and used more and more in the Marine Corps and sometimes replaces the older 55-gpm pumps. It is also used as a distribution pump with the M64 water purification set which accompanies the 1500-gph erdlator. Figure 3-15 shows two views of the pump with the military standard engine (1A08-3). This is a one-cylinder, air-cooled, 1 1/2-horse power gasoline engine. Except for basic requirements which we will discuss later, TM 5-2805-256-14 should be referred to for further echelons of maintenance.





A. Engine view.

1. Pump discharge
2. Pump suction
3. Starting rope sheave
4. Choke
5. Ignition switch

B. Pump view.

1. Filler plug
2. Drain valve

Fig 3-15. Pump, centrifugal, 65-gpm.

b. Installation. As with all pumps, this one should be placed as close to the water supply as possible. Use a strainer on the suction hose to protect the pump from foreign material which could be picked up. The pump should be level and placed no higher than 25 feet above the water source. Some type of flotation device should be used to keep the suction hose under the surface but off the bottom of the water source.

c. Operation. Insure that the military standard gasoline engine has the proper amount of oil and gasoline. Check to see that the oil air filter is clean. Install suction and discharge hoses making sure that the suction hose has a gasket and is tight enough to prevent air from entering the pump. Prime the pump as follows: shut the drain valve on the bottom of the pump body, remove the filler plug on top of pump, pour clean water into the pump until filled, and replace the filler plug. Figure 3-15B shows the priming filler plug and the drain valve.

Caution: The pump seal can be damaged if the pump is operated without water in it.

d. Starting the engine. Allow gasoline to flow into the carburetor by opening the fuel valve located in the fuel line directly below the tank. Close the choke (when engine is cold only) (4, fig 3-15A). Then push up the ignition switch to operate engine (5, fig 3-15A). Wind the starting rope (3, fig 3-15A) around the starter flange in a clockwise manner and pull up hard to start the engine. After the engine has started and warmed up, the choke should be opened.

e. Stopping. To shut down the pump for a short period, shut off the engine by pushing down the ignition switch. For longer periods the engine should be shut off and the fuel valve turned off. If there is danger of freezing, then all hoses should be disconnected, pulled from the source, and drained. The pump should be drained using the pump drain valve (2, fig 3-15B). The gasoline tank should be kept filled to prevent condensation from forming in the tank. The unit should be covered to protect it from the weather.

f. Maintenance and troubleshooting. The maintenance and troubleshooting of this pump is similiar to the pumps discussed previously. For maintenance and lubrication of the engine refer to the proper TM.

3-6. PUMPING ASSEMBLY, DEEPWELL, GASOLINE-ENGINE AND ELECTRIC-MOTOR-DRIVEN (WORTHINGTON)

a. General. This deepwell pump is designed to operate in wells or where limited head room makes it necessary to handle the pump in short sections. Figure 3-16 shows a side view of the deepwell pump ready for operation. The Worthington deepwell pump is capable of pumping water from wells as deep as 250 feet at 60 gpm. The basic components of the deepwell pump are the combination driver (gasoline engine or electric motor), the discharge head, the column pipe, and the pump bowl assembly. Figure 3-17 shows these components.

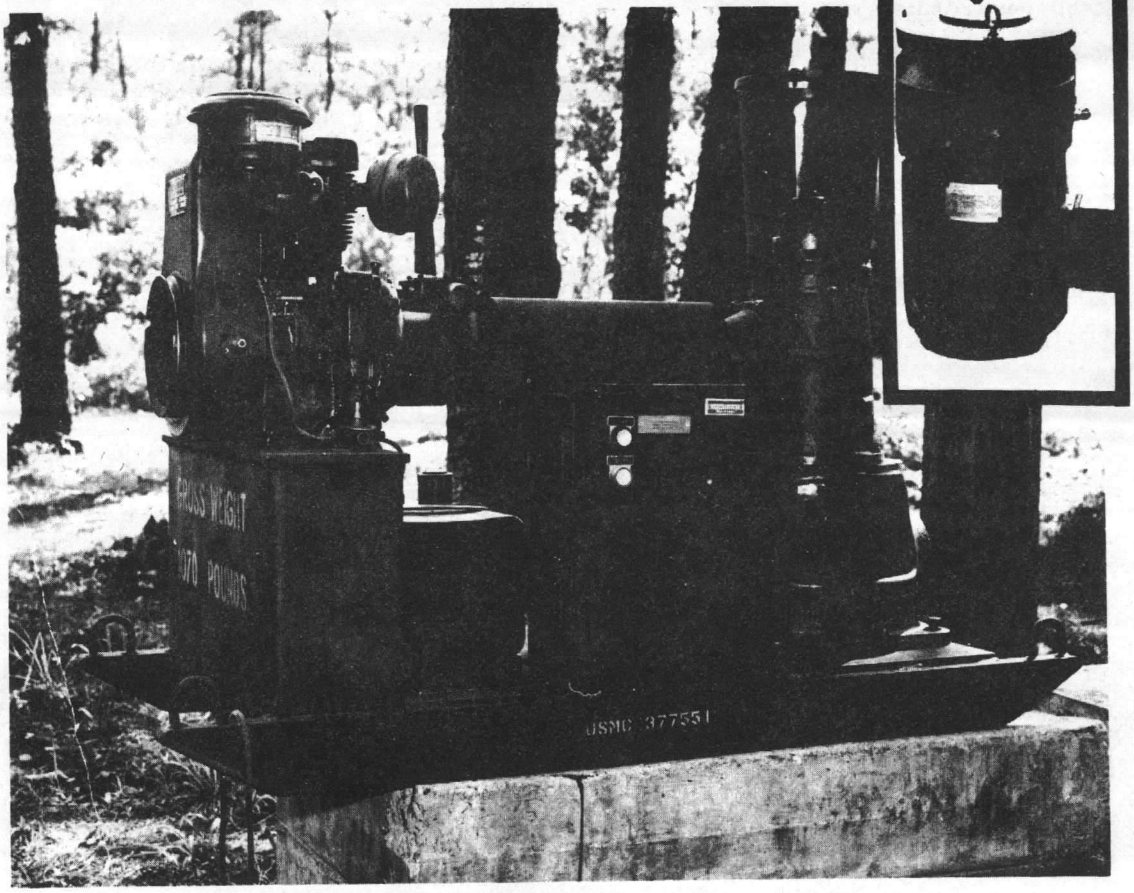


Fig 3-16. Side view of deepwell pump with electric motor (insert).

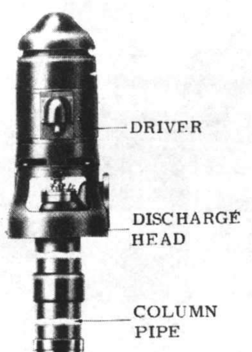


Fig 3-17. Components of the deepwell pump.

b. Power Units.

(1) Gasoline engine. The pump can be operated without any external power source using the gasoline engine. This engine is a Wisconsin model S-12D, four-cycle, one-cylinder, air-cooled engine. Figure 3-18 shows a side view of the engine. Figure 3-19 shows a front view of the engine.

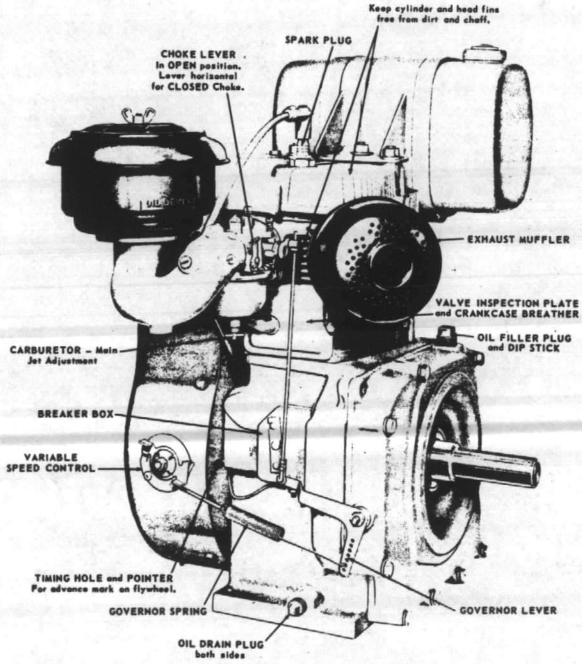


Fig 3-18. Engine, side view.

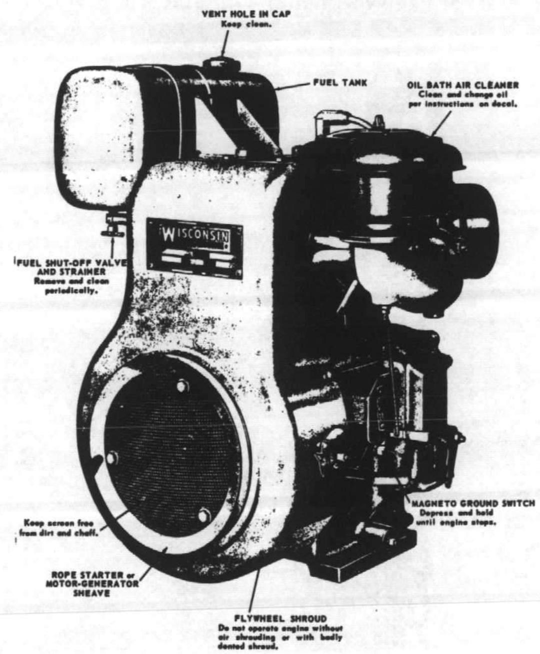


Fig 3-19. Engine, front view.

(a) Starting. The gasoline engine has a compression release that permits fast starting with no dangerous "kickback" when hand starting. Here are the steps to follow when starting the engine.

- Check crankcase oil level and gasoline supply. See figure 3-20 for dipstick location. The type of oil and maintenance will be discussed later on.

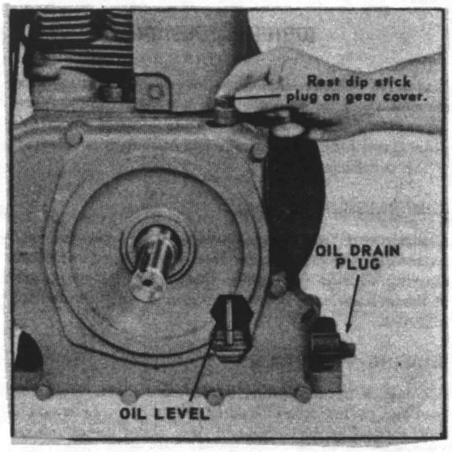


Fig 3-20. Dipstick and drain plug location.

- Disengage the clutch (fig 3-21).

Fig 3-21. Disengaged clutch position.

• Set throttle about 1/2 open and close choke (fig 3-22)

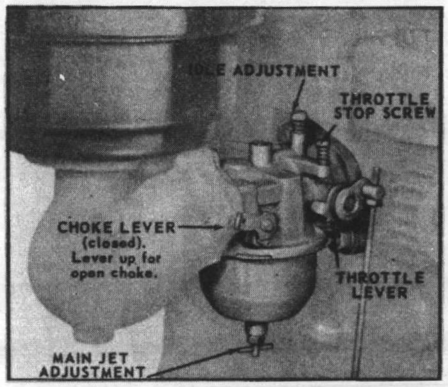


Fig 3-22. Choke positions.

• Wind rope fully on starting sheave in a clockwise manner and pull smartly to turn crankshaft over (fig 3-23).

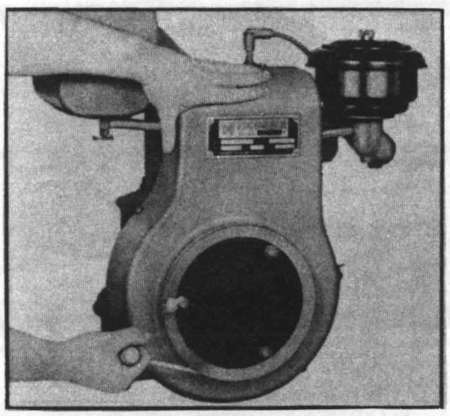


Fig 3-23. Winding of starting sheave.

Note: Above 30° F, open choke halfway if engine does not start after two or three pulls. After engine starts, open choke fully. Before applying load (activating the clutch), allow engine to warm up for a few minutes.

(b) Stopping. To stop the engine, first remove the load from the engine (deactivate the clutch) and reduce engine speed to idle for a few minutes. This will allow the internal temperature of the engine to cool. Then shut the engine off.

(2) Electric motor. These vertical hollow-shaft motors are designed for driving deepwell, turbine-type pumps. These motors are usually equipped with a "self-release" coupling which will automatically release if for some reason the motor's rotation is reversed. This self-release action will prevent the pump shaft joints from unscrewing. Figure 3-24 shows a typical vertical hollow-shaft motor.

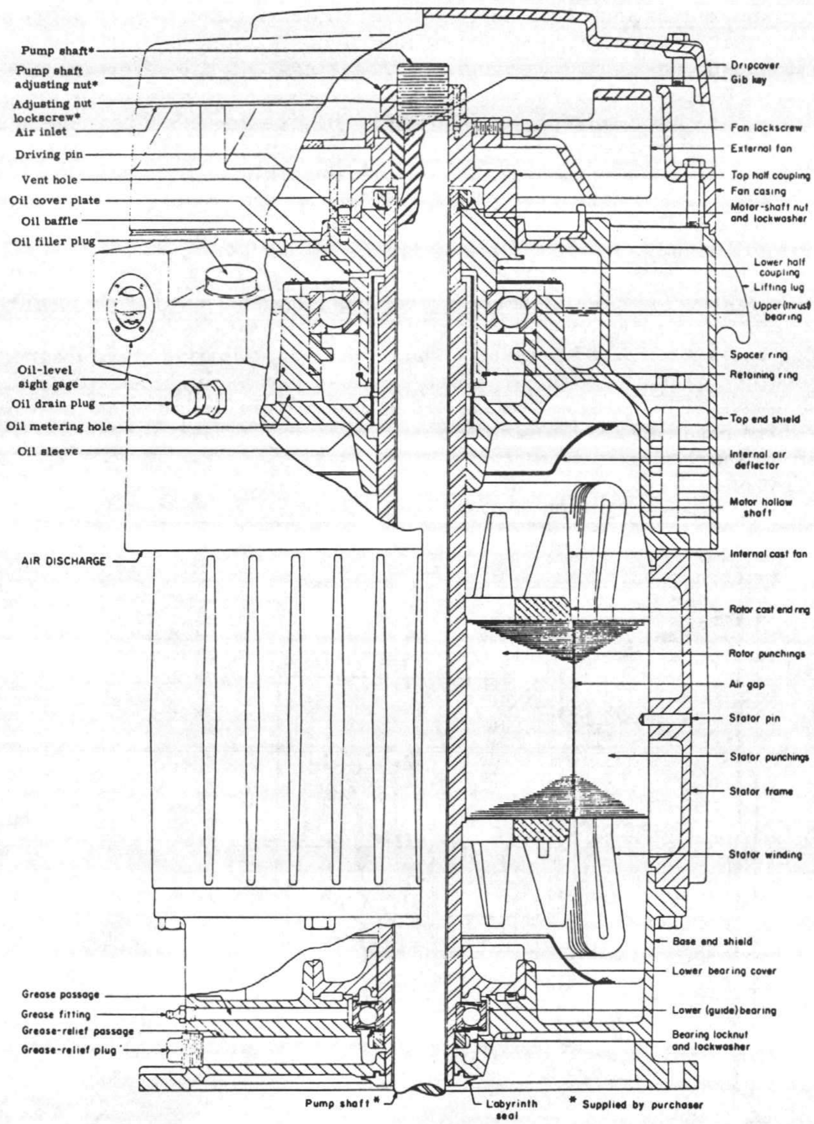
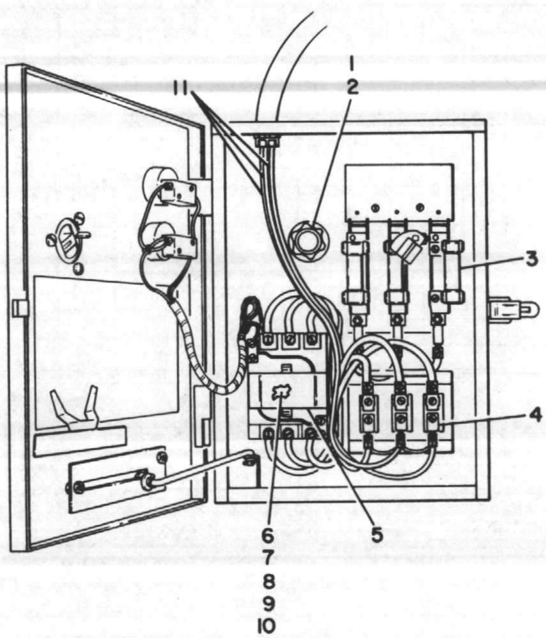


Fig 3-24. Typical vertical hollow-shaft motor.

Note: When in actual operation, the pump discharge valve should be opened slowly before starting the motor and closed slowly after stopping the motor. This prevents surges in the pumping system.

(3) Maintenance and lubrication. The design of the motor will dictate the type of maintenance and lubrication the electric motor has to have. Some are totally free of maintenance and lubrication as they have pregreased bearings. Under severe conditions these bearings should be greased every 3 to 5 years (severe conditions are high temperatures, dirty locations, or motor running continuously). Regreasing these bearings under normal conditions would be every 5 to 7 years. Motors with oil-lubricated bearings are shipped without oil. Before starting, insure that the oil level is 1/8" below the center of the sight gage of the reservoir (fig 3-24). A good grade, oxidation-corrosion-inhibited turbine oil is usually specified for ball bearings. The lubrication nameplate on the motor will supply the specifications for the oil needed.

Caution: Before starting any maintenance procedures, disconnect all power sources. This motor operates on 208 volts a.c. It will operate successfully on 220 volts a.c., plus or minus 10 percent. The outdoor combination starter consists of a magnetic contactor and one or more overload relays combined with a fusable disconnect. The overload relays provide motor protection when there is an overload resulting from a stalled rotor, etc. The fusable disconnect provides built-in short-circuit protection. Figure 3-25 shows the inside of the electrical control box.



KEY	ITEM
1	Nut
2	Packing
3	Fuse
4	Heater
5	Cover
6	Contact
7	Support
8	Holder
9	Coil
10	Relay
11	Wire

Fig 3-25. Electrical control box.

c. Installation.

(1) Equipment. This unit requires special equipment for proper installation because of the weight and length of support columns. For this purpose a lifting device such as a chain hoist, block and tackle, or crane should be used when installing the support column pipe and pump bowl assembly (fig 3-17). The lifting equipment should be of sufficient capacity to lift 1200 pounds.

(2) Location. The unit should be placed where there is ample headroom to allow use of the lifting equipment.

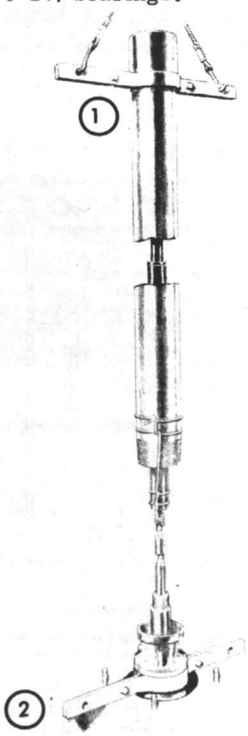
(3) Foundation. The pump foundation may consist of any material which will afford permanent, rigid support. A solid concrete foundation affords the best support. The pumping unit can be bolted down to the concrete. Whatever type of support is used, it should be remembered that the important thing is that the support should allow the least vibration of the pump.

Note: As a field water supply man you probably will not be involved with the actual setting up of the deepwell pump. If the occasion ever arises that you must know the step-by-step installation, refer to the manufacturer's manual (Worthington Corporation). There is no Marine Corps TM for this unit.

(4) Pumping assembly.

(a) Right angle pump drive. When the gasoline engine is the driving force for the pump, then some sort of device must be used to change the power from horizontal to vertical. Two drive gears set up at right angles are used for this purpose. These drive gears are set up in a one-to-one gearing ratio. The clutch (fig 3-21), when engaged, will allow the right angle drive to power the pump.

(b) Support column pipe (fig 3-26). This 3-inch pipe screws into the pump base. The top section that screws into the pump base is 5 feet long. The other sections are 10 feet long. The support column pipe carries the pumped liquids and supports the line shaft (fig 3-27) bearings.



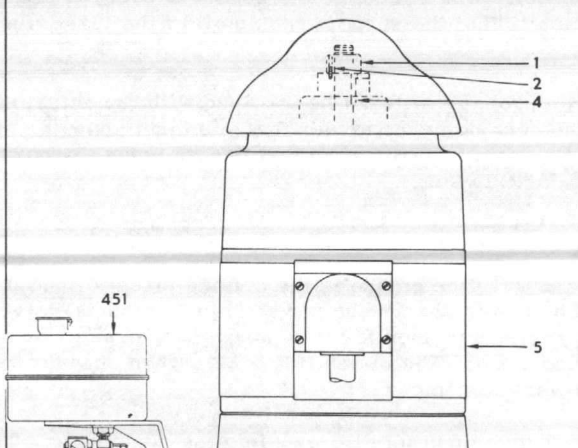
1. Lifting devices

2. Concrete foundation, over the well.

Fig 3-26. Support column pipe.

(c) Line shaft. The line shaft runs through the center of the support column pipe and is made of 1-inch diameter steel. This line shaft comes in 10-foot lengths and transmits power to the pump. The line shaft (23, fig 3-27) connects to the top shaft by a coupling (22, fig 3-27).

(d) Top shaft. This is a 5-foot section of pipe (usually the same size as the line shaft) which extends downward through the motor and base (19, fig 3-27) and, as was mentioned previously, connects to the line shaft. Figure 3-28 shows the installation of the top shaft.



REF. NO.	NAME OF PART
1	TOP SHAFT ADJUSTING NUT
2	ADJUSTING NUT LOCK SCREW
4	DRIVE COUPLING KEY
5	MOTOR
7	SURFACE DISCHARGE HEAD
11E	STUFFING BOX GASKET
15E	PACKING "O" RING
16*	FLANGE GASKET
17E	STUFFING BOX
19	TOP SHAFT
21	TOP COLUMN PIPE
22	LINESHAFT COUPLING
23	LINESHAFT
24	COLUMN PIPE COUPLING
28	COLUMN PIPE
46	SOLENOID OIL VALVE
47	SIGHT FEED OIL VALVE
50	LINESHAFT BEARING
51	SHAFT ENCLOSING TUBE
63	TENSION BEARING
66	SHAFT TUBE STABILIZER
71	SPACER
301	PIPE PLUG
451	OILER TANK W/MTG. BRKT.
452	LUBRICATOR FITTINGS
453	TOP SHAFT ENCLOSING TUBE
457	MOTOR BOLTS AND NUTS
458	STUFFING BOX BOLT
461	TOP COLUMN BOLT

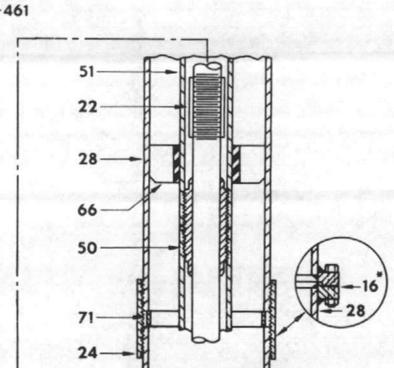


Fig 3-27. Above ground enclosed line shaft pump base.

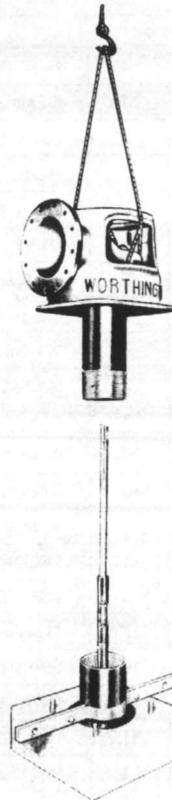
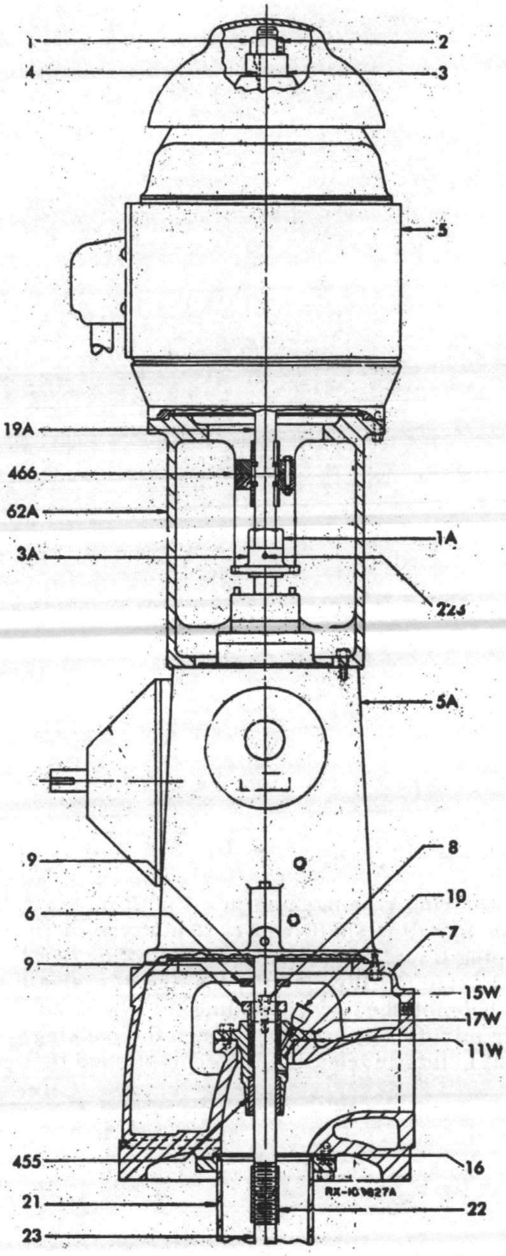


Fig 3-28. Pump head and top shaft installation.

1. Packing. Open line shaft pumps require "O" ring type packing in a "stuffing box" or packing retainer. Figure 3-29 shows an open line shaft motor. This type of line shaft requires a small amount of pumping liquid to lubricate the "stuffing box" bearing. Note that this packing must be adjusted to allow for the leaking of a small amount of water for lubrication. This is accomplished by tightening the gland nut (8, fig 3-29) until 40-60 drops of water per minute are leaking through the packing. On enclosed line shaft motors (451, fig 3-27), this lubrication is accomplished by an oiler.



REF. NO.	NAME OF PART
1	MOTOR ADJUSTING NUT
1A	GEAR ADJUSTING NUT
2	LOCK SCREW
3	MOTOR COUPLING
3A	GEAR COUPLING
4	DRIVE COUPLING KEY
5	MOTOR
5A	RIGHT ANGLE GEAR
6	WATER SLINGER
7	SURFACE DISCHARGE HEAD
8	GLAND STUD AND NUT
9	GLAND
10	GREASE CUP
11W	STUFFING BOX GASKET
15W	PACKING
16	TOP COLUMN PIPE GASKET
17W	STUFFING BOX
19	TOP SHAFT
19A	MOTOR HEAD SHAFT
21	TOP COLUMN PIPE
22	LINESHAFT COUPLING
23	LINESHAFT
62A	MOTOR STAND
223	LOCK SCREW
455	STUFFING BOX BEARING
466	COUPLING COMPLETE

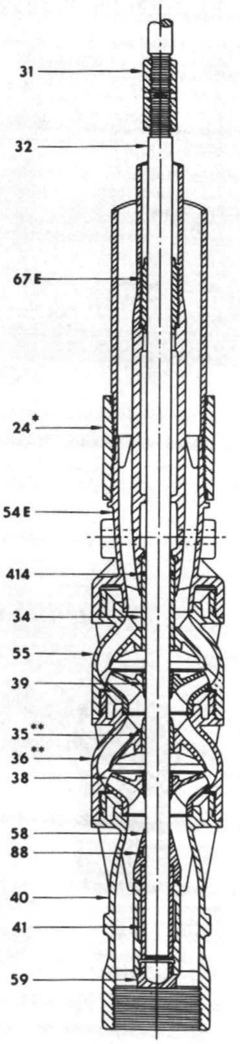
Fig 3-29. Open line shaft pump.

2. Shaft stabilizer. These bronze or hard rubber constructed parts are spaced into the column couplings and are used to keep the shaft alined. Note the beveled part of this stabilizer (66, fig 3-27). This must be installed facing downward into the well.

3. Spacers. Number 71 of figure 3-27 shows a spacer installed in the column pipe. These spacers should be installed at 30-foot intervals. These spacers help to keep the line shaft centered in the column pipe.

d. Pump bowl assembly. The bowl assembly consists primarily of a suction case, one or more pump bowls, and a discharge case (fig 3-30). The pump bowl is that part of the pump which is submerged in the liquid in the well.

(1) Suction case. The suction case serves as the input port to the pump bowls. Figure 3-30 shows a cutaway view of the enclosed bowl assembly, including the suction case. The lower end of the suction case is threaded to mate with the upper end of the column.



REF. NO.	LIST OF PARTS
24	COLUMN PIPE COUPLING
31	PUMP SHAFT COUPLING
32	PUMP SHAFT
34	TOP BOWL BEARING
35	INTERMEDIATE BOWL BEARING
36	INTERMEDIATE BOWL
38	IMPELLER
39	IMPELLER LOCK COLLET
40	SUCTION CASE
41	SUCTION CASE BEARING
54E	DISCHARGE CASE
55	TOP BOWL
58	SUCTION CASE SAND COLLAR
59	SUCTION CASE PLUG
67E	CONNECTOR BEARING
88	SET SCREW
414	TOP BOWL BEARING SEAL RING

Fig 3-30. Enclosed pump bowl assembly.

(2) Pump bowls. The pump bowls house the impeller and are that part of the pump which actually directs or forces the liquid up out of the well. There are two types of pump bowls. Figure 3-30 shows the two types, top and intermediate. Operation of these bowls is identical with the exception that the top bowl discharges fluids into the discharge case and the intermediate bowl discharges fluids into the eye of the impeller of the next stage. Each bowl has a centrifugal-type impeller. Figure 3-31 shows an exploded view of a pump bowl assembly including impeller. The impeller, being spun at high speed, is the part of the pump that creates the difference in pressure needed to extract the fluid from the well.

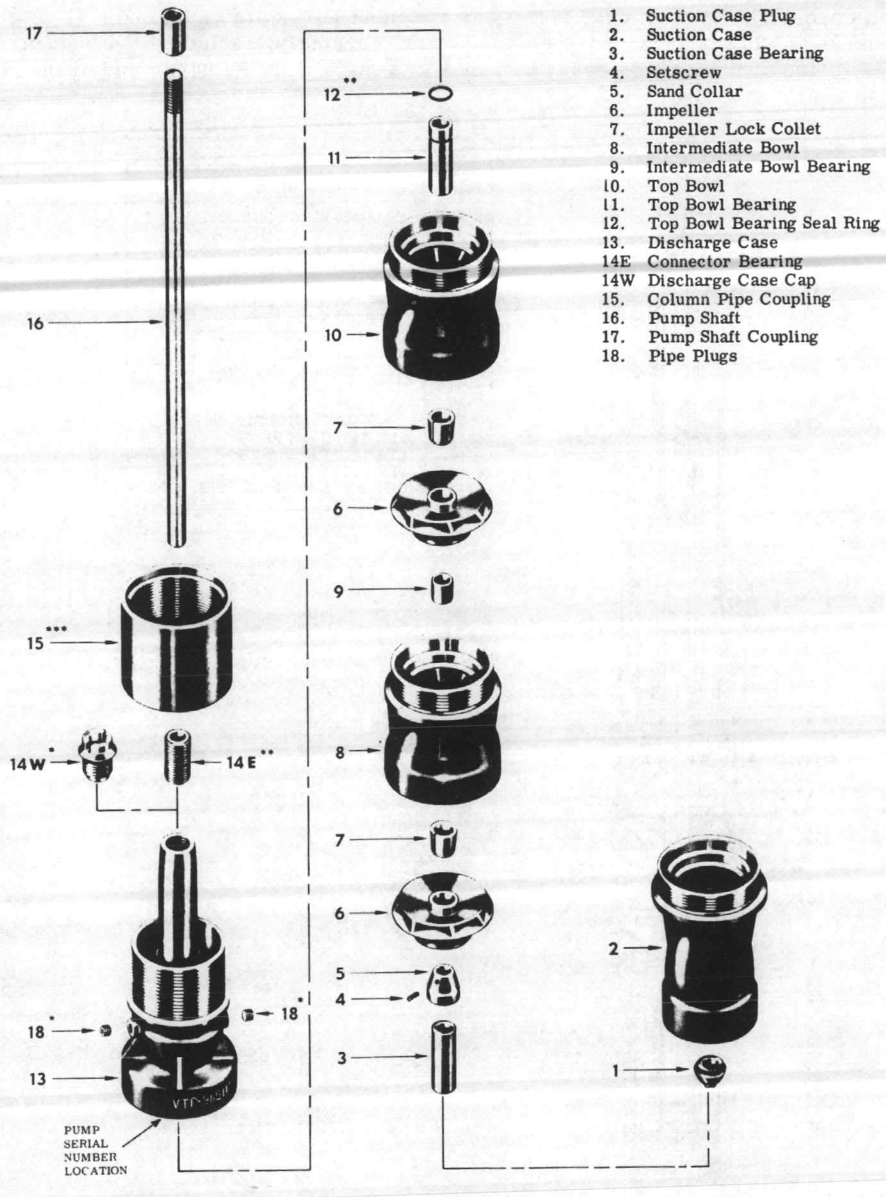


Fig 3-31. Pump bowl assembly--exploded view.

(3) Discharge case. The discharge case receives the fluid from the top bowl and directs it to the column pipe or discharge head. Figure 3-31 shows the discharge case.

Note: With the enclosed type pump, the vent holes in the discharge case are not plugged up. This allows for proper lubrication of the line shaft. Figure 3-31 also shows the pipe plugs.

Proper installation of the deepwell pump requires that a strainer be used on the suction end to insure that small rocks or sand are not directed up into the bowls and impellers to cause possible damage.

e. Maintenance and servicing. Proper installation of the deepwell pump will insure that it will pump water at its designed depth and rate. Proper maintenance and service will insure that it pumps this water for a long period of time.

(1) Preventive maintenance. An important part of any maintenance program is being able to detect a problem area before it actually becomes a problem and causes unit shutdown. A visual inspection prior to operation and during operation is one way of detecting problems early. Look for loose parts, excessive vibration, leaks, and improper alinement. Check to see that the unit has not been tampered with. When the unit is operating, listen for unusual noises. When the unit is shut down for a length of time, cover it up with appropriate covering to keep the unit protected from the dust and weather.

(2) Servicing. Regular periodic service to the deepwell pump will also help to give it long life. Use a good grade of gasoline and oil. Check the lubrication plate on the unit; it will indicate the proper lubricant to use. The manufacturer's manual also gives proper lubricants for the unit. Insure that your gasoline and oil containers are clean before using.

(a) Engine. The spark plug should be removed from the engine and cleaned and reset every 250 hours of operation. The correct gap setting is .030 inch. Check the oil every 8 hours and prior to operation. Add oil if necessary. Change the engine oil every 50 hours of operation. The crankcase capacity is 2 quarts. Once each week of normal operation, the oil bath air cleaner on the carburetor should be serviced. The filtering element should be washed in a solvent. The oil in the air cleaner bowl should be removed and the bowl cleaned. After cleaning this bowl, add the same type of oil as is used in the engine up to the indicator line inside the bowl. Figure 3-32 shows you what the oil bath air cleaner looks like.

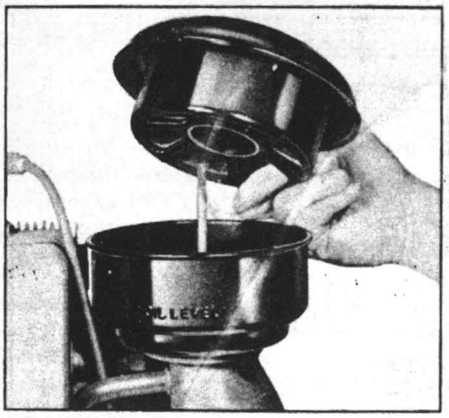


Fig 3-32. Oil bath air cleaner.

(b) Clutch take off (fig 3-33). The clutch is of the wet type; that is, it runs in oil. It uses the same type of oil that is used in the engine crankcase. Fill to the height of the oil level plug, approximately 1 pint. This oil should be changed every 250 hours of operation.

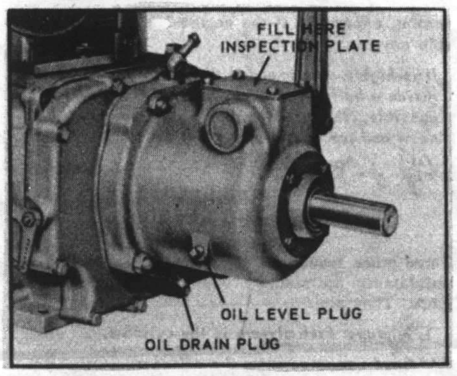


Fig 3-33. Clutch takeoff.

(c) Line shaft oiler. The enclosed line shaft pump has an oiler (451, fig 3-27). Fill the oiler tank with a good grade light turbine oil. This oil has a "drop" setting and it should be set to allow four to six drops per minute into the line shaft tube. This is accomplished by watching the "drop" sight glass and timing the drops of oil. The amount can be increased or decreased by turning a knurled knob on this sight mechanism (47, fig 3-27).

(d) Right angle pump drive. Check the lubrication plate on the unit for proper weight turbine oil to use at varying temperatures. A high grade turbine oil is used. There is a tendency for condensation to form when the temperature fluctuates. Normally the oil is changed every 1000 hours. Fill to within one half inch of the filler oil plug top. If the drive has a sight glass, then fill to level indicated on the glass.

(e) Grease fittings. While some units have pregreased fittings and require no maintenance, some units have grease cups and some have grease fittings. Keep the grease cups filled with clean GAA type grease and turn down the cup cap (approx. one half turn) after every 8 hours of operation. When using a grease gun to grease the fittings, make sure that the fitting is wiped clean. One or two pumps of grease every 8 hours will be sufficient. Do not overgrease.

3-7. GENERAL SAFETY

a. General. As a water supply man, your work involves working with chemicals, fuel, and machinery. If the proper attitude, practices, and discipline are not carried out, there is a possibility that the personal health and welfare of the water supply man or Marines of organizations near him can be affected and/or jeopardized. Safe working practices should be part of every job you do, and horseplay around any work area cannot be justified or tolerated.

b. Chemicals. The chemicals used by water supply men are dangerous. Take care to keep chemical containers covered. Keep chemicals separated and dry. Mixed chemicals can ignite by themselves. Avoid handling chemicals with bare hands and be careful not to let chemicals splash into your eyes or someone else's eyes. Use safety goggles and gloves if provided.

Note: If chemicals do get on the skin or in the eyes, flush areas with plenty of clean water and mild soap and seek medical attention.

Avoid the unnecessary breathing of dust made by chemicals. Dispose of any chemicals in a safe manner. Do not throw chemicals into any water source. If there is a need to dispose of chemicals, bury them deep in strong containers away from water source.

c. Fuel. Keep all fuel in approved, covered containers in open areas and a safe distance (50 feet) away from operating machinery or living areas. "No Smoking" signs should be posted. When refueling machinery, the machine or unit should be shut down and fuel added from proper dispensing cans. Be careful to avoid spilling gasoline on hot carburetors, manifolds, or exhausts. It may ignite. If fuel should get on skin or in eyes, your first action should be to wash the affected area with mild soap and water. Flush with water. Seek medical attention when the eyes are affected or if fuel is swallowed.

d. Machinery. When you are operating machinery, you must take care so that accidents will not happen. Insure that all electrical-type equipment is properly grounded before starting. Your clothing should not be loose enough to be blown by the wind into a drive shaft, starting sheave, or chain, dragging you into the machinery. In this respect, be careful of scarfs or neckties. Do not wear them when working around equipment. Keep the work area uncluttered and as clean as possible so that a person will not slip or fall into an operating unit. Do not operate equipment in enclosed areas where there is a danger that exhaust fumes could be trapped. If a unit with an exhaust must be operated in an enclosed area, insure that the exhaust is piped to the outside and that no leaks occur in the exhaust pipe. Keep all machinery clear. Place items such as oily rags in a covered can. Mark these cans. If a safety guard is removed from a piece of equipment for servicing, be sure to replace it before operating again. Water supply equipment and material is heavy and bulky. Care must be taken when lifting and moving it. The general rule is to seek help when in doubt about lifting or moving a heavy object.

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CHAPTER 4

GENERAL INSTRUCTIONS

GENERAL DESCRIPTION AND SPECIFICATION DATA

PURPOSE OF EQUIPMENT

a. The purpose of the equipment is to provide proper bathing facilities for personnel under field conditions.

b. To provide for maximum useability, the equipment is completely self-contained, portable and will seldom require major repair. The only equipment required for use of the bath unit, not supplied with the unit, is a means of transporting the unit to the desired location.

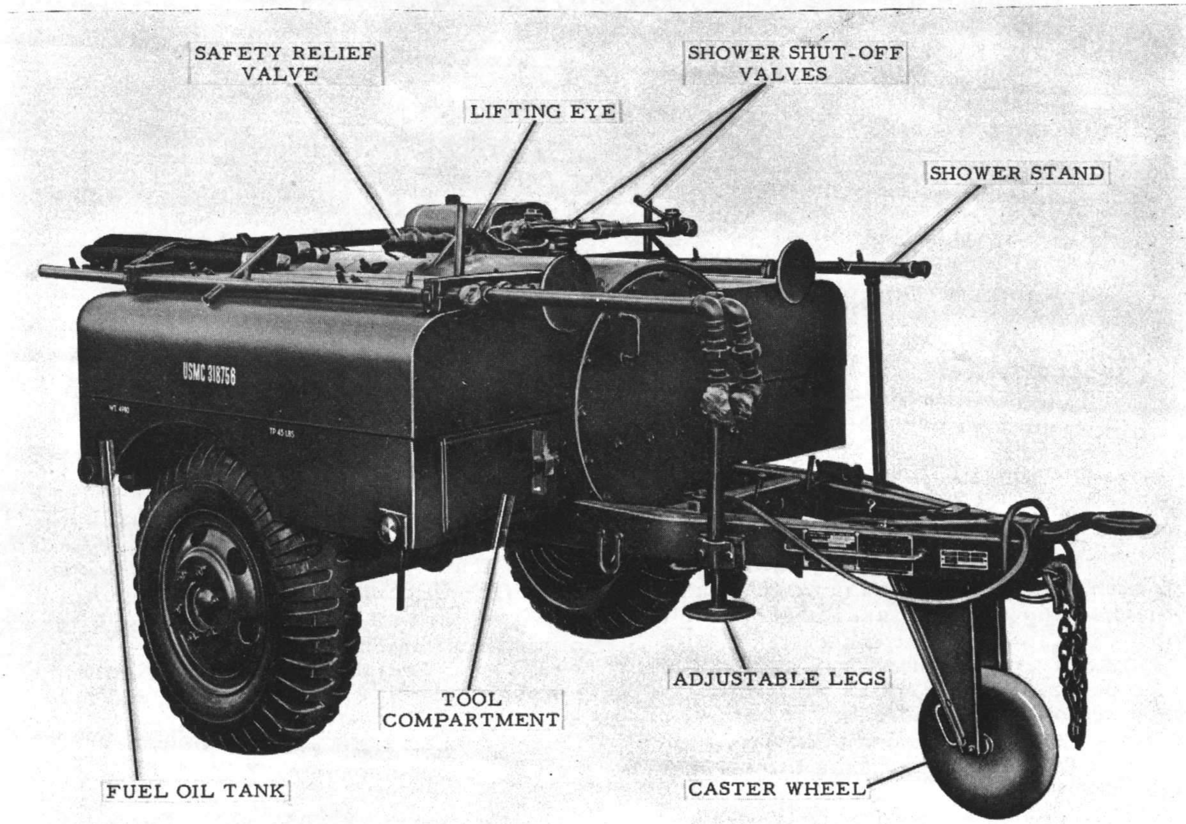


Figure 4-1. Bath unit, 3/4 right side view.

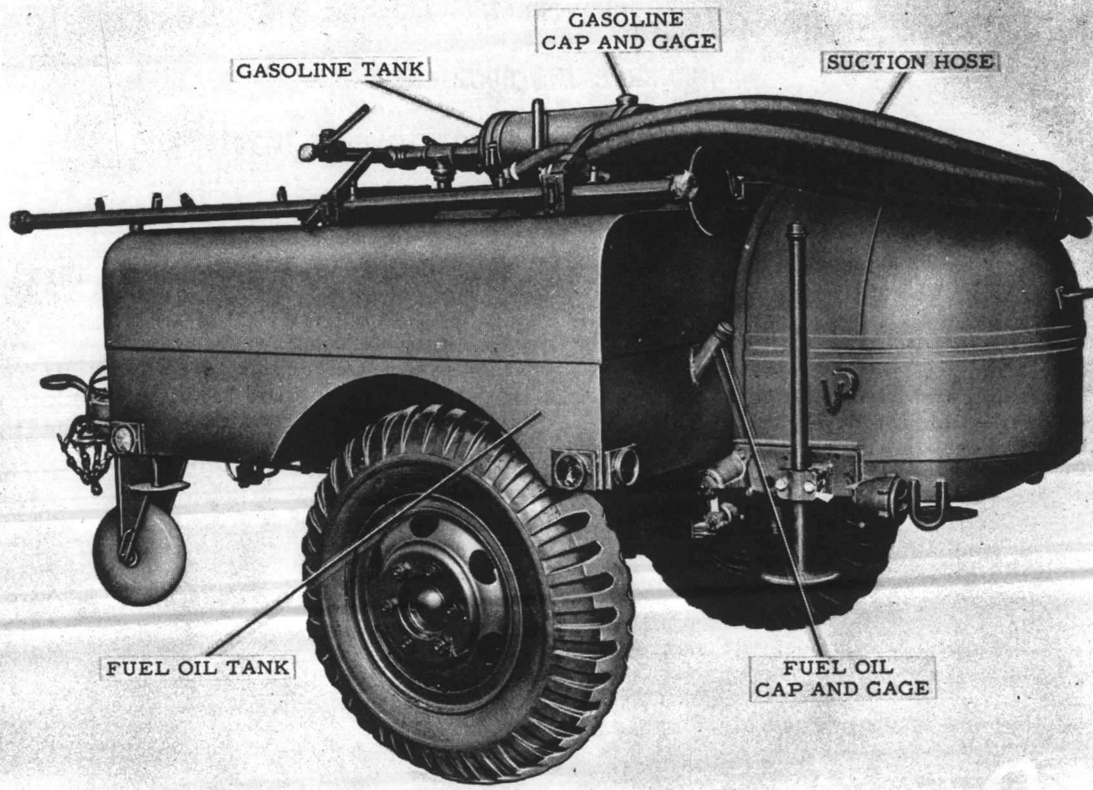


Figure 4-2. Bath unit, 3/4 left side view.

1-3. DESCRIPTION.

a. General.

(1) The Bath Unit, Trailer Mounted is a self-contained, oil fired, water heating plant, designed to deliver approximately 1-1/2 gallons per minute of warm water to each of 24 showerhead nozzles on an attached shower stand assembly. In full operation, properly attended, the unit is capable of processing approximately 400 men per hour. The entire equipment is mounted on a two-wheel trailer with two adjustable legs which can be lowered when the unit is detached from the towing vehicle.

(2) A suction pump draws water from the source of supply through a suction hose and delivers it to the boiler, where it absorbs heat from the fuel oil flame within the tubes. Water, raised to the desired bathing temperature, is forced by the incoming water pressure through the outlets leading into the discharge piping to the shower stand and into the showerheads.

(3) The unit is complete with all controls necessary to operate the engine and to regulate water temperature and fuel oil pressure.

b. Engine. (See figure 4-3) The bath unit is driven by a Wisconsin single cylinder, four cycle, gasoline engine, Model MBKND, which develops 6.4 horsepower at a governed maximum speed of 3600 revolutions per minute. The engine is equipped with a fuel strainer, lubricating oil pump, magneto, air filter, carburetor, and rope starter.

c. Other Components.

(1) Water pump. The water pump is a centrifugal-type, self-priming pump, and is direct-coupled to the engine. The water supply to the boiler is controlled by manual operation of the pump discharge valve.

(2) Boiler. The boiler is of fire-tube construction, and has four complete passes through which the combustion gases are

forced by the blower. The water is heated as it circulates around these hot tubes, and is maintained at constant temperature by regulation of the fuel flow to the oil burner nozzles.

(3) Burner. The burner is of the pressure-atomizing type, using three nozzles with a combined burning rate of 9 gallons per hour. The fuel oil is electrically ignited by a continuous spark from the magneto (figure 4-3) on the engine.

(4) Fuel oil pump and blower. The fuel oil pump and the blower are driven by a belt and pulley arrangement off the engine. The pump draws fuel oil from two fuel oil tanks, through a strainer and a pressure regulator, to the burner. The blower furnishes air for combustion and forces the hot gases through the boiler tubes. A manually operated damper at the blower inlet permits the volume of air to be adjusted in correct proportion to the fuel oil burned.

(5) Fuel tanks Fuel oil for the burner is stored in two identical tanks (figures 4-1, 4-2), one in each fender of the trailer. Gasoline for the engine is stored in a tank (figure 4-2) mounted on the boiler. In this manual, the word "gasoline" will be used consistently to designate the fuel consumed by the engine. "Fuel oil" will be used, where applicable, to specify the fuel which feeds the burner.

1-4. TABULATED DATA.

a. Bath Unit, General.

Manufacturer......... York-Shipley, Inc.
Model........................EC-8B-64
Type........... Self-contained, oil-fired

b. Dimensions and Weight.

Overall length................. 164-1/2"
Overall width.................. 84-1/4"
Overall height......................67"
Shipping cubage.......... 538 cubic feet

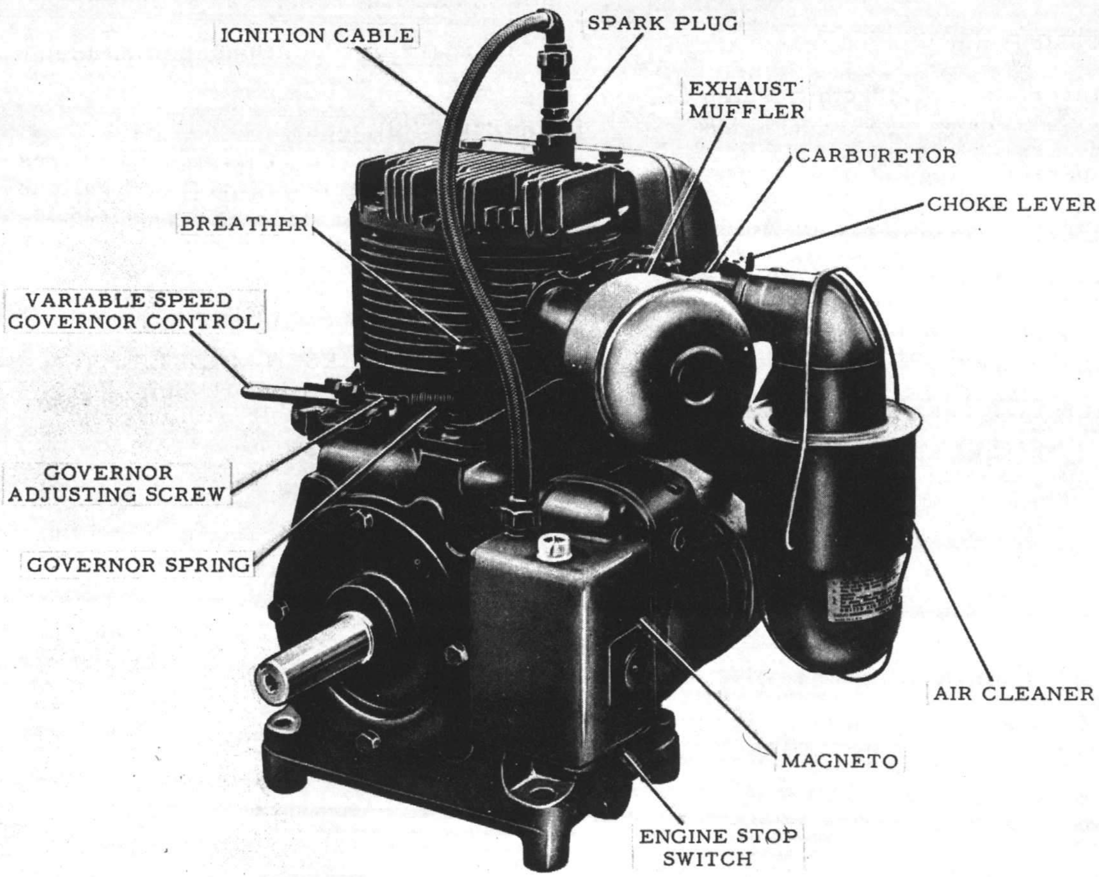


Figure 4-3. Gasoline engine, 3/4 view.

Shipping weight................4980 lbs.

c. Engine.

Manufacturer.....Wisconsin Motor Corp.
Model.......................... MBKND
Type.......................... 4-cycle
Number of cylinders...................1
Bore.......................... 2-7/8"
Stroke.......................... 2-3/4"
Piston displacement.....17.8 cubic inches

d. Carburetor.

Manufacturer...........Marvel-Schebler
Model...........................VH-53
Type........................Horizontal

e. Magneto.

Manufacturer.....Fairbanks-Morse & Co.
Type.....................FM-XE2B7C-1

f. Water Pump.

Manufacturer.......... Barnes Mfg. Co.
Model............................4 MU

g. Fuel Oil Pump.

Manufacturer.......... Tuthill Pump Co.
Model.......................... OLK-C

h. Temperature Regulator.

Manufacturer..........Lawler Automatic Controls, Inc.
Model..................... 1/2" Type ST

i. Pressure Regulator.

Manufacturer......... Monarch Mfg. Co.
Model.............................. G49BR

j. Gasoline Strainer.

Manufacturer.........Tillotson Mfg. Co.
Model....................... OW-418-T

k. Air Blower.

Manufacturer.........Bayley Blower Co.
Model......................... B-2794-6

l. Fuel Oil Burner Nozzle.

Manufacturer......Monarch Mfg. Works, Inc.
Model.............................. F-80
Nozzle types............ 30^{O}HV-2.0GPH, 30^{O}HV-5.0GPH

m. Capacities.

Gasoline tank...................6 gallons
Fender fuel oil tanks................ 25 gallons (each)

n. Approximate Fuel Consumption for an 8-Hour Day.

Burner fuel (oil, gasoline or kerosene)................ 72 gallons
Engine fuel - gasoline.......... 4 gallons
Grease........................... 1/4 lb.
Lubricating oil................... 1/2 pint

1-5. DIFFERENCES IN MODELS. This manual covers only the York-Shipley, Model EC-8B-64 portable bath units.

OPERATING INSTRUCTIONS

THEORY OF OPERATION

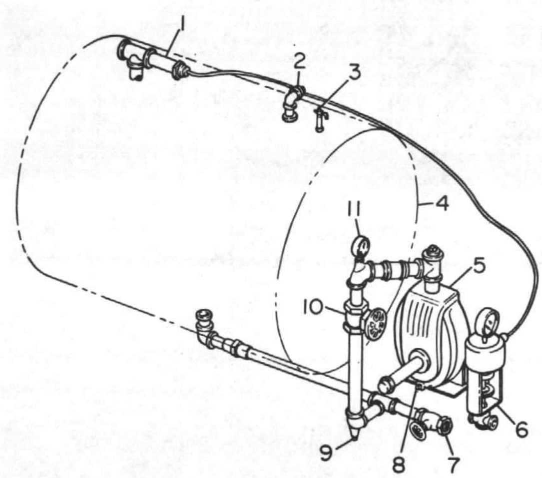
2-1. GENERAL.

a. This section contains a description of the basic theory of operation of the various major systems which compose the complete equipment.

b. Each system is described separately and a detailed description of the operation of each major component of the system is included.

2-2. WATER SYSTEM.

a. Description. (See figure 4-4)



1 Thermostatic bulb
2 Boiler relief valve
3 Boiler petcock
4 Boiler
5 Water pump
6 Water temperature regulator
7 Boiler drain valve
8 Drain plug
9 Drain plug
10 Water pump discharge valve
11 Pressure gage

Figure 4-4 Water system.

(1) The water pump (5) takes suction through the suction hose, and discharges through the water pump discharge valve (10) into the boiler (4). Water discharge pressure may be read on gage (11).

NOTE

DURING THE TIME THE BOILER IS BEING FILLED, THE BOILER PETCOCK (3) MUST REMAIN IN THE OPEN POSITION IN ORDER TO PREVENT THE BOILER FROM BECOMING AIRBOUND. CLOSE THE BOILER PETCOCK AS SOON AS WATER IS SEEN DISCHARGING THROUGH THE PETCOCK. THIS DISCHARGE WILL INDICATE THAT THE BOILER IS FULL.

(2) The boiler (4) is of fire-tube construction and provides four complete passes of hot gas travel. The first pass is through the combustion chamber (the large center tube). During the second, third, and fourth passes, gases are guided by baffle plates along a pre-determined path to provide maximum heat transfer to the boiler water.

(3) Both the front head and the rear head of the boiler are lined with heat resisting refractory.

(4) Water temperature is maintained at the desired temperature by the automatic water temperature regulator (6). This regulator is located in the burner fuel supply lines to the two small side burners. The valve is of the thermostatic (temperature operated) type. A thermostatic bulb (1) located in the water line between the output of the boiler and the input to the shower stand measures water discharge temperature. The bulb then transmits a pressure equivalent to the temperature of the discharge water back to the temperature regulator (6). The valve opens and closes the fuel supply to the side burners in accordance with the setting of the valve. The valve is normally set to regulate water discharge temperature at 102°F.,

(38.9°C.). Therefore, if water temperature should exceed 102°F., (38.9°C.) the temperature regulating valve will reduce the fuel supply to the side burners until discharge water temperature has been reduced to normal.

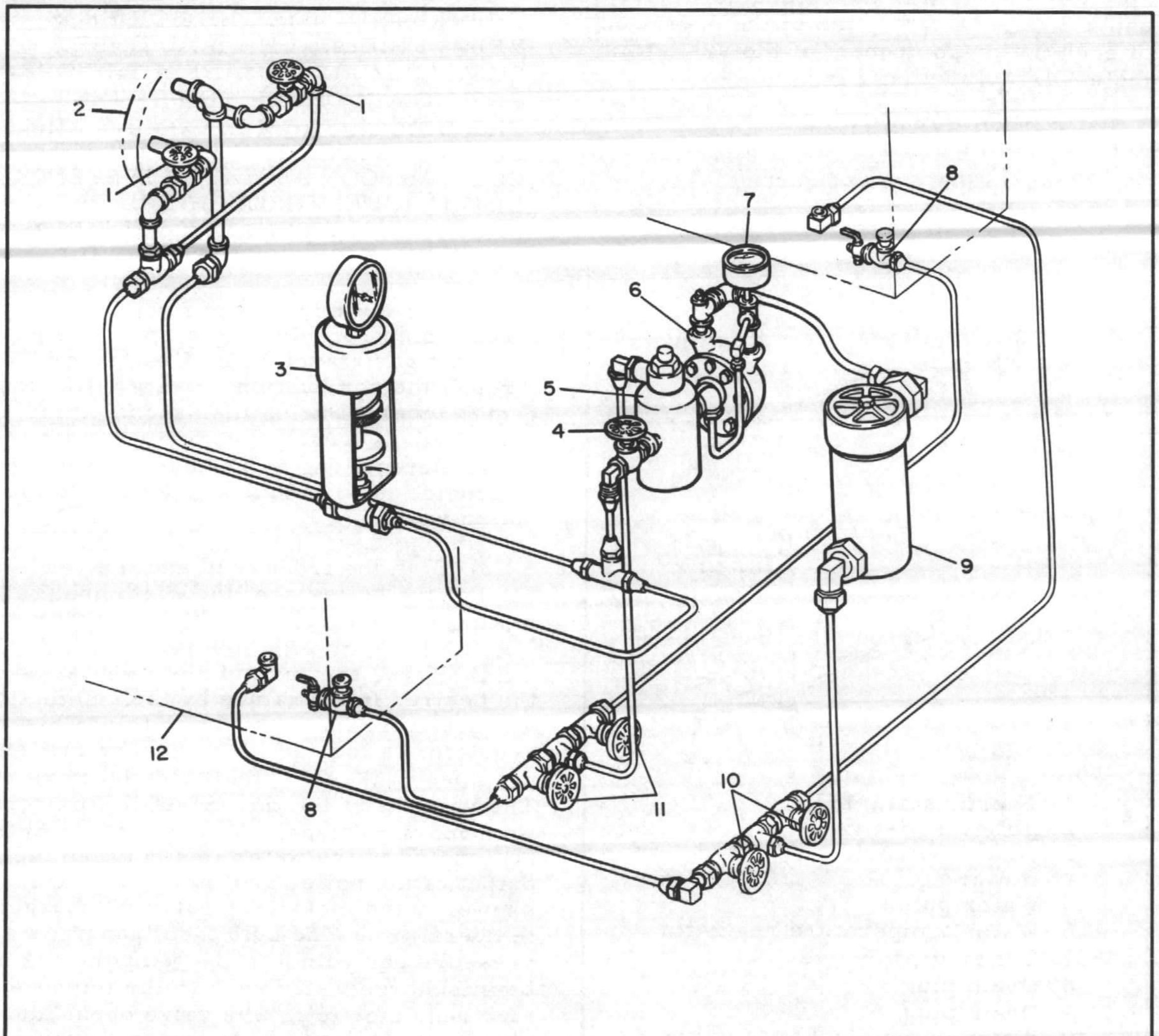
(5) From the boiler, heated shower water passes through the shower valves to the shower stand for the use of personnel.

2-3. BURNER FUEL SYSTEM.

a. Burner Fuel. Use No. 2 U.S. fuel oil.

b. System Operation. (See figure 4-5)

(1) Burner fuel is stored in two 25 gallon tanks (12) located within the fenders, one on each side of the bathing unit.



1 Burner fuel valves	5 Fuel pressure regulator	9 Fuel strainer
2 Burner	6 Burner fuel pump	10 Suction valves
3 Water temperature regulator	7 Pressure gage	11 Return valves
4 Main burner fuel valve	8 Drain valve	12 Burner fuel tank

Figure 4-5 Burner fuel system.

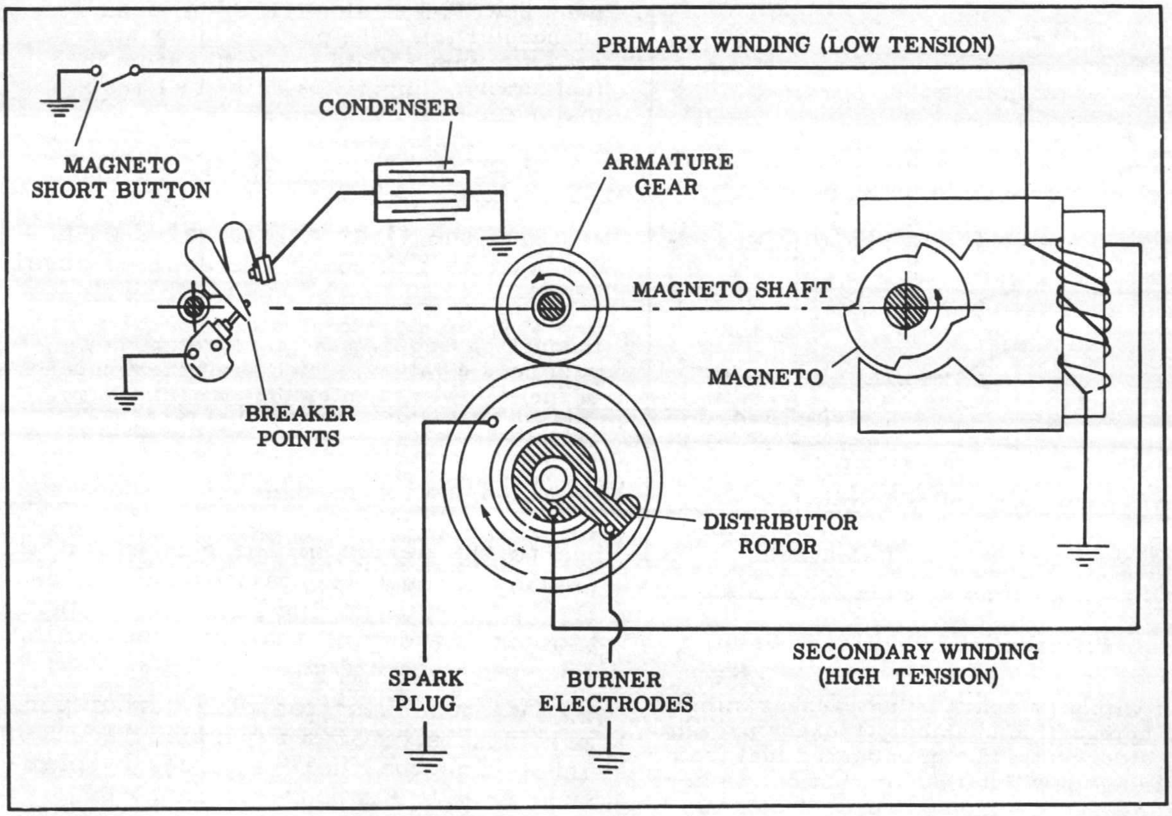


Figure 4-6 Engine and burner ignition system.

(2) The burner fuel pump (6) takes suction from both tanks through the burner fuel strainer (9). The strainer removes solid sediment from the fuel by passing the fuel through a double layer of fine screen mesh, thus protecting the fuel pump, fuel pressure regulator (5), and burner (2) from wear due to solids in the fuel.

(3) The fuel pump discharges into the fuel pressure regulator (5). The purpose of this pressure regulator is to maintain proper fuel pressure at the burners, and to protect the pump and piping from damage during the starting period, when oil may be cold. If pressure at the regulator is too high, the regulator piston will be driven upward, uncovering the return line to the burner fuel tanks, and a portion of the burner fuel will be returned to the tanks. An adjusting setscrew provides a means of adjusting the pressure at which the valve will open. The valve should be adjusted to open at 100 psi as indicated on the fuel pump pressure gage (7).

(4) From the pressure gage, fuel passes through the main burner fuel shutoff valve (4) to two separate lines. One line leads to the two side burner control valves (1) through the water temperature regulator (3), and the other line leads to the main burner.

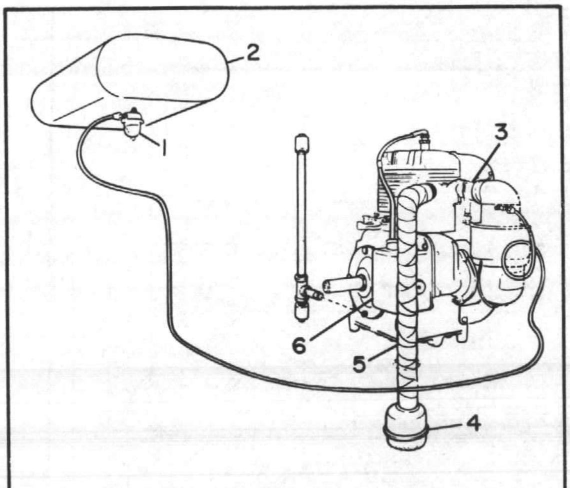
(5) Fuel to the burners is under 100 psi pressure. This pressure forces fuel through the small burner nozzle spray holes at high velocity. This atomizes the fuel and insures efficient and complete combustion. The fuel is ignited by the burner electrodes (figure 4-6 as described in paragraph 2-4.

2-4. ENGINE AND BURNER IGNITION SYSTEMS.

a. Description. (See figure 4-6).

(1) Voltage for both the engine spark plug and burner fuel electrodes is provided by the magneto. The magneto is driven by the engine camshaft gear (figure 4-6).

(2) A continuous connection from the magneto distributor rotor (figure 4-6 to the burner electrodes provides a continuous spark at the electrodes. This provides maximum insurance against operating the



1 Sediment bowl
2 Gasoline tank
3 Carburetor
4 Muffler
5 Exhaust pipe
6 Magneto

Figure 4-7 Engine fuel system.

unit without a spark being present within the combustion chamber, thereby preventing a concentration of unburned fuel from building up within the combustion chamber. An inspection window is provided on the left side of the burner assembly for visual inspection of the burner spark.

(3) Cam operated breaker points provide a second spark for the engine spark plug. This spark is not continuous, and must be timed accurately to engine rotation to provide for most efficient engine operation. See paragraph 3-22 for the method of adjusting breaker points.

2-5. ENGINE FUEL SYSTEM.

a. Description. (See figure 4-7.)

(1) Engine fuel is fed by gravity from the engine gasoline tank (2) through a sediment bowl fuel strainer (1) to the engine carburetor (3). The purpose of the strainer is to remove solid impurities from the fuel supply. Impurities in the fuel are a major cause of engine wear.

(2) Fuel then enters the carburetor float bowl. The float is arranged to close the float needle valve when the bowl is filled to the desired level.

(3) From the float bowl, fuel passes through passages in the carburetor body past needle valves, which limit the amount of fuel allowed to enter the stream of air flowing through the carburetor from the engine air cleaner.

(4) Adjusting needles are necessary for proper adjustment of the carburetor. Due to the design of the carburetor, air flowing through the carburetor follows a different path during high speed operation of the engine than it does during low speed operation.

(5) Air flowing past the carburetor main nozzle creates a partial vacuum into which the fuel is forced by pressure from the carburetor float bowl.

(6) Downward movement of the engine piston during the inlet (or suction) stroke creates a vacuum within the engine cylinder. Air and atomized fuel are sucked into the engine cylinder for combustion.

(7) The fuel is ignited by a spark from the magneto (figure 4-6) at a certain time on the upward compression stroke. After the power stroke, the burned fuel is forced out of the cylinder through the exhaust valve and the exhaust muffler (4) and the engine again draws a new supply of fuel from the carburetor. The cycle now repeats.

SERVICE REQUIREMENTS OF OPERATOR

2-6. SERVICE UPON RECEIPT OF EQUIPMENT.

a. Inspection. Inspect the bath unit as outlined in "Before Operation Services" in Table 1.

b. Lubrication. Refer to the lubrication chart (figure 4-8) which prescribes lubrication requirements for the bath unit, together with the following:

(1) Care of lubrication equipment. Keep lubrication equipment in a place where it will be safe from damage, loss, and free from dust and dirt.

LUBRICATION CHART

BATH UNIT, TRAILER MOUNTED
MODEL EC-8B-64

NOTES:

1. For detailed information on each lubrication point, see paragraph 2-6.
2. Intervals must be reduced to suit abnormal operating conditions.
3. Clean fittings before lubricating.
4. Relubricate after washing or fording.
5. Clean parts with dry cleaning solvent or diesel fuel oil before lubricating.
6. Drain engine crankcase only when heated to normal operating temperature. Replenish and check level when cold.

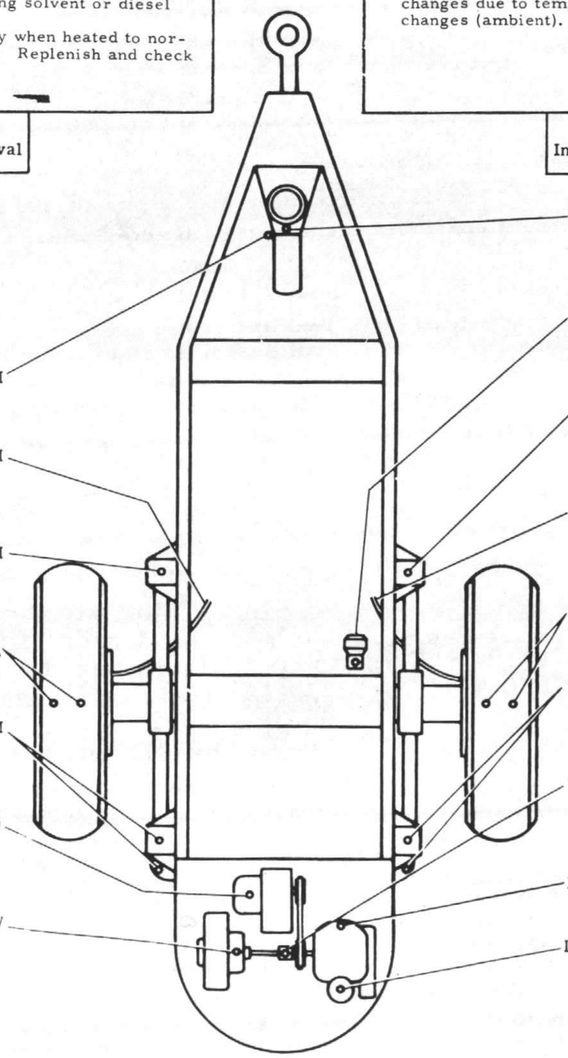
NOTES: (Cont)

7. Hand lubricate throttle, choke, governor linkage, all hinges, and all exposed threads weekly with OE.
8. See paragraph 2-6 for OE weight changes due to temperature changes (ambient).

Interval Symbols

D – Daily
W – Weekly
M – Monthly
A – Annually

Lubrication Point	Lubricant	Interval
Caster Wheel Axle	GAA	M
Parking Brake Cable	GAA	M
Spring Shackle Pin	GAA	M
Wheel Bearings	GAA	A
Spring Shackle Pins	GAA	M
Blower Shaft Bearings	GAA	D
Water Pump Bearings	GAA	W



Interval	Lubricant	Lubrication Point
M	GAA	Caster Mounting Bracket
M	HB	Master Brake Cylinder
M	GAA	Spring Shackle Pin
M	GAA	Parking Brake Cable
A	GAA	Wheel Bearings
M	GAA	Spring Shackle Pins
W	OE	Roller Chain Coupling
D	OE	Engine Crankcase
D	OE	Carburetor Air Cleaner

CAPACITIES

1. Engine crankcase - 1 quart
2. Oil filter - 1/4 pint
3. All other points - as required (see paragraph 2-6)
4. Lubricate parking brake cable sparingly
5. Fill master brake cylinder to 1/2 inch below top of cylinder

Figure 4-8 Lubrication chart.

(2) Cleaning. Be sure to wipe all surfaces surrounding the points of application clean before applying the lubricant. Use an approved cleaning solvent to clean or wash the nearby surfaces. Do not use gasoline for this purpose.

(3) Points of application. The points of application are identified on figure 4-8 Follow the detailed lubrication instructions given for each lubrication point using the lubricant specified.

(4) Unusual conditions. It is the responsibility of the operator to decrease lubrication intervals as required for abnormally dusty, extremely hot, or other unusual operating conditions. Always relubricate the unit after washing or fording a stream or other body of water.

(5) Detailed lubrication instructions.

(a) Engine.

1. When ambient temperature is between 40°F., (4.4°C.) and 120°F., (48.8°C.) use Military Specification OE-30 (Navy Symbol 9250) lubricating oil in the engine crankcase.

2. When ambient temperature is between 5°F., (-15°C.) and 40°F., (4.4°C.) use Military Specification OE-20 (Navy Symbol 9170) lubricating oil in the engine crankcase.

3. When ambient temperature is between -20°F., (-29°C.) and 5°F., (-15°C.) use Military Specification OE-10 (Navy Symbol 9110) lubricating oil.

4. Add lubricating oil to crankcase daily before starting. Remove oil filler plug from top of pipe next to engine and also remove crankcase plug at base of engine. Add oil through the fill pipe, using a funnel to prevent spillage. When oil flows from the crankcase plug opening, the engine base is filled to the proper level, which is two pints. Replace filler pipe plug and crankcase plug. Oil in the crankcase should be drained every 50 operating hours. To drain, remove drain in bottom of fill pipe from underneath base plate of power plant. Drain only when the engine is hot, and be sure to replace drain plug and refill with fresh lubricating oil of the proper type before starting engine.

(b) Carburetor air cleaner. Daily befor starting engine, remove the bowl from the bottom of the air cleaner by pushing the wire bail to one side. Clean the bowl using an approved solvent, and refill to the level indicated with the same lubricating oil used in the engine crankcase.

NOTE

NEVER REMOVE FILTERING ELEMENT FROM THE AIR CLEANER. TO CLEAN THE FILTERING ELEMENT, REMOVE THE ENTIRE UNIT FROM THE CARBURETOR AND FLUSH WITH AN APPROVED SOLVENT WHILE THE BOWL IS DETACHED.

(c) Water pump shaft bearings. Water pump shaft bearings must be lubricated weekly with Symbol GAA grease, automotive and artillery. Grease is added through the grease fitting on the bearing housing. The water pump is fitted with a self-lubricated mechanical seal to which no lubricant should be added.

(d) Roller chain coupling. Lubricate with a few drops of engine lubricating oil each week.

(e) Blower shaft bearings. Lubricate blower shaft bearings daily, or after each eight hours of operation with Symbol GAA grease, automotive and artillery. Lubrication fittings are located on bearing pillow blocks at both the pulley end and the damper end of the blower shaft. Fitting at damper end of shaft is greased by opening damper shutter on cover as far as possible in order to reach the fitting with a grease gun.

(f) Trailer spring shackle pins. Grease the spring shackle pins of the trailer undercarriage once monthly with Symbol GAA grease, automotive and artillery. A fitting is located at each of the six shackle pins.

(g) Trailer caster wheel. Grease the caster wheel axle monthly with Symbol GAA, grease, automotive and artillery at fittings on each side of caster wheel (figure 4-1).

(h) Trailer caster mounting bracket. Grease the caster mounting bracket monthly with Symbol GAA grease, automotive and artillery at fittings on the mounting bracket of trailer caster wheel.

(i) Parking brake cable. Grease both parking brake cables monthly with Symbol GAA grease at the fitting on each cable. Lubricate sparingly.

(j) Hydraulic brake master cylinder. Check level of hydraulic brake fluid in master cylinder once a month. If level is below 1/2 inch from top of cylinder, fill to this level with Symbol HB hydraulic brake fluid.

(k) Wheel bearings. Annually, or after the trailer has been towed 12,000 miles, whichever occurs earlier, remove, clean, dry, and repack the inner and outer bearing cones of each wheel with Symbol GAA grease, automotive and artillery. Before repacking wheels, wash cones in an approved solvent, and clean with a brush. Dry and inspect for defects and wear. Completely fill spaces around rollers and above and beneath cone with lubricant, kneading lubricant into all openings. Thoroughly wash hub to remove all lubricant. Inspect condition of bearing cups, and replace if worn, distorted, or scored. Apply a very thin coating of lubricant to the inside surface of hub and outside of spindle. Do not pack or fill hub with lubricant as this may result in leakage on brake linings.

c. Completeness of Equipment. Make a visual inspection of the bath unit to be certain that all equipment listed in paragraph 1-4 is on the unit and in good condition. Also determine that all necessary publications are included with the equipment.

2-7. SERVICE REQUIREMENTS PRIOR TO, DURING, AND AFTER OPERATION.

a. General. To insure that the equipment is ready for operation at all times, it must be inspected systematically, as outlined in Table 1 before operation, during operation, and after operation so that defects may be discovered and corrected before they result in serious damage or failure. The necessary preventive maintenance services will be performed before operation. Defects discovered during operation of the unit will be noted for future correction, to be made as soon as operation has ceased. Stop operation immediately if a deficiency is noted during operation which would damage the equipment if operating were continued. After-operation-services shall be performed by the operator after every operating period. After-operation-services will be performed at intervals based on the normal operations of the equipment. Reduce interval to compensate for abnormal conditions. Defects or unsatisfactory operating characteristics beyond the scope of the operator to correct must be reported at the earliest opportunity to organizational maintenance.

2-8. REPORTING DEFICIENCIES. The operator will report all deficiencies on DD Form 110.

Table 1 OPERATOR'S DAILY SERVICES

Intervals			
Before Operation	During Operation	After Operation	Procedure
X		X	FUEL. Fill fuel oil and gasoline tanks. Check engine crankcase oil level and fill if required.
X		X	WATER. Verify condition of water supply both for quality and quantity. Check height of the lift from water level to pump.
X		X	TIRES. Check for proper inflation. Remove embedded matter from the treads. Move the trailer a little each day so that no part of the tread carries the load more than 24 consecutive hours. It is desirable to block-up unit to relieve the tires of the load.
X	X		INSTRUMENTS. (Gages.) Check for loose or broken connections, general serviceability and proper readings.

Table 2. OPERATOR'S DAILY SERVICES - Continued

Intervals			
Before Operation	During Operation	After Operation	Procedure
X		X	LEAKS, GENERAL. Inspect unit and underlying terrain for evidence of leakage. Check all fuel and water lines and connections.
	X		UNUSUAL OPERATION AND NOISES. Listen for unusual rattles, knocks, squeaks, or hums. Be alert to detect erratic operation.
		X	LUBRICATION. Lubricate in accordance with the lubrication chart (figure 2-5).
		X	CLEAN EQUIPMENT. Remove silt, dirt, and sediment from the bath unit.
		X	TOOLS AND EQUIPMENT. Clean with approved cleaning solvent and place in proper storage area.
		X	SHUTDOWN PRECAUTIONS. Check to assure that the burner valves are closed and that the blower and engine are stopped.
		X	PROTECTION. See that all hoods and covers are secure and that equipment is properly stowed on trailer.
X		X	VISUAL INSPECTION. Visually check water source for proper quantity, and check unit to assure proper operation.

CONTROLS AND INSTRUMENTS

2-9. GENERAL. This section describes, locates, illustrates, and furnishes the operator sufficient information about the various controls and instruments for the proper operation of the bath unit.

2-10. WATER PRESSURE GAGE. (See figure 4-9).

a. Location. The water pressure gage is mounted near the water pump, in the water discharge line.

b. Purpose. In graduations of 0 to 60 psi (pounds per square inch), this gage indicates the pressure at which the pump is discharging water to the boiler. During normal operation, the pressure will register 25 to 30 pounds.

2-11. MAIN BURNER FUEL VALVE. (See figure 4-9).

a. Location. The main burner fuel valve is located at the side of the fuel pressure regulator. The two smaller valves are located on either side of the oil burner assembly (figure 4-10).

b. Purpose. The main control valve controls fuel oil flow to the center burner nozzle and to the automatic fuel regulator. The two smaller valves, when opened, allow fuel oil to pass from the automatic regulator to the two side nozzles.

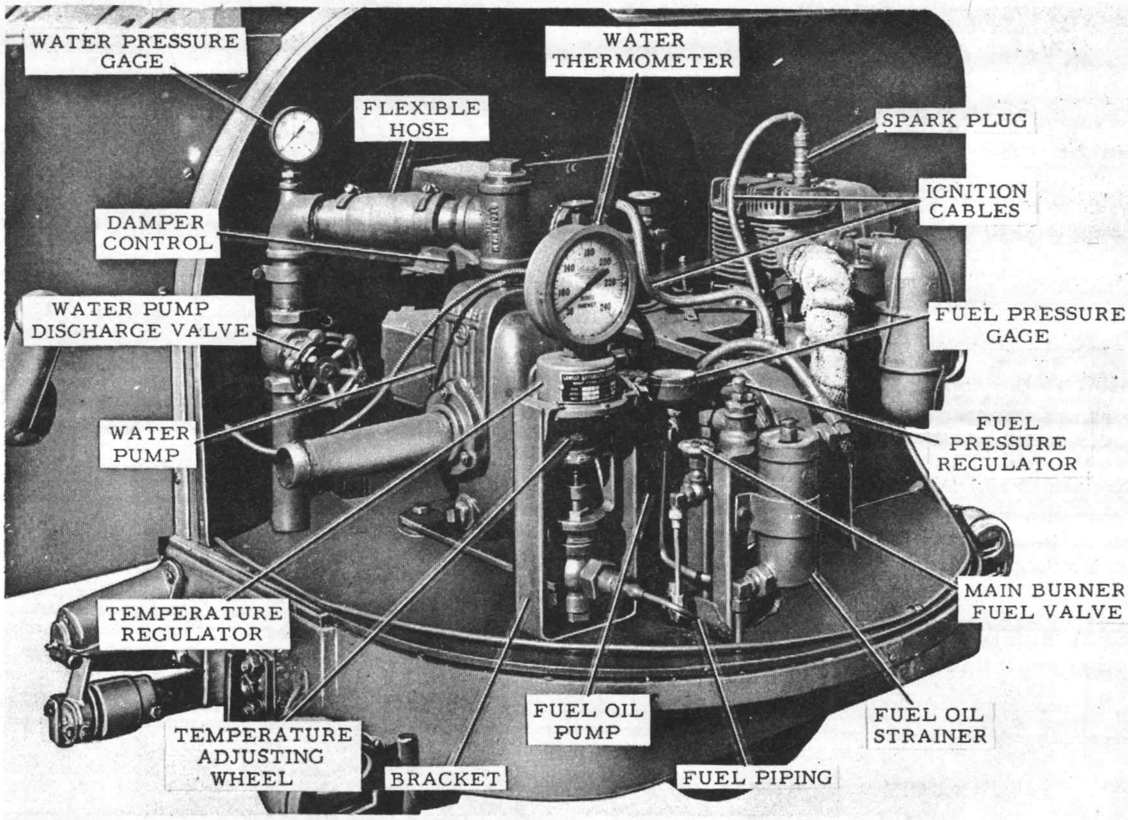


Figure 4-9 Operating components, left side view.

2-12. WATER THERMOMETER. (See figure 4-9).

a. Location. The shower water thermometer is mounted on the temperature regulator.

b. Purpose. This dial-type thermometer, graduated from 30° to 240°F., indicates the temperature of the water leaving the boiler for the showerheads.

2-13. STARTER SHEAVE. (See figure 4-10).

a. Location. The starter sheave is located on the right-hand side of the plant.

b. Purpose. A pull on the starting rope gives two revolutions of the crankshaft, to start the engine.

2-14. FUEL PRESSURE GAGE. (See figure 4-9).

a. Location. The fuel pressure gage is mounted on the side of the fuel oil pump.

b. Purpose. It indicates the fuel pump discharge pressure to the burner, in graduations from 0 to 200 pounds. Pressure during operation should remain at 100 psi.

2-15. TEMPERATURE ADJUSTING WHEEL. (See figure 4-9).

a. Location. The temperature adjusting wheel is on the shaft of the temperature regulator.

b. Purpose. It regulates the temperature of the shower water when turned as indicated by the arrow on the wheel.

2-16. TEMPERATURE REGULATOR. (See figure 4-9).

a. Location. The temperature regulator is located at the left side of the plant near the water pump.

b. Purpose. It provides shower water at the desired temperature by automatically controlling the flow of fuel to the two small burner nozzles.

2-17. DAMPER CONTROL. (See figure 4-9).

a. Location. The damper control is mounted on the blower near the center of the plant.

b. Purpose. It regulates the amount of air supplied to the burner.

2-18. SAFETY RELIEF VALVE. (See figure 4-1).

a. Location. The safety relief valve is located on the top of the boiler.

b. Purpose. The relief valve prevents pressure within the boiler from building up to dangerous levels.

2-19. GASOLINE TANK SHUT-OFF VALVE.

a. Location. This valve is part of the gasoline strainer assembly (figure 3-2), which is installed at the gasoline tank.

b. Purpose. This valve controls the gasoline flow from the tank to the engine carburetor.

