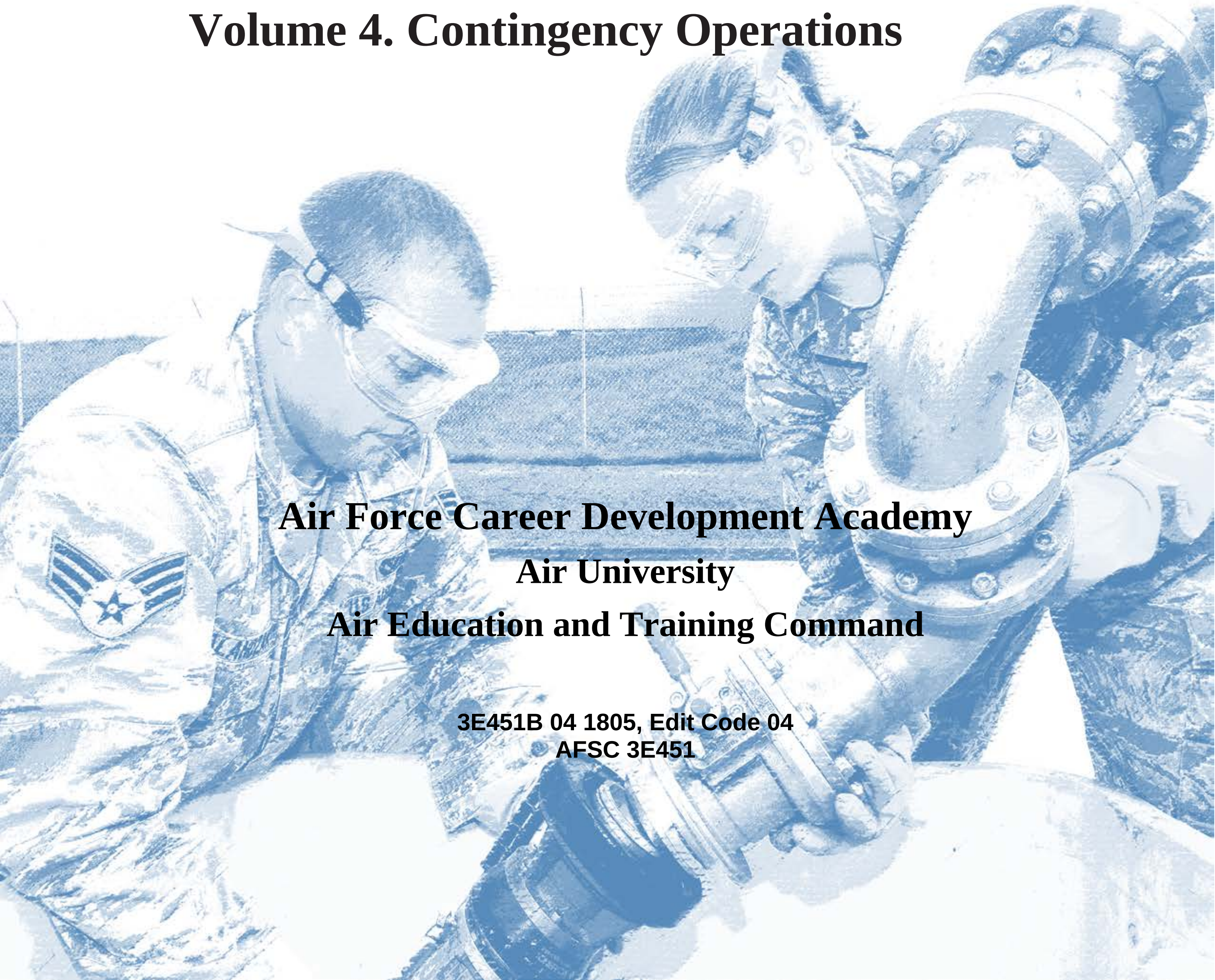
CDC 3E451B

Water and Fuel Systems Maintenance Journeyman

Volume 4. Contingency Operations



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WELCOME TO 3E451B, Volume 4, of your *Water and Fuel Systems Maintenance Journeyman* course. This volume contains 3 units of specialization training that is required to become a Water and Fuel Systems Maintenance Journeyman. This volume will introduce you to most of the wartime equipment we operate and maintain for water, waste, and fuel operations.

Unit 1 covers the Reverse Osmosis Water Purification Unit (ROWPU).

In Unit 2 you will be introduced to expedient beddown methods to include Basic Expeditionary Airfield Resources (BEAR) subsystems and BEAR assets.

Unit 3 covers expedient field construction and repair to include waste disposal systems, sanitary landfills, and alternate water sources and will familiarize you with contingency fuel operations to include the Rapid Utility Repair Kit (RURK I).

Upon completion of this volume, you will have gained the information needed to have a working knowledge of most of the equipment that you will train with at Silver Flag training sites as well as see and use out in the field.

A glossary of terms, abbreviations, and acronyms used in this course is included at the end of this volume.

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This volume is valued at 21 hours and 7 points.

NOTE:
In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Unit 1. The Reverse Osmosis Water Purification Unit

WE HAVE FINALLY ARRIVED at the subject matter that is at the heart of your existence as a Water and Fuel Systems Maintenance (WFSM) journeyman. Your sole reason for being in this Air Force specialty (AFS) is to perform wartime taskings and provide water to a deployed air wing in the field. This volume is by far the most important volume in this course. We cover a lot of detail about the reverse osmosis water purification unit (ROWPU) in this unit. You will study the general characteristics of the unit's basic nomenclature, component identification, use, and maintenance. The first two sections of this unit will familiarize you with the ROWPU. In the third and fourth sections, you will study the operation and maintenance of the ROWPU.

1–1. Identification

Before you can understand how to operate and maintain the ROWPU, you must be able to recognize and identify the various characteristics and components and the purpose of each. This is important because the ROWPU is a very technical and expensive piece of equipment.

601. Characteristics of the ROWPU

In today's Air Force (AF), we operate the 1,500 gallons per hour (gph) model ROWPU. We use Technical Order (TO) 40W4–20–1, *Operations and Maintenance Instruction with Illustrated Parts Breakdown (IPB)—1500 Reverse Osmosis Water Purification Unit (ROWPU),* to operate, service, and maintain the 1,500 gph ROWPU.

1,500 gph

Throughout the text, we will reference the 1500 model shown in figure 1–1. The national stock number (NSN) of the 1,500 gph unit is 4610–01–530–3255. The 1,500 gph model is specifically designed for the United States Air Force (USAF). The 1,500 is skid-mounted (no trailer) with two forklift pockets in the frame and has a dry weight of 8,000 pounds.

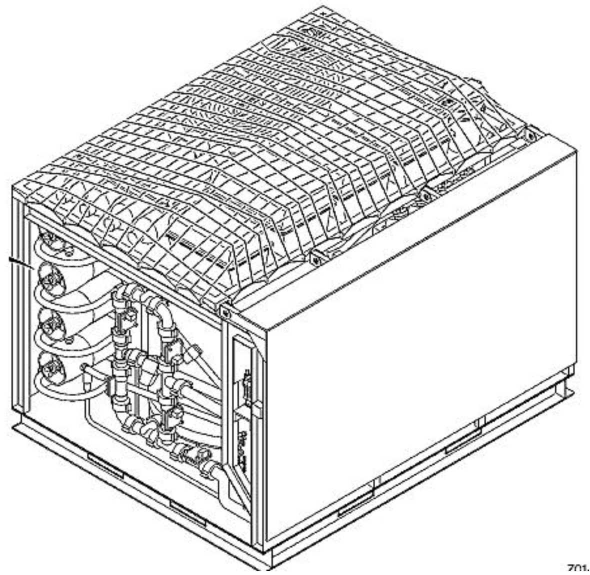


Figure 1–1. 1,500 gph ROWPU.

ROWPU piping

To operate the ROWPU properly, you must recognize the stage of treatment and how the water flows through the unit. As an aid, all ROWPU models have colored bands on the unit piping. These bands are installed so you can identify the stage of treatment of the water each pipe carries. This becomes especially important when you want to “follow” the flow of water as it becomes treated. You can see the color band designations in the table below.

1500 ROWPU Piping Identification			
ROWPU piping is identified according to function by the following colors		ROWPU tubing is identified according to function by the following colors	
FUNCTION	**COLOR**	**FUNCTION**	**COLOR**
Raw water	Black band	Polymer	Blue band
Filtered water	Yellow band	Sodium hexametaphosphate (also called sodium hex)	Green band
Brine water	Purple band	Citric Acid	Yellow band
Product water	Blue band	Chlorine (Cl2)	Red band
Backwash waste	Red band		

The color bands are there to help you recognize the flow-through of unit water during initial use of the unit.