2-20. FUEL PRESSURE REGULATOR. (See figure 4-9).

a. Location. The fuel oil pressure regulator is located directly behind the fuel oil strainer.

b. Purpose. It regulates the pressure of the fuel oil to the burner.

2-21. WATER PUMP DISCHARGE VALVE. (See figure 4-9).

a. Location. The water pump discharge valve is installed in the water line at the left side of the plant.

b. Purpose. It controls the water flow from the pump to the boiler and showers.

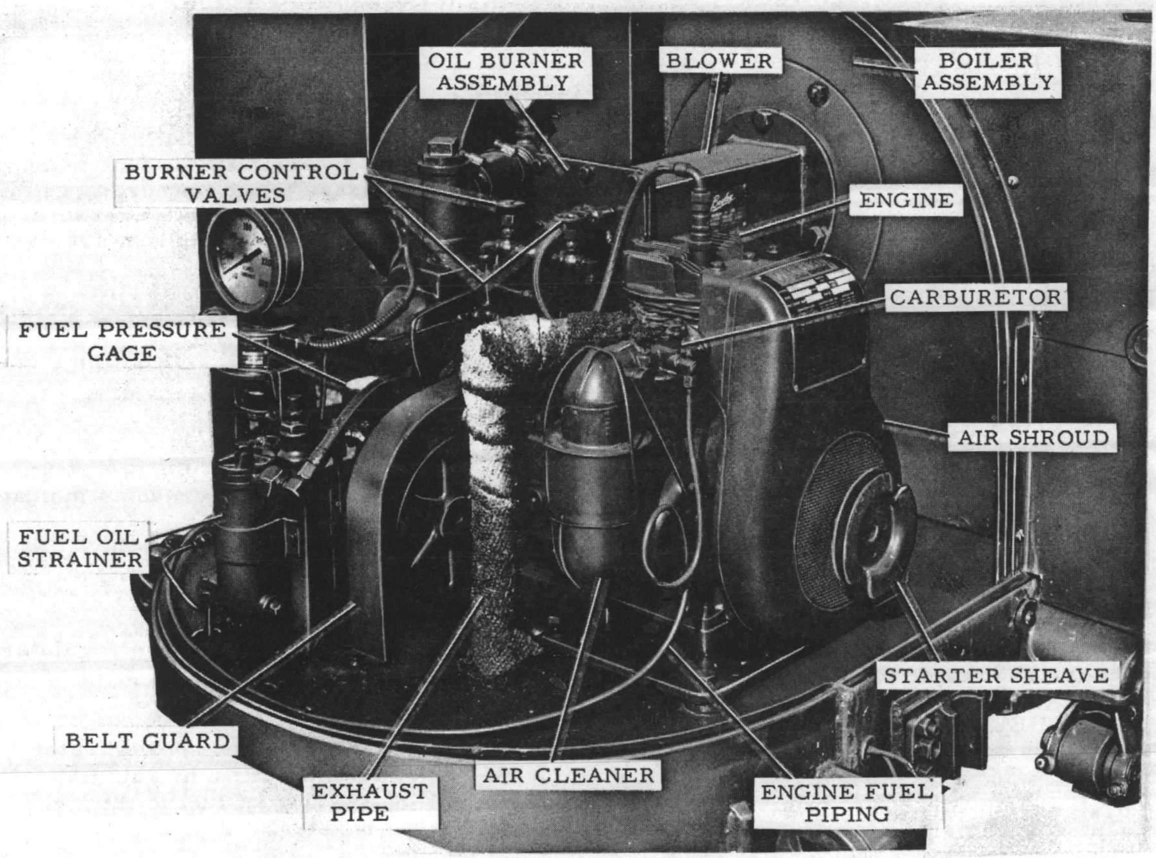


Figure 4-10 Operating components, right side view.

2-22. SHOWER SHUT-OFF VALVES. (See figure 4-1).

a. Location. The shower shut-off valves are installed in the water line on the top of the boiler (towing end).

b. Purpose. They control the flow of water from the boiler to the showerheads. If only 12 showerheads are to be used, one valve is closed; for 24 showerheads, both valves are open.

2-23. FUEL SUCTION VALVES.

a. Location. The fuel suction valves, (figure 4-11are located underneath the boiler.

b. Purpose. These valves control the flow of fuel oil from the fender tanks to the fuel oil pump.

2-24. FUEL RETURN VALVES.

a. Location. The fuel return valves, (figure 4-11 are located underneath the boiler.

b. Purpose. They control the overflow of fuel oil from the fuel regulator to the fuel oil tanks.

2-25. ENGINE STOP SWITCH.

a. Location. The engine stop switch is located underneath the magneto.

b. Purpose. When switch is thrown, it shorts the magneto, thereby stopping the engine.

2-26. FUEL AND GASOLINE TANK MEASURING GAGES.

a. Location. These measuring gages are installed on the individual tanks.

b. Purpose. Each tank is equipped with a bayonet-type gage to measure the liquid level.

2-27. BOILER DRAIN VALVE. (See figure 4-11).

a. Location. The boiler drain valve is located underneath the bath unit on the water pump side of the plant.

b. Purpose. This valve is used to drain the boiler.

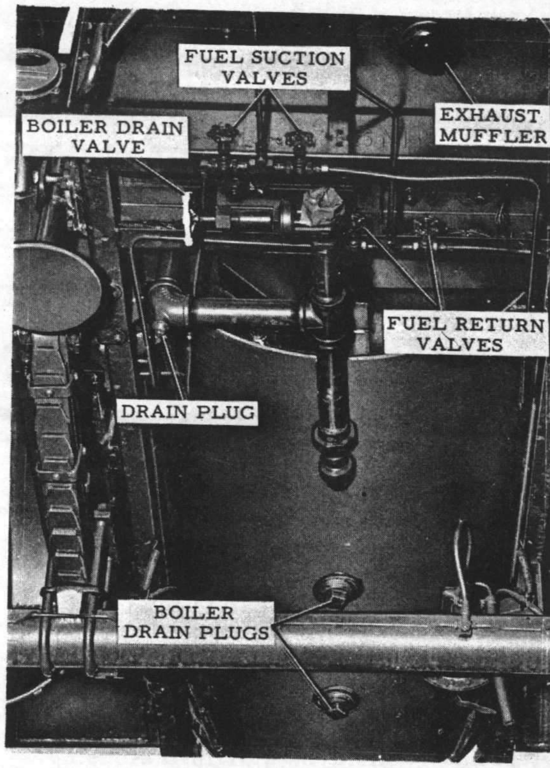


Figure 4-11. Bath unit, underneath view.

2-28. BOILER PETCOCK.

a. Location. The boiler petcock (3) is located on top of the boiler near the boiler safety relief valve.

b. Purpose. When opened, it permits air to be bled from the boiler.

2-29. VARIABLE SPEED GOVERNOR CONTROL.

a. Location. The variable speed governor control is located above the power take-off end (opposite the flywheel) of the engine.

b. Purpose. This control is used to adjust the setting of the carburetor throttle vane, thus controlling the speed at which the engine will operate. It also prevents the engine from overspeeding if the load applied to the engine is suddenly reduced.

2-30. CARBURETOR IDLE ADJUSTING NEEDLE.

a. Location. The idle needle valve is located on the side of the engine carburetor.

b. Purpose. The idle needle valve is used to adjust the flow of fuel to the engine for low speed operation. This control has no effect on fuel flow during high speed operation. It should not be necessary to adjust this control after the original adjustment.

2-31. CARBURETOR MAIN ADJUSTING NEEDLE.

a. Location. The high speed needle valve is located on the bottom of the carburetor.

b. Purpose. The high speed needle valve is used to adjust the flow of fuel to the engine during high speed operation. It has little effect on fuel flow during low speed operation. It should not be necessary to adjust this control after the original adjustment.

OPERATION UNDER SPECIFIC CONDITIONS

2-32. OPERATION UNDER NORMAL CONDITIONS.

a. General.

(1) The instructions in this section are published for the information and guidance of the personnel responsible for the operation of the bath unit.

(2) It is essential that the operator know how to perform every operation necessary to fully utilize the bath unit. This section gives instructions on starting, stopping, and operating details.

b. Starting.

(1) Prestarting instructions.

(a) Perform before - operation services.

(b) Check directional arrow on the water pump casing for proper rotation of the impeller shaft.

(2) Setting the valves.

(a) Open water pump discharge valve (figure 4-4).

(b) Open boiler petcock (3, figure 4-4).

(c) Open shower shut-off valves (figure 4-1).

(d) Close main burner fuel valve (figure 4-9).

(e) Open burner fuel control valves (figure 4-10).

(f) Close burner damper control (figure 4-9).

(g) Close burner fuel drain cocks.

(h) Open all four fuel tank suction and return valves (figure 4-11).

(i) Close boiler drain valve (figure 4-11).

(j) Open gasoline strainer shut-off valve.

(3) Firing the engine.

(a) Turn starter sheave (figure 4-10) clockwise (right) by hand until it is stopped by compression.

(b) Wind starting rope on starting pulley in a clockwise direction.

(c) Close choker fly on carburetor air inlet. It will open automatically after engine has started.

(d) Close main adjusting needle of carburetor then open it 1-1/4 turns. In cold weather, starting is sometimes facilitated by opening the needle valve slightly more.

(e) Exert a quick pull on starting rope. If engine does not start on the first try, repeat the operation.

CAUTION

RACING AN ENGINE OR GUNNING IT, TO HURRY UP THE WARM-UP PERIOD, IS VERY DESTRUCTIVE TO THE POLISHED WEARING SURFACES ON PISTONS, RINGS, CYLINDERS, BEARINGS, AND OTHER PARTS. THE PROPER OIL FILM ON THESE VARIOUS SURFACES DOES NOT DEVELOP UNTIL THE OIL HAS WARMED UP AND BECOMES SUFFICIENTLY FLUID. THIS IS ESPECIALLY IMPORTANT ON NEW ENGINES AND IN COOL WEATHER.

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(f) If choke on carburetor accidentally snaps open during cranking, close it again for two or three turns of the engine. If fuel begins to drip from carburetor, reopen the choke.

(g) Allow the engine to run at moderate speed for a few minutes, until it gradually warms up to operating temperature.

c. Shutting Down the Unit.

(1) Stopping the engine. To stop the engine, throw the engine stop switch (figure 1-3) underneath the magneto.

(2) Shutting down the boiler.

(a) Stop the engine as in paragraph (1), above.

(b) Close all burner fuel valves.

(c) Open damper fully by means of damper control (figure 4-9 to allow gas fumes to escape.

(3) Servicing. Perform after - operation services.

d. Draining the Unit.

(1) Draining water.

(a) Open boiler drain valve (figure 2-8).

(b) Remove drain plug (figure 4-11). from water pump discharge line.

(c) Remove plug at base of water pump.

(d) Open water pump discharge valve (figure 4-9).

(e) Open one or two unions in shower stand.

(f) Uncouple suction hose and drain hose.

(2) Draining gasoline and fuel oil.

(a) Drain gasoline from engine gasoline tank by removing gas filter sediment bowl. Replace bowl after tank is drained.

(b) Drain burner fuel oil from fuel-oil tank by opening drain petcocks beneath tanks. Close petcocks when tanks are drained.

(c) Drain oil from engine crankcase by removing drain plug directly below engine. Replace plug when crankcase has drained and attach a caution tag to engine stating "Crankcase Drained."

e. Operating Details.

(1) Operating cycle. The suction pump draws water from the source of supply through a suction hose, forcing it into the heater. The heat developed in the fire tubes raises the temperature of the water and maintains it at the desired level. The heated water is forced by the pressure of the water pump through the discharge hose to the shower stand, where it is dispensed by the 24 showerheads.

(2) Engine speed. When the engine is warm, its speed should be about 2800 rpm, and should not be allowed to drop lower. At lower speeds, the blower will not supply sufficient air for proper combustion.

(3) Fuel pressure.

(a) When the engine is running, the fuel oil pressure gage (figure 4-9 in the fuel oil pump (figure 4-9 should register 100 psi. If the gage shows no pressure, the fuel oil pump may be airbound. Bleed by loosening a connection in the line from the pump to the burner nozzles until the air has been removed from the pump.

(b) If the pressure gage reads above or below 100 psi, remove the cap on the pressure regulator and, with the engine running, adjust the pressure by turning the adjusting screw with a screwdriver. Turn the screw counterclockwise (left) to decrease pressure or (clockwise) (right) to increase pressure.

CAUTION

SHOULD THE ABOVE EFFORTS FAIL TO PRODUCE ANY FUEL PRESSURE, STOP THE ENGINE IMMEDIATELY TO PREVENT DAMAGE TO THE FUEL PUMP. TIGHTEN ALL FUEL LINE CONNECTIONS. IF THE FUEL PRESSURE DOES NOT COME UP TO 100 PSI, REPORT THE DEFICIENCY TO THE PROPER AUTHORITY.

(4) Filling the boiler.

(a) When the engine is started, the water pump will start pumping water from the source of supply into the boiler.

(b) When the boiler is full, a steady stream of water will flow from the petcock on top of the boiler.

(c) Close the petcock and the water pump discharge valve (figure 2-6) until only a little water flows from the showerheads.

(5) Water temperature regulation.

(a) The water is kept at bathing temperature by the temperature regulator (figure 4-9), which is factory-set to maintain a supply of water at 102°F. to 105°F. If it is necessary to raise or lower the water temperature, the temperature regulator may be adjusted by turning the temperature adjusting wheel on the regulator (figure 4-9).

1. For a temperature rise of 1° to 30°, use only the center burner nozzle, which is controlled by the main burner fuel valve (figure 4-9).

2. For a rise of 30° to 45°, use the center nozzle and either one of the side nozzles controlled by the two smaller burner fuel control valves (figure 4-10).

3. For a rise of 45° to 55°, use all three of the burner nozzles.

(b) The water temperature may be raised quickly at the start by closing the water pump discharge valve (figure 4-9) until only a small amount of water flows from the showerhead. As soon as the temperature, as registered on the water thermometer (figure 4-9) rises to 102°F., the pump discharge valve should again be opened until 25 to 30 psi is registered on the water pressure gage (figure 4-9).

(c) If the water temperature should rise above 105°F., the temperature regulator (figure 4-9) will cut off the flow of fuel to the side nozzles until the temperature falls to about 102°F., at which point the regulator will again permit fuel flow.

(6) Operating the burner.

(a) Before lighting the burner (figure 2-7) check the reading on the water thermometer (figure 4-9) and set the temperature regulator (figure 4-9) as necessary to raise the water temperature to the desired operating level of 102°F. to 105°F. Refer to paragraph (5), above.

(b) Close the damper on the blower by means of the damper control (figure 4-9).

(c) Open the main burner fuel valve (figure 4-9).

(d) A continuous spark at the electrodes in the burner ignites the fuel oil sprayed from the nozzles. As soon as the fuel oil ignites, open the damper by means of the damper control (figure 4-9) until only a gray haze issues from the stack.

WARNING

EXTREME CAUTION MUST BE USED WHEN FIRING THE BURNER. IF THE FUEL FAILS TO IGNITE ON THE FIRST OPERATION, THE BOILER MUST BE PURGED BEFORE A SECOND ATTEMPT IS MADE.

(e) If necessary to purge the boiler, do this by closing the burner fuel valves and removing the burner electrode wire at the magneto. Then operate the blower for at least 15 minutes with the blower damper open.

(f) Readjust the damper each time that one or both of the side nozzles is lighted to obtain a rise in water temperature.

(g) When both of the side nozzles are used, only one burner control valve should be opened at a time.

NOTE

DURING THE FIRST FEW MINUTES OF OPERATION, CONDENSATION MAY DRIP FROM THE BOTTOM OF THE BOILER. DO NOT ASSUME FROM THIS CONDITION THAT THE BOILER HAS SPRUNG A LEAK; THE CONDENSATION WILL CEASE AFTER A FEW HOURS OF OPERATION.

(7) Water flow to showerheads.

(a) As soon as shower water temperature rises above 102°F., as registered on the water thermometer (figure 4-9) open the water pump discharge valve (figure 4-9) until the water pressure gage (figure 4-9) indicates a pressure of between 25 to 30 psi. Water should then flow from each showerhead at the rate of approximately 1-1/2 gallons per minute.

(b) One or both of the shutoff valves on the shower line are open at all times. If only 12 showerheads are to be used, close either shut-off valve. The water-pressure gage will then indicate approximately 30 to 36 psi.

2-33. OPERATION UNDER UNUSUAL CONDITIONS.

a. Operation in Cold Weather.

(1) To operate the bath unit in freezing weather, or if temperatures below freezing are likely to occur during a shutdown, special precautions must be taken to prevent poor performance or total operational failure. If possible, install the equipment in a properly protected shelter.

(2) After any shutdown, drain the boiler completely of water.

(3) Select the correct lubricants for the expected air temperatures as indicated in the lubrication chart (figure 4-8).

(4) Fill the fuel tanks at the end of each day's operation to prevent condensation of moisture in the tanks.

(5) Be especially careful to allow an ample warm-up period, with the engine running at moderate speed.

b. Operation in Sandy or Dusty Locations.

(1) Protect the unit from dust or sand as much as possible. Cleanness of the engine is important for proper cooling and operation.

(2) Watch the air cleaner closely and keep it clean. When adding oil, remove any dirt or sand from around the filler neck. Keep the crankcase breather cap clean. Keep fuel oil, gasoline, and oil containers covered and dust-tight. Clean these containers and the fuel strainers frequently. Check lubrication points frequently and keep lubricated in accordance with the lubrication chart (figure 4-8).

c. Operation in Extreme Heat.

(1) Locate the unit in a well-ventilated area that will allow a maximum amount of cool air for cooling the engine.

(2) Check the shrouding to insure that it is in good condition. Keep the cylinder head free of oil and dirt.

NOTE

NEVER OPERATE THE ENGINE WITH ANY PART OF THE SHROUDING REMOVED BECAUSE THIS WILL RETARD THE AIR COOLING.

(3) Fill the fuel tanks at the end of each day's operation to prevent an accumulation of vapor in the tanks.

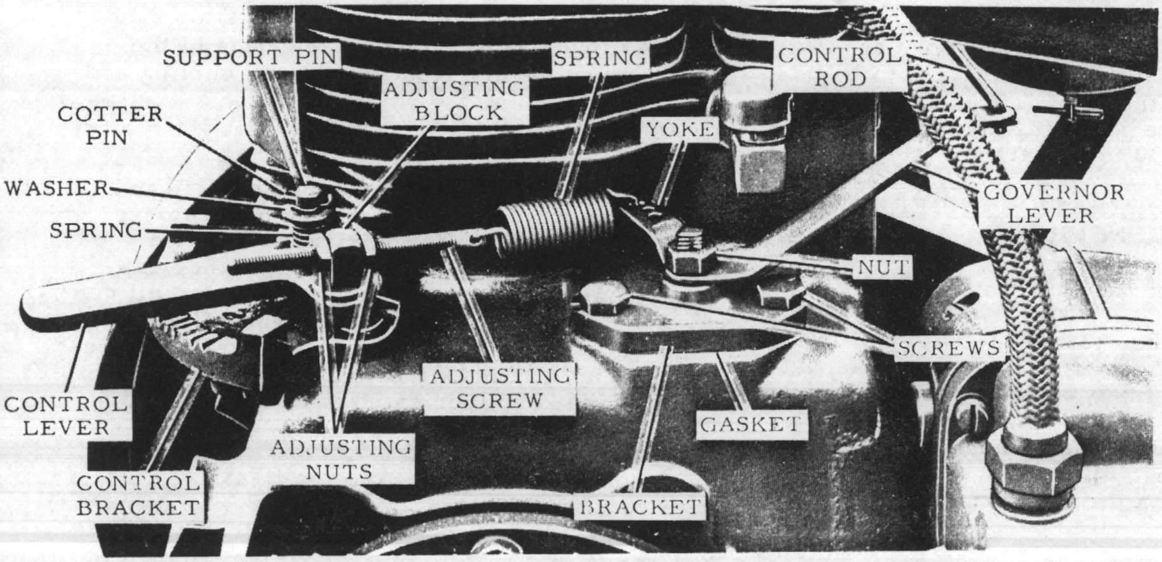

Figure 4-12 Governor adjustment.

TROUBLESHOOTING

GENERAL. Table 3 provides information useful in diagnosing and correcting unsatisfactory operation or failure of the bath unit or any of its components. Each trouble sympton listed is followed by probable causes of the trouble. The possible remedy recommended is described opposite the probable cause.

Table 3 TROUBLESHOOTING CHART

SYMPTOM	PROBABLE CAUSE	POSSIBLE REMEDY
Engine fails to start	Lack of fuel	Fill gas tank
	Carburetor flooded	Open the choker fly and crank until engine fires. If necessary, remove the spark plug and crank engine several times to drive out the rich fuel mixture.
	Carburetor is dry.	Check for clogged or damaged fuel line. Check for vapor lock in fuel line.
	Insufficient choking.	Close choker fly further.
	Gasoline shut-off valve on fuel strainer closed.	Open gasoline shut-off valve.
	Water, dirt, or gum in fuel line.	Clean fuel line.
	No spark.	Check ignition, spark plugs, and magneto.
Engine operates erratically.	Dirt in fuel system.	Drain fuel system and clean fuel lines and tank. Replenish with clean fuel.
	Air leak.	Tighten carburetor mounting bolts. Replace gasket if leaks persist.
	Weak spark.	Check ignition, magneto.
	Improper spark gap.	Check and reset spark plug gap.
	Governor spring hooked in wrong hole.	Check governor adjustment.

TROUBLESHOOTING CHART

SYMPTOM	PROBABLE CAUSE	POSSIBLE REMEDY
Engine stops unexpectedly.	Lack of fuel.	Fill gasoline tank.
	Dirt, gum, or water in fuel system.	Clean fuel line and gasoline tank.
	Clogged air cleaner.	Service air cleaner.
	Defective magneto.	Replace magneto.
Engine overheats.	Crankcase oil supply too low.	Stop engine and add oil.
	Part of air shroud removed from engine.	Install missing air shroud.
	Dirt between cooling fins on cylinders	Clean dirt from between fins.
Water pump not maintaing pressure.	Loss of supply.	Check water supply. See that all hose connections are watertight and airtight. Clean clogged shower pipping or showerheads.
Water supply failure.	Suction lift too great.	See that suction lift does not exceed 15 feet.
	Suction line leaks.	Insure that washers are in all hose connections and connections are tight.
Fuel oil pump not maintaining pressure.	Insufficient supply.	Check oil supply. Clean fuel oil strainer. Check fuel regulator.
	Pump losing speed.	Inspect belts for tightness.
	Pump airbound.	Loosen connections on pump return line and bleed air.
Burner failure.	Fuel oil supply fails.	Check fuel oil tanks for supply.
	Fuel oil pressure incorrect.	Fuel oil pressure should be 100 psi, as indicated by fuel oil pressure gage. Adjust fuel oil pressure regulator.

TROUBLESHOOTING CHART - Continued

Symptom	Probable Cause	Possible Remedy
	Fuel oil strainer or nozzles clogged.	Clean fuel oil strainer. Remove nozzles and clean nozzle strainers. Clean internal surfaces of nozzle tops.
	Reduction in fuel pump capacity.	Change gaskets.
	Fuel oil not atomized.	Remove and clean fuel nozzles.
	Fuel oil not ignited.	Check electrodes for looseness, improper spacing, or pitting.
Outlet water temperature incorrect, or can not be adjusted.	Faulty adjustment of water temperature regulator wheel.	Adjust accordingly.
	Faulty thermostatic element.	Replace if defective.
	Improper adjustment of water pump discharge valve.	Open or close valve to suit.
	Faulty burner operation.	Diagnose cause and correct as needed.

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DETAILED OUTLINE

3000 GALLON TANK

INTRODUCTION

1. GAIN ATTENTION (2 MIN)

Your duties as a Basic Hygiene Equipment Operator are to operate various kinds of water supply equipment which require the use of a 3,000 gallon tank. The lack of the tank or the inability to set it up properly would render the equipment useless because the water could not be stored.

2. LESSON PURPOSE: To provide the student with the knowledge and skill to install the 3,000 tank.

3. INTRODUCE LEARNING OBJECTIVE(S): (2 MIN)

a. ENABLING LEARNING OBJECTIVE(S): Provided with a 3,000 gallon tank and sledgehammer, install the tank in accordance with TM-0105C-14, chapter 2. (1.4.1a)

b. I will do this by lecture, demonstration, and application.

c. There will be a progress test at the end of lecture.

d. You will be tested on installation of the tank during practical application portion of this lesson.

TRANSITION: Now that we have discussed what we are going to do, let's look at the nomenclature of the 3,000 gallon tank.

Show ITV tape (15 MIN)

BODY

1. Nomenclature (MIN)

a. Tank - 3,000 gallon capacity when filled within 7 inches from the top, and is constructed of rubber coated/nylon.

b. Bolt eye - used to tighten down the support tubes.

c. Cloth coated ground - made of black rubber and is round and is used to lay on the ground beneath the tank to prevent the tank from being punctured.

d. Cover assembly top - 14 ft. square, nylon, black and rubber. Used for covering the tank to prevent the water in the tank from becoming recontaminated by flying dust particles.

e. Outlet assemblies - 2" male and female caps used for draining water out of tank.

f. Pin straight headed - used to fasten the stave caps to the support tube.

g. Pin, tent - used to secure guy lines.

h. Repair kit - used to repair holes or tears in the tank.

i. Rope, sisal - used to tie down the tank.

j. Stave, hardwood 3 3/4" wide, 55" long. They are installed on the tank for further support.

k. Stave, cap assembly - used to slide over the staves and used in conjunction with the tube supports. Also supports the tank and has an eyelet for tying down.

l. Stave, cap extension - used to slide over the staves and when used in conjunction with the tube supports give additional support to the tank. Equipped with eyelet for tying down the tank.

m. Tube supports inner and outer. These are long aluminum poles. One slides into the other and can be adjusted to support the tank.

<u>TRANSITION</u>: Now that we know the nomenclature of the 3,000 gallon tank, let us discuss the procedures for setting up the tank.

2. <u>Setting the tank up</u> (MIN)

a. Prepare a location close to the water source for the tank assembly

(1) Prepare a level location at least 10 feet in diameter

(2) Remove any sharp or pointed objects that might pierce the tank

b. Position the tank and components.

(1) Lay out ground cloth in center of prepared location

(2) Place the folded tank in the center of the ground cloth, and unfold the tank.

(3) Place staves, stave caps, tube supports, top cover, and repair kit near the positioned tank

c. Assemble the tank

(1) Insert the wooden staves. Start at the bottom of the tank and pass each stave through each of the five loops or stave pockets, progressing to the top of the tank.

(2) Attach the tank staves.

(a) Select one of the long, aluminum cap assemblies.

(b) Hold the upper eyelets toward the inside of the tank and slip it down over the top of the stave and pocket assemblies.

(c) Skip 4 staves and attach a short stave with the horizontal eyelet, facing to the outside

(d) Attach the last or short stave cap on the fifth stave

(3) Extend each of the pair of telescoping aluminum support tubes to the approximate diameter of the tank.

d. Erect the four staves that have caps, extend the aluminum support tubes across the tank, and match them with the caps using the straight pins and cotter pins as provided.

e. Drive the four wooden tent pins into the ground approximately 5 feet from the base of the tank opposite each cap assembly. Tie each of the 10 foot guy lines to the eyes of the cap assembly, draw it snug, and secure it to the tent pins.

f. Unfold the 14 foot square top cover, and tie the 6 foot lines through the corner grommets. Place the top cover over the tank and tie it down to the pins used for the guy lines.

g. Check tank for holes.

h. Fill tank with water to within 7 inches of the top.

<u>TRANSITION</u>: Now that we know how to assemble the 3,000 gallon tank, let us talk about the proper procedures for folding the tank for storage.

3. <u>Folding of the tank assembly</u> (MIN)

a. Remove and fold the tank cover

(1) Lay tank cover straight on ground

(2) Fold one third over for the first fold

(3) Fold opposite end over top of first fold for second fold

(4) Turn folded cover lengthwise for third fold and fold same as first fold

(5) Fold in half, bring fourth fold over third fold line for fourth fold

b. Drain water from tank if necessary.

(1) Open male outlet

(2) Open female outlet

c. Dismantle tank.

(1) Remove the aluminum support tubes and stave cap eyelets

(2) Remove the 20 wooden staves.

(3) Turn the tank completely over to drain any remaining water. Then turn tank back over.

d. Fold tank for movement

(1) With the tank in collapsed position, take the opposite sides of the tank and fold them toward the center with approximately 18 inches separating the edges.

(2) Make the second fold with the apex ends over at right angles to the previous fold, leaving approximately 29 inches separating the edges.

(3) Make the third fold by folding the sides in the same direction as the first fold to within approximately 1" to 1 1/2 inches of the center but at a right angle to the second fold.

(4) Make the fourth fold in the same direction as the second fold.

(5) Place the folded tank cover in the center of ground cloth.

(6) Place the folded tank on top of tank cover and ground cloth.

(7) Fold two sides of the ground cloth over the ends of the folded tank and top cover.

(8) Fold the other two sides of the ground cloth over top of folded tank and top cover.

(9) Tie package together with two pieces of nylon-coated fabric or use two guy lines.

OPPORTUNITY FOR QUESTIONS (3 MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. How far must the tank be filled up to give you approximately 3,000 gallon of water?

A. 7 inches from the top.

b. How many tent pins go with the 3,000 tank?

A. 4 tent pins

(2 MIN)

SUMMARY: During this period of instruction I have covered the nomenclature, set up, and fold the 3,000 gallon tank.

PROGRESS TEST (5 MIN)

BREAK (10 MIN)

Controlled Practical Application (107 MIN)

a. March class to predesignated area.

b. Divide class into four man teams.

c. Each team will be provided with a tank and all its components and will assemble, disassemble, and fold a 3,000 gallon tank.

(1) Unpack 3,000 gallon tank and equipment

(2) Prepare area.

(3) Spread tank bottom

(4) Position tank on center of ground cloth

(5) Unfold tank

(6) Install staves

(7) Drive guy line stakes

(8) Raise tank

(9) Install tube support assemblies

(10) Tie down tank

(11) Cover tank with tank top.

d. After the assembly is completed, students will disassemble, fold and store the 3,000 gallon tank.

OPPORTUNITY FOR QUESTIONS (0 MIN)

1. QUESTIONS FROM THE CLASS: (All questions would be answered on an individual basis throughout the practical application)

2. QUESTIONS TO THE CLASS: (No questions are required after a practical application phase)

(1 MIN)

SUMMARY: During this lesson we covered the installation of the 3,00 gallon tank.

BREAK (10 MIN)

LIST OF SUPPORTING PAPERS

1. ITV Tape
2. Actual Equipment
3. Advance Sheet/Student Outline

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DETAILED OUTLINE

CENTRIFUGAL PUMPS

INTRODUCTION

1. GAIN ATTENTION: (10 MIN)

If you are running a water point, what would you do about distributing the water that you have purified to the unit which you are supporting? Would you carry the water by buckets? By truck? Possibly. How about using a pump and pumping it?

2. PURPOSE: The purpose of this period of instruction is to provide the student with the knowledge and skill necessary to pump water.

3. INTRODUCE LEARNING OBJECTIVE(S):

a. ENABLING LEARNING OBJECTIVE(S): Provided with a centrifugal pump, fuel, and a water source, pump water in accordance with TM 5-4320-200-15, chapter 3. (1.4.1b)

b. I will do this by lecture, demonstration, and practical application.

TRANSITION: Let us now turn our attention to the nomenclature of the engine used with the 55 GPM Centrifugal Pump.

BODY (TP # 1 ON)

1. Nomenclature of the Wisconsin Model AB Engine (15 MIN)

a. Rated at 3.0 horsepower

(1) Single cylinder

(2) Four cycle

(3) Air cooled

(4) Gasoline engine

b. Cooling of the engine

(1) Fan-flywheel encased in a sheet metal shroud

(2) The air is divided and directed by ducts and baffle plates to insure uniform cooling of all parts.

c. Carburetor provides the proper mixture of gasoline and air at all speeds and loads.

d. Ignition

(1) Furnished by a high tension radio shielded magneto

(2) Driven off timing gears at crankshaft speed

e. Magneto breaker points adjustment. Gap set at .020 inch at full separation.

f. Spark plug gap set at .025 of an inch.

(TP # 1 OFF)

(TP # 2 ON)

g. Lubrication system

(1) Constant oil level splash type

(2) Uses various grades of oil

(a) 120° to 40°F = SAE 30

(b) 40° to 0°F = SAE 20

(c) 0° to -15°F - SAE 10

(3) Holds one quart (TP # 2 OFF)

h. Governor (TP # 3 ON)

(1) Is a centrifugal flyball type

(2) Engines are equipped with either a fixed speed governor or a variable speed regulator.

(3) Three holes are provided on the variable speed governor

(a) For 1800 RPMS the spring should be hooked into hole number 1.

(b) For 2500 to 2950 RPMS place spring in hole number 2.

(c) For speed of 2900 RPMS and over place spring in outer hole.

(d) Smooth operation is obtained when the governor lever is set at 2600 RPMS

(OFF TP # 3)
(ON TP # 4)

i. Fuel

(1) Use good quality gasoline free from dirt and water

(2) Make sure vent holes in fuel tank cap are open

(3) Holds 1 gallon

j. Fuel filter

(1) Bowl type

(2) Separates sediment

(3) Clean every 8 hours

k. Choke lever

(1) Manually operated

(2) After engine starts the choke will automatically open

l. Rope starter gives two revolutions of crankshaft

m. Air filter

(1) Oil bath air filter

(2) Holds 1/4 pint oil

(3) Uses same as crankcase

n. Ground prong to shut off engine

(TP # 4 OFF)

TRANSITION: As we continue, let us take a look at the nomenclature of the Barnes Pump.

2. Barnes Pump Model 7M-US/-

a. Type

(1) Centrifugal

(2) Self-Priming

(3) 55 GPM

b. Suction and discharge ports

(1) Two inches in diameter

(2) Total suction lift is 15 feet

(3) 50 foot total dynamic head

(4) Rubber washers for air tight connection

TRANSITION: Now that we have discussed the nomenclature of the engine and pump associated with the 55 GPM Pump, let's take a look at the nomenclature of the engine on the 65 GPM Pump.

(TP # 5 ON)
(10 MIN)

3. Military Standard Engine

a. Rated at 1 1/2 horsepower

(1) Single cylinder

(2) Four cycle

(3) Air cooled

(4) Gasoline engine

b. Cooling of the engine

(1) Fan flywheel encased in a sheet metal shroud

(2) Air is divided and directed by ducts and baffle plates to insure uniform cooling.

c. "ON-OFF" Switch

d. Carburetor

(1) Handles the proper mixture of gasoline and air

(2) Adjusting high speed needle valve

(a) Counter-clockwise makes mixture richer

(b) Clockwise makes mixture leaner

e. Ignition

(1) Current is generated by a rotating magnet and ignition coil

(2) Low tension cable carries the primary current to the contact sets and capacitors.

(3) High tension cables relay the current directly from the ignition coil to the spark plug

(4) Contact points gap set between 0.016 - 0.020 in.

(5) Spark plug gap set between 0.028 - 0.033 in.

(TP # 5 OFF)

f. Lubrication system

(1) Splash-Vapor type

(a) Lobe on crankshaft splashes oil on the components in the lower part of the engine.

(b) Valves and the upper part of the engine are lubricated by a closed breather

(c) Utilizes crankcase pressure to draw oil vapors into the rocker arm cover

(2) Uses various grades of oil

NOTE: Instructor will draw on chalkboard the various grades of oil and temperatures associated with the oil as stated with the Wisconsin engine.

(TP # 6 ON)

(3) Crankcase holds 1/2 quart

g. Governor

(1) Is a centrifugal flyweight type

(2) Controlled by a control rod assembly

(3) To regulate engine speed turn nut on control rod assembly.

(a) Clockwise - to increase engine speed

(b) Counter clockwise - to decrease engine speed

(4) Develops a maximum 3600 RPMS

(TP # 6 OFF)

h. Fuel

(1) Use good quality gasoline free from dirt and water

(1) Holds one gallon

i. Fuel filter

(1) Bowl type

(2) Separates sediment

(3) Clean every 8 hours

j. Choke lever manually operated

k. Rope starter gives two revolutions of crankshaft

l. Air filter, dry element type

TRANSITION: The pump associated with this type of engine is the Barnes Pump Model 17570.

(TP # 7 ON)
(2 MIN)

4. Barnes Pump Model 17570

a. Type

(1) Centrifugal

(2) Self-priming

(3) Frame mounted

(4) Rated 65 GPM

(TP # 7 OFF)
(TP # 8 ON)

b. Suction and discharge ports

(1) 1 1/2 inches in diameter

(2) Total suction lift 15 feet

(3) 50 foot total dynamic head

(4) Rubber washers for air tight connections (TP # 8 OFF)

TRANSITION: Now that we have discussed the engines and pumps, let's talk about the equipment used with these pumps.

5. Equipment used in Conjunction with Centrifugal Pumps

a. 25 foot cotton discharge hose

b. 20 foot rubber reenforced suction hose

c. Strainer for end of suction hose

d. Float

TRANSITION: Now we have discussed the nomenclatures of the engines and the pumps, let's get them ready to be put into operation.

6. Preoperational Maintenance and Installation (2 MIN)

a. Check for missing or loose components

b. Check all fluid levels (gas, oil, etc.) Fill to proper level

c. Check staging of pumps

(1) Install every 360 ft (maximum)

(2) Install every 300 ft to be safe

(3) Normally installed every 180 ft

d. Insure pump is level

e. Provide protection from the elements, wind, dirt, snow, etc.

TRANSITION: Closely associated with the preoperational maintenance and installation of the pump is the startingprocedures and operational adjustments.

7. Starting Procedures and Operational Adjustments (2 MIN)

a. Prime the suction hose and replace the strainer

b. Place hose in water

c. Close choke

d. Flip "ON-OFF" switch to "ON" position. (mil.std.eng)

e. Adjust throttle lever 1/4 open

f. Wrap starter rope clockwise around pulley and pull until engine starts

g. Once engine starts open choke

h. Let engine warm up for 5 minutes

i. After engine is warm open throttle all the way for maximum RPM's

j. Observe engine and pump during operation for any possible malfunctions.

TRANSITION: Further consideration must be taken when stopping these engines.

8. Stopping Procedures (2 MIN)

a. Wisconsin model engine

(1) Idle engine down for 5 minutes

(2) Cut engine off by grounding the prong on the side of the magneto to the magneto case.

b. Military standard engine

(1) Idle engine down for 5 minutes

(2) To stop engine flip "ON-OFF" switch to "OFF" position

TRANSITION: Once stopped the post operational maintenance must be taken care of.

9. Post Operational Maintenance (1 MIN)

a. Clean all surfaces with approved cleaning solvent

b. Check all fluid levels

c. Check to see if any components vibrated loose and retighten.

PRACTICE (1 MIN)

During the first half hour of practical application the instructor will demonstrate to the students, how to install the gaskets in the hoses, which hoses to use for suction and discharge, how to install a strainer and float to the suction hose, and how to prime these pumps. Once the instructor has completed the demonstration, he will for the remaining time guide each student during the preoperational check, and the priming of these pumps. The students will use both 55 and 65 GPM pumps. Once the pumps are primed, the students will operate the pumps, pumping from the source and discharging into a 3000 gallon tank. When the entire class has completed the operating of these pumps, they will perform 1st echelon and 2nd echelon maintenance on the equipment used during the period of instruction.

PROVIDE HELP: (1 MIN)

During the demonstration and practical application, two instructors will supervise the class and help solve any problems and answer any questions which arise from the students.

OPPORTUNITIES FOR QUESTIONS: (2 MIN)

1. QUESTIONS FROM THE CLASS:

2. QUESTIONS TO THE CLASS:

a. What type of oil does the 55 and 65 GPM pump use between the temperature of 120° to 40°F ?

A. 30 Weight Oil.

b. What type of pump is the 55 and 65 GPM pumps ?

A. Centrifugal type pumps.

c. Do the hoses involved with the 55 and 65 GPM pump have to be air tight?

A. Yes, they do.

SUMMARY: (1 MIN)

During the last period of instruction we have covered the procedures involved in the operation of the 55 and 65 GPM pumps. It will be your responsibility to update yourselves on the additions and modifications of these pumps.

PROGRESS TEST (5 MIN)

BREAK: (10 MIN)

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DETAILED OUTLINE

HASTY PIPELINE

INTRODUCTION:

(5 MIN)

1. GAIN ATTENTION: In the process of establishing your water point, you find out that you cannot set up the equipment close to the water source due to poor drainage, inadequate room, or the water source is inaccessible to the consumer. What means do you have available in order to overcome this problem?

2. PURPOSE: The purpose of this period of instruction is to provide you with the knowledge and skills needed to install a hasty pipeline.

3. INTRODUCE LEARNING OBJECTIVE(S) (MIN)

a. ENABLING LEARNING OBJECTIVE(S): Provided with 5 lengths of 2" pipe, 4 hasty couplings, and a hammer, install a hasty pipeline in accordance with TM 543, chapter 3. (1.4.1c)

b. I will do this by lecture and demonstration.

c. There will be a progress test at the end of lecture.

d. There will be performance test during practical application portion of this lesson.

TRANSITION: Now that we know what we are going to cover during this period of instruction, let us discuss the pipe line.

BODY: (MIN)

1. PIPELINES: The use of pipelines offer the following: (ON TP # 1)

a. Fewer maintenance problems on the equipment.

b. Provides greater potential output than can normally be obtained by other means.

c. Disadvantages of a pipeline:

(1) Cost of materials

(2) Time required for construction

(3) Availability of equipment

(4) Adaptability to field terrain

d. Components of a pipeline are: (ON TP # 2)

(1) Power driven pump - used as the prime mover for pumping the water, usually a 65 GPM or 55 GPM pump.

(2) Pipe and fittings are contained in the plastic pipe fitters assortment set which consists of the following:

(a) 1000 feet 2" polyvinyl chloride (PVC) pipe

(b) 20 hasty couplings or pipe couplings

(c) 24 - 2" two piece flanges, which may be used in place of the hasty couplings.

(d) 24 rubber flange gaskets, used in conjunction with the flanges.

(OFF TP # 2)

TRANSITION: Now that we know what pipelines are used for, the disadvantages, and components, let us look at the planning phase.

(ON TP # 3)(MIN)

2. PLANNING PHASE: The preliminary planning is of the utmost importance because this will determine how efficient the piping system will be. Things to consider are:

a. Distance - determine the distance from the water source to the location which you have selected for the proposed water point. By doing this you can determine the following:

(1) Amount of pipe which will be needed.

(2) How many pumps will be required.

b. Depressions - when selecting the route for the pipeline you should:

(1) Select the most level and direct route.

(2) Identify depressions in order that provisions can be made for supporting the pipe.

c. Elevation of the terrain from the water source to the proposed site should be taken into consideration in order that pumps can be staged properly to insure that the pumps will be able to pump the water at the rated capacity.

d. Staging of pumps - At times it will be necessary to use more than one pump, therefore it is essential that the distance, depressions and elevations be kept in mind.

(1) When staging pumps on level ground the maximum distance between pumps should not exceed 360 feet.

(2) Normal distance between pumps is 180 feet.

(OFF TP # 3)

NOTE: Whenever the elevation of the terrain is steep, the interval between pumps may be less than the normal distance stated.

TRANSITION: Once the planning phase is completed, the next phase is the installation of the hasty pipeline.

(ON TP # 4)(MIN)

3. INSTALLATION OF THE PIPELINE: Begins at the water source in the following sequence.

a. Installation of the first pump.

(1) Position pump near the water source making sure that the pump is as level as possible.

(2) Connect suction hose to the suction side.

(3) Put a foot valve or strainer on end of hose.

(4) Secure suction hose to a float or a stake driven into the water source in order that the suction point is submerged at least 4" under water but not resting on the bottom.

(5) Connect a suction hose to the discharge side if second pump is to be used, this will prevent the second pump from collapsing the hose.

(OFF TP # 4)

NOTE: When staging pumps it is necessary that suction hoses be used on both suction and discharge parts.

TRANSITION: Once the first pump is in place, the next step is to connect the pipes together.

b. Installation of the pipeline begins by connecting the first length of pipe to the hose from the pump discharge port with a hasty coupling.

(1) Place the two ends of the pipes end to end

(a) Place one half of hasty coupling underneath the pipe.

(b) Align the second half of the hasty coupling with the other half.

(c) Place the wedge or spike through the slots on the coupling.

(d) Using a hammer drive wedge until securely fastened.

(2) Use of flanges: (When hasty couplings are not available)

(a) Apply joint compound to threads of pipe and flange.

(b) Connect the flange halves to the end of each pipe.

(c) Place a flange together with flange bolts and two adjustable wrenches.

NOTE: Before going into the third phase, make sure that the pipeline is properly supported at all depressions.

TRANSITION: Once the hasty pipeline is installed and pumps are in place, the next step is to start pumping water through it.

(MIN)

4. STARTING PROCEDURE: When using more than one pump the following procedure must be followed.

a. Perform preoperational maintenance on pumps being used.

b. Prime the pump located at the water source.

c. Start pump at the water source first, then allow water to reach the next pump before attempting to start the subsequent pumps.

d. Once all pumps are operating, walk the length of the pipeline and inspect for leaks.

(1) If hasty couplings are leaking:

(a) Check for alignment of the pipeline.

(b) Tap hasty coupling wedge (spike) with hammer until the leak stops.

(2) If flanges are used and a leak is detected:

(a) Check pipeline for alignment.

(b) Using adjustable wrenches, tighten flange bolts until the leak stops.

e. Check pumps and pipeline frequently to make sure that no more leaks develop and that the pumps are operating properly.

TRANSITION: The last phase of the hasty pipeline is of course nothing more than dismantling it.

5. SECURING HASTY PIPELINE (MIN)

a. Shutdown pumps in the reverse method.

(1) PM all pumps

(2) Drain all water out of the pumps.

b. Disconnect all hoses.

c. Take pipelines apart.

OPPORTUNITY FOR QUESTIONS

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. When selecting the route the pipeline you should.

A. Select the most level and direct route.

b. Once the first pump is in place, the next step is to.

A. Connect the pipes together.

SUMMARY: During the last hour we covered what a pipeline is, the planning phase, installation of, starting procedure and securing the pipeline.

BREAK (10 MIN)

CONTROLLED PRACTICAL APPLICATION: (120 MIN)

During the practice phase the instructor will do the following:

1. Break the class down into teams of no more than five men per team.

2. Issue each team five lengths of 2" pipe, hasty couplings, hammer, and flanges.

3. Before the students construct the pipeline, the instructor will demonstrate step by step procedure for constructing a pipeline with hasty coupling and flanges.

4. Once the pipeline(s) has been constructed, pumps will be placed within the pipeline as instructed in class.

5. After pumps are in place:

a. PM pump

b. Prime pump at water source.

c. Start pump at the water source.

d. Allow water to reach the subsequent pump before starting the pumps.

e. Once the water is flowing out, walk the length of the pipeline and check for leaks. If leaks are detected, repair the leak by either:

(1) Tapping the wedge or strike further into the hasty coupling until leak stops.

(2) Id using flanges and leak is detected, tighten flange bolts until leak stops.

6. Upon completion of the practical application phase, the students will:

a. Disassemble the pipeline.

b. Disconnect hoses from pumps.

c. Drain pumps

d. PM pumps

e. Secure all materials and equipment

<u>PROVIDE HELP:</u> During the practical application phase an instructor will supervise the students and clarify any questions the students may have.

<u>OPPORTUNITY FOR QUESTIONS:</u> (MIN)

1. <u>QUESTIONS FROM THE CLASS</u>

2. <u>QUESTIONS TO THE CLASS</u>

<u>PROGRESS TEST</u> (MIN)

<u>SUMMARY:</u> During the last two hours you had the opportunity to construct a hasty pipeline.

<u>BREAK:</u> (MIN)

LIST OF SUPPORTING PAPERS

1. TP # 1 Pipeline
2. TP # 2 Components of a pipeline
3. TP # 3 Planning phase
4. TP # 4 Installation of pipeline
5.
6. Advance Sheet Student Outline

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DETAILED OUTLINED

HYPOCHLORINATION UNIT

INTRODUCTION

GAIN ATTENTION: (MIN)

How would you disinfect water in large quantities, if a hurricane hit Court House Bay and destroyed the watermain that runs from the storage tower, by the exchange? The water tower is your only water source.

LESSON PURPOSE: To familiarize the student with the operation of the hypochlorination unit.

NOTE: Learning objectives are neither specified nor measured during this lesson.

TRANSITION: We will now cover the nomenclature of the hypochlorination unit.

BODY

(SL # 1 ON)

1. Description and Data

   a. Hypochlorination Unit

      (1) portable

      (2) provide automatic chlorination

      (3) help chlorine residual

         (a) keeps residual the same if character of water remains constant

   b. Capabilities of Treating Water

      (1) rate of flow 2 to 100 GPM

      (2) chlorine feed

         (a) automatically proportioned

         (b) range from 10 to 1

c. Main Components

(1) hydraulically operated hypochlorinator

(2) a water meter

(3) a pressure regulating valve

(4) manual range adjusting valve

(SL # 1 OFF)

TRANSITION: Now let us turn our attention to the nomenclature of the hypochlorination unit.

(TP # 1 ON)

2. Nomenclature (MIN)

a. Stroke Controller

(1) Setting on stroke controller determines

(a) length of stroke of the pumping shaft

(b) quantity of hypochlorite solution pumped per stroke

(c) maximum length of stroke

1 the pointer is set at 10 on the dial

(2) Maximum hypochlorinator pump rate

(a) 60 gallons per 24 hours at 12 strokes per minutes

(TP # 1 OFF)
(SL # 2 ON)

b. Flow Controller

(1) Spring loaded diaphram and needle valve

(2) Maintains a fixed flow rate of water

(3) Stabilizes the force applied to the automatic hypochlorinator valve diaphram

(SL # 2 OFF)
(SL # 3 ON)

c. Hypochlorinator Water Supply Valve

(1) must be wide open during normal operation

(2) shut water supply off to hypochlorinator for maintenance

(SL # 3 OFF)
(SL # 4 ON)

d. Range Adjusting Valve

(1) creates a pressure drop in the main 2 inch water line

(a) turn handle to right to increase drop in pressure

(b) turn handle to left to decrease drop in pressure

(2) the setting on the valve governs the speed of the hypochlorinator

(SL # 4 OFF)
(SL # 5 ON)

e. Water Pressure Regulating Valve

(1) has a spring loaded diaphram

(a) valve is held closed until the pressure reaches 10 PSI under the diaphram

(SL # 5 OFF)
(SL # 6 ON)

f. Water Meter Register

(1) located on top of water meter

(2) totalizes the amount of water flowing through the by-pass line

(3) maximum allowable water pressure

(a) 125 PSI

(SL # 6 OFF)
(SL # 7 ON)

g. Water Pressure Gauge

(1) located on top of the balancing water valve

(2) indicates the hypochlorinator operating water pressure

(3) should maintain 10 PSI or greater

(SL # 7 OFF)
(SL # 8 ON)

h. Balancing Water Valve

(1) consists of

(a) diaphram

(b) valve seat rigidly fastened to the diaphram

(c) valve stem

(d) and a spring

(2) balances the pressure behind the pumping head diaphram, when the diaphram is on the discharge stroke

(SL # 8 OFF)

(SL # 9 ON)

(Instructor: Show back of unit and explain different locations of components on back of unit.)

(SL # 9 OFF)

TRANSITION: Keeping in mind the nomenclature of the Hypochlorination Unit, lets go on to the Priciples of Operation.

(TP # 2 ON)

3. Principles of Operation

a. Hypochlorinator

(1) hydraulically operate displacement pump

b. Flow controller

(1) controls of flow to a chamber behind the valve disphram

c. Cam Roller

(1) no pressure exsists behind the valve diaphram if the cam roller is on low portion of the cam

(a) pilot valve is open

(2) pressure then builds up behind the valve diaphram

(a) enough to overcome the force of the return spring

d. Pump Shaft and Pumping Head Diaphram

(1) moves forward to execute the pumping stroke

e. Pumping Stroke on Poppet Valves

(1) installed heads up, and tails down

(2) suction poppet is closed during this process

(3) discharge poppet is open

(a) solution is pumped out of a space between the head diaphram and pump body

f. Pumping Stroke

(1) continue until cam roller passes over the tip of a cam lobe

(a) the follower immediately drops down to a low portion of the cam

(b) the pilot valve opens

(c) pressure is relieved from behind the valve diaphram

(2) return spring pushes pump shaft back

(a) this opens the balancing water chamber to provide a suction stroke

(b) during this process the suction poppet is open, the discharge poppet is closed and a charge of hypochlorite solution is drawn into the pump body

(3) the number of strokes per minute which is executed by the hypochlorinator is determined by the speed at which the cam rotates.

(4) cam is paced from water meter

(5) speed at which hypochlorinator pumps

(a) will be in direct proportion to the amount of water passing through the meter.

(OFF TP # 2)

TRANSITION: Keeping in mind the principles of operation lets take a look at pre operational maintenance of the hypochlorination unit.

4. Pre-Operational Maintenance (MIN)

a. Inspection

(1) check for breaks, cracks, or missing components

(2) check to determine if all attachments required for operation are present and serviceable

b. Servicing

(1) clean all surfaces

(2) use only an approved cleaning solvent

(3) wash with potable water

BREAK (MIN)

Introductory Transition During the last hour of instruction, we covered the description, nomenclature, principles of operation, and the pre-operatinal maintenance of the Hypochlorination Unit. Let's now take a look at the components of the unit.

5. Installation (MIN)

a. Reservoir Support

(1) Lift from stowed position so that it lies parallel to the floor.

b. Hypochlorite Bag

(1) insert and attach the straps to hooks on the reservoir support

c. Inlet Hose (4 foot long)

(1) attach one end of petcock adapter

(2) place other end of hypochlorite bag

d. Hypochlorinator Suction Hose (5 1/2 foot long)

(1) attach one end to the hypochlorinator suction fitting

(2) attach a strainer to the other end and place in hypochlorinator bag

e. Waste Water Hose (8 foot long)

(1) attach one end to hypochlorinator adapter

(2) place the other end away from apparatus

f. Hypochlorinator Discharge Hose (20 inches long)

(1) connect between hypochlorinator discharge fitting and hose connector at inlet coupling

g. Connections at Inlet and Outlet

(1) 2 inch female pipe connections

(2) in some cases, adapters are furnished for

(a) 3 inch house

(b) 4 inch pipe discharge connection

<u>TRANSITION</u>: Now that we are familiar with the installation of the hypochlorinator unit, let's prepare it for starting.

6. <u>Preparation for Starting</u>

a. Check water piping, hose connections, and tube connections for leaks.

b. Make hypochlorite solution and pour into reservoir.

(1) use high test hypochlorite powder to clear water

(2) 10 ounces of hypochlorite powder to 5 gallons of water

(a) makes up 1 percent solution

(b) used for a rated flow near 100 GPM

c. Remove hypochlorite suction hose and strainer from solution reservoir and clean if necessary.

(1) replace hose and strainer in solution reservoir

d. Hypochlorinator Stroke Control

(1) indicator pointer set a 10 on dial

e. Open water supply valve in hypochlorilnator water supply line

(1) open range adjusting valve wide

f. Install poppet valves

(1) heads up, tails down

(2) two on unit

(3) located on suction and discharge side of pump body

(4) consists of:

(a) 2 gaskets

(b) 1 disc

(c) 1 poppet

TRANSITION: Once everything is preset on the hypochlorination unit it is ready to be put into operation.

7. Starting the Hypochlorination Unit (MIN)

a. Place unit into water line that is to be treated

(1) inlet and outlet markings must be observed

b. Decide what maximum flow is to be treated

(1) produce this flow through the apparatus

(a) maximum flow not to exceed 100 GPM

(2) range adjusting valve

(a) adjusts speed of hypochlorinator to 12 strokes per minute for maximum flow

c. Unit must be set so that the number of strokes per minute divided by 12 equals, actual flow at time of adjustment dived by maximum flow to be treated.

d. Hypochlorinator

(1) check to see if it is primed

(a) usually self priming

(2) priming may be aided by bleeding air out of the pump block priming plug.

(a) plug should be unscrewed during pumping stroke

(b) and quickly tightened at beginning of suction stroke

(c) if unit cannot be primed

1 check hypochlorinator suction line for air leaks

e. After hypochlorination unit has been in operation for a short time, take a chlorine residual test.

(1) if reading is low

(a) increase strength of hypochlorite solution

(2) if reading is to high

(a) set stroke control at "8" on dial

(3) if reading is still to high

(a) reduce stroke control setting to "6" on dial

(4) if reading is still above maxiumum

(a) dilute hypochlorite solution and repeat test

(5) chlorine residual test should be taken at frequent intervals

(6) hypochlorinate solution

(a) When solution drops to within 2 to 3 inches of the strainer a new batch is required.

(b) Unit will pump 60 gallons of solution in a 24 hour period, running at 12 stroke per minute.

(c) At a setting of "6" on the stroke control and a speed of 12 strokes per minute

1 unit will pump 36 gallons of solution in a 24 hour period.

TRANSITION: Once completed with the operation of the pump we must now stop it.

8. Stopping the Hypochlorination Unit (MIN)

a. The hypochlorinator will stop when water stops flowing through the main water line under treatment.

(1) Remove the hypochlorinator suction hose and strainer from the solution reservoir when unit is not in operation.

(a) remove suction and discharge poppet valves

(b) empty hypochlorite suction reservoir and rinse with fresh water

(2) Flush entire system with fresh water.

(3) Examine balancing water valve strainer and clean if necessary.

b. Cold Weather Shut Down

(1) Extremely essential that all water be drained from the unit.

(a) open all valves

(2) Take advantage of natural shelters

(a) construct wind breakers

(b) erect tenting

TRANSITION: Now that we have shut down the unit, lets take a look at the post operational maintenance of the hypochlorination unit.

9. Post Operational Maintenance (MIN)

a. Check for damage to unit from operation

b. Check all attachments and hoses for servicability

c. Clean all surfaces

PRACTICE: (MIN)

During the first hour of the practical application period, the instructor will have the students marched down to Camp Sweat, where he will discuss the nomenclature and operation of the hypochlorination unit. The instructor will also demonstrate how to install the hypochlorination unit into a hasty pipeline.

During the next three hours of the practical application time, the student will hook up a fifty-five GPM centrifugal pump, using one suction hose, a strainer, a float, a discharge hose, and gaskets. The students will then make all connections, airtight and prime the pump. They will then run a hasty pipeline, using at least seven sections of two inch pipe (galvanized or PUC), and a discharge hose at the end of the hasty pipeline. When the student incorporate the hypochlorination unit into the system they may place the unit anywhere in the pipeline past the discharge side and hose of the fifty-five GPM centrifugal pump. When they install the hypochlorination unit no extra hoses may be used other than those assigned to the unit.

(NOTE: Hypochlorinated water should be collected in a 3,000 gallon tank at the end of the discharge hose on the hasty pipeline, and a chlorine residual taken. All students will perform all necessary tasks involved.)

HELP PROVIDED: (MIN)

The instructor will remain with the students during their practical application time to aid in any problems or to provide any help that might be needed. An assistant instructor should also be on hand to assist.

OPPORTUNITY FOR QUESTIONS: (5 MIN)

1. QUESTIONS FROM THE CLASS:

2. QUESTIONS TO THE CLASS:

   a. How is the hypochlorinator operated?

   ANSWER: Hydraulically

   b. What is the maximum water flow?

   ANSWER: 100 GPM

   c. What do you use in cleaning the hypochlorinator unit?

   ANSWER: Approved cleaning solvent and potable water.

SUMMARY: (1 MIN)

During this period of insturction, we have covered the hypochlorination unit involved in the disinfection of water when the clorine residual must remain the same.

BREAK (10 MIN)

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DETAILED OUTLINE

U-22446 Water Purification Unit

INTRODUCTION

1. GAIN ATTENTION: (MIN)

As a Basic Hygiene Equipment Operator there will be times that you will have to provide safe drinking water for human consumption and other uses. One method of producing purified water is by the use of the U-22446 Water Purification Unit. Operated properly by knowing the proper procedures, this unit will produce 10-40 GPM.

2. PURPOSE: The purpose of this period of instruction is to provide you with the knowledge and skill necessary to properly operate the U-22446 Water Purification Unit.

3. INTRODUCE LEARNING OBJECTIVE(S) (MIN)

a. TERMINAL LEARNING OBJECTIVE(S): Provided with a U-22446 water Purification Unit, chemicals, fuel, and water supply, purify water in accordance with TM-01056C-14, chapter 2. (1.4.1)

b. ENABLING LEARNING OBJECTIVE(S): Provided with a U-22446 water Purification Unit, chemicals, fuel, and water supply:

(1) Point out the major components of the unit. (1.4.1d)

(2) Perform before operation maintenance on the unit. (1.4.1e)

(3) Install the unit. (1.4.1f)

(4) Start the unit. (1.4.1g)

(5) Add chemicals. (1.4.1h)

(6) Perform operational adjustments. (1.4.1i)

(7) Shut the unit down. (1.4.1j)

(8) Perform after operation maintenance on the unit. (1.4.1k)

in accordance with TM-01056C-14. Chapter 2.

TRANSITION: We know what our main objective is. Before we can achieve that objective we have to find out what the components are that make up the U-22446 Water Purification Unit.

(TP #1 ON)
BODY

(MIN)

1. Nomenclature - (Refer to SR-UT-P02, pp. 2-46 to 2-51.) The water Purification Unit is a frame-mounted, diatomic type unit with an adjustable flow rating of 10 to 40 gallons per minute. The unit consists of the following: (TP #1 OFF)
(TP #2 ON)

a. Machinery section - Consists of a pumping unit, a tool box, a diatomic slurry feeder and slurry hopper, hypochlorinator solution feeder and solution reservoirs, all necessary valves and fittings for connecting 2 inch hoses, and is frame mounted. This section's weight is 450 lbs.
(TP #2 OFF)
(TP #3 ON)
(TP #3 OFF)

(1) Pumping unit - consists of a centrifugal pump capable of continuously delivering 55 GPM against a total head of 50 feet including a 15 foot suction lift.

(2) Engine - is a single cylinder, four cycle, air cooled, rope-started, gasoline engine which drives the pump.

(a) Engine ignition system has a magneto, ignition cable, and spark plug

(b) Engine is stopped by pushing the magneto stop switch.
(TP #4 ON)
(TP #4 OFF)

(3) Tool box - has compartments for storing the color comparator, tools and spare parts.

(4) Slurry feeder - mounted alongside the gasoline engine and is operated at one-quarter engine speed by a V-belt and pulleys.

(a) Filter aid is mixed in the slurry hopper

(b) The hopper has a strainer and clamp-on cover

(c) A diaphragm type air compressor, pumps air to the slurry hopper keeping the slurry mix agitated.

(5) Hypochlorinator - mounted in line with the slurry feeder and is driven through a flexible coupling from an extension shaft off the slurry feeder. Calcium hypochlorite and water solution is mixed in the hypochlorinator reservoir.
(TP #5 ON)

b. Filter section

(1) The pressure type filter has a steel shell attached to a steel base in which are mounted seven cylindrical elements

(2) Valves, controls and hose adapters are mounted on the filter section for basic operations of, precoating, filtering and backwashing cycles.

(3) Adjustable flow controller maintains a constant preset flow during filtering.

(4) A steel cover protects the top of the filter section during transportation and is used as a precoat and recirculating tank during operation.
(TP #5 OFF)
(TP #6 ON)
(TP #6 OFF)
(TP #7 ON)

(5) Filter elements - consists of seven identical elements, individually mounted on nipples welded to a false bottom of the filter base. Each filter element is made up of a plastic sleeve, perforated steel tube assembly, a brass top cap, a tie rod, (12) plastic cups, two spacers, a cast bronze base, and an O-ring gasket.
(TP #7 OFF)

c. Precoat and recirculating tank

(1) When the filter is not in use, the steel precoat and recirculating tank (which is part of the filter section) fits over the filter shell. The tank is secured by four clamps.

(2) The tank holds 30 gallons of water when in use.

(3) The diatomaceous earth used for precoat is mixed in the precoat tank.

d. Accessory Equipment

(1) Color comparator and its components

(2) One - two quart measuring cup for D.E.

(3) One - five ounce measuring cup for chlorine

(4) Diatomic filter aid - may vary on how much water is to be purified and the water source.

(5) Calcium hypochlorite - may also vary on amount of water to be purified.

(6) Three - 25 foot length, 2" discharge hoses

(7) Six - 10 foot length, 2" suction hoses

(8) One - 2 inch strainer

(9) 3,000 gallon tanks - for storage and settling tanks

e. Distribution equipment

(1) Pumps, 3 - 55 GPM pump

(2) Hoses, suction and discharge hoses

(3) Water cans

(4) Tanks

<u>TRANSITION</u>: Now that we have identified the components of the unit and briefly discussed their function in the unit, lets move on to the installation of the unit for operation.

2. <u>Installation</u> (MIN)

a. Location - each item of equipment must be planned and the site prepared, to meet the following site conditions.

(1) Ground should be level as possible

(2) Ground should also be solid, (firm enough to handle weight of unit.)

(3) Drainage should run away from or downstream from raw water inlet at source.

(4) Sufficient space to set up settling tanks

(5) Good access to and enough space for storage area and distribution point

b. Raw water pump

(1) Set pump as close to source as possible. Must be located less than 15 feet above water.

(2) Connect a 1 1/2" or 2" suction hose with strainer to the suction side of pump.

(3) Connect a 1 1/2" or 2", 25 ft discharge hose to discharge side of pump to settling tanks.

c. Settling tanks

(1) Set up two tanks within 50 ft from source

(2) Fill and coagulate tanks

d. Filter and Machinery Section

(1) Filter and machinery sections should be set up approximately on the same level as and near the settling tanks.

(2) Machinery section should be set up so the suction hose from the machinery section can reach almost to the bottom of both tanks. The machinery section cannot be more than 15 ft above the bottom of the tank or the pump will not operate.

(3) Filter section should be set one hose length, (within 10' ft) from machinery section and towards closest direction to storage area.

(4) Precoat and recirculating tank should be set slightly off to the side and in between the filter and machinery sections.

e. Install hoses and drain plugs

(1) Install pump drain plugs

(2) Install slurry reservoir drain plug

(3) Take hypochlorinator drain hose and lift it up and tie the end to the side of the tank.

(4) Check all hoses for:

(a) serviceablity

(b) washers

(c) when installed - for an air tight fit

(5) One - 2 inch, 10 ft long suction hose from the pump suction valve to the source. (settling tank)

(6) One - 2 inch, 10 ft long suction hose from the restrictor valve to the filter inlet valve.

(7) One - 2 inch, 10 ft long suction hose from the filter outlet valve to the precoat tank.

(8) One - 2 inch, 10 ft long suction hose from the precoat tank to the opposite side of the pump suction valve.

(9) One - 2 inch, 10 ft long suction hose from the filter drain to the drainage area, which must run away from the source.

(10) one - or more if needed, 2 inch - 25 ft long discharge hose(s) from the flow control valve to the storage area.

f. Prepositioning of the valves:

(TP #8 ON)

(1) Filter section

(a) Filter inlet valve - OPEN. <u>NOTE</u>: This will allow the water being pumped from the machinery section to enter the filter section.

(TP #8 OFF)

(b) Adjustable flow controller - set between 10-40 GPM. (Normally set at 20 GPM.)

(TP #9 ON)

(c) Filter outlet valve - precoat position

(d) Filter drain valve - closed

(e) Filtered water sampling valve - closed

(TP #9 OFF)
(TP #10 ON)

(f) Air release valve - closed

(g) Air bleed valve - OPEN

(h) Petcocks (on flow controller) - closed

(TP #10 OFF)
(TP #11 ON)

(2) Machinery section

(a) Pump suction valve - set at source

(b) Solution make-up valve - OPEN

(c) Hypochlorinator pump - Poppet valves are installed with a gasket on bottom, a clear disc, the poppet heads up - tail down, and a gasket on top.

(TP #11 OFF)
(TP #12 ON)

(d) Hypochlorinator control setting - set on minimum of "2".

(e) Slurry feeder control setting - set on minimum of "0".

(f) Install slurry sight glass.

g. Storage tanks

(1) Set up the proper amount of tanks needed at the distribution point. Determined by the unit to be supported.

(2) Set up distribution pumps, hoses, and nozzles

(TP #12 OFF)

OPPORTUNITY FOR QUESTIONS (MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. What is diatomaceous earth used for?

A. Precoating filter elements inside the filter section.

b. What should you look for when installing hoses?

A. Serviceability, washers, and airtight fit.

BREAK (10 MIN)

INTRODUCTORY TRANSITION (MIN)

We now have the unit set up for operation; the installation of the unit, pumps, tanks and hoses. The next step prior to operation is maintenance.

BODY

3. Preoperation Maintenance (MIN)

a. Visual Inspection: Make a complete visual inspection of the equipment checking for:

(1) Broken, damaged or missing parts

(2) To determine if all units are mounted securely

(3) Check for leaks, fuel, oil water

(4) Check machinery section components for any type of leaks

(5) Fuel-tank holds 1 gallon of gas

b. Lubrication schedule and lubricants

(1) Lubricants

(a) SAE-30 for temperatures between 40°F to 120°F

(b) SAE-20W for temperatures between +5°F to +40°F

(c) SAE-10W for temperatures between -20°F to +5°F

(TP #13 ON)

(2) Lubrication Schedule

(a) Engine: Crankcase - holds 1 qt of SAE-30

1 Check prior to operation every 8 hours of operation

2 Change every 50 hours of operation or whenever necessary:

a Black - means it's burnt

b Milky in color - water in oil

c Brown - also indicates water in oil

(TP #13 OFF)
(TP #14 ON)

(b) Oil bath air filter

1 Check prior to operation

2 Change whenever necessary

3 Clean weekly

4 Oil recommended - SAE-30 above 32°F, SAE-10W below 32°F

(TP #14 OFF)
(TP #15 ON)

(c) Pump shaft seal

1 Check prior to operation

2 Every 8 hours of operation

3 Recommended oil - 2 to 3 squirts of SAE-10W

(TP #15 OFF)

(d) Slurry feeder gear box

1 Check prior to operation

2 Holds 7/8 of a quart of SAE-30W oil

3 Change when necessary

(e) Hypochlorinator gear box

1 Check prior to operation

2 Holds 3 1/2 quarts of SAE-30W oil

3 Change when necessary

TRANSITION: So far in preparing the U-2244b for operation, we have covered the installation and preoperation maintenance. We have the unit prepared for operation so now let's talk about the proper procedures for starting the unit.

4. Starting Procedures

a. Pump - Primed through the priming plug or

(1) Take a 3 gallon bucket of water and pour the water down the suction hose, from coagulated tank to pump until water comes out of solution make-up valve.

(2) Close solution make-up valve.

b. Engine

(1) Check fuel tank, fill if necessary

(2) Open fuel shut-off valve - at sediment bowl

(3) Open carburetor main fuel adjusting valve between 3/4 and 1 1/4 turns, (however, the fuel valve should already be preset)

(4) Adjust governor control to 1/4 speed

(5) Close carburetor choke lever

(6) Wind starting rope on pulley-clockwise

(7) Pull rope briskly to turn crankshaft over rapidly to start engine.

(8) If engine fails to start, repeat steps.

c. Filter section: As water flows into filter the air bleed valve must be adjusted as follows. Air bleed valve - closed when a good steady stream of water is flowing out. Note: (You will get a good steady stream of water once all the air has been bled out of the filter section)

d. Precoat tank

(1) The water will flow from the filter into the precoat tank.

(2) Allow the tank to fill 3/4 full.

e. Pump suction valve: Change to precoat/recirculating position

<u>TRANSITION</u>: At this time the unit is in the recirculating position, this is the time when you prepare and add your chemicals.

5. <u>Chemical Requirements</u>

a. Calcium hypochlorite

(1) Precoat tank - prepare 1/4 cup or 1-1/4 oz of HTH to be added in precoat cycle - (only needed during initial start).

(2) Hypochlorinator Reservoir - add 5 ounces of HTH in 2 qts of water, mix solution.

(a) Solution is added to reservoir and must be strained to catch calcium crystals.

(b) Fill reservoir up to 2 to 3 inches from top, using solution make up valve.

b. Diatomaceous earth

(1) Precoat tank - prepare 2 qts of D.E. to be added in precoat cycle.

(2) Slurry feeder - add 3 gallons of water. Add (5) two quart containers of D.E. into slurry hopper. (Note: for school purposes only; 2 qts of D.E. is added in the slurry hopper).

OPPORTUNITY FOR QUESTIONS (MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. How often should you change oil inside engine crankcase.

A. Every 50 hours of operation.

b. How much oil does the slurry feeder gear box hold?

A. 7/8 of a quart.

BREAK (10 MIN)

INTRODUCTORY TRANSITION

We have discussed the procedures for preoperation maintenance, starting of the unit and chemicals that are required. Let's finish with the operation procedures of the U-22446 Water Purification Unit.

BODY

6. Operational Adjustments (MIN)

a. Precoat cycle

(1) At this time add the 1 1/4 ounces of HTH and 2 quarts of diatomaceous earth to the precoat tank.

(2) Adjust the engine speed to 2600 RPM's, approximately 3/4 speed on governor control.

(3) Hypochlorinator control - Set control at "10" for 1 to 2 minutes, then back down to the minimum.

(4) Slurry feeder control - will remain on "2" until filter cycle.

(5) Precoat cycle will run until the water in the precoat tank is clear, and there is a good coat of D.E. on the filter sleeves.

(6) Flow of water - During pre-coating, the filter aid slurry is drawn from the precoat tank through the precoat suction line, through the pump suction valve to the pump. The pump forces the slurry through pump discharge line and through filter inlet valve into filter shell. In the filter shell the filter aid is deposited on filter elements and the water from the slurry passes through the elements. The water collects in the false bottom of the shell and pressure forces it through the filter outlet valve, through precoat discharge orifice, and through precoat discharge line back into the precoat tank. The pump continues to recirculate the precoat water until all the filter aid has been deposited on the filter elements.

b. Filter cycle

(1) Pump suction valve - change from recirculate to source

(2) Filter outlet valve - change to the filter position

(3) Hypochlorinator control - Normal setting would be set at 6 to 7, depending on chlorine residual of water being filtered.

(4) Slurry feeder control - Normal setting set at 2.

(5) Flow of water for filter cycle - Flow of water during the filter cycle is from the settling tank through raw water suction line and through the pump suction valve to the pump. The pump forces the raw water through pump discharge line to the filter inlet valve into the filter shell. Then passes through filter elements, depositing suspended matter, organisms, and the filter aid added by the slurry feeder. The water is forced out the false bottom of the filter shell through the filter outlet valve, out the adjustable flow control valve, to the filtered water discharge line to the filtered water storage tank.

(6) Take a chlorine reading of filtered water by using the filtered water sampling valve.

(7) Continue the filter cycle until one of the following occurs. If for any reason, any of these incidents occur then it would be necessary to go into the backwash.

(a) Effluent pressure gauge drops to 4 PSI

(b) The supply of settled water is exhausted

(c) The filtered water storage tank is full

(d) Interruption in the filter cycle

c. Backwash and Filter Flush-out

(1) Backwashing is necessary whenever the filter cycle is stopped.

(2) Backwashing removes the old filter cake from the elements, and drains it out through the drain valve.

(3) To change over from filter to backwash, proceed as follows:

(a) Close filter outlet valve

(b) Observe pressure on the effluent pressure gauge. When pressure on the effluent and influent gauges equal pressure, close filter inlet valve.

(c) Lower RPM's to idle speed.

(d) <u>Slap</u> open air release valve and at the same time open the filter drain valve. During this time you will hear a loud "bang" caused by a rush of air from the filter. This air blasts the filter cake off the outside of the filter elements. Then the broken filter cake and water will drain out of the filter shell, through the drain valve. Allow filter to drain.

(e) Flush out the bottom of the shell by opening the filter inlet valve one turn. Water from the pump will flow into the filter shell and flush out any filter cake or foreign matter remaining in the filter bottom.

(Note: Re-backwash should not be necessary, but if observation through the filter window discloses that all of the sticky cake was not completely removed it will be necessary to re-backwash.)

d. Re-Backwash Procedures

(1) Close down valve

(2) Close air release valve

(3) Open filter inlet

(4) Open air bleed valve until water flows out of it, then close air release valve.

(5) Allow effluent pressure to build up to the influent pressure.

(6) Close filter inlet valve.

(7) Slap open air release valve and open filter drain valve at the same time. Allow filter to drain completely.

(8) Flush out the bottom of the shell again by opening filter inlet valve one or two turns.

<u>TRANSITION</u>: The last two hours we have discussed the preoperation and operational procedures for the U-22446 Water Purification Unit. Now we will discuss the procedures for properly shutting down the unit.

7. Shut Down Procedures: When backwash and filter flush-out are completed and there are no further operations, shut down the Water Purification Unit as follows:

a. Set all valves for filter bottom flush-out - All valves in open position.

b. Set the slurry feeder dial and hypochlorinator dial to the minimum.

c. Operate the engine at idle speed for several minutes. Set throttle control at 1/4 speed.

d. Stop the engine by using the magneto ground switch.

e. Perform operator's service

TRANSITION: The most important part of a shut-down on any unit is post operation maintenance and checks.

8. Post-Operation Maintenance

a. Visual Inspection - Make a complete visual inspection of the equipment.

(1) Check for damage to unit from operation

(2) Check for leaks - fuel, oil, water

(3) Check fuel sediment bowl and turn off feed valve

(4) Perform scheduled preventive maintenance

b. Lubrication

(1) Engine

(a) Check engine crankcase oil - add if necessary

(b) Oil both air filters. Check and clean oil cup - refill with 1/4 cup of oil

(2) Pump shaft seal

(a) Check for leaks

(b) Lubricate with 1-2 squirts of oil

(3) Slurry feeder gear box. Check oil - if milky in color change oil and refill.

(4) Hypochlorinator gear box. Check oil - if milky in color change oil and refill.

c. Services

(1) Check V-belt for serviceability

(2) Remove sight glass and drain plug from slurry hopper

(3) Lower drain hose for hypochlorinator and drain hypochlorinator reservoir

(4) Clean both the hopper and reservoir

(5) Clean and empty precoat tank

(6) Disconnect all hoses

(7) Remove pump drain plug

(8) Replace precoat tank on top of the filter section

(9) Check raw water and distribution pumps

OPPORTUNITY FOR QUESTIONS (MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. What is the normal setting for the hypochlorinator control?

A. Normal setting is 6 to 7.

b. How much D.E. is added to the slurry hopper?

A. Five 2-quart containers to 5 gallons of water.

PROGRESS TEST (10 MIN)

DEMONSTRATION (MIN)

1. The primary and assistant instructor will have a U-22446 Water Purification Unit set up and will explain the complete installation procedures, preoperation procedures (show where all lubrication joints are), chemical preparation, and proper procedures for adding chemical solutions.

2. Starting procedures and operation adjustments will be explained and performed by instructor going through all cycle to shut down.

3. Shut down of unit and an explanation of post-operation maintenance and checks will be given.

4. The instructor will then instruct the students to break down into four teams and proceed with the practice application on the U-22446 Water Purification Unit.

CONTROLLED PRACTICAL APPLICATION

1. The students will break down into four teams, with the settling tanks already set up and treated water in the tanks. The students will install the unit, perform preoperation maintenance and checks, and gather and prepare the chemicals required.

2. The students will then start the unit and as a team go through the operating procedures as instructed.

3. The students will go through all the cycles of operation of the unit up to the shut-down of the unit. After the unit is shut down they will explain to each other the post-operation procedures.

4. At the end of each day the units will be completely secured, PM, and cleaned.

5. During the time of operation as the settling tanks empty, the students will be required to retreat (coagulate) a fresh tank to continue with the practical application phase.

NOTE: The primary and assistant instructor will remain with the students during the entire time of the practical application in order to answer any questions or problems and to give any additional instruction on the unit that will help the students in learning the unit.

OPPORTUNITY FOR QUESTIONS (MIN)

1. Questions from the Class: All questions will be answered on an individual basis during practical application.

2. Questions to the Class: No questions required after practical application.

BREAK (10 MIN)

LIST OF SUPPORTING PAPERS

1. Advance Sheet/Student Outline

2. Transparencies

    1. Nomenclature
    2. Machinery Section
    3. Pumping Unit
    4. Engine
    5. Filter Section
    6. Filter Section
    7. Filter Elements
    8. Filter Section
    9. Filter Outlet Valve
    10. Air Valve
    11. Machinery Section
    12. Control Settings
    13. Lubrication Schedule
    14. Air Filter
    15. Pump Shaft Seal

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DETAILED OUTLINE

600 GPH ERDLATOR

INTRODUCTION: (3 MIN)

1. GAIN ATTENTION: Purifying a 3,000 gallon tank of water using the U-22446 can take you up to an hour or better by the time you mix the chemicals, settle the tank and purify the water. The unit we are going to discuss now is an easy unit to operate. It may look complex, but once set up you are purifying water at a rate of 600 GPH, The water will be crystal clear, good tasting, and germ free, all within an hour.

2. PURPOSE: The purpose of this period of instruction is to provide the knowledge and skill needed to properly operate the 600 GPH Erdlator.

3. INTRODUCE LEARNING OBJECTIVES:

a. TERMINAL LEARNING OBJECTIVE(S): Provided with a 600 GPH Water Purification Unit (Erdlator), chemicals, two 3 gallon buckets, power supply, and water supply, purify water in accordance with TM-03957A-15, chapter 2. (1.4.2)

b. ENABLING LEARNING OBJECTIVE(S): Provided with a 600 GPH Water Purification Unit (Erdlator), chemicals, power supply, water supply, and two 3 gallon buckets:

(1) Point out the major components of the unit. (1.4.2a)

(2) Install the unit. (1.4.2b)

(3) Perform before operation maintenance on the unit. (1.4.2c)

(4) Prepare the required chemicals. (1.4.2d)

(5) Start the unit. (1.4.2e)

(6) Perform operational adjustments. (1.4.2f)

(7) Shut the unit down. (1.4.2g)

(8) Perform after operation maintenance on the unit.(1.4.2h)

in accordance with TM-03957A-15, chapter 2.

TRANSITION: As mentioned in the terminal learning objective, you will be tasked with the operation of the unit. Before you can go into operation you need to know about the components that make up the 600 GPH Erdlator.

BODY (47 MIN)

1. Nomenclature

a. The 600 GPH Erdlator, when operated properly, will produce 600 GPH of crystal clear, good tasting, and germ free water. It is a complex unit with some critical procedures that must be followed. At the same time, once the unit is set up, and the operator understands the unit, it is a simple unit to operate. (ON TP # 1)

b. Trailer

(1) The 600 GPH Erdlator is mounted on a 2 1/2 ton, 2 wheel trailer

(2) The trailer is equipped with air-operated hydraulic brakes, an electrical system for the stop and tail lights, and leveling jacks on the four corners of the trailer.

(3) A 2 1/2 ton - 6 x 6 truck or equal tactical vehicle is suitable for towing the trailer. (Off TP # 1) (ON TP # 2)

c. The Erdlator assembly consists primarily of the tank, influent launder, effluent launder, wet well sludge concentrator tank, slurry weir box, down comer tube, and agitator shaft with disks. Also part of the Erdlator assembly is the agitator speed reducer, drive motor, air pump, and bridge rails. The Erdlator assembly is mounted on a separate aluminum base equipped with six carrying handles. (OFF TP # 2) (ON TP # 3)

d. Erdlator Tank

(1) The erdlator tank is a circular funnel-shaped unit of one piece aluminum construction, with a capacity of approximately 245 gallons.

(2) A stub shaft and bearing support for the agitator are mounted in the bottom of the tank. There is a ring near the bottom secured to the tank with a series of short baffles which support the downcomer tube.

(3) A drawoff port is located opposite the weir box and another near the top which opens into the wet well.

(4) There are two drains, an upper drain for partial draining and a lower drain for complete draining.

(5) The erdlator tank serves as a separator which hydraulically separates the slurry blanket from the clear water in the upper section of the tank, which is known as the separation zone.

(6) It also serves as a clarifier as the flow of coagulated water is deflected at the bottom of the tank and directed in an upward rotating direction into the clarification zone. (OFF TP # 3)

e. Influent Launder

(1) The influent launder is of one-piece aluminum construction and is attached to the two bridge rails.

(2) The raw water is introduced into the influent launder, through the aspirators, from where it overflows into the downcomer tube or mixing zone.

f. Effluent Launder.

(1) The effluent launder is a one-piece hexagon shaped aluminum trough that surrounds the downcomer tube.

(2) It is attached to the bridge rails by three adjustable rods.

(3) It collects the clear water from the upper section of the erdlator tank and discharges it into the wet well tank.

g. Wet well tank.

(1) The wet well tank is made of aluminum and consists of a triangular section welded to the rear quadrant of the erdlator tank for collection of the effluent from the erdlator.

(2) It provides for limited storage of coagulated water, and serves as a sump for the suction of the filter pump.

(3) It contains an overflow pipe, to permit operation of the erdlator at rated capacity when the filter is stopped.

(4) A drain in the bottom of the wet well permits complete drainage of the tank to waste when water unsuited for filtering is obtained from the erdlator.

h. Sludge concentrator tank.

(1) The sludge concentrator tank is welded externally to the rear of the well tank.

(2) It is a square funnel-shaped aluminum tank with a shorter circular tank welded to the inside of it.

(3) There is an inlet in the side of the main tank near the bottom which permits the flocculent slurry to enter by gravity.

(4) The inner tank has an opening in the bottom controlled by a manually operated plug valve to permit intermittent drainage of slurry to waste.

(5) There is an outlet near the top of the main tank with a manually operated valve to control the flow of clear coagulated water to the wet well.

(6) There is also an outlet in the bottom for draining the tank.

i. Slurry weir box.

(1) The slurry weir box is a small aluminum tank welded externally to the erdlator tank.

(2) It houses the drawoff port near the top of the erdlator tank and permits gravity flow of flocculent slurry from the erdlator tank to the sludge concentrator tank. (TP # 3 ON)

j. Agitator and downcomer tube.

(1) The agitator consists of a tubular shaft with four equally spaced circular disks attached.

(2) It is mounted in the center of the erdlator tank on a bearing support.

(3) The agitator is surrounded by the downcomer tube and baffle ring to form the mixing zone. (TP # 3 OFF)
(TP # 4 ON)

k. Agitator speed reducer.

(1) The speed reducer is mounted on two spacers attached to the agitator bearing mounting plate.

(2) It reduces the speed from the agitator drive motor to the erdlator drive shaft.

l. Agitator drive motor.

(1) The agitator motor is mounted on a blanket attached to the bridge rails.

(2) It is a single-phase totally inclosed motor with oblong mounting holes in the base for use in adjusting the drive belt.

(3) The agitator drive motor also drives the air pump.

m. Air pump.

(1) The air pump is an oilless type with intake filter.

(2) It is mounted to the bearing mounting plate and driven off an extended shaft from the speed reducer.

(3) It is used to furnish air to the duplex chemical slurry feeders.

n. Bridge rails.

(1) The bridge rails consist of two aluminum channels attached to the top of the tank.

(2) They are used for supporting components of erdlator located over the tank.

TRANSITION: The erdlator unit also has the following components: (ON TP # 5)

o. Filter section: The filter section is mounted in a tubular frame and consists of:

(1) A filter specially designed to use diatomaceous earth.

(2) A filter pump for pumping coagulated water through the filter.

(3) Two pressure gauges for indicating the pressure on the effluent and influent sides of the filter.

(4) Precoat funnel, for adding prepared diatomite slurry for precoating the filter elements.

(5) Air release valve, for releasing air trappped in the filter elements.

(6) Flow controller, for maintaining a fixed constant rate of flow, through the filter.

(7) Additional valves and piping necessary for the operation of the filter. (TP # 5 OFF)

p. Chemical feeders.

(1) The chemical slurry feeder.

(a) An aluminum tank-like unit, mounted to brackets welded to the erdlator tank.

(b) Two identical chemical compartments and water collection troughs and two weirs, one of which contains a float operated needle valve.

(c) One compartment supplies pulverized limestone slurry (coagulant aid), to the mixing zone.

(d) One compartment supplies diatomite slurry to the suction inlet of the filter pump. (TP # 6 ON)

(2) Chemical solution feeder.

(a) Constructed of corrosive resistant material and is mounted to the erdlator mounting base.

(b) Consists of two diaphram pumps operated by one electric motor by means of a gear reduction mechanism.

(c) The chemical solution feeder pumps ferric chloride and calcium hypochlorite solutions from two rubber pails into the mixing zone.

(TP # 7 ON)

q. Raw water and filter pumps.

(1) The raw water and filter pumps are identical. Both are centrifugal, vertical type, powered by a self-contained, integrally built universal motor.

(2) Raw water pump.

(a) Used for pumping the raw water to the erdlator.

(b) It is mounted in a tubular frame designed to mount on the erdlator base when not in use.

(3) Filter pump.

(a) Used for pumping coagulated water from the wet well tank to the filter.

(b) It is mounted on the erdlator base.

r. Generator: generator set - 10 KW - 30 KW, is used for power source, when commercial power is not available.

TRANSITION: We have discussed what components make up the 600 Erdlator and have briefly explained their functions, now let's move to the installation of the unit.

(TP # 8 ON)

2. INSTALLATION

a. Site selection.

(1) Select a site that is relatively level.

(2) Natural camouflage.

(3) Existing roads available for access.

(4) Within 50 ft of water source.

(5) Minimum improvement required.

b. Trailer.

(1) Position trailer and disconnect from towing vehicle.

(2) Lower the four leveling jacks and level the unit.

c. Accessories.

(1) Set up distribution tanks, trying to remain within 50 ft of unit.

(2) Set up distribution pump.

d. Safety check.

(1) Ground the 600 Erdlator with a 6 ft ground rod and cable.

(2) Check all circuit breakers. They must be in the "Off" position.

(3) Check all wires and make sure there are no loose or frayed wires.

e. Install hoses.

(1) Check all hoses for the following:

(a) Serviceability - no cracks, cuts, crushed sections in hose.
(TP # 8 OFF)
(TP # 9 ON)

(b) Type - the hose is either a rubber suction hose or cotton discharge, must have the proper type.

(c) Size - the hose must be the proper size for the flow of water.

(d) Washers - the hose must have a washer in it to prevent leakage and form an air tight fit on the connections.

(2) Connections

(a) 1" x 10" suction hose with strainer source to raw water pump.

(b) 1" x 25' discharge hose, raw water pump to raw water inlet pipe.

(c) 1" x 10' suction hose, (SV-12) filter pump discharge valve to (CV-13) filter input valve.

(d) 1" x 10' suction hose, (CV-23) filter outletvalve at 45° elbow to wet well tank.

(e) 1" x 25' discharge hose, (CV-23) filter outlet valve at 90° elbow to storage tank.

(f) 1 1/2" x 10' suction hose (DV-3) complete drain valve to waste

(g) 1 1/2 x 10' suction hose (DV-16) filter drain valve to waste.
(TP # 9 OFF)
(TP # 10 ON)

f. Valve - pre-operation positions.

(1) FCV-1 raw water restrictor valve 10 GPM

(2) LL CV-1 raw water bypass valve Open

(3) BV-1 raw water inlet valve Open

(4) CV-2 limestone slurry feed valve Partially Open

(5) DV-3 complete drain valve Closed

(6) DV-4 partial drain valve Closed

(7) CV-5 solution make-up valve Closed

(8) BV-6 weir box outlet valve Open

(9) CV-7 liquid level control valve Closed

(10) CV-8 sludge control valve Open to first notch

(11) CV-9 sludge drain valve Closed

(12) DV-10 wet well drain valve Open

(13) CV-11 DE slurry feed valve Closed

(14) BV-12 filter pump discharge valve Closed

(15) CV-13 filter input valve Filter

(16) VV-14 vent valve Open

(17) CV-15 precoat feed valve Closed

(18) DV-16 filter discharge valve Closed

(19) ARV-17 air release valve Filter

(20) BV-18 filter discharge valve Open

(21) DC-19 drain cock Closed

(22) CV-20 flow control valve Set at 10 GPM

(23) DC-21 drain cock Closed

(24) DC-22 drain cock Closed

(25) CV-23 filter output valve Recirculate

(26) CV-24 air control valve, Partially Open

(27) DV-25 drain plug for raw water pump Closed

(28) DV-26 drain plug for filter pump Closed

(TP # 10 OFF)

BREAK (10 MIN)

INTRODUCTORY TRANSITION: (1 MIN)

The past hour we discussed the nomenclature, the components of the unit, and also the installation procedures. Let's finish with preparing the unit and move to the operation of it.

ENABLING LEARNING OBJECTIVE(S):

1. When provided with a 600 GPH erdlator, perform preoperational maintenance on the unit in accordance with TM-03957A-15. (1.4.6.3)

2. When provided with a 600 GPH erdlator, prepare the required chemicals for the unit in accordance with TM-03957A-15. (1.4.6.4)

3. When provided with a 600 GPH erdlator, start the unit in accordance with TM-03957A-15. (1.4.6.5)

BODY (49 MIN)

3. Chemical Solutions.

a. Chemical requirements.

(1) Ferric chloride.

(a) Used as a coagulant.

(b) Solution - 1 lb of ferric chloride mixed in a 3 gallon pail.

(2) Pulverized limestone.

(a) Used as the coagulant aid.

(b) Solution - 120 PPM of limestone mixed in slurry hopper.

(c) Solution is recharged every hour with 120 PPM.

NOTE: Limestone is not added until erdlator air pump is operating.

(3) Calcium hypochlorite (4th).

(a) Is a disinfectant.

(b) Solution - 0.15 pounds of calcium hypochlorite mixed in a 3 gallon pail.

(4) Diatomaceous earth (D.E.).

(a) Used as a filter aid.

(b) Solution - the D.E. slurry is used in two places.

1 0.4 lbs of D.E. mixed in filter precoat funnel.

2 .10 lbs of D.E. mixed in slurry hopper.

3 D.E. is recharged in slurry hopper every hour with .10 lbs.

NOTE: D.E. is not added in hopper until precoat cycle is finished.

(5) Activated carbon.

(a) Used as an absorbent.

(b) Removes any unpleasant odor or taste in the water.

(c) Solution - 0.25 lbs of activated carbon is mixed into the limestone slurry hopper when needed.

CAUTION: Do not mix ferric chloride and calcium hypochlorite together. When the two chemicals are mixed they form a poisonous chlorine gas.

b. Chemical Scale Settings.

(1) Ferric chloride - indicator set at 1.2 on the scale of the chemical solution.

(2) Calcium hypochlorite - indicator set at 5.0 on the scale until tank is filled.

TRANSITION: The next step in preparation is maintenance. The unit has to be checked and preoperation maintenance must be performed. This stage can be performed anytime during preparation.

4. Preoperation Maintenance - daily services.

a. Visual inspection.

(1) Check for leaks, water, oil, fuel.

(2) Check for loose or missing bolts, screws, nuts.

(3) Inspect for damage to unit, especially in cold weather operations.

(a) Check for frozen, or cracked valves.

(b) Check for frozen pipes or sections of unit.

(4) Instruments and controls.

(a) Check for loose connections.

(b) Check for cracked or broken glass (gauges).

(TP #8a ON)

b. Lubricants and Lubricant Interval.

(1) Lubricants.

(a) OT-10 insulating oil, electrical.

(b) OE-10 oil, engine, heavy duty.

(c) GO lubricant, gear oil.

(d) GOS lubricant, gear oil sub-zero temperature.

(e) GAA grease, automotive and artillery. (TP # 8a OFF)
(TP # 8b ON)

(2) Lubrication Schedule.

(a) Solution feeder.

1 Drive arms - every 50 hours
- sparingly with OE-10

2 Lever arm - every 50 hours
- sparingly with OE-10

3 Drive arm bearings - every 250 hours
- sparingly with GAA

4 Gear case - checked before operation
- every 10 hours of operation
- changed every 500 hours
- 1 1/4 Qt OT-10 (TP # 8b OFF)
(TP # 9a ON)

(b) Agitator.

1 Agitator reduction gear - every 50 hours
- sparingly with GAA
- drained and refilled every 1,000 hours
- GO every 10 hours

2 Agitator shaft bearing - every 50 hours
- sparingly with GAA

(TP # 9a OFF)
(TP # 9b ON)

(c) Trailer - leveling jacks - when in use every 250 hours
- sparingly with GAA

(TP # 9b OFF)

NOTE: Lubricants are applied sparingly or approximately 1 to 2 ounces.

TRANSITION: Once everything is set up, the unit has been checked and scheduled maintenance performed, you are then ready to start the unit.

5. Starting the unit.

a. Generator.

(1) Perform before operation maintenance.

(2) Make sure unit is grounded.

(3) Start generator.

b. Raw water pump - prime raw water pump.

c. Circuit breakers.

(1) Turn on main breaker.

(2) Turn on raw water pump.

(3) Prime and start solution feeder. Solution feeder is started as soon as you have water in the influent launder.

d. Agitator - start agitator drive as soon as you have 1 foot of water in erdlator tank.

e. Solution feeder.

(1) Fill both compartments in slurry feeder with water.

(2) Once air pump starts agitating water add 120 PPM of limestone to limestone slurry hopper compartment.

(a) Add .25 lb activated carbon if needed.

(b) Set timer on front for recharge.

(c) Limestone is recharged every hour with 120 PPM.

BREAK (10 MIN)

INTRODUCTORY TRANSITION (1 MIN)

We discussed the maintenance, chemicals, and starting procedures of the unit in the last hour. Now that we have the unit in operation there are procedures that we must follow in order to operate the unit properly.

ENABLING LEARNING OBJECTIVE(S):

1. When tasked with the operation of the 600 GPH erdlator, perform operational adjustments to the unit in accordance with TM-0397A-15. (1.4.6.6)

2. When tasked with the operation of the 600 GPH erdlator, shut the unit down in accordance with TM-0397A-15. (1.4.6.7)

3. When tasked with the operation of the 600 GPH erdlator, perform post operational maintenance on the unit in accordance with TM-03957A-15. (1.4.6.8)

BODY (49 MIN)

6. During Operation Adjustments - under normal conditions.

a. Chemical adjustments.

(1) Ferric chloride.

(a) If water in erdlator tank is cloudy, increase the ferric chloride.

(b) If water in erdlator tank is red, decrease ferric chloride.

(2) Limestone.

(a) If the floc in the erdlator tank appears to be light and rising, increase limestone.

(b) If the floc in the erdlator tank appears heavy and rolling, decrease limestone.

(3) Activated carbon - if there is any unpleasant odor or taste to the water that is purified, add activated carbon to the limestone side of the slurry hopper.

b. Belt - rotating adjustments.

(1) If floc blanket in the tank is banking and sloshing against the sides, decrease the speed on the agitator speed reducer.

(2) If there is little or no movement in floc blanket, increase the speed of the agitator speed reducer.

c. Effluent launder.

(1) As water fills in the erdlator tank one side of the effluent launder is lowered. This allows foreign matter to drain off into the wet well and be drained out to waste.

(2) Once the tank is clear, level the effluent launder so that the water flows evenly through the holes in the sides. This allows constant flow of coagulated water into the wet well.

d. Chemical solution feeder adjustment - HTH - adjust scale setting down to 1.2 on chemical solution feeder.

e. Valve adjustments.

(1) DV-10 - wet well drain valve - closed.

(2) CV-9 - sludge drain valve - partially opened.

(3) CV-7 - liquid level control valve - opened.

f. Wet well - turn on wet well low level alarm.

(1) Circuit breaker - in control cabinet.

(2) Toggle switch - on outside of control cabinet.

g. Four cycles of operation.

(1) <u>Precoat cycle</u>.

(a) Fill precoat funnel - 2/3 full with coagulated water.

(b) Take 0.4 lbs of D.E. and mix it with the water in the precoat funnel.

(c) Open CV-15, precoat feed valve, and allow slurry to drain into bottom of filter.

(d) Close CV-15 when funnel is empty.

(e) Open BV-12 filter pump discharge valve.

(f) Start the filter pump.

(g) Close VV-14 when a steady stream of water comes from the valve hose.

(h) Precoat cycle may last from 4 to 6 minutes or until you can see a good coat or cake of D.E. on the filter sleeves.

(i) Flow of water during precoat cycle: The water leaves the wet well through a yellow pipe into the filter pump. It travels through DV-12, through the 10' piece of suction hose into CV-13. It drops down through CV-13 into the bottom of the filter section. It rises on the inside of the filter housing on the outside of the filter sleeves, until it reaches the top of the housing. The water is then forced through the filter sleeves and elements leave a cake of D.E. on the outside of the filter sleeves. Water then drops down through the effluent section through the bottom housing into BV-18, CV-20, into CV-23 which is in the recirculate position, out the 45° elbow through the 10' suction hose and back into the well tank.

(2) <u>Filter cycle</u>.

(a) Chemical slurry: D.E. - add .10 lbs to diatomite slurry hopper

(b) Valves.

1 Change CV-23 from recirculate to filter.

2 Crack CV-11 to allow a small amount of D.E. to enter the line behind the filter pump to the filter housing.

(c) Filter cycle may run from 10 minutes to 10 hours, depending on the source conditions.

(d) Flow of water for filter cycle: The flow of water from the wet well and through the filter is the same as the flow in the precoat cycle until the water reaches CV-23. During filter, CV-23 is set on "FILTER" position. The flow of water leaves CV-23 out the 90° elbow and the 1"x25' cotton discharge hose to the storage tank.

(3) Backwash.

(a) Reasons or times for backwash.

1 Source is dry - no longer capable of drawing sufficient water from source.

2 Storage tanks are full.

3 Interruption in operation.

4 Effluent pressure gauge drops to 5 PSI caused by filter element clogging up with impurities and D.E.

(b) Valve adjustments.

1 Close BV-18 - filter discharge valve.

2 Close CV-11 - diatomite slurry feed valve.

3 Filter effluent pressure gauge must equalize the pressure of the influent pressure.

4 Turn off filter pump.

5 Immediately close BV-12 filter pump discharge valve.

6 Change ARV-17 air release valve, from filter to backwash and open DV-16 filter drain at same time.

7 Open VV-14 vent valve.

8 Allow filter to drain completely.

(4) Wash cycle.

(a) Change CV-13 - filter input valve, from filter to wash.

(b) Open BV-12

(c) Start the filter pump and wash for one minute.

(d) Turn off the filter pump.

(e) Close BV-12

(f) Allow filter to drain completely.

TRANSITION: At this time you would determine if you were going back into operation again or if you are going to secure and shut down the unit. We are now going to discuss the shut down procedures.

7. Shut Down Procedures.

a. Turn off agitator drive circuit breaker.

b. Remove chemical solution suction hose from buckets.

c. Allow solution feeder to run until all the chemical is pumped out of tubing.

d. Empty HTH and ferric chloride pails.

CAUTION: Do not dump HTH and ferric chloride in the same waste area.

e. Turn OFF chemical solution feeder.

f. Turn OFF raw water pump.

g. Turn OFF wet well alarm circuit breaker.

h. Turn OFF wet well alarm toggle switch.

i. Shut down main breaker.

j. Generator.

(1) Shut down generator.

(2) Disconnect power cable.

k. Valve adjustments.

(1) Open DV-4

(2) Open DV-3

NOTE: If shut down does not exceed 2 days or the unit is not going to be moved, do not open DV-3. This will allow the unit to be started without having to form a new floc.

(3) Open CV-5, after water level has dropped below the valve.

(4) Open CV-11

(5) Open DV-10

(6) Open CV-9

(7) Open CV-7 and CV-8

(8) Remove vent plugs on limestone and D.E. slurry compartments.

NOTE: Drain slurries into a pail.

(9) Open BV-12

l. Disconnect raw water pump discharge and suction hose.

m. Remove all hoses, drain and put in proper storage area.

n. Remove drain plugs DV-25 and DV-26 from filter pump and raw water pump.

o. Once pumps are drained reinstall plugs.

p. Clean the raw water pump and wrap up electric cord, and place pump in proper storage area.

TRANSITION: In addition to the steps which we have discussed previously the most important part of securing a unit is cleaning and post operational maintenance.

8. Post Operation Maintenance

a. Visual inspection.

(1) Check for leaks, water, oil, fuel.

(2) Check for loose or missing bolts, screws, nuts.

(3) Check for damage to the unit from operation.

b. Tools and equipment.

(1) Make sure all tools are cleaned and still in serviceable condition.

(2) Accessory equipment assigned to the unit is cleaned, serviceable and properly stowed or mounted.

c. Trailer and unit.

(1) Clean foreign matter from external parts of unit.

(2) Remove oil, grease, mud, chemical from unit.

(3) Clean trailer, bed, sides, tailgate, ladder.

d. Lubrication.

(1) Perform scheduled preventive maintenance from consolidated log.

(2) All lubrication points should be checked.

e. Canvas or Paulin.

(1) Replace all roof bows.

(2) Place paulin on roof bows properly.

(3) Secure tie down ropes to lashing hooks on sides, front and rear of trailer.

(4) Buckle straps on front and rear corners of paulin.

f. Leveling jacks - if unit is to be moved to another area raise leveling jacks.

PROGRESS TEST (10 MIN)

BREAK: (10 MIN)

DEMONSTRATION: (50 MIN)

The instructor will move the class to Camp Sweat for a complete demonstration on the 600 GPH erdlator.

Show and explain how the unit is installed, preoperational maintenance, preparation and required chemicals, operation of unit; starting the unit, operational adjustments, shutdown of unit, post operational maintenance.

BREAK: (10 MIN)

PRACTICE: (MIN)

After the demonstration the class will be broken down into 4 teams. Each team will use their notes and references to put their unit into full operation. Four 600 GPH erdlators will be utilized for the practical application.

The students will go through all procedures one at a time, with the rest of the team at the unit following along with their notes.

NOTE: Trailer mounted units may be used if necessary.

PROVIDED HELP:

The primary instructor and one assistant instructor will remain with the students during the entire practical application of the unit. Survey all 4 teams to make sure they are following their notes and applying the procedures correctly. Answer any questions from the students concerning the operation of the unit. Aid students who are in need of additional instruction.

OPPORTUNITY FOR QUESTIONS: (10 MIN)

1. QUESTIONS FROM THE CLASS:

2. QUESTIONS TO THE CLASS:

a. What type of oil goes into the chemical solution feeder pump?

ANSWER: Electrical insulating oil.

b. What are the four cycles of operation?

ANSWER: Precoat, filter, backwash, and wash.

c. What chemical solution would be adjusted to correct the floc in the erdlator tank if it is heavy and rolling?

ANSWER: Decrease limestone.

SUMMARY:

During this period of instruction you were provided with the knowledge and skill to identify the components, install the unit, perform peroperation maintenance, operational procedures, shutdown and post operational maintenance on the 600 GPH erdlator.

POST TEST: (MIN)

BREAK: (10 MIN)

LIST OF SUPPORTING PAPERS

1. TP #1 - Trailer Mounted Unit
2. TP #2 - Erdlator Assembly
3. TP #3 - Erdlator Tank
4. TP #4 - Agitator Speed Reducer
5. TP #5 - Filter Section
6. TP #6 - Chemical Solution Feeder
7. TP #7 - Raw Water Pump
8. TP #8 - Installation
9. TP #9 - Hose Connections
10. TP #10 - Valves
11. TP #8a - Lubricants
12. TP #8b - Lubrication Chart
13. TP #9a - Agitator
14. TP #9b - Trailer Lube Chart
15. SR-UT-P02 Student Handout
16. Advance Sheet
17. Student Outline

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DETAILED OUTLINE

1500 GPH WATER PURIFICATION UNIT

INTRODUCTION:

1. GAIN ATTENTION: (MIN)

The 1500 GPH Erdlator is larger and a little more complicated than the 600 GPH Erdlator, but the 1500 GPH Erdlator does operate relatively similiar to the 600 GPH Erdlator. The 1500 GPH Erdlator will produce potable and palatable drinking water from raw water at a rate of 1,500 gallons per hour.

2. PURPOSE: The purpose of this period of instruction is to provide the information and knowledge necessary to operate the 1500 GPH Erdlator.

3. INTRODUCE LEARNING OBJECTIVES (MIN)

a. TERMINAL LEARNING OBJECTIVE(S): Provided with a 1500 GPH water Purification Unit (Erdlator), chemicals, two 3 gallon buckets, power supply, and water supply, purify water in accordance with TM-04461A-15, Chapter 2. (1.4.3)

b. ENABLING LEARNING OBJECTIVE(S): Provided with a 1500 GPH water Purification Unit (Erdlator), chemicals, power supply, water supply, and two 3 gallon buckets

(1) Point out each major component of the unit. (1.4.3a)

(2) Install the unit. (1.4.3b)

(3) Perform before operation maintenance on the unit. (1.4.3c)

(4) Prepare the required chemicals. (1.4.3d)

(5) Start the unit. (1.4.3e)

(6) Perform operational adjustments. (1.4.3f)

(7) Shut the unit down. (1.4.3g)

(8) Perform after operation maintenance on the unit. (1.4.3h)

in accordance with TM-04461A-15, Chapter 2.

TRANSITION: As mentioned earlier, the 1500 GPH Erdlator does operate relatively similar to the 600 Erdlator, but the components are larger and some are different from the 600 Erdlator. Let's cover the components that make up the 1500 Erdlator.

(TP #1 ON)

BODY

1. NOMENCLATURE

a. Van type body mounted water purification unit, Met-Pro Model 1500-2600, which consists of water purification equipment installed in an insulated and heated van body.

(TP #1 OFF)

(TP #2 ON)

(TP #2 OFF)

(TP #3 ON)

b. Erdlator assembly

(1) Erdlator tank - is a circular funnel-shaped unit of one piece construction with a capacity of approximately 530 gallons.

(2) Agitator shaft with circular disks. The agitator shaft is a tubular shaft with five equally spaced circular disks attached. The agitator is surrounded by the downcomer tube and baffle plates to form the mixing zone.

(3) Sludge concentrator tank - is welded to the front of the wet well tank. It is a square funnel-shaped aluminum tank with a shorter circular tank welded inside of it. The inlet for the main tank is near the bottom which permits flocculant slurry to enter by gravity.

(4) Wet well tank - is made of aluminum and is a triangular section welded to the erdlator tank for collection of effluent from the erdlator.

(5) Influent launder - unlike the 600 Erdlator, the 1500 Erdlator has two influent launders mounted on the two bridge rails. The raw water is introduced into the influent launders by four aspirators from where it flows into the downcomer tube.

(6) Aspirators - the four aspirators are located at the end of the raw water piping. They direct the raw water into the influent launder and provide aeration of the raw water.

(TP #3 OFF)

(7) Agitator drive motor - is mounted on an adjustable sliding base attached to the bridge rails.

(8) Speed reducer - is a worm-gear type used to reduce the drive speed from the agitator drive motor to the agitator shaft.

(TP #4 ON)

(9) Filter section - consists of: One diatomite filter, one filter pump, a precoat funnel, air release valve, and additional valves and piping necessary for the flow and operation of the filter.

(TP #4 OFF)

(TP #5 ON)

c. Chemical feed equipment

(1) Slurry feeder - provides pulverized limestone to erdlator tank and a diatomite slurry to the filter. The slurry feeder is an aluminum alloy casting with two watertight compartments. Each compartment has a capacity of 14 gallons of water.

(TP #5 OFF)

(TP # 6 ON)

(2) Chemical solution feeder assembly - feeds ferric chloride and calcium hypochloride solutions into the erdlator tank. The assembly consists of two diaphragm pumps, electric motor, gear reduction mechanism, reciprocating mechanism, and priming levers. Has an adjustable feed rate of 1/2 gph to 2 gph without stopping the pump with scale setting of 1.0-5.0 ppm.

(TP #6 OFF)

(TP #7 ON)

d. Supporting equipment

(1) Electric pumps, two electric self-priming, portable centrifugal pumps. Electric motor, 208 volts AC, 3 phase, 60 cycle. Pumps have a 1-1/2 inch suction and discharge ports with a capacity of 65 gpm at a 50 foot head.

NOTE: One electric pump is generaly used as a distribution pump. Both pumps may be used in series for pumping raw water farther than 50 feet.

(2) Auxiliary pump is a gasoline engine driven pump and is a 2 inch integral, self-priming pump capable of producing 65 gpm at a 50 foot head.

(TP # 7 OFF)

(3) Water storage tanks, three collapsible fabric tanks, 3,000 gallon capacity each, used for storage of filtered water. (TP # 8 ON)

(4) Personnel heater; is used for protection of personnel when operating during inclement conditions. The heater is thermostatically controlled, multi-fuel, combustion air motor and blower, with safety controls. It operates on 115 volts AC, 60 cycle, single phase and is rated at 60,000 BTU's.

NOTE: If gasoline is used, 1 pt of oil must be added to each 5 gallons of gasoline.

(5) M-64 set - contains all necessary fittings, floats, tools, power cables, measuring cups, and color comparator.

OPPORTUNITY FOR QUESTIONS: (MIN)

1. Questions from the class:

2. Questions to the class: None are required at this time.

SUMMARY: (MIN)

During the past hour, I covered the nomenclature of the 1500 GPH Water Purification Unit.

BREAK: (MIN)

INTRODUCTORY TRANSITION:

We have identified the components of the 1500 Erdlator. Let's cover the preoperation procedures with installation.

2. INSTALLATION: (MIN)

a. Locate source and set up unit as close to source as possible on relatively level terrain.

(TP # 9 ON)

b. Remove leveling jacks from the storage box and place one under each corner of the van.

c. Check levels on sides and rear of van to ensure the van is level.

(TP # 9 OFF)

d. Open side panel doors (weather permitting) for easy access to installed equipment.

e. Unload all supporting equipment - M-64 set.

TRANSITION: The next phase is to set the valves before the unit can be started.

(TP # 10 ON)

f. Preoperation valve settings - (REFER STUDENTS TO STUDENT HANDOUT). Valve sequence or codes are:

ARC - Air Release Valve
CV - Control Valve
DV - Drain Valve
VC - Vent Cock
DC - Drain Cock
BPV - Bypass Valve
FV - Float Valve

(TP # 11 ON)

Symbol	Location	Name & Function	Position
DC-1	Raw water line flow indicator manifold	Draincock - influent side of manifold	Closed
DC-2	Raw water line flow indicator manifold	Draincock - effluent side of manifold	Closed
BPV-3	Raw water line flow indicator manifold	Bypass valve - Raw water line flow indicator	Closed
CV-4	Raw water line flow indicator manifold	Control valve - influent side of raw water line flow indicator	Open
CV-5	Raw water line flow indicator manifold	Contol valve - effluent side of raw water line flow indicator	Open
CV-6	Raw water line to slurry feeder	Ventcock - Top of raw water line	Closed
CV-7	Raw water line to limestone slurry feeder	Control valve - Raw water feed for limestone slurry feeder	Open

Symbol	Location	Name & Function	Position
CV-8	Raw water line to slurry feeder tank	Control valve - Limestone hopper water feed valve	Partially open
CV-9	Raw water line to manifold aspirator	Control valve - Raw water influent valve	Open
CV-10	Raw water influent line to aspirator	Control valve - Raw water aspirator valve	Open
CV-11	Raw water influent line to aspirator (Rear influent launder)	Control valve - Raw water aspirator valve	Open
BPV-12	Raw water level alarm piping	Bypass valve - controls raw water rate of flow	Open
CV-13	Raw water level alarm piping	Control valve - controls flow of raw water on bypass line	Open
CV-14	Coagulated water line from slurry takeoff weirbox to sludge	Weir box outlet valve - Permits drainage of sludge	Closed
CV-15	Coagulated water line from erdlator tank to diatomite dilution box	Solution make-up valve - supplies coagulated water for mixing chemicals	Closed
CV-16	False bottom of the concentrate tank	Sludge control valve - Controls waste sludge draw-off	Closed
CV-17	Orifice plug valve	Liquid level control valve - Controls clear water into wet well from sludge concentrate	Closed
FV-18	Raw water level alarm piping	Float valve	Open
DV-19	Partial drain line for erdlator tank	Partial drain valve	Closed
DV-20	Complete drain line for erdlator	Complete drain valve	Closed
DV-21	Sludge draw-off for concentrator	Partial drain valve for concentrator	Partially open
DV-22	Complete drain line for sludge concentrator	Sludge concentrator complete drain valve	Closed

Symbol	Location	Name & Function	Position
DV-23	Drain line from waste tank	Waste tank drain valve	Open
CV-24	Drain line from wet well	Check valve - prevents backup of waste water into settled water in wet well	Closed
DV-25	Drain water line from wet well	Complete drain valve for wet well	Open
DV-26	Drain line from chemical slurry feeder	Drain valve - diatomaceous earth slurry compartment	Closed
DV-27	Drain line from chemical slurry feeder	Drain valve - Limestone slurry compartment	Closed
CV-32	Slurry feeder filtered water line	Control valve - Allows filtered water to diatomaceous earth slurry compartment	Closed
CV-33	Slurry feeder filtered water line	Solution make-up valve - filtered water	Closed
CV-34	Coagulated water line to suction side of filter pump	Filter pump feed valve	Closed

OPPORTUNITY FOR QUESTIONS: (MIN)

1. Questions from the class:

2. Questions to the class: None are required.

SUMMARY: (MIN)

During the last hour I covered preoperation of the unit.

BREAK: (10 MIN)

INTRODUCTORY TRANSITION: The past hour we identified the valves and controls of the unit. Let us now continue with the remaining steps for the installation procedures and then move on to the preoperational maintenance and chemical requirement.

h. Trailer mounted generator set. 10-30 kw

(1) Locate not more than 50 feet away from water purification unit.

(2) Perform preoperation maintenance check.

(3) Perform safety check.

(a) Make sure that both units are grounded.

(b) Check for loose or frayed wires.

(c) Make sure that all breakers are off.

(4) Connect power cable by color code as follows:

L_1 - Black L_3 - Blue

L_2 - Red L_0 - White

NOTE: Make sure that code and terminal connects correspond on generator terminal and control cabinet.

i. Raw water pump - Locate as close to source as possible. If pump is more than 50 feet away from unit, set both electric pumps in series.

j. Hoses.

(1) A 1-1/2 inch, 25 foot discharge hose to pump discharge and the water intake connection on van.

(2) A 1-1/2 inch, 10 foot suction hose with strainer and float to suction side of pump.

(3) A 1-1/2 inch, 25 foot discharge hose to the female hose connection on left side of van.

(4) A 2 inch, 20 foot suction hose to erdlator drain on right side of van.

(5) A 2 inch, 20 foot suction hose to filter drain on left side of van.

NOTE: Drain hoses must run away from source.

k. Set up storage tanks no farther than 50 feet from erdlator.

l. Set up distribution pump.

TRANSITION: The last hour we discussed the nomenclature of the unit and found out what the installation procedures are. Let's move on with the maintenance requirements.

3. LUBRICATION INTERVALS AND LUBRICANTS

a. Lubrication intervals are performed according to the lubrication instructions (LI) posted in the TM of each unit.

b. Lubrication Points (TP #12 ON)

(1) Agitator

(a) Agitator drive shaft bearings

1 GAA grease

2 50 hours

(b) Agitator gear assembly

1 Check oil level before operation and every 10 hours of operation.

2 GO - Gear Oil

(c) Agitator shaft bearing

1 GAA grease

2 50 hours

(d) Agitator gear assembly drained and refilled every 1,000 hours.

(2) Filter section plug valves - ACF grease, 50 hrs.

(TP #12 OFF)

(TP #13 ON)

(3) Chemical slurry feed equipment

(a) Slip clutch and slurry feeder bearings

1 50 hours

2 GAA - Grease

(b) Slurry feeder chain tightener

1 50 hours

2 GAA - Grease

(c) Slurry feeder gear assembly speed reducer

1 GO - Gear oil

2 Check every 10 hours

3 Drain and refill every 1,000 hours

(4) Chemical solution feeder assembly gear case fill and level gauge

(a) OT Insulating oil, electrical

(b) Check every 10 hours

(c) Drain and refill every 500 hours

(TP #13 OFF)

TRANSITION: Still working on preparation; once maintenance has been completed, the next step is to measure and add chemicals. Let's look at what type and how much of each chemical are needed.

4. CHEMICAL REQUIREMENTS

a. Ferric chloride - is used as the coagulant, 2 lbs. to 4 gallons of water

b. Calcium hypochloride - used as a disinfectant, 8 ozs to 4 gallons of water

c. Pulverized limestone - coagulant aid, 14 pounds to 14 gallons of water

d. Diatomatious earth - filter aid

(1) Precoat funnel - 1-1/2 pounds to 1 gallon of water.

(2) Slurry hopper - 7 pounds to 14 gallons of water.

e. Activated carbon - absorbant

(1) Added to limestone slurry hopper

(2) 1.4 pounds

OPPORTUNITY FOR QUESTIONS: (MIN)

1. Questions from the class:

2. Questions to the class: None are required.

(MIN)

SUMMARY: During the past hour, I covered installation procedures, preoperational maintenance, and preparing the required chemicals.

BREAK: (10 MIN)
(MIN)

INTRODUCTORY TRANSITION: The next phase is to put the 1500 Erdlator into operation.

5. STARTING (MIN)

a. Prime and start raw water pump

(1) Push start switch in control cabinet

(2) Push start switch on pump

b. Chemical solution feeder

(1) Prime feeder

(2) Set feed indicators

(a) Ferric chloride set at 1.5 ppm

(b) Calcium hypochlorite set at 5.0 ppm

c. Chemical slurry feeder

(1) Adjust flow into feeder by adjusting valve CV-8

(2) Set FEI-6 at 50 PPM (Limestone feed variator)

(3) Charge limestone hopper with 14 lbs of limestone. When hopper is full to proper level:

(a) Close CV-8

(b) Adjust CV-7 to gradually feed limestone to erdlator tank

d. Agitator - Start agitator when the erdlator tank has 1 foot of water in it.

e. Bleed air from raw water flow indicator.

f. Adjust CV-9 to read 15 PSI on gauge.

g. When erdlator tank is full, drain off all foreign material from the top of the tank by lowering the effluent launder.

h. Once all waste is drained, level the effluent launder.

i. Partially open CV-14, Slurry weir box valve

j. Open CV-16 to first notch

k. When sludge concentrator tank is full, completely open CV-14.

l. When clear water is in the top of sludge tank, open CV-17.

m. Adjust chemical solution feeder. Reduce calcium hypochlorite to 1.5 gph

n. When clear coagulated water is flowing into the wetwell, close DV-25.

<u>TRANSITION:</u> The unit is in operation, the next step will be the operational adjustments that are necessary to perform the four cycles of operation.

6. <u>OPERATIONAL ADJUSTMENTS</u>

a. Precoat cycle

(1) Preposition valves

(a) Close CV-32, D.E. slurry feed valve

(b) Close CV-33, Solution make-up valve

(c) Set CV-36 to filter

(d) Close CV-37 precoat funnel feed valve

(e) Open CV-38 filter vent valve

(f) Close DC-39 draincock

(g) Open CV-40, filter discharge valve

(h) Open DC-41, draincock

(i) Close DC-42, draincock

(j) Open DC-43, draincock

(k) Close DC-44, draincock

(l) Adjust CV-45 to 25 gpm's, flow controller

(m) Set CV-46 on recirculate, filter output

(n) Close DV-47, filter drain valve

(o) Close DC-48, draincock

(p) Set ARV-49 to filter, air release valve

(q) Close CV-50, filtered water control valve

(TP #14 OFF)

(2) Mix D.E. in bucket, (1-1/2 lbs. of D.E. to 1 gallon of water. Pour into precoat funnel

(3) Open CV-37, allow mix to completely drain into filter.

(4) Close CV-37

(5) Open CV-34, filter pump feed valve

(6) Start filter pump

(7) Close CV-38, when water flows out

(8) Precoat for 4-6 minutes

(a) Until good cake of D.E. on filter is present

(b) Until water in filter is clear

b. Filter cycle

(1) Change CV-46 to filter

(2) Open CV-50

(3) Prepare 7 pounds of D.E. for slurry hopper

(4) Open CV-33

(5) Close CV-33 when water flows out

(6) Open CV-32, adjust for proper flow

(7) Add D.E. to compartment

(8) Set FEI-5 to 50 PPM

(9) Close CV-32 when hopper is full

(10) Filter cycle lasts 10 minutes to 10 hours

c. Backwash

(1) Four reasons for backwash

(a) An interruption in the filter cycle

(b) Storage tanks are full

(c) Source is empty

(d) When influent and effluent pressure gauges differ by 5 psi

(2) To go into backwash do the following procedures:

(a) Close CV-40 and CV-50

(b) Let pressure gauges equalize

(c) Shut down filter pump

(d) Close CV-34

(e) Close DV-23, drain for sludge tray

(f) Turn ARV-49 to backwash and open DV-47 at the same time.

(g) Open CV-38

(h) Allow filter to completely drain

d. Wash cycle valve adjustment

(1) Change CV-36 to wash

(2) Open CV-34

(3) Start filter pump

(4) Wash for 1 to 2 minutes

(5) Stop the filter pump

(6) Close CV-34

(7) Allow filter to drain

OPPORTUNITY FOR QUESTIONS: (MIN)

1. Questions from the class:

2. Questions to the class:

(MIN)

SUMMARY: During the past hour, I covered starting the unit and performing operational adjustments.

BREAK: (10 MIN)

INTRODUCTORY TRANSITION: When you have completed the operational adjustments, there are two things you can do, restart with precoat, or go into the shutdown procedures which we are going to cover.

7. SHUTDOWN

a. If operation of the unit will be within 24 hours from time of shutdown, only the partial drain valve on the erdlator tank may be opened. (Unless operating in freezing temperatures)

b. Close slurry feeder variators FEI-5 and 6.

c. Open drain valves DV-26 and DV-27.

d. Turn off slurry feeder drive.

e. Remove chemical hoses from solutions and allow chemical pump to pump dry.

f. Empty solution trays.

g. Stop solution feeder.

h. Stop the agitator drive.

i. Open all valves and draincocks.

j. Stop raw water pump.

k. Open the petcock valve on the base of the raw water pump.

l. Disconnect all hoses

m. Shut down generator

TRANSITION: Once shutdown procedures are completed, the next phase in post-operation is post-operation maintenance.

8. POST-OPERATION MAINTENANCE

a. After operation services must be performed after every operating period.

b. General

(1) Inspect unit for any damage from operation

(2) Keep work area clean and free from muddy conditions around the unit.

c. Lubrication

(1) All lubrication points should be checked

(2) All scheduled lubrication must be performed.

d. Check the unit for leaks: piping, valves, pumps.

e. Personnel heater if used, make sure sediment bowl is cleaned, inspected, and clean filter.

f. Clean equipment, remove oil, mud, chemicals, or any other foreign matter.

g. Check and clean chemical hoppers and trays.

h. Make sure that all tools and support equipment are clean and stored away properly.

i. Make sure van-body side panels and doors are secured properly.

j. If unit is not going to be used again, disconnect;

(1) the electrical cable to generator

(2) remove leveling jacks and place in holder inside van.

DEMONSTRATION: (MIN)

The primary instructor and assistant instructor will have the students set up the unit and give a demonstration on the unit. They will identify the components and valves. The instructors will put the unit into operation going through the proper procedures, explaining them as they are being performed. After the demonstration, the instructor will break the students down into teams for the practical application on the 1500 GPH Erdlator.

PRACTICE: (MIN)

The students under supervision of the instructor will perform the operational procedures, perform the proper maintenance checks, and prepare the proper chemicals. After the day of operation, the unit will be properly secured, PM and cleaned.

OPPORTUNITY FOR QUESTIONS: (MIN)

1. QUESTIONS FROM THE CLASS:

2. QUESTIONS TO THE CLASS:

a. What is the amount of limestone added to the limestone slurry hopper?

A. 14 lbs of limestone

b. Backwash is performed on the unit when the influent and effluent pressure gauges differ by how many psi?

A. 5 psi

SUMMARY: (MIN)

This period of instruction on the 1500 GPH Erdlator covered the components, explaining what makes up the unit, pre-operation covering maintenance, installation, preparing chemcial. Then we went into the operation of the unit, covering starting procedures, the four cycles of operation precoat, filter, backwash, and wash. The last phase which is the shutdown procedures and post-operational maintenance checks.

WRITTEN EXAM: (60 MIN)

Upon conclusion of the practical application phase, the students will be administered a 50 question written examination.

NOTE: See Written Examination, Instructor's Guide.

LIST OF SUPPORTING PAPERS

1. Student Outline

2. Student Handout

3. Transparencies

    1 - Van

    2 - Water Purification Unit

    3 - Erdlator Assembly

    4 - Filter Section

    5 - Chemical Feed Equipment

    6 - Chemical Solution Feeder

    7 - Supporting Equipment (Pumps)

    8 - Personnel Heater

    9 - Leveling Jacks

    10 - Valve Sequence - Codes

    11 - Water Purification Unit (Valves)

    12 - Lubrication Points (1)

    13 - Lubrication Points (2)

    14 - Filter Section (Valves)

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DETAILED OUTLINE

SINGLE DIAPHRAGM RECIPROCATING PUMP (MUD HOG)

INTRODUCTIQN (3 MIN)

GAIN ATTENTION: Can someone explain what mud is? Mud is wet, soft earth. Can someone explain what a hog is? A hog is a mammal of the Suidae family. So, if we combine the two to make Mud-Hog, we can safely say we have a hog that feeds on mud, correct?

LESSON PURPOSE: To familiarize the student with the single diaphragm reciprocating pump (mud hog).

TRANSITION: Now that I have stated the purpose of this period of instruction, lets talk about the Single Diaphragm Reciprocating Pump or what is commonly known as the Mud Hog.

BODY

1. Description of the Pump (25 MIN)

There are basically two types of Mud Hogs, the Gorman Rupp Model 4D2A016 and the Rex Chanbelt Model 40G. Both have the same operating principles and are equipped with a military standard engine. I will point out the differences between the two models during the demonstration.

(ON TP # 1)

a. General Description

(1) Engine

(a) Two cylinder, 4 cycle, air cooled gasoline engine, military standard model

(b) Rated horsepower - 3.00 HP

(c) Maximum speed 3600 RPM

(d) Normal operating speed - 3500 RPM

(e) Spark plug gap - .020 inches

(f) Crank shaft driven magneto - gap set at .020

(g) Fuel tank - 1.5 gallons gasoline

(h) Average fuel consumption - 0.35 gph or 2.7 gallons per 8 hour day

(i) Engine crankcase

(a) Uses dipstick to measure oil level

(b) Crankcase holds 1 qt 30 wt oil

(c) Check oil every 5 hours of operation

(d) Change oil every 25 hours of operation

(OFF TP # 1)
(ON TP # 2)

(2) Reduction gear case

(a) Power from engine

(b) Reduces speed of connecting rod to 60 strokes per minutes.

(c) Connecting rod assembly

1 Connected to gear case

2 Has grease cup for lubricating bearings

3 It raises and lowers diaphragm

(d) Capacity

1 Gear case

a Uses lubricating oil

b Holds 2 pts

(1) Check daily

(2) Change every 1000 hours of operation

2 Connecting rod bearings

a Lubrication is checked daily

b Grease when required with GAA grease

(OFF TP # 2)
(ON TP # 3)

(3) Pump Body

(a) Rubber Diaphragm

1 Secured to rim of pump body

2 Fastened to connecting rod

(b) Check Valves

1 Suction and discharge

2 4 inch ports

(c) Clean out door with drain plugs

(OFF TP # 3)

(ON TP # 4)

b. Capabilities of the pump

(1) Used for dewatering job sites

(2) Liquid carries a high percentage of trash

(3) Can pump 40% mud and 60% water

(4) Has a total dynamic head of 35 feet

(a) Static suction head should not exceed 25 feet

(b) Static discharge head is 10 feet

(5) Pumps at a rate of 100 GPM

(OFF TP # 4)

(ON TP # 5)

c. Trailer

(1) Located on two wheels

(a) Nonpneumatic wheels (without air)

(b) Sealed-type ball bearings

(2) It has lift or tow bail for easy movement.

(3) It has two lifting- tie down eyes in the center. (OFF TP # 5)

(ON TP #6)

d. Accessories

(1) Data Plates

(a) Transportation - gives dimensions for transportation

(b) Contains engine serial number

(c) Contains federal stock number for ordering

(2) Foot Valve - 4 inch in diameter

(3) Hoses

(a) There are four, 4 inch, 10 foot long suction hoses

(b) They are used for both suction and discharge side of the pump

(OFF TP # 6)

TRANSITION: Now let us turn our attention to the installation of the pump.

2. Installation of the Pump (7 MIN)

a. Pump Site

(1) Level area

(2) Close to source as possible

(3) Block wheels so pump does not shift during operation

b. Hoses

(1) Check hose for serviceability - Cuts or breaks in hoses

(2) Check connections

(a) Air tight

(b) Gaskets

(3) Suction lift

(a) Should not exceed 25 feet

(b) Install strainer or foot valve when possible

(4) Discharge hose

(a) Should not exceed 10 ft above machine

(b) Hose should not exceed 50 feet in length

(c) All hoses come in 10 foot sections

TRANSITION: After you have installed the pump, you should be ready to begin putting the machine into operation.

3. Operation of the Pump (15 MIN)

a. Pre-Operation Check

(1) Fill fuel tank with regular motor fuel

(2) Check engine crankcase oil level

(a) Observe level indicated on dip stick

(b) Add if necessary

(3) Check oil level in pump reduction gear case - Add if necessary

(4) Connecting rod needle bearing

(a) Hand turn down grease cup slightly to force grease into the bearings

(b) Add if necessary

(5) Prime pump body through priming hole

b. Starting the pump

(1) Flip engine "on-off" switch to "on" position

(2) Close choke valve

(3) Wind engine pull rope on the pulley clockwise and pull the rope

(4) Open choke valve slowly to obtain smooth engine operation

(5) Adjust the engine throttle to obtain desired engine speed

c. Stopping the pump - Shut off engine by flipping the "on-off" switch to the "off" position

TRANSITION: Let us now turn our attention to the maintenance procedures for the pump.

(ON TP # 7)

(8 MIN)

4. Maintenance of the Pump

a. Engine fuel tank - Fill if necessary

b. Engine Crankcase

(1) Check oil every five hours.

(2) Change every 25 hours of operation.

c. Connecting Rod Bearings

(1) Check grease cup daily

(2) Turn 1/4 turn twice daily during operation

(3) Fill cup as required

(OFF TP # 7)

(ON TP # 8)

d. Pump Body

(1) Flush with clean water after operation

(2) Drain after each operation

(OFF TP # 8)

OPPORTUNITY FOR QUESTIONS (3 MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. How many hoses come with the single diaphragm pump?

A. Four, 4 inch, 10 foot long suction hoses

b. What is the ratio of mud to water this pump can pump?

A. 40% mud and 60% water

c. How often do you change the engine crankcase oil?

A. Every 25 hours

(2 MIN)

SUMMARY: During the last hour, we have covered the single diaphragm pump installation, operation, and maintenance.

BREAK (10 MIN)

DEMONSTRATION (30 MIN)

1. Have students to march to Camp Sweat for the purpose of demonstrating the single diaphragm pump.

2. The instructor will demonstrate for 30 minutes, the correct procedures for setting up and operating the single diaphragm pump.

3. The students will connect the hoses, gaskets, and foot valves assigned to the single diaphragm pump.

4. The students will perform, pre-operational check, prime, and put the unit into operation.

OPPORTUNITY FOR QUESTIONS (2 MIN)

1. QUESTIONS FROM THE CLASS: Will be answered during demonstration.

(2 MIN)

SUMMARY: During the last period of instruction we covered the:

1. Set up the single diaphragm reciprocating pump

2. Performed preoperation maintenance

3. Started the unit

4. Shutdown the unit

BREAK (10 MIN)

LIST OF SUPPORTING PAPERS

1. Advance Sheet/ Student Outline
2. Transparencies:
3. TP - 1 - General Description
4. TP - 2 - Reduction Gear Case
5. TP - 3 - Pump Body
6. TP - 4 - Capabilities of the Pump
7. TP - 5 - Trailer
8. TP - 6 - Accessories
9. TP - 7 - Maintenance of the Pump
10. TP - 8 - Maintenance of the Pump Body

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FIELD EXERCISE

BASIC HYGIENE EQUIPMENT

INSTRUCTOR'S GUIDE

INSTRUCTIONS:

1. Students will be divided into five teams.

   a. Team #1 U-2244b and Dist. Sets.

   b. Team #2 600 x 1500 Erdalators.

   c. Team #3 Reverse Osmosis and Accessories.

   d. Team #4 Bath Unit and Decon Unit

   e. Team #5 Laundry Unit.

2. The teams will be responsible for ascertaining that a complete inventory of each Water and Hygiene Equipment set is conducted in accordance with all references, SL's, and guidelines as dictated by the instructor.

   a. Instructors (4) will be assigned and will supervise the inventory being conducted by each team.

   b. Upon completion of the inventory, the teams will stage all equipment to include all end items and accessory gear as directed by the Chief Instructor.

3. In the event that the field exercise is to be conducted away from the school's area, the equipment and accessories will be loaded on 6 x 6 tactical vehicles according to priority.

4. Once the vehicles are loaded, the vehicles will move to training site in a military convoy. Upon arrival of vehicles at the site, the chief instructor will direct the unloading of equipment and accessory gear at each predesignated site selected for each unit.

5. Once the equipment is unloaded, the chief instructor will muster the students and go over the plan of the day, i.e., preparation of each site before setting up equipment and location of head facilities in relation to camp site.

6. Upon termination of brief, the students will perform tasks assigned.

a. Level all areas to be utilized for setting up equipment (U-22446).

(1) Unpack all gear for the U-22446 and set up in accordance with TM's and all previous instructions.

(a) Set up 3,000 gal. tanks (2) for the coagulation of water.

(b) Set up 3,000 gal. tanks (2) for storage of purified water.

(c) Connect raw water pump for pumping water into 3,000 gal. tanks.

(d) Conduct a coagulation jar test to determine the amount of chemicals required for the treatment of the water before it can be purified.

(e) Conduct a chlorine demand test in order to find out the bacterial contents in the water.

(f) Upon the completion of the routine tests, the students will add chemicals to the 3,000 gal. tanks in accordance with TM's and guidelines given by instructor.

(g) Once the chemicals have been added to the raw water and given time to react, the students will go into the water purification process in accordance with TM's and instructions given by the instructor.

(2) The team assigned the 600 and 1500, GPH water Purification Unit, will unpack the units and put into position selected for this purpose and:

(a) Level the trailers on the units by use of the leveling jacks.

(b) Set up 3,000 gal. (1) each to be used for storing purified water.

(c) Connect all hoses on the units in accordance with TM's and instructions given by the instructor.

(d) Ascertain all the switches are in the OFF position.

(e) Ground the units.

(f) Connect units to the generator in accordance with TM's and instructions given by the instructor.

(g) Prepare chemicals, i.e., ferric chloride, limestone, and chlorine in the containers provided.

(h) Connect raw water pumps for pumping water to unit.

(i) Check the position of all valves prior to going into the actual operation. This will be done in accordance with TM's and instructions given by the instructor.

(j) Start water purification process by activating raw water pump and follow the sequence in accordance with the TM's and instructions given by the instructor.

(3) The team assigned the R. O. will unpack all pumps and accessories and:

(a) Connect all hoses in accordance with TM's and instructions given by the instructor.

(b) Connect raw water hoses and electrical connections to the unit on raw water pump(s).

(c) Check all switches to make sure that they are in the OFF position.

(d) Mix all chemicals in containers in accordance with TM's and instructions given by the instructor.

(e) Check position of valves prior to starting unit.

(f) Put unit into operation by activating raw water pump.

(g) Operation of the R. O. will be accomplished in accordance with TM's and guidelines given by the instructor.

(4) The teams assigned the Bath Unit, Laundry Unit, and Decon Unit will situate units at locations selected and will:

(a) Unpack all gear necessary for installing bath unit.

1. Level bath unit.

2. Set up 3,000 gal. tank for the water for showers.

3. Connect hoses to unit.

4. Perform daily PM.

5. Set up tent.

6. Set up shower stand assembly.

7. Set up duckboards.

8. Dig drainage for waste water.

The installation will be done in accordance with TM's and guidelines given by the instructor.

(b) Unpack accessories for laundry unit.

1. Set up laundry unit in accordance with TM's and guidelines.

2. Perform preoperation checks.

3. Install raw water pump and hoses to the unit.

4. Put unit into operation in accordance with TM's and guidelines.

NOTE: Upon completion of the initial installation of all the equipment:

1. Each team will operate the equipment assigned for one full day.

2. Second day teams will be assigned to operate another piece of equipment.

3. All teams will have night time operation during the entire field exercise. The schedule for night time operation will be decided by the senior instructor on duty.

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Aug 1984

STUDENT HANDOUT

REVERSE OSMOSIS WATER PURIFICATION UNIT (ROWPU)

600 GPH

MARINE CORPS ENGINEER SCHOOL
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

WARNING

When selecting a site for the reverse osmosis be sure that ground is firm and level.

Electricity can kill you on contact; take proper precautions when working around electrical control boxes or junction boxes.

Insure that the reverse osmosis is provided with a good ground so you will not become its ground rod.

Whenever possible select the best available water source in order to get maximum use of the unit.

You are working with dangerous chemicals both before and after you mix them. Carelessness can cause irritation of eyes, lungs, and skin. Protect yourself and others by using extreme care.

Never attempt to make electrical repairs while the unit is in operation.

Noise level of the generator can cause hearing damage. Ear protectors, as recommended by the medical and safety officer, must be worn when working near this set.

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INTRODUCTION

GENERAL INFORMATION

1-1 Scope. This student handout describes the operating procedures and operators maintenance procedures for the 600 GPH Reverse Osmosis Water Purification Unit (ROWPU).

1-2 Operating Records. You must always keep good operating records by recording all the necessary data in order that if the unit malfunctions, you can refer to them before performing corrective maintenance.

1. INITIAL ADJUSTMENTS AND CHECKS

   a. CLOSE: Seven Drains

   b. OPEN: Vent Pulse Dampener Valve
      Vent Cartridge Filter Valve
      Vent Multimedia Filter Valve
      Vent Vessels Valve
      Vent Product Water Valve
      Regulate Product Flow Valve

   c. Set Element Cleaning Switch to OFF

   d. Set Backwash Valve to NORMAL

   e. Set all Control Box Switches to STOP or OFF

   f. Push in Emergency Stop Button

   g. Ground the Unit

   h. Set Timer

      (1) Set white cam to "SR".

      (2) Set reconditioning knob to "IDLE" position.

   i. Set up Chemical Feed Pump

      (1) Install chemical hoses.

      (2) Set up chemical buckets.

      (3) Set pump valves to prime.

   j. Check oil in chemical feed pump and RO pump

   k. Install pumps and hoses as follows:

Attach float to strainer with enough rope to allow strainer to go under water but not touch bottom. Hook up raw water system (fig. 1-1). Use only enough hose to reach between water source and the ROWPU.

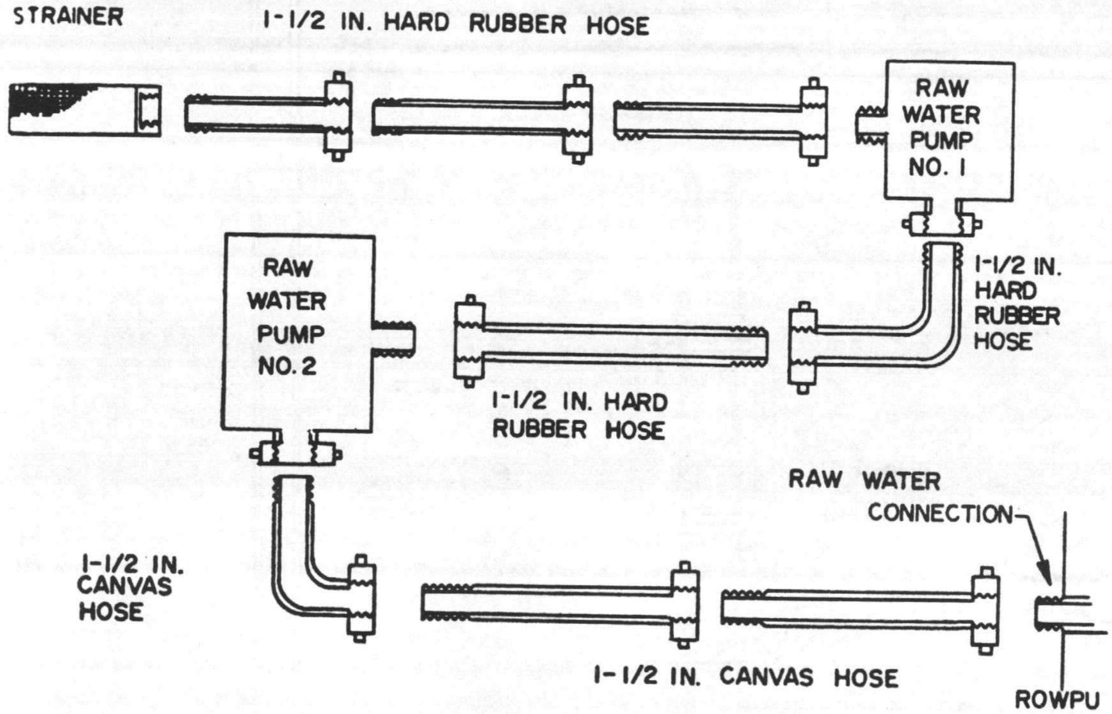

FIGURE 1-1. RAW WATER SYSTEM

CAUTION

Make all hose connections tight. If raw water hose draws in air, you cannot prime the pump. Never operate pumps without strainer. You don't want to draw leaves and dirt into the ROWPU. They will damage it.

Connect the backwash water tank and pump to the ROWPU as shown in figure 1-2. Start at the ROWPU and work toward the tank.

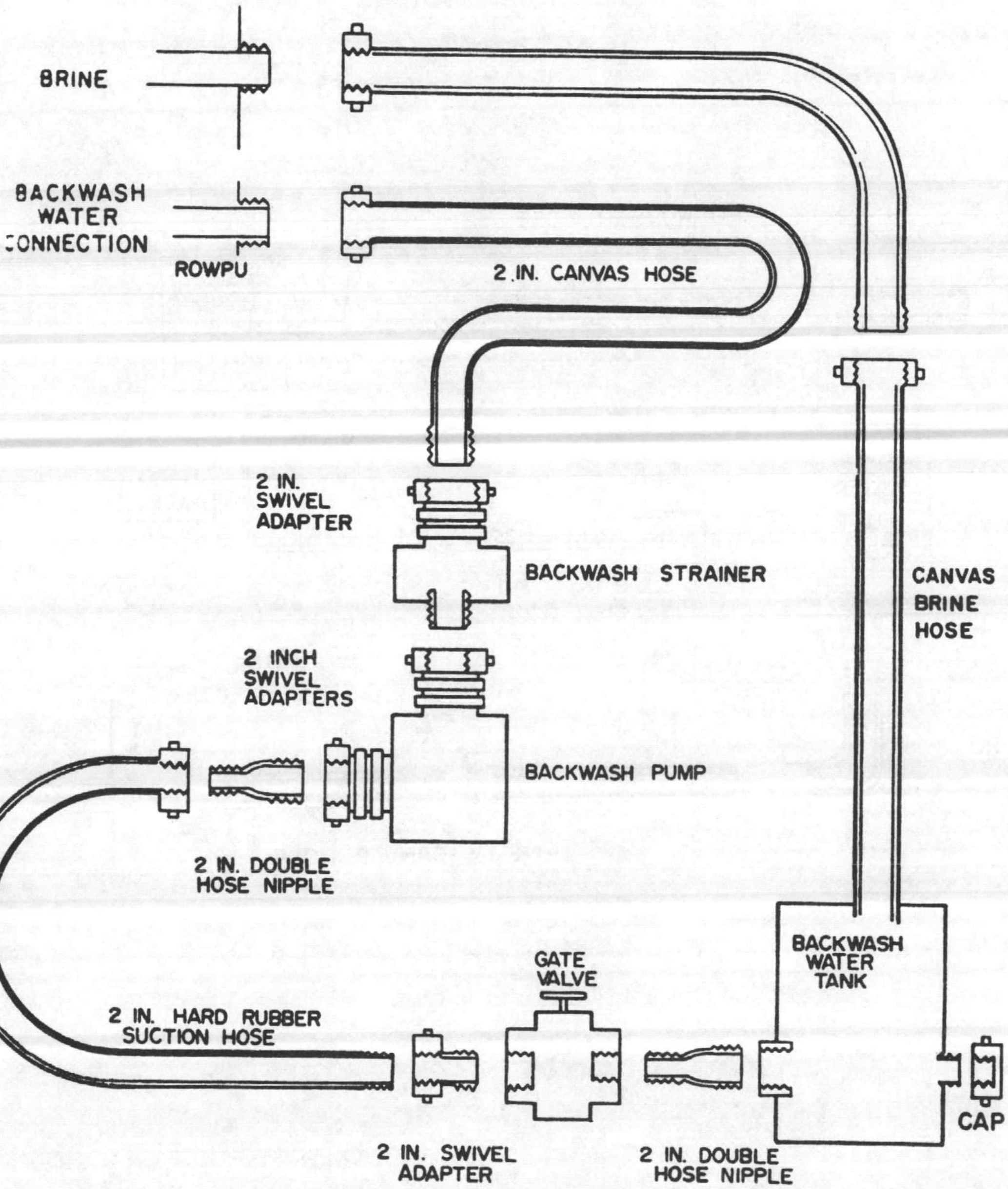

FIGURE 1-2. BACKWASH WATER SYSTEM

2 Attach distribution nozzle to canvas hose as shown in figure 1-3 and hose to the product water distribution pump. Work backwards until last connection is made at the ROWPU. Make sure pump drain valve is closed.

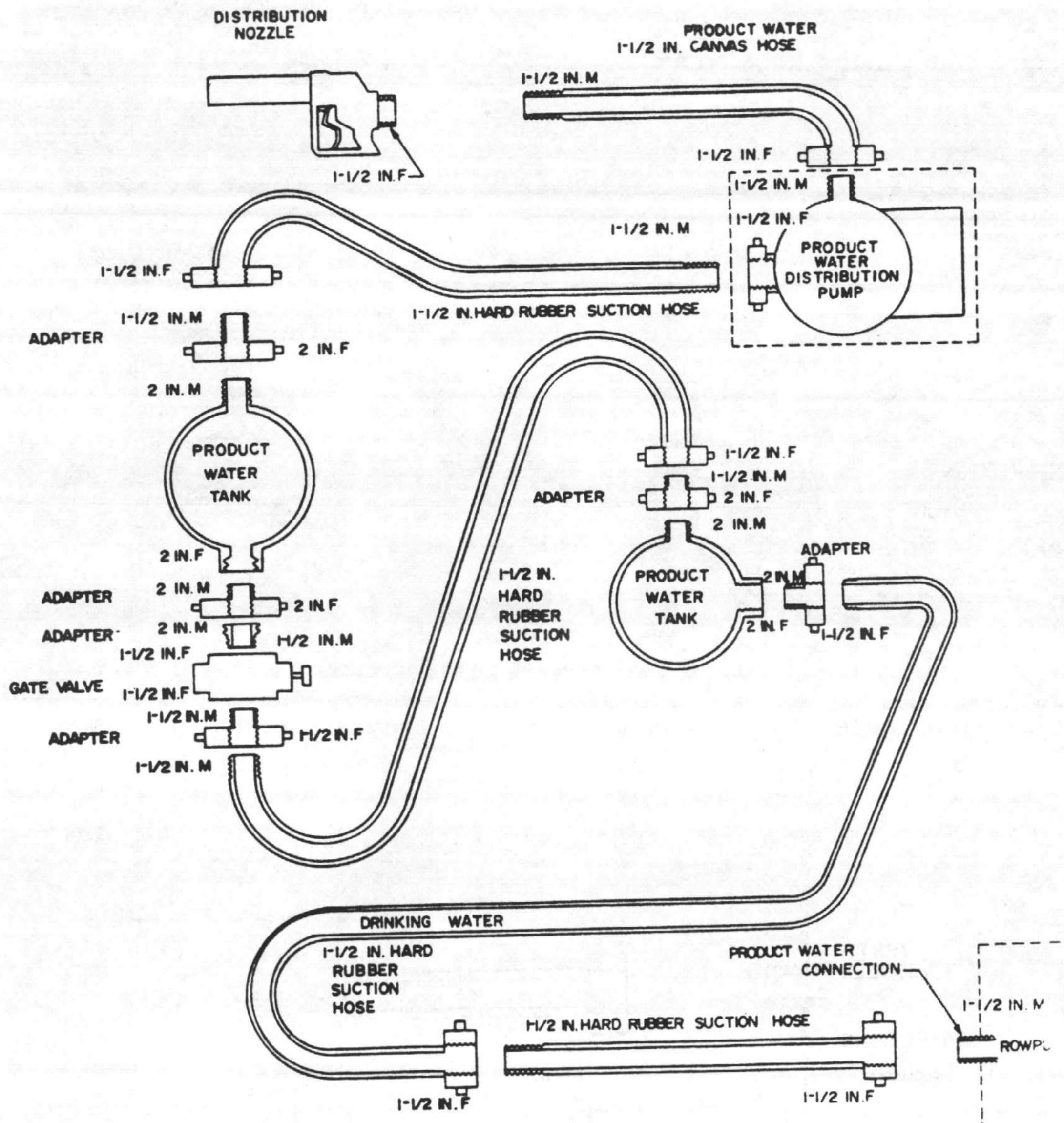

FIGURE 1-3. PRODUCT WATER SYSTEM

Hook up waste water and vent vessels systems as shown in figure 1-4. Start at ROWPU end with hose going down and away from THE ROWPU, and downstream of raw water intake.

NOTE

Recheck all your hose connections to make sure they are tight.

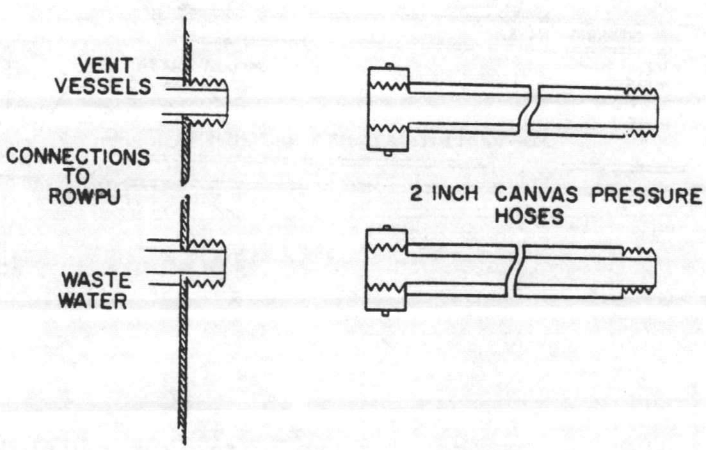

FIGURE 1-4. WASTE WATER SYSTEM

2. OPERATING PROCEDURE

a. START Generator.

b. Pull Out Emergency Stop Button (Yellow light will come on).

c. Prime Raw Water Pump(s).

d. START Raw Water Pump(s).

e. START Chemical Feed Pump.

f. Mix 107 ml of polymer in 3 gallons of raw water.

g. Prime and calibrate polymer chemical pump.

(1) Set polymer chemical feed control knob to 5.

(2) Wait until no more air bubbles are seen.

(3) Set polymer chemical feed control knob to 2.6.

(4) Obtain 60 ml of solution in one minute from tube without strainer. (If not, readjust control knob setting.)

h. Set polymer pump valve to RUN.

i. Close vent multimedia filter valve.

j. Start booster pump.

k. Close vent cartridge filter valve.

l. Reset RO pump.

m. Start RO pump.

n. Close vent pulse dampener valve.

o. Wait 10 minutes. (During which you mix .2 lbs. of chlorine and .1 lbs. of sodium hex.)

p. Prime and calibrate chlorine and sodium hex (same as polymer pump).

q. Set sodium hex pump valve to RUN. (Leave chlorine pump valve on PRIME.)

r. Leave citric acid pump on PRIME and control valve on 10.

s. After 10 minutes examine filtered water for clarity.

(1) Obtain 600 ml of water from cartridge filter drain valve No. 1.

(2) You should see the bulls-eye clearly (if not, reduce control setting on polymer feed pump, wait 10 minutes and recheck the water).

(3) Once the clarity test is satisfactory, do the following:

t. Turn vent vessel valve clockwise slowly until fully closed.

u. Adjust regulate product flow valve slowly clockwise until proper gauge reading is obtained. (See chart below.)

v. Set chlorine pump valve to RUN.

w. Close product water vent valve.

x. Monitor all gauges during operation.

3. GAUGE READINGS, NORMAL AND TROUBLE POINTS

GAUGE INDICATOR	NORMAL READING	TROUBLE POINT READING
1. Cartridge Filter	8 to 20 psid	Over 20 psid
2. Multimedia Filter	0 to 10 psid	5 psid over first reading
3. Raw Water Flow	27 to 33 gpm	Drop to 25 gpm or less
4. Brine Flow	16 to 24 gpm	Below 15 gpm
5. Product Water Flow		
a. Salt Water	6 to 12 gpm	Above 12.0 gpm
b. Brackish Water	Up to 13.5 gpm	Above 13.5 gpm
c. Fresh Water	Up to 13.5 gpm	Above 13.5 gpm
6. RO Pressure psi		
a. Salt Water	800 psi or less	Above 900 psi
b. Brackish Water	500 psi or less	Above 600 psi
c. Fresh Water	500 psi or less	Above 600 psi
7. RO Vessels	50 to 100 psid	Above 100 psid
8. TDS of Product Water	Below 1500 ppm	Above 1500 ppm

4. NORMAL SHUT DOWN (SHORT SHUT DOWN)

a. Turn all chemical pumps back to prime.

b. Open regulate product flow valve.

c. Open vent vessels valve.

d. Open all vent valves.

e. Stop all pumps (in sequence).

f. Push in emergency stop button.

5. POST-OPERATION MAINTENANCE

a. Inspect the unit and all components for damage.

b. Clean all components.

c. Check oil in RO and chemical feed pumps.

6. PACK THE UNIT FOR STORAGE (LONG SHUT DOWN)

a. Backwash multimedia filter.

b. Perform normal shut down.

c. Open seven drains and drain the ROWPU.

d. Drain RO pump using JOG switch (after water stops flowing out of seven drains).

e. Drain booster pump.

f. Drain pressure vessels (disconnect product water lines).

g. Drain lines on the back of backwash timer (one at a time).

h. Drain chemical feed pump.

i. Drain, clean, and fold all storage tanks.

j. Drain all pumps.

k. Disconnect, drain, and roll all hoses.

l. Repack all accessories inside each storage box.

m. Install pumps, storage boxes, pails, hoses, sledge hammer, and aluminum paddle inside ROWPU.

n. Install trailer cross braces.

7. BACKWASH OF MULTIMEDIA FILTER

a. Reasons for backwashing.

(1) When multimedia filter gauge rises above 10 psid, or 5 psid above the initial reading.

(2) When RO unit will not be operated for 30 days or longer.

(3) Before movement.

b. Backwash procedures.

(1) Perform normal shutdown of unit.

(2) Open gate valve on bottom of the brine tank.

(3) Open backwash pump draincock to insure that pump is primed.

(4) Turn backwash handle to backwash.

(5) Activate backwash switch.

(6) Backwash pump should come on within 3 to 5 minutes.

8. R.O. ELEMENT CLEANING

a. Reason for cleaning.

(1) Whenever the R.O. pressure psi gauge rises above the maximum allowable pressure and at the same time the product water flow gauge drops below minimum output (6 gpm).

(2) Upon termination of field exercise (operation).

(3) TDS of product water gradually rises above 1500 TDS.

(4) Brine flow increases noticeably and adjustment of regulate product flow valve does not correct the product water flow.

(5) R.O. vessels gauge rises above 100 psid.

b. Cleaning procedures.

(1) Backwash multimedia filter.

(2) Adjust water level in brine tank to 7 inches from the bottom.

(3) Mix 70 lbs. of citric acid.

(4) Open regulate product flow valve.

(5) Open vent vessels valve.

(6) Switch hose from backwash hose connection to vent vessels outlet.

(7) Remove product water hose from the product water storage tank.

(8) Insure that brine hose is placed inside the brine tank.

(9) Turn on element cleaning switch.

(10) Operate for 45 minutes or until temperature of brine water reaches 110°F.

(11) Turn off element cleaning switch.

(12) Reconnect backwash hose to backwash hose connection and vent vessels hose.

(13) Operate unit normally for 10 minutes with regulate product flow valve fully OPEN.

(14) After 10 minutes adjust regulate product flow valve.

(15) After 3 minutes place product water hose into product water tank.

(16) If citric acid solution does not help, repeat the same process using 1800 ml of "TRITON X-100" detergent.

9. CITRIC ACID FEED

NOTE: Citric acid feed is performed at least once every 20 hours of operation, or to get pH of the brine water down below 8.0. Citric acid makes R.O. membranes tighter (stronger) to improve salt rejection. The R.O. membranes operate best in water containing 5.5 pH. For example: Water with 5.5 pH might produce 500 ppm TDS product water, where as same water with pH of 7.5 might produce a product water with 1000-1500 ppm TDS.

a. Procedures

(1) Put three-quarters (3/4) of a pound of citric acid into citric acid pail, using citric acid measure.

(2) Fill the pail with 3 gallons of brine water.

(3) Stir chemical and brine with wooden paddle until chemical is fully dissolved.

(4) While the ROWPU is operating normally, set the citric acid chemical feed pump valve on RUN, and set chemical feed control knob to 10.

(5) Continue operation until the pail is empty.

(6) Draw a 250 ml water sample from the brine hose to insure that the pH is below 8.0.

(7) If that reading is not below 8.0, feed a new batch of citric acid chemical mix.

(8) When reading is below 8.0 set feed pump valve to PRIME and refill the pail with water.

(9) Feed is completed.

10. STERILIZATION OF R.O. ELEMENTS

a. Purpose for sterilization - To prevent biological growth inside the R.O. element which would cause deterioration of the membrane. This process should be performed when:

b. Return to CONUS from foreign soil.

c. R.O. unit is to be idle for over a 30 day period.

NOTE: When water source contains a high concentration of plant life or biological growth the lapse time for non-usage should be no longer than 15 days vise 30 days.

11. REMOVING THE ELEMENTS FOR THE PURPOSE OF STORAGE

a. Procedures

(1) Add 12 gallons or 36 lbs. of formaldehyde to 7 inches of brine water in the brine tank.

(2) Follow same procedures as in regular cleaning of R.O. elements but operate for only 30 minutes.

NOTE: If elements are to be removed from unit for storage, allow element to remain inside vessels for 12 hours before removal from vessels and repacking.

(3) Remove elements and drain for 10 minutes VERTICALLY if they will be repacked in plastic bags.

NOTE: Elements do not have to be taken out of unit and repacked in plastic bags unless unit will not be in use for a long period of time (6 months or longer).

CAUTION: Care should be taken in using any type of formaldehyde. Strict attention to label directions and precautions in handling is a MUST. Vapors can be harmful or irritating if adequate ventilation is not provided. Protective clothing and common sense should be used.

UNITED STATES MARINE CORPS
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Camp Lejeune, North Carolina 28542

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DETAILED OUTLINE

OPERATION OF REVERSE OSMOSIS WATER PURIFICATION UNIT

INTRODUCTION (MIN)

1. GAIN ATTENTION: (Pass around a glass full of product water from Reverse Osmosis Unit) What can you tell me about the water in that glass? For example, can you tell me where the water that you are drinking came from? How many of you like the taste of salt water? The water that you are drinking came from the ocean right here by our base.

2. PURPOSE: The purpose of this lesson is to provide you with the knowledge and skills necessary to operate the Reverse Osmosis Water Purification Unit.

3. INTRODUCE LEARNING OBJECTIVE(S)

a. TERMINAL LEARNING OBJECTIVE(S): Provided with a Reverse Osmosis Water Purification Unit, chemicals, power supply, water supply, necessary tools, and reference materials, purify water in accordance with TM 5-4610-215-10, pp. 2-27 to 2.96. (1.5.1)

(ON TP # 1, REVERSE OSMOSIS WATER PURIFICATION UNIT)

b. ENABLING LEARNING OBJECTIVE(S): Provided with a Reverse Osmosis Water Purification Unit, chemicals, power supply, water supply, necessary tools, and reference material:

(1) Install the unit (1.5.1a)

(2) Perform pre-operation maintenance (1.5.1b)

(3) Prepare chemical solution (1.5.1c)

(4) Start the unit (1.5.1d)

(5) Adjust the unit (1.5.1e)

(6) Shut down the unit (1.5.1f)

(7) Perform post-operation maintenance (1.5.1g)

(8) Pack the unit for long shutdown (1.5.1h)

in accordance with TM 5-4610-215-10, pp. 2-27 to 2-96.

NOTE: Whenever we refer to the front of the R.O. unit we refer to the side with the control panel on it, and the back of the R.O. unit is the side which holds the pressure vessels, plus the respective right and left side of the unit.

TRANSITION: Now that we know what we have to learn, let's begin with the first item; identification of components.

(OFF TP #1)

BODY (44 MIN)

1. Identification of Components

Before I begin describing the Reverse Osmosis Unit, let me take a couple minutes to show you a chart.

(ON TP #2, RANGES OF SEPARATION)

This chart shows different types of filtration processes, which range from conventional filtration such as: screens and strainers, sand, cloth and fiber, and diatomaceous earth filters, all the way to the Reverse Osmosis process. This chart also shows the approximate size of various particles removable by each type of filtration.

(OFF TP #2)

TRANSITION: Let's continue now with identifying the components of the unit. I'm going to identify the components of the unit as I cover the flow of water through the unit.

(ON TP #3, 600 GPH ROWPU)

a. The water is delivered to the RO unit through the raw water pump. There are two raw water pumps and they can, if needed, be connected in series. Make sure that whenever using any type of pump, when pumping from the source, use a strainer on the end of suction hose and rubber washers on all hoses for air tight connection. The raw water pumps are:

(1) Centrifugal

(2) Self-priming

(3) Rated at 30 gpm with a 105 ft. head

(4) Powered by 2 HP electric motor

(OFF TP #3)

(ON TP #3A, MULTIMEDIA FILTER)

b. When the water enters the ROWPU it goes through the multimedia filter first. The multimedia filter consists of 425 lbs of bedding (gravel: fine through medium). On top of the bedding is located the filter media, weighing 805 lbs. This media consists of: 3" of garnet, 12" of filtered sand, 15" of coal, and 2" of plastic material. The top layer of plastic is the lightest and the bottom layer of garnet is the heaviest. Water enters the filter through the top inlet pipe and passes through the layers of media to the bottom of the filter. Once on the bottom the water enters the perforated pipes on the bottom of the filter and it travels out the outlet pipe located on the bottom of the filter. The filter has a 30" inside diameter and is Hi-Flo depth (HD-30).

(OFF TP #3A)
(ON TP # 3, ROWPU)

c. From the multimedia filter the water is picked up by the booster pump. This pump is:

(1) Centrifugal.

(2) Rated at 30 gpm with a 50 ft. head.

(3) Powered by a 1 HP electric motor.

d. The booster pump pushes the water through a cartridge filter. The cartridge filter consists of eight 40 inch long cloth fiber cartridges and provides secondary stage filtration by removing any suspended matter in the water missed by the multimedia filter.

e. From the cartridge filter the water is picked up by the RO pump. The RO pump is a high pressure pump with:

(1) Positive displacement (pistons).

(2) Rated at 51 gpm with a 980 psi head.

(3) Driven by V-belts from a 20 HP electric motor.

f. The RO Pump holds 2 gal. of heavy duty (HD) - 40W, or 30W nondetergent oil: use Shell Turbo 69 oil, which is changed:

(1) Before first operation of the unit.

(2) After first six weeks of operation.

(3) Every three months or 1000 operating hours.

g. The RO pump pushes the water through the pulse dampener (which reduces the shock (pulses) caused by pistons of RO pump) and into the RO vessels. There are four vessels connected in series from top to bottom, and each vessel holds two RO elements.

(OFF TP # 3)

(ON TP #4, RO VESSEL W/TWO ELEMENTS)

(1) This diagram shows the RO vessel which contains two RO elements. These elements are connected in the middle by an interconnector. The other ends of RO elements are connected to the end caps of the RO vessel by the end connectors. The end connectors look just like the interconnector on the outside, except that one end has a larger opening than the other end, whereas the interconnector has the same diameter hole throughout. The end connector will fit only one way. The smaller opening must be facing the end cap.

(OFF TP #4)

(ON TP #5, RO ELEMENTS AND CONNECTORS)

The end connector, interconnector and end cap require O-rings when assembling the RO vessel. The RO elements require a brine seal during assembly. The brine seal is 6.00 inches in O.D. The interconnector O-ring has a 1.756 inch O.D. The end connectors have 1.680 and 1.756 inch O.D. O-rings.

NOTE: All seals and O-rings should be lubricated with a silicone base lubricant.

(OFF TP #5)

(SHOW RO ELEMENT)

(2) This is a Spiral Wound RO Element which is designed to reject a minimum of 98.5% of salt from the water and about 99% of all organic material in the water.

(ON TP #6, RO ELEMENT)

This element is made up of two a layered membrane (BLUE) with a permeate carrier (GREEN) between the layers which forms a sandwich. A perforated plastic pipe (BLACK) is placed at one end of the sandwich. The edges of the membrane are sealed with the porous backing material inside the resulting envelope.

This membrane envelope and a mesh spacer (RED) is then rolled up onto the plastic pipe to produce a compact unit so that it will fit into a simple tubular pressure vessel.

At the open ends of the element the mesh spacer creates a gap that will allow the feed water to pass through the roll. As the pressure is applied to the RO vessels, some of the water passes through the membrane and collects in the permeate carrier within the sealed envelope. The water spirals inward along the permeate carrier to the center, out of the envelope through the pipe perforations, through the pipe and out of the module (RO elements). As the water passes through the membranes the remaining feed fluid becomes more concentrated. This concentrated fluid (brine) continues to flow through the mesh in the roll and emerges through the mesh spacer gaps at the other end of element.

The brine flow then enters the next element and the process repeats itself, until water goes through all eight RO elements. Then it leaves the RO unit and is stored in the brine tank for backwashing filters.

The water which passes through the membranes comes out of each RO vessel and then leaves the RO unit as a product water

(OFF TP #6)

h. The product water is distributed from the product tank by using a water distribution pump. The distribution pump and electric motor are the same as the booster pump and motor.

(ON TP #7, CHEMICAL FEED PUMP)

i. The RO unit also uses certain chemicals to aid in production of product water. There are four chemical feed pumps:

(1) Polymer feed pump - adds polymer (polyelectrolyte) solution to raw water to collect small pieces of floating solid matter into groups large enough to be removed by the filters.

(2) Chlorine feed pump - adds chlorine to product water to kill bacteria so water in tanks remains drinkable.

(3) Sodium hex feed pump - feeds diluted sodium hex (sodium hexametaphosphate) to the water filters to prevent calcium scaling.

(4) Citric acid feed pump - adds diluted acid (tricarboxylic acid) to filtered water as required for cleaning RO elements.

The chemical feed pump has a 3.17 gal/hr capacity and is powered by a 1/3 HP electric motor. The chemical feed pump holds 1 pt. of Shell Omala 220 gear oil (with rust inhibitor). The oil is checked weekly and changed every 4000 hours of operation or each year.

(OFF TP #7)

<u>OPPORTUNITY FOR QUESTIONS</u> (1 MIN)

1. <u>Questions from the class</u>

2. <u>Questions to the class</u>

a. What does the multimedia filter consist of?

A. 425 lbs. bedding (gravel, fine to medium)

A. 805 lbs. filter media

b. What is the purpose of the cartridge filter?

A. Remove any suspended matter missed by the multimedia filter

(1 MIN)

SUMMARY: During the first hour of instruction we partially covered the identification of components of ROWPU.

BREAK: (10 MIN)

(1 MIN)

INTRODUCTORY TRANSITION: During the second hour of instruction we will cover the remaining components for proper identification

BODY Cont'd: (46 MIN)

(ON TP #8, CONTROL PANEL)

j. Control Panel - the control panel consists of various gauges, valves, lights, switches, and hose connections.

(1) Control Box Assembly - consists of indicator lamps and switches to start, operate, and stop all pumps.

(2) Panel Light - provides light for inside of the ROWPU and for the control panel.

(3) Vent, Cartridge Filter - relieves air from cartridge filter.

(4) Vent, Pulse Dampener - relieves air from pulse dampener. Pulse dampener reduces the shock (pulses) caused by the pistons of the RO pump.

(5) Vent Multimedia Filter - relieves air from multimedia filter.

(6) Backwash Valve - valve used to wash multimedia filter.

(7) Multimedia Filter Gauge - shows pounds of pressure rise in multimedia filter and indicates when filter is dirty.

(8) Waste Hose Hook Up - connection for dirty brine that was used to wash the multimedia filter.

(9) RO Vessels Gauge - shows pounds of pressure rise in the RO pressure vessels and indicates the condition of RO elements.

(10) Raw Water Flow Meter - measures in gallons per minute the amount of water drawn in by raw water pumps and fed into ROWPU.

(11) Backwash Water - connection for backwash hose from backwash pump.

(12) Raw Water - connection for hose from raw water pumps.

(13) Ground Rods - help protect operator from electrical shock.

(14) Backwash Gauge - measures amount of water flowing through multimedia filter during backwash cycle.

(15) RO Pressure PSI Gauge - shows discharge pressure of the RO pump in pounds per square inch (psi). Gauge reading depends on setting of the regulated product flow valve.

(16) Brine Flow Meter - measures amount of brine flow from the ROWPU in gallons per minute.

(17) Regulate Product Flow Valve - closes the outlet of the RO vessels. Controls the rate of flow of the product water.

(18) Brine - connection for salty water hose from the ROWPU to brine tank.

(19) Vent Vessels - allow water to bypass pressure vessels when operator is not ready to purify water.

(20) Product Water Flow - gauge shows the number of gallons per minute of drinking water put out by the ROWPU.

(21) Cartridge Filter Gauge - measures pounds of pressure rise in the cartridge filter and indicates when filter is dirty.

(22) Product Water - connection for drinking water hose from ROWPU to product water tank.

(23) RO Element Cleaning Switch - used to operate backwash pump during cleaning of RO elements. Switch is located on left side of control panel under a spring-loaded safety guard.

CAUTION: Switch must be OFF when backwashing the multimedia filter. Operating the RO element cleaning switch during backwashing can cause damage to the RO elements.

(OFF TP #8)

OPPORTUNITY FOR QUESTIONS (2 MIN)

1. Questions from the class

2. Questions to the class

a. What is the purpose of vent filter valve?

A. Relieves air from the filter

b. What controls the pressure reading on the RO Pressure PSI Gauge?

A. Regulate Product Flow Valve

(1 MIN)

SUMMARY: During this hour we covered most of the controls and connections on the RO unit. After the break we will cover the remaining components.