Technical capabilities

The 1500 ROWPU is capable of purifying water at an average rate of 1,500 gph. It is designed to produce water for 20 hours each day—reserving the remaining 4 hours for downtime maintenance actions. It can purify water that is highly polluted, turbid, colored, salty, or contaminated. It is even capable of purifying water contaminated by nuclear, biological, and chemical (NBC) contaminants. It is designed to be air, rail, and truck transportable and flexible in its application in the field to meet various requirements. It can be powered by a 35 kilowatt (kW) per hour generator or commercial power and has an easily accessible, useful control panel. The ROWPU’s most outstanding feature is that it is designed to be compact, allowing you to pack all the required hoses, bladders, pumps, tools, and test equipment within the structural confines of the unit itself. When shipped to your deployed location, this unit is literally designed to have everything you need to purify water with the exception of calcium hypochlorite ($Ca(C1O)_2$).

602. Component identification

The ROWPU consists of various major components described in the text below.

Major components

Each of these components plays an integral part in purifying water. To understand how the ROWPU works, you must be able to identify and understand what each component does. Refer to figure 1–2 and the following two tables as we identify and discuss each of these unit components and purpose.

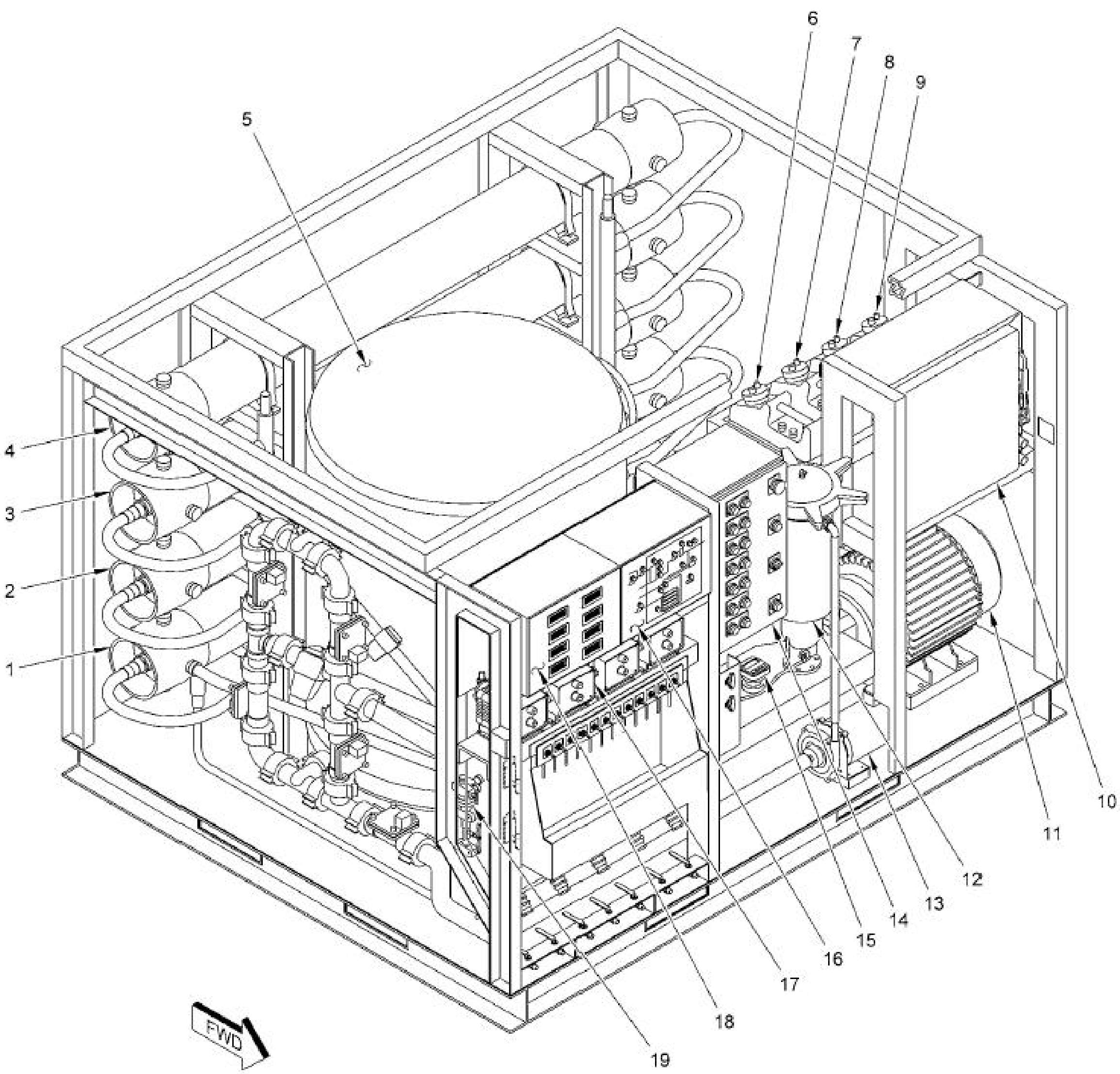


Figure 1–2. 1,500 gph ROWPU major components.

Major ROWPU Components						
FIGURE & INDEX NUMBER	PART NUMBER	CAGE	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY	USABLE ON CODE	SMR CODE
1	701–1500–1	0AK83	1500	1		
1	410–1500–12–1	0AK83	. RO PRESSURE VESSEL #1	1		
2	410–1500–12–2	0AK83	. RO PRESSURE VESSEL #2	1		
3	410–1500–12–3	0AK83	. RO PRESSURE VESSEL #3	1		
4	410–1500–12–4	0AK83	. RO PRESSURE VESSEL #4	1		
5	410–1500–10	0AK83	. MEDIA FILTER	1		
6	701–13226E7990–4	0AK83	. CHEMICAL CAN,	1		
7	701–13226E7990–1	0AK83	. CHEMICAL CAN,	1		
8	701–13226E7990–2	0AK83	. CHEMICAL CAN, SODIUM	1		
9	701–13226E7990–3	0AK83	. CHEMICAL CAN, CITRIC	1		
10	701–1500–28	0AK83	. DISCONNECT JUNCTION	1		
11	404–1500–8	0AK83	. RO PUMP ASSEMBLY	1		
12	801–1500–11	0AK83	. BAG FILTER HOUSING	1		
13	701–1500–22	0AK83	. BOOSTER PUMP	1		
14	701–1500–29	0AK83	. PUSH BUTTON CONTROL BOX	1		
15	801–1500–21	0AK83	. TDS/PH	1		
16	701–1500–30	0AK83	. PILOT LIGHT ENCLOSURE	1		
17	404–RO781–1	0AK83	. PUMP, CHEM	4		
18	701–1500–31	0AK83	. ANALOG	1		
19	410–1500–112	0AK83	. HIGH-PRESSURE BOOSTER	1		

Component Identification and Purpose		
Item	***Component***	***Purpose***
1–4	Reverse osmosis (RO) pressure vessels	Third stage of filtration—there are four RO pressure tubes, each containing two RO elements. The elements are designed to purify water by removing dissolved solids.
5	Media filter	First stage of filtration—large particles of suspended solids are removed by the various layers of filter material in the tank.
6–9	Chemical cans	There are four chemical cans—Cl2, polymer, sodium hex, and citric acid.
10	Disconnect junction	Main breaker for power supply.
11	RO pump assembly	Electrically driven high-pressure pump increases system water pressure to the RO Pressure Vessels for operation of the RO process.
12	Bag filter	Second stage of filtration—removes finer suspended solids that pass through the multimedia filter.
13	Booster pump	Electrically driven, centrifugal pump increases water pressure to the bag filter.
14	Pushbutton control box	Contains start-stop buttons for all pumps, backwash cycle, vent vessel switch, light panel reset/test, and emergency stop button.
15	Total dissolved solids (TDS)/potential of hydrogen (pH) meter	Displays TDS/pH entering bag filter.
16	Pilot light enclosure	Displays status of pumps (on/off), position of vent switch, and any faults.

Component Identification and Purpose		
Item	***Component***	***Purpose***
17	Chemical feed pump	A four-chemical feed pump that pumps chemicals out of cans to the desired injection point. Provides the operator with a single point of chemical feed control.
18	Analog	Holds analog displays for water flow throughout the ROWPU system.
19	High-pressure booster	Turbo charger that takes the discharge from the RO pump and increases the pressure using energy recovered from the brine water discharge.