BREAK (10 MIN)

(1 MIN)

INTRODUCTORY TRANSITION: During the third hour of instruction we will cover the remaining components of RO unit.

BODY (46 MIN)

(ON TP #9, CONTROL BOX ASSEMBLY)

(24) RO Pump Low Pressure Indicator Lamp - yellow lamp that comes on when RO pump suction pressure drops below 10 psi. This lamp also indicates that RO pump should have shut off.

(25) RO Pump High Pressure Indicator Lamp - red lamp that comes on when RO pump discharge pressure is higher than 1250 psi. This lamp also indicates that RO pump should have shut off.

(26) Distribution Pump Indicator Lamp - green lamp comes on when distribution pump motor is running normally.

(27) Raw Water Pump No. 1 Indicator Lamp - green lamp comes on when raw water pump No. 1 motor is running normally.

(28) Raw Water Pump No. 2 Indicator Lamp - green lamp comes on when raw water pump No. 2 motor is running normally.

(29) Chemical Feed Pump Indicator Lamp - green lamp comes on when chemical feed pump motor is running normally.

(30) Booster Pump Indicator Lamp - green light comes on when booster pump motor is running normally.

(31) RO Pump Indicator Lamp - green light comes on when RO pump motor is running normally.

(32) Emergency Stop Switch - when pushed in, this switch shuts off power to all pump motors.

NOTE: Green lamp indicates that the pump motor starting relay is activated, and does not indicate that the pump is running normally. This applies to items 27-31.

CAUTION: The Emergency Stop Switch should not be used to shut off the ROWPU except in emergency condition. To do so can cause damage to the equipment.

WARNING: Push emergency stop button in ONLY if any of the following conditions exists:

(a) Operating personnel could be injured or the equipment could be damaged if operation of the ROWPU is allowed to continue.

(b) Red high pressure lamp associated with RO pump comes on but unit does not automatically stop.

(c) Yellow low pressure lamp associated with RO pump comes on but unit does not automatically stop.

(d) Some other serious trouble (malfunction) is indicated by noise, vibration, large water leaks, etc.

(e) When backwash pump lamp and backwash pump itself come on during normal filtering operation.

(f) When high pressure relief valve activates during operation.

(g) When rupture disc activates during normal operation.

(33) Start Backwash Switch - toggle switch used to start the backwash cycle.

(34) Backwash Pump On Indicator Lamp - white lamp comes on when the backwash pump motor is running normally.

NOTE: All indicator lights have a blackout adjustment on them. By turning the lamp cover right or left you can increase or decrease the amount of light showing on the lamp.

(35) RO Pump Start Switch - toggle switch used to start, run, and stop the RO pump motor.

(36) Booster Pump Start Switch -toggle switch used to start, run, and stop the booster pump motor.

(37) Chemical Feed Pump Start Switch - toggle switch used to start, run, and stop the chemical feed pump motor.

(38) Raw Water Pump No. 2 Start Switch - toggle switch used to start, run, and stop the raw water pump No. 2 motor.

(39) Raw Water Pump No. 1 Start Switch - toggle switch used to start, run, and stop the raw water pump No. 1 motor.

(40) Distribution Pump Start Switch - toggle switch used to start, run, and stop the distribution pump motor.

(41) RO Pump Reset Switch - toggle switch that resets the high or low pressure switch after it shuts off the RO pump. If the malfunction has been corrected this switch will turn off the low pressure or high pressure indicator.

(42) RO Pump JOG Switch - toggle switch that can be used to run the RO pump for 3 to 5 seconds.

(43) Panel Light Switch - toggle switch used to turn the panel light on and off.

(OFF TP #9)

(ON TP #10, VENT VESSELS VALVE)

(44) Vent Vessels Valve - the vent vessels valve bypasses the flow of raw water into the RO vessels. The vent vessel valve is located on left side behind the control panel.

(OFF TP #10)

(ON TP #11, VENT PRODUCT WATER VALVE)

(45) Vent Product Water Valve - the vent product water valve allows air to escape from product water line and lowers product water pressure. The vent product water valve is located to the right of the top RO vessel.

(OFF TP #11)

(ON TP #12, CHEMICAL FEED PUMP CONTROLS)

(46) Chemical Feed Pump Controls - used to control the flow of each chemical. One knob is located on the back of each chemical feed pump.

<u>NOTE</u>: The sight glass for checking oil level on chemical feed pump is located in the back of the chemical pump on the right side. When changing oil you have to siphon out oil through openings or remove right side of the pump and allow the oil to drain out.

(OFF TP #12)

(ON TP #13, CHEMICAL FEED PUMP VALVES)

(47) Chemical Feed Pump Valves - four valves are used to prime the chemical feed pumps, and direct chemicals into the purification cycle. The valve settings are:

(a) Up for RUN.

(b) Left for OFF.

(c) Down for PRIME

(OFF TP #13)

(ON TP #14, DRAIN VALVES)

(48) Drain Valves - seven drain valves are located at the right back of the ROWPU. They are used to draw samples at various stages of purification and to empty water from the unit before moving.

(OFF TP #14)

(ON TP #15, CIRCUIT BREAKER PANEL)

(49) Circuit Breakers - circuit breakers are located in the junction box. They are used to shut off power to pump motors, utility outlets, and backwash timer if there is an electrical malfunction in the circuit.

(OFF TP #15)

(ON TP #16, JUNCTION BOX)

(50) Junction Box - junction box on the right side of control panel is used for attaching pump cords and has two utility outlets.

(OFF TP #16)

(ON TP #17, BACKWASH TIMER)

(51) Backwash Timer - the timer is contained in a metal box and located on the side of the control valve for the multimedia filter. The timer is used to control the backwash cycle of the multimedia filter.

(OFF TP #17)

(ON TP #18, SAFETY VALVES)

(52) Safety Valves - the ROWPU has two automatic safety valves. The high pressure relief valve and the rupture disc assembly.

(a) The high pressure relief valve is located just after the pulse dampener. If RO pressure goes above 1100 psi this valve opens automatically and discharges water through a pipe at the back of ROWPU.

NOTE: If this valve activates immediately press the push emergency stop switch. When the pressure drops below 1100 psi the valve will close automatically.

(OFF TP #18)

(ON TP #19, RUPTURE DISC)

(b) The rupture disc assembly is located on the pipe between the RO pump and the pulse dampener. The rupture disc is a thin sheet of metal that tears when the pressure goes above 1425 psi.

NOTE: If the rupture disc assembly ever activates press the push emergency stop switch and open the regulate product flow valve. When pressure drops, replace the ruptured disc. Also notify maintenance to troubleshoot the high pressure relief valve and the high pressure switch.

(OFF TP #19)

NOTE: The ROWPU piping is identified according to function by the following colors:

FUNCTION	COLOR
Raw water	Black band
Backwash waste	Red band
Filtered water	Yellow band
Product water	Blue band
Brine discharge	Purple band
Brine piping on RO pressure vessels	Purple band

We have identified all major components of the ROWPU. The other minor components will be identified as we operate the unit.

OPPORTUNITY FOR QUESTIONS (2 MIN)

1. Questions from the class:

2. Questions to the class:

   a. What are the two safety features for the RO pump?

      A. High and low pressure switch

   b. What is the purpose of backwash timer?

      A. Control the backwash cycle of multimedia filter

(1 MIN)

SUMMARY: During this hour of instruction we finished covering the identification of components.

BREAK (10 MIN)

(1 MIN)

INTRODUCTORY TRANSITION: During the fourth hour of instruction we will cover:

1. Installation of ROWPU.

2. Performing pre-operational maintenance.

INSTRUCTORS NOTE: Continuation of the class should be made at this point on the RO units. Instructor should combine the rest of this lecture with demonstration by pointing out the subject on the unit itself instead of transparencies. However, if the instructor chooses to continue this lesson in the classroom, he can continue using the transparencies as stated in this lesson plan.

BODY (30 MIN)

(ON TP #20, CHOOSING SITE)

2. Install the Unit

a. Choosing the site - When choosing the site to set up and run the ROWPU, remember the following:

(1) If you're going to use a stream or lake as the raw water source, stage the ROWPU upstream from the camp.

(2) The raw water hoses can reach about 75 ft. Be sure you stage the ROWPU close enough so the hoses can reach the stream or lake, but also be sure that the ground is solid and fairly level.

(3) Take advantage of any nearby forest cover.

(4) Take advantage of any finished roads. They can furnish a solid, level surface.

(OFF TP 20)

b. Preparation for Use

(1) Roll up canvas cover over the ROWPU frame and fasten with tie-back straps.

(2) Remove the two frame cross braces. Release cargo straps.

(3) Remove one suction hose float and five chemical pails.

(4) Remove three hard rubber suction hoses that are used for raw water input.

(5) If carrying storage tanks with the ROWPU, remove them and the:

(a) Paddle

(b) Sledge hammer

(c) Three hard rubber drinking water hoses and eight canvas hoses consisting of four 1 1/2" and four 2" hoses.

(6) Remove the two storage boxes but do not empty them. Storage box No. 1 contains:

(a) Turbidity tube

(b) Input strainer

(c) Distribution nozzle

(d) Thermometer

(e) Flashlight, drop cord and lamps

(f) Tools and spanner wrenches

(g) TDS meter

(h) Chemical measures (cylinders)

(i) Tape for wrapping pipe threads

(j) Hose reducing nipples

(k) 100 watt light bulb

(l) RO vessel end cap pullers

(m) RO pump valve seat tools.

(7) The other (storage box No. 2) contains:

(a) Chemical feeding tubes

(b) Chemicals

(c) Water testing kit

(d) Chemical mixing wooden paddles

(e) Color comparator kit

(f) 100 ml plastic cylinder.

(8) Remove two raw water pumps.

(9) Remove backwash pump.

<u>NOTE</u>: This pump is very heavy. Get help when lifting or moving this pump.

(10) Product water distribution pump will have to be shipped separately outside the ROWPU.

(11) Test source water using TDS meter. The TDS (Total Dissolved Solids) meter measures the amount of dissolved solids in raw and product water.

(SHOW METER AND BEAKER)

Test source water as follows:

(a) Obtain 250 ml (sample beaker) of sample water.

(b) Obtain TDS meter and RE-10 range extender.

(c) Rinse cell cup of TDS meter and range extender with sample water three times.

(d) Fill cup of the meter with sample water.

(e) Push range extender into cup (when using brackish or sea water) seating the O-ring seal.

(f) Set meter at highest scale.

(g) Press button on the TDS meter to get reading.

(h) If using range extender, multiply the reading by ten (10).

(i) Record reading.

(j) Remove range extender and rinse cup and extender with fresh water. (Use distilled water if possible).

NOTE: Fresh water is between 0 - 1500 TDS.
Brackish water is between 1500 - 10,000 TDS.
Sea water is 10,000 + TDS
Average sea water is 35,000 TDS.
Water fit for human consumption 0 - 1500 TDS.

c. Installation

(1) Lay out the equipment removed from the unit near the water source as follows:

(ON TP #21, FIELD INSTALLATION)

(2) Assemble the brine tank and product water tank(s).

(OFF TP #21)

(ON TP #22, RAW WATER SYSTEM)

(3) Install raw water system.

(a) Hook up raw water pump(s) between source and the ROWPU.

(b) Install strainer and float at the end of water suction hose connected to pump suction outlet.

(c) Connect canvas discharge hose(s) between pump discharge outlet and raw water connection on the ROWPU.

(d) Connect electrical cable from pump(s) to junction box.

(OFF TP #22)

(ON TP #23, BACKWASH PUMP AND STRAINER)

(4) Install the backwash strainer onto the backwash pump.

(a) Remove the two mounting bolts, nuts, and washers from bracket.

(b) Place backwash strainer bracket against the frame and line up the holes.

(c) Insert bolts into holes, add washers and nuts.

(d) Attach strainer inlet connection to swivel on backwash pump.

(e) Tighten all connections.

(OFF TP #23)

(ON TP #24, BACKWASH WATER SYSTEM)

(5) Connect backwash water system.

(a) Connect 2" canvas brine hose(s) from brine outlet on the ROWPU and have it drop into the backwash water tank.

(b) Connect 2" canvas hose from the backwash water connection on the ROWPU and the backwash strainer on the backwash pump..

(c) Connect 2" suction hose between backwash pump (using a 2" double hose nipple) and gate valve on the backwash water tank (using 2" swivel adapter). Close the gate valve.

(d) Connect electrical cord to junction box.

(OFF TP #24)

(ON TP #25, PRODUCT WATER SYSTEM)

(6) Connect product water system.

(a) Connect 1 1/2" hard rubber hoses between product water outlet on the ROWPU and adapter on the storage tank.

(b) If using two storage tanks, connect 1 1/2" hard rubber suction between the tanks using a 1 1/2" gate valve and adapters.

(c) Install hard rubber hose to the storage tank using a 2" to 1 1/2" reducer and connect the other end to the distribution pump and distribution nozzle.

(d) Connect canvas hose between distribution pump and distribution nozzle.

(e) Connect electrical cable from distribution pump to junction box.
(OFF TP 25)
(ON TP #26, WASTE WATER SYSTEM)

(7) Connect waste water system

(a) Connect 2" canvas hose between vent vessels outlet on ROWPU and drain system.

(b) Connect 2" canvas hose between waste water connection on ROWPU and drain system.

(OFF TP #26)
(8) Recheck all hose connections to make sure they are tight. (ON TP #27, CHEMICAL FEED PUMP TUBES)

(9) Attach tubes to chemical feed pumps.

(a) Remove chemical tubes from storage box No. 2

(b) Install tubes without strainers to the chemical feed pump valves, and the tubes with strainers to the feed pump in this order:

1. Clear tubes with inside support to polymer

2. Regular clear tubes to chlorine

3. Yellow tubes to sodium hex

4. Black tubes to citric acid

(c) Set pump valves to prime

(d) Set up chemical buckets

(OFF TP # 27)
(10) Ground the ROWPU with the ground rod.

NOTE: Normal electrical hookup to the ROWPU is:

L1 - Black	L3 - Green or Blue
L2 - Red	L0 - White

(11) Initial Adjustments

(a) Open five vent valves.

1. Vent multimedia filter valve

2. Vent pulse dampener valve

3. Vent cartridge filter valve

4. Vent vessel valve

5. Vent product water valve

(b) Set backwash valve to normal.

(c) Push in emergency stop button.

(d) Set all control box switches to STOP or OFF position.

(e) Open regulate product flow valve (counterclockwise).

(f) Set element cleaning switch to OFF.

(g) Set backwash timer.

(ON TP #28, TIMER RECONDITIONING KNOB)

1. Set reconditioning knob to idle position.

(OFF TP #28)

(ON TP #29. TIMER MECHANISM)

2. Push up on the latch and remove timer mechanism.

3. Set white cam on "SR" position.

4. Replace timer mechanism and close cover.

(OFF TP #29)

(h) Close seven drains in the rear of the unit.

(i) Make sure all hoses and lines are properly connected.

3. Perform Pre-Operation Maintenance

a. Check oil levels

(1) R.O. pump - oil level should be at least half way up on sight glass.

(2) Chemical feed pump - oil level should be to the middle of the sight glass.

b. Perform visual inspection

(1) General - Inspect the general appearance and possible damage of the unit and all its accessories.

(2) Filters - Check for loose connections and leaking gaskets.

(3) Gauges and Indicators - Inspect for broken glass and loose mountings. Check for salt residue inside the gauges.

(4) Pumps - Check for possible damage, damaged fittings, inspect drive belts on R.O. pump.

<u>OPPORTUNITY FOR QUESTIONS</u> (2 MIN)

1. <u>Questions from the class</u>

2. <u>Questions to the class</u>

a. What is the maximum amount of TDS in drinking water?

A. 1500 ppm

b. During the pre-operation check, all control box switches are set at?

A. OFF or STOP

(1 MIN)

<u>SUMMARY</u>: During this hour of instruction we covered the installation and operator's maintenance on the ROWPU.

<u>BREAK</u> (10 MIN)

(1 MIN)

<u>INTRODUCTORY TRANSITION</u>: Now that our unit is set up and maintenance has been performed, let's continue with preparing the required chemicals, starting the unit, and performing operational adjustments

4. <u>Preparing Chemical Solution</u> (10 MIN)

As we discussed earlier, the ROWPU used four types of chemicals, let's prepare a solution of each:

a. Mix polymer solution:

(1) Fill 107 ml measure to the 107 ml (milliliter) mark with liquid polymer chemical.

(2) Pour liquid chemical into polymer pail.

(3) Add brine or raw water up to 3 gal. mark.

(4) Stir with wooden paddle for at least a minute.

(5) Set solution in front of polymer pump and put both clear tubes that have inside supports into the polymer pail.

NOTE: The chlorine, sodium hex, and citric acid solution should be mixed after the unit is put into operation.

b. Mix chlorine solution

(1) Pour 3 gal. of brine into raw water pail.

(2) Fill calcium hypochlorite measure with .2 pounds (91 grams) of calcium hypochlorite.

(3) Pour calcium hypochlorite into pail marked chlorine.

(4) Pour brine from raw water pail into chlorine pail.

(5) Stir with wooden paddle for one minute.

(6) Set solution in front of chlorine pump.

(7) Put both clear tubes into chlorine pail.

c. Mix sodium solution

(1) Pour one-tenth (.1) of a pound (45 grams) of sodium hex into sodium hex measure.

(2) Put sodium hex into pail marked sodium hex.

(3) Add brine to pail marked sodium hex to 3 gal. mark.

(4) Stir with wooden paddle for 1 minute.

(5) Set solution in front of sodium hex pump.

(6) Put both yellow tubes into sodium hex pail.

d. Mix citric acid solution.

(1) Pour three quarters (3/4) of a pound (340 grams) of citric acid into citric acid measure.

(2) Put citric acid into pail marked citric acid.

(3) Add brine to pail marked citric acid to the 3 gal. mark.

(4) Stir with wooden paddle for one minute.

(5) Set solution in front of citric acid pump..

(6) Put both black tubes into citric acid pail.

NOTE: Do not use chemical pails and wooden paddles for jobs other than intended.

TRANSITION: Now that our chemicals are prepared we can go and start the unit.

BODY

5. Starting the Unit (16 MIN)

a. Start generator set, and apply power to ROWPU.

b. Pull out emergency stop button.

NOTE: Yellow lamp, RO pump low pressure, on ROWPU control box assembly comes on as soon as generator supplies power to the ROWPU.

(ON TP #30, EMERGENCY STOP)

c. Push emergency stop button in if any of the following conditions exist.

(1) Operating personnel could be injured or the equipment could be damaged if operation of the ROWPU is allowed to continue.

(2) Red high pressure lamp associated with RO pump comes on but unit does not automatically stop.

(3) Yellow low pressure lamp associated with RO pump comes on but unit does not automatically stop.

(4) Some other serious trouble (malfunction) indicated by noise, vibration, large water leaks, etc.

NOTE: If low or high pressure switch shut down the ROWPU automatically, they can only be reset with the reset switch.

(OFF TP #30)

(ON TP #31, RAW WATER PUMP)

d. Prime the raw water pump(s).

(1) Make sure the drain valves are closed.

(2) Prime the pump through the priming plug or the discharge outlet on the pump.

(OFF TP #31)

e. Start raw water pump(s).

(1) Set switch upward to START.

(2) Hold switch up until green lamp comes on.

(3) Release the switch.

(4) Switch will return to RUN

(5) Look at raw water input hose, if pump is drawing water, the hose will pulsate and fill with water.

(6) The raw water flow rate will jump from 0 to 40 gpm and then gradually drop down to between 25 and 35 gpm flow.

f. Turn on chemical feed pump.

(ON TP #32, PRIMING CHEMICAL PUMP)

g. Prime polymer chemical feed pump.

(1) Set polymer chemical feed control knob to 5.

NOTE: Adjust controls of chemical feed pumps only while motor is running.

(OFF TP #32)

(2) Allow pump to run on prime until no more air bubbles are seen in the solution flowing in the reinforced clear plastic tube.

NOTE: If pump fails to prime, set control knob to 10. Pump will pick up the prime in a few sections. Return control knob to 5.

h. Calibrate the pump.

(1) Set control knob to 2.6.

(2) Obtain your 100 ml graduated plastic cylinder.

(3) While the polymer pump is running, lift tube without strainer out of pail and catch flow for 1 minute.

(4) Flow should be 60 ml. If not, adjust the control knob setting until you get a 60 ml per minute flow.

(5) Record the knob setting.

i. With raw water pump(s) working and the chemical feed pump running, set polymer pump valve from PRIME to RUN.

j. Go around to control panel.

k. Close vent multimedia filter valve as soon as a full stream of water flows out of vent pipe, (located at the bottom right-hand front of the unit, below RO pump belt guard).

l. Start booster pump.

m. Set vent cartridge filter valve to CLOSE as soon as a full stream of water flows out of vent pipe.

n. Set RO pump reset switch upward to RESET.

(1) Release switch.

(2) Yellow RO pump low pressure lamp goes off.

(3) Switch returns to ON.

o. Start RO pump.

NOTE: RO pump will not start with low pressure lamp on.

p. Observe RO pump.

(1) Make sure the RO pump is running.

(2) Make sure the belts are not slapping.

(30 Make sure the pump is running smoothly.

q. Set vent pulse dampener valve CLOSE as soon as you see a full stream of water coming from the vent pipe.

r. At this time the filtered water is bypassing the RO vessels.

s. Operate unit like this for 10 minutes.

t. While waiting the 10 minutes, prime and calibrate the chlorine and sodium hex chemical pumps just like the polymer chemical pump.

u. Set citric acid pump knob to 10, and leave it on prime. (It requires no calibration).

v. After calibration set sodium hex valve to RUN.

w. After 10 minutes of operation, examine the filtered water for clarity.

(ON TP #33), TURBIDITY CHECK)

(1) Obtain the 1000 ml graduate cylinder with the white bulls-eye set in a black background on the bottom of the tube.

(2) Draw a sample of 600 ml of water from drain No. 1 cartridge filter into the turbidity tube.

(3) Look down into the turbidity tube and you should be able to see both the white bull's-eye and the black disc at the bottom of the tube clearly.

(4) If both cannot be seen clearly (water is chalky), run the ROWPU another 10 minutes. Repeat the sampling test.

(5) If after second sampling test, water is not clear, readjust polymer chemical feed control knob setting to 2.0.

(6) Wait 5 minutes then examine another sample of water.

(7) If water is still not clear, repeat this process and keep reducing the chemical setting by .5 each time and waiting 5 minutes until the water is clear.

(8) Obtaining a clear sample of water means that you have the right amount of polymer mixed with raw water for better filtration.

(OFF TP #33)

TRANSITION: At this point the unit is all set up, and ready to go into the final operational adjustments.

6. Adjust the Unit (5 MIN)

a. Slowly close vent vessels valve, (located behind vent vessels outlet). This closes off the water's path of least resistance and allows filtered water to enter RO vessels.

b. Slowly adjust regulate product flow valve to the right (clockwise).

(1) Watch for rise on product water flow gauge.

(2) Watch for decrease on brine flow gauge.

(3) Watch for rise of pressure on RO pressure PSI gauge.

NOTE: Normally, product water flow should not exceed 13.5 GPM. RO pressure PSI gauge should not go above 900 PSI. Keep in mind that the higher the TDS of raw water the more pressure it will take to pump it through the RO vessels.

By closing the regulate product flow valve, you are blocking off the flow of water on the other side of vessels, which results in higher pressure within the RO vessels pushing water through the RO elements.

NOTE: Close regulate product flow valve very slowly. Sudden high pressure to the RO vessels could damage the RO elements.

c. Watch gauges until you obtain proper balance (as stated below). Record gauge reading.

d. Gauge readings, normal and trouble points. (46 MIN)

GAUGE/INDICATOR	NORMAL READING	TROUBLE POINT READ
1. Cartridge Filter	1 to 20 psid	Over 20 psid
2. Multimedia Filter	0 to 10 psid	5 psid over first reading
3. Raw Water Flow	26 to 33 gpm	Drop to 25 gpm or less
4. Brine Flow	16 to 24 gpm	Below 15 gpm
5. Product Water Flow		
a. Salt Water	6 to 12 gpm	Above 12.0 gpm
b. Brackish Water	Up to 13.5 gpm	Above 13.5 gpm
c. Fresh Water	Up to 13.5 gpm	Above 13.5 gpm
6. RO Pressure psi		
a. Salt Water	800 psi or less	Above 900 psi
b. Brackish Water	500 psi or less	Above 600 psi
c. Fresh Water	500 psi or less	Above 600 psi
7. RO Vessels	50 to 100 psid	Above 100 psid
8. TDS of Product Water	Below 1500 ppm	Above 1500 ppm

e. Set chlorine valve to RUN position. Close vent product water valve.

f. Watch water level in brine tank. When tank is full, remove brine hose from tank and put it in the drain. After next backwash, put hose back into tank to refill it.

g. Watch water level in product tank.

(1) Keep tanks clean and covered.

(2) To distribute water, start distribution pump.

h. Obtain occasional chlorine readings from product water hose. If too high or too low, adjust setting on chlorine chemical feed pump.

i. Monitor all gauges during operation.

TRANSITION: At this point the Reverse Osmosis Unit is operating normally. The next area to cover is the normal (or short) shutdown procedures.

7. Normal (Short) Shutdown Procedures

a. Set all chemical pump valves to prime.

b. Open regulate product flow valve.

c. Open vent vessels valve.

d. Open four vent valves:

(1) Vent cartridge filter valve

(2) Vent pulse damper valve

(3) Vent multimedia filter valve

(4) Vent product water valve

e. Place Reverse Osmosis pump switch down to STOP (yellow low pressure lamp will come on).

f. Place booster pump switch down to STOP.

g. Place chemical feed pump switch down to STOP.

h. Place raw water pump switch(es) down to STOP.

i. Push in emergency stop button.

NOTE: If unit will not be operated within 12 hours, open the seven drains and drain the unit.

TRANSITION: After shutting down the Reverse Osmosis Water Purification Unit, just like with any other piece of equipment, you must do the post-operational maintenance.

8. Post-Operation Maintenance (15 MIN)

a. General - Inspect general appearance of the unit. Inspect for water leaks, loose or missing bolts, screws, nuts, and hoses. Inspect for signs of damage and loose or broken cable connections.

b. Frame and Equipment - Remove oil, grease, mud, chemical spills, and other matter from all parts of Reverse Osmosis Water Purification Unit.

c. Multimedia and Cartridge Filters - Inspect for leaks and loose connections and mountings.

d. Gauges and Flow Indicators - Inspect for broken glass and look for loose mountings and tube connections.

e. Chemical Feed Pump - Inspect for loose mounting nuts. Inspect for cracked or broken fittings. Check oil level and condition of oil.

f. Reverse Osmosis Pump - Check all five V-belts for cracks, rubbing, and signs of wear. Check belt tension. Check oil level and condition of oil.

TRANSITION: Upon completion of any operation you must pack up the unit for movement or storage.

9. Preparation for Movement or Storage (45 MIN)

NOTE: Preparation for storage must also be performed during short shutdown if the temperature will drop below freezing.

a. Backwash multimedia filter (backwash will not have to be performed when shutting down for short shutdown).

b. Shut off Reverse Osmosis Water Purification Unit using normal shutdown.

c. Open seven drains in the back of Reverse Osmosis Water Purification Unit.

d. After water stops flow out of seven drains, drain the Reverse Osmosis pump.

(1) Set Reverse Osmosis pump jog switch to jog position and hold it for 3 to 5 seconds.

(2) Repeat this step until no more water comes out of pulse dampener drain valve.

e. Drain booster pump.

(1) After water stops flowing out of seven drains set the booster pump switch to RUN position.

(2) Allow booster pump to run for no more than 5 seconds. Set the booster pump switch to STOP position.

(3) Repeat these steps until no more water comes out of cartridge filter drain valve.

f. Disconnect plastic tubing from each vessel so they can drain. Reconnect tubing when vessels are fully drained.

g. Disconnect the plastic connectors holding the plastic lines on the backwash valve assembly (one at a time) on the multimedia filter and allow lines to drain. Reconnect the drained lines back to the valve assembly.

h. Drain chemical feed pumps.

(1) Empty and rinse all chemical utility pails and fill them with brine water.

(2) Set pump valves to prime.

(3) With pump motor running set pump controls to 10.

(4) After 2 minutes remove chemical hoses from all chemical utility pails.

(5) Stop pump and remove all hoses from chemical pumps.

(6) Disconnect, drain, and reconnect the chemical hoses from the back of chemical pump valves.

(7) Start the chemical pump and run it for 5 to 10 seconds to drain all water from inside the chemical pumps.

i. Drain product water tank(s).

j. Drain brine tank.

k. Drain raw water, distribution, and backwash pumps.

l. Shut off generator and disconnect cables.

m. Disconnect, drain, and roll all hoses.

n. Clean and fold all water tanks.

o. Repack all accessories (as indicated) in each storage box.

p. Install pumps, storage boxes, pails, hoses, sledge hammer and aluminum paddle inside Reverse Osmosis Water Purification Unit.

q. Install trailer cross braces.

The Reverse Osmosis Water Purification Unit is now ready for movement or storage.

OPPORTUNITY FOR QUESTIONS (2 MIN)

1. Questions from the class

2. Questions to the class

a. When priming chemical feed pump, the control knob should be adjusted to what setting?

A. 5.0

b. When adjusting regulate product flow valve, the two most important gauges to watch are ?

A. R.O. pressure PSI gauge and product water flow gauge.

(1 MIN)

SUMMARY: During the past period of instruction we covered the preparation of chemicals, starting the unit, operational adjustments and normal (short) shutdown. After the break we will put the units into operation and practice what we learned.

NOTE: ADMINISTER PROGRESS TEST (15 MIN)

BREAK (10 MIN)

(1 MIN)

INTRODUCTORY TRANSITION: During this period of instruction we will operate the units. You will perform all pre-operational maintenance, start the unit, prepare chemicals, perform operational adjustments, and perform normal (short) shutdown.

CONTROLLED PRACTICAL APPLICATION (959 MIN)

1. Instructor will cover the flow of water through the unit.

2. Instructor will pass out "Student Reference Text" on the R.O. unit to each student. (2 MIN)

3. Instructor will demonstrate the complete operation of the R.O. unit.

4. Instructor will demonstrate the operation of the TDS meter.

5. Students will use the rest of the time to practice the operation of the R.O. unit.

OPPORTUNITY FOR QUESTIONS: (0 MIN)

1. Questions from the class: All questions will be answered on an individual basis throughout practical application.

2. Questions to the class: No questions are required after a practical application phase.

INTRODUCTORY TRANSITION: By now we know how the unit operates and how to make adjustments. The next area we will cover is backwashing the multimedia filter and performing citric acid feed. Both of these procedures are performed to aid the R.O. unit in producing the best water possible.

10. Backwash of Multimedia Filter (45 MIN)

a. Reason for backwash. To remove any dirt and solid material which got caught inside multimedia filter layers. During the backwash cycle the filtered water from the brine tank is pumped by the backwash pump through the multimedia filter layers in reverse (from bottom to top) and any dirt and solid materials are washed out from the filter media.

b. When to backwash. The multimedia filter should be backwashed:

(1) Every 20 hours of operation.

(2) When multimedia filter gauge rises 5 psid above the initial reading.

(3) When R.O. unit will not be operated for a long time.

(4) Before movement.

c. How backwash cycles work. Before we get into how to backwash, let's cover the backwash timer. As we know the backwash timer controls the backwash cycles of the backwash procedures. We will cover all four cycles and how the timer affects each one. The backwash timer opens and closes the six valves at certain times, and the six valves allow the water to pass in a certain direction which results in a backwash cycle of the multimedia filter.

(ON TP # 34, INSIDE BACKWASH TIMER)

When the backwash switch is activated it causes the gear teeth of the reconditioning knob to come in contact with the gear teeth of the timer motor and the reconditioning knob begins to slowly rotate. As it rotates it causes the four cams to which it's attached to rotate also. Those four cams each have slots which start the microswitch (each switch activates at a different time). The microswitch causes the white cam to rotate to it's next setting. Each setting on the white cam opens and closes certain valves which allow water to flow a certain way. Let's cover each of the four backwash cycles and see how the six valves operate.

(OFF TP # 34)
(ON TP # 35, "BW" BACKWASH STAGE)
The four cycles of backwash are:

(1) "BW" backwash - When the white cam rotates first, it stops on "BW" or backwash stage. During the backwash stage the water enters the valve area (always in the middle). Valves 3 and 4 are the only open valves which force the water to go through the valve 3 and out the bottom pipe to the bottom outlet of the filter. This water then flows through the multimedia filter upward and comes out through the filter inlet pipe and comes back into valve 1 chamber. At this point valve 4 is open, and the water is then forced to travel down (inside valve 4 and 5 body) and out to the waste outlet pipe which is connected to the waste hose outlet. There are three stages to this backwash cycle: Normal backwash, high speed backwash, and normal backwash again. Inside the timer there is a separate cam and microswitch which starts and STOPS high speed backwash.

(OFF TP # 35)
(ON TP # 36, NORMAL BACKWASH)

During normal backwash, the waste water which leaves the six valves flows straight through the flow restrictor valve and out of the unit. This restrictor valve allows only 70 GPM to flow through it, which registers on the flow gauge.

(OFF TP # 36)
(ON TP # 37, HIGH SPEED BACKWASH)

During high speed backwash, the single cam inside the timer activates and opens a diaphragm valve which allows additional flow of waste water to go through another restrictor valve. Together both restrictor valves allow about 100 - 120 GPM flow of waste water which causes the water inside multimedia filter to flow faster.

(OFF TP # 37)

When the high speed cam deactivates the switch it causes the closing of diaphragm valve, which puts the waste water into normal backwash again. All three cycles of backwash last between 10 and 14 minutes, and during this cycle all the dirt is washed out from the media layers.

(ON TP # 38, "BR" OFF STAGE)

(2) "BR" Off Stage - As the four cams rotate the second cam activates the microswitch which rotates the white came to the "BR" setting. During this stage only valve 5 is open. Since the water which enters the valve cavity has no place to go, there is no flow of water through the filter. This allows the filter media to settle down after the backwash. The flow meter should register 0 GPM flow water.

(OFF TP # 38)
(ON TP # 39, "CR" RINSE CYCLE)

(3) "CR" Rinse Cycle - As the four cams rotate they cause the third microswitch to activate, which rotates the white cam to the "CR" setting. During this cycle, valves 1 and 5 are open and the water which enters the valve cavity flows through valve 1 and through multimedia filter and comes into the valves from the filter outlet. Valve 5 allows the rise water to go out the waste outlet and out to the waste hose hookup.

(OFF TP # 39)
(ON TP # 40, "SR" Service Cycle)

(4) "SR" Service Cycle - When the white cam rotates fourth and last time it puts the six valves into service position. Valves 1 and 2 are open which allows water from pump cavity to go up through valve 1 and out to filter inlet line. The water flows from top to bottom normally, and reenters the valves from filter outlet valves. Valve 2 allows the water to pass through, and exits through the outlet to the booster pump. Also at this stage the backwash pump is turned off and backwash cycle is completed.

(OFF TP # 40)

<u>TRANSITION</u>: Now that we know that the backwash cycle works, let's go and see how it's done.

d. <u>Performing backwash</u>

(1) Shut down the R.O. unit normally (short shutdown)

(2) Make sure the element cleaning switch is OFF

(3) Check water level in brine tank

<u>NOTE</u>: You need at least 1500 gal. of brine water to backwash one R.O. unit.

(4) Open brine tank valve (connecting tank and backwash pump suction hose)

(5) Prime backwash pump. (Open drain cock on the bottom of the pump or loosen discharge hose on the pump to get a water flow.)

(6) Turn backwash valve handle down to "backwash"

(7) Set START backwash switch up and release immediately.

CAUTION: To avoid damage to the controls, DO NOT hold start backwash switch up for more than 5 seconds.

(8) Backwash pump and backwash cycle should start within 2 to 3 minutes. The cycle is started when the white lamp comes on, and is ended when the backwash pump stops and white lamp goes OFF. The complete backwash cycle lasts about 20 minutes.

NOTE: During backwash cycle, the operator must observe the R.O. unit and the control panel for proper operation, and make sure the brine tank does not go dry before the backwash cycle is completed. The proper gauge reading on the backwash gauge is 0 to 70 to 120, depending on which cycle of backwash the unit is in.

(9) When backwash is completed and the white lamp goes off, turn backwash valve handle to normal.

(10) Close brine tank valve.

(11) Start the R.O. unit normally.

CAUTION: Backwash should NEVER be performed if the R.O. unit multimedia filter is drained or partially drained. If so, operate the R.O. unit normally for at least 30 minutes nonstop to prime the filter and to remove all air from inside the filter.

TRANSITION: Now that we know how to backwash, let's perform Citric Acid feed.

11. Citric Acid Feed is performed after 20 hours of operation, to get pH of the brine water measurement down to 5. - 8. Citric acid makes RO membranes tighter (stronger) to improve salt rejection. The RO membranes operate best in water containing 5.5 pH. For example: Water with 5.5 pH might produce 500 ppm TDS product water, whereas same water with pH of 7.5 might produce a product water with 1000 - 1500 ppm TDS. Due to cost of citric acid it is recommended to use citric acid only after each 20 hours of operation.

a. Performing Citric Acid Feed.

(1) Put three - quarters (3/4) of a pound of citric acid into citric acid pail using citric acid measure.

(2) Fill the pail with 3 - gal. of brine water.

(3) Stir chemical and brine with wooden paddle.

(4) While the ROWPU is operating normally, set the citric acid chemical feed pump valve on RUN and set chemical feed control knob to 10.

(5) Wait for 10 minutes.

(6) Draw a 250 ml water sample from the brine hose where it enters brine tank and check pH reading.

(7) If that reading is not below 8 feed a new batch of citric acid chemical mix.

(8) When reading is below 8 set feed pump valve to PRIME.

(9) Feed is completed.

OPPORTUNITY FOR QUESTIONS (2 MIN)

1. Questions from the class

2. Questions to the class

a. What is the most important item to remember before starting backwash cycle?

A. That the multimedia filter has been primed with water.

b. Is it safe to perform citric acid feed more frequently than every 20 hours?

A. Yes. Citric acid feed helps to strengthen the element membrane for better salt rejection.

(1 MIN)

SUMMARY: During the past hour we covered the backwash of multimedia filter and citric acid feed. After the break we will perform these procedures.

BREAK

(1 MIN)

INTRODUCTORY TRANSITION: During the past hour we learned about the performance of the backwash and citric acid feed. Now let's go out and put all that knowledge to good use.

CONTROLLED PRACTICAL APPLICATION (359 MIN)

1. Make sure that each unit to be backwashed has sufficient amount of water in the brine tank. If not, operate the R.O. unit normally but leave the regulate product flow valve fully open until the proper amount of water in the brine tank is obtained.

2. Make sure all units to be backwashed have primed multimedia filter. If not, operate the unit for at least 30 minutes.

3. Demonstrate procedures for backwash and then for citric acid feed.

4. Have students backwash the units.

5. After backwash have students perform citric acid feed during normal operation of the R.O. units.

6. Any time left will be used on practicing the operation of the R.O. units.

TRANSITION: Up to now we only operated the R.O. unit under normal conditions. Let's cover now a couple of different operating conditions.

12. Operation Under Unusual Conditions

NOTE: The ROWPU with supporting equipment can operate under different temperature and weather conditions.

a. Cold Weather

(1) Inspect the unit more closely during cold weather.

(2) Don't let water freeze anywhere on the unit, pumps, or hoses.

(3) CAUTION: Turn valves slowly during cold weather because metal contracts and becomes very brittle.

(4) WARNING: Wear rubber gloves when handling and setting valves. Your hands can freeze to the metal.

(5) If raw water hoses freeze, poor water flow will reduce pressure in RO pump. The RO pump low pressure lamp will come and RO pump will shut itself off. Bring hoses under cover until ice melts.

(6) The ROWPU will make less product water when temperature of raw water drops.

(7) When the ROWPU is shut down during cold weather (temperature falls below 32°F for longer period of time), remove the RO elements. Store the elements indoors or in a tent where the temperature is above freezing and allow them to dry.

(8) Always keep the side covers down to reduce wind chill factor of the weather.

b. Hot Weather

(1) When it's 90° or above, park the unit in the shade and leave canvas cover over the unit. Leave control panel uncovered.

(2) Plant life in water will clog filters and, therefore reduce time between filter cleanings during hot weather.

(3) Check raw water and product water more often during hot weather, plant life becomes more common in water during hot weather.

(4) Check motors and motor starters for high temperature. If any get too hot the motors will shut off.

(5) Check wire insulation more carefully to prevent problems.

c. Dusty and Sandy Area

(1) Protect equipment. Leave side covers down except over control panel.

(2) Keep ground around unit damp so sand and dirt won't blow too easily.

(3) Cover all storage tanks.

d. Rainy and Damp Areas

(1) CAUTION: To avoid electrical shorts, keep all electrical items dry.

(2) Provide good water drainage.

(3) Protect chemicals.

e. Salt Water Areas

(1) Wash and wipe ROWPU with product water and wipe dry.

(2) Paint all metal starting to rust.

f. Nuclear, Biological, and Chemical Contaminated Areas

(1) The ROWPU has equipment which is used as a post treatment when nuclear or chemical contaminants are present. The RO membrane itself will remove any biological contaminants in the water. For nuclear or chemical treatment, the equipment consists of a cartridge to remove nuclear contaminants; and a cartridge used to remove chemical contaminants; and the adapters, bushings, clamps, couplings, reducers, and tubing needed for assembly.

(2) For nuclear contamination, use the cartridge marked "FOR USE WITH RADIOACTIVE CONTAMINATED WATER ONLY".

(3) For chemical contamination, use the cartridge marked "FOR USE WITH CHEMICALLY CONTAMINATED WATER ONLY".

(ON TP #41, NUCLEAR AND CHEMICAL FILTERING)

(4) Install the equipment between the two product water tanks. Use one of the raw water pumps to force the water through the cartridge.

(5) Operate the ROWPU in the normal manner.

(6) Change the cartridges after every 100 hours of operating time.

(OFF TP # 41)

OPPORTUNITY FOR QUESTIONS (2 MIN)

1. Questions from the class

2. Questions to the class

   a. Will the output of water during cold weather increase or decrease?

      A. Decrease

   b. How long should you hold the JOG switch when draining RO pump?

      A. Not more than 5 seconds

(1 MIN)

SUMMARY: Now we have covered most of the operation, and after the break we will go into the long shutdown.

BREAK (10 MIN)

(1 MIN)

INTRODUCTORY TRANSITION: Before the break we discussed the long shutdown, now let's perform the long shutdown procedures.

CONTROLLED PRACTICAL APPLICATION (359 MIN)

1. Students will perform all steps necessary to complete a long shutdown within the R.O. unit only. All pumps and hoses located outside the unit don't have to be removed and secured. However, instructor will describe how they would be secured normally.

2. Any time left after completion of long shutdown will be spent on practicing the operation of the unit.

(1 MIN)

INTRODUCTORY TRANSITION: By now we know how to operate, clean, and secure the R.O. unit. The only area left to cover is the maintenance portion. The subjects covered will be cleaning, post-operational maintenance, and operator's maintenance.

BODY (46 MIN)

13. RO Element Cleaning Methods. It will be necessary to clean the RO elements to improve total dissolved solids (TDS) rejection, and reduce operating pressure (RO pressure PSI). Two methods of cleaning elements are available. One method, which is used more often, is to flush citric acid solution through the vessels. The second method is to flush triton X-100 soapy cleaning solution through the vessels. This second method is used usually as a backup for the first method, if the first method can't do the job. These solutions remove unwanted material from the membranes.

   a. The RO elements must be cleaned:

      (1) Whenever the pressure in the RO vessels shown on RO pressure PSI indicator rises to either 900 for seawater or 600 for fresh water, and at same time product water flow gauge drops below minimum reading (6GPM).

(2) Product matter output drops several gallons per minute on product water flow indicator with no change in temperature. (The unit operates better in warmer weather than in colder, ideal is 74°F).

(3) Brine flow increases noticeably and adjustment of regulate product flow valve does not correct the product water flow indication.

(4) Before movement or after completion of exercise.

b. RO element cleaning procedure.

(1) Element cleaning switch must be OFF except while cleaning RO elements.

(2) Backwash multimedia filter.

(3) Adjust water level in brine tank to 7 inches. Check for 7 inch brine water level with telescoping aluminum mixing paddle.

(4) Remove backwash hose from outlet on backwash pump and connect Vent Vessel hose to outlet of the backwash pump.

(5) Add 70 lbs (two 3-gal. bucket full) of citric acid to 7 inches of water in 3000 gal. tank.

NOTE: If using 1500 gal. tank use only 35 lbs (one 3 gal. bucket full) of citric acid)

(6) Mix the chemical with mixing paddle for one minute.

(7) Make sure Regulate Product Flow Valve is open

(8) Open Vent Vessel Valve.

(9) Make sure the valve on bottom of tank is open.

(10) Remove product water hose from product water tank, and allow to drain on the ground.

(11) Push element cleaning switch up to START position.

(12) Brine flow indicator should show a flow of 20 gpm or more.

(13) Allow citric acid solution to flow for 45 minutes.

NOTE: Temperature of the water will rise during element cleaning. At no time should it exceed 120°F, stop flushing with citric acid solution. After flushing, system will be rinsed by 5 minutes of normal operation.

(14) Stop flushing by pushing the element cleaning switch down to OFF.

(15) Remove vent vessels hose from outlet of the backwash pump and connect backwash water hose to backwash pump outlet.

(16) Drain the citric acid solution into a shallow, man-made lagoon a reasonable distance away from the unit.

(17) Perform startup procedures for normal filtering operation.

(18) Close vent vessels valves.

(19) Allow the ROWPU to operate for 10 minutes with the regulate product flow valve fully open (turned fully to the left until it stops) to rinse the RO pressure vessels.

(20) Adjust regulate product flow valve until product water flow indicator reads less than 13.5 gpm and RO Pressure PSI indicator reads between 500 and 900 psi.

(21) Allow the ROWPU to run for 3 minutes, then place product water hose into product water storage tank above water level.

NOTE: If the Regulate Product Flow Valve adjustment will not give a proper product water flow indicator reading after 2 hours of operation, shut down the ROWPU normally.

(22) Flush out the ROWPU with 1800 ml Triton X-100 detergent added to 7 inches of water in the 3000 gal. backwash tank. (If using 1500 gal. backwash tank cut the dosage in half). Rinse the RO vessels in the same way you did with acid for 15 minutes or until detergent can no longer be seen in the rinse water.

c. Sterilization of R.O. Elements

(1) Sterilize R.O. elements when:

(a) Returning to storage for a long time.

(b) Not operating unit for more than one week during hot climate or for more than two weeks during cold climate.

(c) Returning from out of CONUS deployment (out of country)

(2) Purpose for sterilization - to prevent biological growth inside the R.O. elements.

(3) How to repack elements - Before elements can be reinserted inside their plastic bags they must first be treated with a formaldehyde solution as follows:

(a) Add 12 gallons or 36 lbs of sterilization material to 7 inches of nonchlorinated filtered water (brine).

(b) Follow same procedure as in regular cleaning of R.O. elements, but operate for only 30 minutes.

(c) Let unit and elements set for 12 hours.

(d) Remove elements and drain for 10 minutes vertically.

(e) Insert elements in proper plastic bags, and tape the open end.

(4) The following solutions are recommended:

(a) Formaldehyde, use 6505-00-139-1321

(b) Formaldehyde analyzed reagent, 6810-00-817-0353

(c) Paraformaldehyde (available commercially)

(d) Hydamine 3500 (available commercially)

(e) Roccal-2 (available commercially)

NOTES: 1. If the R.O. unit will not be operated for a period of couple weeks, rinse the elements with formal dehyde and leave that water inside the vessels.

2. If using hydamine 3500 or roccal-2 in the solution change quantity to 2.6 lbs.

CAUTION: Care should be taken in using any of the listed materials above. Pay strict attention to label directions and precautions in handling. Vapors can be irritating. Good ventilation and common sense are a must.

TRANSITION: After performing the post operational maintenance, let's see what the operators maintenance is all about.

14. Operator's Maintenance

a. Changing RO elements.

NOTE: RO elements are replaced anytime TDS of product water exceeds 1500 pm. Each RO vessel contains two RO elements.

During the initial shipment of ROWPU from the factory the RO elements are shipped separately from the RO vessel.

CAUTION: Unit must be shutdown and all pressure relieved before removing the RO element, or loosening any parts of the RO pressure vessels.

(1) Pre-removal Procedures

(a) Shut the ROWPU down normally.

(b) Open all vents, drains, and controls.

(c) Mark end caps and vessel (alignment marks), to insure that end caps are installed in the same position to reduce chances of leaks.

(ON TP #42, END CAP REMOVAL)

(2) End Cap Removal

(a) Open quick disconnect (1) and pull out tube (2).

(b) Remove nut (3), screw (4), clamp (5), and coupling (6).

(c) Loosen nut on elbow (12) and swing elbow (7) away from the end cap (10).

(d) Remove end cap nuts (8) and washers (9) from the end cap (10).

(OFF TP 42)
(ON TP 43, END CAP REMOVAL)

CAUTION: Do not attempt to pry end cap from vessel. This could damage the seal.

(e) Screw two end cap puller bolts (1/4 - 20 x 2 in.) into threaded holes in end cap.

(f) Alternately rotate each bolt one complete turn until end cap and O-ring are separated from the RO pressure tube. Remove end cap and O-ring.

(g) Repeat this procedure to remove the rear end cap.

(OFF TP 43)
(ON TP #44, ELEMENTS AND CONNECTORS)

(3) Installation of RO Elements

(a) Lubricate O-rings with a silicone base O-ring lubricant.

(b) Install O-rings (1) and (3) in connectors (2) and (5).

(OFF TP #44)

NOTE: The end connectors require two different O-rings. End connector O-ring (1) has an O.D of 1.680 in. O-ring (3) has an O.D. of 1.756 in.

WARNING: RO elements are packaged in sealed plastic bags with a protective chemical called formaldehyde which is poisonous; avoid fumes and keep away from eyes and mouth. Handle with extreme care. After handling wash hands thoroughly with soap and water.

CAUTION: After removing RO element from sealed plastic bag, take care to keep element clean. Failure to do so will bring dust and dirt into RO element and cause early element failure.

Remove element from plastic bag only when you are ready to install it .

(ON TP #45, INSERTING RO ELEMENTS)

(c) Remove new RO element from sealed plastic bag.

(d) Lubricate brine seal with a silicone based lubricant.

(e) Install brine seal (1) in groove of RO element (2) making sure open tip of the seal faces the end of element closest to the groove.

(f) Insert by hand the first RO element (2) into RO vessel (3) until brine seal (1) touches end of RO vessel.

(OFF TP #45)

CAUTION: When inserting RO elements into RO vessel make sure that the end of the element without brine seal goes in first on the front side of the RO vessel (with direction of flow).

(ON TP #46, JOINING RO ELEMENTS)

(g) Place interconnector (3) on product water tube (2) of first RO element.

(h) Remove second RO element from sealed plastic bag.

(i) Lubricate and install brine seal.

(j) Insert product water tube (2) of the second RO element into interconnector (3).

(OFF TP #46)
(ON TP #47, CENTERING RO ELEMENTS)

(k) Slide both RO elements (1) and interconnector (2) into the RO vessel (3) until they are centered in the vessel.

(l) Place end connectors (4) on both ends of product water tubes of RO elements.

(OFF TP #47)

(m) Lubricate and install end cap O-rings and end caps.

(n) Align end caps with match mark on RO vessel.

(o) Press end caps into studs and install ten washers and nuts onto studs.

CAUTION: 65 in. lbs. is maximum torque for end cap nuts.

(p) Reconnect tubes and pipes to RO vessel.

NOTE: During operation observe for leaks.

(4) Removal of RO Elements

(a) Remove both end caps.

(ON TP #48, ELEMENT PULLER)

(b) Assemble element puller.

1. Connect together the puller rod and puller rod handle.

2. Insert elements puller (1) into RO vessel (2). Push puller through end connector (3), through the product water tubes of the two RO elements (4), and through the interconnector (5) between the two RO elements.

3. Place element puller plate (6) on assembled element puller (1) and secure with flat washer (7) and nut (8).

(c) Slowly pull both RO elements (4) from RO vessel (2), being careful to keep element puller centered in tube.

(OFF TP #48)

CAUTION: When removing RO elements from RO vessel make sure you remove them from the opposite end of installation (always with the direction of flow).

(d) Disconnect the element puller after both elements are removed.

(e) Separate RO elements by removing RO element interconnector.

NOTE: It will require at least two people when removing elements. One to pull on the element puller assembly and one to hold the elements as they come out.

CAUTION: O-rings and brine seals should be replaced each time the elements are removed. However, they might be able to be reused if great caution is used during removal and installation of elements. Inspect the O-rings and brine seal carefully before reusing. Worn or damaged seals can cause brine water to leak into the product water tube.

b. Changing cartridge filter tube elements.

(ON TP #49, CARTRIDGE FILTER)

NOTE: The cartridge filter contains eight filter tube elements and a spring loaded seat and clamp assembly with a clamp hook that goes through each filter tube element. The clamp hook attaches to the lower seat plate. Cartridge filter tube elements should be changed when cartridge filter gauge differential pressure rises above 20 psid.

(1) Removal of cartridge filter tube element.

(a) Shut down ROWPU in the normal manner.

(b) Open vent cartridge filter valve.

(c) Open drain No. 1 cartridge filter valve fully.

(d) Loosen three eye nuts (1) and slide eye nuts and washers (2) from the three cover brackets (3).

(e) Lift cover (4) and remove cover seal O-ring (5) from filter. Be careful not to damage cover seal O-ring (5) and vent hose (6).

NOTE: Check O-ring for cracks, breaks, and hardening. Replace defective O-ring.

(f) Grasp handle of filter seat and clamp hook assembly (7) and pull up until it catches and stays open. Extend clamp hook to handle length (by about 1 inch) and lock it in extended position.

(g) Let assembly fall to resting (original) position.

NOTE: Arrow stamped on the upper seat plate (8), near handle, shows direction of filter seat and clamp hook (9).

(h) Tilt assembly until hook is free from lower seat plate (10).

(i) Lift assembly and remove cartridge filter.

(2) Installation of cartridge filter tube element.

(a) Remove and discard used filter tube (11).

(b) Place new filter tube (11) on assembly and rotate slightly to assure seating on upper seat plate (8).

(c) Insert assembly into filter shell with hook and tube in hole of lower seat plate (10).

(d) Engage hook on underside of lower seat plate (10).

(e) Grasp handle of filter seat and clamp hook assembly and pull up until it uncocks allowing holding spring to retract.

(f) Rotate assembly slightly to assure seating.

(g) Allow handle to go down so filter tube seats on plate.

NOTE: Upper seat plate on the filter seat and clamp hook assembly should be centered on the tube thereby covering all of the center hole of the tube.

(h) With one hand on the handle of the filter seat and clamp hook assembly (7), and the other hand on filter tube (11) attempt to remove each assembly without tipping handle to one side and unhooking.

NOTE: If filter tube and seat and clamp assembly can be removed without tipping handle to one side and unhooking, the installation is incorrect. Pull hook from handle to catching position and reinstall filter element.

(i) Make sure the cover seal O-ring is lubricated and correctly in place.

(j) Carefully replace cover (4) on cartridge filter. Avoid damage to O-ring (5) and plastic vent tube(6).

(k) Swing the three eye nuts and bolts up through the ears on cover brackets (3) and tighten eye nuts (1) evenly until cover is fully down. Do not over tighten.

(l) Inspect filter during operation for leaks.

(OFF TP #49)

NOTE: During the initial shipment of the unit from the factory the cartridge filter tube elements are shipped outside the filter unit.

(ON TP #50, BACKWASH PUMP STRAINER)

c. Backwash pump strainer.

(1) Removal, cleaning, and installation.

(a) Shutdown ROWPU in normal manner.

(b) Loosen T-handle screw assembly (1) by turning to the left to release pressure on the strainer cap (4).

(c) Loosen the two bolts (2) and swing the yoke (3) and the T-handle out of the way.

(d) Lift off strainer cap (4) from strainer housing (8).

(e) Remove gasket and inspect it.

(f) Remove screen (6) from strainer housing.

(g) Remove drain plug (7) from bottom of strainer housing (8).

(h) Flush strainer screen and strainer housing with product water to remove foreign matter and dirt.

NOTE: Make sure all holes in the screen are open.

(i) Install strainer screen and drain plug in strainer housing.

(j) Install gasket, cap, and close and tighten the yoke.

(k) Tighten T-handle.

(OFF TP #50)
(ON TP #51, RUPTURE DISC)

d. Removal and installation of rupture disc.

NOTE: The rupture disc is a safety device for the RO pump high pressure discharge lines. If that pressure ever reaches 1425 psi on the RO Pressure PSI gauge, the rupture disc tears open (ruptures). The disc is mounted in a screw type mount body on top of the RO pump discharge pipe. You must replace the rupture disc after it blows, before you start the ROWPU again.

CAUTION: If you continue operation after the rupture disc opens, you could damage the ROWPU. Immediately shut off the ROWPU with the emergency stop button and open the regulate product flow valve all the way.

(1) Removal

(a) Remove hold down screw (1) from body (4).

(b) Remove hold down ring (2).

(c) Remove ruptured disc (3).

(2) Installation

(a) Place the side of the new disc (3) that curves upward toward the top.

(b) Insert it into the body (4).

(c) Replace hold down ring (2).

(d) Return hold down screw (1).

(OFF TP # 51)

e. Disassemble and assemble chemical pump head assembly

(ON TP #52, CHEMICAL FEED PUMP HEAD ASSEMBLY)

(1) Remove chemical hoses

(2) Hold studs (22) in place against pump body (2) and remove two nuts (14) from studs (22).

(3) Remove flange (15) from studs (22) and valve carrier (16).

(4) Remove valve carrier (16) and seal ring (17) from ball valve (18).

(5) Remove ball valve (18) and seal ring (19) from pump body (12).

NOTE: Notice position of the ball valve (up or down).

(6) Repeat the same steps for the lower part of chemical pump head assembly.

(7) If any pump parts need cleaning, soak them in solution of baking soda and water, rinse, and allow to air dry.

(8) To assemble chemical pump head assembly perform steps 2 to 6 in reverse order.

(OFF TP #52)

OPPORTUNITY FOR QUESTIONS (2 MIN)

1. Questions from the class

2. Questions to the class

a. How much citric acid is used in 3000 gal. tank when cleaning R.O. elements?

A. 70 lbs.

b. During cold weather operation, how should you turn the valves?

A. Slowly, because metal contracts and becomes brittle.

(1 MIN)

SUMMARY: During the last hour of lecture we covered:

1. Cleaning R.O. elements

2. Post operational maintenance

3. Operators maintenance

BREAK (10 MIN)

(1 MIN)

INTRODUCTORY TRANSITION: Now that we know how to perform the cleaning of R.O. elements, and to perform the operator's maintenance, let's us go and actually do it.

CONTROLLED PRACTICAL APPLICATION (347 MIN)

1. Have students clean the R.O. elements in each unit. If possible have some units cleaned with citric acid and some with Triton x-100 detergent.

2. Have students change one set of elements in each unit. They can re-install the same elements.

3. Have each student remove and install same cartridge filter.

4. Have students take apart one chemical pump head assembly on each R.O. unit.

5. If there is any time left over, the students can cover any area that they feel they need extra time on in preparation for the test.

OPPORTUNITY FOR QUESTIONS

1. Questions from the class: All questions will be answered on an individual basis throughout the practical application.

2. Questions to the class: No questions are required after a practical application.

(2 MIN)

SUMMARY: During the past couple of days we covered all areas necessary to properly operate and properly maintain a R.O. unit. Knowing and properly following these procedures will keep your R.O. unit in constant mission ready condition.

BREAK (10 MIN)

LIST OF SUPPORTING PAPERS

1. Advance Sheet/Student Outline
2. Transparency #1, Reverse Osmosis Unit
3. Transparency #2, Range of Separation Process
4. Transparency #3, 600 ROWPU
5. Transparency #3A, Multimedia Filter
6. Transparency #4, R. O. Vessel with two Elements
7. Transparency #5, R. O. Elements and Connectors
8. Transparency #6, R. O. Element
9. Transparency #7, Chemical Feed Pump
10. Transparency #8, Control Panel
11. Transparency #9, Control Box Assembly
12. Transparency #10, Vent Vessels Valve
13. Transparency #11, Vent Product Water Valve
14. Transparency #12, Chemical Feed Pump Controls
15. Transparency #13, Chemical Feed Pump Valves
16. Transparency #14, Drain Valves
17. Transparency #15, Circuit Breaker Panel
18. Transparency #16, Junction Box
19. Transparency #17, Backwash Timer
20. Transparency #18, Safety Valves
21. Transparency #19, Rupture Disc
22. Transparency #20, Choosing the Site
23. Transparency #21, Field Installation
24. Transparency #22, Raw Water System
25. Transparency #23, Backwash Pump and Strainer

26. Transparency #24, Backwash Water System
27. Transparency #25, Product Water System
28. Transparency #26, Waste Water System
29. Transparency #27, Tubes to Chemical Feed Pump
30. Transparency #28, Timer's Reconditioning Knob
31. Transparency #29, Timer mechanism
32. Transparency #30, Emergency Stop
33. Transparency #31, Raw Water Pump
34. Transparency #32, Priming Chemical Pump
35. Transparency #33, Turbidity Check
36. Transparency #34, Inside Backwash Timer
37. Transparency #35, "BW" Backwash Stage
38. Transparency #36, Normal Backwash
39. Transparency #37, High Speed Backwash
40. Transparency #38, "BR" Off Stage
41. Transparency #39, "CR" Rinse Cycle
42. Transparency #40, "SR" Service Cycle
43. Transparency #41, Nuclear and Chemical Filtering
44. Transparency #42, End Cap Removal
45. Transparency #43, End Cap Removal
46. Transparency #44, Elements and Connectors
47. Transparency #45, Inserting R.O. Elements
48. Transparency #46, Joining R.O. Elements
49. Transparency #47, Centering R.O. Elements
50. Transparency #48, Element Puller
51. Transparency #49, Cartridge Filter
52. Transparency #50, Backwash Pump Strainer
53. Transparency #51, Rupture Disc
54. Transparency #52, Chemical Feed Pump Head Assembly
55. Performance Test

OPERATING LOG

FOR THE

REVERSE OSMOSIS WATER

PURIFICATION UNIT

GENERAL INFORMATION

This operating log has been developed to document the performance of the 600-gph Reverse Osmosis Water Purification Unit (ROWPU). The history of operation and performance are critical in determining causes of premature membrane failure and other problems affecting the unit as well as to evaluate the overall reliability of the system.

The log documents the Reverse Osmosis elements serial numbers, ROWPU operating time, overall performance, chemical usage, and your comments.

Section I should be completed whenever you start or stop the ROWPU. Indicate the quantity of product water produced when the ROWPU is operated. If the ROWPU is operated 24 hours a day without stopping, indicate the quantity of product water produced during 24 hours. Use the following formula to calculate water production over 24 hours when you know the flow rate in gallons per minute (gpm): 24 hr/day x 60 min/hr x flow rate (gpm) = gal/day.

Section II is the performance record and should be completed every one to eight hours of operation. (If data collection is every hour, divide entry blocks in half to accommodate number of daily entries.) Please complete all entries in this section. The water quality should be measured with the test kits provided with the ROWPU.

Section III should be completed whenever you change the chemical feed pump settings.

Section IV documents your comments about the overall operation of the unit. Please also identify the date and time of routine events such as filter backwashings, backwash water flow rate, membrane cleanings, equipment failures, routine maintenance, problems, etc.

The pages are identified with an A and B for each given page number. When any part of a page is completed, leave the remaining unused spaces blank and proceed to the next page number.

When a serious problem arises with the ROWPU, forward ROWPU location, a problem description, copies of appropriate log book pages, personnel to contact, mailing address, and/or telephone number (if any) to Belvoir R&D Center, STRBE-GS, Fort Belvoir, VA 22060, and call Autovon 354-5472/5172 or Commercial (703) 664-5472/5172.

ROWPU SERIAL NUMBER ____________________

REVERSE OSMOSIS ____________ ____________ ____________ ____________

ELEMENTS SERIAL
NUMBERS ____________ ____________ ____________ ____________

I OPERATING TIMES AND WATER PRODUCTION

START	DATE											
	TIME											
STOP	DATE											
	TIME											
ESTIMATED QUANTITY OF WATER PRODUCED												

II UNIT PERFORMANCE

	OPERATOR											
	DATE											
	TIME											
PANEL GAGES	MULTIMEDIA FILTER, PSID											
	RAW WATER FLOW, GPM											
	RO VESSELS, PSID											
	RO PRESSURE, PSI											
	BRINE FLOW, GPM											
	CARTRIDGE FILTER, PSID											
	PRODUCT WATER FLOW, GPM											
WATER QUALITY	RAW WATER TDS, PPM											
	PRODUCT WATER TDS, PPM											
	BRINE TEMPERATURE, DEGREES F											
	BRINE pH, UNITS											
	PRODUCT WATER, CHLORINE, PPM											

III CHEMICAL ADDITION

	DATE											
	TIME											
POLYMER	MICRO-METER SETTING											
	FLOW, ML/MIN											
	POLYMER USED											
	POLYMER ON-HAND											
CHLORINE	MICRO-METER SETTING											
	FLOW, ML/MIN											
	CHLORINE USED											
	CHLORINE ON-HAND											
SODIUM HEXAMETA PHOSPHATE	MICRO-METER SETTING											
	FLOW, ML/MIN											
	SODIUM-HEX USED											
	SODIUM-HEX ON-HAND											
CITRIC ACID	MICRO-METER SETTING											
	FLOW, ML/MIN											
	CITRIC ACID USED											
	CITRIC ACID ON-HAND											

IV COMMENTS: Document Times and Dates of Filter Backwash, Backwash Water Flow Rate (gpm), Membrane Cleanings, Problems, Equipment Failure, Routine Maintenance, Etc.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

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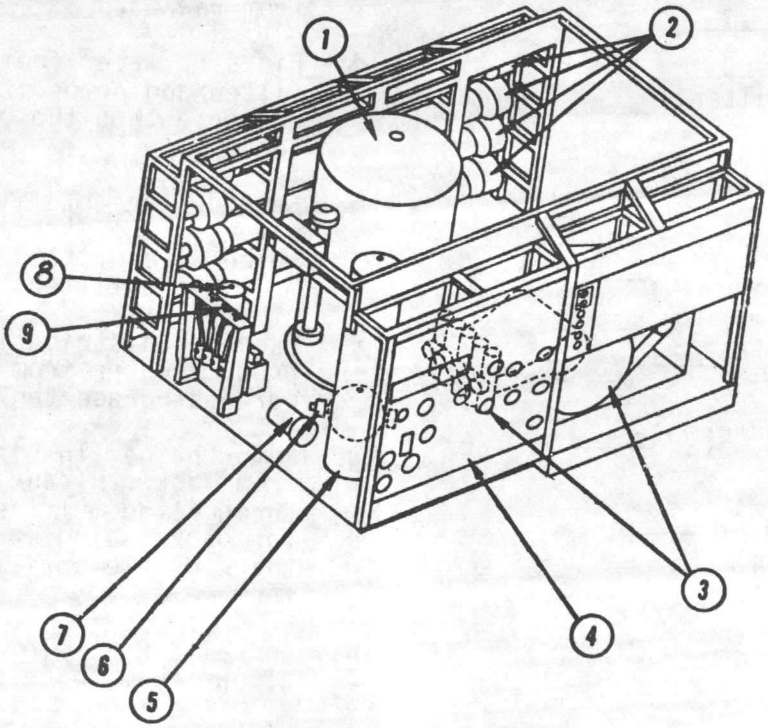
STUDY ASSIGNMENT

REVERSE OSMOSIS WATER PURIFICATION UNIT

SECTION I - POINT OUT EACH MAJOR COMPONENT

Point out each major component of the R.O. Unit by selecting the number from the illustration which corresponds with it's name listed below. Place the number from the illustration which corresponds with its component.



a. Chemical pump valves ______
b. Booster pump ______
c. R.O. pump ______
d. Cartridge filter ______
e. Control panel ______
f. Pulse dampener ______
g. Chemical pump motor ______
h. Multimedia filter ______
i. R. O. pressure vessels ______

SECTION II - FUNCTION OF COMPONENTS

With the use of notes and references, match the component in column "A" with their function in column "B". In the space provided by column "A" write the letter from column "B" which defines the function of each component.

COLUMN "A"

1. Raw water pump _____

2. Distribution pump _____

3. Booster pump _____

4. Backwash pump _____

5. R. O. pump _____

6. Multimedia filter _____

7. Cartridge filter _____

8. Pressure vessels _____

9. R. O. elements _____

10. Chemical feed pump _____

11. Pulse dampener _____

COLUMN "B"

a. Pumps chemicals (polymer, chlorine, sodium hex, and citric acid) to aid the filtration process.

b. Reduces the shock (pulses) caused by the pistons of the R.O. pump, of the flow of raw water.

c. First stage of filtration, removes unsafe foreign matter from raw water.

d. Picks up water from cartridge filter and pumps it under great pressure thru the pressure vessels.

e. Second stage of filtration, removes fine dirt particles which were omitted by multimedia filter.

f. Used for distribution of product water from product water strorage tank(s).

g. Pumps brine flushing water from backwash tank (brine tank) through the multimedia filter for backwashing, or through the R.O. elements for cleaning them.

h. Contains R.O. elements, and allows them to be pressurized.

i. Picks up filtered raw water from multimedia filter and pumps it into the cartridge filter.

j. Spiral-wound membrane material used in separating the dissolved solids from the raw filtered water.

k. Draws raw water from the source and pumps it into the R.O. Unit.

SECTION III - TROUBLESHOOTING R.O. UNIT

Hypothetical Situation - You are an R.O. unit operator. While monitoring the operation of the R.O. unit you observe signs that there is something wrong with the unit. You, as the operator, must identify the problem and select a proper remedy to rectify the problem.

Instructions: In the following situations, Part "A" lists all gauge readings, test results, and observations which you made during monitoring of the unit. Part "B" lists possible faults with the unit, and Part "C" lists the possible remedies which may rectify the problems.

1. With the use of notes and references, read Part "A" of each situation to determine the possible fault.

2. Once you have identified the fault in Part "A" circle the letter in Part "B" which best defines the fault.

3. Read Part "C" at the end of each situation and circle the possible remedy which would correct the fault.

SITUATION - 1

Part "A"

Raw water source (TDS) - 30,000 ppm
Multimedia filter gauge - 3 psid
Cartridge filter gauge - 10 psid
Raw water flow meter - 32 gpm
R.O. vessel gauge - 70 psid
R.O. pressure PSI gauge - 900 psi
Brine flow meter - 27 gpm
Product water flow meter - 5 gpm
Product water TDS - 900 ppm
Brine water P^H - 7.5

Part "B" - Fault

a. Defective R.O. elements
b. Fouled up multimedia filter
c. Improperly adjusted backwash timer
d. Dirty R.O. elements

Part "C" - Remedies

a. Change cartridge filter elements
b. Adjust white cam on backwash timer
c. Clean R.O. elements
d. Replace connector O-rings

SITUATION 2

Part "A"

Raw water source TDS - 15,000 ppm
Multimedia filter gauge - 5 psid
Cartridge filter gauge - 18 psid
Raw water flow meter - 32 gpm
R.O. vessel gauge - 60 psid
R.O. pressure PSI gauge - 700 psi
Brine flow meter - 19 gpm
Product water flow meter - 13 gpm
Product water TDS - 300 ppm
Brine water P^H - 7.0
R.O. pump low pressure lamp keeps coming "ON".

Part "B" - Fault

a. Dirty R.O. elements.
b. Clogged raw water pump strainer.
c. Fouled up cartridge filter elements
d. Dirty multimedia filter.

Part "C" - Remedy

a. Change R.O. elements.
b. Backwash multimedia filter.
c. Readjust backwash timer.
d. Replace cartridge filter elements.

SITUATION - 3

Part "A"

Raw water source (TDS) - 2,500 ppm
Multimedia filter gauge - 15 psid
Cartridge filter gauge - 5 psid
Raw water flow meter - 33 gpm
R.O. vessel gauge - 65 psid
R.O. pressure PSI gauge - 400 psi
Brine flow meter - 20 gpm
Product water flow meter - 13 gpm
Product water TDS - 100 ppm
Brine water P^H - 6.5
Raw water coming out of waste hose.

Part "B" - Fault

a. Dirty R.O. elements
b. Improperly adjusted backwash timer.
c. Defective O-rings inside connectors.
d. Dirty cartridge filter.

Part "C" - Remedy

a. Readjust backwash timer.
b. Backwash multimedia filter.
c. Perform citric acid feed.
d. Clean R.O. elements.

SITUATION 4

Part "A"

Raw water source TDS - 15,000 ppm
Multimedia filter gauge - 10 psid
Cartridge filter gauge - 4 psid
Raw water flow meter - 33 gpm
R.O. vessel gauge - 50 psid
R.O. pressure PSI gauge - 300 psi
Brine flow meter - 20 gpm
Product water flow meter - 13 gpm
Product water TDS - 100 ppm
Brine water P^H - 7.5
R.O. pump low pressure lamp keeps coming "ON".

Part "B" - Fault

a. Dirty R.O. elements.
b. Dirty cartridge filter.
c. Dirty multimedia filter.
d. Dirty timer strainer.

Part "C" - Remedy

a. Clean timer strainer.
b. Backwash multimedia filter.
c. Change cartridge filter elements.
d. Change R.O. elements.

SITUATION - 5

Part "A"

Raw water source TDS - 49,000 ppm
Multimedia filter gauge - 4 psid
Cartridge filter gauge - 10 psid
Raw water flow meter - 33 gpm
R.O. vessel gauge - 50 psid
R.O. pressure PSI gauge - 800 psi
Brine flow meter - 23 gpm
Product water flow meter - 10 gpm
Product water TDS - 500 ppm
Brine water P^H - 7.4
Raw water coming out of waste hose.
Backwash timer set on "idle" and "SR"

Part "B" - Fault

a. Dirty raw water pump strainer.
b. Dirty multimedia filter
c. Dirty cartridge filter
d. Dirty backwash timer strainer.

Part "C" - Remedy

a. Backwash multimedia filter.
b. Change cartridge filter elements
c. Clean backwash timer strainer
d. Clean R.O. elements

SITUATION 6

Part "A"

Raw water source TDS - 35,000 ppm
Multimedia filter gauge - 6 psid
Cartridge filter gauge - 10 psid
Raw water flow meter - 34 gpm
R.O. vessel gauge - 70 psid
R.O. pressure PSI gauge - 780 psi
Brine flow meter - 24 gpm
Product water flow meter - 10 gpm
Product water TDS - 600 ppm
Brine water P^H - 8.5

Part "B" - Fault

a. p^H too high.
b. Dirty R.O. elements.
c. Dirty cartridge filter.
d. Improperly adjusted backwash timer.

Part "C" - Remedy

a. Clean R.O. elements.
b. Perform citric acid feed.
c. Backwash multimedia filter.
d. Replace cartridge filter elements.

SITUATION - 7

Part "A"

Raw water source TDS - 3,500 ppm
Multimedia filter gauge - 3 psid
Cartridge filter gauge - 7 psid
Raw water flow meter - 33 gpm
R.O. vessel gauge - 110 psid
R.O. pressure PSI gauge - 450 psi
Brine flow meter - 20 gpm
Product water flow meter - 13 gpm
Product water TDS - 150 ppm
Brine water P^H - 7.4

Part "B" - Fault

a. Dirty multimedia filter
b. Dirty R.O. elements
c. Raw water pump not pumping at rated capacity.
d. White cam on timer not set properly.

Part "C" - Remedy

a. Change R.O. elements.
b. Clean cartridge filter elements.
c. Clean R.O. elements.
d. Change O-rings on connectors.

SITUATION 8

Part "A"

Raw water source TDS - 500 ppm
Multimedia filter gauge - 15 psid
Cartridge filter gauge - 6 psid
Raw water flow meter - 34 gpm
R.O. vessel gauge - 65 psid
R.O. pressure PSI gauge - 300 psi
Brine flow meter - 21 gpm
Product water flow meter - 13 gpm
Product water TDS - 50 ppm
Brine water P^H - 7.3
Water coming out of waste hose.
Backwash timer is set on "idle" and "SR".
Backwash timer strainer is clean.

Part "B" - Fault

a. Fouled control valves.
b. Dirty multimedia filter.
c. Dirty cartridge filter.
d. Dirty R.O. elements.

Part "C" - Remedy

a. Clean R.O. elements.
b. Replace O-rings on connectors.
c. Clean control valves.
d. Clean raw water strainer.

SITUATION - 9

Part "A"

Raw water source TDS - 31,500 ppm
Multimedia filter gauge - 2 psid
Cartridge filter gauge - 8 psid
Raw water flow meter - 12 gpm
R.O. vessel gauge - 57 psid
R.O. pressure PSI gauge - 775 psi
Brine flow meter - 21 gpm
Product water flow meter - 10 gpm
Product water TDS - 475 ppm
Brine water P^H - 7.8
R.O. Pump low pressure lamp keeps coming "ON".

Part "B" - Fault

a. Dirty cartridge filter.
b. Air leak or blockage on raw water suction line.
c. Dirty multimedia filter.
d. Dirty R.O. elements.

Part "C" - Remedy

a. Change R.O. elements.
b. Clean multimedia filter.
c. Inspect raw water suction line for blockage.
d. Replace O-rings on connectors.

SITUATION - 10

Part "A"

Raw water source TDS - 42,000 ppm
Multimedia filter gauge - 4 psid
Cartridge filter gauge - 9 psid
Raw water flow meter - 35 gpm
R.O. vessel gauge - 60 psid
R.O. pressure PSI gauge - 800 psi
Brine flow meter - 25 gpm
Product water flow meter - 10 gpm
Product water TDS - 1550 ppm
Brine water P^H - 7.6

Part "B" - Fault

a. Dirty R.O. elements.
b. Defective R.O. elements.
c. Improperly adjusted backwash timer.
b. Dirty multimedia filter.

Part "C" - Remedy

a. Replace R.O. elements.
b. Clean R.O. elements.
c. Backwash multimedia filter.
d. Replace cartridge filters.

SITUATION - 11

Part "A"

Raw water source TDS - 17,000 ppm
Multimedia filter gauge - 5 psid
Cartridge filter gauge - 5 psid
Raw water flow meter - 33 gpm
R.O. vessel gauge - 60 psid
R.O. pressure PSI gauge - 200 psi
Brine flow meter - 33 gpm
Product water flow meter - 0 gpm
Product water TDS - 17,000 ppm
Brine water P^H - 7.4

Part "B" - Fault

a. Improperly adjusted backwash timer.
b. Clogged raw water pump strainer.
c. Dirty R.O. elements.
d. Defective R.O. elements.

Part "C" - Remedy

a. Replace R.O. elements.
b. Replace cartridge filter elements.
c. Readjust backwash timer.
d. Unclog strainer on raw water pump.

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ADVANCE SHEET/STUDENT OUTLINE

OPERATION OF REVERSE OSMOSIS WATER PURIFICATION UNIT

PURPOSE: The purpose of this lesson is to provide you with the knowledge and skills necessary to operate the Reverse Osmosis Water Purification Unit.

TERMINAL LEARNING OBJECTIVE(S): Provided with a Reverse Osmosis Water Purification Unit, chemicals, power supply, water supply, necessary tools, and reference materials, purify water in accordance with TM 5-4610-215-10, pp. 2-27 to 2-96. (1.5.1)

ENABLING LEARNING OBJECTIVE(S): Provided with a Reverse Osmosis Water Purification Unit, chemicals, power supply, water supply, necessary tools, and reference material:

1. Install the unit (1.5.1a)
2. Perform pre-operation maintenance (1.5.1b)
3. Prepare chemical solution (1.5.1c)
4. Start the unit (1.5.1d)
5. Adjust the unit (1.5.1e)
6. Shut down the unit (1.5.1f)
7. Perform post-operation maintenance (1.5.1g)
8. Pack the unit for long shutdown (1.5.1h)

in accordance with TM 5-4610-215-10, pp. 2-27 to 2-96.

STUDENT REFERENCE(S): TM 5-4610-215-10.

ASSIGNMENT: None.

OUTLINE

1. Identification of Components

a. Water delivered through raw water pump.

(1) Centrifugal

(2) Self-priming

(3) Rated at 30 gpm

(4) Powered by 2 HP electric motor

b. Water goes through multimedia filter. Media consists of: 3" of garnet, 12" of filtered sand, 15" of coal, and 2" of plastic material.

c. Water is picked up by booster pump.

(1) Centrifugal.

(2) Rated at 30 gpm

(3) Powered by a 1 HP electric motor.

d. Booster pump pushes water through cartridge filter. Filter consists of eight 40 inch long cloth fiber cartridges.

e. From cartridge filter water is picked up by RO pump.

(1) Positive displacement

(2) Rated at 51 gpm

(3) Driven by V-belts

f. RO Pump oil changed:

(1) Before first operation

(2) After first six weeks of operation.

(3) Every three months or 1000 operating hours.

g. RO pump pushes water through pulse dampener and into RO vessels.

(1) RO vessel contains two RO elements.

(2) Spiral Wound RO Element is designed to reject 98.5% of salt from water and 99% of organic material.

Element is made up of two layered membrane with a permeate carrier.

h. Product water is distributed from the product tank by a water distribution pump.

i. Chemical feed pumps:

(1) Polymer feed pump - adds polymer solution to raw water.

(2) Chlorine feed pump - adds chlorine to product water.

(3) Sodium hex feed pump - feeds diluted sodium hex to water filters.

(4) Citric acid feed pump - adds diluted acid to filtered water.

j. Control Panel

(1) Control Box Assembly

(2) Panel Light

(3) Vent, Cartridge Filter

(4) Vent, Pulse Dampener

(5) Vent Multimedia Filter

(6) Backwash Valve

(7) Multimedia Filter Gauge

(8) Waste Hose Hook Up

(9) RO Vessels Gauge

(10) Raw Water Flow Meter

(11) Backwash Water

(12) Raw Water

(13) Ground Rods

(14) Backwash Gauge

(15) RO Pressure PSI Gauge

(16) Brine Flow Meter

(17) Regulate Product Flow Valve

(18) Brine

(19) Vent Vessels

(20) Product Water Flow Gauge

(21) Cartridge Filter Gauge

(22) Product Water

(23) RO Element Cleaning Switch

(24) RO Pump Low Pressure Indicator Lamp

(25) RO Pump High Pressure Indicator Lamp

(26) Distribution Pump Indicator Lamp

(27) Raw Water Pump No. 1 Indicator Lamp

(28) Raw Water Pump No. 2 Indicator Lamp

(29) Chemical Feed Pump Indicator Lamp

(30) Booster Pump Indicator Lamp

(31) RO Pump Indicator Lamp

(32) Emergency Stop Switch

WARNING: Push emergency stop button ONLY if any of the following conditions exist:

(a) Operating personnel could be injured or equipment could be damaged.

(b) Red high pressure lamp associated with RO pump comes on but unit does not automatically stop.

(c) Yellow low pressure lamp associated with RO pump comes on but unit does not automatically stop.

(d) Serious trouble is indicated by noise, vibration, large water leaks, etc.

(e) when backwash pump lamp and backwash pump come on during normal filtering operation.

(f) When high pressure relief valve activates during operation.

(g) When rupture disc activates during normal operation.

(33) Start Backwash Switch

(34) Backwash Pump On Indicator Lamp

(35) RO Pump Start Switch

(36) Booster Pump Start Switch

(37) Chemical Feed Pump Start Switch

(38) Raw Water Pump No. 2 Start Switch

(39) Raw Water Pump No. 1 Start Switch

(40) Distribution Pump Start Switch

(41) RO Pump Reset Switch

(42) RO Pump JOG Switch

(43) Panel Light Switch

(44) Vent Vessels Valve

(45) Vent Product Water Valve

(46) Chemical Feed Pump Controls

(47) Chemical Feed Pump Valves

(a) Up for RUN.

(b) Left for OFF.

(c) Down for PRIME

(48) Drain Valves

(49) Circuit Breakers

(50) Junction Box

(51) Backwash Timer

(52) Safety Valves

(a) High pressure relief valve. If RO pressure goes above 1100 psi this valve opens.

(b) Rupture disc assembly tears when pressure goes above 1425 psi.

ROWPU piping identified according to colors:

FUNCTION	COLOR
Raw water	Black band
Backwash waste	Red band
Filtered water	Yellow band
Product water	Blue band
Brine discharge	Purple band
Brine piping on RO pressure vessels	Purple band

2. Install the Unit

a. Choosing the site

(1) Stage ROWPU upstream.

(2) Stage ROWPU close enough so hoses can reach but be sure ground is solid and fairly level.

(3) Take advantage of forest cover.

(4) Take advantage of finished roads.

b. Preparation for Use

(1) Roll up canvas cover and fasten.

(2) Remove frame cross braces.

(3) Remove one suction hose float and five chemical pails.

(4) Remove three hard rubber suction hoses.

(5) If carrying storage tanks remove them and

(a) Paddle

(b) Sledge hammer

(c) Three hard rubber drinking water hoses and eight canvas hoses.

(6) Remove storage boxes. Storage box No. 1 contains:

(a) Turbidity tube

(b) Input strainer

(c) Distribution nozzle

(d) Thermometer

(e) Flashlight, drop cord and lamps

(f) Tools and spanner wrenches

(g) TDS meter

(h) Chemical measures

(i) Tape

(j) Hose reducing nipples

(k) 100 watt light bulb

(l) RO vessel end cap pullers

(m) RO pump valve seat tools.

(7) Storage box No. 2 contains:

(a) Chemical feeding tubes

(b) Chemicals

(c) Water testing kit

(d) Chemical mixing wooden paddles

(e) Color comparator kit

(f) 100 ml plastic cylinder.

(8) Remove raw water pumps.

(9) Remove backwash pump.

(10) Product water distribution shipped separately.

(11) Test source water.

(a) Obtain sample.

(b) Obtain TDS meter and RE-10 range extender.

(c) Rinse TDS meter and range extender with sample water.

(d) Fill cup with sample water.

(e) Push range extender into cup.

(f) Set meter at highest scale.

(g) Press button on TDS meter.

(h) If using range extender, multiply reading by ten.

(i) Record reading.

(j) Remove range extender and rinse cup and extender.

c. Installation

(1) Lay out equipment.

(2) Assemble brine tank and product water tank.

(3) Install raw water system.

(a) Hook up raw water pump.

(b) Install strainer and float.

(c) Connect canvas discharge hose.

(d) Connect electrical cable.

(4) Install backwash strainer.

(a) Remove mounting bolts.

(b) Place backwash strainer against frame.

(c) Insert bolts.

(d) Attach strainer inlet connection to swivel.

(e) Tighten all connections.

(5) Connect backwash water system.

(a) Connect 2" canvas brine hose from brine outlet into backwash water tank.

(b) Connect 2" canvas hose from backwash water connection to backwash strainer.

(c) Connect 2" suction hose between backwash pump and backwash water tank.

(d) Connect electrical cord.

(6) Connect product water system.

(a) Connect 1 1/2" hard rubber hoses between ROWPU and storage tank.

(b) If using two storage tanks, connect 1 1/2" hard rubber suction between tanks.

(c) Install hard rubber hose to storage tank and distribution pump.

(d) Connect canvas hose between distribution pump and distribution nozzle.

(e) Connect electrical cable.

(7) Connect waste water system

(a) Connect 2" canvas hose between vent vessels outlet and drain system.

(b) Connect 2" canvas hose between waste water connection and drain system.

(8) Recheck hose connections.

(9) Attach tubes to chemical feed pumps.

(a) Remove chemical tubes from storage box No. 2

(b) Install tubes without strainers to the chemical feed pump valves, and the tubes with strainers to feed pump.

1. Clear tubes with inside support to polymer

2. Regular clear tubes to chlorine

3. Yellow tubes to sodium hex

4. Black tubes to citric acid

(c) Set pump valves to prime

(d) Set up chemical buckets

(10) Ground ROWPU.

NOTE: Normal electrical hookup is:

L1 - Black	L3 - Green or Blue
L2 - Red	LO - White

(11) Initial Adjustments

(a) Open five vent valves

1.

2.

3.

4.

5.

(b) Backwash valve

(c) Emergency stop button

(d) Control box switches

(e) Regulate product flow valve

(f) Element cleaning switch

(g) Backwash timer

1. Reconditioning knob

2. White cam

(h) Seven drains

(i) Hoses and lines

3. Perform Pre-Operation Maintenance

a. Check oil levels

(1) R.O. pump

(2) Chemical feed pump

b. Perform visual inspection

(1) Inspect general appearance

(2) Filters

(3) Gauges and indicators

(4) Pumps

4. Preparing Chemical Solutions

a. Mix polymer solution:

(1) Fill 107 ml measure with liquid polymer chemical.

(2) Pour into polymer pail.

(3) Add brine or raw water.

(4) Stir.

(5) Set solution in front of polymer pump and put both clear tubes that have inside supports into the polymer pail.

b. Mix chlorine solution

(1) Pour brine into raw water pail.

(2) Fill calcium hypochlorite measure with calcium hypochlorite.

(3) Pour into pail marked chlorine.

(4) Pour brine from raw water pail into chlorine pail.

(5) Stir.

(6) Set in front of chlorine pump.

(7) Put both clear tubes into chlorine pail.

c. Mix sodium solution

(1) Pour sodium hex into sodium hex measure.

(2) Put into pail marked sodium hex.

(3) Add brine to pail.

(4) Stir.

(5) Set in front of sodium hex pump.

(6) Put yellow tubes into sodium hex pail.

d. Mix citric acid solution.

(1) Pour citric acid into citric acid measure.

(2) Put into pail marked citric acid.

(3) Add brine.

(4) Stir.

(5) Set in front of citric acid pump.

(6) Put black tubes into citric acid pail.

5. <u>Starting the Unit</u>

a. Start generator set, and apply power to ROWPU.

b. Pull out emergency stop button.

c. Push emergency stop button in if any of the following conditions exist.

(1) Personnel could be injured or equipment could be damaged.

(2) Red high pressure lamp comes on but unit does not stop.

(3) Yellow low pressure lamp comes on but unit does not stop.

(4) Serious trouble indicated by noise, vibration, large water leaks, etc.

d. Prime the raw water pump(s).

(1) Drain valves closed.

(2) Prime through priming plug or discharge outlet.

e. Start raw water pump.

(1) Switch up to START.

(2) Hold until green lamp comes on.

(3) Release.

(4) Switch will return to RUN

(5) If pump is drawing water, hose will pulsate and fill.

(6) Raw water flow rate will jump to 40 gpm and drop to between 25 and 35 gpm.

f. Turn on chemical feed pump.

g. Prime polymer chemical feed pump.

(1) Set polymer chemical feed control knob to 5.

(2) Run until no more air bubbles are seen.

h. Calibrate the pump.

(1) Set control knob to 2.6.

(2) Obtain 100 ml graduated plastic cylinder.

(3) Catch flow for 1 minute.

(4) Flow should be 60 ml.

(5) Record the knob setting.

i. Set polymer pump valve from PRIME to RUN.

j. Go to control panel.

k. Close vent multimedia filter valve.

l. Start booster pump.

m. Set vent cartridge filter valve to CLOSE.

n. Set RO pump reset switch to RESET.

(1) Release switch.

(2) Yellow lamp goes off.

(3) Switch returns to ON.

o. Start RO pump.

p. Observe RO pump.

(1) Pump running.

(2) Belts not slapping.

(3) Pump running smoothly.

q. Set vent pulse dampener valve CLOSE.

r. Filtered water bypassing RO vessels.

s. Operate for 10 minutes.

t. Prime and calibrate chlorine and sodium hex chemical pumps.

u. Set citric acid pump knob to 10, and prime.

v. Set sodium hex valve to RUN.

w. After 10 minutes examine filtered water.

(1) Obtain 1000 ml graduate cylinder with white bulls-eye on bottom.

(2) Draw a sample of 600 ml of water.

(3) Look into turbidity tube and should be able to see white bulls-eye and black disc clearly.

(4) If not run ROWPU another 10 minutes. Repeat test.

(5) If not clear, readjust polymer chemical feed control knob.

(6) Wait 5 minutes.

(7) If water is still not clear keep reducing chemical setting by .5.

(8) Clear sample means right amount of polymer.

6. Adjust the Unit

a. Slowly close vent vessels valve.

b. Adjust regulate product flow valve clockwise.

(1) Rise on product water flow gauge.

(2) Decrease on brine flow gauge.

(3) Rise of pressure on RO pressure PSI gauge.

c. Obtain proper balance.

d. Gauge readings, normal and trouble points.

	GAUGE/INDICATOR	NORMAL READING	TROUBLE POINT READ
1.	Cartridge Filter	1 to 20 psid	Over 20 psid
2.	Multimedia Filter	0 to 10 psid	5 psid over first reading
3.	Raw Water Flow	26 to 33 gpm	Drop to 25 gpm or less
4.	Brine Flow	16 to 24 gpm	Below 15 gpm
5.	Product Water Flow		
	a. Salt Water	6 to 12 gpm	Above 12.0 gpm
	b. Brackish Water	Up to 13.5 gpm	Above 13.5 gpm
	c. Fresh Water	Up to 13.5 gpm	Above 13.5 gpm
6.	RO Pressure psi		
	a. Salt Water	800 psi or less	Above 900 psi
	b. Brackish Water	500 psi or less	Above 600 psi
	c. Fresh Water	500 psi or less	Above 600 psi
7.	RO Vessels	50 to 100 psid	Above 100 psid
8.	TDS of Product Water	Below 1500 ppm	Above 1500 ppm

e. Set chlorine valve to RUN. Close vent product water valve.

f. When tank is full, remove brine hose and put in drain.

g. Watch water level in product tank.

(1) Keep tanks clean and covered.

(2) To distribute water, start distribution pump.

h. Obtain occasional chlorine readings from product water hose.

i. Monitor all gauges.

7. Normal (Short) Shutdown Procedures

a. Set all chemical pump valves to prime.

b. Open regulate product flow valve.

c. Open vent vessels valve.

d. Open four vent valves:

e. Place Reverse Osmosis pump switch to STOP.

f. Booster pump switch to STOP.

g. Chemical feed pump switch to STOP.

h. Raw water pump switch to STOP.

i. Push IN emergency STOP button.

8. Post-Operation Maintenance

   a. General

   b. Frame and equipment

   c. Multimedia and cartridge filter

   d. Gauges and flow indicators

   e. Chemical feed pump

   f. R.O. pump

9. Preparation for Movement or Storage

   a. Backwash multimedia filter

   b. Perform normal shutdown

   c. Drain ROWPU

d. Drain R.O. pump

e. Drain booster pump

f. Drain vessels

g. Drain lines on backwash timer

h. Drain chemical feed pump

i. Drain product water tank(s)

j. Drain brine tank

k. Drain all pumps

l. Shut off and disconnect generator

m. Disconnect, drain, and roll all hoses

n. Clean and fold all storage tanks

o. Repack all accessories as indicated in each storage box

p. Install pumps, storage boxes, pails, hoses, sledge hammer, and aluminum paddle inside ROWPU

q. Install trailer cross braces

10. Backwash of Multimedia Filter

a. Reason for backwash.

b. When to backwash.

(1) Every 20 hours of operation.

(2) When multimedia filter gauge rises 5 psid above initial reading.

(3) When R.O. unit will not be operated for a long time.

(4) Before movement.

c. Backwash cycles.

(1) "BW" backwash

(2) "BR" Off Stage

(3) "CR" Rinse Cycle

(4) "SR" Service Cycle

d. Performing backwash

(1) Shut down R.O. unit.

(2) Element cleaning switch OFF

(3) Check water level in brine tank

Need at least 1500 gal. of brine water.

(4) Open brine tank valve.

(5) Prime backwash pump.

(6) Turn backwash valve handle to "backwash".

(7) Set START backwash switch up and release.

(8) Backwash pump should start within 2 to 3 minutes. Backwash cycle lasts about 20 minutes.

(9) When backwash is completed turn backwash valve handle to normal.

(10) Close brine tank valve.

(11) Start R.O. unit.

11. Citric Acid Feed

a. Performing Citric Acid Feed.

(1) Put three-quarters of a pound of citric acid into citric acid pail.

(2) Fill pail with brine water.

(3) Stir with wooden paddle.

(4) Set citric acid chemical feed pump valve on RUN and chemical feed control knob to 10.

(5) Wait 10 minutes.

(6) Draw a sample and check pH reading.

(7) If not below 8 feed a new batch.

(8) When below 8 set feed pump valve to PRIME.

(9) Feed is completed.

12. Operation Under Unusual Conditions

a. Cold Weather

(1) Inspect closely.

(2) Don't let water freeze on unit.

(3) Turn valves slowly.

(4) Wear rubber gloves when handling and setting valves.

(5) If raw water hoses freeze, bring under cover until ice melts.

(6) ROWPU will make less product water when temperature drops.

(7) When shut down during cold weather remove the RO elements.

(8) Keep side covers down.

b. Hot Weather

(1) Park unit in shade and leave canvas over unit.

(2) Plant life will clog filters and reduce time between filter cleanings.

(3) Check raw water and product water more often.

(4) Check motors and motor starters for high temperature.

(5) Check wire insulation.

c. Dusty and Sandy Area

(1) Protect equipment.

(2) Keep ground damp.

(3) Cover storage tanks.

d. Rainy and Damp Areas

(1) Keep electrical items dry.

(2) Provide good water drainage.

(3) Protect chemicals.

e. Salt Water Areas

(1) Wash and wipe ROWPU with product water and wipe dry.

(2) Paint all metal starting to rust.

f. Nuclear, Biological, and Chemical Contaminated Areas

(1) ROWPU has equipment which is used as a post treatment when nuclear or chemical contaminants are present.

(2) For nuclear contamination, use the cartridge marked "FOR USE WITH RADIOACTIVE CONTAMINATED WATER ONLY".

(3) For chemical contamination, use the cartridge marked "FOR USE WITH CHEMICALLY CONTAMINATED WATER ONLY".

(4) Install equipment between product water tanks.

(5) Operate the ROWPU in the normal manner.

(6) Change cartridges every 100 hours.

13. <u>RO Element Cleaning Methods</u>.

a. <u>The RO elements must be cleaned</u>:

(1) When pressure in RO vessels rises to 900 for seawater or 600 for fresh water.

(2) Product matter output drops several gallons per minute with no change in temperature.

(3) Brine flow increases noticeably.

(4) Before movement or after completion of exercise.

b. <u>RO element cleaning procedure</u>.

(1) Element cleaning switch OFF.

(2) Backwash multimedia filter.

(3) Adjust water level in brine tank to 7 inches.

(4) Remove backwash hose from outlet on backwash pump and connect Vent Vessel hose.

(5) Add 70 lbs of citric acid to 7 inches of water in 3000 gal. tank.

(6) Mix with mixing paddle.

(7) Regulate Product Flow Valve open.

(8) Open Vent Vessel Valve.

(9) Valve on bottom of tank open.

(10) Remove product water hose from product water tank.

(11) Element cleaning switch to START.

(12) Brine flow indicator should show a flow of 20 gpm or more.

(13) Allow to flow for 45 minutes.

(14) Stop flushing.

(15) Remove vent vessels hose from outlet of the backwash pump and connect backwash water hose.

(16) Drain citric acid solution into shallow, man-made lagoon.

(17) Perform startup procedures for normal filtering operation.

(18) Close vent vessels valves.

(19) Allow ROWPU to operate for 10 minutes to rinse.

(20) Adjust regulate product flow valve.

(21) Allow ROWPU to run for 3 minutes, then place product water hose into product water storage tank.

(22) Flush ROWPU with 1800 ml Triton X-100 detergent added to 7 inches of water in the 3000 gal. backwash tank.

c. Sterilization of R.O. Elements

(1) Sterilize R.O. elements when:

(a) Returning to storage.

(b) Not operating unit for more than one week.

(c) Returning from out of CONUS deployment.

(2) To prevent biological growth.

(3) Repack elements.

(a) Add 12 gallons of sterilization material to 7 inches of nonchlorinated filtered water.

(b) Follow same procedure as in regular cleaning of R.O. elements, but operate for 30 minutes.

(c) Let unit and elements set for 12 hours.

(d) Remove elements and drain for 10 minutes.

(e) Insert in plastic bags and tape.

(4) Solutions recommended:

(a) Formaldehyde, use 6505-00-139-1321

(b) Formaldehyde analyzed reagent, 6810-00-817-0353

(c) Paraformaldehyde

(d) Hydamine 3500

(e) Roccal-2

14. Operator's Maintenance

a. Changing RO elements.

(1) Pre-removal Procedures

(a) Shut the ROWPU down.

(b) Open all vents, drains, and controls.

(c) Mark end caps and vessel.

(2) End Cap Removal

(a) Open quick disconnect (1) and pull out tube (2).

(b) Remove nut (3), screw (4), clamp (5), and coupling (6).

(c) Loosen nut on elbow (12) and swing elbow (7) away from the end cap.

(d) Remove end cap nuts (8) and washers (9) from the end cap.

(e) Screw two end cap puller bolts into threaded holes.

(f) Alternately rotate each bolt one complete turn.

(g) Repeat to remove rear end cap.

(3) Installation of RO Elements

(a) Lubricate O-rings.

(b) Install O-rings.

(c) Remove new RO ELEMENT.

(d) Lubricate brine seal.

(e) Install brine seal.

(f) Insert first RO element

(g) Place interconnector on product water tube.

(h) Remove second RO element.

(i) Lubricate and install brine seal.

(j) Insert product water tube in interconnector.

(k) Slide RO ELEMENTS AND INTERCONNECTOR INTO RO vessel.

(l) Place end connects on ends of product water tubes.

(m) Lubricate and install end cap O-rings and end caps.

(n) Align end caps with match mark on RO vessel.

(o) Press end caps into studs and install ten washers and nuts.

(p) Reconnect tubes and pipes.

(4) Removal of RO Elements

(a) Remove both end caps.

(b) Assemble element puller.

1. Connect puller rod and puller rod handle.

2. Insert elements puller into RO vessel. Push through end connector, product water tubes, and interconnector.

3. Place element puller plate on assembled element puller and secure.

(c) Pull both RO elements from vessel.

(d) Disconnect element puller.

(e) Separate RO elements.

b. Changing cartridge filter tube elements.

(1) Removal of cartridge filter tube element.

(a) Shut down ROWPU.

(b) Open vent cartridge filter valve.

(c) Open drain No. 1 cartridge filter valve.

(d) Loosen eye nuts and slide from cover brackets.

(e) Lift cover and remove seal O-rings.

(f) Grasp handle of filter seat and clamp hook assembly and pull up. Extend clamp hook and lock.

(g) Let assembly fall to resting position.

(h) Tilt assembly.

(i) Lift assembly and remove cartridge filter.

(2) Installation of cartridge filter tube element.

(a) Remove and discard used filter tube.

(b) Place new filter tube on assembly and rotate.

(c) Insert assembly into filter shell.

(d) Engage hook on underside of lower seat plate.

(e) Grasp handle of filter seat and clamp hook assembly and pull up.

(f) Rotate assembly.

(g) Allow handle to go down so filter tube seats on plate.

(h) With one hand on the handle of the filter seat and clamp hook assembly and the other on filter tube attempt to remove each assembly.

(i) Make sure cover seal O-ring is lubricated and in place.

(j) Replace cover on cartridge filter.

(k) Swing eye nuts and bolts up and tighten.

(l) Inspect filter during operation for leaks.

c. Backwash pump strainer.

(1) Removal, cleaning, and installation.

(a) Shutdown ROWPU.

(b) Loosen T-handle screw assembly.

(c) Loosen bolts and swing yoke and T-handle out of the way.

(d) Lift off strainer cap.

(e) Remove gasket and inspect it.

(f) Remove screen from strainer housing.

(g) Remove drain plug from strainer housing.

(h) Flush strainer screen and strainer housing.

(i) Install strainer screen and drain plug.

(j) Install gasket, cap, and close and tighten the yoke.

(k) Tighten T-handle.

d. Removal and installation of rupture disc.

(1) Removal

(a) Remove hold down screw.

(b) Remove hold down ring.

(c) Remove ruptured disc.

(2) Installation

(a) Place new disc.

(b) Insert into body.

(c) Replace hold down ring.

(d) Return hold down screw.

e. <u>Disassemble and assemble chemical pump head assembly</u>

(1) Remove chemical hoses

(2) Hold studs and remove nuts

(3) Remove flange and valve carrier

(4) Remove valve carrier and seal ring from ball valve

(5) Remove ball valve and seal ring from pump body

(6) Repeat steps for lower part

(7) If pump parts need cleaning, soak them, rinse and air dry

(8) To assemble in reverse order.

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5

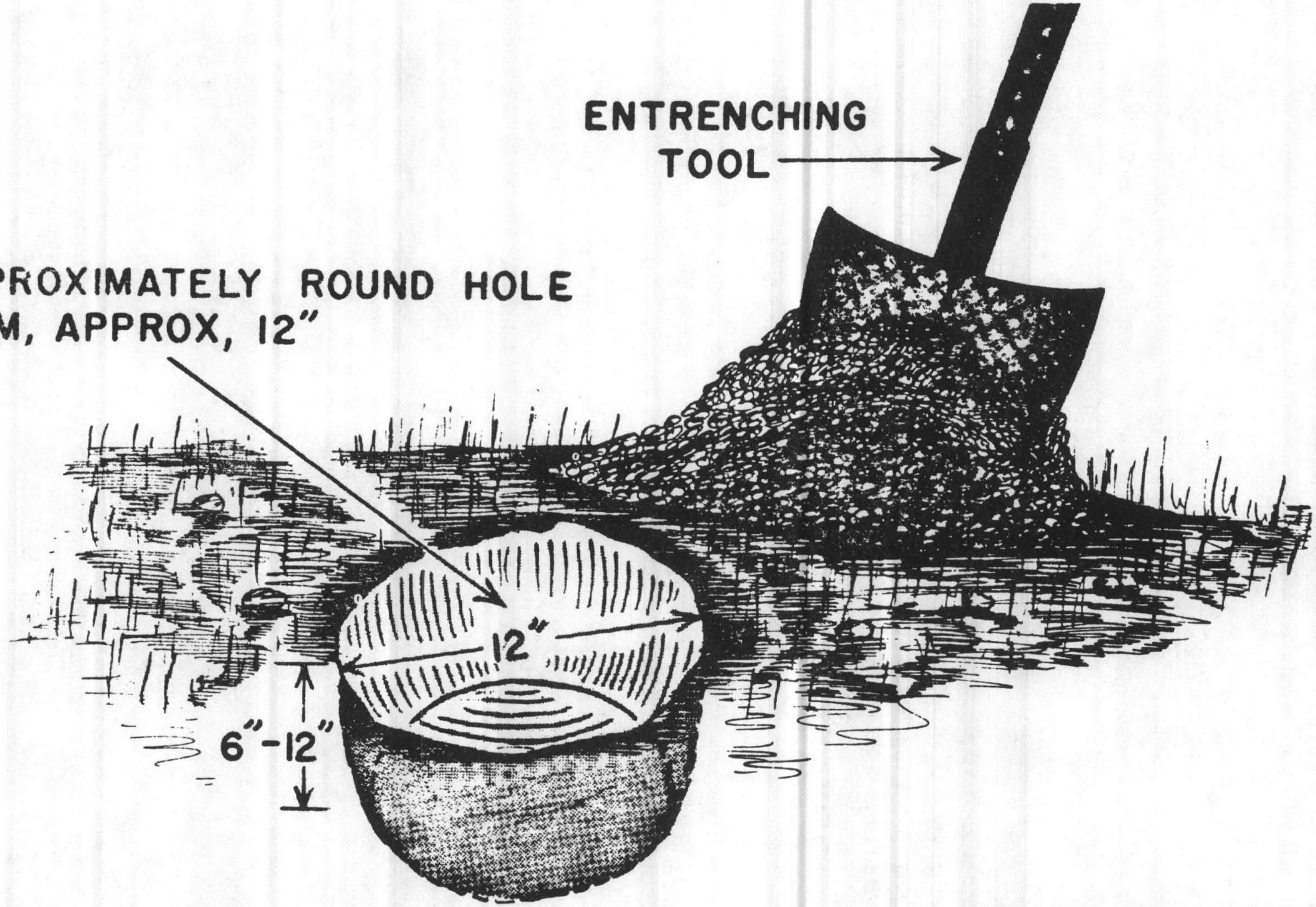
FIELD SANITATION DEVICES

SRT - UT - 1111

MARINE CORPS ENGINEER SCHOOL
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

FIELD SANITATION DEVICES

NOTE: This booklet has been compiled from FM 21-10, MILITARY SANITATION and the LANDING PARTY MANUAL, OPNAV P 34-03. There are certain conflicts between these two publications and where such conflicts arose the best of each publication was used.

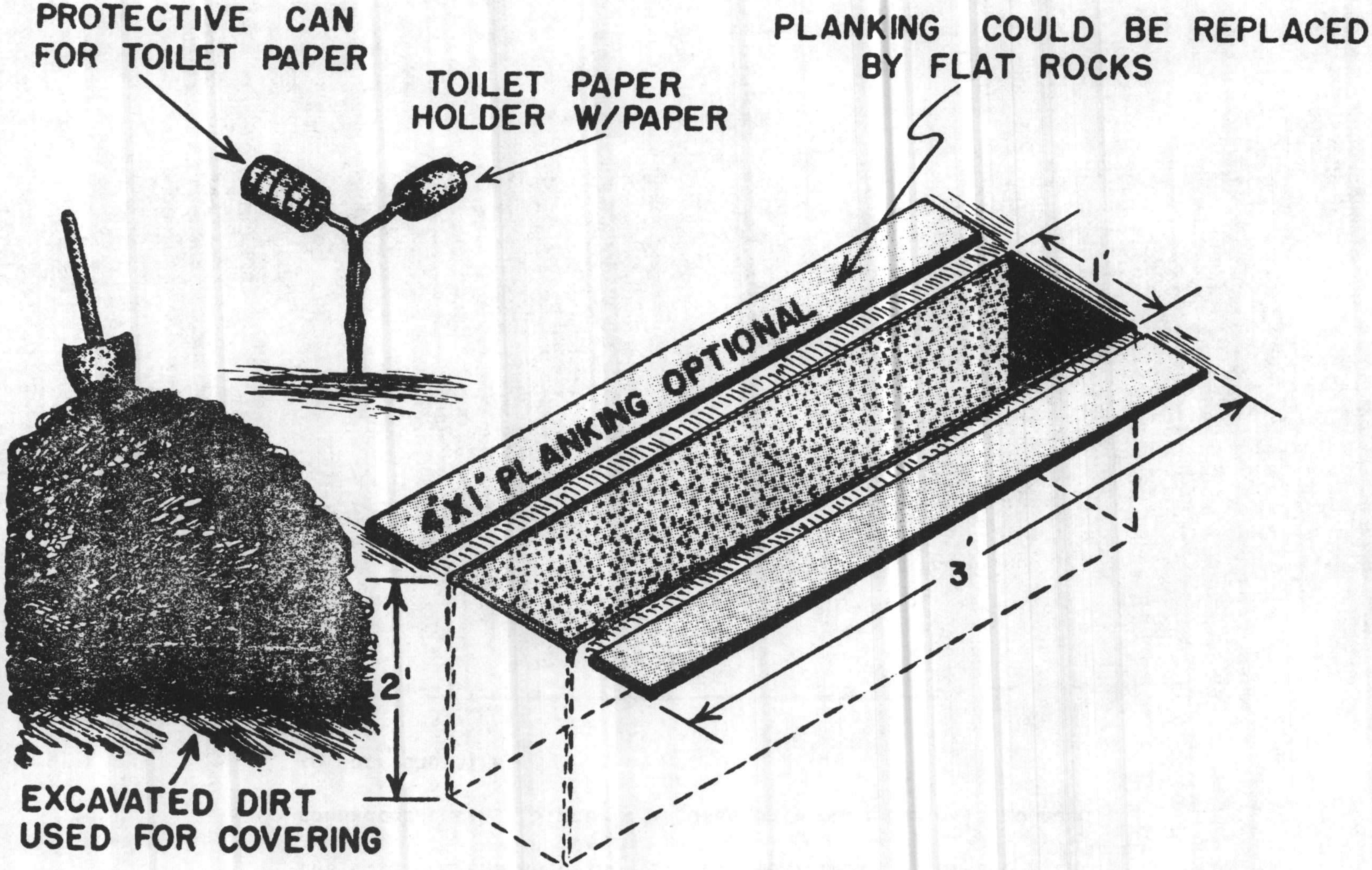

ENTRENCHING
TOOL
APPROXIMATELY ROUND HOLE
DIAM, APPROX, 12"
12"
6"-12"

CAT HOLE

CAT HOLE

The "cat hole" is to be used by troops on the move. It is merely a hole 6 to 12 inches deep; excrement is deposited in the hole and the hole is filled immediately after use with compacted earth. Since it is used only once there is no need to mark the site.

NOTES

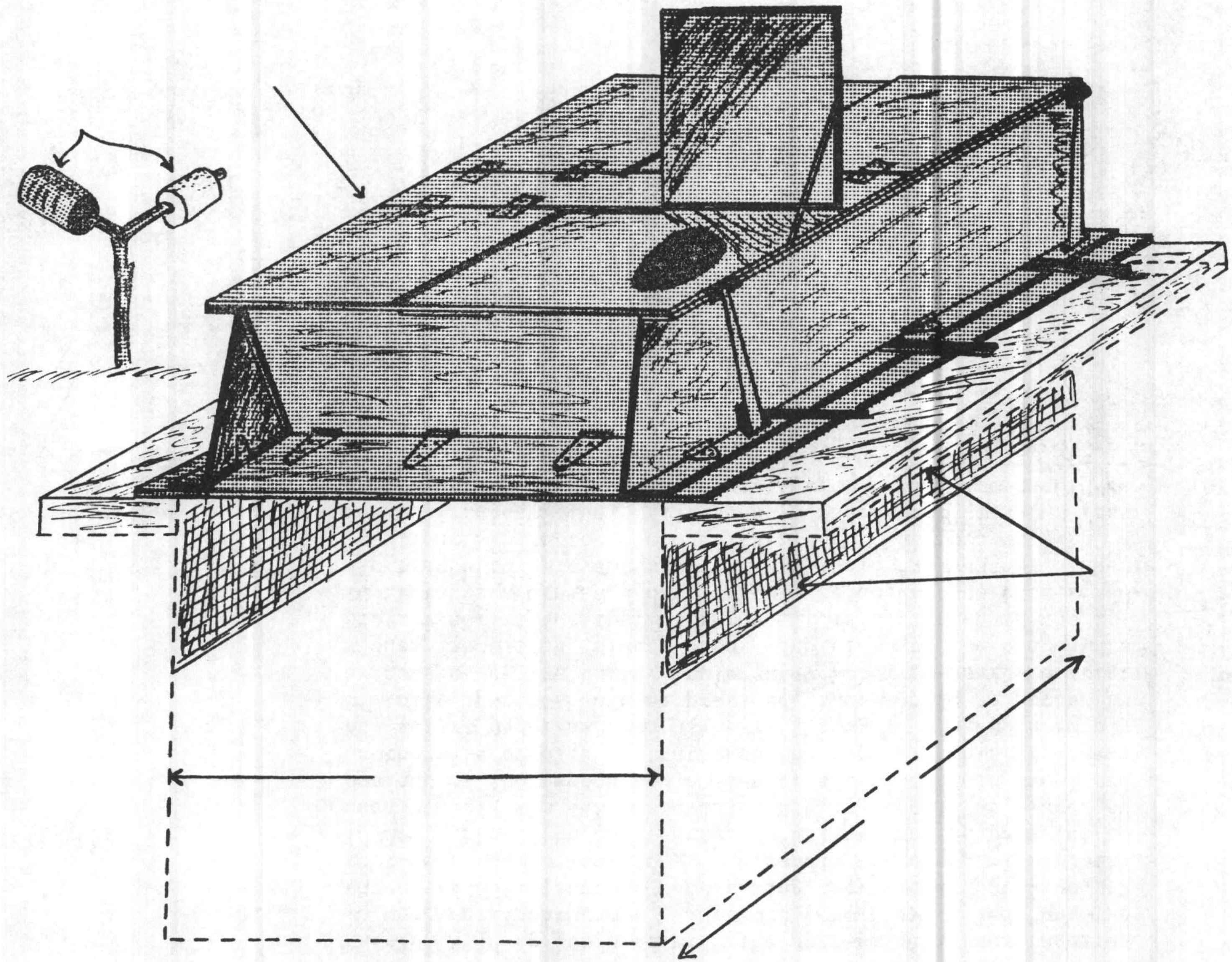


STRADDLE TRENCH

STRADDLE TRENCHES

These trenches are used for bivouacs and temporary camps and should NOT be confused with the deep-pit latrines required in more permanent camps. They are generally called "one-two-three straddle trenches" indicating they are 1 foot wide, 2 feet deep, and 3 feet long. Straddle trenches, 1 for each 10 men, should be constructed on a line and be parallel to each other. The dirt removed in digging should be placed at one end of the trench and a can or shovel should be placed on the pile of dirt so that each man can cover his excrement and toilet paper as soon as he is through. An ample supply of toilet paper should be provided, and should be protected by cans or canvas during inclement weather. Boards or flat stones should be placed along each side of the trench to provide a firm footing. Although it is not shown in the illustration, a drainage ditch should be dug around each straddle trench to prevent flooding in inclement weather. When the trenches are to be closed they should be sprayed with a residual insecticide, filled and mounded over with two feet of compacted earth, and sprayed again. The site should be marked with a sign labeled LATRINE CLOSED and the date it was closed.

NOTES

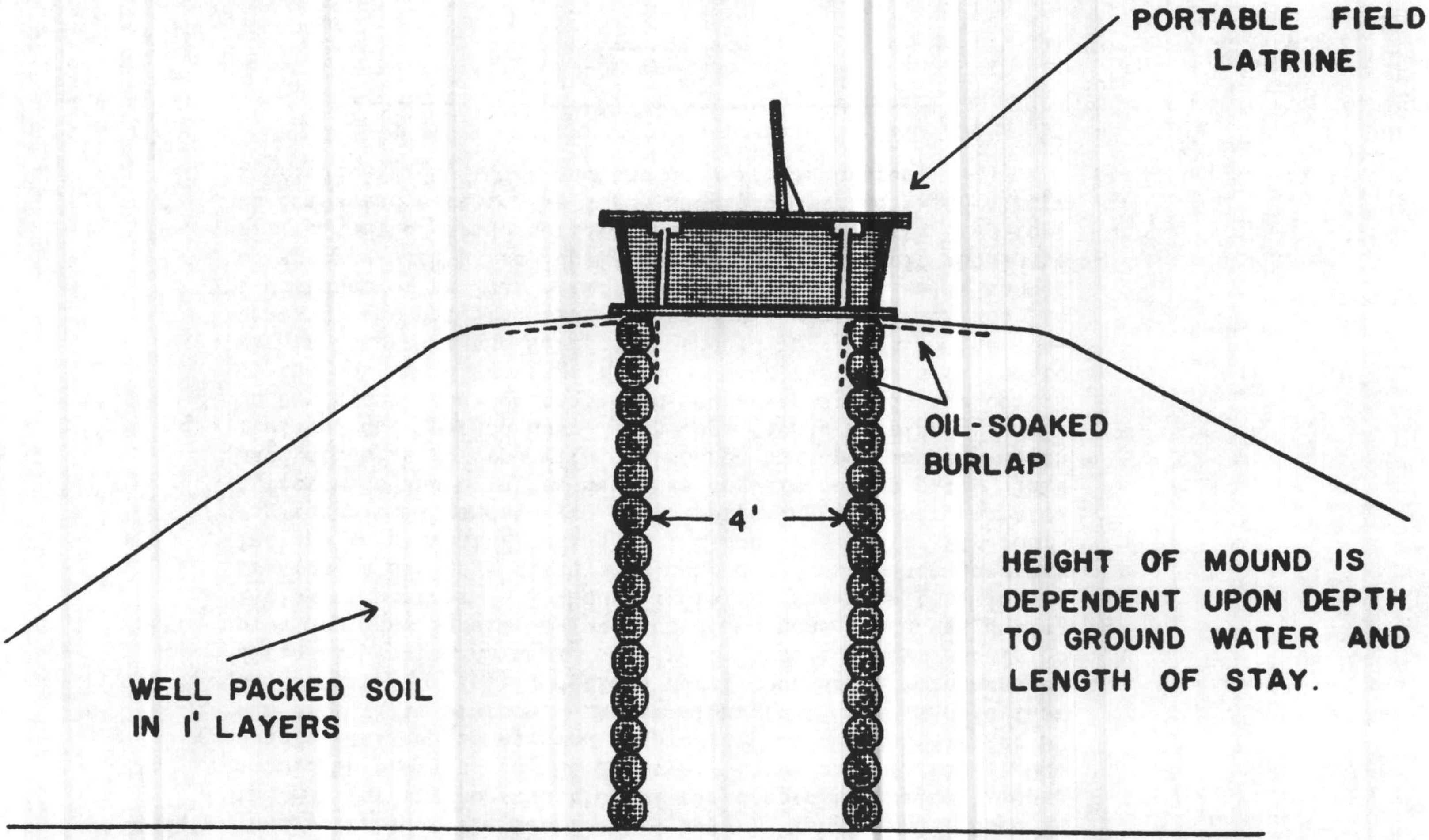


DEEP-PIT LATRINE

DEEP-PIT LATRINE

The deep-pit latrine is designed for more permanent camps. The portable field latrine (4-holer) is generally used in the FMF for the construction of the deep-pit latrine. Seats should be provided on the basis of 1 for each 12 men. One 4-hole latrine is assumed to provide accommodation for 50 men or 1 rifle platoon. A pit four feet deep should last two weeks. For longer periods add 1 foot depth for each additional week. An ample supply of toilet paper should be provided, and should be protected by cans or canvas during inclement weather. Although it is not shown in the illustration, a drainage ditch should be dug around each deep-pit latrine to prevent flooding in inclement weather. Flyproofing the pit is mandatory. In flyproofing the pit, an area 4 feet wide and 6 inches deep is dug around the pit. This excavation is covered with oil-soaked burlap, and the earth replaced and packed down. The box should be placed firmly on the ground and earth should be packed around the bottom of the box to discourage flies. When the pit is filled to within 2 feet of the surface it should be closed. The contents of the pit, the side walls, and the ground surface to a distance of at least two feet from the side walls should be sprayed with a residual insecticide. The pit should be filled to the ground surface and mounded over with two feet of compacted earth. The site should be marked with a sign labeled LATRINE CLOSED and the date it was closed.

NOTES

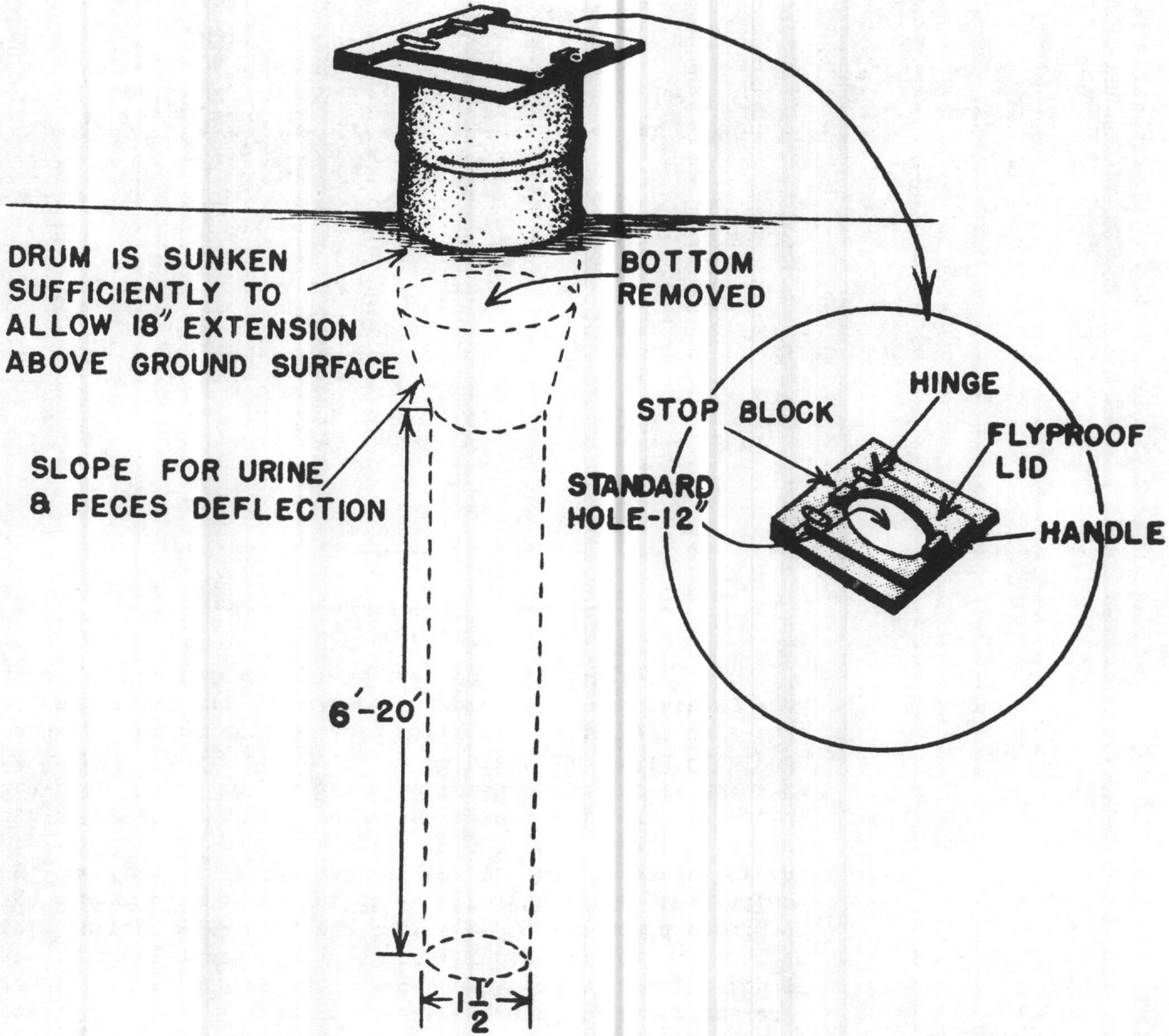


MOUND LATRINE

MOUND LATRINE

This type of latrine may be used when a high ground water level, or a rock formation near the ground surface, prevents the digging of a deep pit. A mound of earth having a top at least 8 feet square should be constructed so that a portable field latrine may be placed on its top. The mound should be high enough to meet the pit's requirement for depth, allowing one foot from the base of the pit to the water or the rock level. The mound is built in one foot layers. The surface of each layer is roughened before the next is added. When the desired height has been reached, the pit is dug into the mound. It may be necessary to brace the walls with wood, sandbags, or other suitable material to prevent cave-ins. The mound latrine should be flyproofed, maintained, and closed in the same manner as the deep-pit latrine.

NOTES

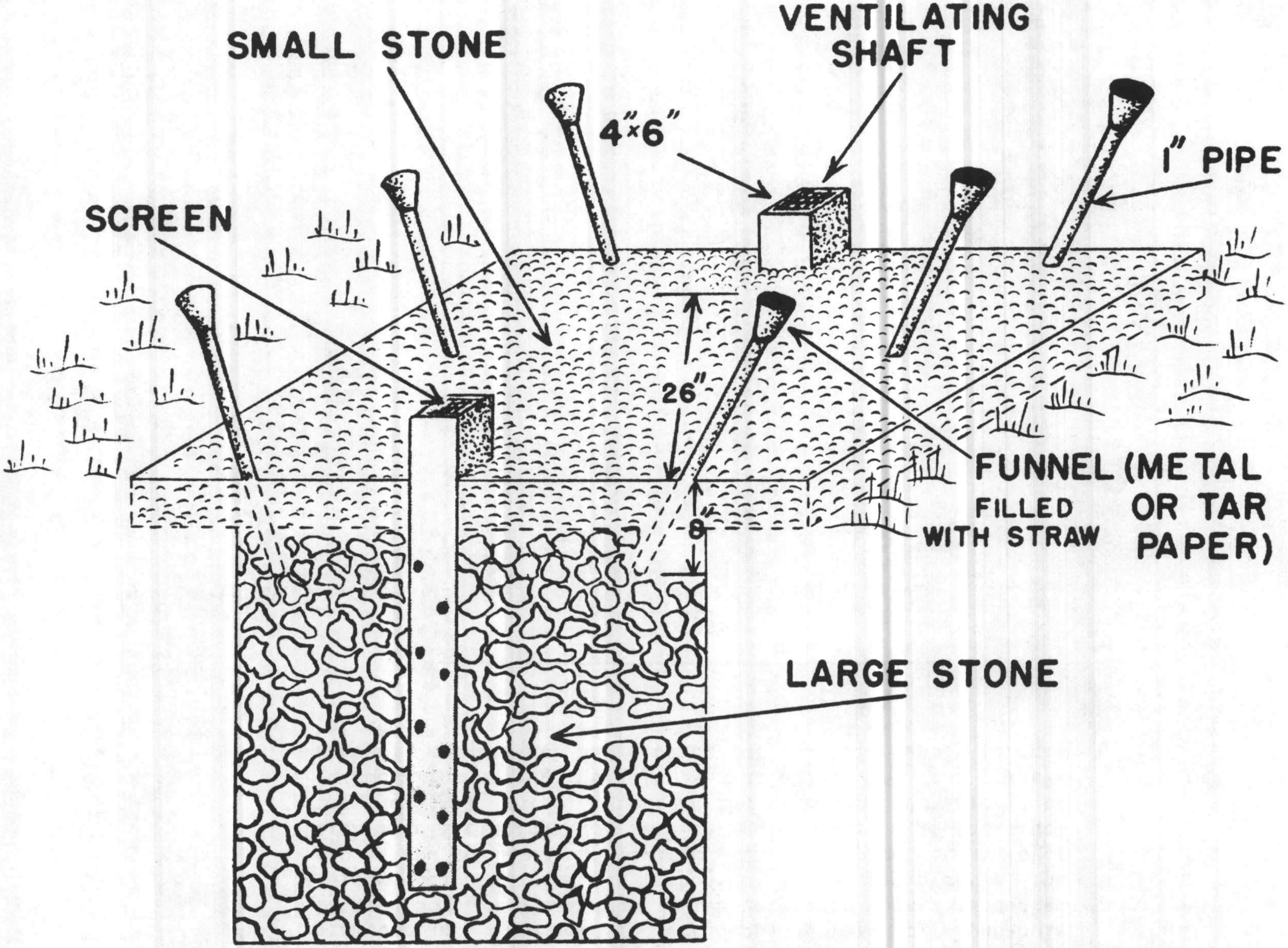


BORED HOLE LATRINE

BORED HOLE LATRINE

This type of latrine consists of a hole, about 18 inches in diameter and from 6 to 20 feet deep, covered by a one-hole latrine box. A metal drum, with both ends open, is sunken sufficiently to allow 18 inches of it to remain above the ground and the drum is covered with a flyproof seat cover with a self-closing lid. This type of latrine is satisfactory for small units, provided the necessary mechanical equipment for boring the hole is available. The same principles of maintenance and closing of a latrine apply to this latrine.

NOTES

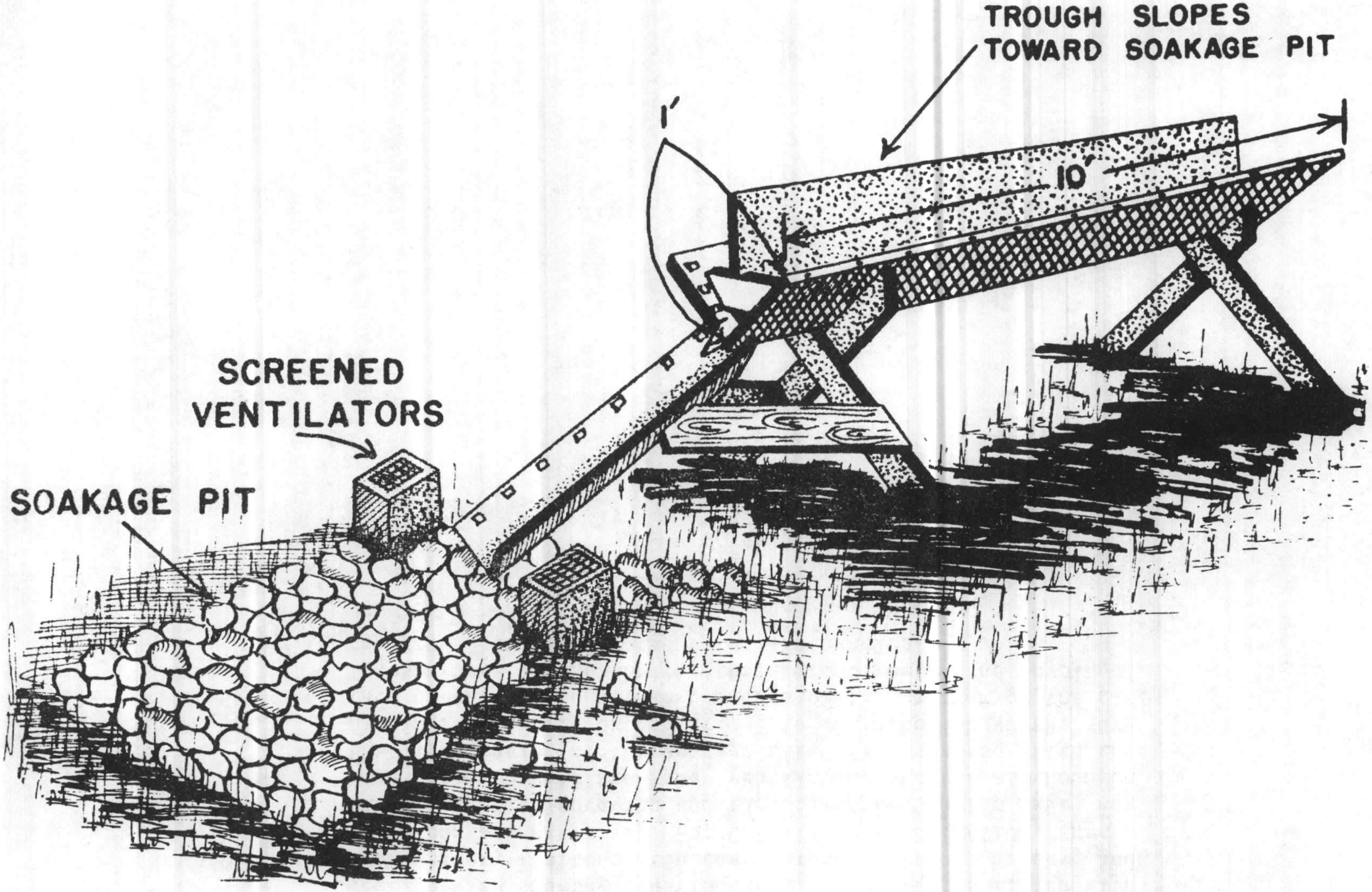


URINE SOAKAGE PIT

URINE SOAKAGE PIT

This reproduction shows pipe urinals of salvage pipe and improvised tin funnels and depicts a soakage pit with a cross section view showing construction. The pit is filled with broken rock, flattened tin cans, broken bottles, bricks, and other contact material. For CLARITY OF ILLUSTRATION, the 6 inches of earth covering and the oil-soaked burlap have not been shown. Note the same ventilating shafts as shown on the illustration of the soakage pit. The shafts, with the openings screened, extend from 6 to 12 inches above the surface of the pit to within 6 inches of the bottom of the pit. The surfaces of the shafts that extend below the level of the ground are perforated with 1-inch holes.

NOTES

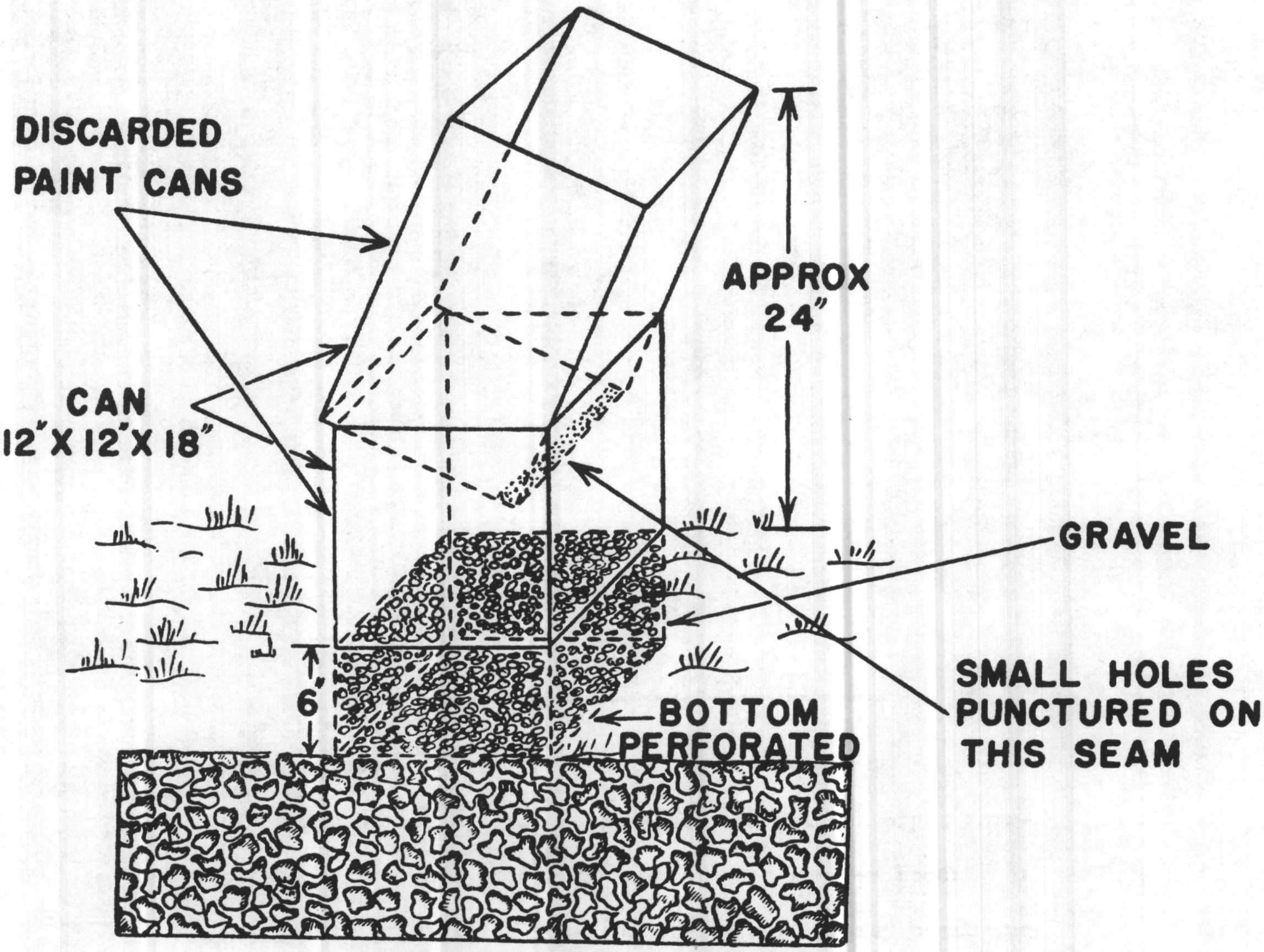


TROUGH URINAL

V-TYPE URINAL AND SOAKAGE PIT

This figure illustrates a V-type urinal with splash board and soakage pit. This urinal is made of wood and tar paper, or may be improvised of tin, galvanized iron, or any other suitable material.

NOTES

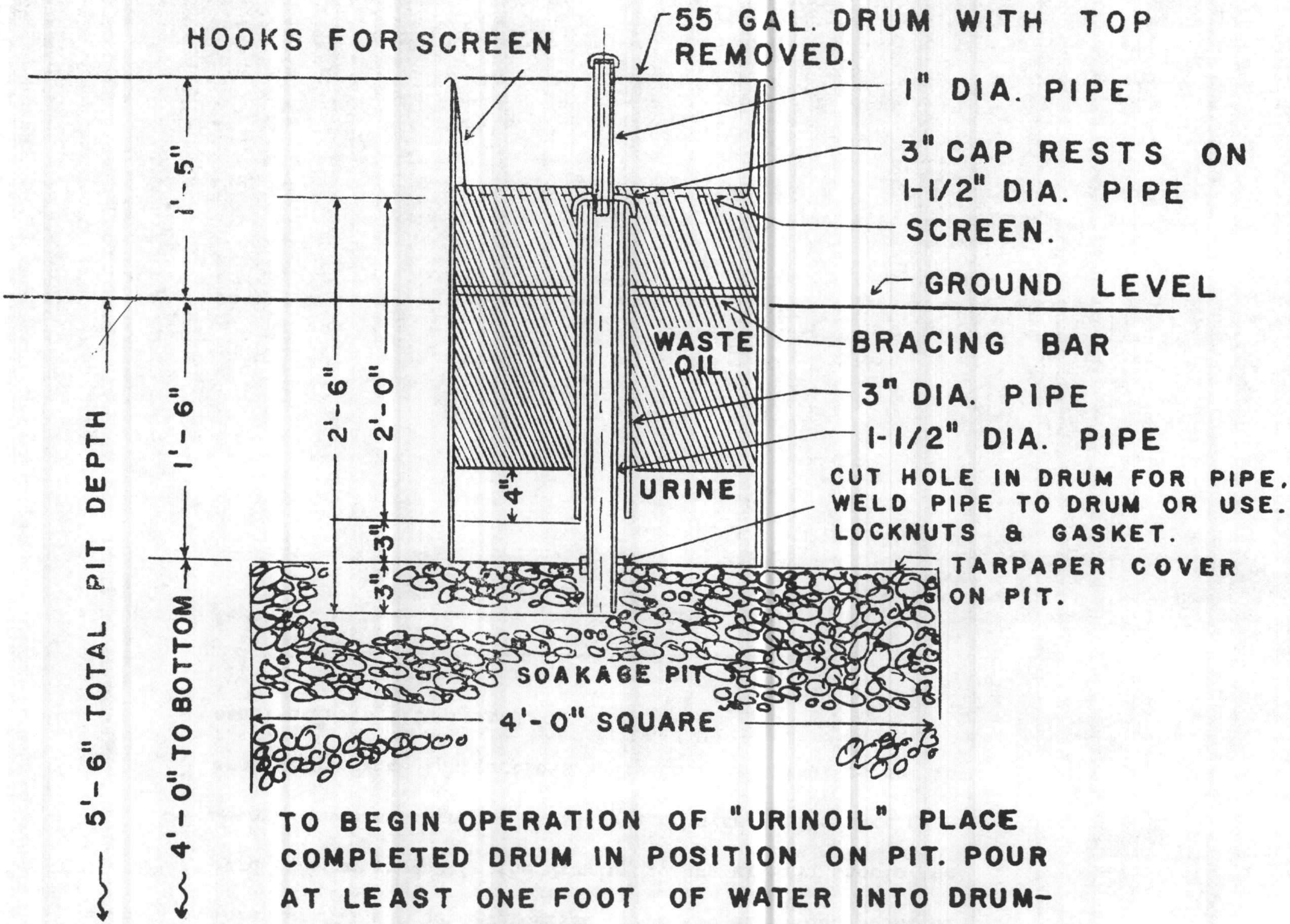


IMPROVISED URINAL

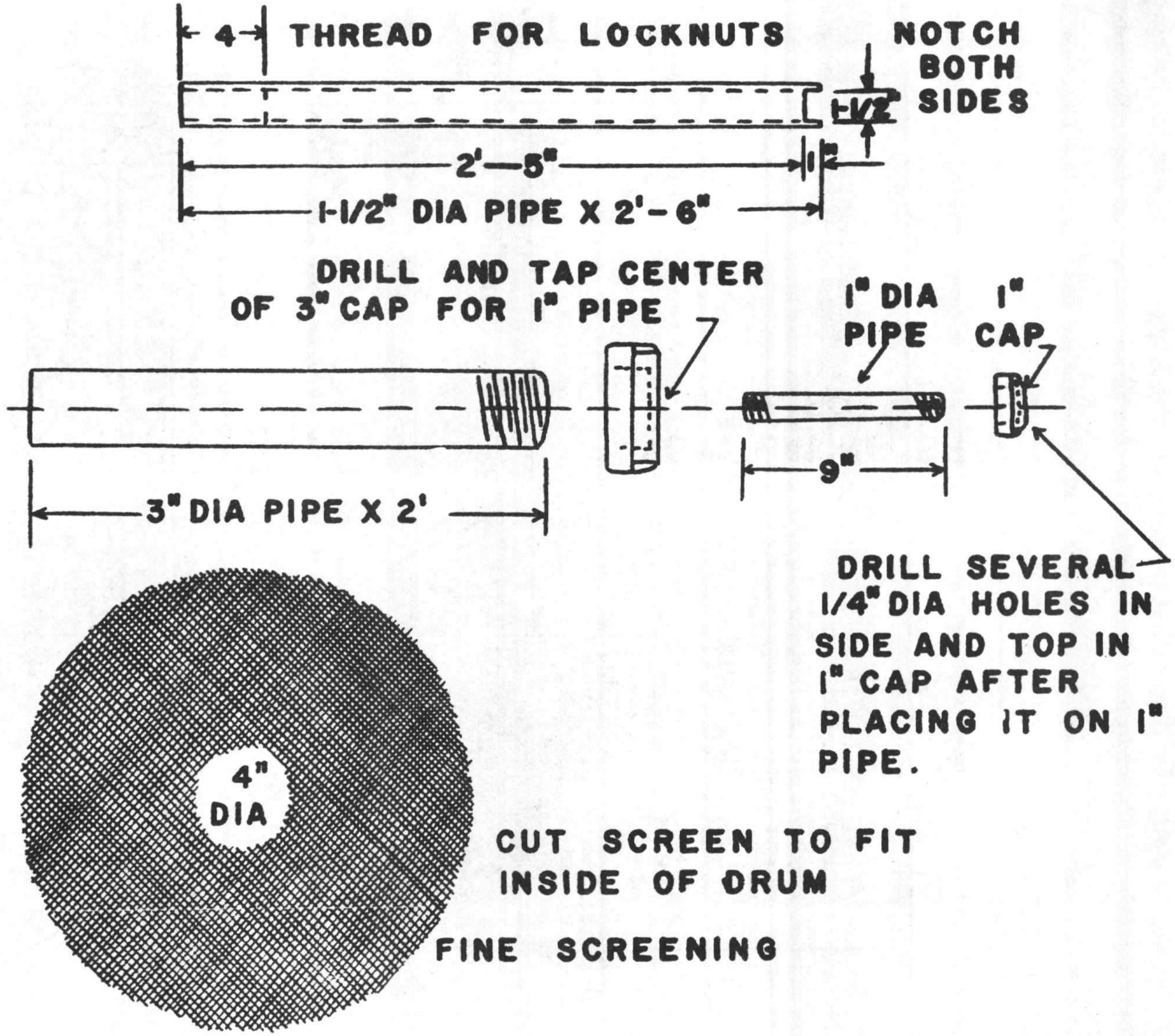
IMPROVISED URINAL

This urinal may be improvised from two discarded paint or lard cans as shown in the drawing. The urinal should be mounted on a soakage pit of sufficient size. The same general maintenance instructions apply to this urinal as do to other urinals illustrated.

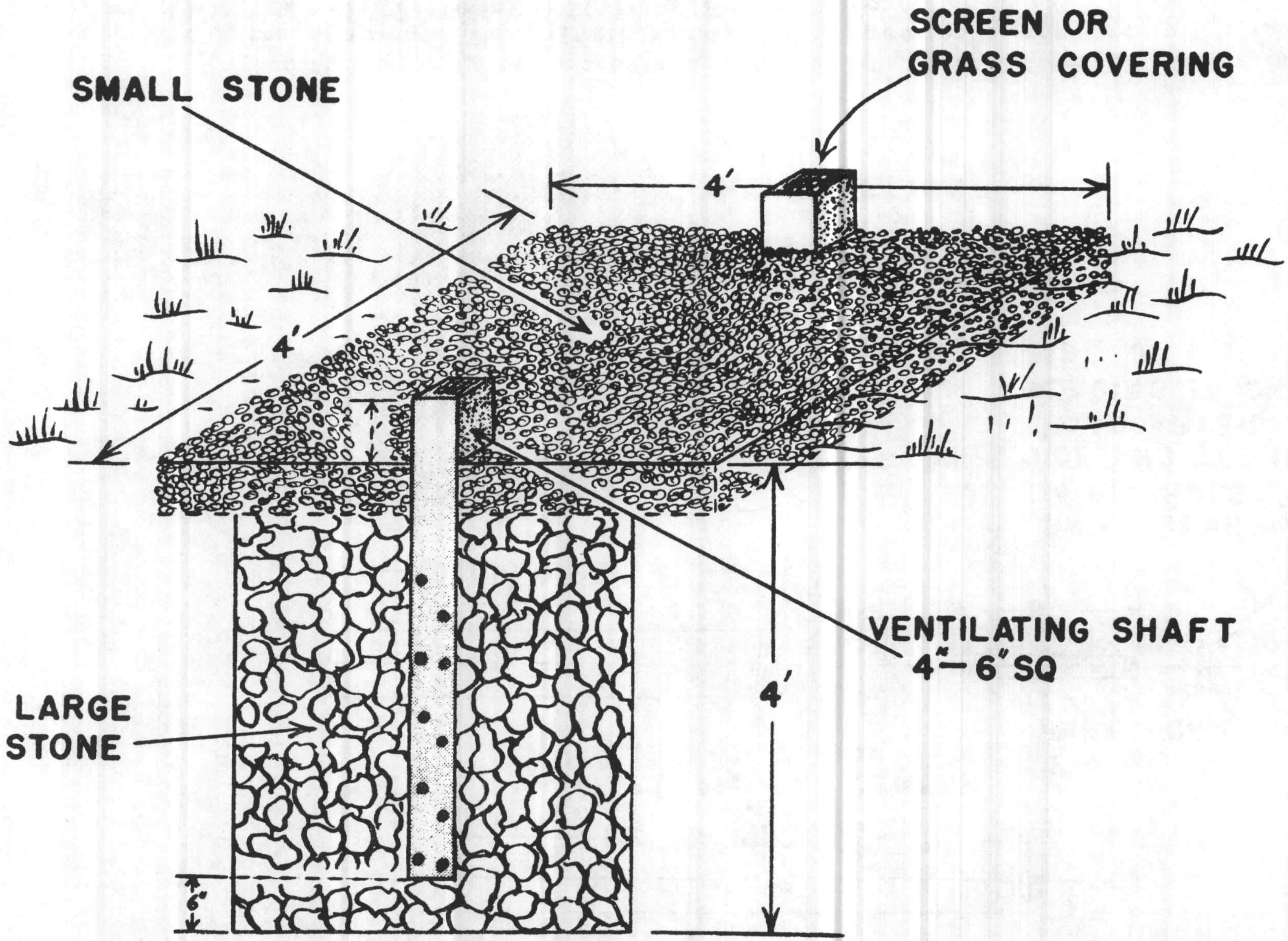
NOTES



TO BEGIN OPERATION OF "URINOIL" PLACE COMPLETED DRUM IN POSITION ON PIT. POUR AT LEAST ONE FOOT OF WATER INTO DRUM— THEN ADD WASTE OIL - APPROX. 32 GAL.— UNTIL IT REACHES POINT SHOWN.



The urinoil may be improvised from a 55-gallen drum as shown in the drawing. The urinoil should be placed on a soakage pit when possible, or installed with a French drain.

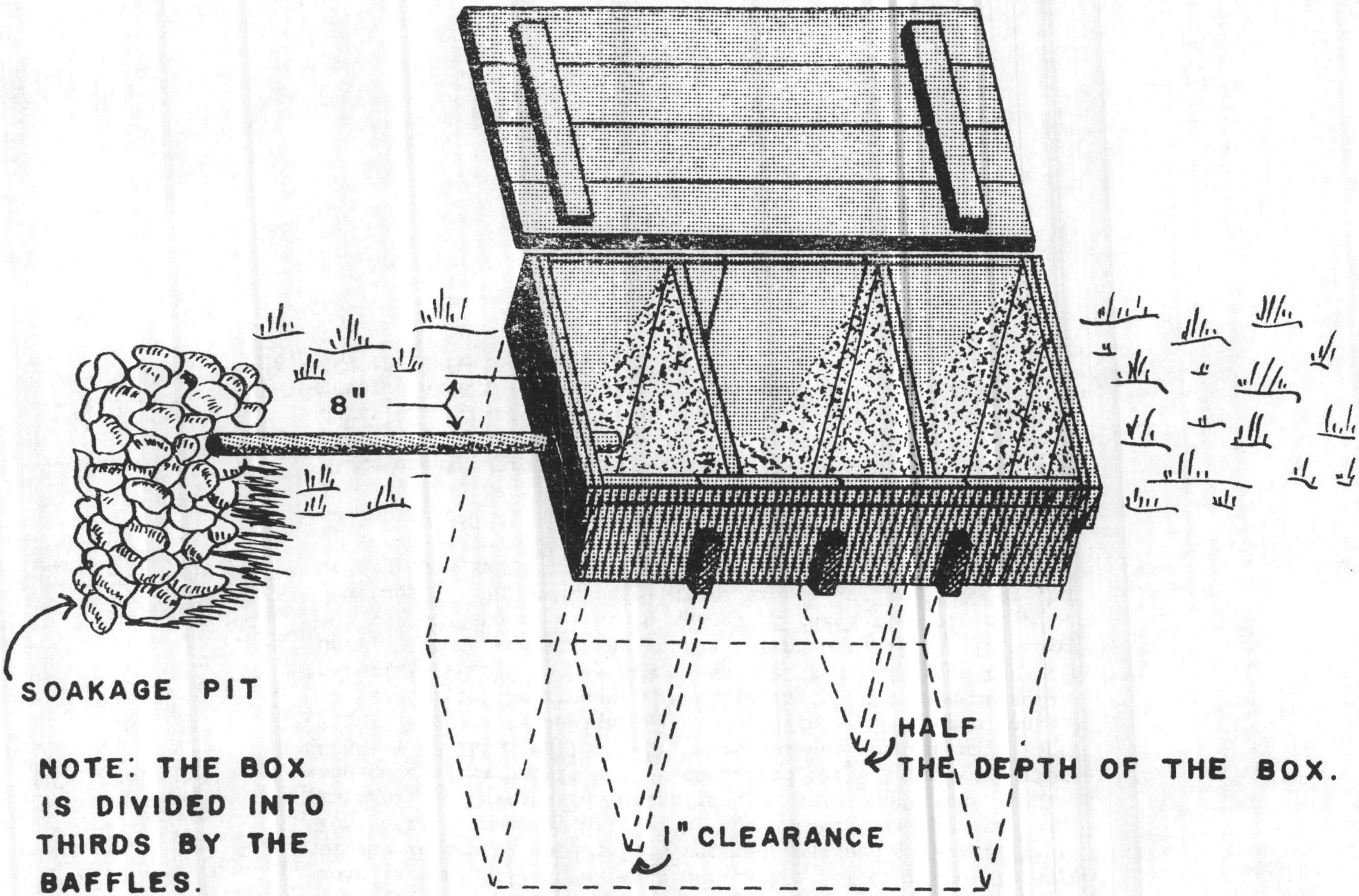

SCREEN OR
GRASS COVERING
SMALL STONE
4′
4′
VENTILATING SHAFT
4″–6″ SQ
4′
LARGE
STONE
6″

SOAKAGE PIT

SOAKAGE PIT

The soakage pit is used to dispose of all types of liquid wastes. The pit is dug 4 feet square and 4 feet deep. The hole is then filled to within 6 inches of the top with any of the following materials: rocks, flattened tin cans, broken bottles, rubble, bricks, or any other suitable contact material. Oil-soaked burlap is then spread over the stones and covered with 6 inches of compacted earth, however, for CLARITY OF ILLUSTRATION ONLY, this has not been shown. The liquid waste entering the pit is held in void spaces until it seeps into the ground. Ventilating shafts made of scrap materials 4 to 6 inches square may be used to lessen the odors. These ventilating shafts extend 6 to 12 inches above the surface and to within 6 inches of the bottom of the pit. Numerous 1-inch holes are interspersed in the sides of the underground sections. The tops of these shafts are covered by screen, straw, or grass. The purpose of these shafts is to introduce air throughout the pit to avoid septic conditions. An adequate air supply allows decomposition to take place under aerobic conditions with fewer odors. When the pit is to be closed it should be sprayed with a residual spray and covered with 2 feet of compacted earth and the covered site marked with a sign labeled CLOSED SOAKAGE PIT and the date the pit was closed.

NOTES



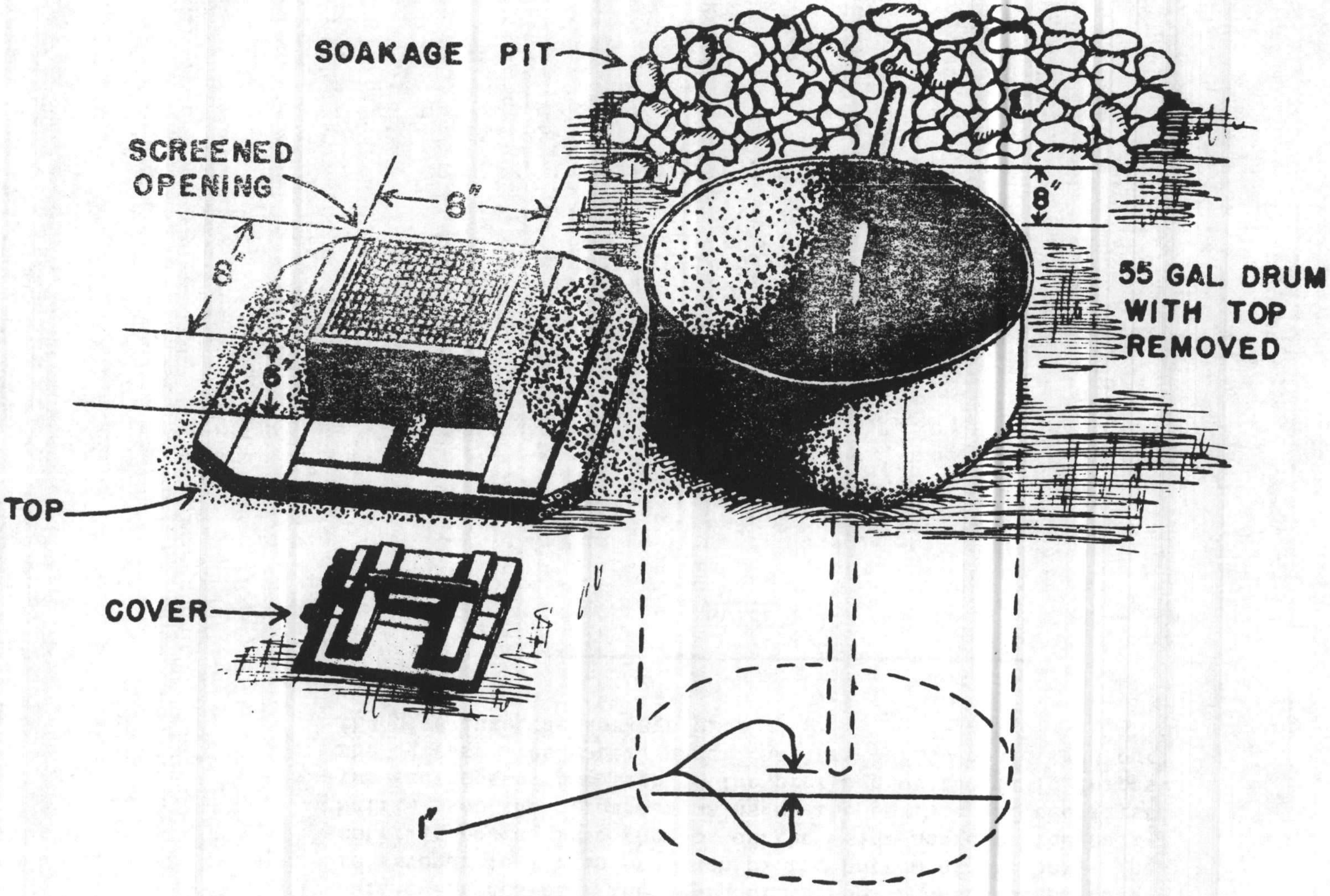
NOTE: THE BOX IS DIVIDED INTO THIRDS BY THE BAFFLES.

BAFFLE GREASE TRAP

BAFFLE GREASE TRAP

In this picture is shown the box-type baffle grease trap. Baffles may be used in boxes, drums, or barrels in the construction of a grease trap. Salvaged boxes or barrels may be reinforced and/or treated to serve this purpose. One baffle extends half the depth of the box and the other baffle extends to within one inch of the bottom of the box. The water is poured into the box on the side nearest the half-baffle and the grease remains on the surface of the first two sections of the trap. The pressure of the fluid forces the grease free water under the last baffle board and out the pipe into the soakage pit.

NOTES

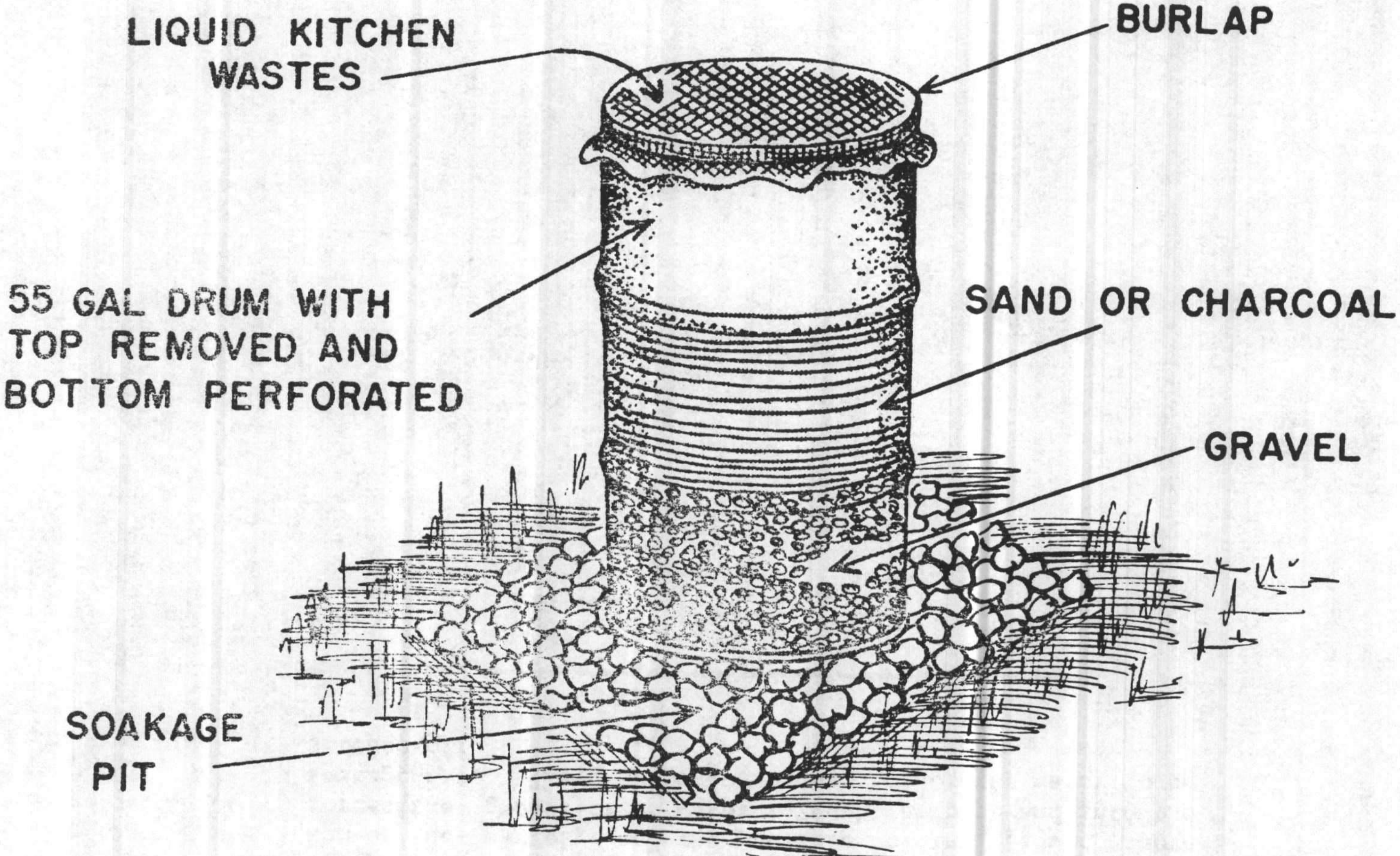


BARREL GREASE TRAP

BARREL GREASE TRAP

Shown in this illustration is the barrel-type grease trap with strainer and lid. Salvaged materials, including oil drum, pipe, screen, and scrap lumber are utilized in constructing this sanitary device. The principle employed in this grease trap is the same as that utilized in the box-type baffle grease trap. In this instance the pipe serves the purpose of a baffle. Its intake is 1 inch from the bottom of the barrel, and the pressure of the liquid above forces the grease-free water through the pipe and into the soakage pit. The grease remains on top of the water to be scooped off.

NOTES

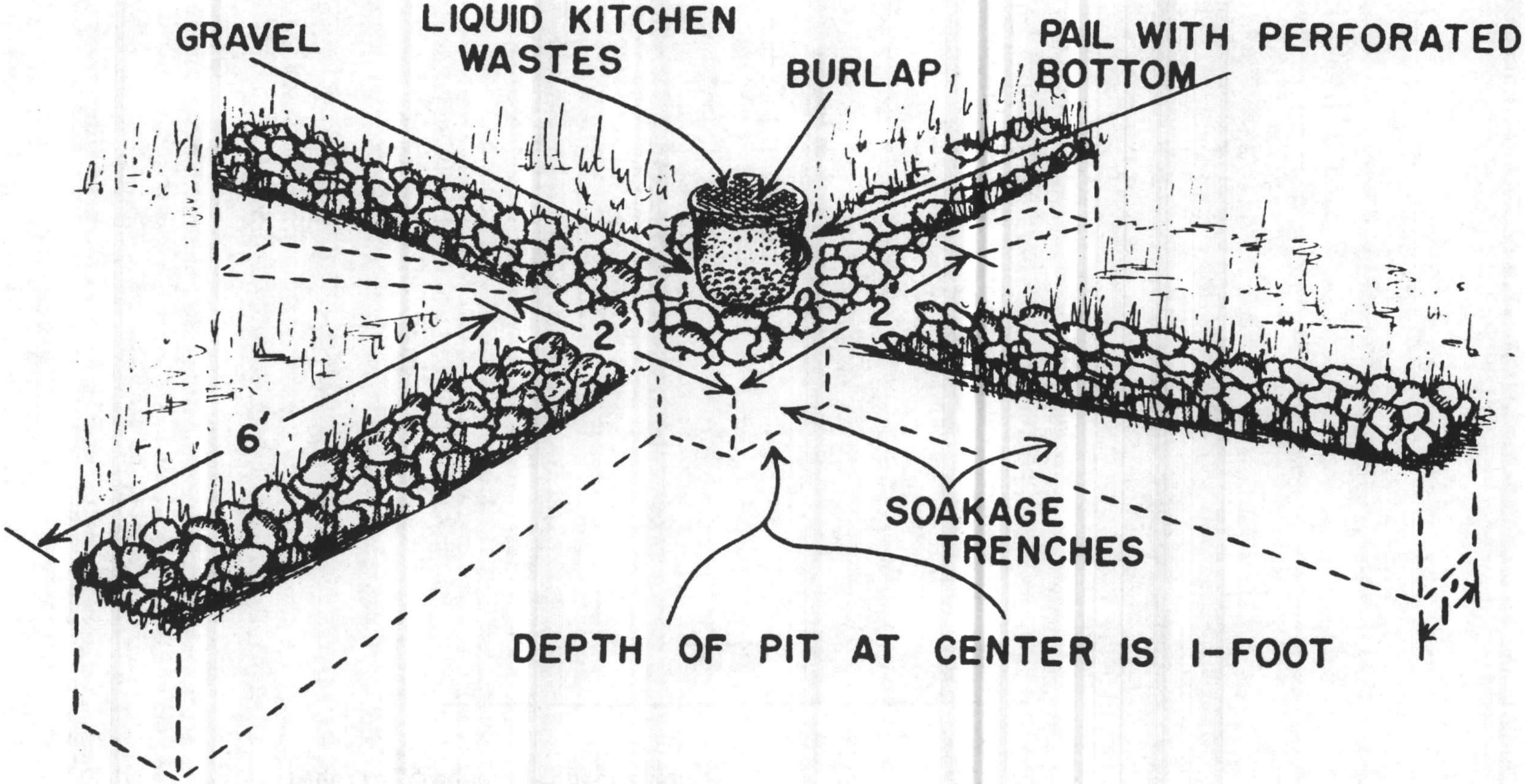


FILTER GREASE TRAP

FILTER GREASE TRAP

This grease trap may be used in place of the baffle types on the previous pages. It will effectively remove grease from liquid kitchen wastes, however, the top layer of sand will require frequent replacement.

NOTES

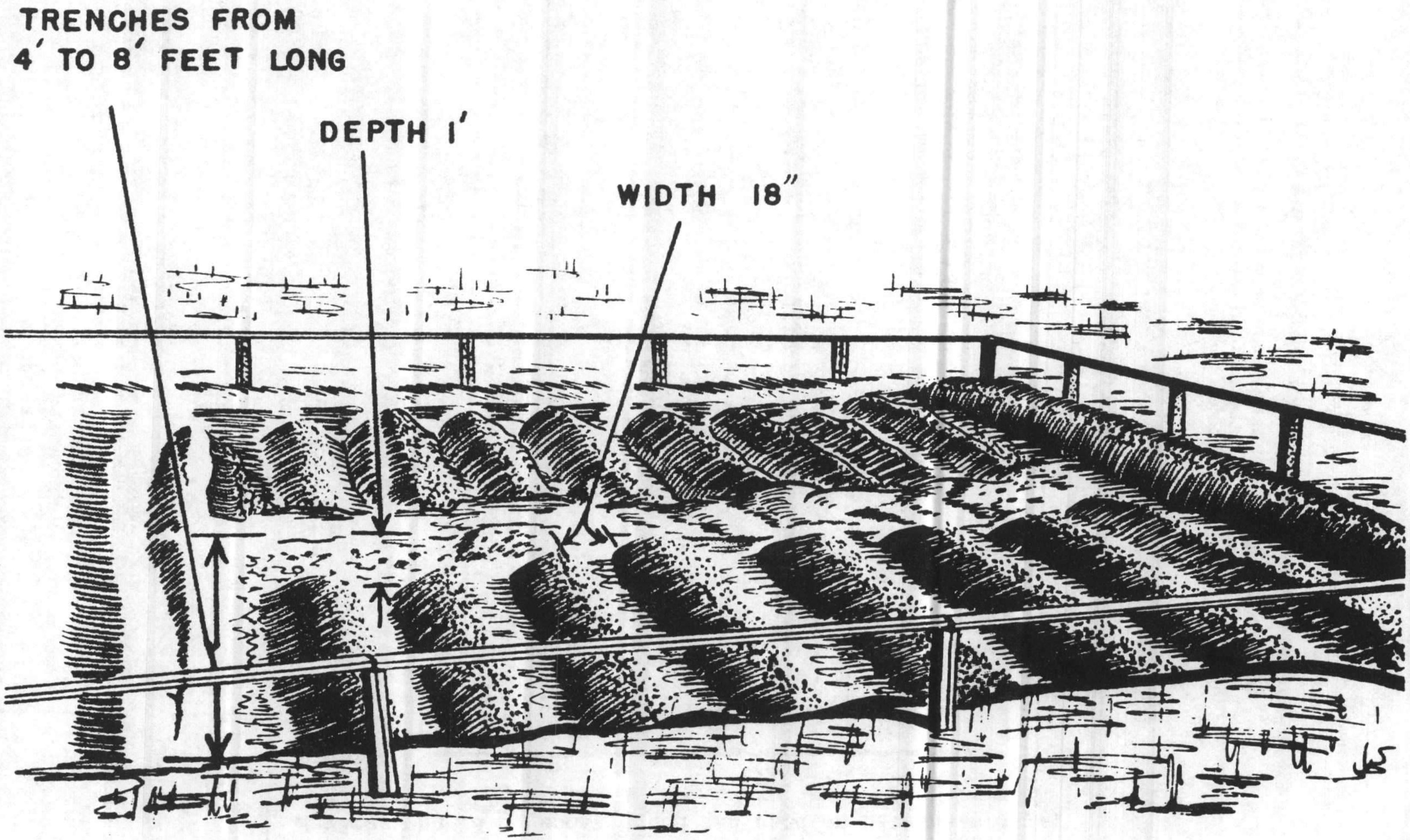


PAIL GREASE TRAP

PAIL GREASE TRAP

This grease trap utilizes crossed soakage trenches and a pail as shown in the illustration. For normal operation, two such devices should be constructed and used on alternate days.