All of the items mentioned in the table are the major internal components of the ROWPU. These components are not easily interchangeable and are complicated to repair or replace.

Basic issue items

The major internal components are not the only items necessary to operate the ROWPU; instead, additional components, called basic issue items (BII), are used with the major components to operate the ROWPU. In the following information, we will lay out the complete "picture" of what a ROWPU looks like when it is completely set up.

NOTE: Some accessories are heavy and difficult to handle. To prevent injury to personnel and damage to the equipment, two people are required to lift and remove the raw water pumps, BII, and distribution pump from the ROWPU.

Strainer and float

Attach the strainer (fig. 1–3) to the suction hose of one of the raw water pumps to prevent the intake of damaging objects. Use a float to keep the strainer off the bottom of the water source. Without the float, the suction hose would needle itself into the bottom of the water source.

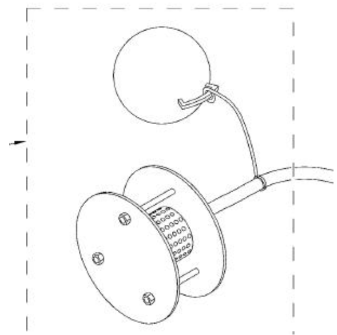


Figure 1–3. Strainer and float.

Ocean Intake Structure System

The 1500 ROWPU may use the Ocean Intake Structure System (OISS) (fig. 1–4). The OISS allows seawater to be extracted from the ocean through low and high tides. However, it can also be used with freshwater sources (lakes, streams, etc.). Depending on the source, you can also use the ocean intake system or the strainer float. The ocean intake structure uses wellpoints that are jetted into the floor of the water source by using a raw water pump. The wellpoints are especially used to extract water from low-water depth sources or when low-tide conditions are a factor. Install the OISS at maximum low tides to eliminate the need to move the wellpoints as tides change.

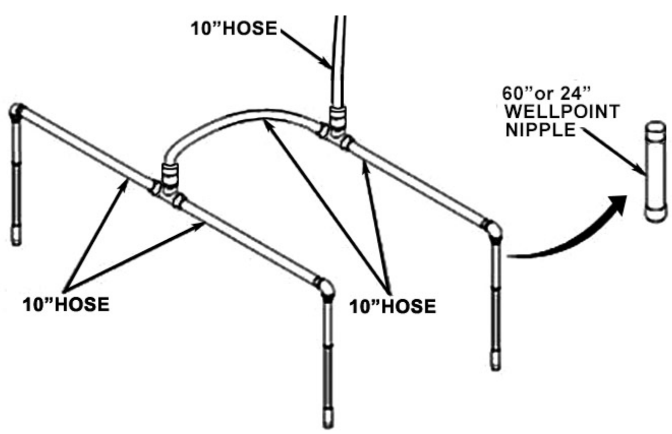


Figure 1–4. OISS.

Raw water pumps

The ROWPU can use two electrical centrifugal pumps (fig. 1–5) for pumping raw water from the water source to the ROWPU when head requirements demand. These pumps are designed to pump 50 gallons per minute (gpm) at a head of 105 feet (') and 20' of suction lift. These pumps are normally connected in series with each other unless the unit is 125' or less from the water source where only one raw water pump is sufficient.

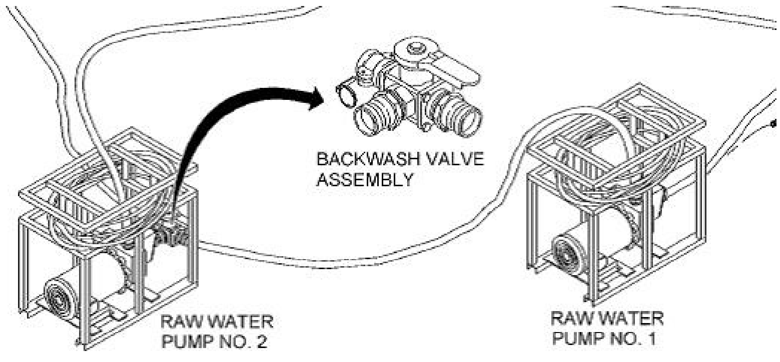


Figure 1–5. Raw water pumps/backwash valve.

Product water tanks

Product water tanks, also referred to as *product water bladders* (fig. 1–6), can hold 20,000 gallons (gal.) of purified water.

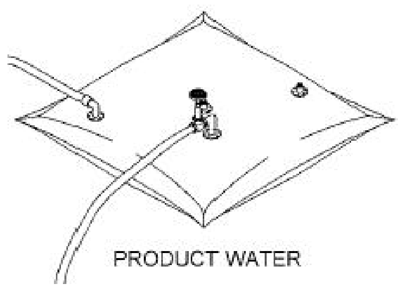


Figure 1–6. 20,000 gal. water bladder.

Distribution pump

The distribution pump (fig. 1–7) is an electrically driven centrifugal pump used to pump water from the product tanks to the end user point. The distribution pump has a capacity of 50 gpm at 50' of head.

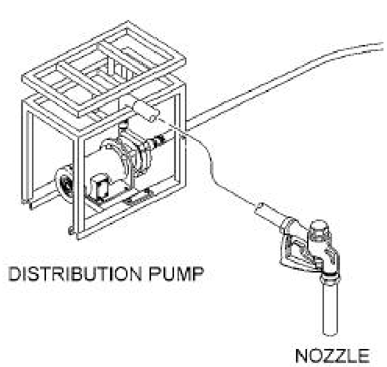


Figure 1–7. Distribution pump/dispensing nozzle.

Dispensing nozzle

The nozzle controls water flow from the distribution pump shown in figure 1–7. This nozzle is hand operated by depressing a lever, very much like pumping gasoline into your vehicle. In order to minimize contamination, do not leave the nozzle on the ground when not in use.

Backwash water tank

The backwash water tank is also known as the *brine* tank (fig.1–8). This 20,000 gal. bladder is used to collect brine water, which is a byproduct of the ROWPU as it purifies raw water. The brine tank acts as a ready reserve of backwash water. Always label the brine tank with large distinguishable letters to prevent others from trying to use it for product water.

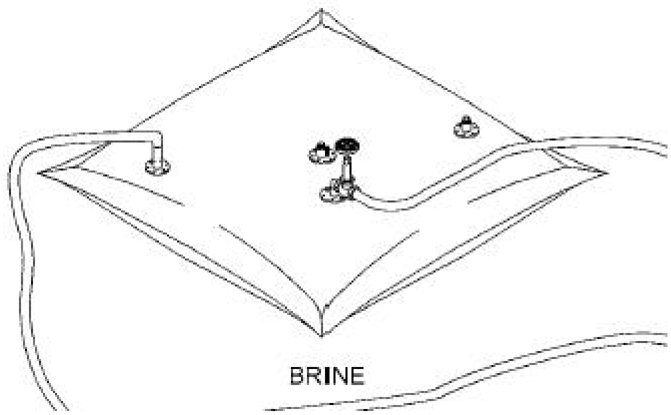


Figure 1–8. Brine, 20,000 gal. water bladder.

Suction hoses

These black wire wound rigid hoses shown in figure 1–9, are used at all pump inlets and anywhere else where negative pressures may occur within the ROWPU system. Quick-disconnect (QD) couplings at the ends of the hoses aid the rapid assembly and disassembly of hose connections during operations. Suction hoses with a blue stripe running the length of the hoses are only intended for use with product water (purified water). Do not use the blue striped hoses in the raw water or backwash water systems.

Discharge hoses

These white rubber lined hoses shown in figure 1–10, are designed to be connected at all pump discharges and to distribute water away from the pumps or the ROWPU under pressure. When not under pressure, these hoses lose their form and become flat. QD couplings at the ends of these hoses aid in the rapid assembly and disassembly of hose connections during operations. Discharge hoses intended for product water use only have a blue stripe running the length of the hose. Do not use these blue striped discharge hoses for the raw water or backwash system.

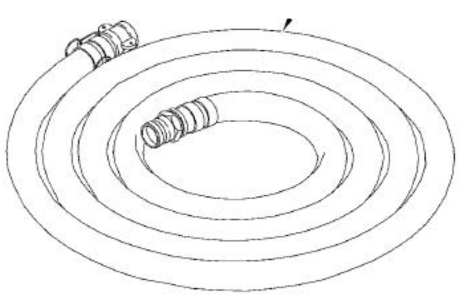


Figure 1–9. Wire reinforced hose assembly (suction hose).