NOTES

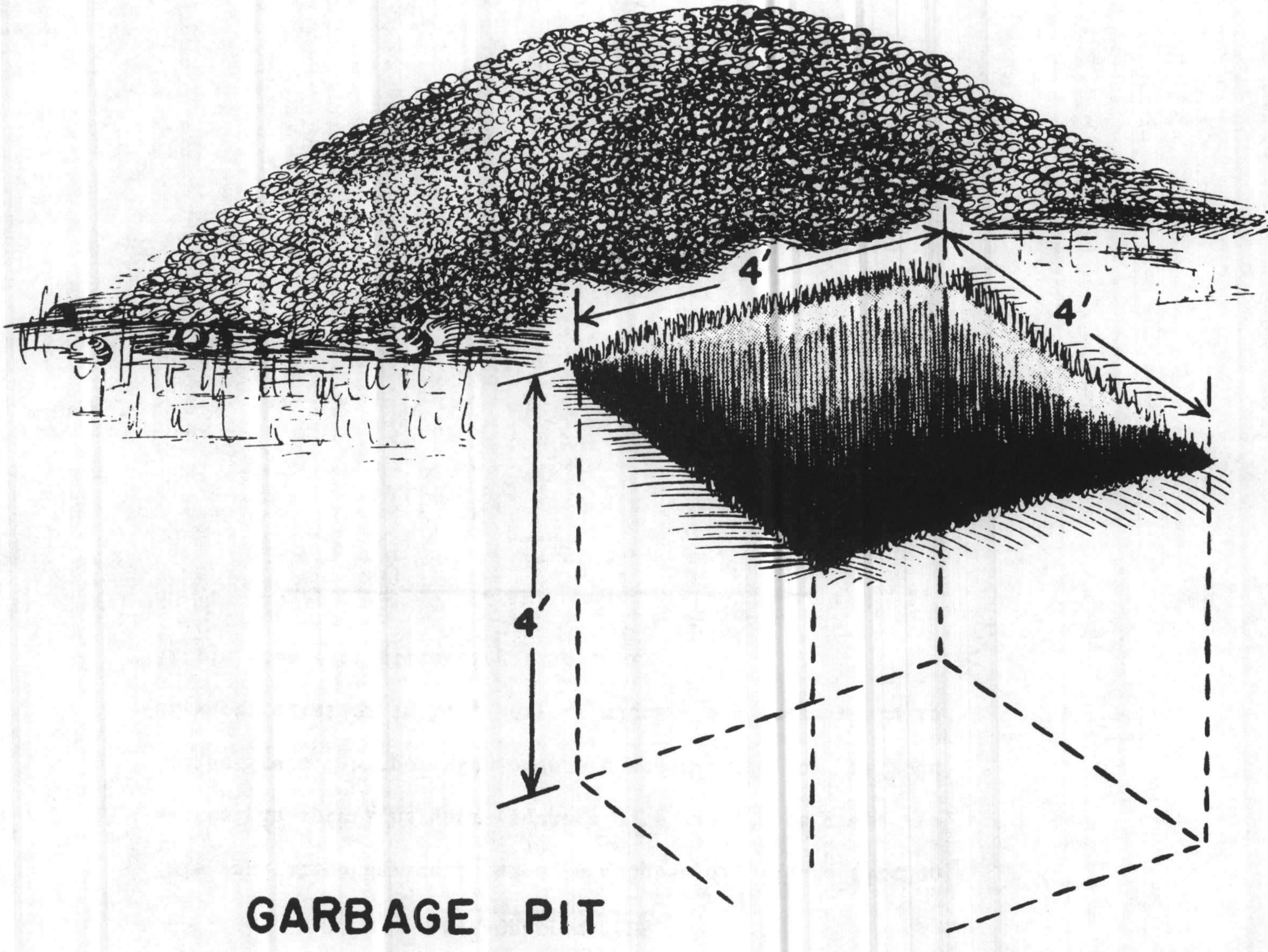


EVAPORATION BED

EVAPORATION BEDS

This sanitation device is used to dispose of liquid kitchen wastes in locations where soakage pits and grease traps are impractical. Evaporation beds are recommended for periods of short duration in hot, dry climates, and where there is little chance of attracting flies.

NOTES

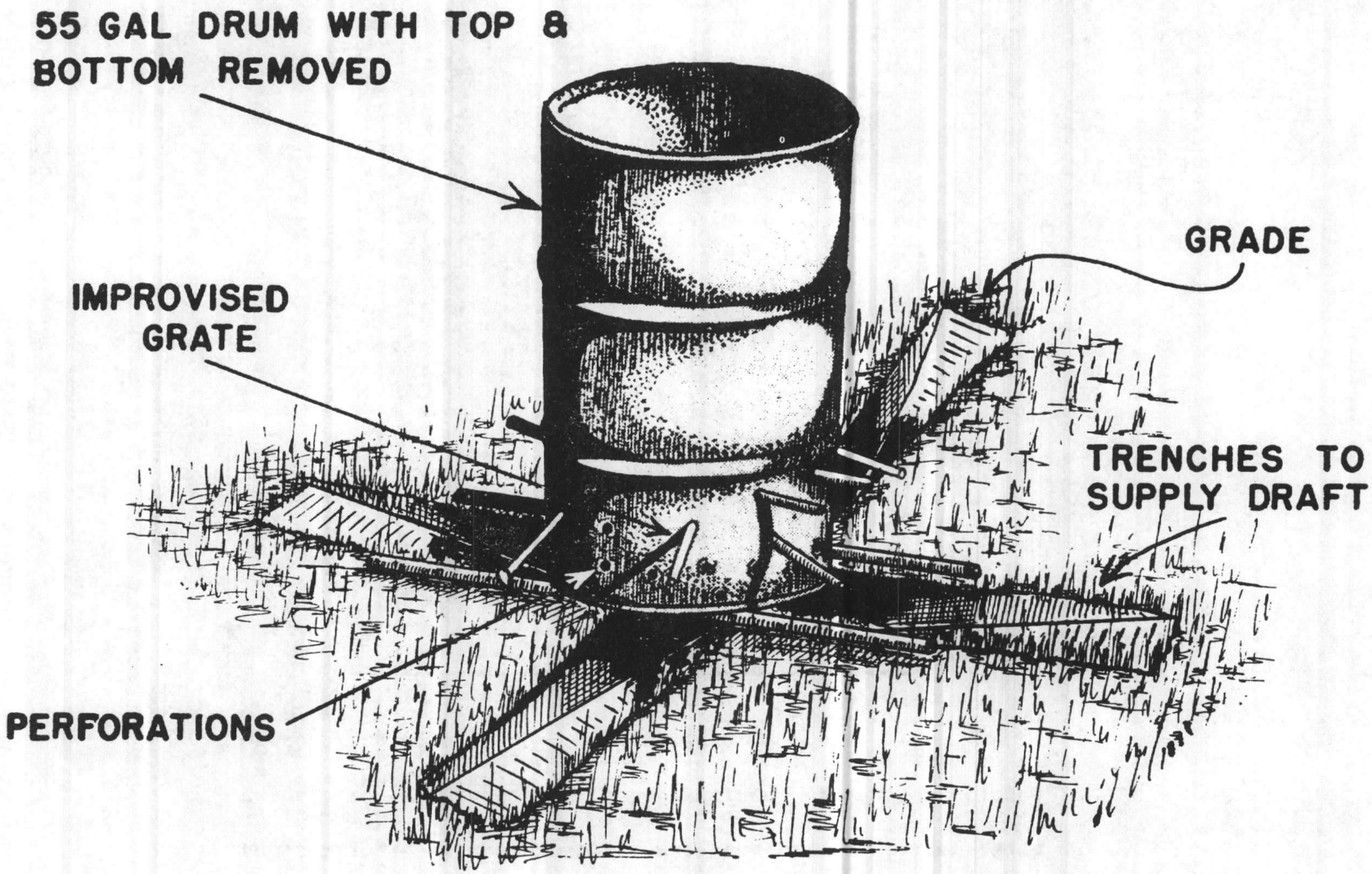


GARBAGE PIT

GARBAGE PIT

Shown in this reproduction is a standard size pit which will serve one hundred men for one day for the disposal of solid and semisolid kitchen waste. When the pit is filled with garbage to within 2 feet of the surface, it must be closed by covering with tightly packed earth.

NOTES

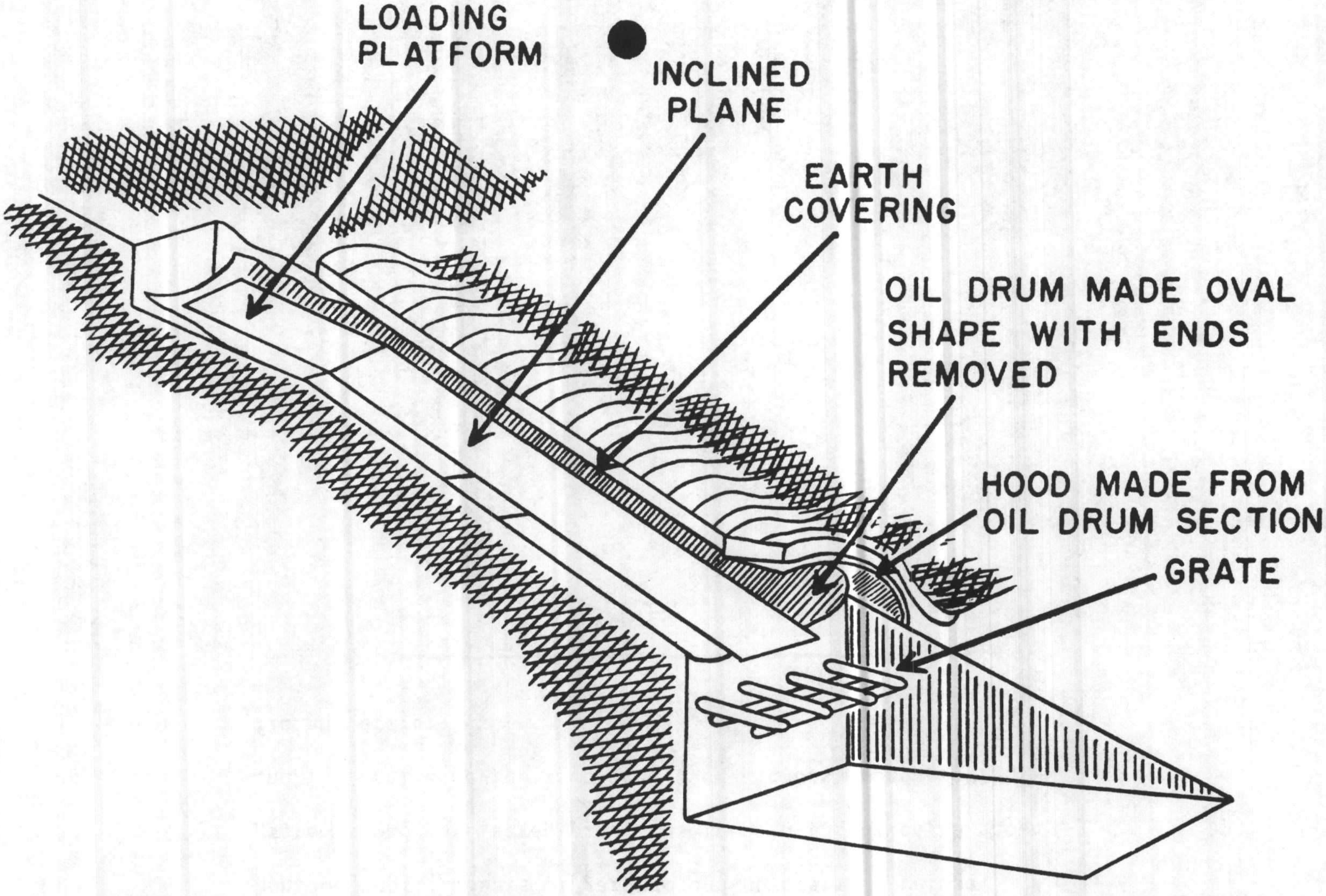


BARREL INCINERATOR

BARREL INCINERATOR

This incinerator is easily improvised and will effectively consume small amounts of garbage and combustible refuse. A grate is made of scrap pipe inserted in the holes as shown and the entire device is placed over a cross trench for sufficient draft.

NOTES

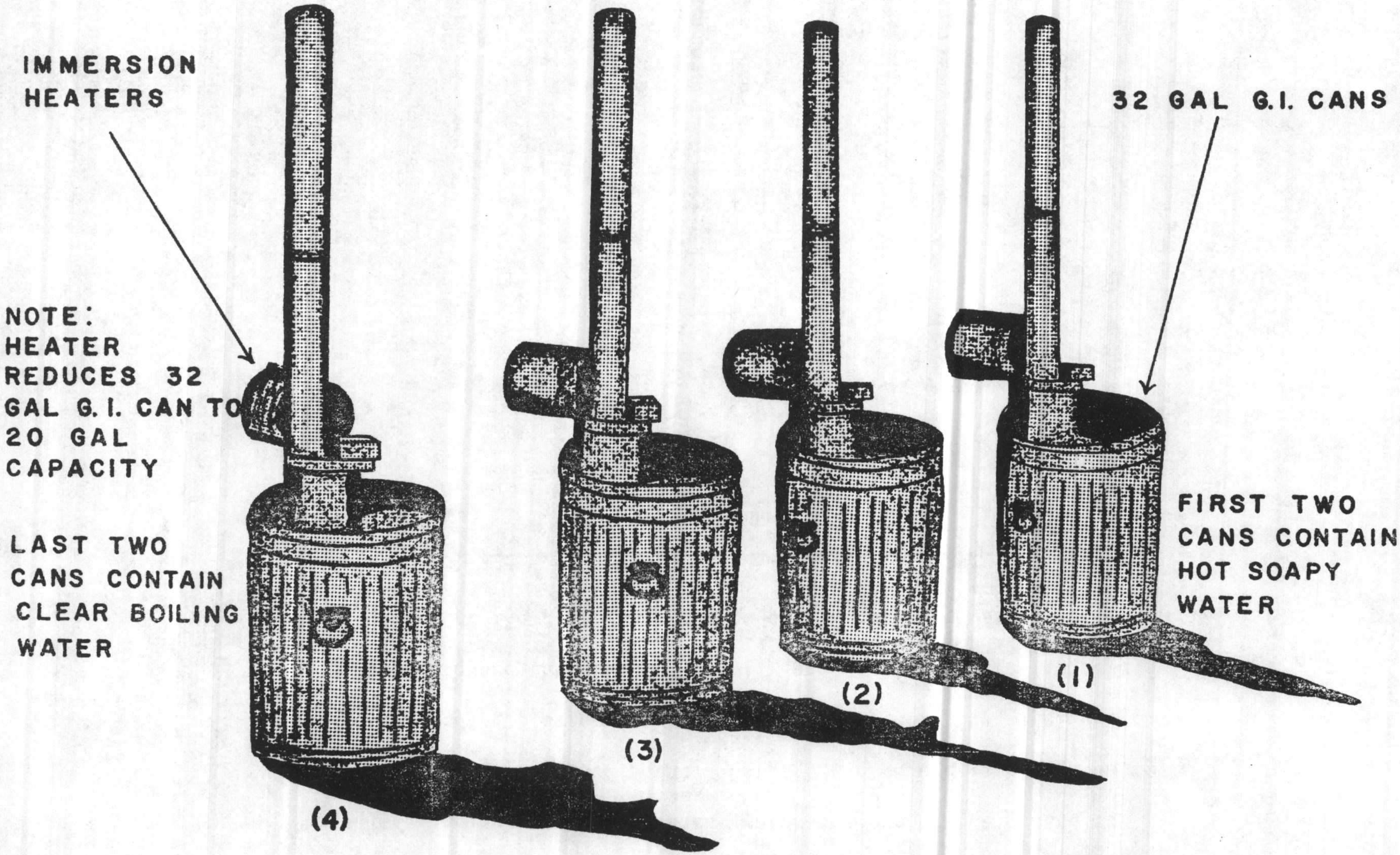


INCLINED PLANE INCINERATOR IMPROVISED
ON SIDE OF A BANK

INCLINED PLANE INCINERATOR ON SIDE OF A BANK

This incinerator utilizes the natural slope of the ground to provide the inclined plane. Garbage and refuse is placed on the loading platform and fed continuously down the inclined plane toward the grate. Usually an auxiliary fire is required at the grate in order to obtain good combustion.

NOTES

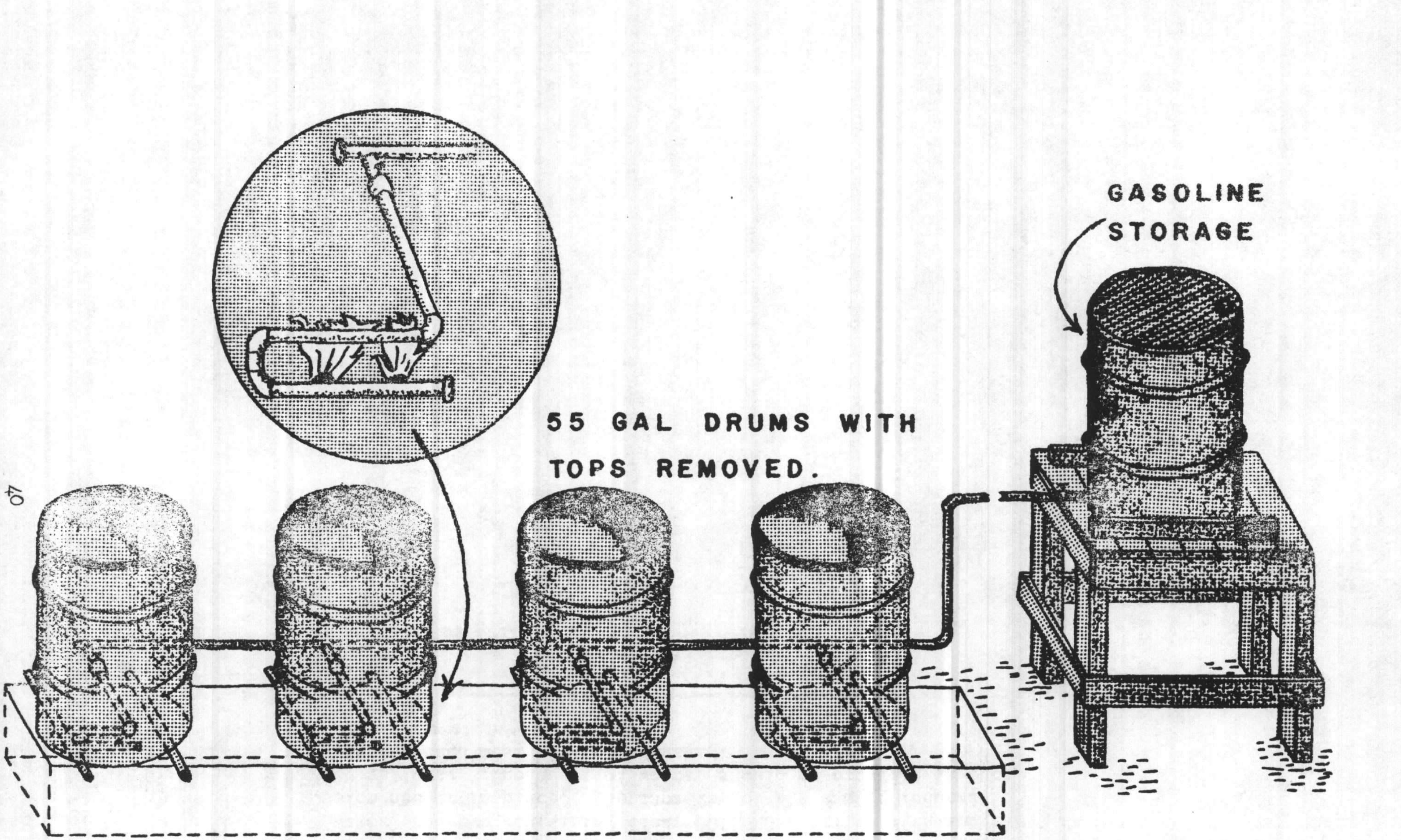


MESS-KIT WASHING SET-UP

MESS KIT WASHING SET-UP

This is the standard set-up for washing mess kits, utilizing issue immersion heaters and 32-gallon galvanized iron cans. As shown, 4 cans are required: Two containing hot soapy water, and two containing clear BOILING water. With immersion heater in place, the capacity of the can is reduced to 20 gallons. One quart of water should be provided in each can for each mess kit to be washed.

NOTES

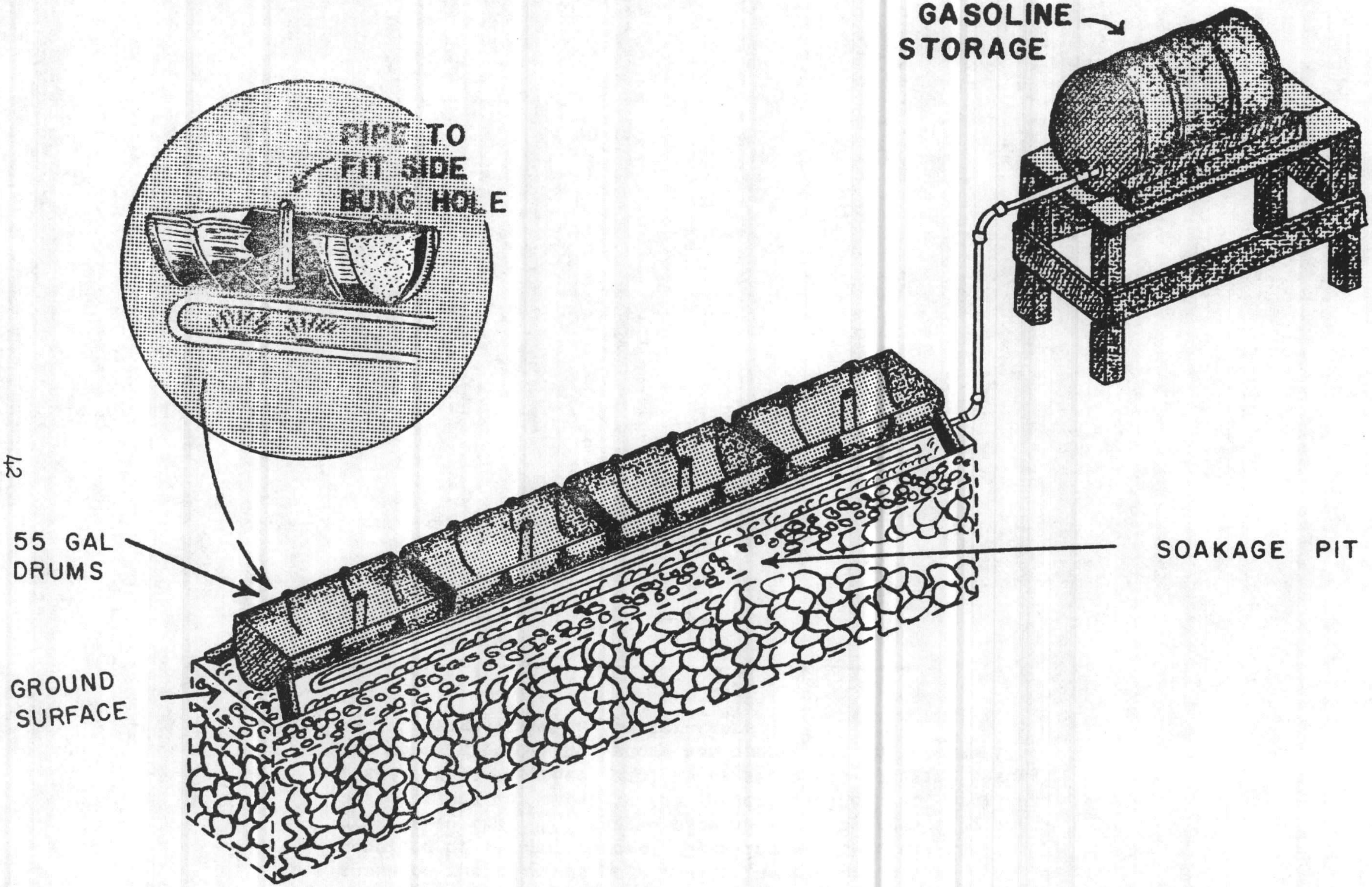


MESS KIT WASHING SET-UP VAPOR BURNER

MESS KIT WASHING SET-UP WITH VAPOR BURNER

This installation is similar to the mess kit washing line shown on the previous page, with the exception that heat is supplied by a vapor burner. Gasoline or stove oil is fed by gravity to the "U" shaped pipe where it emerges from small perforations as shown in the insert. The heat from this flame vaporizes the gasoline or stove oil passing through the upper pipe. The vapor then bruns with an intense flame as it emerges from the perforations.

NOTES

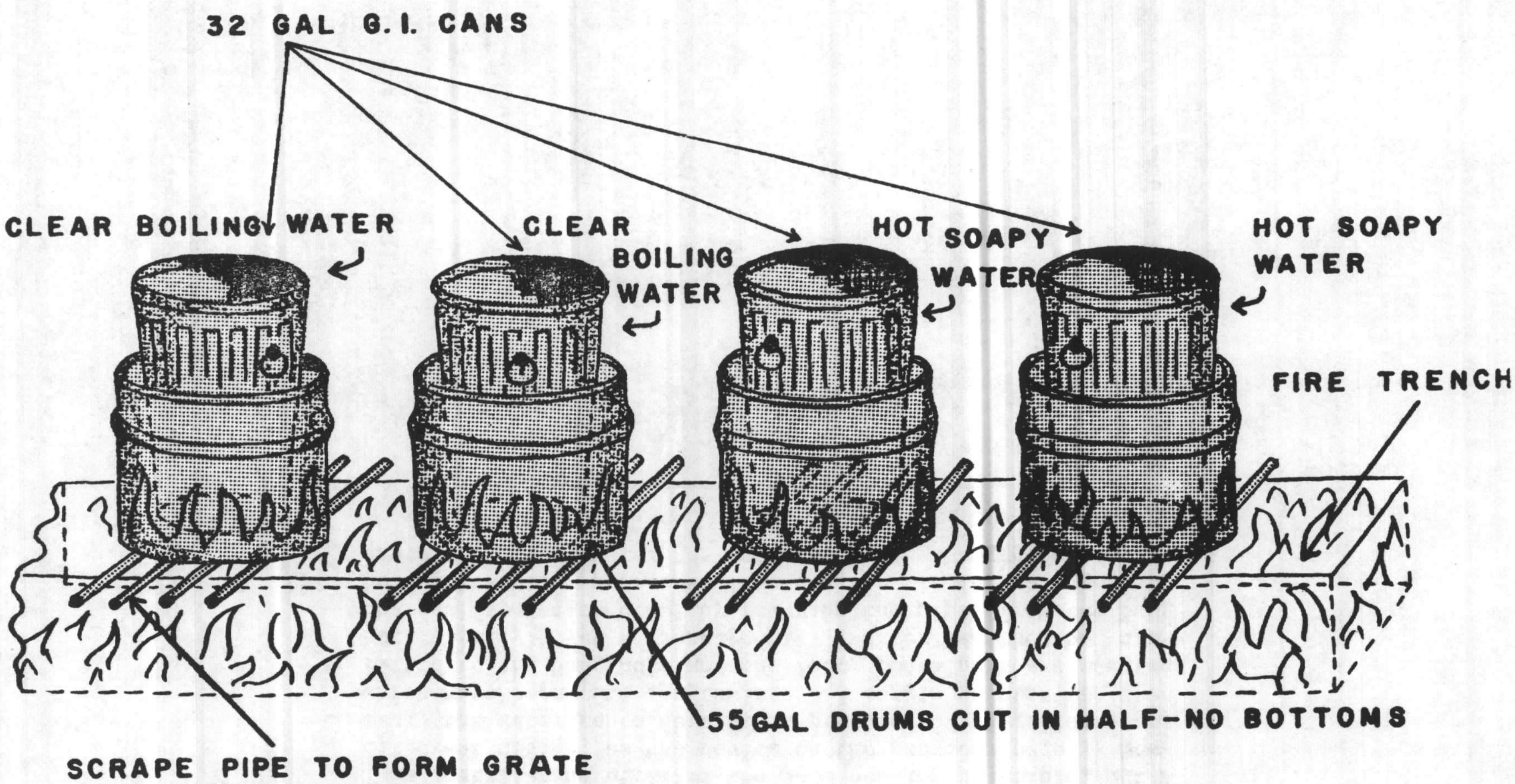


MESS KIT WASHING SET-UP VAPOR BURNER

MESS KIT WASHING SET-UP WITH VAPOR BURNER

This installation utilizes the same heating principle, but a different design, as the device on the previous page. However, the water containers are improvised of 55-gallon drums which have been cut lengthwise. A length of pipe is then fitted to the bung hole and the four containers are mounted horizontally over a soakage pit. Water can then be discharged from each drum by removing the pipe from the bung hole, however, grease will accumulate in the soakage pit, since the greasy water has not gone through a grease trap.

NOTES

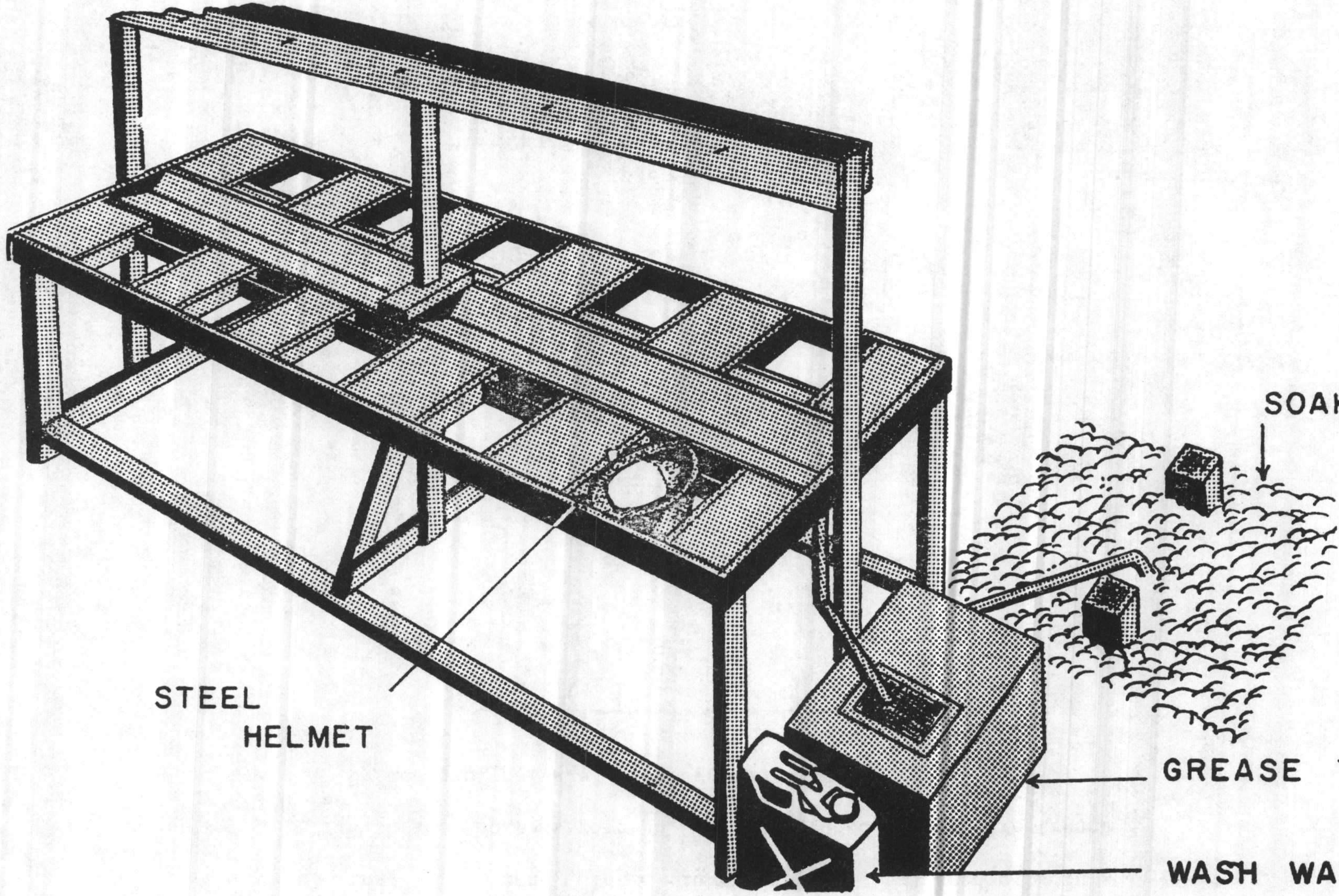


MESS KIT WASHING SET-UP WITH FIRE TRENCH

MESS KIT WASHING SET-UP WITH FIRE TRENCH

This installation is used in heating water in four containers, two hot soapy and two clear boiling, for mess kit washing. G. I. cans, placed in the halved, salvaged oil drums with the bottoms removed, are suspended over a fire trench by means of salvaged pipe or other metal scrap.

NOTES

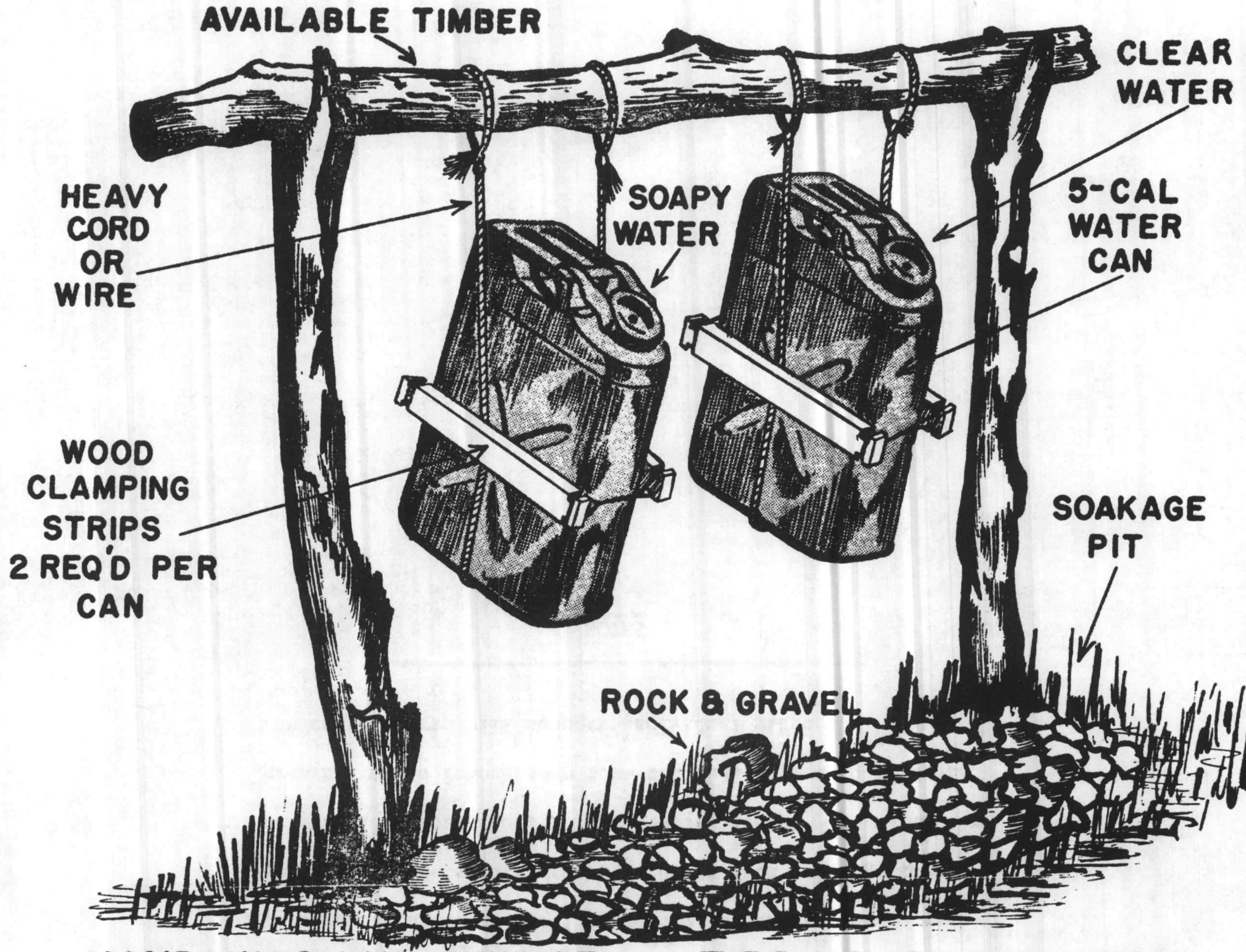


HELMET WASH RACK

HELMET WASH RACK

This device utilizes steel helmets as basins for hand washing, etc. The structure can be built from salvage lumber, or trees, or branches. The center trough drains into a grease trap to remove soap scum and then into a soakage pit. The center strip will support individual mirrors.

NOTES

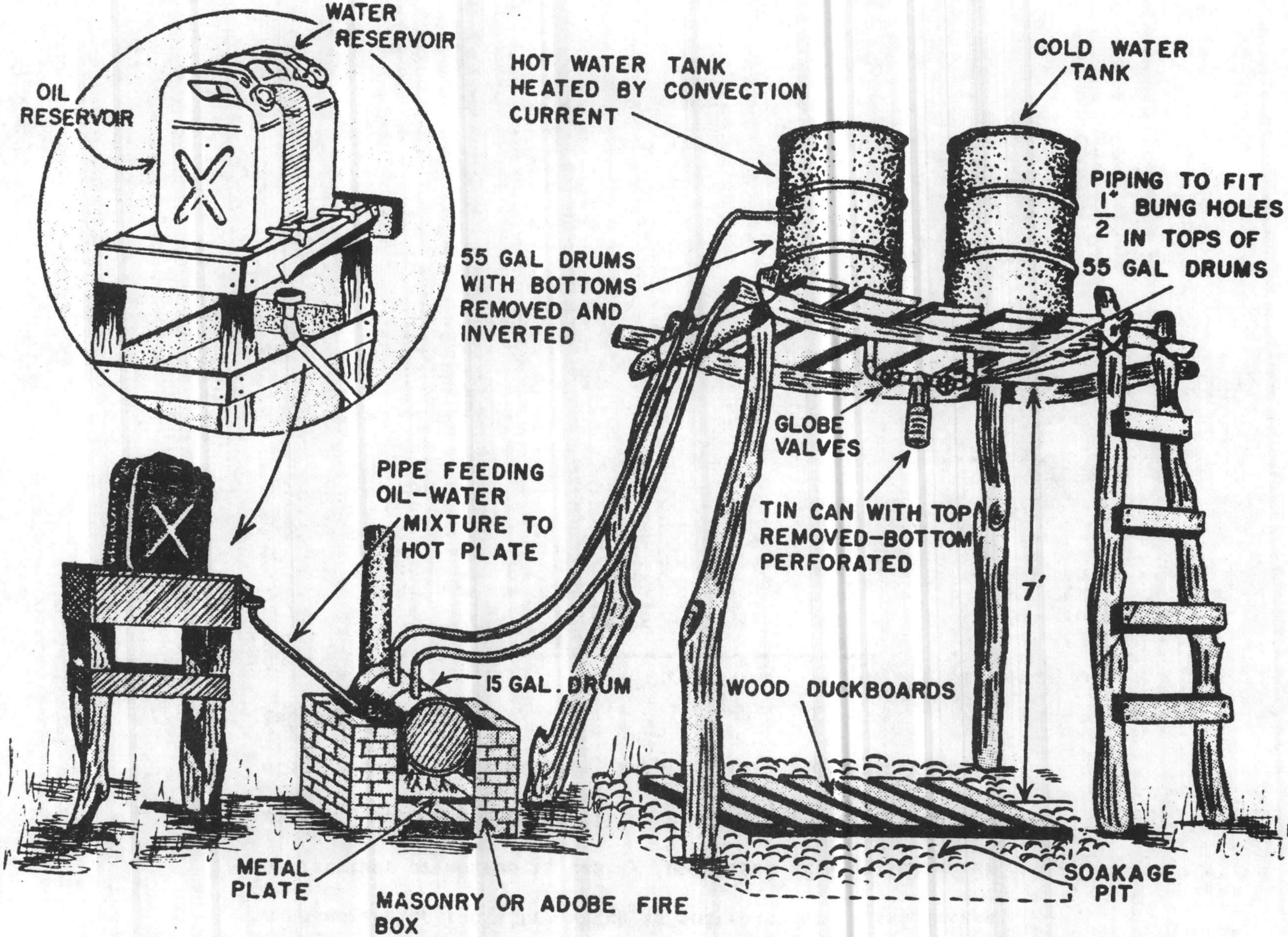


HAND WASHING DEVICE — TIPPING 5-GAL CAN

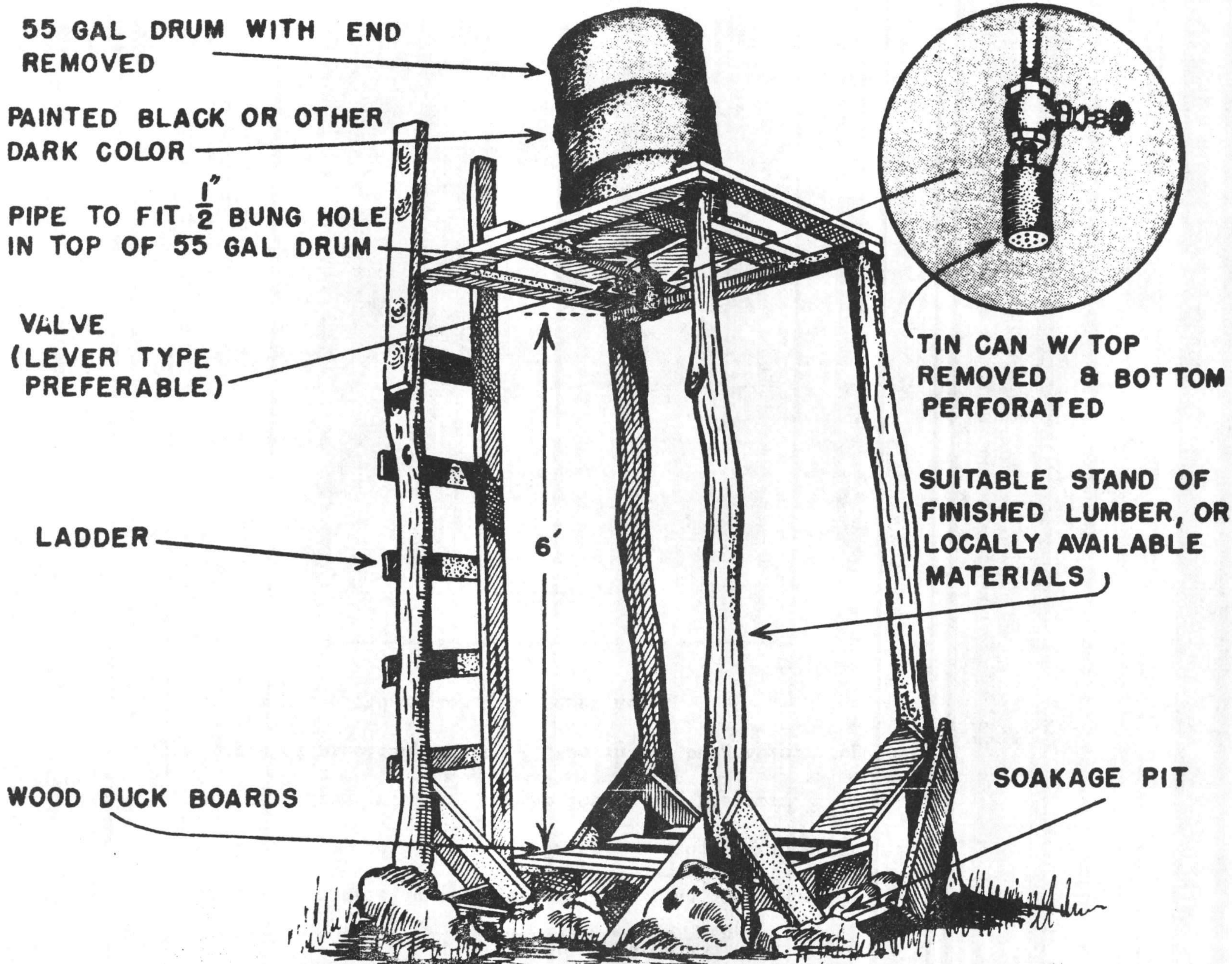
HAND WASHING DEVICE - TIPPING 5 GALLON CAN

A handwashing facility which is suitable for installation by latrines or messes is easily improvised of 5 gallon water cans. One can should be filled with clear water and the other should be filled with soapy water and appropriately labeled.

NOTES



SHOWER UTILIZING OIL — WATER FLASH BURNER



SHOWER — SOLAR HEATED

SHOWER - SOLAR HEATED

This is a simple device which utilizes the sun's heat to warm bath water. The bottom of a 55-gallon drum should be removed and the drum inverted on the improvised platform. A short length of pipe can then be fitted in one bung-hole, together with a valve and improvised shower head.

NOTES

UNITED STATES MARINE CORPS
Utilities Instruction Company
Marine Corps Engineer School
Marine Corps Base
Camp Lejeune, North Carolina 28542

U-10E02
Oct 1983
(D-565)ed

STUDENT OUTLINE

SINGLE TRAILER LAUNDRY UNIT

PURPOSE: The purpose of this period of instruction is to provide the knowledge and skills required to properly operate the single trailer laundry unit.

REFERENCE(S): TM 10-3510-208-12 w/c1, c2.

TERMINAL LEARNING OBJECTIVE(S): Provided with a single trailer laundry unit, detergent, water supply, power supply, and articles to be laundered, launder the articles in accordance with TM 10-3510-280-12, pp. 2-1 to 2-26. (1.5.3)

ENABLING LEARNING OBJECTIVE(S): Provided with a single trailer laundry unit, power supply, and water supply:

1. point out the major components of the unit. (1.5.3b)

2. install the unit. (1.5.3c)

3. perform before operation maintenance on the unit. (1.5.3d)

4. start the unit. (1.5.3e)

5. perform operational adjustments. (1.5.3f)

6. shut the unit down. (1.5.3g)

7. perform after operation maintenance on the unit. (1.5.3h)

in accordance with TM 10-3510-208-12, pp. 2-10 to 2-26.

OUTLINE:

1. NOMENCLATURE: The single trailer laundry unit, when properly operated, can produce 120 pounds of clothing, washed and dried in one hour. The single trailer laundry unit consists primarily of the water heater, washer-extractor, dryer, water pump, and air compressor, mounted on a trailer.

a. Trailer

b. Water heater.

(1) Heats incoming water

(2) Two automatic, air operated valves, control the water

(3) Fuel nozzle

(4) Burner nozzle and ignition electrodes

(5) Blower

(6) Fuel pump

c. Water pump

(1) Portable, centrifugal water pump

(2) Will deliver 18 to 20 gallons of water per minute

d. Air compressor

(1) Provides air pressure for operation of the laundry unit.

(2) Requires 80 to 95 PSI

e. Washer-extractor

(1) End-loading reversible, cylinder type.

(2) Constructed of corrosion-resistant metal

(3) Two electric motors one for washing operations and one for extraction operations.

(4) Designed to be operated either manually or automatically.

f. Tumbler

(1) Open-end, nonreversible type.

(2) A motor operates the cylinder

g. Air heater

(1) Located on top of the tumbler shell

(2) External fuel supply

2. INSTALLATION

a. Site selection

(1) Natural protection

(2) Firm, level, well drained ground

(3) Near a plentiful supply of clean water

(4) Accessible to a traveled route or road network

b. Trailer

(1) Lower the front support.

(2) Set trailer brakes

(3) Unhook trailer

(4) Removing and folding the laundry cover

(a) Remove the cover

(b) Fold the cover

(5) Level trailer

(6) Lower rear support

c. Water Pump

(1) Remove from storage location

(2) Connect the water pump power cables

(a) Remove power cables from storage

(b) Connect male plug connector to water pump service outlet receptacle.

(c) Uncoil the second cable and connect the two power cables.

(d) Water pump motor switch to OFF position.

(e) Connect the second cable to the water pump receptacle connector.

(3) Install strainer and 25 foot suction hose

(a) Remove strainer from storage

(b) Remove suction hose from drain bin

(c) Uncoil hose

(d) Check suction hose and strainer couplings

(e) Connect suction hose to strainer.

(f) Connect suction hose to water pump in-take port.

(g) Place suction hose strainer into water source

(h) Connect hoses between pump and water heater.

(i) Uncoil hoses from water pump towards water heater

(j) Connect the hoses

(k) Check water heater inlet adapter

(l) Connect second hose to water heater water inlet.

d. Water heater (TP # 6 ON)

(1) Release the low water indicator rod.

(2) Install the fuel lines

(a) Remove fuel hose from storage

(b) Install barrel plug adapter

(c) Connect hose to barrel plug adapter "SUPPLY".

(d) Connect hose to fuel filter

(e) Tighten connections

(f) Connect fuel hose to barrel plug adapter "RETURN".

(g) Connect hose to fuel pump

(h) Tighten connections

(3) Install water heater exhaust duct

(a) Remove exhaust duct from storage

(b) Connect the two sections of the exhaust duct.

(c) Check the sections

(d) Connect joined duct to water heater exhaust vent

(4) Fuel pump motor switch in OFF position.

e. Dryer-tumbler

(1) Install fuel lines from fuel container to fuel filter and fuel pump

(a) Remove fuel hose from storage

(b) Install barrel plug adapter

(c) Connect fuel hose to barrel plug adapter "SUPPLY".

(d) Connect fuel hose to fuel filter

(e) Tighten connections

(f) Connect fuel hose to barrel plug "RETURN".

(g) Connect fuel hose to fuel pump

(h) Tighten connections

(2) Connect canvas duct to dryer-tumbler air exhaust port.

(a) Remove duct from storage

(b) Unfold canvas duct

(c) Round out the duct

(d) asbestos-lined end towards the dryer-tumbler air exhaust port.

(e) Spring lock clips

(f) asbestos-lined duct band inside discharge opening

(g) Spring lock clips

(h) Elevate free end of canvas duct off

(3) Connect flexible exhaust duct to dryer-tumbler

(a) Remove flexible duct from storage

(b) Locate flanged end

(c) Align flange stud pins

(d) Lock in place

(e) Secure duct to duct plate

(4) Remove cushioning material from the mercury bulb housing of air temperature control.

f. Washer-Extractor

(1) Install the trailer step assembly.

(2) Remove washer-extractor front tiedown bar.

(3) Remove washer-extractor rear support.

(4) Remove the washer-extractor front support.

(5) Install the washer-extractor drain hose.

(6) Unlock the washer-extractor drain valve lever.

(7) Install a grounding system to the laundry unit.

3. PRE-OPERATION MAINTENANCE:

a. Daily Services

(1) Visual inspection

(a) Leaks

(b) Loose or missing bolts, screws and nuts.

(c) Damage

(d) Cold weather operations

<u>1</u> Frozen or cracked valves and hoses.

<u>2</u> Frozen pipes

<u>3</u> Broken or missing V-belts

(2) Instruments and controls

(a) Loose connections

(b) Cracked or broken glass

(3) Check switches for operation

(4) Check valves for operation

(a) Air compressor

(b) Water heater

(c) Washer extractor

(d) Washer-extractor control valve

(e) Fuel valves

(5) Check fuel supply connections

(6) Check exhaust connections

(7) Check water and drain connections

(8) Check operation of the manual drain valve.

b. Lubricants and Lubrication Intervals

(1) Lubricants

(a) GO

(b) GOS

(c) GAA

(d) OE

(2) Lubrication interval

(a) 50 hours of operation

1 Washer extractor

2 Drying tumbler

(b) 100 hours of operation

1 Washer-Extractor

2 Drying tumbler:

(c) 250 hours of operation

1 Washer-Extractor:

2 Drying-tumbler:

(d) 500 hours of operations

1 Washer-Extractor

2 Drying-tumbler

(e) Trailer

1 Front leveling jack:

2 Rear stabilizing jack:

NOTES;

1. Washer motorslide:

2. Motor bearings:

3. Oil can points:

4. Trunnion bearings:

5. Gear reducer:

6. Drive chain:

7. Burner blower motor bearings:

8. Intervals

9. Lubricants are applied sparingly or approximately 1 or 2 ounces.

4. OPERATION

   a. Main power switch

   b. Start the air compressor

      (1) Bleeder valve

      (2) ON-OFF switch

      (3) Air pressure

      (4) Open bleeder valve

      (5) Close bleeder valve

      (6) Walk around the laundry unit noting excessive air leaks.

   c. Pump service outlet switch

   d. Start the water pump

      (1) Prime the pump

(2) Start the water pump motor.

(a) Water pump motor switch cover

(b) Switch upward to ON

(c) downward to OFF

(d) Move switch upward to ON position

(e) Release switch cover

e. Start the water heater

(1) Open heater vent valve

(2) Close heater vent valve

(3) Float hold down rod

(4) Water temperature control thermal switch

(5) Water heater OFF/ON switch

(6) Fuel pressure gauge

(7) Pump pressure adjusting set-screw

(8) Observe through the burner or spark sightglass to determine if a flame is present.

(9) Burner shutter lever

(10) Fuel shutoff valve

(11) Make adjustments as necessary

f. Start the dryer tumbler

(1) Temperature control

(2) Start button

(3) Fuel pump

(4) Pressure gauge.

(5) Adjust the fuel

(6) Start button of lower manual starter assembly.

(7) Burner fuel cutoff valve

g. Operate the washer-extractor

(1) Automatic cycle

(a) Formula control

(b) Washing and extracting the load.

1 AUTO-MANUAL control switch

2 Load washer-extractor

3 Check air compressor gauge

4 Add washing supplies

5 AUTO-MANUAL switch to AUTO

6 Warning bell and the signal light

7 Using a multi-suds formula

8 At completion of washing but before pre-extract-extract cycle

9 At completion of formula

10 Repeat washing-extracting operations

(2) Manual cycle

(a) Load washer

(b) Select formula

(c) Set fingers for manual operation.

(d) Check air compressor pressure gauge

(e) Add washing supplies

(f) Push AUTO-MANUAL to MANUAL

(g) Set electrical timer

(h) Add water to proper level

(i) Rinse

(j) Extraction

(k) BRAKE-DRAIN switch to DRAIN

(l) WASH-PRE-EXT switch to PRE-EXT

(m) EXTRACT switch from OFF to EXTRACT

(n) Extract the clothes

(o) When timer has elapsed push EXTRACT switch to OFF

(p) BRAKE-DRAIN switch to OFF

(q) AUTO-MANUAL switch to OFF

(r) Remove clothes

(s) Repeat washing and extraction operations

h. Drying the load (Cotton or Wool)

(1) Place clothes into the dryer.

(2) Close tumbler door

(3) Set temperature control switch

(a) cotton

(b) wool

5. DURING OPERATION MAINTENANCE

a. Air compressor

(1) Air pressure

(2) Airleaks

b. Water pump

(1) Unusual noise

(2) Water leaks

c. Water heater

(1) water temperature

(2) Fuel combustion and fuel adjustments

(3) Temperature adjustments

d. Washer-Extractor

(1) Observe cycle movement.

(2) Unusual air leaks

(3) Water leaks

(4) Observe extraction

e. Drying-tumbler

(1) Observe temperature reading

(2) Insure proper temperature for proper garments.

(3) Fuel leaks

(4) Adjust fuel pressure

6. SHUTTING DOWN OR STOPPING THE LAUNDRY UNIT

a. May begin while the last load of wash is being dried

b. All washer-extractor control panel switches in OFF position.

c. Turn OFF the air compressor.

d. Close water heater fuel shutoff valve.

e. Turn OFF water pump switch

f. Drain the heater, valves, and hoses

g. Open air vent valve

h. When drying operations are completed, push the stop-reset button of the lower manual starter assembly on the tumbler.

i. Turn off fuel cutoff valve

j. Open tumbler door and allow the tumbler to cool

k. Stop the blower and burner

7. POST OPERATION MAINTENANCE

a. Water holding equipment

b. Water valves

c. Air line valves

d. Fuel lines

e. Hoses

f. Electrical cords

g. Water pump

h. Canvas exhaust duct

i. Cushion material

d. Fuel lines

e. Hoses

f. Electrical cords

g. Water pumps

h. Canvas exhaust duct

i. Cushion material

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DETAILED OUTLINE

FIELD SANITATION

INTRODUCTION (5 MIN)

(TP #1 ON)

1. GAIN ATTENTION: In the armed forces, manpower is the most valuable asset. Everything possible must be done to conserve this asset. In recent wars more deaths have resulted from enemy actions than from disease, but disease still causes the greatest loss of manpower through disability and time lost from duty.

Success in battle - the ultimate objective of any military force demands that troops be maintained in a constant state of combat readiness. Field hygiene and sanitation contributes to this effort by employing all of the measures designed to protect and improve the health of Marine Corps personnel.

2. PURPOSE: To familiarize the student with the procedures for installing and maintaining field sanitation devices.

3. INTRODUCE LEARNING OBJECTIVE(S): Learning objectives are neither specified nor measured during the lesson.

TRANSITION: Before we cover the procedures for installing and maintaining field sanitation devices, let's talk about the areas of responsibility for field sanitation.

(TP #1 OFF)

BODY (38 MIN)

1. Areas of responsibility: Many personnel are responsible for your health while in the field. They are:

(TP #2 ON)

a. Commanding Officer

(1) The commanding officer of a military organization is responsible for the health of his command. In the fulfillment of this responsibility, he is assisted by a staff of trained specialists. Using the technical advice and guidance of these individuals, he issues orders and enforces measures which will most effectively maintain sanitation and practices conducive to the health and well being of his troops.

(2) To provide for the accomplishment of the many time consuming duties essential to the establishment and maintenance of a healthful field environment for the troops, the commander appoints a field sanitation team and makes arrangements for the team members to receive the training which they need to accomplish these duties effectively.

The duties entail performing, instructing, supervising, assisting, inspecting, and reporting, as applicable, to insure that appropriate field sanitation facilities are established and maintained, that effective sanitation and control measures are applied, and that effective sanitation and protective methods are practiced by the troops.

(TP #3 ON)

b. Medical Officer: The commander's chief advisor in maintaining the health of his troops is the medical officer. The medical officer is responsible for providing effective medical services, including treatment of disease and injury; devising, recommending, and supervising activities and training directed toward disease prevention, personal hygiene, and first aid; furnishing technical advice and supervision in connection with the health aspects of camp sites, water supply food and its preparation, waste disposal, bathing facilities, housing, clothing, and insect and animal control. While it is the commander's direct responsibility to enforce the practices of field sanitation, it is the medical officer's responsibility to advise what should be done. Only in matters involving technical knowledge does the medical officer specify how it should be done. The commander may authorize the medical officer to give orders in his (the commander's) name for immediate correction of defects in sanitation. Even then, full responsibility remains with the commander.

(TP #4 ON)

c. Medical Department

(1) The preventive medicine officer recommends to the medical officer and the commander, a preventive medicine program which will meet the particular needs of the command. He supervises the commander's preventive medicine program which encompasses communicable disease control, personal hygiene, environmental sanitation, and nutrition.

(2) The bioenvironmental engineer and the sanitary engineer give technical advice to the preventive medicine officer and the medical officer regarding problems of environmental engineering and the control of disease carrying insects and rodents.

(3) The veterinary officer serves as an assistant and technical adviser to the medical officer and is responsible for the inspection of foods of animal and nonanimal origins, sanitary inspection of civilian food establishments, zoonosis control, and veterinary care and treatment of government owned animals and authorized privately owned pets.

(4) Preventive medicine units - comprised of preventive medicine officers, entomologists, bioenvironmental engineers, sanitary engineers, veterinarians, laboratory specialists, and preventive medicine specialists supervise and assist in the execution of measures of disease control within the command as directed by the medical officer.

(TP #4 OFF)

d. Combat Service Support Units: Combat service support units are responsible for food supply and service, clothing stock and issue, laundry and dry cleaning facilities, field shower units, and self-service supply centers. They provide for the repair of clothing, footwear, and tentage, supplies and materials required for personal hygiene, insect and rodent control and sanitation are provided under the combat service supply system.

e. The Individual: The promotion of the health of the service is the responsibility of every individual member. A person's ignorance of or indifference to the practice of military sanitation can counteract much of the combined effort of many services working for his welfare.

For his own sake, as well as for the sake of his buddies, it is imperative that every individual know and observe the rules of hygiene and sanitation and adhere to the principles of good health and good living.

<u>OPPORTUNITY FOR QUESTIONS</u> (3 MIN)

1. <u>QUESTIONS FROM THE CLASS</u>

2. <u>QUESTIONS TO THE CLASS</u>

a. Who is the most important person in maintaining good sanitary habits?

A. The individual

b. Who advises the commander in matters of hygiene and sanitation?

A. The medical officer

(2 MIN)

<u>SUMMARY</u>: During the first hour I covered the responsibilities of the commanding officer, medical officer, combat service support units and the individual.

<u>BREAK</u> (10 MIN)

<u>INTRODUCTORY TRANSITION</u>: During the second hour of instruction we will cover waste disposal.

BODY (45 MIN)

2. Medical Importance of Waste Disposal

a. Large quantities of all types of waste, liquid and solid, are generated each day under field conditions. These materials must be removed promptly and thoroughly; otherwise the camp or bivouac will quickly become an ideal breeding area for flies, rats, and other vermin. Filthborne diseases such as dysentery (amebic and bacillary), typhoid, paratyphoid, cholera, and plague could become prevalent.

b. The term waste includes all types of refuse resulting from the living activities of humans or animals. The following types of wastes will be discussed:

(1) Human waste (feces and urine)
(2) Liquid wastes (wash, bath, and liquid kitchen wastes)
(3) Garbage
(4) Rubbish

c. The methods which should be used for the disposal of wastes depend upon the military situation and the unit location. Burial and burning are the methods most commonly used in the field.

3. Disposal of Human Wastes

a. The devices most generally used for disposal of human wastes in the field are:

(1) Straddle trench heads
(2) Deep pit heads
(3) Burn-out heads
(4) Mound heads
(5) Bored hole heads
(6) Pail heads
(7) Urine soakage pits.

b. The devices for disposing of human waste in the field vary with the situation -

(1) When troops are on the march, each person uses a "cat hole" during short halts. It is dug approximately 1 foot deep and is completely covered and packed down after use.

(2) In temporary bivouac of 1 to 3 days the straddle trench is most likely to be used unless more permanent facilities are provided for the unit.

(3) In temporary camps deep pit head and urine soakage pits are usually constructed. Until such time as the construction of deep pit can be completed, straddle trench heads are used. Where the construction of deep pit head is not practicable, other types of heads are used. Whatever head device is used, the unit is responsible for its construction, maintenance, and closure.

4. Rules Common to the Construction, Maintenance, and Closing of Latrines

a. In determining the type of head to be constructed, consider the following:

(1) Length of stay - how long you will be at that location.

(2) Water level - how deep you can dig before hitting the water level. To protect water from contamination, do not extend the depth of a pit or trench below the underground water level.

(3) Soil condition - is it stable or must the hole be revetted.

b. In determining the location within the camp area for construction of heads consider the following.

(1) The protection of food and water from contamination. To protect food and water from contamination, select a location which is at least 100 yards from the unit mess and 100 feet from the nearest water source and which drains away from all water sources.

(2) The accessibility of the users. Choose a location which is accessible to the users but reasonably near the end of the unit area.

(TP #5 ON)

c. After the heads have been completed, construct the necessary protective and hygiene devices:

(1) Place canvas or brush screens around the heads or tents over them. In a cold climate the shelters should be heated if possible.

(2) To prevent surface water from flowing into the shelters dig drainage ditches around them.

(3) In each head shelter, provide toilet paper on suitable holders with tin cans for covering the toilet paper to keep it from getting wet during bad weather.

(4) Install a simple, easily operated handwashing device just outside each head shelter. These devices should be kept filled with water at all times so that each individual can wash his hands after he uses the head.

(5) At night, if the military situation permits, keep the heads lighted; otherwise extend cords from trees or stakes to the latrines to serve as guides.

d. Police the heads properly and maintain a good fly control program in the entire camp area to prevent fly breeding and to reduce odors.

(1) Keep the lids on the head seats closed and all cracks sealed.

(2) Scrub the head seats and boxes with soap and water daily.

(3) Spray the inside of the shelters with a residual insecticide twice weekly. If a fly problem exists, also spray the pit contents and the interior of the boxes twice weekly with a residual insecticide. Using lime in the pits or burning out the pit contents, except in burn-out heads, is not effective for fly or odor control; these methods are not, therefore not recommended.

e. At such time as a head pit becomes filled with waste to a point 1 foot from the surface if it is to be abandoned, remove the box and close it as follows:

(1) Using an approved residual insecticide, spray the pit contents, the side walls, and the ground surface extending 2 feet from the side walls.

(2) Fill the pit to the ground level with successive 3 - inch layers of earth, packing each layer down before adding the next one; then mound the pit over with at least 1 foot of dirt and spray it again with insecticide. This prevents any fly pupa, which may hatch in the closed head from getting out.

(3) Place a rectangular sign on top of the mound. The sign must indicate the type of pit and the date closed as well as the unit designation in nonoperational areas.

(TP #5 OFF)

OPPORTUNITY FOR QUESTIONS (3 MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. What type of head is used in a temporary bivouac area?

A. The straddle trench

b. How far away from the mess hall and the water source should the head be located?

A. At least 100 Feet.

(2 MIN)

SUMMARY: During this second hour of instruction we have covered the types of wastes, disposal of human wastes and rules common to the construction, maintenance, and closing of heads.

BREAK (10 MIN)

<u>INTRODUCTORY TRANSITION</u>: During the next hour we will cover the construction of head facilities

<u>BODY</u> (47 MIN)

4. Construction of head facilities (TP #6 ON)

a. Straddle trench

(1) A straddle trench is dug 1 foot wide, 2 1/2 feet deep, and 4 feet long.

(2) This will accommodate two men at the same time.

(3) The number of trenches provided should be sufficient to serve at least 8 percent of the unit strength at one time. Thus for a unit of 100 men, at least 16 feet of trench or four-trenches are needed. The trenches should be at least 2 feet apart. There are no seats in this type of head but boards may be placed along both sides of the trenches to provide better footing.

(4) Some of the earth removed is piled at the end of each trench, and a shovel or paddle provided so that each man can promptly cover his excreta and the toilet paper which he uses.

(5) If possible tin cans should be provided to protect toilet paper during inclement weather.

b. Deep pit head - nothing more then a deep pit with a standard 4 seat box placed over it.

(1) The pit is dug 2 feet wide and 7 1/2 feet long. This allows 3 inches of earth surface on each side of the pit to support the box.

(2) Depth of the pit depends upon the estimated length of time head is to be used. As a guide, a depth of 1 foot is allowed for each week of estimated use, plus 1 foot of depth for dirt cover when it is to be closed.

(3) It is not generally desirable to dig the pit more than 6 feet deep because of the danger of the walls caving in. Rock or high ground water level may also limit the depth of the pit. In some soils, supports of planking or other material may be necessary to prevent the walls from caving in. Earth should be packed tightly around the bottom edges of the box so as to seal any openings through which flies could gain entrance.

(4) Deep pit box - The standard box has four seats and is 8 feet long and 2 1/2 feet wide at the base.

(5) A unit of 100 men requires two 4 seat boxes or 16 feet of head space.

(6) The holes should be covered with flyproof, self-closing lids. Any cracks should be fly proofed by nailing strips of wood or tin over them. A metal deflector should be placed inside the front of the box to prevent urine from soaking into the wood. The deflector may be made from flattened cans.

(7) It is sometimes desirable to install a vent stack in the more permanent pit head to release the moisture ladened gases of decomposition, thus preventing condensation from forming on inside of the self-closing lids which may come in contact with an individual's back. The vent stack should extend from the upper part of the pit to approximately 6 feet above the ground level. The outside opening of the vent stack must be screened.

(TP #8 ON)

c. Burn-out head - May be used when the following conditions exist

(1) When soil conditions (hard, frozen, rocky) make digging a deep pit head difficult.

(2) Particularly suitable in jungle areas with high water tables.

(3) Burn-out head should not be used when air pollution regulations prohibit open fires.

(4) For a unit of 100 men, at least 8 are needed.

(5) A 55 gallon drum is placed into the ground, leaving enough of the drum above the ground for a comfortable sitting height.

(a) The drum may be cut in half, thus making two heads of less capacity.

(b) A wooden seat with a flyproof, self-closing lid is placed on top of the drum.

(6) The head is burned out daily by adding ufficient fuel to incinerate the fecal matter.

(a) Highly volitile fuel such as gasoline or JP4 should not be used because of its explosive nature.

(b) A mixture of 1 quart of gasoline to 5 quarts of diesel oil is effective but still it must be used with caution.

(7) If the drum must be moved to another site before it is burned out, handles should be welded to the sides of the drum to make it possible for two men to carry the drum with ease. Furthermore, it is convenient to have two sets of drums, one set for use while the other set is being burned clean. If the contents are not rendered dry and odorless by one burning, they should be burned again. Any remaining dry ash should be bruned.

(TP #9 ON)

d. Mound head

(1) May be used when The water level or a rock formation near the ground surface prevents the digging of a deep pit.

(2) A mound of earth with a top at least 6 feet wide and 12 feet long is formed so that a four-seat, flyproof box may be placed on top of it.

(3) The mound is made high enough to meet the pit's requirements for depth allowing 1 foot from the base of the pit to the water or rock level.

(4) Before the mound is built, the area where it is to be placed should be broken up or plowed in order to aid seepage of liquids from the pit.

(5) The mound is formed in approximately 1 foot layers. The surface of each layer is roughened before the next is added.

(6) When the desired mound height has been reached, the pit is dug into the mound.

(7) It may be necessary to brace the walls with wood, sandbags, or other suitable material to prevent cave-ins. The exact size of the base of the mound depends upon the type of soil; it should be made large enough to avoid a steep slope. It may be necessary to provide steps up the slope.

(8) An alternate method for constructing the mound head is to build the pit first on top of the ground, using lumber, logs, corrugated sheet metal, or other available material. The dirt is then piled around the pit and up to its brim, thus creating the mound.

(9) The mound head is seldom used because of the variety of disposal devices available.

TP #10 ON)

e. Bored hole head: The bored hole head is satisfactory for a small unit, however, the necessary mechanical equipment for boring the hole must be available.

(1) A hole about 18 inches in diameter and 15 to 20 feet deep is bored into the ground. The hole is then covered by a one seat box.

(2) If box is not available, a metal drum which has both ends removed is sunk into the ground over the hole, leaving about 18 inches of the drum above the ground surface. A flyproof, self-closing lid is then fitted securely on top of the drum.

(3) Bored hole head should be constructed on basis of eight per 100 men.

(TP #11 ON)

f. Pail head

(1) A pail head may be built when conditions (populated areas, rocky soil, marshes are such that a head of other types cannot be constructed.

(2) A standard type box may be converted for use as pail head by:

(a) Placing a hinged door on the rear of the box

(b) Adding a floor

(c) Placing a pail under each seat.

(3) If the box is located in a building, it should be fitted with an opening from outside the building.

(4) The seats and rear door should be self-closing and the entire box should be made flyproof.

(5) The floor of the box should be made of an impervious material (concrete, if possible) and should slope enough toward the rear to facilitate rapid drainage of water used for cleaning the box.

(6) A urinal may also be installed in the head enclosure with a drain pipe leading to a pail outside. This pail also should be enclosed in a flyproof box.

(7) The waste in pails may be disposed of by burning or by hauling to a suitable area and burying.

(8) The emptying and hauling of containers of waste must be closely supervised to prevent careless spillage.

(9) The use of plastic bag liners for pails reduces the risk of accidental spillage. The filled bags are tied at the top; then they are disposed of by burning or burial.

(TP #11 OFF)

TRANSITION: Now that we have covered the different types of head facilities, let's talk about urine disposal facilities.

5. Urine Disposal Facility - is any device which is primarily used for urine disposal.

a. Urine disposal facilities should be able to provide the following:

(1) Should be able to accommodate at least 5 percent of the command at one time. This means that five urinal pipes are needed for a unit of 100 men.

(2) When trough urinal pipes are used, 10 feet of length should be allowed for 100 men.

(3) When urinals are provided, one is required per 100 men.

b. Urinals should be drained either into a soakage pit or into a standard deep pit head if the urinals are constructed in conjunction with it. The urine may be drained into a deep pit head through a pipe, a hose, or a screened trough.

(1) If a soakage pit is to be used, it should be dug 4 feet square and 4 feet deep and filled with rocks, bricks, broken bottles, or similar rubble.

(2) It should be covered with tar paper, boards, or other suitable material and a layer of earth.

c. If the urine disposal facility is located some distance from the sleeping area, another urinal should be provided at a convenient location for use at night.

(TP #12 ON)

d. Urinal pipes-should be at least 1 inch in diameter and approximately 36 inches long.

(1) They are placed at each corner of the soakage pit and if needed, on two sides halfway between the corners.

(2) The pipes are inserted to a point 8 inches below the surface of the pit with the remaining 28 inches slanted outward above the surface.

(3) A funnel made of tar paper, sheet metal which has no rough edges, aluminum foil, plastic, or similar material is placed on the top of each pipe.

(TP #13 ON)

e. Urinal trough - about 10 feet long should be provided when material for its construction is more readily available than pipes.

(1) Trough is made of sheet metal or wood with eight V or U shaped ends.

(2) If the trough is made of wood, it is lined with heavy tar paper or metal.

(3) A splash board is inserted down the middle of the trough.

(4) The legs which are to support the trough are cut slightly shorter on one end. At this lower end a shallow trough or a pipe is attached to carry the urine from the urinal trough to the soakage pit or deep pit.

(TP #14 ON)

f. Urinoil

(1) In areas where the ground water level is not too high, that is more than 3 feet below the surface, the urinoil is an acceptable type of urine disposal facility.

(2) The urinoil is a 55 gallon drum designed to receive and trap urine and to dispose of it into a soakage pit. Urine voided through the screen onto the surface of the oil immediately sinks through the oil to the bottom of the drum.

(3) As urine is added, the level rises within 3 inch diameter pipe and overflows onto the 1 1/2 in diameters pipe through the notches cut in the top of this pipe. The oil acts as an effective seal against odors and against the entrance of flies. The screen on top of the oil is lifted by supporting hooks and cleaned of debris as necessary.

g. Urine Soakage Pit

(1) In order for a urine soakage pit to function properly, the troops must not urinate on the surface of the pit. The funnels or trough must be cleaned daily with soap and water and the funnels replaced as necessary.

(2) Oil and grease must never be poured into the pit, as they may clog it. When a urine soakage pit is to be abandoned or it becomes clogged, it should first be sprayed with a residual insecticide; then it must be mounded over with a 1 foot covering of compacted earth and marked.

(TP #14 OFF)

OPPORTUNITY FOR QUESTIONS (3 MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. What are the dimensions of a straddle trench?

A. 1 foot wide, 2 1/2 feet deep, 4 feet long.

b. How many urinal pipes are needed for a unit of 100 men?

A. 5

SUMMARY: During our third hour of instruction we have covered the different types of head and urine disposal facilities.

BREAK (10 MIN)

INTRODUCTORY TRANSITION: During the last hour, I will cover the disposal of liquid waste, garbage and rubbish.

BODY (27 MIN)

6. Liquid Waste

a. In the field, wash, bath, and liquid kitchen wastes are disposed of in the soil usually by means of either soakage pits or soakage trenches. In order for the soil to absorb these liquids, grease and soap, as well as any soil particles, must first be removed from them.

a. Soakage pits

(1) In a temporary camp the disposal of liquid waste may be disposed of by the use of a soakage pit.

(2) The size of the pit may vary but it should be at least 4 feet square and 4 feet deep. This normally will be adequate to dispose of liquid kitchen waste for 200 persons. If the troops are to remain in the camp for 2 weeks, two pits should be constructed - Each pit should be used on alternate days, thus lessening the possibility of clogging.

(3) All washing and bathing devices should be provided with soakage pits. These soakage pits are constructed in the same way as a urinal soakage pit except that the urinal pipes are omitted.

(4) A grease trap is provided for each pit, except those under showers.

(5) The area under field showers, as well as under drinking devices, should be excavated a few inches and then filled with small, smooth stones to keep the water from standing.

(6) Should a soakage pit become clogged, it is closed.

(a) Soakage pit is closed by covering it with 1 foot of compacted earth and marked.

(b) A new one is constructed.

(TP #15 ON)

c. Soakage trenches

(1) If the ground water level or rock formation exists close to the surface, soakage trenches instead of pits should be used. A soakage trench consists of a pit 2 feet square and 1 foot deep with a trench extending outward from each of its sides for a distance of 6 or more feet.

(2) Trenches are 1 foot wide and vary in depth from 1 foot at the central pit to 1 1/2 feet at the outer ends.

(3) The pit and trenches are filled with the same materials used in a soakage pit.

(4) Two such units should be built to dispose of liquid kitchen waste for every 200 persons, and each should be used on alternate days. One unit should be built for each washing device provided.

(5) A grease trap is provided for each soakage trench. A soakage trench is closed by covering it with 1 foot of compacted earth and marked.

(TP #16 ON)

c. Grease traps - all soakage pits and soakage trenches should be provided with grease traps. There are basically two types of grease traps.

(1) Baffle grease trap

(a) A baffle grease trap may be made from a drum or from a water-tight box.

(b) The drum or box is divided vertically into an entrance chamber and an exit chamber by attaching a wooden baffle.

(c) The baffle should be placed so that the entrance chamber will be approximately twice the size of the exit chamber.

(d) The baffle should hang to a point within 1 inch of the bottom.

(e) A strainer which may be made from a small perforated bow filled with straw, hay, or burlap is inserted into the lid above the entrance chamber.

(f) A pipe is inserted into the exit chamber about 3 to 6 inches below the top as an outlet to the soakage pit.

(g) This baffle grease trap is usually placed on the ground at the side of the soakage pit with the outlet pipe extending 1 foot beneath the surface at the center of the pit. If a grease trap is not water-tight, it must be placed partially under the ground.

(h) Before the grease trap is used, the chambers are filled with cool water. The waste liquid is poured through the strainer which retains any solids. As the warm liquid strikes the cool water, the grease rises to the surface of the entrance chamber; and the liquid runs under the baffle, filling the exit chamber when the liquid reaches the outlet pipe near the top of the exit chamber, it runs through this pipe into the soakage pit. Unless the grease trap is of sufficient capacity, the warm greasy liquid poured into the trap will heat the cool water in the trap, thus allowing the grease to remain uncongealed and to pass through the trap. The efficiency of this grease trap can be increased by constructing it with multiple baffles. Also, a series of traps may be used.

(i) The baffle grease trap must be properly maintained to prevent clogging of the soakage pit. The grease retained in the trap should be skimmed from the surface of the water daily or as often as required and either buried or burned. The entire trap should be emptied and thoroughly scrubbed with hot, soapy water as often as necessary.

(TP #17 ON)

(2) Barrel Filter Grease Trap.

(a) The barrel filter grease trap may be made from a 30 to 50 gallon barrel or drum which has the top removed and a number of large holes bored into the bottom.

(b) Eight inches of gravel or small stones are placed in the bottom and covered with 12 to 18 inches of ashes or sand.

(c) A piece of burlap is fastened to the top of the barrel to serve as a coarse filter.

(d) The trap may be placed directly on the soakage pit, or it may be placed on a platform with a trough leading to the pit.

(e) Every 2 days the grease trap should be emptied, washed, and refilled. The material removed should be buried. The burlap filter should be either washed or replaced every day.

(f) A pail strainer may be used instead of the burlap filter. It is made by boring holes in the bottom of an old metal pail or can and filling it with grass or straw. This strainer will remove coarse particles of food and a small part of the grease. It is placed on top of the barrel grease trap.

(TP #18 ON)

d. Evaporation Beds

(1) In places where clay soil prevents the use of standard soakage pits, evaporation beds may be used if the climate is hot and dry.

(2) Adequate number of 8 by 10 foot beds are constructed to allow 3 square feet of surface area per person per day for kitchen waste and 2 square feet per person per day for wash and bath wastes.

(3) The beds are spaced so that the wastes can be distributed to any one of the beds.

(4) In the construction of a bed, the top soil is first scraped to the edges, thus forming a small dike around it.

(5) The earth within the bed is spaded to a depth of 10 to 15 inches and raked into a series of rows, making the ridges approximately 6 inches above the depressions. These rows may be formed either lengthwise or crosswise as deemed desirable for best distribution of water.

(6) Rotation of beds

(a) One bed is flooded during the day with liquid waste to the top of the ridges, which is equivalent to an average depth of 3 inches over the bed; then the liquid waste is allowed to evaporate and percolate.

(b) After 3 or 4 days this bed is usually sufficiently dry for respading and reforming. The other beds are flooded on successive days and the same sequence of events is followed.

(c) Careful attention must be given to proper rotation, maintenance, and dosage of evaporation beds. It is also essential that the kitchen waste be run through an efficient grease trap before it is allowed to enter the evaporation beds. If these beds are used properly, they create no insect hazard and only a slight odor. Other modifications of waste disposal methods are possible and should be used when they are more adaptable to the particular situation.

(TP #18 OFF)

e. Garbage disposal

(1) Garbageis solid or semi-solid waste resulting from the preparation, cooking, and serving of food. Garbage is disposed of by burial or incineration.

(2) Burial

(a) When troops are on the march, in bivouac, or in camps for less than 1 week duration, garbage is disposed of by burial in pits or trenches.

(b) These pits or trenches should not be over 30 yards from the mess area.

(c) Garbage pits must not be located closer than 100 feet to any source of water used for cooking or drinking.

(d) Pits are preferred for burying garbage during overnight halts.

(e) A pit 4 feet square and 4 feet deep is suitable for 1 day for a unit of 100 men.

(f) At the end of the day or at such time as the pit is filled to 1 foot below the ground surface, it should be sprayed with insecticide; then it must be filled with earth, mounded over with an additional foot of compacted earth, and marked.

(g) The continuous trench is more adaptable for stays of 2 days or more.

(h) The trench is first dug about 2 feet wide, 3 to 4 feet deep, and long enough to accommodate the garbage for the first day.

(i) As in the pit method, the trench is filled to not more than 1 foot from the top. The trench is extended as required, and the excavated dirt is used to cover and mound the garbage already deposited. This procedure is repeated daily or as often as garbage is dumped. It is a very efficient field expedient for depositing of garbage.

(3) Incineration.

(a) In temporary camps of over 1 week, the garbage is often burned in open incinerators. Excellent types of open incinerators may be constructed from materials which are readily available in any camp area.

(b) Since incinerators will not handle wet garbage, it is necessary to separate the liquid from the solid portion. This is done by straining the garbage with a coarse strainer such as an old bucket, salvaged can, or 55 gallon drum in which holes have been punched in the bottom.

1 The solids remaining in the strainer are incinerated.

2 The liquids are poured through a grease trap into a soakage pit or trench.

(c) Field incinerators should be located at least 50 yards downwind from the camp to prevent their being an odor nuisance.

(d) The inclined plane incinerator will dispose of the garbage of an entire battalion, evacuation hospital, or other unit of similar size.

(TP #19 ON)

(e) The inclined plane incinerator can easily be protected from rain or wind. Time and skill, however, are required in building it.

(f) The construction of the inclined plane incinerator begins by inserting a sheet metal plane through telescoped 55 gallon drums from which the ends have been removed.

(g) The metal plane should extend approximately 2 feet beyond the upper end of the telescoped drums to serve as a loading or stoking platform.

(h) The telescoped drums are positioned on an inclined surface.

(i) A grate is placed at the lower end of the telescoped drums.

(j) A wood or fuel oil fire is provided under the grate.

(k) After the incinerator becomes hot, drained garbage is placed on the stoking platform. As the garbage becomes dry, it is pushed through the telescoped drums in small amounts to burn.

(l) Dig a fire pit at the bottom of an incline, line it with rocks, and place a grate over it.

(m) Place three telescoped drums in a shallow trench up the incline, letting the lower end of the telescoped drums extend somewhat over the fire pit so the flame will be drawn up the drums.

(n) If a sheet metal plane is available, is should be used as it permits more thorough drying of the garbage.

(TP #19 OFF)

f. Rubbish Disposal

(1) In temporary camps or bivouac, all rubbish usually is buried in pits or in trenches with the garbage. If this is done, flatten the tin cans and break down boxes before they are added to the rubbish.

(2) In camps where the length of stay is over 1 week, the combustible rubbish is usually burned in a barrel incinerator. The noncombustible rubbish is either buried or hauled to a suitable disposal site.

(3) Should the unit be located near an ocean or on an island, rubbish, as well as garbage, may be disposed of by having it hauled out to sea and dumped.

(TP #20 ON)

g. Barrel incinerator

(1) A barrel incinerator is made from a 55 gallon drum by cutting out both ends, punching many holes near the bottom, and inserting grates inside the barrel several inches above the holes.

(2) The barrel is supported several inches above the ground on stones, bricks, or dirt filled cans thus allowing space to build a fire under the barrel.

(3) The rubbish is put into the barrel on the top grate.

(TP #20 OFF)

OPPORTUNITY FOR QUESTIONS (3 MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. What methods of waste disposal are most commonly used in the field?

A. Burial and burning

b. When do you use an evaporation bed?

A. Where clay soil prevents the use of standard soakage pits?

SUMMARY: During this fourth hour of instruction we have covered disposal of liquid wastes, and disposal of garbage and rubbish.

PROGRESS TEST (20 MIN)

BREAK (10 MIN)

DEMONSTRATION (50 MIN)

1. The instructor will take the students to mock up area.

2. Students will proceed through area, with the instructor explaining each type of head facility.

BREAK (10 MIN)

LIST OF SUPPORTING PAPERS

1. ADVANCE SHEET/STUDENT OUTLINE
2. TP# Field Sanitation
3. TP# Commanding Officer
4. TP# Medical Officer
5. TP# Medical Department
6. TP# Straddle Trench Head With Hand Washing Device
7. TP# Straddle Trench
8. TP# Deep Pit Head
9. TP# Burn Out Head
10. TP# Mound Head
11. TP# Bored Hole Head
12. TP# Pail Head
13. TP# Urinal Pipe With Soakage Pit
14. TP# Urinal Trough
15. TP# Urinoil
16. TP# Soakage Trenches
17. TP# Barrel Grease Trap
18. TP# Barrel Grease Trap
19. TP# Evaporation Beds
20. TP# Inclined Plane Incinerator
21. TP# Barrel Incinerator
22. PROGRESS TEST

UNITED STATES MARINE CORPS
Utilities Instruction Company
Marine Corps Engineer School
Marine Corps Base
Camp Lejeune, North Carolina

U-10E02
SEP 1984
(D-540) esw

DETAILED OUTLINE

FIELD BATH UNIT

INTRODUCTION (5 MIN)

1. GAIN ATTENTION: When you're working outdoors, especially in dirt or muddy area, there is nothing that you want to do better at the end of the day than take a nice hot shower and in some cases, go into town and party. A field bath unit provides such luxury for the troops in the field and at the same time is a good morale booster. It's going to be your job as a hygiene equipment operator to provide such showers using a field bath unit.

2. PURPOSE: The purpose of this period of instruction is to provide you with the knowledge and skill necessary to set up and operate a field bathing facility.

3. INTRODUCE LEARNING OBJECTIVES

a. TERMINAL LEARNING OBJECTIVE(S): Tasked to set up a field bathing facility and provide with a Field Bath Unit, fuel, and water supply, operate the unit in accordance with TM-00848D-15, chapter 2. (1.5.1)

b. ENABLING LEARNING OBJECTIVE(S): Provide with a Field Bath Unit, fuel, and water supply.

(1) Point out each major component of the unit. (1.5.1b

(2) Install the unit. (1.5.1c)

(3) Perform before operation maintenance on the unit. (1.5.1a)

(4) Start the unit. (1.5.1d)

(5) Adjust the unit. (1.5.1e)

(6) Shut the unit down. (1.5.1f)

(7) Perform after operation maintenance on the unit. (1.5.1h)

in accordance with TM-00848D-15, chapter 2.

c. I will do this by lecture, demonstration, and practical application.

b. There will be a performance test at the end of the class.

TRANSITION: Now that we know what this class is all about and what is expected, lets begin with the description of the unit.

BODY (40 MIN)

1. General Description NOTE: Refer to SR-UT P02, pp. 4-1 thru 4-23 for full details.

a. Model - EC8B-64 and EC8B-79

b. Portable field bath unit

c. Liquid fuel fired

d. Will deliver approximately 1 1/2 gal. per min. of 102° F water to each of its 24 shower nozzles on an attached shower stand assembly.

e. The unit is trailer mounted, and is equipped with:

(1) Trailer lights.

(2) Hydraulic air brakes.

(3) Mechanical hand brake

f. The unit is capable of processing approximately 400 men per hour.

TRANSITION: The next thing which I am going to discuss is the different components which make up the field bath unit.

2. Components and theory of operation (POINT OUT EACH COMPONENT)

a. Water system (ON TP#1)

(1) The water pump picks up the water from the source through a 1 1/2" suction hose which is connected to the suction port on the pump. The water is then discharged through the water pump outlet through the pump discharge valve into the bottom of the boiler.

(2) The water pressure is registered on the pressure gauge located directly above the water pump discharge valve.

(3) The water pump is directly coupled to the engine by a shaft and roller chain coupling.

(OFF TP#1)

b. Boiler (ON TP#2)

(1) Boiler is of fire tube construction with four passes of flue gases. These gases are forced through the fire tubes by the blower.

(2) The combustion chamber is the first pass of flue gas. This is where the highest concentration of heat is generated.

(3) The second, third and fourth passes take place when the flue gases travel through a predetermined path through the fire tubes, which provides maximum heat to the water within the boiler.

(4) Both the front head and the rear head of the boiler are lined with heat resisting refractory material which aids in retaining the heat.

(OFF TP#2)

c. Burner fuel system (ON TP#3)

(1) The burner fuel is stored in two 25 gallon tanks located within the fenders on each side of the bath unit.

(2) The following fuels may be used.

(a) Diesel

(b) Number 1, 2, and 3 US fuel oil (No. 1 and 2 in extremely cold weather.)

(c) Lubricated kerosene - (add 1 cup of lubricating oil to each gallon of kerosene. Note: Use diesel fuel when possible. Avoid gasoline when possible.)

(3) The fuel pump draws the fuel from the fuel storage tanks through fuel suction lines which are located on the bottom of each tank. Each fuel suction line has it's own shutoff valve.

NOTE: These valves may be used to draw fuel out of each tank separately if desired thus preventing syphoning action when the unit is shut down. These fuel suction lines are connected to the fuel strainer on the fuel system.

(4) The fuel strainer removes foreign materials from the fuel by passing the fuel through a double layer of fine screen mesh. Removing these materials from the fuel will protect the fuel pump, fuel pressure regulator, and burner from wear due to solid sediment in the fuel.

(5) The fuel pump draws the fuel from the fuel storage tanks through the fuel suction lines and suction shut off valves, through the fuel strainer to the fuel pump. The fuel pump, then pumps the fuel to the fuel pressure regulator.

(6) The fuel pressure regulator maintains proper fuel pressure at the burners. The fuel pressure is regulated by an adjusting set screw. This adjusting set screw when adjusted properly will maintain (148 psi. for the EC8B-79 and 100 psi. for all other models) the regulator allows the proper amount of fuel to pass through the fuel pressure gauge to the main fuel burner valve.

(7) The main fuel valve is nothing more than a control valve that allows the fuel to enter the main fuel line when this valve is open. Once the fuel goes through the main fuel control valve it will flow to either:

(a) The main fuel line which carries the fuel to the burner.

(b) The other fuel line leads through the water temperature regulator to the two side burner valves. (Most commonly known as secondary valves.) These side burner valves are used mostly in cold weather. The water temperature regulator meters the fuel to these valves.

(8) The water temperature regulator controls the temperature of the water by regulating the amount of fuel being supplied to the two side burner valves. This is accomplished by the water temperature regulator which is equipped with a thermastatic bulb. When heat is applied, the liquid turns to gas which expands and travels through the capillary tube. The gas transmits a pressure equivalent to the temperature of the water, thus regulating the amount of fuel to the side burner valves. This pressure controls the piston valve by causing the piston to open or close the fuel supply to the two side burner valves. From the two side burner valves the fuel flows to the burner fuel nozzles

(OFF TP#3)

(ON TP#4)

(9) The fuel being supplied to the fuel nozzles is under pressure (148 psi. on the EC8B-79 and at 100 psi. on the EC8B-64 model bath unit). This high velocity of fuel insures that the fuel is atomized as the fuel leaves the burner nozzle tips and insures efficient and complete combustion. The three burner nozzles are rated at:

(a) All shower units main nozzle rated at 5 GPH.

(b) EC8B-79 two secondary nozzles rated at 1.35 GPH.

(c) On all other models, the secondary nozzles are rated at 2.0 GPH.

(10) The fuel is ignited by a continuous spark from the magneto.

(a) The electrodes are connected by an ignition cable to the magneto distributor rotor which provides a continuous spark when the engine is operating and the electrode gaps are properly set.

(b) Spark plug gap between electrode points should be gapped at 1/8 inch between the tips.

(c) Electrode tips should be adjusted to be 3/16 inch forward and 3/16 inch above the center of the nozzles tips.

(d) The nozzle tips should be 17/32 inch from the face of the diffuser plate.

(OFF TP#4)

(ON TP#5)

d. Blower: Once the fuel is ignited, the combustion chamber must be provided with an adequate supply of air for proper combustion. The needed air is provided by the blower. The blower is driven by a v-belt and pully arrangement off the engine. The blower supplies the air for combustion and also forces the hot air through the boiler fire tubes, The blower has a manually operated damper at the blower inlet which regulates the amount of air which must be in proportion to the amount of fuel being burned.

(OFF TP#5)

(ON TP#6)

e. Engine

(1) Wisconsin engine

(2) Single cylinder

(3) Four cycle

(4) Air cooled

(5) Gasoline operated

(6) EC8B-64 6.5 H.P.

(7) EC8B-79 7 H.P.

(8) EC8B-64 maximum speed 3300 rpm's

(9) EC8B-79 maximum speed 3600 rpm's

(OFF TP#6)

OPPORTUNITY FOR QUESTIONS (5 MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. What is the operating fuel pressure for the EC8B-79?

A. 148 psi.

b. What is the main fuel nozzle rated at?

A. 5 GPH.

SUMMARY: During this first hour I have pointed out the major components of the bath unit.

BREAK: (10 MIN)

INTRODUCTORY TRANSITION: During the last period of instruction, I covered the components of the bath unit, but in order for you to become more knowledgeable about the unit you must know how to set it up and run it. In order for you to learn how to do this, I will cover how to:

1. Install the unit.

2. Perform before operation maintenance on the unit.

3. Start the unit.

4. Adjust the unit.

5. Shut the unit down.

BODY (45 MIN)

3. Install the unit (1.5.1c)

a. Location: the bath unit should be located as close to the camp as possible and at the same time close to the water source as possible.

b. Water Source: Naval regulations state that we must use disinfected water for showers. However, ground or surface water can be used if it's approved by the medical officer.

(ON TP#7)

c. Drainage: Position the unit and dig a drainage ditch around it so that the waste water cannot drain back into the supply suction inlet.

d. Shower stand:

(1) Set up shower stands

(2) Shower stands should be shielded from the wind by cheese cloth or canvas. The best shield to use is a GP tent. Showers should be shielded from view when the camp contains both sexes.

(3) Duck boards should be used when possible to prevent troops from standing in the mud during shower time.

(OFF TP#7)

e. Dressing Room: During cold weather or when both sexes are present in the camp, a dressing area should be set up by the showers. The best thing to use is a GP tent. Tent stoves may be installed in them during cold weather.

f. Install 1 1/2" suction hose from suction outlet on the water pump to the water source.

NOTE: A 1 1/2" discharge hose may be installed to the boiler drain valve to facilitate draining of the boiler.

NOTE: Make sure that all hoses have rubber washers and that all connections are air tight.

TRANSITION: Now that I have covered how to properly install the unit, let's discuss how to perform before operation maintenance of the unit.

4. Perform before operation maintenance of the unit (1.5.1d)

a. Pre-operation checks

(1) Inspect all parts of the unit for damage, dents or corrosion.

(2) Water system

(a) Install water pump and boiler drain plugs.

(b) Close water pump discharge valve.

(c) Prime water pump.

(d) Open water pump discharge valve.

(e) Open boiler petcock.

(f) Open shower shutoff valve (at least one).

(g) Close boiler drain valve.

(ON TP#8)

(3) Engine fuel system

(a) Check engine fuel tank to make sure the tank is full, and that an adequate supply is available.

(b) Open fuel sediment bowl needle valve under the fuel tank.

(4) Engine

(a) Check engine crankcase oil

1. If oil low fill it to the proper level.

2. If oil is contaminated, it should be changed with one quart of the following types of oil.

3. Types of oils that may be used.

a. 40°-120° USE OE-30.

b. 5°-40° USE OE-20.

c. 20°-5° USE OE-10.

4. Oil is checked daily before and after operation.

5. Change after every 50 hours of operation.

(b) Carburetor air cleaner

1. Type of oil - same as crankcase.

2. Check daily - before and after operation.

3. Change as required (1/4 pt.).

(OFF TP#8)

(c) Blower shaft bearings

1. Grease fittings are located on bearing pillow blocks at both the pully end and the damper end of the blower shaft.

2. Lubricate daily with GAA grease, and after every 8 hours of operation.

(d) Water pump shaft bearings - Lubricate weekly with GAA grease.

(e) Roller chain coupling - Lubricate weekly with a few squirts of oil.

(f) Monthly lubrication points

(1) Trailer spring shackle pins.

(2) Trailer caster wheels.

(3) Trailer caster mounting bracket.

(4) Parking brake cable.

(5) Burner fuel system

(a) Make sure burner fuel tanks are full and that an adequate reserve supply is available.

(b) Open the suction and return valves located on the bottom of the unit.

(c) Close main fuel valve.

(d) Crack open one of the secondary fuel valves.

(e) Close damper.

TRANSITION: The unit is now ready for operation, which brings us to the next step.

5. Start the unit: (1.5.1e) (Refer to SR-UT-P02 PP.4-6 for details)

a. The high speed needle valve should be opened 1 1/4 turns from closed position.

b. Close choke.

c. Set throttle 1/4 speed.

d. Wind starting rope clockwise on sheave.

e. Pull starting rope (HARD).

f. If engine fails to start repeat steps a. to e.

g. Let engine idle at low speed for about 5 minutes. This will allow the engine to warm up gradually.

h. After 5 minutes increase engine speed to full throttle.

TRANSITION: Not that the engine is operating, let us move on to the operating adjustments.

6. Adjust the unit: (1.5.1f)

a. Once the boiler is full, there will be a steady stream of water shooting out of the boiler petcock. At this time close boiler petcock.

b. Check water pressure to insure that the unit pump is providing the needed pressure.

(1) If both shower valves are open the pressure should read 25-30 psi.

(2) If one shower valve is open the pressure should read 30-35 psi.

(3) Adjust water pressure by increasing or decreasing the engine rpms.

NOTE: Temperatures of the water may be raised by closing the pump discharge valve until the flow is down to a minimum flow out of the shower heads.

c. Check fuel pressure gauge for correct pressure reading. The EC8B-79 model should register 148 psi and all other models 100 psi. If the gauge reads above or below the proper reading, remove the cap on the pressure regulator, keep the engine running at full throttle and adjust the pressure regulator by turning the adjusting screw with a screwdriver of an allen wrench. Turn the screw counterclockwise to decrease pressure and clockwise to increase pressure.

d. Close damper on the blower by means of the control lever.

e. Lighting the boiler - the following procedures are for lighting the boiler in the automatic mode.

(1) Open the main burner fuel valve partially or approximately 1/4 of a turn and at the same time slightly open the damper by the damper control to allow an adequate supply of air to aid combustion. Combustion occurs when the fuel oil is ignited by a continuous spark between the electrodes.

(2) Once ignition has been accomplished adjust the damper control lever until a gray haze is emitted from the exhaust stack. Now the unit is in full operation.

TRANSITION: Now that we know how to operate the field bath unit. Let us discuss shutting the unit down.

7. Shut the unit down: (1.5.1g)

a. Normal shut down procedure. If the field bath unit is to be used again within a 48 hour period when ambient temperatures is above freezing the following procedures must be adhered to.

(1) Extinguish boiler.

(2) Close the secondary and main fuel valves.

(3) Open the damper fully.

(4) Allow engine to operate at full throttle for 2 to 3 minutes in order to purge the combustion chamber.

b. Stopping the engine.

(1) Once purging of the combustion chamber has been completed reduce the engine speed to an idle for at least 5 minutes to allow the engine to cool down.

(2) If magneto switch is of pressure type, merely push the switch up, this will shut down the engine.

(3) If the magneto is equipped with a toggle switch, push switch to the rear to shut down the engine.

OPPORTUNITY FOR QUESTIONS: (5 MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. What types of oil are used in the engine crankcase for an ambient temperature of 30° F?

A. OE 20.

b. What is the setting of the high speed needle valve?

A. 1 1/4 turn from the closed position.

c. What is the operating water pressure for 24 shower nozzles?

A. 25-30 psi.

d. What is the first step in lighting the boiler in the automatic mode?

A. Open main fuel valve partially or approximately 1/4 of a turn and at the same time open damper control enough to allow an adequate supply of air to aid combustion.

SUMMARY: During the last hour we covered the installation, before operation maintenance, starting the unit, adjusting the unit, and shutting the unit down.

BREAK (10 MIN)

INTRODUCTORY TRANSITION: During the next period of instruction I will cover the short and long shut down of the field bath unit and perform after operation maintenance on the unit.

BODY (35 MIN)

8. Types of shut down

a. Once a normal shut down of the bath unit has been completed the unit will be put into a short or a long shut down.

b. Short shut down - if the bath unit is to be used again within 48 hours when the ambient temperature is above freezing the following procedures will apply.

(1) Perform normal shut down.

(2) Close fuel suction and return valves.

(3) Close water pump discharge valve.

(4) Close gasoline tank sediment bowl valve.

NOTE: Upon completion of a short shut down, the operator should perform after operation maintenance on the unit (Will be covered after long shut down).

c. The unit will be placed in a long shutdown for any of the following conditions:

(1) When securing for transport.

(2) When the unit will not be operated for an extended period of time.

(3) When temperatures drop below 40° F.

(4) Long shut down includes the following:

(a) Normal and short shut down and:

(b) Open water pump discharge valve.

(c) Drain boiler by opening drain valve.

(d) Remove water pump drain plug.

(e) Break loose one or two unions during freezing conditions.

(f) Disconnect and drain suction hoses.

TRANSITION: Once the bath unit has been placed in a short or long shut down the ability to perform operation maintenance on the unit is a must in order that the unit is ready for the next operation.

9. Perform after operation maintenance on the unit (1.5.1h)

   a. Daily services must be done to the unit.

   b. Engine - Check engine oil, if low add, if contaminated change.

   c. Fuel system

      (1) Fill gasoline tank.

      (2) Fill diesel tanks.

      (3) Check for fuel leaks, make repairs as soon as practical.

   d. Lubricate unit in accordance with Lube Order.

   e. Visually inspect the unit.

      (1) Check for damaged or broken parts.

      (2) Check for loose or missing nuts and bolts.

   f. Clean the unit.

      (1) Insure that the engine compartment is free of grease and oil.

      (2) Clean the unit with only approved solvents.

<u>OPPORTUNITY FOR QUESTIONS</u> (5 MIN)

1. <u>QUESTIONS FROM THE CLASS</u>

2. <u>QUESTIONS TO THE CLASS</u>

   a. What are three types of shut down?

      A. Normal, short and long shut down.

   b. What must be done to the field bath unit during freezing weather?

      A. Drain all the water out the unit.

<u>SUMMARY</u>: During the last hour I covered the types of shut down and how to perform after operation maintenance of the unit.

<u>PROGRESS TEST</u>: (10 MIN)

<u>BREAK</u> (10 MIN)

DEMONSTRATION (The class will be taken to the bath unit area. The instructor will do the following. The unit will be set up beforehand)

1. Point out each major component of the unit.

2. Explain the installation procedure.

3. Perform before operation maintenance on the unit.

   a. inspect the unit for damage, bend or corrosion and missing parts.

   b. Water system - explain what has to be done to this system.

   c. Engine fuel system - explain what has to be done.

   d. Engine

      (1) Check oil

      (2) Check air cleaner oil

   c. Lubrication - explain areas which must be lubricated.

      (1) Blower shaft bearing

      (2) Water shaft pump bearing

   d. Burner fuel system - Point out location

4. Start the unit - Instructor will explain starting procedure:

   a. Set high speed needle valve

   b. Close choke

   c. Set the unit

   d. Allow engine to warm up.

   e. Increase speed to full throttle.

5. Adjust the unit - Instructor will explain the adjustments to be performed.

   a. When boiler is full close petcock.

   b. Increase or decrease engine speed in order to obtain correct water pressure.

(1) 25-30 psi for 24 shower heads.

(2) 30-35 psi for 12 shower heads.

c. Check fuel pressure that it registers at:

(1) 148 psi for EC8B-79 model.

(2) 100 psi for all other models.

d. Close damper.

6. Lighting of the boiler - Instructor will explain the:

a. Automatic mode.

b. Manual mode.

c. Once the fuel ignites - adjust damper to obtain a gray haze from the exhaust stack.

7. Shut the unit down - The instructor will explain the:

a. Normal shut down.

b. Short shut down.

c. Long shut down.

PRACTICAL APPLICATION (HOURS)

Upon conclusion of the demonstration the class will be divided into two groups and will be assigned to one of the two units. The primary and assistant instructor will observe each student as they actually put the unit into full operation. The students not actually operating the unit will observe and study the handouts.

OPPORTUNITY FOR QUESTIONS

1. QUESTIONS FROM THE CLASS: All questions will be answered on an individual basis throughout the practical application.

2. QUESTIONS TO THE CLASS: No questions are required after the practical application phase.

SUMMARY: During this period of instruction, you were provided with the knowledge and skill to install, operate, and perform maintenance on the bath unit.

Hopefully, the information that was presented to you today will stay with you throughout your career. By correctly operating the bath unit, you will not only provide a great morale booster, but also a personal hygiene factor for the troops in the field.

BREAK (10 MIN)

LIST OF SUPPORTING PAPERS

TP#1 Water System

TP#2 Boiler

TP#3 Burner Fuel System

TP#4 Oil Burner Assembly

TP#5 Blower

TP#6 Engine

TP#7 Shower Unit

TP#8 Engine Fuel System

SR-UT-P02 Field Water Supply and Water Purification Equipment

Advance Sheet/ Student Outline

UNITED STATES MARINE CORPS
Utilities Instruction Company
Marine Corps Engineer School
Marine Corps Base
Camp Lejeune, North Carolina

U-10E02
SEP 1984
(D-262) esw

ADVANCE SHEET/STUDENT OUTLINE

FIELD BATH UNIT

PURPOSE: To provide you with the knowledge and skills necessary to set up and operate a field bathing facility.

TERMINAL LEARNING OBJECTIVE(S):

Tasked to set up a field bathing facility and provide with a Field Bath Unit, fuel, and water supply, operate the unit in accordance with TM-00848D-15, chapter 2. (1.5.1)

ENABLING LEARNING OBJECTIVE(S):

Provide with Field Bath Unit, fuel and water supply:

1. Point out each major component of the unit. (1.5.1b)
2. Install the unit. (1.5.1c)
3. Perform before operation maintenance on the unit. (1.5.1d)
4. Start the unit. (1.5.1e)
5. Adjust the unit. (1.5.1f)
6. Shut the unit down. (1.5.1g)
7. Perform after operation maintenance on the unit. (1.5.1h)

in accordance with TM-00848D-15, chapter 2.

STUDENT REFERENCE(S): TM-00848E-15/1

ASSIGNMENT: Read SR-UT-P02, chapter 4 P 4-1 through 4-23

OUTLINE

1. General Description

   a. Model

b. Portable

c. Liquid fuel fired

d. Will deliver approximately 1 1/2 gal. per min. of 102° F water to each shower nozzles.

e. Trailer mounted

f. Capable of processing 400 men per hour.

2. Components and theory of operation

a. Water system

(1) Water pump picks up water from source.

(2) Water pressure registered on pressure gauge.

(3) Water pump directly coupled to engine.

b. Boiler

(1) Fire tube construction with four passes of flue gases.

(2) Combustion chamber is first pass

(3) Second, third and fourth passes when gases travel through fire tubes.

(4) Front head and rear head of boiler lined

c. Burner fuel system

(1) Two 25 gallon tanks

(2) Following fuels may be used.

(a) Diesel

(b) Number 1, 2, and 3 US fuel oil

(c) Lubricated kerosene

(3) Fuel pump draws fuel from fuel storage tanks.

(4) Fuel strainer removes foreign materials.

(5) Fuel pump pumps fuel to fuel pressure regulator.

(6) Fuel pressure regulator maintains proper fuel pressure at burners.

(7) Main fuel valve allows fuel to enter main fuel line.

(8) Water temperature regulator controls temperature of water by regulating fuel.

(9) Fuel is under pressure.

(10) Fuel ignited by magneto.

(a) Electrodes connected to magneto distributor rotor

(b) Spark plug gap 1/8 inch

(c) Electrode tips 3/16 inch forward and above center of nozzles tips.

(d) Nozzle tips 17/32 inch from face of diffuser plate.

d. Blower supplies air for combustion.

e. Engine

(1) Wisconsin engine

(2) Single cylinder

(3) Four cycle

(4) Air cooled

(5) Gasoline operated

(6) EC8B-64 6.5 H.P.

(7) EC8B-79 7 H.P.

(8) EC8B-64 maximum speed 3300 rpm's

(9) EC8B-79 maximum speed 3600 rpm's

3. Install unit

a. Location: close to camp and close to water source.

b. Water Source: ground or surface water if approved by medical officer.

c. Drainage:

d. Shower stand:

(1) Set up shower stands

(2) Shower stands should be shielded.

(3) Duck boards should be used.

e. Dressing room:

f. Install suction hose

4. Perform before operation maintenance of the unit.

a. Pre-operation checks

(1) Inspect all parts for damage, dents or corrosion.

(2) Water system

(a) Install water pump and boiler drain plugs.

(b) Close water pump discharge valve.

(c) Prime water pump.

(d) Open water pump discharge valve.

(e) Open boiler petcock.

(f) Open shower shutoff valve.

(g) Close boiler drain valve.

(3) Engine fuel system

(a) Check engine fuel tank.

(b) Open fuel sediment bowl needle valve.

(4) Engine

(a) Check engine crankcase oil.

1. If low fill.

2. If contaminated, change.

3. Types of oils.

a. 40°-120° USE OE-30.

b. 5°-40° USE OE-20.

c. 20°-5° USE OE-10.

4. Oil checked daily

5. Change every 50 hours

(b) Carburetor air cleaner

1. Oil - same as crankcase.

2. Check daily

3. Change as required

(c) Blower shaft bearings

1. Grease fittings

2. Lubricate daily and every 8 hours.

(d) Water pump shaft bearings

(e) Roller chain coupling

(f) Monthly lubrication points

(1) Trailer spring shackle pins.

(2) Trailer caster wheels.

(3) Trailer caster mounting bracket.

(4) Parking brake cable.

(5) Burner fuel system

(a) Burner fuel tanks full

(b) Open suction and return valves.

(c) Close main fuel valve.

(d) Crack open one secondary fuel valves.

(e) Close damper.

5. Start the unit:

a. High speed needle valve opened 1 1/4 turns.

b. Close choke.

c. Set throttle 1/4 speed.

d. Wind starting rope clockwise.

e. Pull starting rope.

f. If engine fails to start repeat steps.

g. Let engine idle to warm up.

h. After 5 minutes increase engine speed to full throttle.

6. Adjust the unit:

   a. Once boiler is full close boiler petcock.

   b. Check water pressure.

   c. Check fuel pressure gauge.

   d. Close damper on blower.

   e. Lighting the boiler.

      (1) Open main burner fuel valve partially and slightly open damper

      (2) Once ignition has been accomplished adjust the damper control

7. Shut the unit down:

   a. Normal shut down procedure.

      (1) Extinguish boiler.

(2) Close secondary and main fuel valves.

(3) Open damper fully.

(4) Allow engine to operate at full throttle for 2 to 3 minutes.

b. Stop the engine.

(1) Reduce engine speed to idle for at least 5 minutes.

(2) If magneto switch is of pressure type, push the switch up.

(3) If the magneto is equipped with a toggle switch push switch to rear.

8. Types of shut down

a. Once normal shut down has been completed put into short or long shut down.

b. Short Shut down if unit is to be used again within 48 hours.

(1) Perform normal shut down.

(2) Close fuel suction and return valves.

(3) Close water pump discharge valve.

(4) Close gasoline tank sediment bowl valve.

c. Placed in long shutdown for any of the following conditions:

(1) When securing for transport.

(2) When not operated for extended period.

(3) When temperatures drop below 40° F.

(4) Long shut down

(a) Normal and short shut down

(b) Open water pump discharge valve.

(c) Drain boiler

(d) Remove water pump drain plug.

(e) Break loose one or two unions.

(f) Disconnect and drain suction hoses.

9. Perform after operation maintenance on the unit.

a. Daily services

b. Engine

c. Fuel system

d. Lubricate unit

e. Visually inspect

f. Clean the unit.

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JAN 1985
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DETAILED OUTLINE

DELOUSING UNIT

INTRODUCTION (3 MIN)

1. GAIN ATTENTION: As Marines we all go to the field and at times our clothing and bodies become infected by all types of insects. Ticks and red bugs are fairly easy to remove from your clothing and bodies, but lice (body, head, and crab) and their eggs are more difficult to remove. Lice also carry typhus fever, relapsing fever, and trench fever. How would you kill these disease producing insects?

2. PURPOSE: To familiarize the student with the operation of the Delousing Unit.

3. INTRODUCE LEARNING OBJECTIVE(S)

a. Learning objectives are neither specified nor measured during this lesson.

b. I will do this by lecture, demonstration, and practical application.

TRANSITION: Before we can operate a delousing unit, we must know the nomenclature of the unit.

BODY (42 MIN)

1. NOMENCLATURE OF A DELOUSING UNIT

(TP #1 ON)

a. The delousing unit is a portable self contained unit mounted on a tubular steel frame.

b. It is powered by a one cylinder gasoline engine that is connected to the air compressor by means of a flexible coupling.

c. The total weight of the unit is 260 pounds.

d. Ten dusting guns for dispensing dusting agents are connected to the air manifold by hose assemblies.

(TP #1 OFF)

TRANSITION: Now that we have a description of the unit, let's cover the engine.

(TP #2 ON)

2. ENGINE

a. The engine is manufactured by Kohler.

b. Model: K161P.

c. Type: 4-cycle, air-cooled.

d. Rated: 4.7 hp at 3,600 RPM.

e. Fuel tank: 1 gallon.

f. Fuel strainer is located in the sediment bowl.

g. The unit is started by a pull rope.

h. Air cleaner holds 5/32 qt of oil.

i. Magneto gap on points is 0.015 in.

j. Spark plug gap is 0.030 in.

TRANSITION: Let's now cover the lubrication of the delousing unit.

3. LUBRICATION OF THE DELOUSING UNIT

a. Crankcase

(1) Fill and check level daily.

(2) Change engine oil every 50 hours of operation. The unit holds one quart of oil.

(3) When the temperature is above 30°F use OE 30 wt.

(4) When the temperature is from 30°F to 10°F use OE 10 wt.

(TP #2 OFF)

(5) When the temperature is 0°F to -65°F use OES 10.

(TP #3 ON)

b. Air Cleaner

(1) Fill oil reservoir to level mark.

(2) Clean daily.

(3) Holds 5/32 qt.

(TP #3 OFF)
(TP #4 ON)

c. Fuel Tank

(1) Add fuel as required.

(2) Clean strainer inside tank whenever necessary.

(TP #4 OFF)
(TP #5 ON)

d. Fuel Strainer (sediment bowl)

(1) Clean sediment bowl screen when necessary.

(2) Tighten thumb nut if gasket is leaking.

e. Oil Can Points. Lubricate control linkages and all exposed adjusting threads.

f. Spark Plug

(1) Replace when/if it has a cracked insulator or burned electrode tip.

(2) Clean and set spark plug for 0.030 inch.

(3) Replace lead wire if frayed or broken.

(4) Clean and tighten loose connections.

g. Magneto

(1) Replace pitted or burned magneto points.

(2) Proper point gap adjustment is 0.015 inch.

(3) Check adjustment every 500 hours.

(TP #5 OFF)
(TP #6 ON)

h. Idle Adjustment Screw. Turn screw 3/4 to 1-1/4 turns open.

(TP #6 OFF)

i. High Speed Needle Valve. Turn screw 1-1/2 to 2 turns open.

(TP #2 ON)

j. Compressor Blower Screen: Remove and clean with approved cleaning solvent and dry thoroughly with compressed air.

k. Compressor Air Cleaner: Clean whenever necessary with compressed air.

l. Engine Shroud Screen: Clean with compressed air.

(OFF TP #2)

TRANSITION: Now that we have covered the nomenclature and lubrication points of the unit, we can get into starting the unit.

4. STARTING PROCEDURES

a. Open the compressor relief cock.

b. Open the fuel shutoff valve.

c. Set the governor control lever three notches back from the maximum position.

d. Close the choke.

e. Pull down the magneto stop switch.

f. Wrap starting rope around sheave and pull with a hard steady pull.

g. Open the choke until engine warms up.

h. Set governor speed to 2200 RPMS which would be full throttle.

i. Connect the guns and hose assemblies to the ten connectors.

j. Fill the dusting guns with the proper dusting agent and secure the dusting cans to the guns.

k. When the air pressure gauge reads 25 psi, delousing operation can be started.

TRANSITION: Now that we know the operation of the delousing unit, let's learn the operation of the unit under unusual conditions.

5. OPERATION UNDER UNUSUAL CONDITIONS

a. Operation in extreme cold (below 0°F).

(1) Remove snow and ice from fuel tank cap prior to filling the tank and keep the tank full at all times.

(2) Keep fuel tank cap tight to prevent moisture and dirt from entering the tank.

(3) Service the fuel strainer more frequently than during normal conditions.

(4) Remove ice and snow from the spark plug, magneto, and cable and keep it clean and free of moisture.

(5) Lubricate the delousing outfit in accordance with required type oil and service the air cleaner more frequently.

b. Operation in extreme heat.

(1) Efficient cooling, adequate ventilation, and lubrication are of vital importance.

(2) Check the flywheel shroud, cylinder crankcase, air compressor fins, and blower scroll screen for insufficient ventilation of the engine and air compressor.

c. Operation in dusty or sandy areas.

(1) Service the air cleaner frequently and replace oil in bowl when it becomes dirty. Remove the two compressor air cleaners and blow out the dirt and dust, replacing when necessary. Also keep the compressor blower scroll screen clean and free of clogging.

(2) Provide adequate protection to keep sand and dirt from entering the fuel system and service the fuel strainer as often as necessary.

(3) Keep the flywheel shroud, cylinder crankcase, compressor fins, and blower scroll screen free from dust and dirt.

(4) Lubricate the delousing outfit in accordance with the required type of oil.

d. Operation under rainy or humid conditions.

(1) When the unit is not operating, place a canvas or other waterproof covering over the unit. Do not use the unit in the rain unless it is protected by a tarpaulin. Dry unit before operating.

(2) Spark plugs, magneto, and cable should be checked often because of high humidity. Defective parts should be replaced.

e. Operation in salt water areas.

(1) Salt water causes a strong corrosive action on metal. Care must be taken to avoid direct contact with salt water. Wash down the unit with clean fresh water at frequent intervals, taking care not to contaminate the fuel system or damage the ignition system with water.

(2) Remove any rust immediately and paint exposed surfaces.

f. Operation at high altitudes.

(1) The air compressor air output in cubic feet per minute and pounds per square inch will gradually decrease as operating altitude above sea level increases. For each 1,000 feet of altitude above sea level, there will be a reduction in horsepower of 3 percent.

(2) Should the air compressor cfm decrease because of high altitudes, increase engine speed by advancing the governor control linkage.

(3) Service the two air compressor air cleaners as necessary.

(4) Open the needle valves slightly more than normal, and readjust to normal running position after engine is started.

(5) Lubricate as required.

TRANSITION: Now that we know the operation of the unit under abnormal conditions, let's go into the shutdown procedures.

6. SHUTDOWN PROCEDURES

a. Idle the engine down to the minimum for 3 to 5 minutes by using the governor control.

b. Push up on the magneto stop switch.

c. Close the fuel shutoff cock.

d. Disconnect the guns and hose assemblies.

e. Check the unit for any damage that might have occurred during operation.

f. Check all lubrication.

OPPORTUNITY FOR QUESTIONS (5 MIN)

1. QUESTIONS FROM THE CLASS

2. QUESTIONS TO THE CLASS

a. At what setting do you set the high speed needle valve?

A. 1-1/2 to 2 turns to open.

b. What is the gap setting for the spark plug?

A. 0.030 inch.

SUMMARY: During this period of instruction we covered the nomenclature, lubrication, starting procedures, how to operate under any type of weather or terrain, and finally how to shut the unit down.

BREAK (10 MIN)

CONTROLLED PRACTICAL APPLICATION (50 MIN)

1. The instructor will move the class to Camp Sweat for a demonstration on the unit.

2. After the demonstration the class will be broken down into two teams. Each team will use their notes and references to put the unit into operation.

BREAK (10 MIN)

LIST OF SUPPORTING PAPERS

1. Advance Sheet/Student Outline

2. Transparencies

   1 - Nomenclature

   2 - Air Compressor

   3 - Air Cleaner

   4 - Fuel Tank

   5 - Magneto

   6 - Idle Adjustment

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Camp Lejeune, North Carolina 28542

U-10E07
Nov 1983
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STUDENT OUTLINE

INTRODUCTION TO FIELD LAUNDRY OPERATIONS

PURPOSE: To familiarize the student with the duties and responsibilities of personnel in laundry operations.

NOTE: Learning objectives are neither specified nor measured during this lesson.

OUTLINE:

1. MISSION OF A LAUNDRY SECTION

2. PERSONNEL AND THEIR DUTIES IN A LAUNDRY SECTION

a. Laundry Foreman

b. Assistant Laundry Foreman

c. Dryer Operator

d. Laundry Equipment Repairman

e. Washer Operator

f. Laundry Clerk

g. Laundry Workers

3. WORK FLOW OF A LAUNDRY SECTION

a. Supported unit

b. Laundry personnel at the receiving area

c. Soiled laundry

d. Production estimates

e. Laundry is washed

f. Transferred to drying tumbler

g. Dry laundry dilivered to the shipping area

h. At the shipping area

i. When operating in conjunction with a bath and clothing exchange facililty

4. OPERATOR'S MAINTENANCE IS DONE IN THREE PHASES

a. Before Operation Maintenance

b. During Operation Maintenance

(1) Observe and listen

(2) Continuous job

c. Post or After Operation Maintenance

(1) After shut down

(2) Basically as before operation

5. THE FORMULAS FOR THE FIELD LAUNDRY UNIT

a. Formula I

(1) To launder clothing and decontaminate cotton

(2) Sea water can be used

(3) A bleaching agent

b. Formula II

(1) To launder woolen items

(2) To reduce shrinkage and strain on the items

c. Formula III

(1) To launder cotton items used in hospitals

(2) Sea water can be used

(3) A bleaching agent

d. Formula IV

(1) To launder outer clothing

(2) If the garments show poor water repellency

(3) Water repellent garments never starched

e. Formula V

(1) For mothproofing woolen items

(2) After washing

(3) Dry

f. Formula VI

(1) To decontaminate clothing

(2) For woolen clothing

(3) Recommended organic chelating agent

(4) When hard water is used

(5) Substituted for organic chelating agents

g. Formula VII

(1) To launder and decontaminate unimpregnated cotton and woolen items

(2) Detergent and super tropical bleach mix

(3) Cotton and woolen items

h. Formula VIII

(1) To launder durable press garments

(2) Two-thirds capacity

6. <u>DISPOSING OF WASTE WATER</u>

a. Drainage Ditch

b. Ocean

c. Report location to higher headquarters

7. <u>PROTECTIVE CLOTHING</u>

a. Chemically Protective Outfit

b. Mask and Hood

c. Rubber Gloves

8. BULK LAUNDRY

a. Consists of

b. When supporting a hospital

c. At clothing exchange facility

d. In support of a clothing and textile maintenance facility

9. ORGANIZATIONAL LAUNDRY

a. Consists of

b. Differs from bulk laundry

c. Differs from individual laundry

10. INDIVIDUAL LAUNDRY

a. Corresponds to commercial practices

b. Deals directly with individual

c. Pin system of identification is used

d. Specific mission assigned to the laundry section

11. LAUNDRY FORMS

a. Laundry Schedule

(1) Done by the NCOIC

(2) Consists of

b. DA Form 3136 (Roster and Statement)

(1) Used with bundle laundry

(2) Used by receiving clerk for accountability

(3) Kept and maintained by laundry section

c. DA Form 1974 (Laundry List) Medical Treatment Facility and Organization

(1) Used for accountability

(2) DA Form 1974

(3) Form must show

(4) Ordered through regular supply system

d. DA Form 2886 (Individual Laundry List)

(1) Used by individual

(2) Maintained at laundry section

(3) Done in triplicate

12. RECEIVING LAUNDRY TURN-INS

a. What unit

b. Turn-in scheduled

c. Type of laundry turn-in

(1) Individual

(2) Organizational

(3) Bulk

d. Check forms accompanying laundry

e. Make a count

f. Count individual pieces of organizational laundry

g. Sign a receipt

h. Return one signed copy to unit representative

13. CLASSIFYING LAUNDRY TURN-INS

a. Prepare the laundry area

b. Organizational laundry

c. Bulk laundry

d. Individual laundry

e. Mark (pin) individual turn-ins

f. Pin individual turn-ins

(1) Identify each piece

(2) Pin mark according to

(a) Utility jacket

(b) Utility trousers

(c) Utility cover

(d) Socks

(e) Undershirts

(f) Underdrawers

(g) Laundry bags

14. CHEMICALS

a. Water

b. XXCC3 Impregnate

c. Detergent Type II

d. Kerosene

15. PREPARATION OF CLOTHING

a. Clean and dry

b. Unbuttoned, unfolded and pockets turned out

c. Separate into two groups

d. Reimpregnate outer garments separately

e. One washer load consist

16. PREPARATION OF THE REIMPREGNATION SOLUTION

a. General

(1) Temperature

(2) Stirring

(3) Waste water

(4) Protective clothing

b. Procedure

17. LAUNDERING AND REIMPREGNATING

a. Formula

(1) Formula used

(2) Do not pour prepared batch of XXCC3 into washer until temperature has reached

(3) Slosh warm water around and pour into washer

(4) Run the washer

(5) Garmets removed when

b. Cleaning

c. Storing and Packaging Reimpregnated Clothing

18. M-2 IMPREGNATE TEST KIT

a. Used to determine if the clothing contains sufficient impregnate

b. Test portions of clothing where impregnate is subject to rapid deterioration

c. Test procedure

(1) Prepare the kit

(2) Test clothing items

(3) Safety and workmanship

(a) Wear respirator

(b) Mark all containers

(c) Store in well ventilated dry room

(d) Read instructions entirely

(e) Clothes unbuttoned, unfolded and pockets turned out

(f) Allow the clothes to cool before packing

(g) Firefighting equipment

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STUDENT HANDOUT #2

FIELD WASHING FORMULAS

UNIT OF INSTRUCTION: Field Laundry Washing Formulas

FORMULAS

All formulas in this handout are for use with the single trailer laundry unit. Water level, time, and temperature of the laundry operation for the single trailer laundry unit are shown in each formula. The detergents in each formula are effective in both soft and hard water.

a. Formula I

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	8	5	100/38	Detergent, type I, 6 oz
Suds	8	5	130/55	Detergent, type I, 4 oz
Suds	8	5	140/60	Detergent, type I, 2 oz
Rinse	12	2	140/60	....
Rinse	12	2	120/49	....
Rinse	12	2	100/38	Sour, 2 oz

b. Formula II

Formula II is used to launder woolen items such as blankets, winter uniforms, winter underwear, and socks. To reduce shrinkage and strain on the items, the washer should be fully loaded and stopped during filling and draining. Also, the tumbler should be fully loaded.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	12	5	90/32	Detergent, type II, 6 oz
Suds	12	5	90/32	Detergent, type II, 4 oz
Rinse	12	2	90/32	....
Rinse	12	2	90/32	....
Rinse	12	2	90/32	Sour, 2 oz

c. Formula III

Formula III is used to launder cotton items used in hospitals. When the supply of fresh water is low, seawater can be used if type II detergent is used in twice the amount shown for each suds operation. Fresh water should be used for the last two rinses. A bleaching agent should be used when white clothing or bedding is laundered.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	8	5	100/38	Detergent, type I, 6 oz
Suds	8	5	130/55	Detergent, type I, 4 oz
Suds	8	5	140/60	Detergent, type I, 2 oz
Rinse	12	2	160/71	....
Rinse	12	2	140/60	....
Rinse	12	2	110/43	Sour, 1 oz

d. Formula IV

Formula IV is used to make outer clothing, such as field wear and raincoats, water-repellant. Soiled garments sometimes lose repellancy. If the garments show poor water-repellancy after they are laundered and dried they should be treated again. Water-repellant-treated garments must never be starched.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	8	5	100/38	Detergent, type I, 6 oz
Suds	8	5	130/55	Detergent, type I, 4 oz
Rinse	12	2	140/60	....
Rinse	12	2	140/60	....
Rinse	12	2	120/49	....
Rinse	12	2	120/49	....
Water-repellant treatment	1 1/2	10	100/38	Compound, water-repellant, textile-finish, type I aqueous, 3 pints

e. Formula V

Formula V is used for mothproofing woolen items before they are stored for the summer or returned to stock. After washing the clothing put it in the extractor for 4 minutes. Then dry the clothing at not more than 140° F/60° C.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	12	5	100/38	Detergent, type II, 6 oz
Suds	12	5	100/38	Detergent, type II, 3 oz
Rinse	12	3	100/38	....
Rinse	12	3	100/38	....
Rinse	12	3	100/38	Insecticide,DDT,1 1/2 pt

f. Formula VI

Formula VI is used to decontaminate clothing that has been radioactively contaminated above the maximum tolerance level. For woolen clothing, the formula must be changed to use type II powder detergent with water temperature not more than 100° F/38° C. Also, the washer-extractor cylinder must be fully loaded and stopped during filling and draining. For white clothing or bedding, a bleaching agent should be used. A recommended organic chelating agent is tetrasodium salt of enthylene diamine tetraacetic acid which is available commercially as Versene, Nullapon, or Sequestrene S.T. When hard water is used, the amount of chelate should be increased at the rate of 1 ounce cheltate per 83 grains of water hardness. An equal weight of sodium hexametaphosphate or sodium tetraphosphate may be substituted for the organic chelating agent.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	9	5	90/32	Detergent. type I, 6 oz
Acid	12	5	140/60	Citric acid crystals, 4 lb
Acid	12	5	140/60	Citric acid crystals, 2 lb
Chelate	12	5	140/60	Chelating agent. 1 lb. dry weight
Chelate	12	5	140/60	Chelating agent, 1 lb. dry weight
Rinse	12	3	140/60	....
Rinse	12	3	120/49	....
Sour	12	5	tap water	Laundry sour, 1 1/2 oz (use equal parts of sodium silicoflouride and sodium acid flouride)

g. Formula VII

Formula VII is used to launder and decontaminate unimpregnated cotton and woolen items that have been chemically or biologically contaminated. Detergent and super tropical bleach (NSN 6850-00-264-8942) must be mixed together in water before they are put in the washer. Cotton and woolen items must not be put in the same wash load. When items such as belts, webbing, canteen covers, and pack carriers are washed, the time of the first suds should be increased to 15 minutes.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	12	5	90/32	Detergent, type II, 6 oz; decontaminating agent; super tropical bleach (STB), 2.5lb
Suds	12	5	90/32	Detergent, type II, 4 oz
Rinse	12	2	90/32	....
Rinse	12	2	90/32	....
Rinse	12	2	90/32	Sour, 2 oz

h. Formula VIII

Formula VIII is used to launder durable press garments. Be sure the washer is loaded to only two-thirds of its capacity.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	12	5	140/60	Detergent, type II, 8 oz
Suds	12	5	125/52	Detergent, type II, 4 oz
Rinse	12	3	110/43	....
Rinse	12	3	100/38	....
Rinse	12	3	100/38	....

i. Formula XI

Launder and reimpregnating formula: This formula is used for laundering and reimpregnating chemical protective clothing outfit.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	11	3	90/32	Detergent, type II, 6 oz
Suds	11	3	90/32	Detergent, type II, 3 oz
Rinse	11	3	90/32	....
Rinse	11	3	90/32	....
Reimpregnation	11	10	120/49	6lbs XXCC3 - prepared as a slurry

NOTE: In the last operation, do not pour the prepared batch of XXCC3 into the washer until after the water at 120°F has been put into the washer. Slosh about a gallon of warm water around in the can to loosen the remaining XXCC3 slurry, and pour this into the washer. It is important to get as much of the XXCC3 into the washer as possible. Run the washer for 10 minutes, extract for one minute and dry. The garments are to be removed from the dryer when warm to the touch.

j. Formula X

Delicate garments.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies per 100 lbs. clothing (1)
Suds	12-15"	5	120°F	5 ozs. Detergent laundry Type II (2)
				8 ozs. Sodium Metasilicate (3)
Suds	12-15"	10	120°F	3 ozs. Detergent Laundry Type II
				6 ozs. Sodium Metasilicate
Rinse	12-15"	3	120°F	Water
Rinse	12-15"	3	100°F	Water
Sour	12-15"	5	95°F	Sour to pH 5.0 (4)

(1) The washer should be about 2/3 the rated capacity of the washer.

(2) Detergent Laundry Federal Specification P-D-245, FSN 7930-99-1221.

(3) Sodium Metasilicate Federal Specification O-S-604, FSN 6810-281-2054.

(4) 2-3 ozs. Sodium Silico Fluoride, Federal Specification P-S-683, Sour Laundry, FSN 7930-291-8321.

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OPERATION AND OPERATORS MAINTENANCE OF FIELD LAUNDRY SYSTEM

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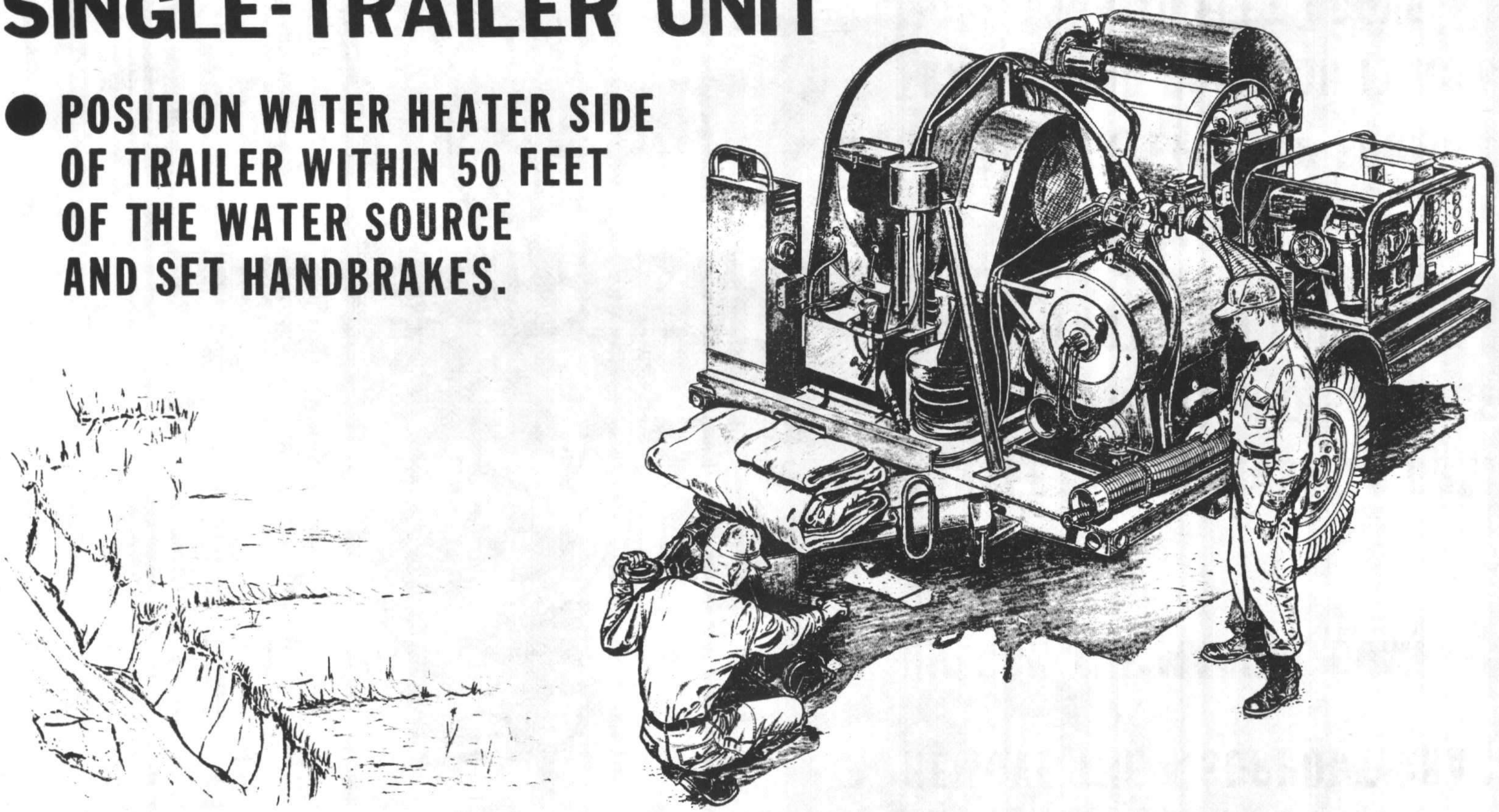
MARINE CORPS ENGINEER SCHOOL
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

LAUNDRY OPERATION SETUP

SINGLE-TRAILER UNIT

- POSITION WATER HEATER SIDE OF TRAILER WITHIN 50 FEET OF THE WATER SOURCE AND SET HANDBRAKES.

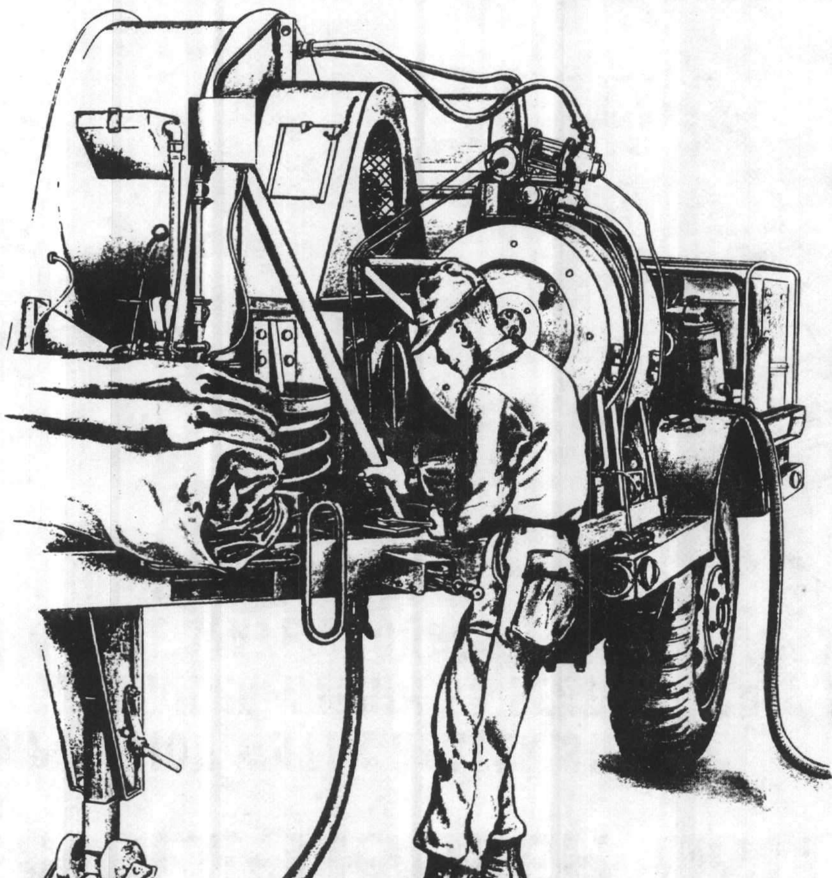


- LOWER TRAILER SUPPORT AND REAR STABILIZING JACK.
- REMOVE TRAILER TARPAULIN AND LEVEL THE UNIT

(REMOVE ALL PAPER, TAPE, AND PRESERVATIVE FROM NEW UNITS.)

LAUNDRY OPERATION SETUP

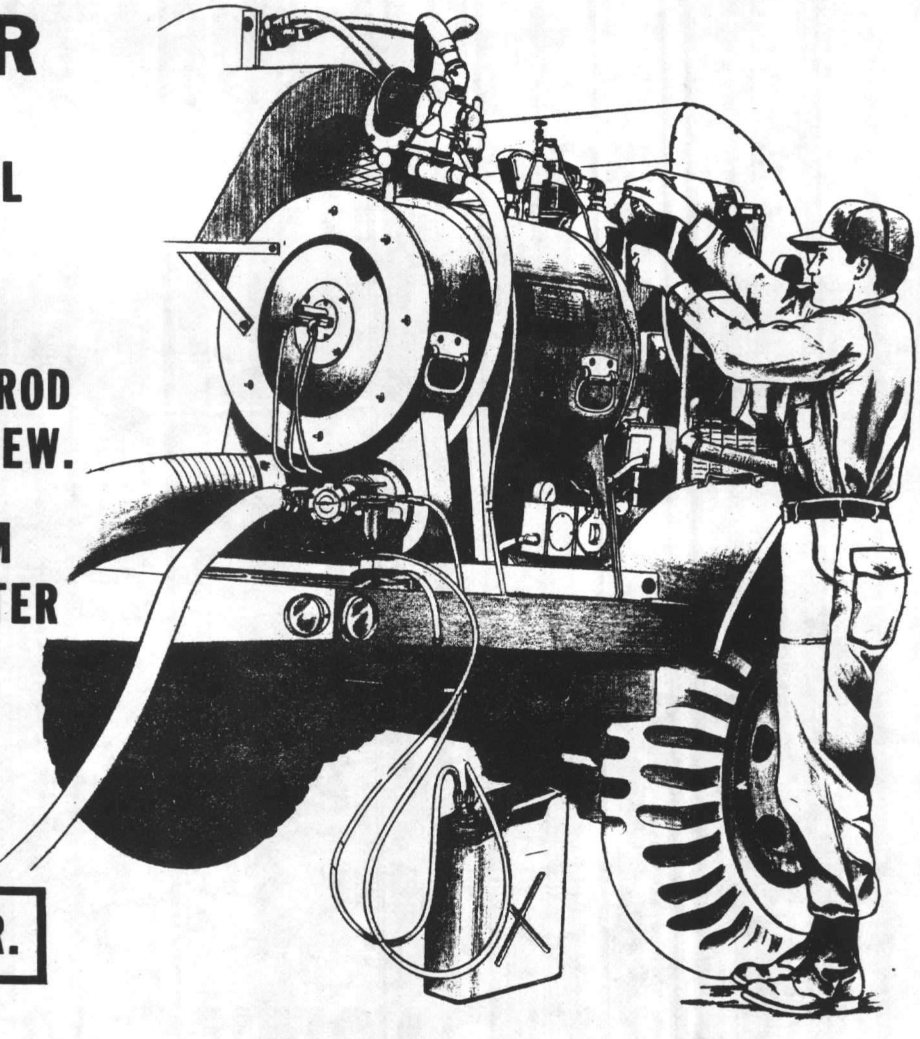
WASHER-EXTRACTOR



- REMOVE THE 4 SUPPORT BRACES.
- UNLOCK THE MANUAL DUMP VALVE LEVER.
- CONNECT DRAIN HOSE TO DRAIN PAN AND POSITION DISCHARGE END DOWNSTREAM FROM THE SUCTION HOSE.
- REMOVE WATER PUMP FROM TRAILER AND POSITION IT NOT MORE THAN 10 FEET ABOVE WATER SOURCE.

LAUNDRY OPERATION SETUP

WATER HEATER



- CLOSE WATER HEATER FUEL AND VENT VALVES.
- RELEASE AND RAISE LOW WATER FLOAT HOLDDOWN ROD AND SECURE WITH SETSCREW.
- CONNECT FUEL LINES FROM FUEL SUPPLY TO FUEL FILTER AND TO FUEL PUMP.
- CONNECT 7'' DUCT TO EXHAUST PORT.

VENT EXHAUST TO OPEN AIR.

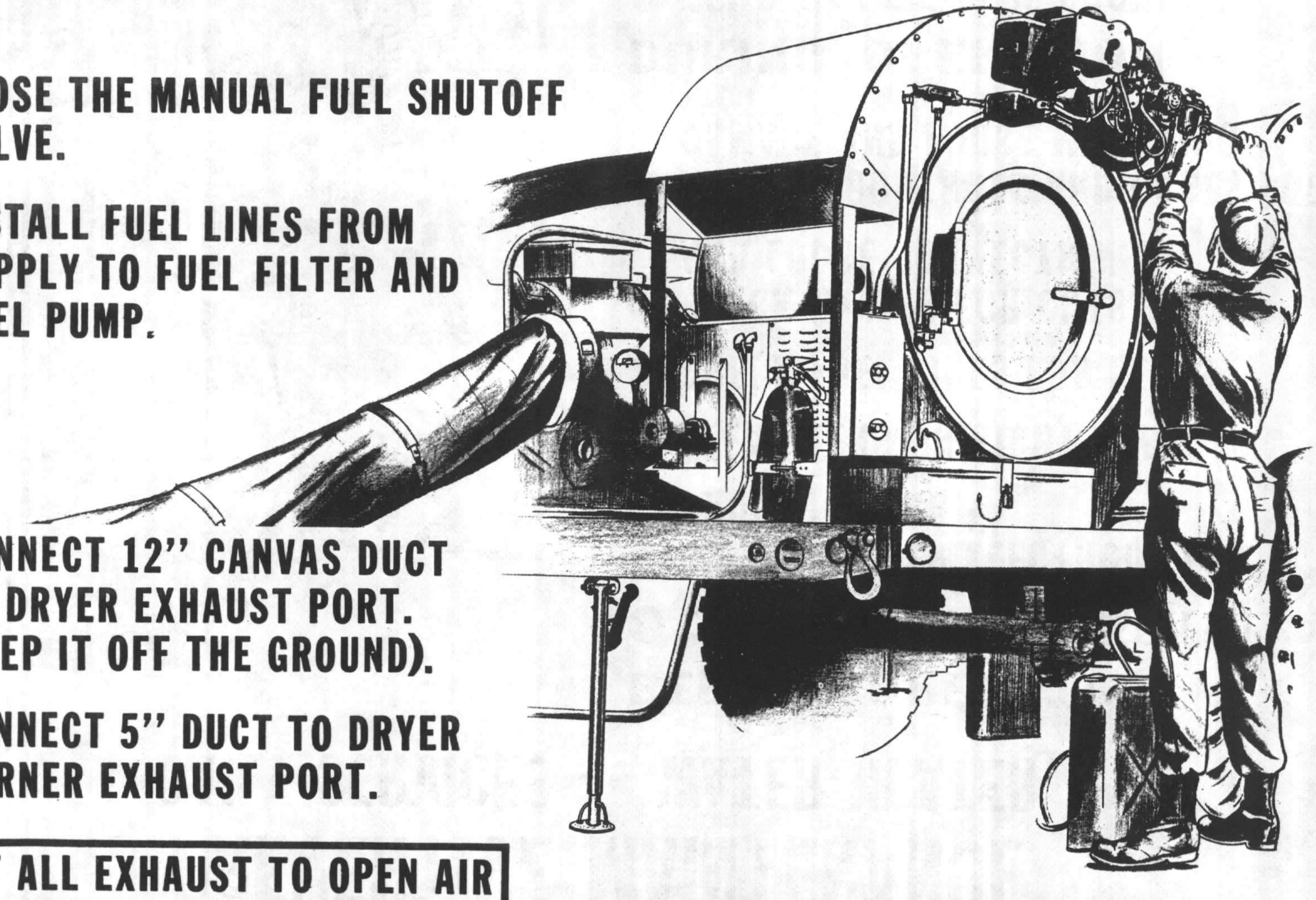
LAUNDRY OPERATION SETUP

WATER PUMP

- CONNECT SUCTION HOSE TO WATER PUMP INLET.
- INSTALL STRAINER TO END OF HOSE AND ELEVATE IT OFF OF STREAM BED.
- CONNECT INLET HOSE FROM WATER PUMP OUTLET TO WATER HEATER INLET.
- CONNECT POWER CABLE TO WATER PUMP POWER RECEPTACLE AND TO PUMP SERVICE OUTLET.

LAUNDRY OPERATION SETUP

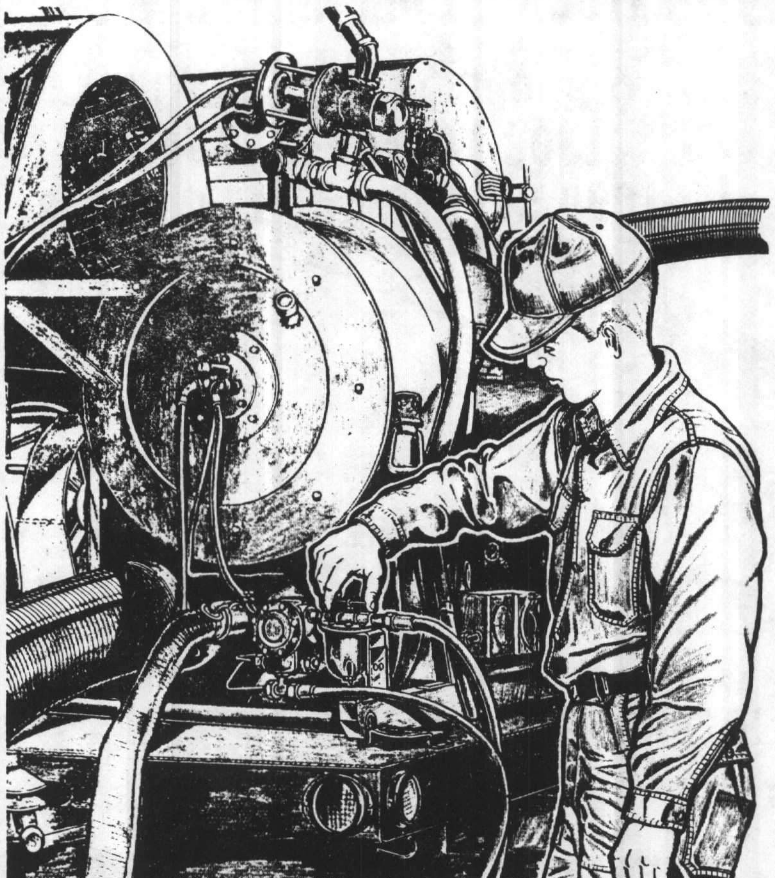
DRYER-TUMBLER



- CLOSE THE MANUAL FUEL SHUTOFF VALVE.
- INSTALL FUEL LINES FROM SUPPLY TO FUEL FILTER AND FUEL PUMP.
- CONNECT 12" CANVAS DUCT TO DRYER EXHAUST PORT. (KEEP IT OFF THE GROUND).
- CONNECT 5" DUCT TO DRYER BURNER EXHAUST PORT.

VENT ALL EXHAUST TO OPEN AIR

PREVENTIVE MAINTENANCE
DAILY SERVICES -- WATER HEATER



LUBRICATE IN ACCORDANCE WITH CURRENT LUBRICATION ORDER.

BEFORE OPERATION

- CLEAN FUEL FILTER (WEEKLY).
- CHECK BURNER ELECTRODE FOR PROPER SPARK.
- CLEAN LENS ON SIGHT TUBE.
- CHECK FUEL LINES FOR LEAKS.
- CHECK WIRING FOR CUTS, FRAYS, AND LOOSE CONNECTIONS.
- INSPECT CONTROLS AND GAGES FOR DAMAGE AND LOOSE MOUNTING.

DURING OPERATION

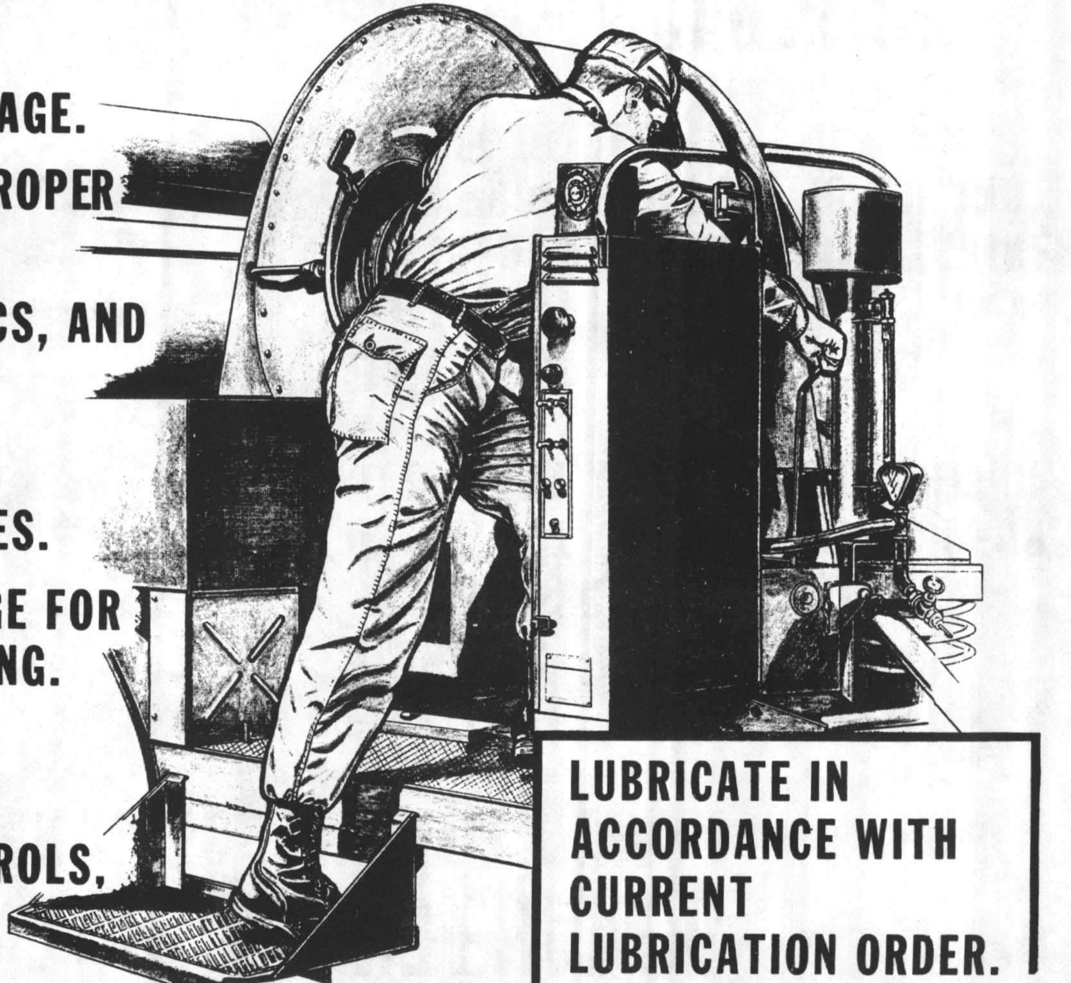
- TEMPERATURE GAGE SHOULD READ 95° TO 160° F.
- FUEL PRESSURE GAGE SHOULD READ 60 P.S.I. TO 100 P.S.I.

PREVENTIVE MAINTENANCE

DAILY SERVICES -- WASHER-EXTRACTOR

BEFORE OPERATION

- INSPECT CYLINDER FOR DAMAGE.
- CHECK DRAIN VALVES FOR PROPER OPERATION.
- CLEAN SHEAVES, BRAKE DISCS, AND SHOES.
- CHECK BELT TENSION.
- CHECK WIRING AND AIR HOSES.
- INSPECT CONTROLS AND GAGE FOR DAMAGE AND LOOSE MOUNTING.



DURING OPERATION

- CHECK DRAIN VALVES, CONTROLS, AND INSTRUMENTS FOR PROPER OPERATION.

LUBRICATE IN ACCORDANCE WITH CURRENT LUBRICATION ORDER.

PREVENTIVE MAINTENANCE
DAILY SERVICES -- WATER PUMP

BEFORE OPERATION

- INSPECT AND CLEAN STRAINER (WEEKLY).
- INSPECT CONTROL SWITCH FOR DAMAGE AND LOOSE MOUNTING.

BEFORE & DURING OPERATION

- INSURE THAT SUCTION STRAINER IS PROPERLY POSITIONED AND FREE OF DEBRIS.

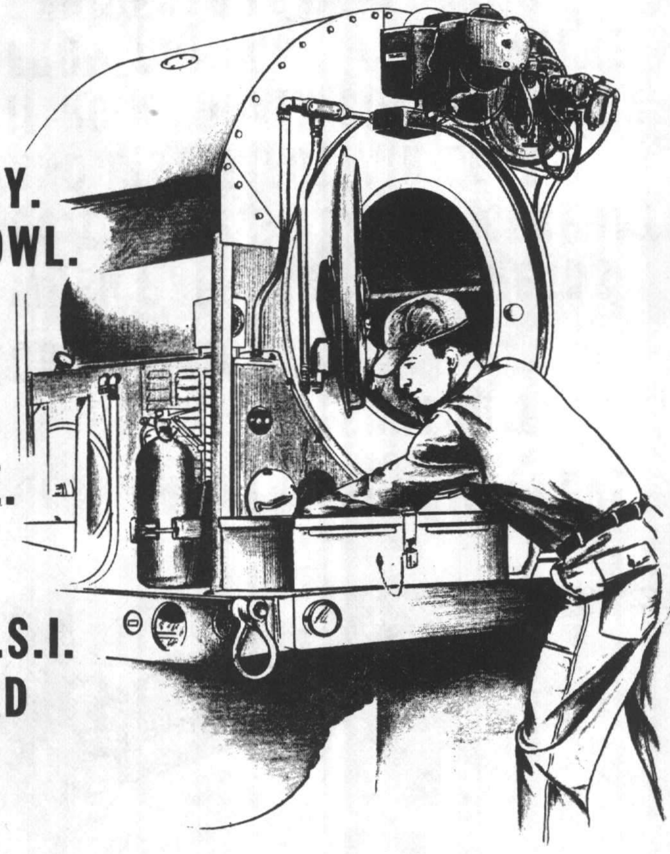
DURING OPERATION

- OBSERVE FOR LEAKS, UNUSUAL NOISE, OR VIBRATION.

LUBRICATE IN ACCORDANCE WITH CURRENT LUBRICATION ORDER.

PREVENTIVE MAINTENANCE

DAILY SERVICES -- DRYER-TUMBLER



BEFORE OPERATION

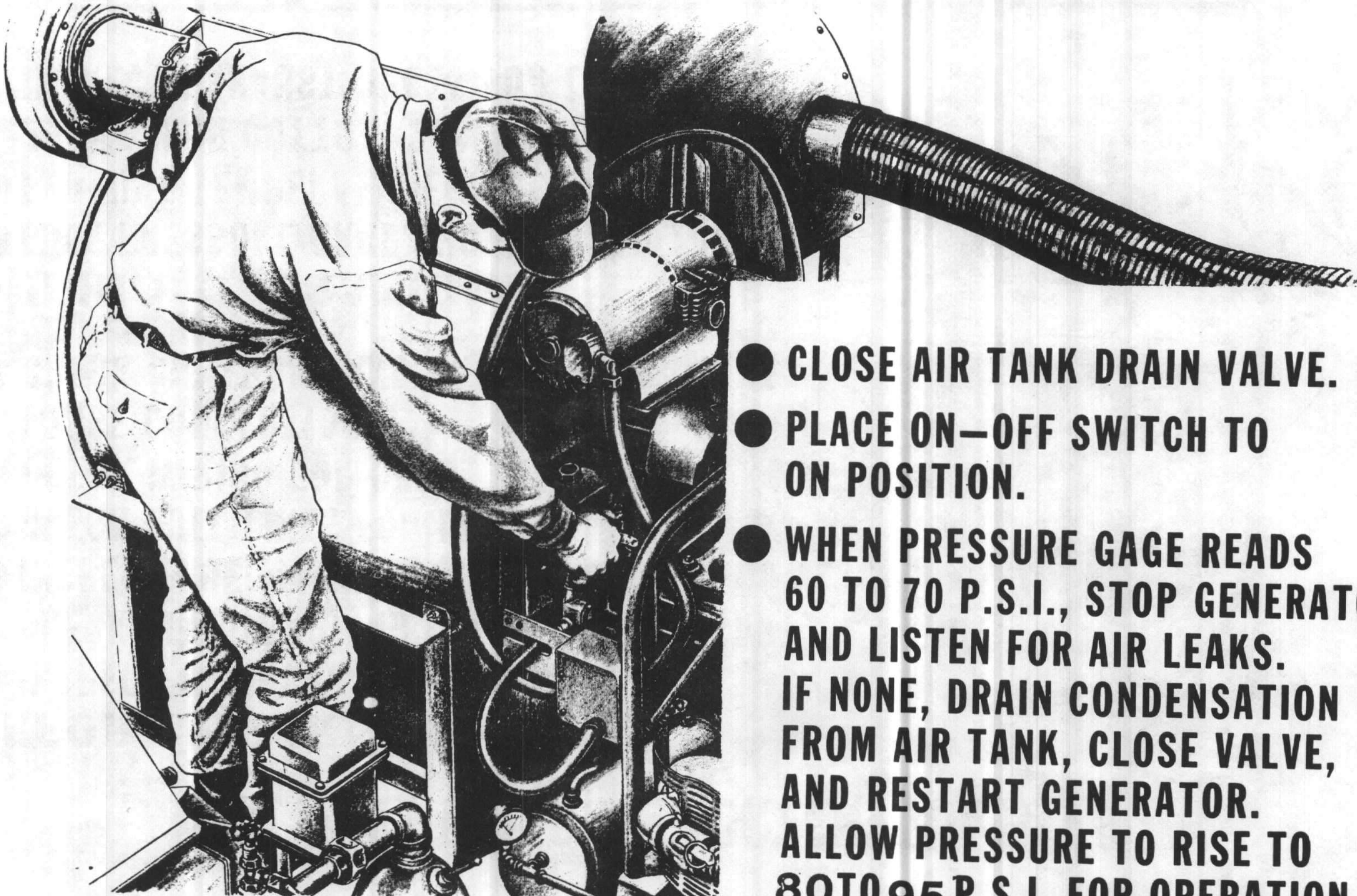
- INSPECT CYLINDER FOR DAMAGE.
- CHECK LINT TRAP AND CLEAN IF NECESSARY.
- INSPECT FUEL FILTER FOR SEDIMENT IN BOWL.
- CHECK FUEL LINES FOR LEAKS.
- CHECK WIRING FOR CUTS, FRAYS, AND LOOSE CONNECTIONS.
- CHECK CONTROLS AND GAGES FOR DAMAGE.

DURING OPERATION

- FUEL PRESSURE GAGE SHOULD READ 100 P.S.I.
- EXHAUST TEMPERATURE GAGE SHOULD READ 250° F. FOR COTTON; 200° F. FOR WOOL.
- INSPECT EXHAUST DUCTS FOR LEAKS.

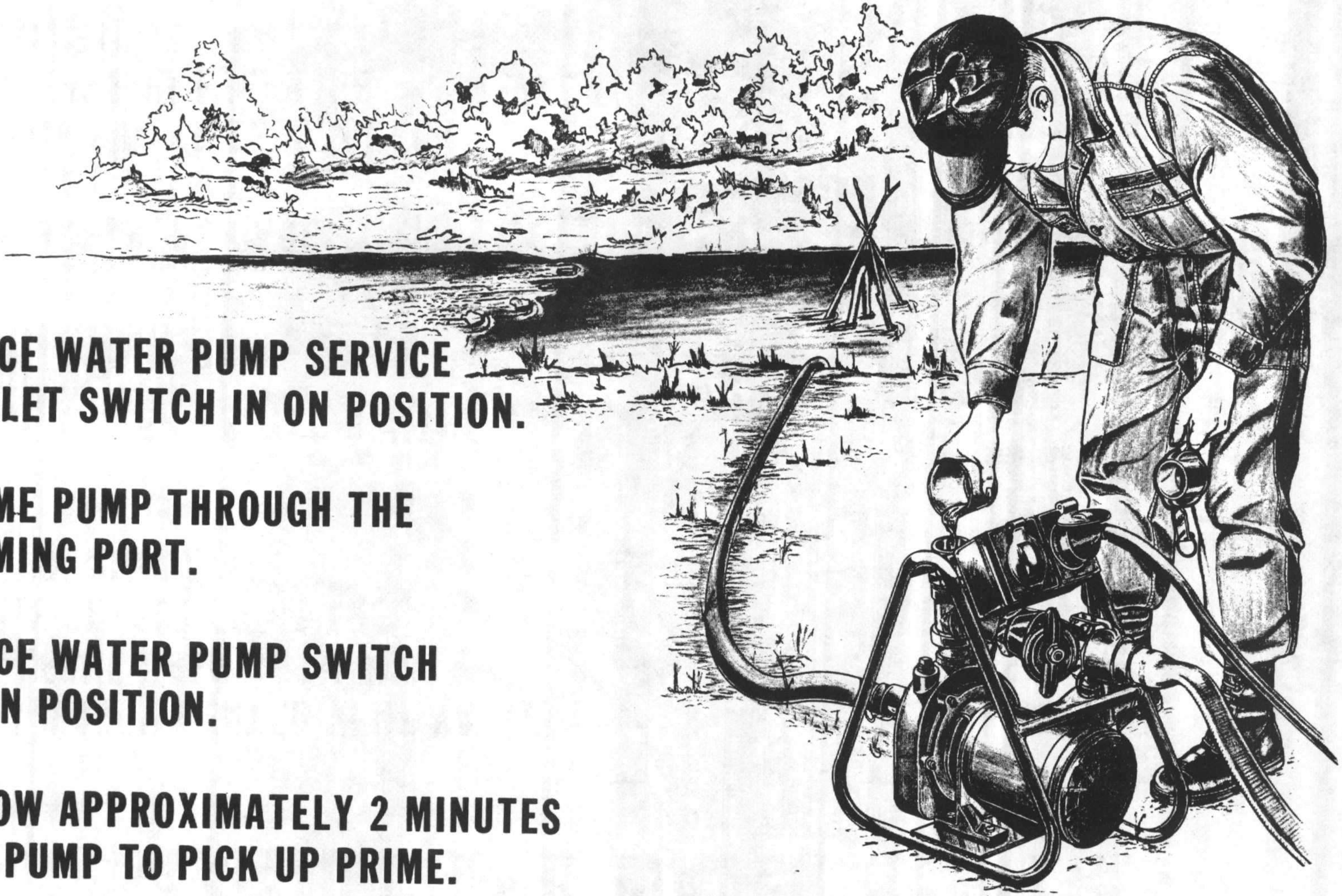
LUBRICATE IN ACCORDANCE WITH CURRENT LUBRICATION ORDER.

STARTING THE AIR COMPRESSOR



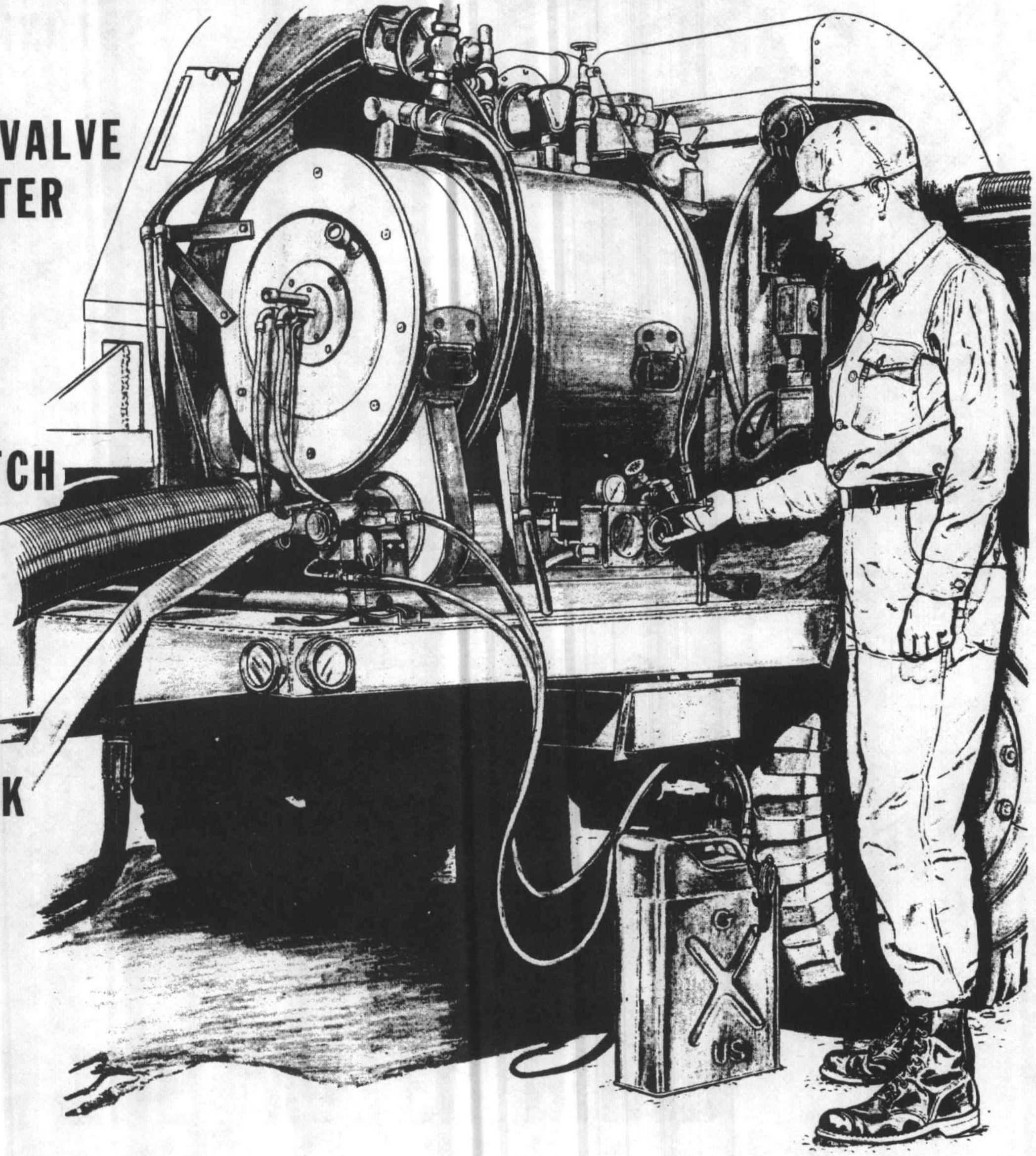
- CLOSE AIR TANK DRAIN VALVE.
- PLACE ON—OFF SWITCH TO ON POSITION.
- WHEN PRESSURE GAGE READS 60 TO 70 P.S.I., STOP GENERATOR AND LISTEN FOR AIR LEAKS. IF NONE, DRAIN CONDENSATION FROM AIR TANK, CLOSE VALVE, AND RESTART GENERATOR. ALLOW PRESSURE TO RISE TO 80 TO 95 P.S.I. FOR OPERATION.

STARTING THE WATER PUMP



- PLACE WATER PUMP SERVICE OUTLET SWITCH IN ON POSITION.
- PRIME PUMP THROUGH THE PRIMING PORT.
- PLACE WATER PUMP SWITCH IN ON POSITION.
- ALLOW APPROXIMATELY 2 MINUTES FOR PUMP TO PICK UP PRIME.

STARTING THE WATER HEATER



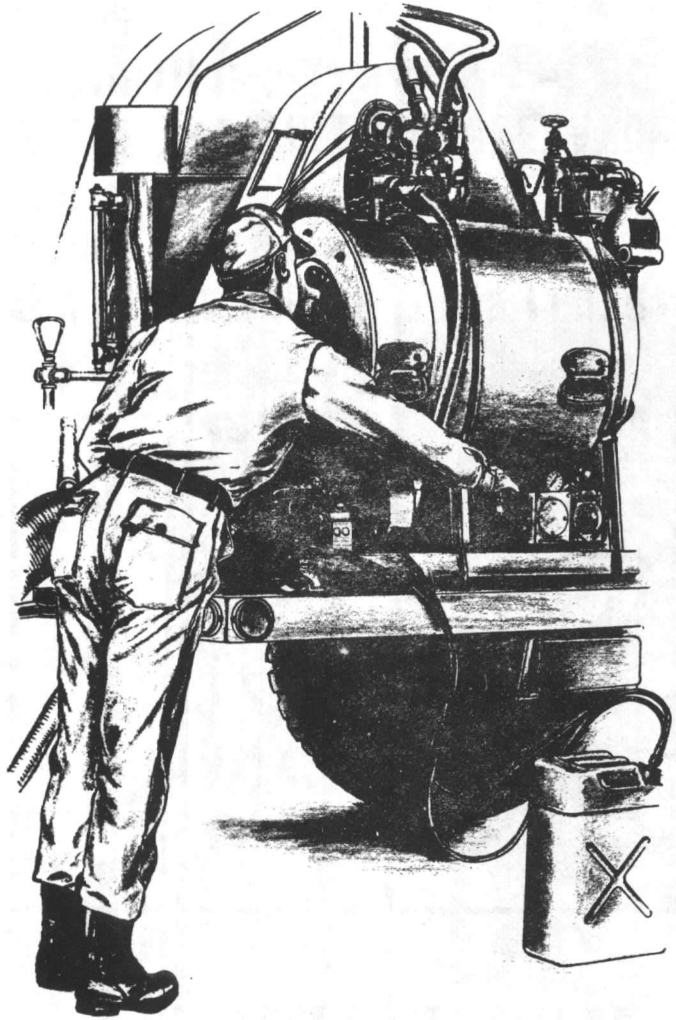
- OPEN WATER HEATER VENT VALVE AND LEAVE OPEN UNTIL WATER FLOWS FREELY FROM THE VENT DRAIN VALVE.

- PLACE WATER HEATER SWITCH IN ON POSITION.

- FUEL PRESSURE GAGE SHOULD READ 80 P.S.I. IF GAGE SHOWS LESS, CHECK FOR LEAKS IN FUEL LINE CONNECTIONS.

- ADJUST FUEL PRESSURE TO READ 60 TO 80 P.S.I.

STARTING THE WATER HEATER (CON.)