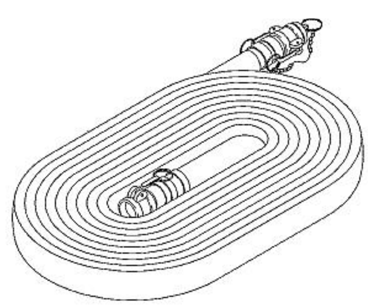


Figure 1–10. Canvas hose (discharge hose).

Gate valves and couplings

Gate valves (fig. 1–11) are used throughout the ROWPU setup to control flow and isolate tanks during operations. Various sizes of couplings, adapters, reducers, and nipples are supplied with the unit to meet operational requirements.

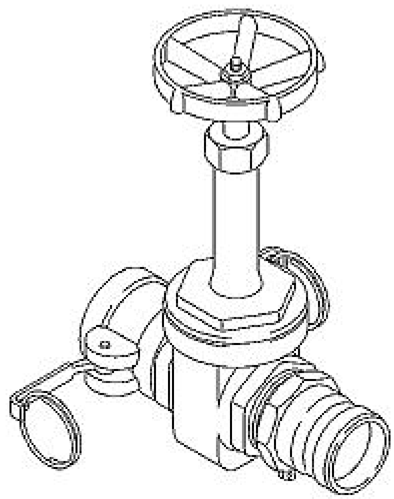


Figure 1–11. Gate valve assembly.

Deionization cartridges

The deionization (DI) cartridges, shown in figure 1–12, are used to remove NBC contaminants from product water. Four different cartridges are used—two to remove chemical/biological contaminants and another two to remove nuclear contaminants.

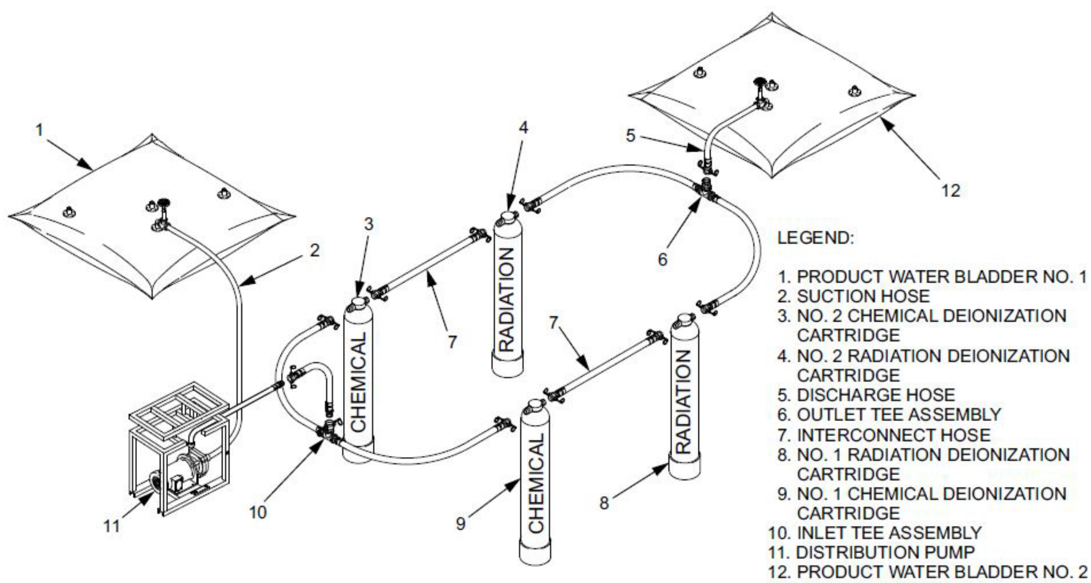


Figure 1–12. DI cartridges.

Reverse osmosis elements

Two RO elements (fig. 1–13) are installed in each of the four RO vessels. The RO elements remove dissolved solids (salts) from the water. The RO elements are the heart of the ROWPU; without them, the ROWPU cannot purify water high in dissolved solids, such as seawater.

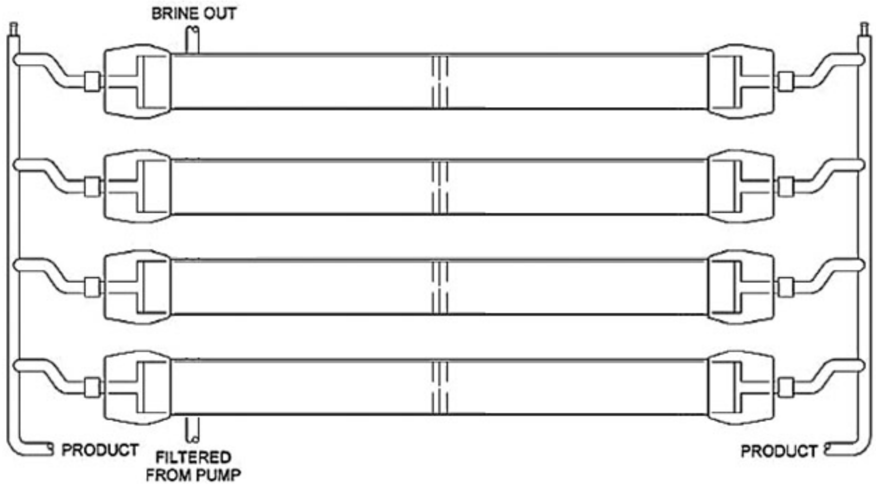


Figure 1–13. RO vessels/RO elements.

Storage chests

Five storage chests (fig. 1–14) are included on the ROWPU during transportation. These chests contain all the chemicals, tools, and small system components necessary for operation. These items are stored inside the chests to prevent them from becoming lost or damage. You'll find a parts inventory of the contents of each chest on the inside of the chest cover.

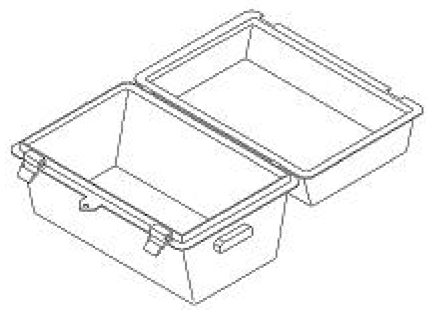


Figure 1–14. Storage chest.

Bag filter

This filter removes finer suspended solids that pass through the multimedia filter. The bag filter is a 5-micron cleanable filter that should be cleaned or replaced when the filter gauge differential pressure rises above 20 pounds per square inch differential (psid).

Turbidity meter

The turbidity meter (fig. 1–15) is a hand-held device that measures the turbidity of the product water.

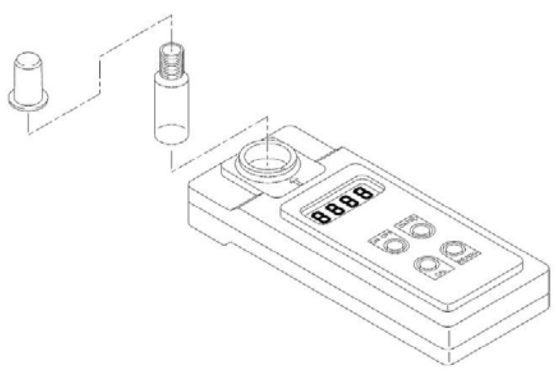


Figure 1–15. Turbidity meter.

Ultrameter, 6P

The Ultrameter, 6P (fig. 1–16) is an advanced meter that can measure pH, TDS, and temperature.

Chemical cans

Chemical cans (fig. 1–17) are used to contain the four chemicals used during operations. These chemicals are citric acid, sodium hex, polymer, and Cl2. The chemical cans act as reservoirs for the chemical feed pump supported by a metal frame inside of the unit.

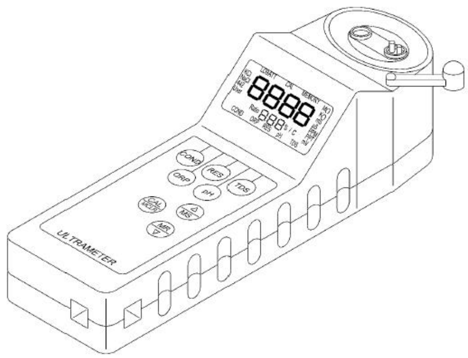


Figure 1–16. Ultrameter, 6P.

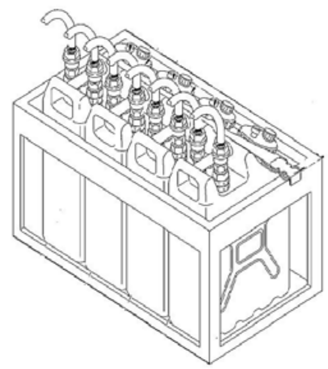


Figure 1–17. Chemical cans.

Generator

A 35 kW, 208-volt, 60-hertz generator (fig. 1–18) is needed to power the ROWPU. When ordering the ROWPU kit, make sure you include the unit type code (UTC) for the generator and the amount of generators required.

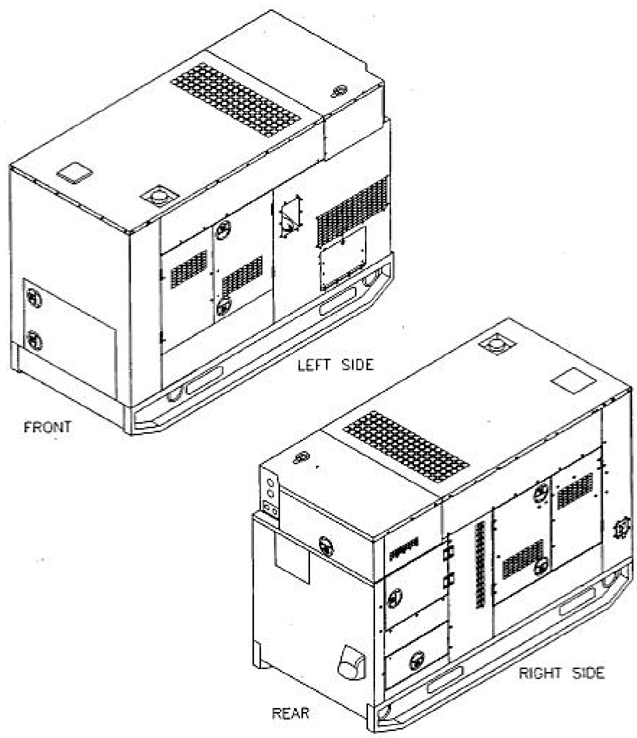


Figure 1–18. 806B–816B generator.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

601. Characteristics of the reverse osmosis water purification unit

1. What model ROWPU is specifically designed for the USAF?

2. What aids the operator in identifying the stage of treatment each pipe carries on the ROWPU?

3. What ROWPU color band designation identifies piping contents as raw water?

4. What is the average rate of water a 1500 ROWPU can purify?

602. Components identification

1. What is the purpose of the high-pressure booster?

2. What is used with the major components to operate the ROWPU?

3. What does the OISS use to extract water from the source?

4. How much water can the “product water bladders” hold?

5. What is the purpose of the DI cartridges?

6. How many RO elements are installed in each RO vessel?

1–2. Principles

By now, you have probably figured out the ROWPU is a very complicated piece of equipment. After our last lesson, we are confident you know and can identify all the components of the ROWPU. Let us turn our attention to the basic principles of ROWPU operation; in other words, how the ROWPU works. After the formation of the rapid deployment force (RDF) in the late 70s, the need arose for the development of a water purification unit that could produce potable water from seawater for deployed troops. In response to this need, a 600 gph water purification unit was developed. Over the years, modernization of the unit inspired a new model—the 1,500 gph ROWPU. The AF's 1,500 gph unit has the ability to produce potable water from either brackish, seawater, sewage, or NBC water.

603. Technical principles of the ROWPU

The main principle of water treatment in the ROWPU revolves around the use of a process called *reverse osmosis*. RO is the process by which purified water is separated from available seawater or brackish water sources. This water is forced under extreme pressures through a spiraled module of tightly wrapped layers of a porous material. To understand RO, you must first understand osmosis.

Osmosis

Osmosis is a natural process occurring in all plants and animals. Osmosis is the process that occurs when two water solutions, one high in solids and the other low in solids, are separated by a membrane that only allows the water molecules to pass through.

The water, having a low concentration of solids, flows toward the side that has a high concentration of solids (fig.1–19). This osmotic pressure then equalizes the dissolved solids on both sides of the membrane. The movement of water through a permeable membrane from an area of lesser concentration to an area of higher concentration to equalize the concentration of the water on both sides of the membrane is called *osmosis*. This is very much like what happens when you sweat. When you sweat, the salt contained in your body will diffuse through your skin until an equal amount of salt remains on your skin after your skin dries. This is osmosis.

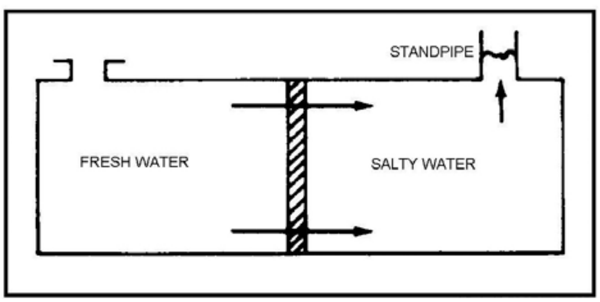


Figure 1–19. Osmosis.

Reverse osmosis

RO is then what the name implies—the reversal of the natural osmosis process. RO is not a natural act; instead, it can only be done through mechanical means. In the RO process, pressure is applied to the water that is high in dissolved solids.

This pressure forces the water through a semi-permeable membrane. This membrane allows the water to pass but not the solids (fig. 1–20). The water on the other side of the membrane has little or no dissolved solids present.

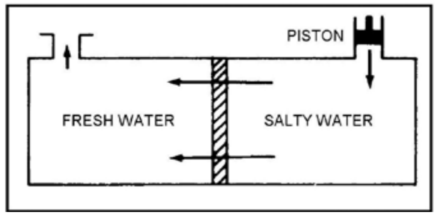


Figure 1–20. Reverse osmosis.

ROWPU process

For the ROWPU to complete the RO process effectively without plugging up the RO elements, first remove turbidity from the water to be treated. The ROWPU purifies water using four distinct, separate treatment stages (multimedia filtration, bag filtration, RO [desalination], and chemical disinfection). These depend on each other to continue the process of water purification until the water is safe to drink. All four of these treatment stages were specifically designed to deal with any situational contingencies US forces might encounter in the field. Now, let us look at these four separate stages in more detail.

Multimedia filtration

The raw water pump delivers water from the source through a strainer or the OISS (to protect the raw water pump) to the multimedia filter. This is the first stage of purification in the ROWPU process. Large particles of suspended solids in the raw water are first removed by the multimedia filter. The multimedia filter is a pressure-sand filter very much like the ones found in swimming pool filtration systems, similarly containing four separate layers of filtering media. Because the multimedia filter in the ROWPU is relatively small (as compared to other filters of same capacity) and the design flow rate through the filter relatively high (6.5 gpm/square foot), the multimedia filter filters raw water with the aid of a coagulant aid called *polymer*. Polymer is a milky, syrupy substance that is used in this filtration process to combine fine suspended solids into large enough particles (coagulation) so they may be filtered quickly and effectively. Both the filtration and coagulation processes are used in the multimedia filter to remove large suspended solids, which are solids that do not settle on their own.

Bag filtration

In the ROWPU process, removing any fine suspended solids that pass through the multimedia filter is done by using a bag filter. This is the second stage of purification in the ROWPU. The cartridge filter is a pressurized vessel that holds a 5-micron filter. You can clean, then reuse or replace this filter. Before the water is allowed to go to the RO pressure vessels, the bag filter will remove most of the remaining fine suspended solids from the water. This process is done at a rate of 50 gpm through the aid of the booster pump. The bag filter is a very critical component of the ROWPU because this is the last chance to remove fine suspended solids before the water goes to the RO pressure vessels. Without the removal of these fine suspended particles, the RO elements inside the RO vessels would plug up prematurely. Up to this point, all but the dissolved solids have been removed by coagulation and filtration.

Reverse osmosis (desalination)

Salts are classed as dissolved solids. This is because the salt solids are actually dissolved in the water. These solids are so small they cannot be seen with the naked eye. The desalination (removal of salts) from filtered water is the third stage of water purification in the ROWPU. The purification of seawater occurs during this third stage of treatment. This process occurs in the RO pressure vessels. In the ROWPU, filtered water from the bag filter flows (with positive pressure from the booster pump) towards the RO pump. The RO multistage centrifugal pump then pressurizes the water to extremely high pressures. This water, which is at high pressure, is forced to go through the RO elements and calibrated through the use of the regulate feed valve to 48–50 gpm.