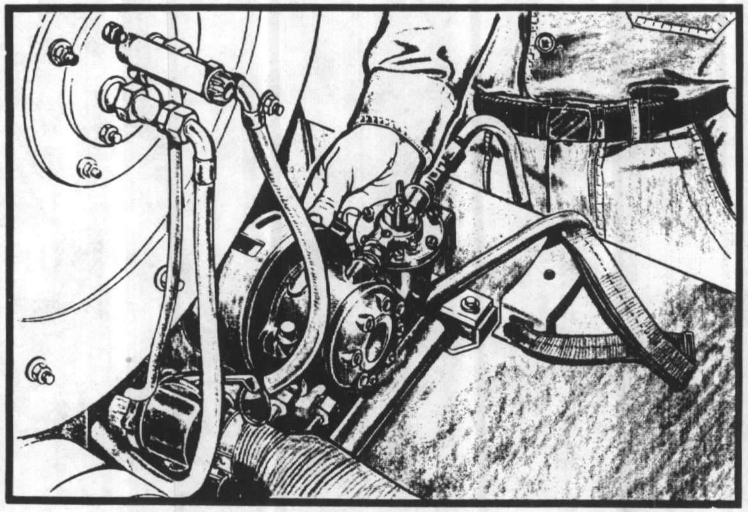


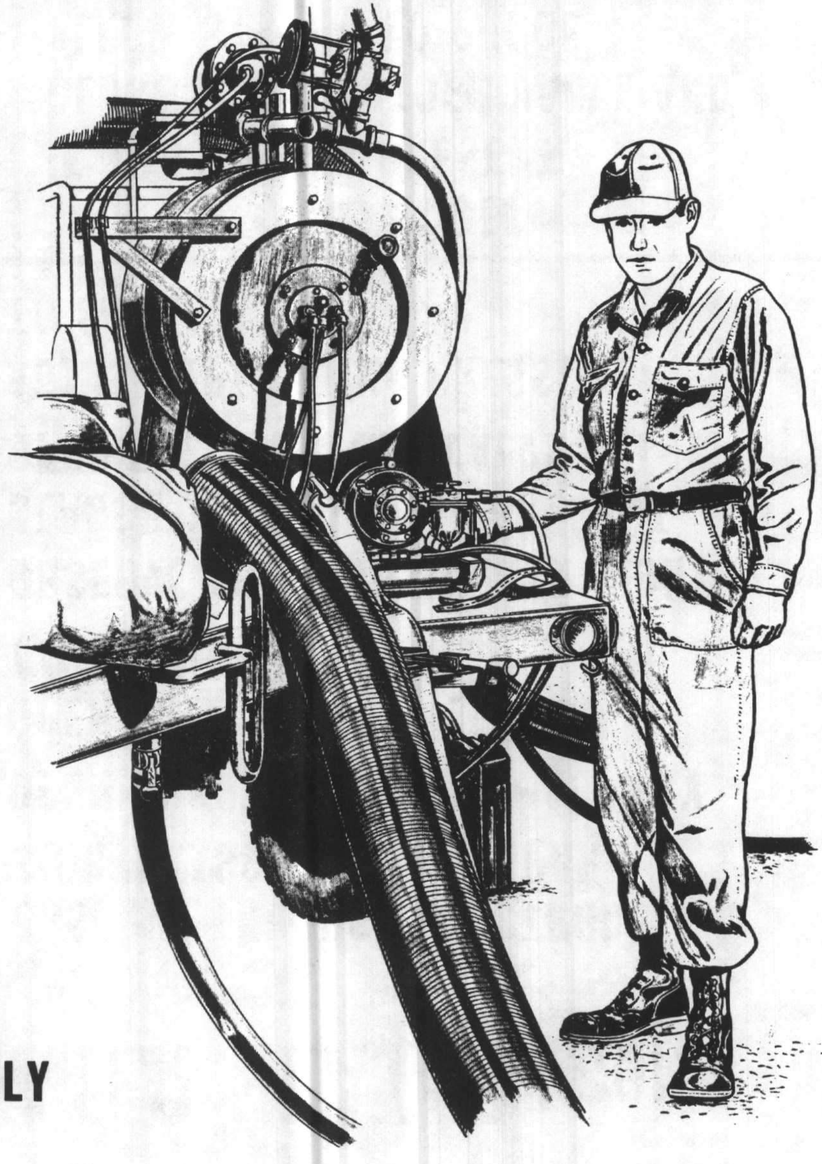
- OBSERVE THROUGH ELECTRODE SIGHTGLASS FOR BLUE SPARK.
- OPEN BURNER SHUTTER HALFWAY.
- OPEN FUEL SHUTOFF VALVE 1/4 TURN.
- OBSERVE THROUGH BURNER SIGHT GLASS FOR FLAME; IF PRESENT, OPEN FUEL SHUTOFF VALVE FULLY.
- ADJUST OPERATING PRESSURE TO 80 P.S.I.

CAUTION

IF NO FLAME IS PRESENT, CLOSE FUEL SHUTOFF VALVE AND ALLOW SYSTEM TO PURGE FOR 15 SECONDS.

STARTING THE WATER HEATER (CON.)

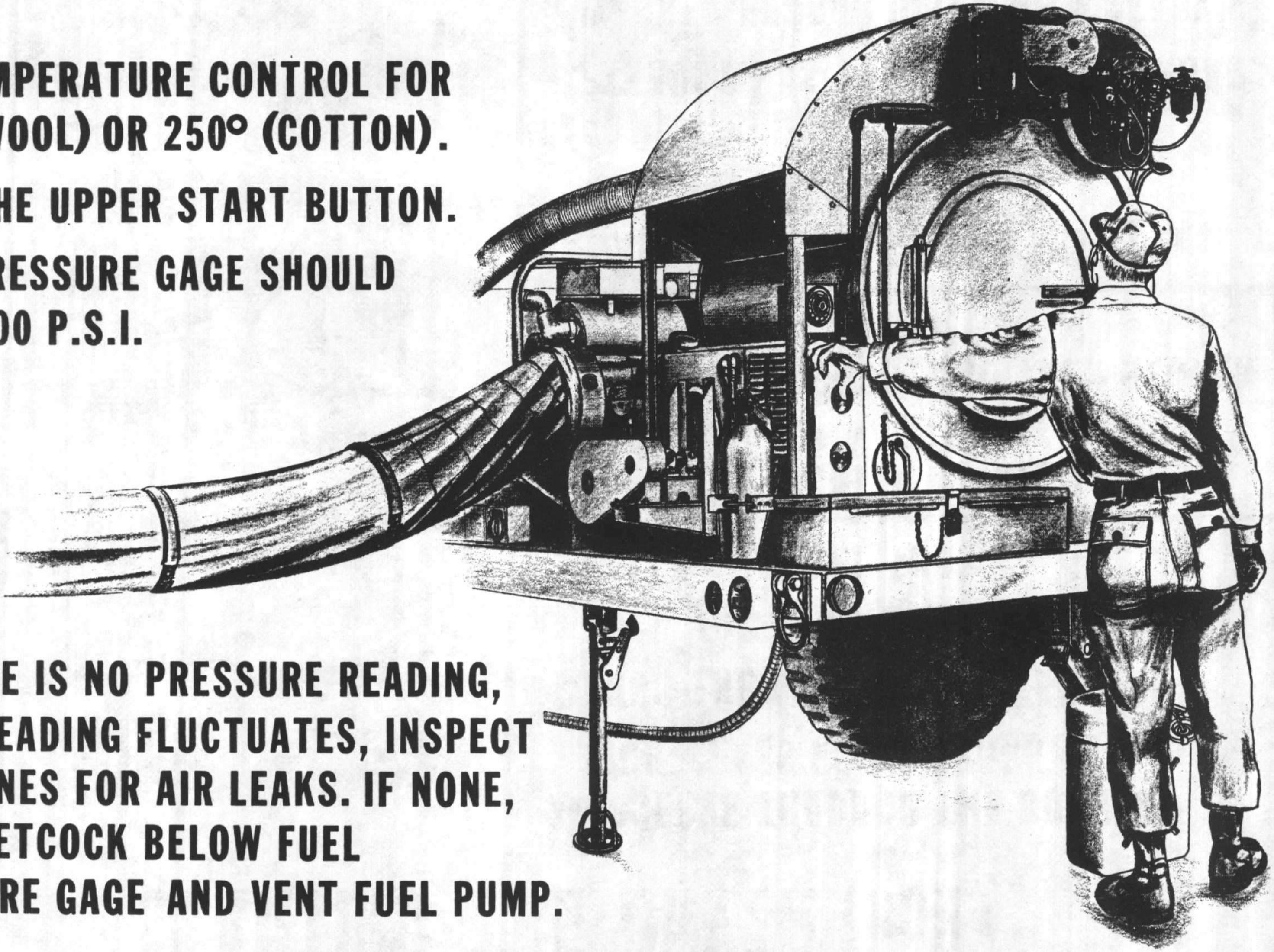




- ADJUST THE SHUTTER LEVER UNTIL EXHAUST IS CLEAR.
- SET THE WATER TEMPERATURE CONTROL TO #4
- ADJUST THE WATER TEMPERATURE CONTROL SO HEATER AUTOMATICALLY SHUTS OFF AT 160°.

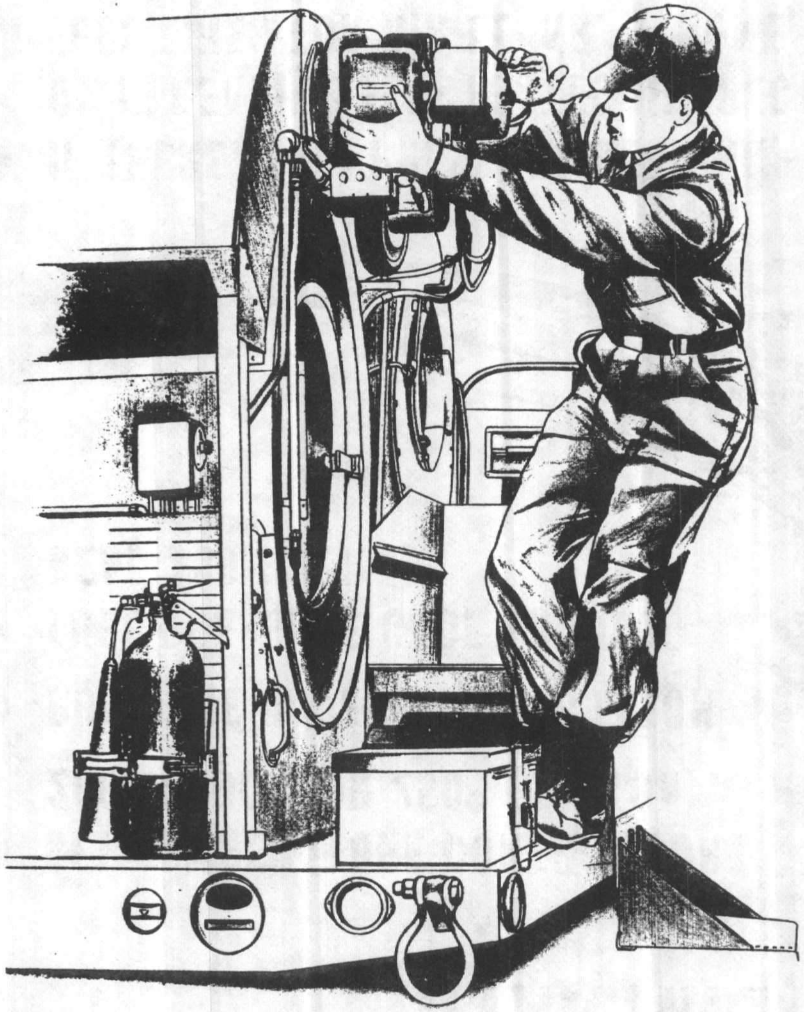
STARTING THE DRYER

- SET TEMPERATURE CONTROL FOR 200° (WOOL) OR 250° (COTTON).
- PUSH THE UPPER START BUTTON.
- FUEL PRESSURE GAGE SHOULD READ 100 P.S.I.



- IF THERE IS NO PRESSURE READING, OR IF READING FLUCTUATES, INSPECT FUEL LINES FOR AIR LEAKS. IF NONE, OPEN PETCOCK BELOW FUEL PRESSURE GAGE AND VENT FUEL PUMP.

STARTING THE DRYER (CON.)



- OBSERVE THROUGH THE BURNER SIGHTGLASS FOR A SPARK.
- PUSH THE LOWER START BUTTON.
- OPEN THE BURNER FUEL SHUTOFF VALVE ONE FULL TURN.

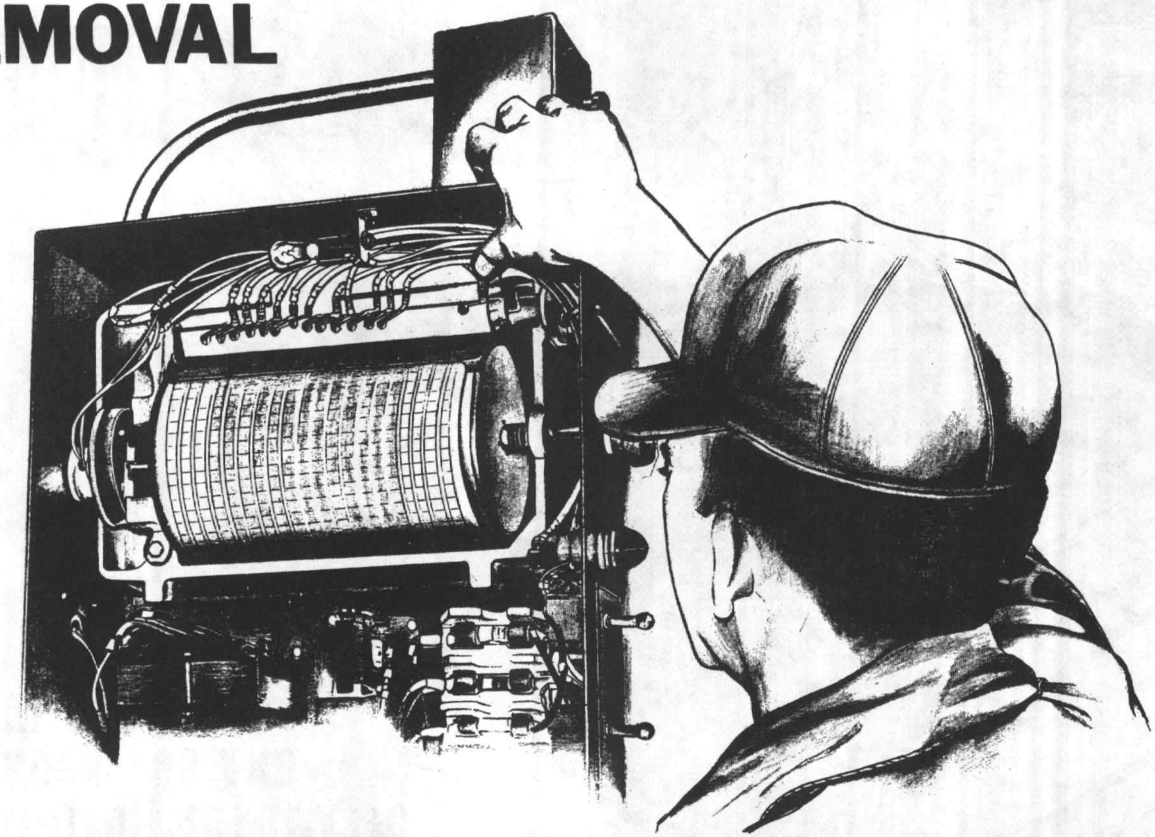
FUEL MUST IGNITE WITHIN 10 SECONDS. IF NOT, CLOSE VALVE, WAIT 15 SECONDS, AND THEN REOPEN VALVE FOR IGNITION.

- WAIT 10 SECONDS AND OPEN FUEL VALVE COMPLETELY.
- ADJUST BURNER SHUTTER UNTIL EXHAUST HAS STEADY MUFFLED ROAR.

(WASHER-EXTRACTOR IS NOW READY FOR OPERATION.)

FORMULA CONTROL RECORD

REMOVAL



- TURN OFF POWER SOURCE AND REMOVE CONTROL BOX COVER.
- RAISE FINGER LOCK, OPEN LOCK HANDLE, AND RAISE FINGER BLOCK OUT OF THE WAY.

FORMULA CONTROL RECORD

REMOVAL (CON.)

- PULL OUT ON AUTOMATIC CONTROL KNOB AND REMOVE FORMULA DRUM FROM DRUM HEADS.

FORMULA CONTROL RECORD

INSTALLATION

- REMOVE RECORD LOCK FROM THE TUBE IN THE DRUM AND REMOVE FORMULA RECORD.

- MOUNT DESIRED FORMULA RECORD OVER DRUM SCREEN WITH BENT ENDS OF RECORD IN SLOT OF DRUM. INSTALL RECORD LOCK, BEING SURE IT SEPARATES ENDS OF RECORD.

FORMULA CONTROL RECORD

INSTALLATION (CON.)

- PULL OUT ON AUTOMATIC CONTROL KNOB AND MOUNT DRUM ON SHOULDER OF DRIVE END OF DRUM HEAD, ROTATING DRUM SLOWLY UNTIL DRIVE CLIPS SEAT IN DRUM HEAD.

- RELEASE KNOB SO THAT FREE END OF DRUM HEAD ENTERS DRUM. TURN KNOB COUNTERCLOCKWISE UNTIL NOTCH IN DRUM HEAD SEATS OVER CLIP.

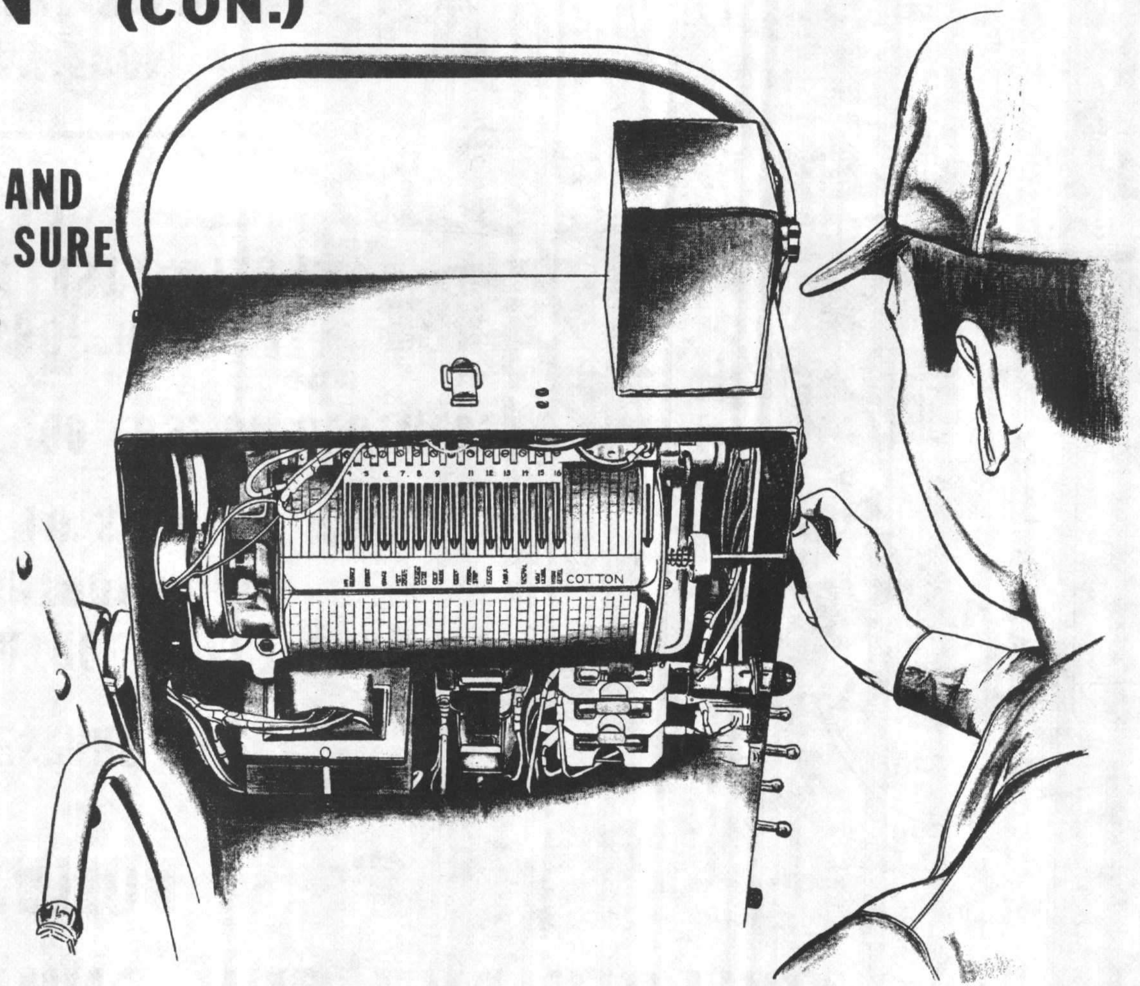
FORMULA CONTROL RECORD

INSTALLATION (CON.)

- LOWER FINGER BLOCK AND LOCK IN PLACE. MAKE SURE FINGER CONTACTS ARE IN PROPER ALINEMENT WITH COLUMNS ON FORMULA RECORD.

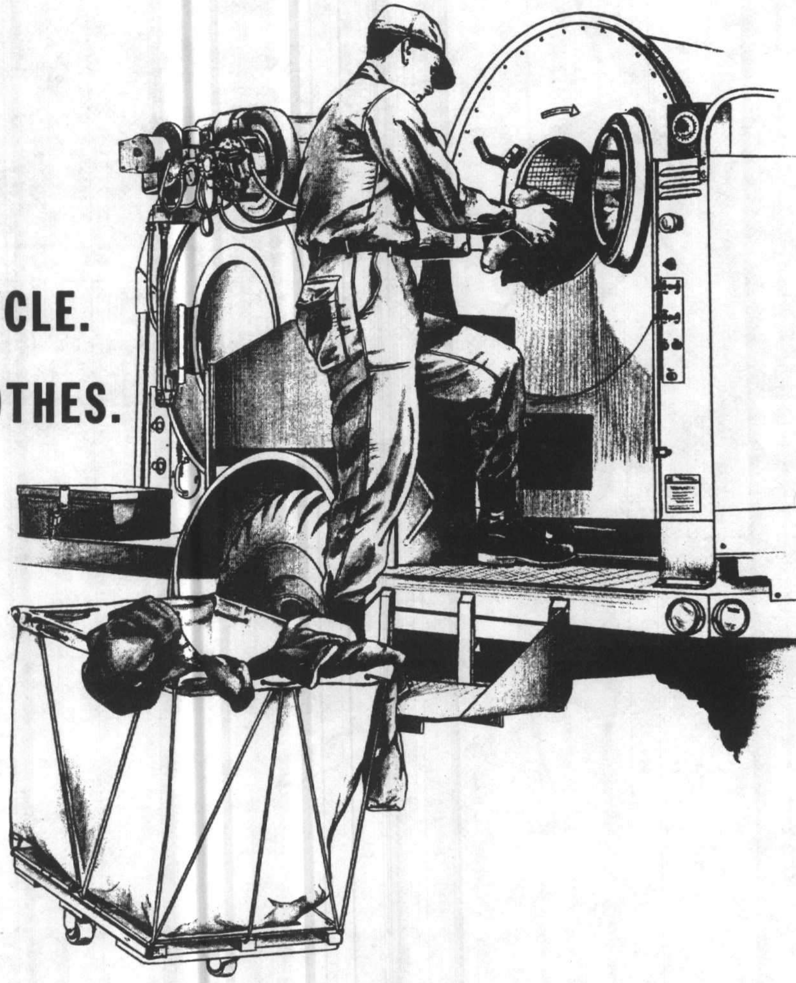
- CLOSE CONTROL BOX

- TURN POWER SOURCE ON.



WASHING AND EXTRACTING

AUTOMATIC OPERATION



- INSURE ALL SWITCHES ARE OFF.
- WITH PROPER FORMATROL CHART ON THE DRUM, TURN CONTROL KNOB COUNTERCLOCKWISE TO START OF CYCLE.
- LOAD A MAXIMUM OF 60 LBS. OF CLOTHES.
- CHECK AIR COMPRESSOR GAGE; IT MUST REGISTER AT LEAST 80 P.S.I. (95 P.S.I. IS DESIRED.)

KEEP MOISTURE AWAY FROM ENGINE-GENERATOR AND KEEP SURROUNDING AREA DRY.

WASHING AND EXTRACTING

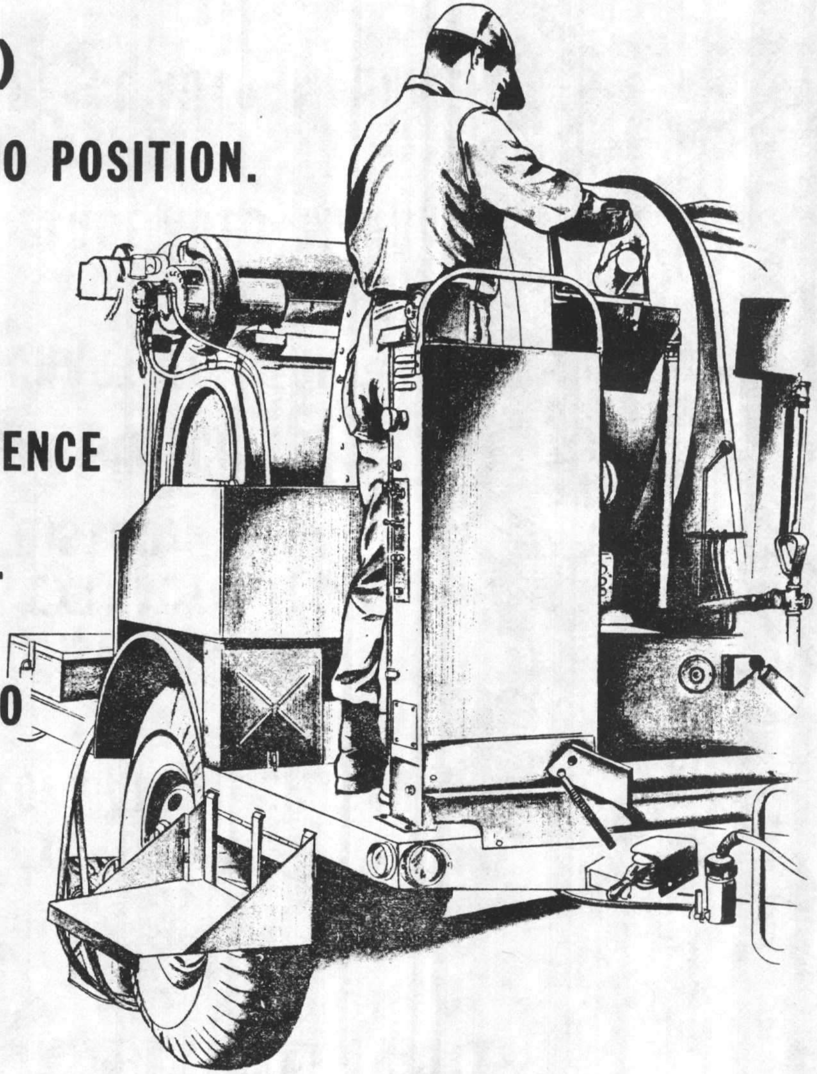
AUTOMATIC OPERATION (CON.)

- TURN AUTO–MANUAL SWITCH TO AUTO POSITION.

(BELL WILL RING AT END OF EACH WASH CYCLE AND AT BEGINNING OF PRE–EXTRACT CYCLE.)

- WHEN BELL RINGS, OPERATOR'S PRESENCE IS MANDATORY TO DEPRESS SIGNAL SWITCH AND ADD WASHING SUPPLIES.

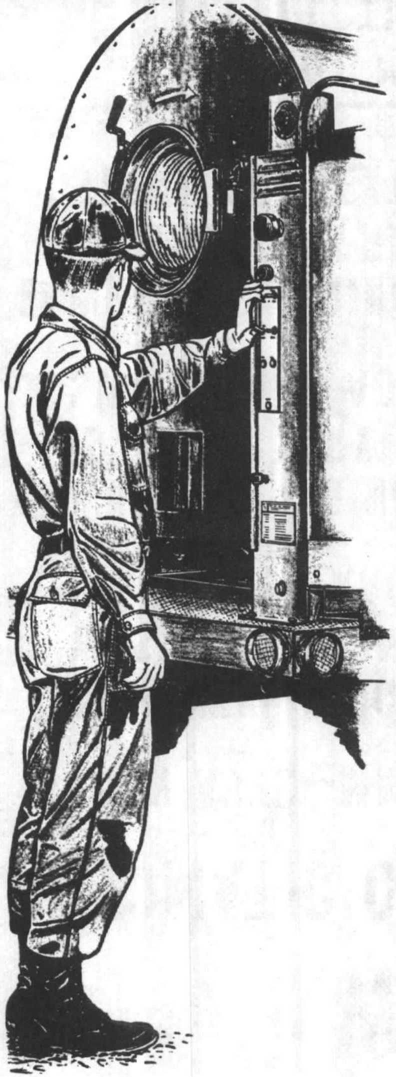
- WHEN BELL RINGS PRIOR TO PRE–EXTRACT, DEPRESS SIGNAL SWITCH TO START PRE–EXTRACT CYCLE.



DO NOT MAKE ELECTRICAL CONNECTIONS OR CHANGE FORMATROL CHART WHILE UNIT IS IN OPERATION.

WASHING AND EXTRACTING

AUTOMATIC OPERATION (CON.)



- IF EXTRACTION IS EXTREMELY ROUGH, PLACE AUTO-MANUAL SWITCH IN MANUAL.
- PLACE BRAKE-DRAIN SWITCH IN BRAKE AND ALLOW EXTRACTOR TO COME TO COMPLETE STOP.
- PLACE AUTO-MANUAL SWITCH TO OFF.
- TURN FORMATROL CHART TO START OF PRE-EXTRACT.
- WAIT 40 SECONDS, PLACE AUTO-MANUAL SWITCH IN AUTO.
- WHEN BELL RINGS, PLACE AUTO-MANUAL SWITCH IN OFF.
- OPEN WASHER DOOR, REMOVE CLOTHES, AND PLACE THEM IN DRAIN BIN.

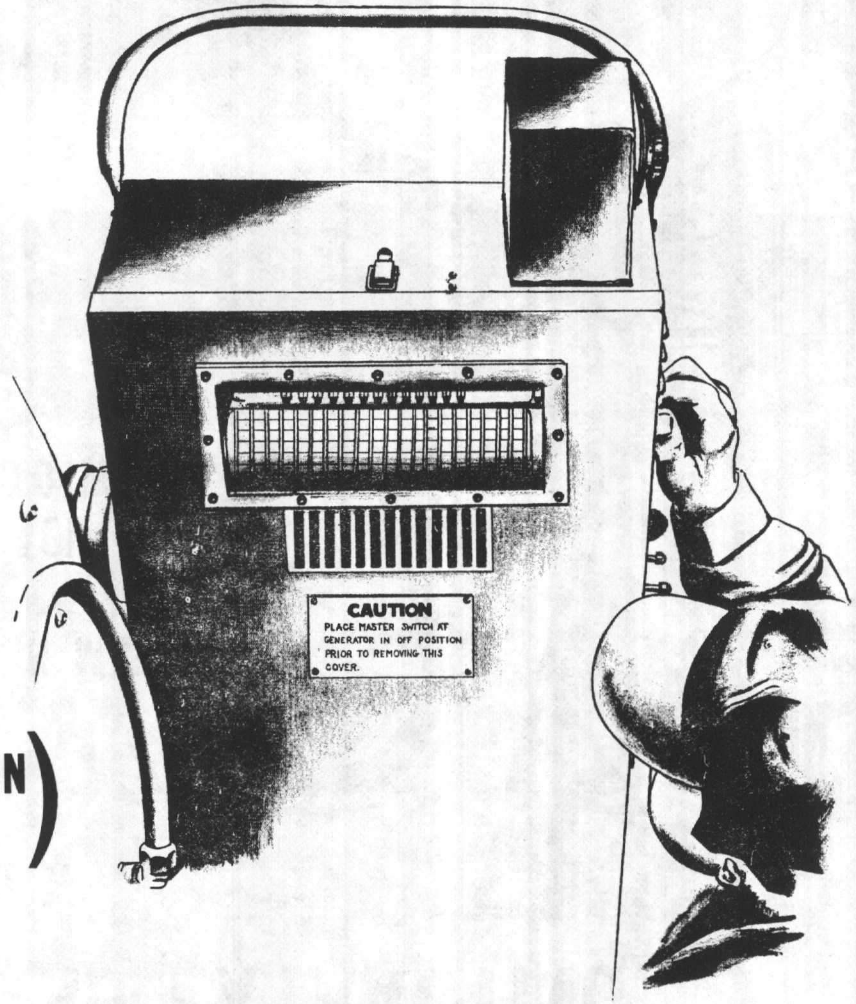
WASHING AND EXTRACTING

MANUAL OPERATION

(REFER TO TABLES 3 & 4 OF TM 10-3510-208-12.)

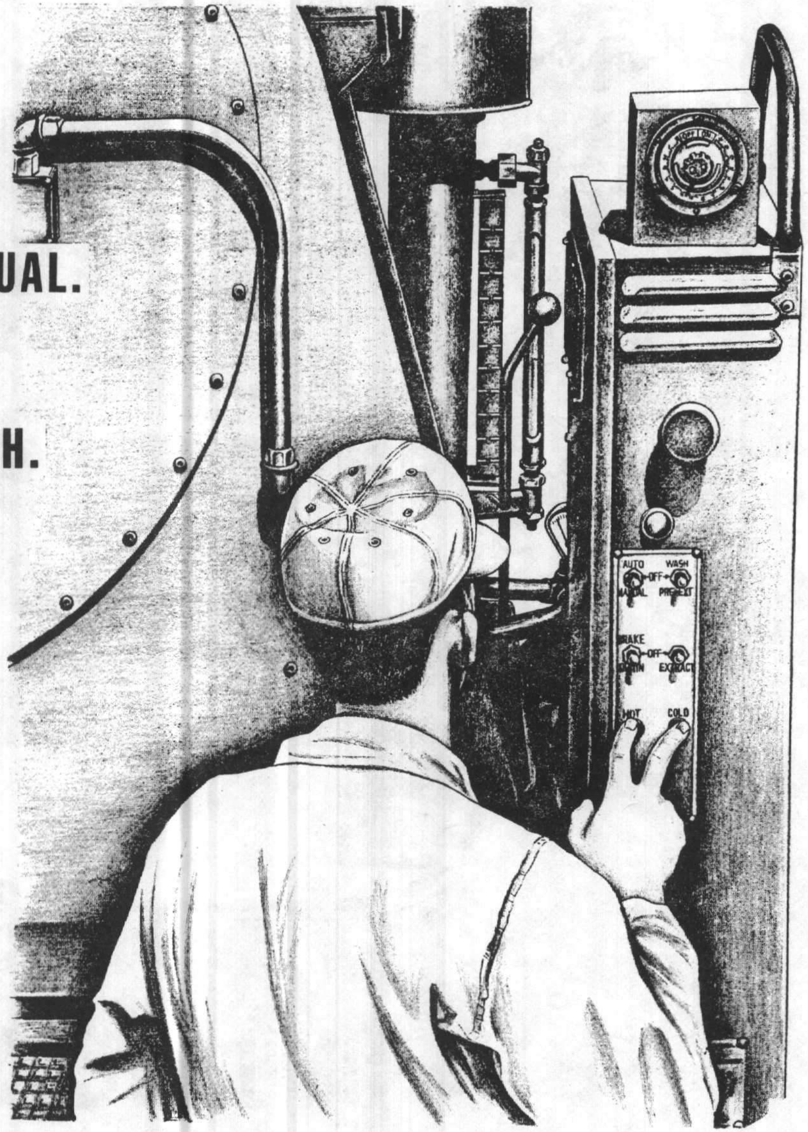
- LOAD A MAXIMUM OF 60 LBS. OF CLOTHES.
- TURN FORMATROL CHART UNTIL ALL SLOTS ARE CLEAR OF CONTACT FINGERS.
- CHECK AIR COMPRESSOR GAGE TO READ AT LEAST P.S.I.

(9 P.S.I. IS DESIRED READING ON AIR COMPRESSOR.)



WASHING AND EXTRACTING

MANUAL OPERATION (CON.)



- INSURE ALL SWITCHES ARE OFF.
  PLACE AUTO—MANUAL SWITCH IN MANUAL.

- SET ELECTRICAL TIMER AND PLACE
  WASH—PRE—EXTRACT SWITCH TO WASH.

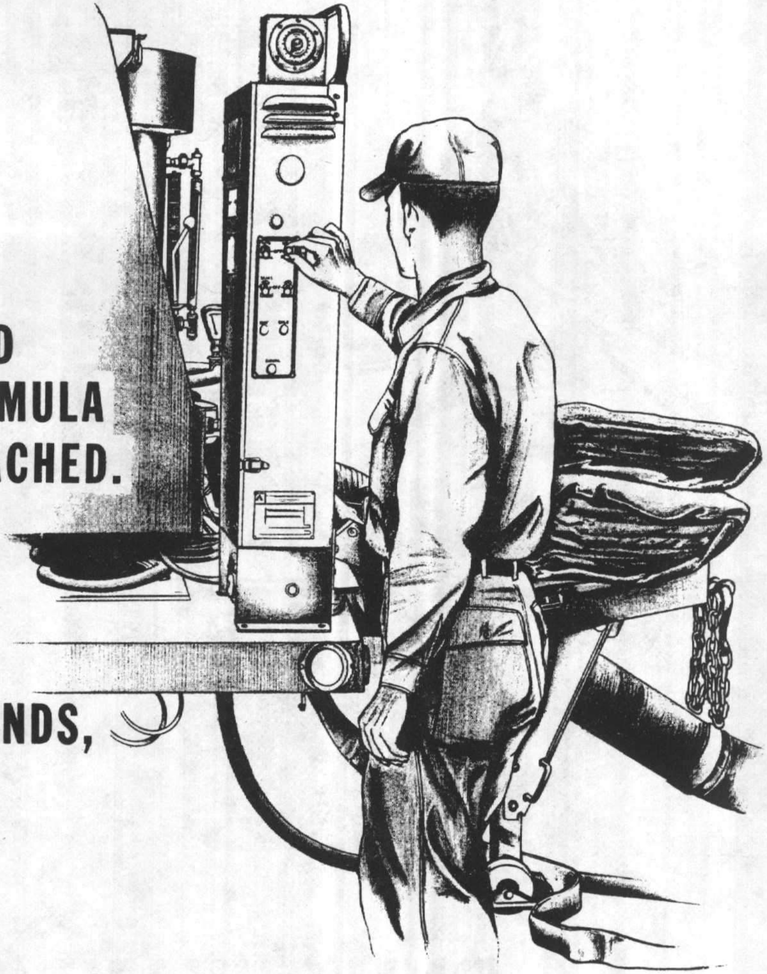
- OPERATE HOT AND COLD WATER
  SWITCHES UNTIL FORMULA LEVEL
  AND TEMPERATURE ARE REACHED.

(IF TOO MUCH WATER, PLACE
BRAKE—DRAIN SWITCH TO DRAIN
AND THEN TO OFF WHEN
FORMULA LEVEL IS REACHED.)

- ADD DETERGENTS.

WASHING AND EXTRACTING

MANUAL OPERATION (CON.)



- WHEN WASH CYCLE IS COMPLETE, PLACE BRAKE—DRAIN SWITCH IN DRAIN.
- TO RINSE, PLACE BRAKE—DRAIN SWITCH IN OFF. OPERATE HOT AND COLD WATER SWITCHES UNTIL FORMULA LEVEL AND TEMPERATURE ARE REACHED.
- TO EXTRACT, PLACE BRAKE-DRAIN SWITCH IN DRAIN. PLACE WASH—PRE—EXT SWITCH TO PRE—EXT POSITION, WAIT 10 SECONDS, AND PLACE EXTRACT SWITCH TO EXTRACT POSITION.

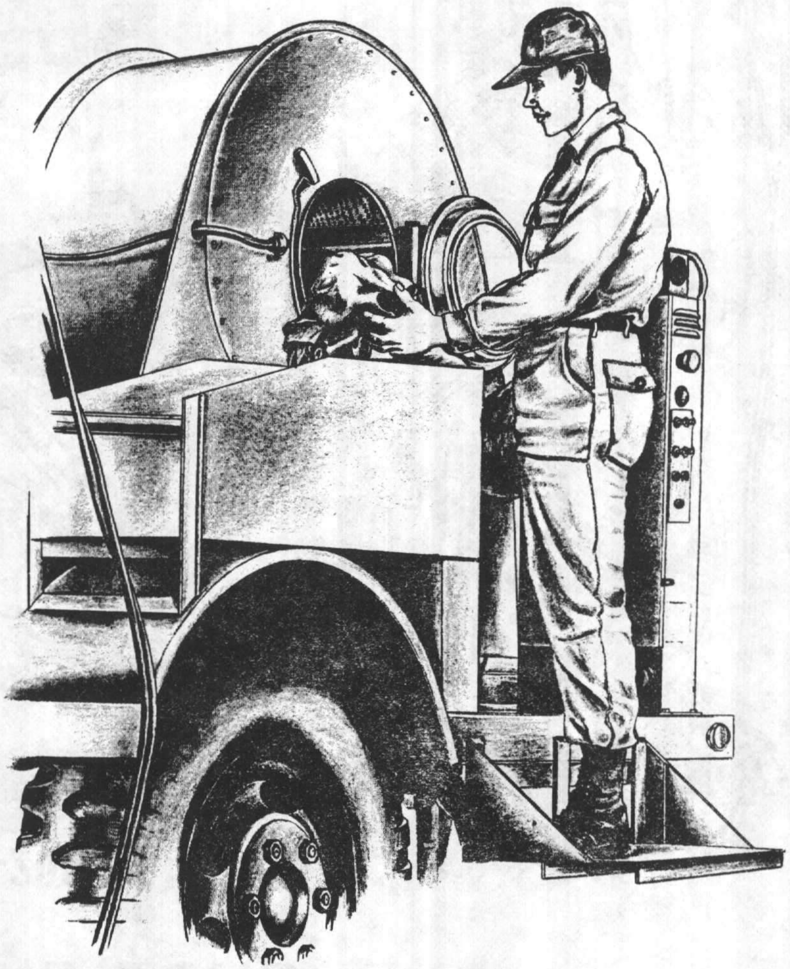
WASHING AND EXTRACTING

MANUAL OPERATION (CON.)

- IF EXTRACTION IS EXTREMELY ROUGH, PLACE EXTRACT AND PRE–EXT SWITCH IN OFF.
- PLACE BRAKE–DRAIN SWITCH IN BRAKE.
- WHEN CYLINDER STOPS, PLACE BRAKE–DRAIN SWITCH IN OFF.
- WAIT 40 SECONDS AND PLACE WASH–PRE–EXT SWITCH IN PRE–EXT.
- PLACE BRAKE–DRAIN SWITCH IN DRAIN.
- PLACE EXTRACT SWITCH TO EXTRACT; RELEASE PRE–EXT SWITCH.

WASHING AND EXTRACTING

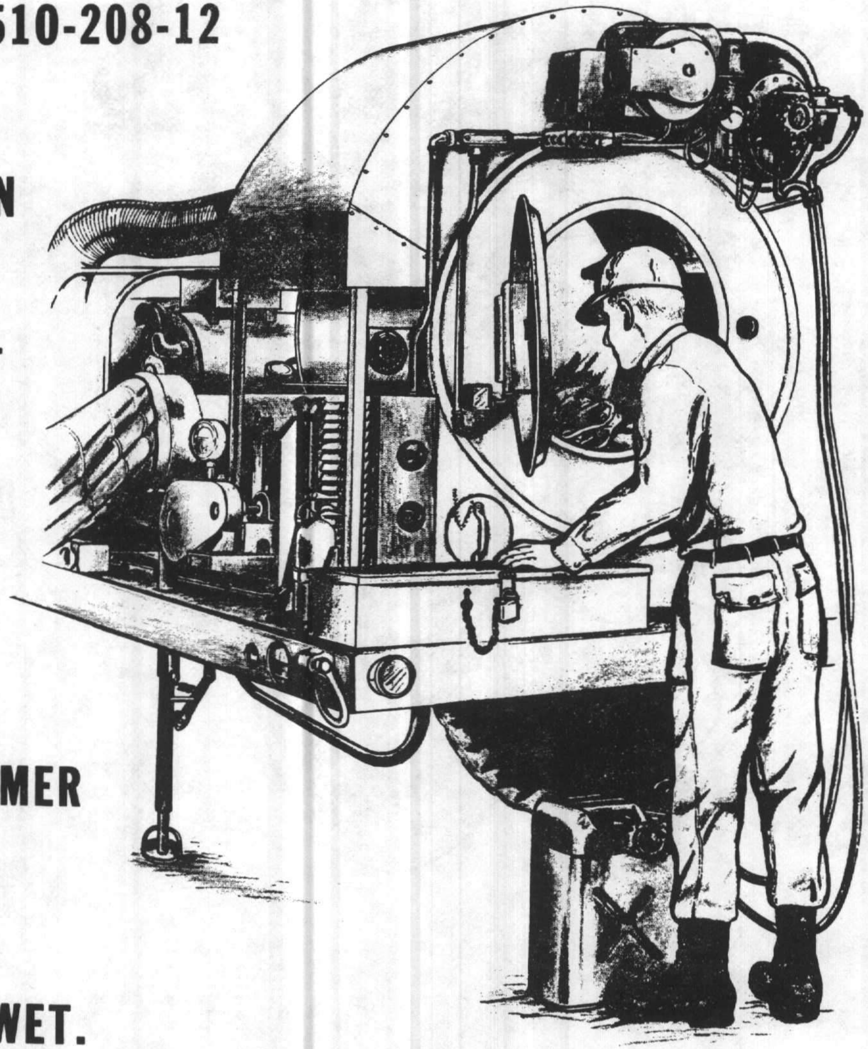
MANUAL OPERATION (CON.)



- EXTRACT LOAD FOR 5 MINUTES, THEN PLACE EXTRACT SWITCH TO OFF.
- PLACE BRAKE–DRAIN SWITCH TO BRAKE AND THEN TO OFF WHEN CYLINDER STOPS.
- WHEN DOOR LOCK PIN RETRACTS, PLACE AUTO–MANUAL SWITCH IN OFF.
- REMOVE CLOTHES AND PLACE IN DRAIN BIN.

DRYING THE LOAD

- REFER TO TABLE 5 OF TM 10-3510-208-12 FOR DRYING TEMPERATURE.
- PLACE HALF OF WASHER LOAD IN THE DRYER TUMBLER.
- CLOSE DOOR SECURELY AND SET ELECTRICAL TIMER TO REQUIRED DRYING TIME.
- SET TEMPERATURE CONTROL TO PROPER TEMPERATURE.
- WHEN BUZZER SOUNDS, TURN TIMER OFF, OPEN DRYER DOOR, AND CHECK CLOTHES FOR DRYNESS.
- REPEAT IF CLOTHES ARE STILL WET.

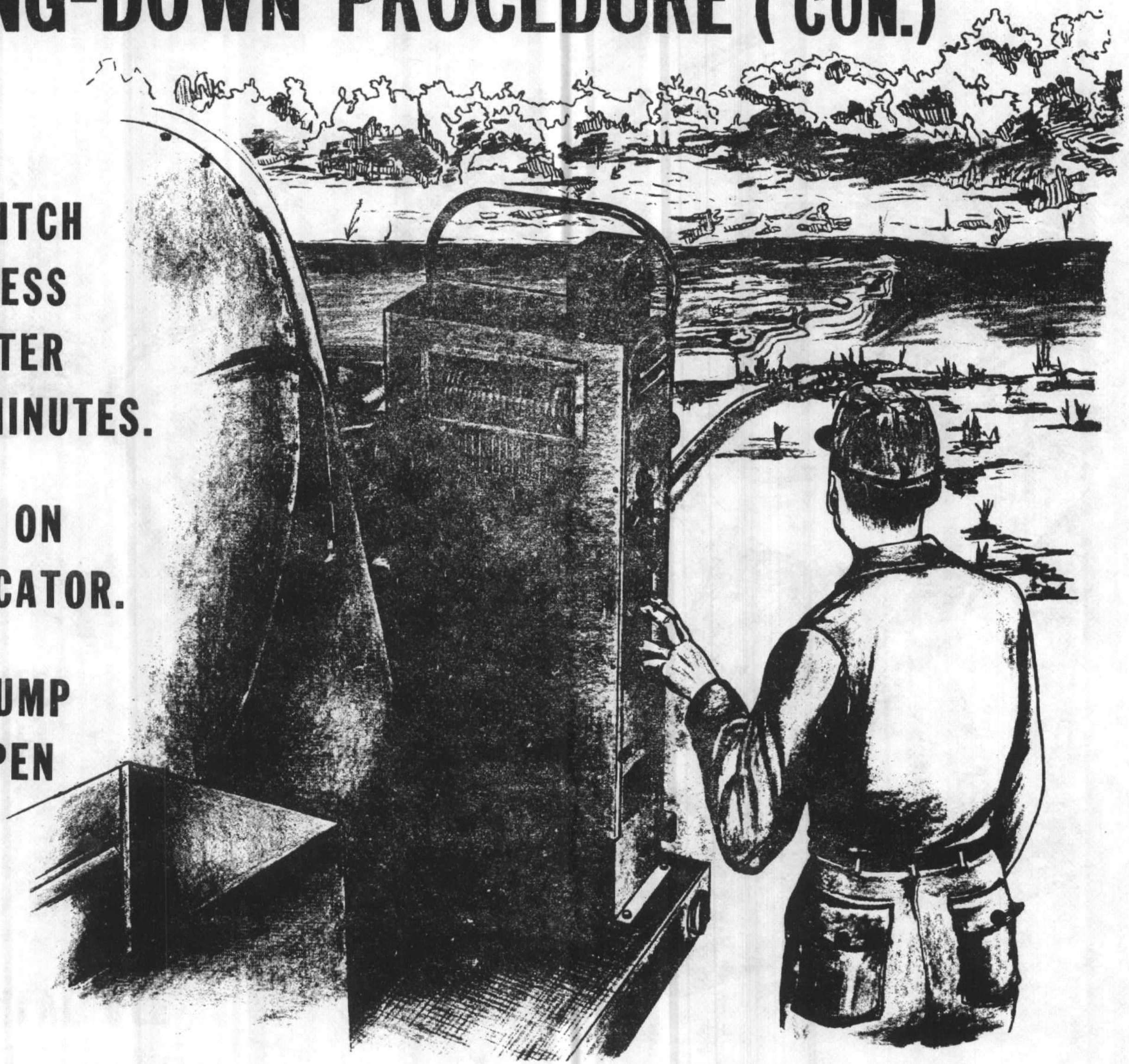


SHUTTING-DOWN PROCEDURE

- TURN DRYER FUEL VALVE OFF.
- TURN WATER HEATER FUEL SHUTOFF VALVE OFF.
- TURN WATER PUMP OFF AND DISCONNECT POWER CABLE.

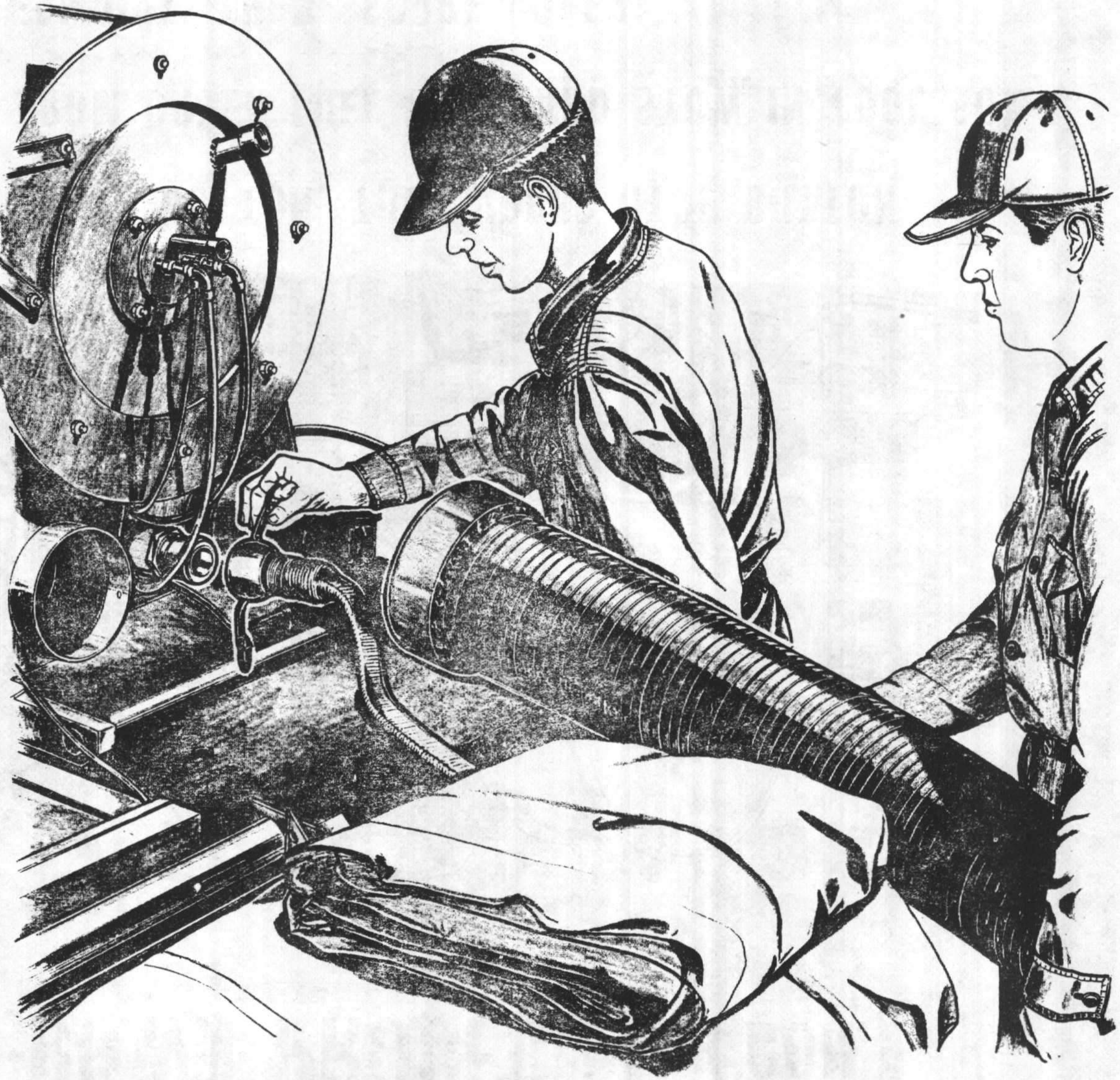
- DISCONNECT SUCTION AND OUTLET HOSE AT WATER PUMP AND OPEN PETCOCK DRAIN.

SHUTTING-DOWN PROCEDURE (CON.)



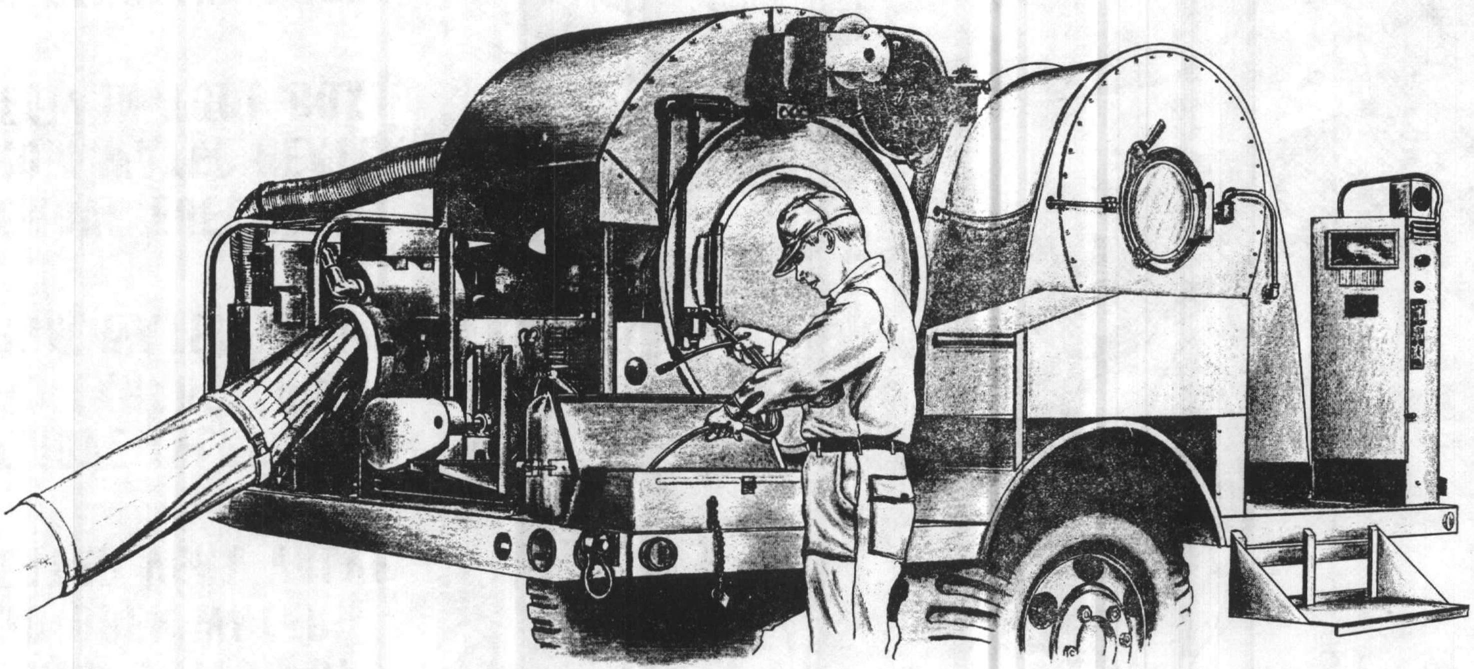
- PLACE WASHER AUTO–MANUAL SWITCH IN MANUAL AND PRESS HOT AND COLD WATER SWITCHES FOR 2 MINUTES.
- OPEN DRAIN VALVE ON WATER LEVEL INDICATOR.
- SECURE WASHER DUMP VALVE LEVER IN OPEN POSITION.

SHUTTING-DOWN PROCEDURE (CON.)



- TURN WATER HEATER POWER SWITCH OFF AND OPEN WATER HEATER VENT VALVE.
- REMOVE INLET HOSE AND EXHAUST DUCT FROM WATER HEATER.
- REMOVE FUEL LINES FROM WATER HEATER; STOW IN TOOL BOX.
- DEPRESS AND LOCK LOW WATER FLOAT HOLDDOWN ROD.

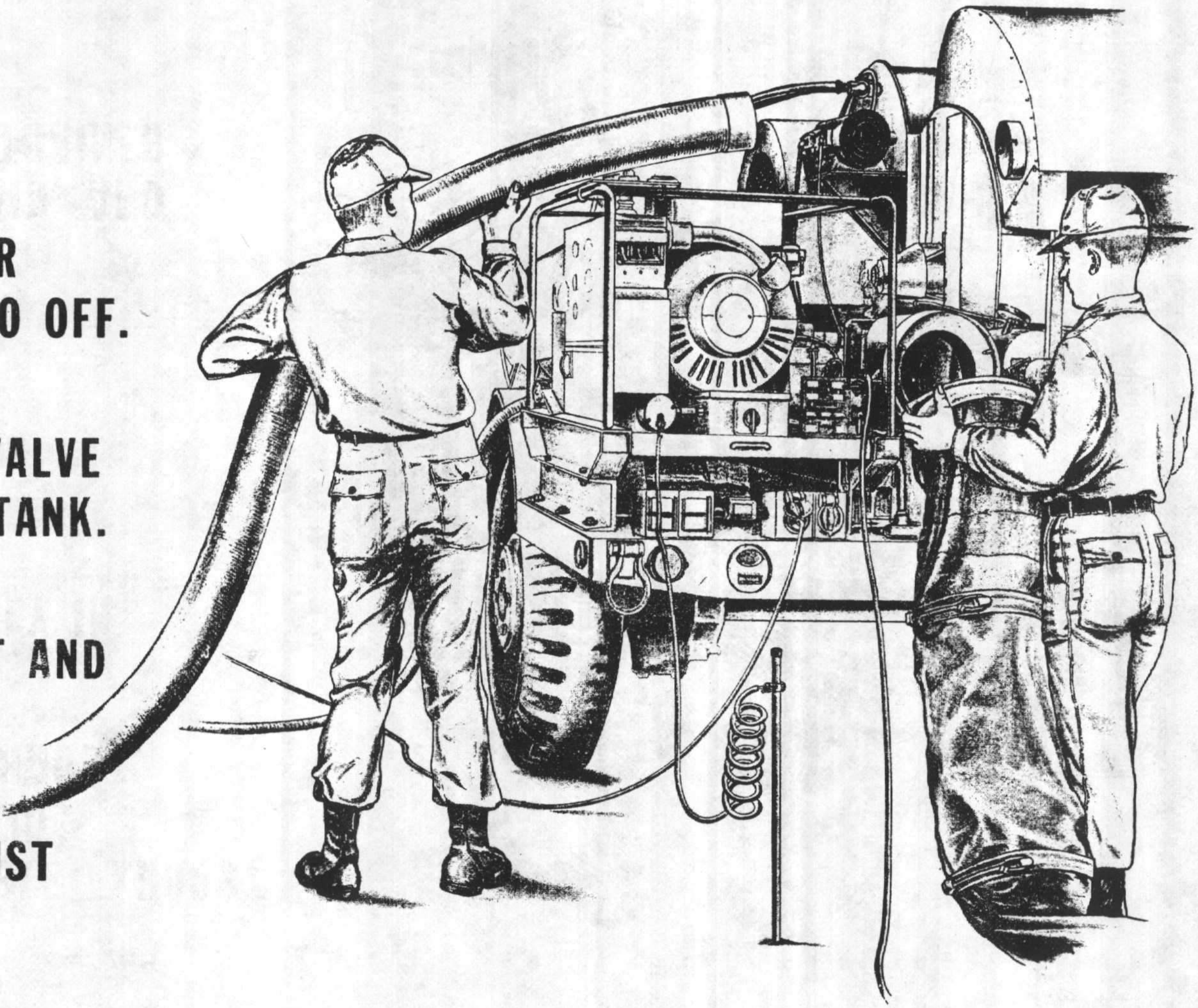
SHUTTING-DOWN PROCEDURE (CON.)



- PRESS DRYER LOWER STOP BUTTON, THEN UPPER STOP BUTTON.
- REMOVE FUEL LINES FROM DRYER FUEL PUMP AND STOW IN TOOL BOX.
- OPEN LINT TRAP, CLEAN OUT, THEN SECURE COVER.

SHUTTING-DOWN PROCEDURE (CON.)

- CLOSE THE DRYER SHUTTER VALVE.
- TURN COMPRESSOR ON–OFF SWITCH TO OFF.
- OPEN AIR DRAIN VALVE ON COMPRESSOR TANK.
- REMOVE 12" DUCT AND STOW IN DRYER.
- REMOVE 5" EXHAUST FROM DRYER.



SHUTTING-DOWN PROCEDURE (CON.)

- REMOVE 1.5" FLEXIBLE EXHAUST FROM GENERATOR AND STOW INSIDE 5" EXHAUST.

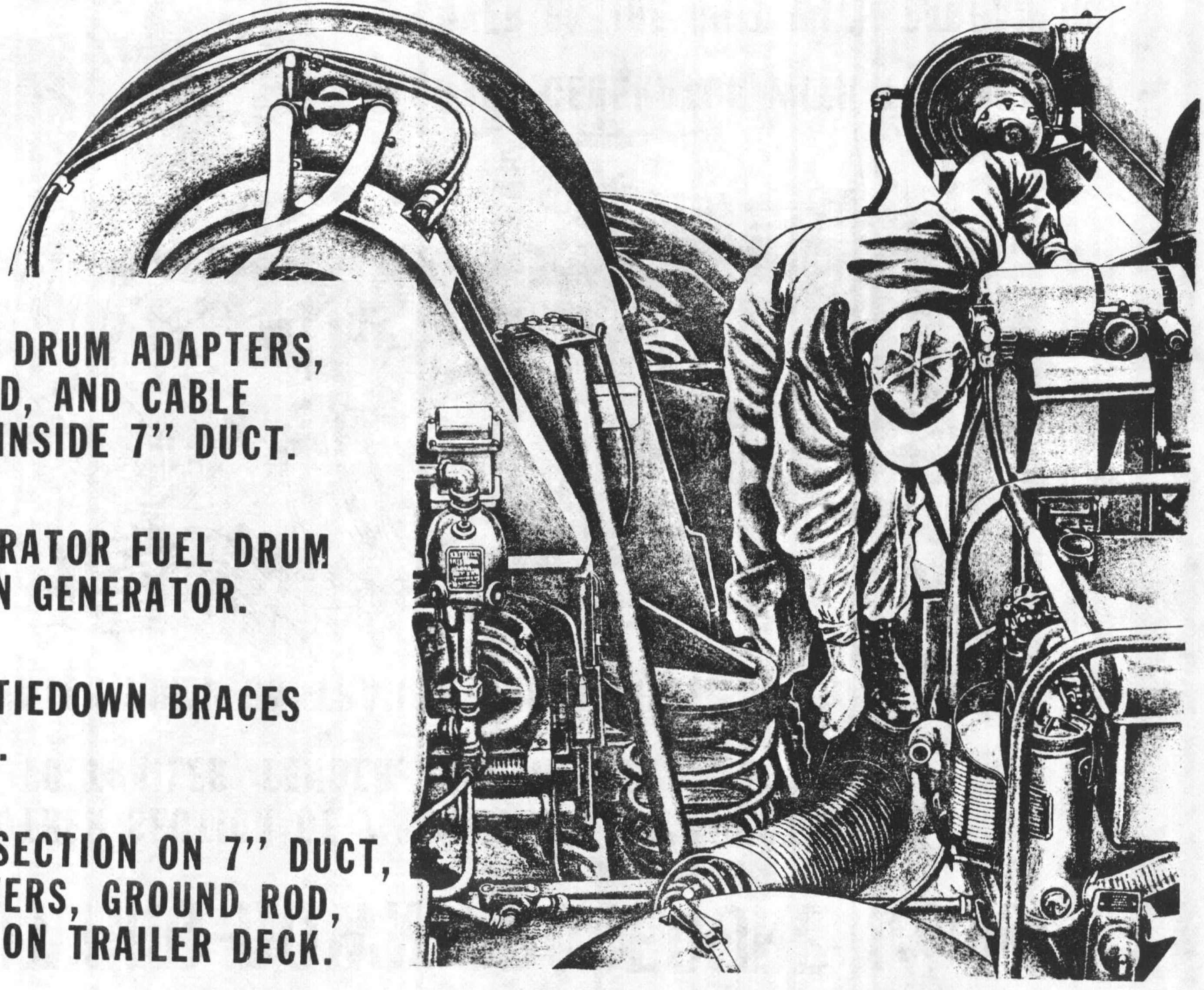
- STOW STEP ASSEMBLY IN DRAIN BIN.

- REMOVE DRAIN HOSE FROM DRAIN PAN.

- STOW SUCTION, DRAIN, AND INLET HOSES AND STRAINER IN DRAIN BIN.

- STOW ELECTRICAL CORDS IN DRAIN BIN.

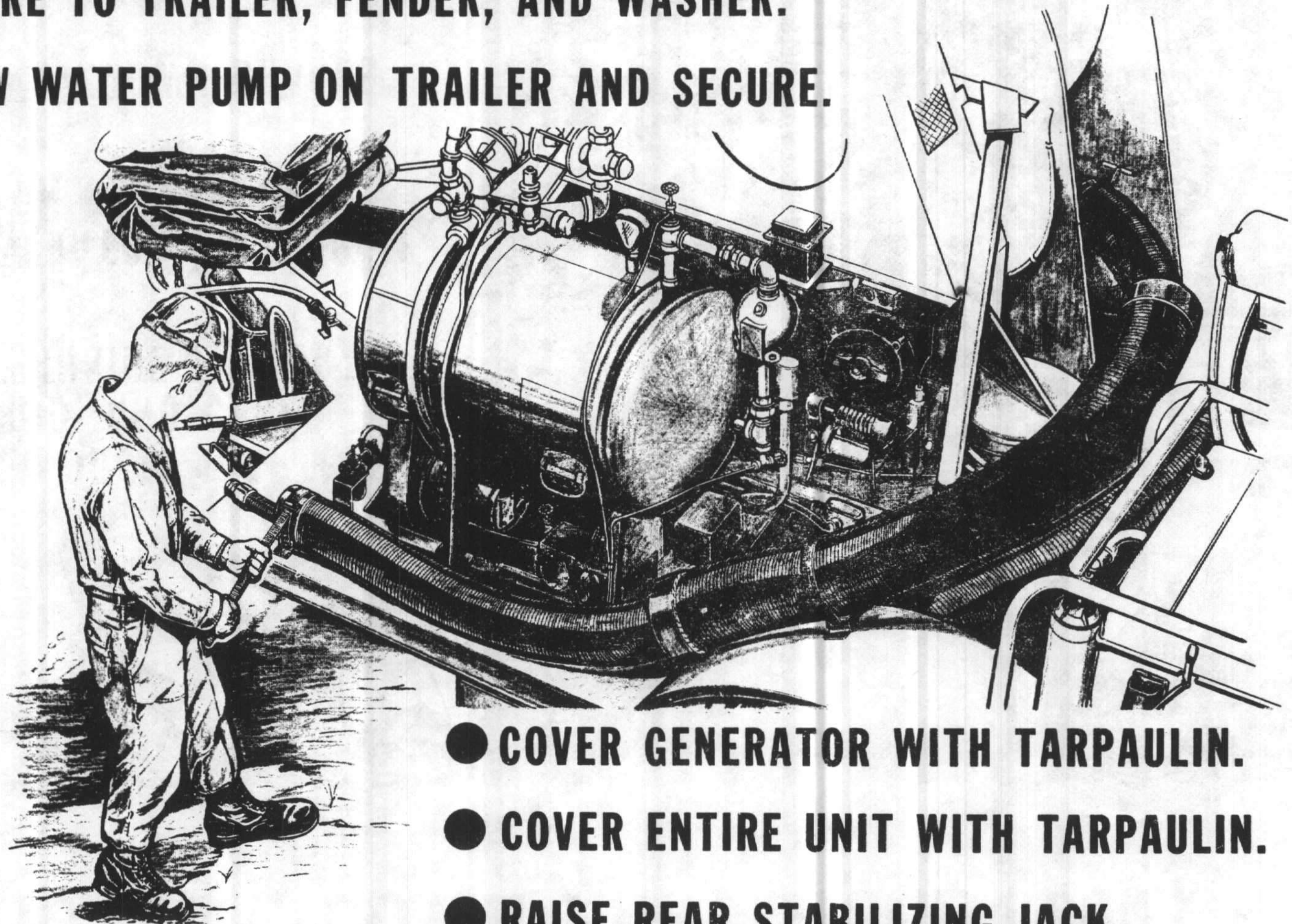
SHUTTING-DOWN PROCEDURE (CON.)



- STOW FUEL DRUM ADAPTERS, GROUND ROD, AND CABLE ASSEMBLY INSIDE 7" DUCT.
- STOW GENERATOR FUEL DRUM ADAPTER ON GENERATOR.
- INSTALL 4 TIEDOWN BRACES OF WASHER.
- STOW ONE SECTION ON 7" DUCT, FUEL ADAPTERS, GROUND ROD, AND CABLE ON TRAILER DECK.

SHUTTING-DOWN PROCEDURE (CON.)

- PLACE OTHER SECTION OF 7" DUCT OVER 5" DUCT AND SECURE TO TRAILER, FENDER, AND WASHER.
- STOW WATER PUMP ON TRAILER AND SECURE.



- COVER GENERATOR WITH TARPAULIN.
- COVER ENTIRE UNIT WITH TARPAULIN.
- RAISE REAR STABILIZING JACK.

UNITED STATES MARINE CORPS
Utilities Instruction Company
Marine Corps Base
Camp Lejeune, North Carolina 28542

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Nov 1983
(D-404)drf

STUDENT HANDOUT #2

FIELD WASHING FORMULAS

UNIT OF INSTRUCTION: Field Laundry Washing Formulas

FORMULAS

All formulas in this handout are for use with the single trailer laundry unit. Water level, time, and temperature of the laundry operation for the single trailer laundry unit are shown in each formula. The detergents in each formula are effective in both soft and hard water.

a. Formula I

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	8	5	100/38	Detergent, type I, 6 oz
Suds	8	5	130/55	Detergent, type I, 4 oz
Suds	8	5	140/60	Detergent, type I, 2 oz
Rinse	12	2	140/60	....
Rinse	12	2	120/49	....
Rinse	12	2	100/38	Sour, 2 oz

b. Formula II

Formula II is used to launder woolen items such as blankets, winter uniforms, winter underwear, and socks. To reduce shrinkage and strain on the items, the washer should be fully loaded and stopped during filling and draining. Also, the tumbler should be fully loaded.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	12	5	90/32	Detergent, type II, 6 oz
Suds	12	5	90/32	Detergent, type II, 4 oz
Rinse	12	2	90/32	....
Rinse	12	2	90/32	....
Rinse	12	2	90/32	Sour, 2 oz

c. Formula III

Formula III is used to launder cotton items used in hospitals. When the supply of fresh water is low, seawater can be used if type II detergent is used in twice the amount shown for each suds operation. Fresh water should be used for the last two rinses. A bleaching agent should be used when white clothing or bedding is laundered.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	8	5	100/38	Detergent, type I, 6 oz
Suds	8	5	130/55	Detergent, type I, 4 oz
Suds	8	5	140/60	Detergent, type I, 2 oz
Rinse	12	2	160/71	....
Rinse	12	2	140/60	....
Rinse	12	2	110/43	Sour, 1 oz

d. Formula IV

Formula IV is used to make outer clothing, such as field wear and raincoats, water-repellant. Soiled garments sometimes lose repellancy. If the garments show poor water-repellancy after they are laundered and dried they should be treated again. Water-repellant-treated garments must never be starched.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	8	5	100/38	Detergent, type I, 6 oz
Suds	8	5	130/55	Detergent, type I, 4 oz
Rinse	12	2	140/60	....
Rinse	12	2	140/60	....
Rinse	12	2	120/49	....
Rinse	12	2	120/49	....
Water-repellant treatment	1 1/2	10	100/38	Compound, water-repellant, textile-finish, type I aqueous, 3 pints

e. Formula V

Formula V is used for mothproofing woolen items before they are stored for the summer or returned to stock. After washing the clothing put it in the extractor for 4 minutes. Then dry the clothing at not more than 140° F/60° C.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	12	5	100/38	Detergent, type II, 6 oz
Suds	12	5	100/38	Detergent, type II, 3 oz
Rinse	12	3	100/38	....
Rinse	12	3	100/38	....
Rinse	12	3	100/38	Insecticide,DDT,1 1/2 pt

f. Formula VI

Formula VI is used to decontaminate clothing that has been radioactively contaminated above the maximum tolerance level. For woolen clothing, the formula must be changed to use type II powder detergent with water temperature not more than 100° F/38° C. Also, the washer-extractor cylinder must be fully loaded and stopped during filling and draining. For white clothing or bedding, a bleaching agent should be used. A recommended organic chelating agent is tetrasodium salt of enthylene diamine tetraacetic acid which is available commercially as Versene, Nullapon, or Sequestrene S.T. When hard water is used, the amount of chelate should be increased at the rate of 1 ounce cheltate per 83 grains of water hardness. An equal weight of sodium hexametaphosphate or sodium tetraphosphate may be substituted for the organic chelating agent.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	9	5	90/32	Detergent, type I, 6 oz
Acid	12	5	140/60	Citric acid crystals, 4 lb
Acid	12	5	140/60	Citric acid crystals, 2 lb
Chelate	12	5	140/60	Chelating agent, 1 lb. dry weight
Chelate	12	5	140/60	Chelating agent, 1 lb. dry weight
Rinse	12	3	140/60	....
Rinse	12	3	120/49	....
Sour	12	5	tap water	Laundry sour, 1 1/2 oz (use equal parts of sodium silicoflouride and sodium acid flouride)

g. Formula VII

Formula VII is used to launder and decontaminate unimpregnated cotton and woolen items that have been chemically or biologically contaminated. Detergent and super tropical bleach (NSN 6850-00-264-8942) must be mixed together in water before they are put in the washer. Cotton and woolen items must not be put in the same wash load. When items such as belts, webbing, canteen covers, and pack carriers are washed, the time of the first suds should be increased to 15 minutes.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	12	5	90/32	Detergent, type II, 6 oz; decontaminating agent; super tropical bleach (STB), 2.5lb
Suds	12	5	90/32	Detergent, type II, 4 oz
Rinse	12	2	90/32	....
Rinse	12	2	90/32	....
Rinse	12	2	90/32	Sour, 2 oz

h. Formula VIII

Formula VIII is used to launder durable press garments. Be sure the washer is loaded to only two-thirds of its capacity.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	12	5	140/60	Detergent, type II, 8 oz
Suds	12	5	125/52	Detergent, type II, 4 oz
Rinse	12	3	110/43	....
Rinse	12	3	100/38	....
Rinse	12	3	100/38	....

i. Formula XI

Launder and reimpregnating formula: This formula is used for laundering and reimpregnating chemical protective clothing outfit.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies
Suds	11	3	90/32	Detergent, type II, 6 oz
Suds	11	3	90/32	Detergent, type II, 3 oz
Rinse	11	3	90/32	....
Rinse	11	3	90/32	....
Reimpregnation	11	10	120/49	6lbs XXCC3 - prepared as a slurry

NOTE: In the last operation, do not pour the prepared batch of XXCC3 into the washer until after the water at 120°F has been put into the washer. Slosh about a gallon of warm water around in the can to loosen the remaining XXCC3 slurry, and pour this into the washer. It is important to get as much of the XXCC3 into the washer as possible. Run the washer for 10 minutes, extract for one minute and dry. The garments are to be removed from the dryer when warm to the touch.

j. Formula X

Delicate garments.

Operation	Water level (in.)	Time (min.)	Temperature °F/°C	Supplies per 100 lbs. clothing (1)
Suds	12-15"	5	120°F	5 ozs. Detergent laundry Type II (2)
				8 ozs. Sodium Metasilicate (3)
Suds	12-15"	10	120°F	3 ozs. Detergent Laundry Type II
				6 ozs. Sodium Metasilicate
Rinse	12-15"	3	120°F	Water
Rinse	12-15"	3	100°F	Water
Sour	12-15"	5	95°F	Sour to pH 5.0 (4)

(1) The washer should be about 2/3 the rated capacity of the washer.

(2) Detergent Laundry Federal Specification P-D-245, FSN 7930-99-1221.

(3) Sodium Metasilicate Federal Specification 0-S-604, FSN 6810-281-2054.

(4) 2-3 ozs. Sodium Silico Fluoride, Federal Specification P-S-683, Sour Laundry, FSN 7930-291-8321.

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DETAILED OUTLINE

TENT PITCHING, STRIKING, AND FOLDING

INTRODUCTION: (5 MIN)

1. GAIN ATTENTION: During your time in the military you will be required to sometimes spend a few nights in the field. Sometimes the weather gets really nasty and you will need a shelter. This class will teach you what you will need to know in order to provide yourself and your fellow Marines with this shelter.

2. PURPOSE: The purpose of this period of instruction is to provide the student with the procedures, knowledge and skill required to pitch, strike, and fold tents.

3. INTRODUCE LEARNING OBJECTIVES:

a. ENABLING LEARNING OBJECTIVE(S): Provided with a Tent, GP Medium, and a mallet, erect the tent in accordance with TM 10-8340-211-13, chapter 3. (1.5.1a)

b. I will do this by lecture and application.

TRANSITION: Now that we have discussed what we are to do during this period of instruction let us take a look at a general description of the tent.

BODY (MIN)

1. TENT (TP # 1 ON)

a. The medium tent is rectangular and has a slanted roof (TP # 1 OFF)

(TP # 2 ON)

b. The tent is made in one piece, the walls are split at the four corners and are fastened with zippers (slide fasteners).

c. The tent has two doors, one at each end. (TP # 2 OFF)

2. COMPONENT HARDWARE (TP # 3 ON)

a. Pins. There are two sizes of wooden pins: The large ones are 24" long and the small ones are 16" long. (TP # 3 OFF) (TP # 4 ON)

b. Lines and fairlead. Most guylines are attached to the tent through a metal fairlead. (TP # 4 OFF) (TP # 5 ON)

c. Poles. There are four sizes of poles. The eaves and door poles come in one piece (the door pole is a little longer than the eave pole). The center pole is almost twice as long as the eave pole It comes in two sections. The ridge pole is the longest. It also comes in two sections. (TP # 5 OFF) (TP # 6 ON)

3. STEPS FOR SETTING UP TENT (MIN)

a. Remove the tent from the tent cover

(1) Untie the tent cover

(2) Slip the 3'x3' folded tent off the tent cover.

(TP # 6 OFF)

b. Remove wooden pins from the box

c. Lay poles near the cleared area

d. Prepare the pins, poles, and ridge guy lines.

(1) Separate the long pins from the short pins

(2) Separate the door poles from the eave poles

(3) Separate the center pole section from the ridge pole section

(4) Join the center pole and ridge pole sections. (Top of the ridge pole sections are slightly rounded; they must match when joined).

(5) Take one of the 50 foot ridge guy lines, and fold in half.

(6) Do the same for the other ridge guy lines.

e. Unfold the tent. (TP # 7 ON)

(1) Place the 3'x3' folded tent in the middle of a cleared area

(TP # 7 OFF)
(TP # 8 ON)

(2) Unfold the tent to a 3'x6' fold (TP # 8 OFF)

(TP # 9 ON)

(3) Unfold the tent to a 16'x6' fold (TP # 9 OFF)

(4) Unfold second fold of the tent roof.

(5) Unfold first fold of the tent roof.

(TP # 10 ON)

(6) Unfold side walls

(7) Unfold end walls and doors

(8) Untie flaps on both stove pipe openings on tent roof.

(TP # 10 OFF)
(TP # 11 ON)

f. Position laid-out tent

(1) Make sure that the corners of the tent are square.

(2) Tuck walls under tent, but leave guy lines stretched out away from tent. (TP # 11 OFF)
(TP # 12 ON)

g. Position the pins and poles

(1) Drive a short wooden pin straight into the ground next to each corner of the tent.

(2) Slip corner foot stops over the pin. (TP # 12 OFF)
(TP # 13 ON)

(3) Lay the eave poles 90° to the tent so that the spindle ends face the tent walls at each eave grommet. (TP # 13 OFF)
(TP # 14 ON)

(4) From the other end of the eave pole, measure 24" (the length of one long wooden pin) out from each side of the pole, and drive long wooden pins into the grommet. (TP # 14 OFF)
(TP # 15 ON)

(5) Drive long pins into the grommet at a 60° angle with the top of the pins leaning toward the tent notches facing away from the tent.

(6) Attach side guy lines to the pins (As you are looking at the tent, the top lines goes to your left and the bottom lines goes to your right.
(TP # 15 OFF)
(TP # 16 ON)

(7) Lay two eave poles 90° to the corner of the tent.

(8) Measure over 12" from the smooth end of each eave pole toward the corner of the tent (one half the two length of a long wooden pin).(TP # 16 OFF)

(9) Drive in two long wooden pins at 60° angle so the top of the pins lean toward the tent and the notches face away from the tent.

(10) Remove one eave pole, and leave the other with the spindle end facing the grommet.

(11) Attach corner guy lines to pins. (As you are looking at the fair lead on the tent the top guy line goes to the left and the bottom guy line goes to the right.)

(12) Repeat steps (7),(8),and (9) for the other three corners

(13) Go to each corner pin (4) closest to the doors, and lay the smooth end of an eave pole so that the pole is lying straight out away from the tent.
(TP # 18 ON)

(14) Measure out to the metal band below each spindle (5') and drive in long wooden pins. (TP # 18 OFF)

(15) Lay one eave pole 90° to each side of the door opening.
(TP # 19 ON)

(16) Measure over 12" from the smooth end of each eave pole away from the door opening (one-half the length of a long wooden pin).

(17) Drive in two long wooden pins at 60° angle so that the top of the pins lean toward the tent and the notches face away from the tent.

(18) Attach door guy lines (2) to pins. (TP # 19 OFF)
(TP # 20 ON)

(19) Make sure your final tent layouts look like this: (TP # 20 OFF)

h. Raise the tent walls. (TP # 20 ON)

(1) Slip the corner eave poles under the tent walls, and push the spindle end through the grommets. (One person must be at each corner.)
(TP # 20 OFF)
(TP # 21 ON)

(2) Lift each corner pole to the upright position

(3) Tighten guy lines just enough to hold tent corners in the upright position. (TP # 21 OFF)
(TP # 22 ON)

(4) Slip the eave poles under the tent walls, and push the spindle end through the eave grommets.

(5) Lift each eave pole to the upright position. (TP # 22 OFF)

(6) Tighten guy lines just enough to hold tent walls in the upright position.

(7) Slip the door poles (6'x2") under the tent walls near the door openings and push the spindled end through the eave grommets above the front and rear doors.

(8) Tighten door guy lines just enough to hold the doors in the upright position.

i. Set up and assemble poles.

(1) Take the ridge pole into the tent through the door.

(2) Slide the two center poles into the tent under the side wall.

(3) Put the spindles of the center poles through the holes in the ridge pole, and have the rounded side facing towards the roof.

(4) Raise the center poles in order to put the same spindles through both the ridge plates and the grommets in the tent roof.

j. Straighten the tent.

(1) Reach through the stove pipe openings next to each grommet in the tent roof with the folded end of the 25 foot ridge guy line.

(2) Attach the ridge guy lines to the spindle of the center poles.

(3) Toss the lines to someone outside the tent for attaching to the long pins.

(4) Raise the center poles straight up (vertical) inside the tent. This might take two persons at each pole.

(5) Tighten ridge guy lines and secure.

(6) Be sure that all guy lines are now attached to the pins and that the poles are straight. Tighten lines just enough to remove all wrinkles from the tent.

(7) Close zippers (slide fasteners) at the four corners.

(8) From the inside of the tent, tie jumper lines attached near each pole to all the eave poles and door poles.

(9) Fasten tie tapes at inside corners of tent around corner eave poles.

(10) Drive short wooden pins at remaining side and end wall-foot stops, and attach foot stops to pins.

k. Dig a trench around the tent.

(1) Dig the side next to the tent wall 5" deep straight down and 4 to 5" away from the foot stop pins.

(2) Slant the other side of the ditch.

l. Additional Information

(1) Taking down the tent. Striking (taking down) the tent is done by <u>REVERSING</u> all the steps you have just learned.

<u>OPPORTUNITY FOR QUESTIONS:</u> (MIN)

1. <u>QUESTIONS FROM THE CLASS</u>

2. <u>QUESTIONS TO THE CLASS</u> (MIN)

a. How long are the door poles?

ANSWER: 6'5" long

b. How many center poles come with the tent

ANSWER: Two (2)

c. How far from the upright poles are the tent pins driven?

ANSWER: 24" on each side

CONTROLLED PRACTICAL APPLICATION:

a. Divide the class into two teams

b. March class to Predesignated area.

c. Teams will be given one tent and all components and will

(1) Prepare the area

(2) Unfold the tent

(3) Prepare pins, poles, and ridge guy lines

(4) Position laid out tent

(5) Position the pins and poles

(6) Raise the tent walls.

(7) Set up and assemble ridge poles

(8) Set up and assemble center poles

(9) Raise the roof

(10) Straighten the tent

(11) Dig a trench around the tent

d. After the assembly is completed, students will disassemble, fold and store the tent for storing.

SUMMARY

a. Procedures for pitching a tent.

b. Procedures for striking a tent.

c. Procedures for folding a tent.

POST TEST: NONE

BREAK (10 MIN)

LIST OF SUPPORTING PAPERS

1. Student Outline
2. Transparency # 1 Medium Tent

Transparency	# 1	Medium Tent
	# 2	Four Corners
	# 3	Pins
	# 4	Lines
	# 5	Poles
	# 6	Performance Steps
	# 7	Unfold Tent 3x3
	# 8	Unfold Tent 3x6
	# 9	Unfold Tent 16x6
	#10	Unfold Tent Roof
	#11	Layout
	#12	Position Poles and Pins
	#13	Eave
	#14	Wooden Pins
	#15	Long Pins
	#16	Eave Poles
	#18	Metal Band
	#19	Measure Eave Pole
	#20	Final Tent Layouts
	#21	Set Corner Poles
	#22	Lift Eave Poles