The spiral-wound, semi-permeable RO media (fig. 1–21) is wrapped so tightly around a perforated plastic tube that not all of the pressurized water can pass through the elements at one time. The filtered/desalinized water is collected from the RO vessels and flows towards the chemical feed pump to be chlorinated. The remaining water that did not go through the RO elements becomes saturated with salts and is called *brine*. The brine is allowed to go into the brine tank where it will later be used to backwash the ROWPU and clean the RO elements. Brine goes to waste when the brine tank is full.

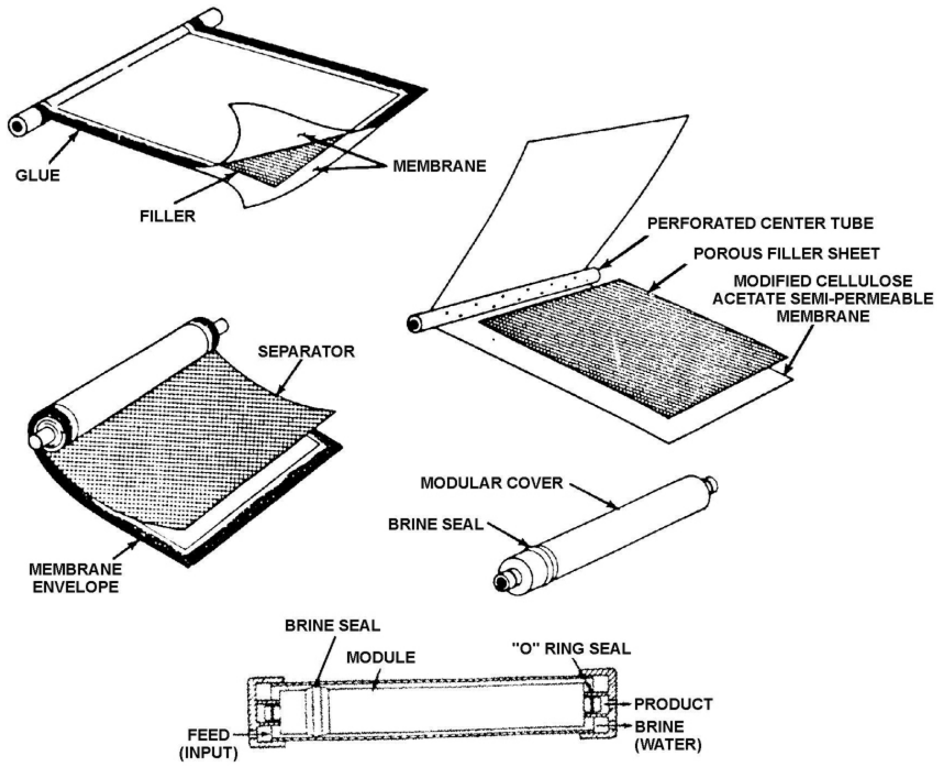


Figure 1–21. Typical spiral module.

Chemical disinfection

To eliminate the remaining organic wastes in the water, the water now has to be disinfected. To do this, inject a Cl2 solution into the product water line before it leaves the confines of the ROWPU for the product tank. The chemical feed pump on the ROWPU feeds a selected rate of Cl2 to satisfy Cl2 demand. Once the Cl2 demand is met, Cl2 residual will be established. Adjust the feed rate to meet the required Cl2 residual. Unless otherwise directed by medical personnel, you should maintain a Cl2 residual of two parts per million (ppm) free available Cl2 in the product water leaving the ROWPU. This fourth and final stage of treatment completes the ROWPU water treatment process.

Secondary chemical treatment processes

In addition to feeding Cl2, the chemical feed pump also feeds three other very important chemical solutions. These solutions are polymer, sodium hex, and citric acid. Polymer, which we have already discussed, is used as a coagulant aid in the multimedia filter. Polymer is injected into the raw water inlet line going to the multimedia filter to aid in the removal of suspended solids. Sodium hex is also fed into the raw water inlet of the multimedia filter influent. Sodium hex is fed to reduce scale and corrosion inside the pipe network of the ROWPU. The last chemical, citric acid, is fed into the discharge line of the multimedia filter before going to the booster pump. Citric acid is fed into filtered water to primarily maintain the optimum pH required by the RO elements. A secondary reason for the addition of citric acid is the prevention of scale build up on the RO elements. The optimum pH for the RO elements is 5.5 but should be maintained between 5.0 and 8.0.

604. ROWPU controls and indicators

Now that you are familiar with the ROWPU water treatment process, let's discuss all of the unit's indicators and control functions. To operate the ROWPU properly and efficiently, it's important you know what each control component of the unit does and what each indicator tells you. The ROWPU is a machine that you must operate properly to avoid any damage. As the operator, you are responsible for monitoring and controlling the treatment process that is occurring; therefore, your success as a good operator will depend on your knowledge of this information. The ROWPU has two types of operating components: control and indicating. Although only indicating, these components help you decide what to do.

Product water meter

The product water meter is an important component of the ROWPU. You use it for the following reasons:

1. Track the total number of gal. produced each day.
2. Establish an approximate production run in gal. produced per backwash.
3. Determine an approximate amount of production time left at any one time.

Control panel

The ROWPU control panel is the nerve center of the unit. The control box consists of various switches, valves, gauges, and hose connection ports. You can run the ROWPU directly from the control panel. This is because all of the ROWPU control functions are either on the control panel or very near it. The control panel can sometimes seem imposing to those who do not readily identify the function of each control or indicator component. Look at figures 1–22 and 1–22a as we discuss the function of each control panel components.

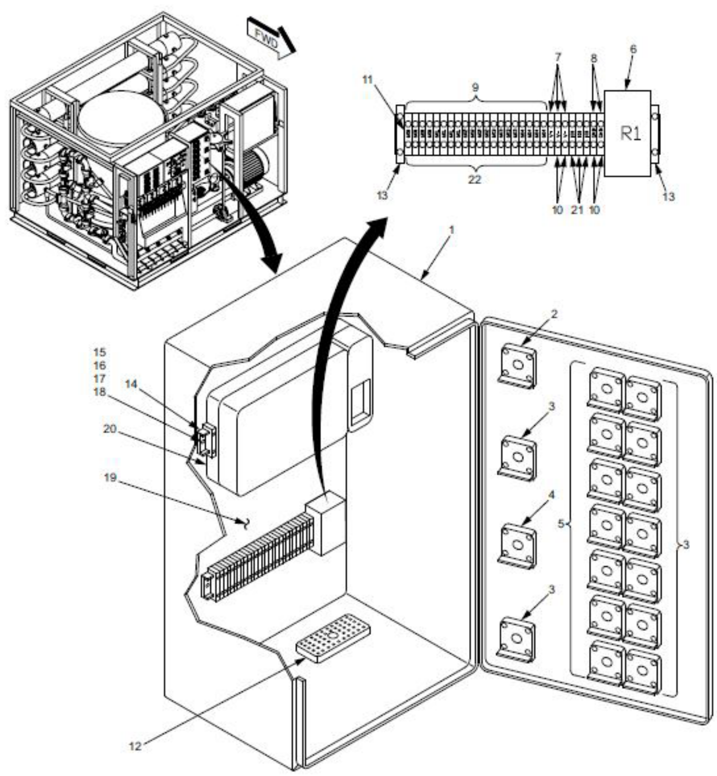


Figure 1–22. Components of the ROWPU.

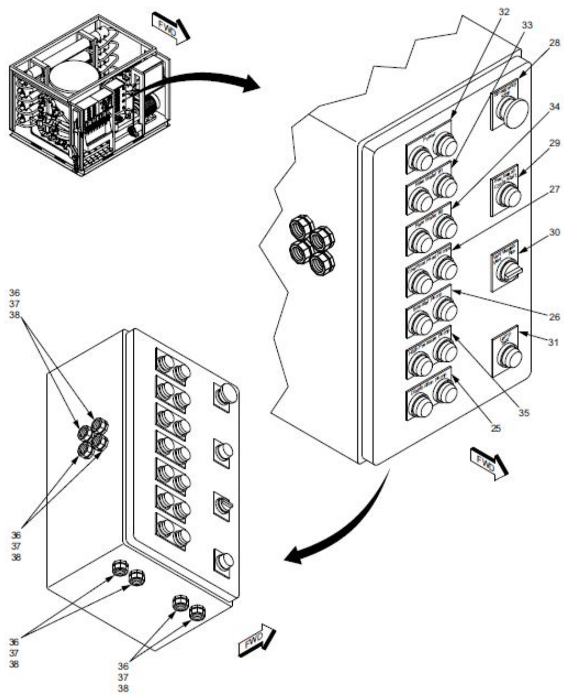


FIGURE & INDEX/ SHEET NO.	PART NUMBER	CAGE	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY	USABLE ON CODE	SMR CODE
14-	701-1500-29	0AK83	PUSHBUTTON CONTROL BOX	REF		XBOOO
1/2	701-1500-29-1	0AK83	. ENCLOSURE, Pushbutton.	1		XBOOO
2/2	800H-FRXT6D4	01121	. SWITCH, E-Stop	1		PAOZZ
3/2	800H-AR1D1	01121	. PUSHBUTTON, N.O. Green flush head	9		PAOZZ
4/2	800H-HR2A	01121	. SWITCH, Selector, 2 pos.	1		PAOZZ
5/2	800H-BR6D2	01121	. PUSHBUTTON, N.C. Red	7		PAOZZ
6/2	AB100C16DJ10	01121	. RELAY, Contactor, DC coil	1		XBOOO
7/2	1492-HM1B	01121	. TERMINAL BLOCK, Blue	6		XBOOO
8/2	1492-HM1G	01121	. TERMINAL BLOCK, Green	2		XBOOO
9/2	1492-HM1GY	01121	. TERMINAL BLOCK, Gray	20		XBOOO
10/2	1492-N42	01121	. SIDE JUMPER, 2 Pole	2		XBOOO
11/2	1492-NM36	01121	. END BARRIER, Terminal	1		XBOOO
12/2	2219K91	39428	. DESICCANT CANISTER	1		PAOZZ
13/2	1492-EAH35	01121	. END ANCHOR	4		XBOOO
14/2	199-DR1	01121	. MOUNTING RAIL	2		PAOZZ
15/2	93482A661	39428	. NUT, Rivet, 10-32, aluminum (AP)	4		PAOZZ
16/2	103-2-014-6-4-1-1-2-4-0	0AK83	. SCREW, Machine, #10-32 x 1/2 inch, pan. . . . . . head phillips, standard grade ss (AP)	4		XBOOO
17/2	104-1-005-1-2-6-0	0AK83	. WASHER, Flat, SAE, #10, standard grade ss . . . (AP)	4		XBOOO
18/2	104-2-005-1-2-6-0	0AK83	. WASHER, Split lock, #10, standard grade ss. . . . (AP)	4		XBOOO
19/2	701-1500-29-2	0AK83	. BACKPANEL, Pushbutton	1		XBOOO
20/2	701-1500-29-PLC (SN's 0510-333 and below) or 701-1500-29-PLC-REVA (SN's 0510-334 and above)	0AK83	. Programmable Logic Chip (PLC)	1		PAOZZ
21/2	701-AB1492-SJ6-10-3	0AK83	. SIDE JUMPER, 3 Pole	1		XBOOO
22/2	701-AB1492-SJ6-10-4	0AK83	. SIDE JUMPER, 4 Pole	5		XBOOO
-23	701-1500-29-W31	0AK83	. WIRE HARNESS, W31	1		XBOOO
-24	701-1500-29-W51	0AK83	. CABLE ASSEMBLY, W51	1		XBOOO
25/1	801-1500-100-10	0AK83	. RING TAG, Distribution pump	1		XBOOO
26/1	801-1500-100-11	0AK83	. RING TAG, Booster pump	1		XBOOO
27/1	801-1500-100-12	0AK83	. RING TAG, Chem feed pumps	1		XBOOO
28/1	801-1500-100-2	0AK83	. RING TAG, E-stop	1		XBOOO
29/1	801-1500-100-3	0AK83	. RING TAG, Start backwash	1		XBOOO
30/1	801-1500-100-4	0AK83	. RING TAG, Vent vessels	1		XBOOO
31/1	801-1500-100-5	0AK83	. RING TAG, Lamp test/fault reset	1		XBOOO
32/1	801-1500-100-6	0AK83	. RING TAG, Power on	1		XBOOO
33/1	801-1500-100-7	0AK83	. RING TAG, Raw water 1	1		XBOOO
34/1	801-1500-100-8	0AK83	. RING TAG, Raw water 2	1		XBOOO
35/1	801-1500-100-9	0AK83	. RING TAG, High pressure pump	1		XBOOO
36/1	506-T&B2522	0AK83	. CORD GRIP, 0.375 - 0.50 Inch grip, 1/2 inch. . . . NPT	8		XBOOO
37/1	AA50553-31PX01S	58536	. LOCKNUT, 1/2 Inch NPT (AP)	8		PAOZZ
38/1	9452K28	39428	. O-RING, 1/2 Inch NPT	8		PAOZZ

Figure 1–22a. Components of the ROWPU.

Pushbutton control box

The pushbutton control box is a major component located on the ROWPU control panel. This control panel component is important because this is where all the electrical components necessary to operate the ROWPU are controlled. The pushbutton control box also has a pushbutton to reset and test all indicator lamps (fig. 1–23).

Pilot light enclosure

The pilot light enclosure contains all the indicator lights to indicate the operation mode of all electrical components on the ROWPU. It also contains trouble indicator lights to warn you of potential trouble to the unit and components.

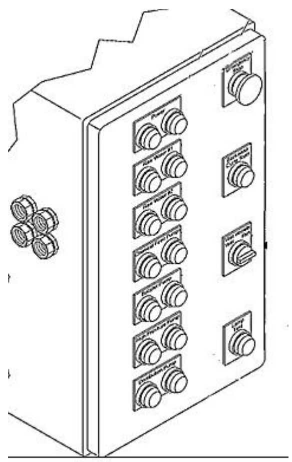


Figure 1–23. Control box.

Vent vessels switch

The vent vessels switch is located on the control panel. It is the second-most important valve on the ROWPU. When the switch is set to VENT, the switch electronically opens a valve to direct water away from the RO elements until the polymer feed rate is properly adjusted and the multimedia filter settles. Setting the switch to RUN forces water to go towards the RO vessels.

Chemical feed pump controls

The chemical feed pumps dispense the four chemicals used when the unit operates. Their location is shown in figure 1–24. This chemical feed pumps are unique in that they separately feed the four different chemicals the ROWPU uses at the same time. The suction lines are at the bottom of each feed body while the feed lines are on top of the feeder body. Each feed body is designed to feed the chemical indicated in figure 1–25. From left to right, these are polymer, sodium hex, citric acid, and Cl2.

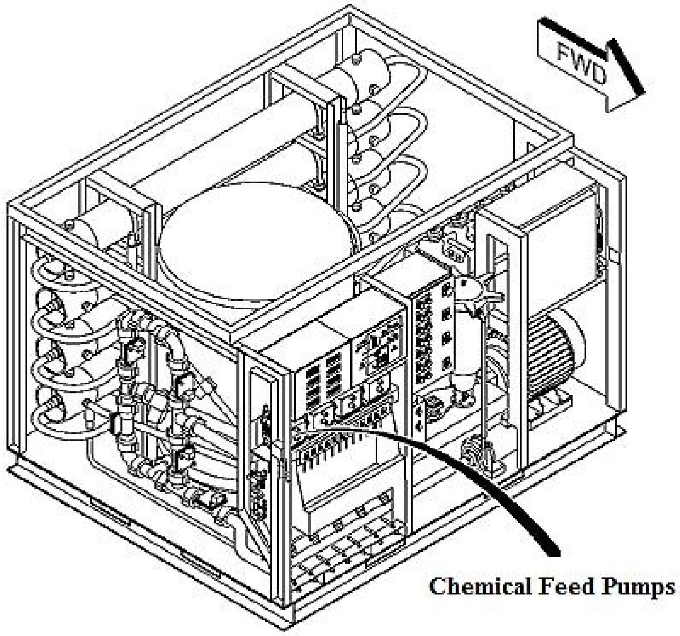


Figure 1–24. Chemical feed pump location.

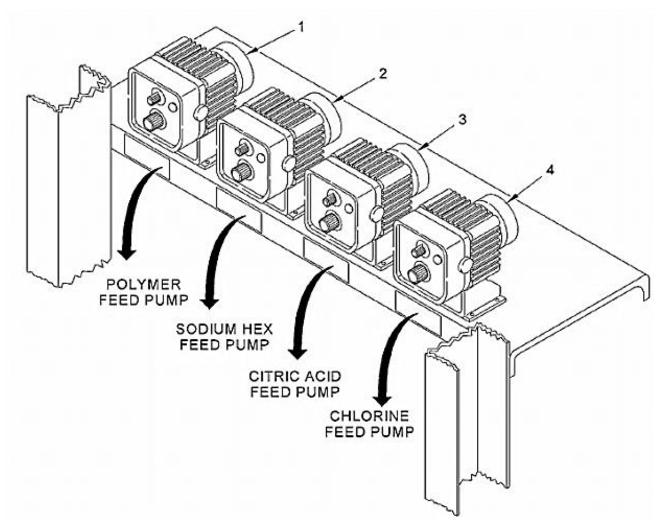


Figure 1–25. Chemical feed pumps.

NOTE: Do not get these feed locations mixed up because the injection points are different for each chemical. For example, it would be dangerous to feed Cl2 at the polymer feed point because Cl2 would damage the RO elements.

Gate valves

There are various gate valves installed in the ROWPU set up—one at the inlet and outlet of the brine tank, product tanks, and waste tanks. There is also a valve at the inlet of the raw water connection on the ROWPU control panel.

Drain valves

As figure 1–26 shows, there are seven drain valves installed on the ROWPU. These valves serve to drain water completely out of the ROWPU before shipping or storing. The battery of drain valves is conveniently collocated below the canvas hose connections for operator ease.

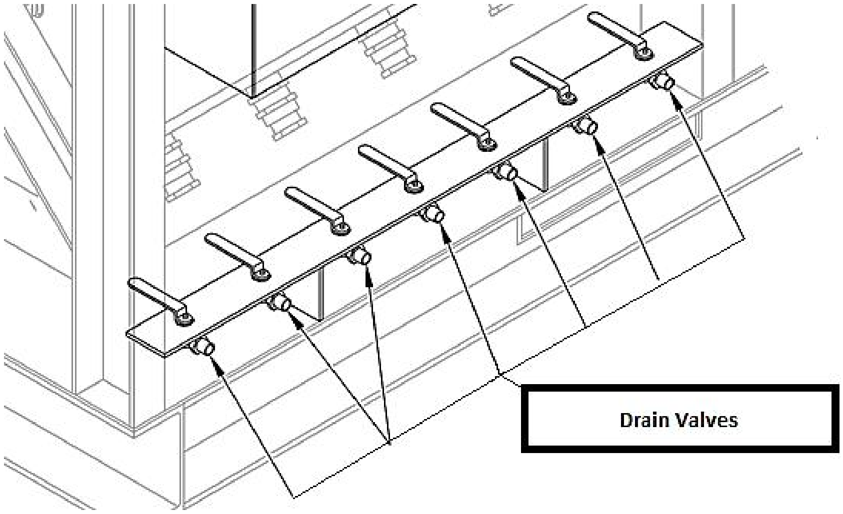


Figure 1–26. Drain valves.

Chemical feed pump valves

The chemical pump has two operating positions for each chemical feed—run and prime. As figure 1–27 illustrates, four valves are provided for this function. Use the prime position when calibrating the feed body and removing air from the suction lines. After priming is completed, set the valves to the run position during normal operations. For operator ease, each valve handle has an arrow at one end of the either valve handle pointing to "run" or "prime."

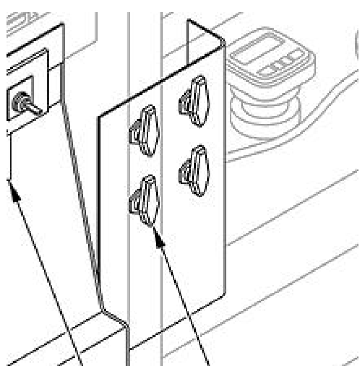


Figure 1–27. Chemical feed pump valves.

Quality control indicators

You will perform five quality control tests while operating the ROWPU: TDS, temperature, pH, turbidity, and Cl2. We will now look at the equipment used to perform these tests.

TDS, temperature, and pH

The Ultrameter, P6, will allow you perform these tests. In very simple terms, the TDS test measures the "salts" concentration of water. This test is important when purifying seawater because the maximum allowable TDS is 1,000 ppm. Use a photometer such as the one in figure 1–28 to perform this test. The pH readings of the brine water are taken to make sure it is not below 5 or above 8. Additionally, pH readings of brine water must also be taken regularly during the RO element cleaning procedure. The reason you do not take the pH readings from the product water line is that the Cl2 affects the pH levels.

Figure 1–28. Pocket photometer.

Turbidity

The turbidity test indicates the amount of suspended solids in water. Draw water from the filtered water sample valve, then transfer a portion to the turbidity meter, and perform a turbidity test. Refer back to figure 1–16.

Chlorine

A pocket photometer is included with the ROWPU. With this kit, you can check the Cl2 residual of the water. Cl2 readings are taken regularly to make sure proper Cl2 levels are in the product water. A stirring rod is also provided to break up the diethyl-phenylene-diamine (DPD) tablet during the Cl2 test. Keep the color photometer secured when you are not using it.

Backwash timer

A specially designed backwash timer is installed on the ROWPU. The purpose of the timer is to control the sequence of valve operations once you have initiated the multimedia filter backwash cycle. There are two stages in the backwash cycle. Backwashing actually takes place during stage one and the entire process last 8 minutes. Rinsing takes place during stage two of the backwash process; this process last for 4 minutes and completes the backwash cycle.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

603. Technical principles of ROWPU operation

1. What principle is used in treating water with the ROWPU?

2. How many stages of purification are employed by the ROWPU? What are they?

3. What is brine?

4. What chemical is used to disinfect product water?

5. What chemical is added to the influent line of the multimedia filter to aid in the removal of suspended solids (turbidity)?

6. What is the purpose of feeding sodium hex into the ROWPU?

604. ROWPU controls and indicators

1. Which ROWPU component is the "nerve center" of the unit?

2. Which valve regulates the pressure exerted on the RO vessels and regulates the amount of product water flow?

3. What component controls all the electrical components necessary to operate the ROWPU?

4. What happens when the vent vessels switch is set to run?

5. What is used to dispense the four chemicals used when the unit operates?

6. What kit is used to check the Cl2 residual of the water?

1–3. Operating the ROWPU

In the previous two sections of this unit, we discussed basic information designed to enhance your comprehension of the characteristics and operating principles of the ROWPU. Now you are ready to learn how to operate the ROWPU. As we discuss the operation of this expensive piece of equipment, pay particularly close attention to the specific procedures and steps used to set up the ROWPU.

605. Site selection

Before you set up and operate the ROWPU, first you must select a proper site. Site selection is one of the most important considerations during the initial set-up procedures of the unit because an improper location can lead to major troubles later during water treatment operations. The medical authorities will have already selected the proposed site for set up. Medical staff may require your input about the site as the ROWPU operator because of your experience. If you feel the water parameters are not conducive for efficient water production, make sure your opinions are clear and voiced adamantly that the site selection does not follow the criteria for productive water treatment operations.

Water source

The source of the water is paramount in determining the proper site for the setup of the ROWPU. You obviously do not want to use a source of water polluted by industry or municipalities. Keep the following things in mind as you determine the proper water source:

1. Water clarity.
2. Water velocity.

3. Water depth.
4. Intake point location.
5. Intake point security.

Water clarity

Pick a water source where the water is as clear as possible. Although clear water is not an absolute indicator of a lack of pollution, it is better than picking a site with turbid water. Clear, raw water means you backwash the multimedia filter less frequently and replace the cartridge filter elements less. This is just one example on how an improper site will affect your ROWPU operations.

Water velocity

If possible, use a source of water that is flowing. Water that is not moving will have a tendency to become stagnant. It will also absorb impurities from the surrounding area. This includes such things as bacteria from decaying animals or decaying plants near the water source. Water velocity enhances your chances of obtaining a water source that is relatively free of pathogens. Remember, the more pathogens in the water, the more the Cl2 demand there will be. This, too, will affect your daily operations if you have to feed more Cl2 to meet the Cl2 demand.

Water depth

If possible, choose a site where you can set up your raw water intake hose in water that is consistently deeper than 4’. If the set up point is the ocean, consider the implications of rising and falling tides. How will this affect your intake hose and raw water pump location? Also, consider the fact you do not want your raw intake hose to start sucking mud or sand when the water level is shallow.

Remember, you must have at least 1’ of freeboard (space) above the raw water intake hose to prevent a vortex or air forming at the end of the hose when the pump is on. If you start sucking air into the ROWPU, you can be sure the unit will not stay on. Additionally, if you start sucking mud or sand, you will prematurely clog up the multimedia and cartridge filters. As you can see, water depth is another important operational consideration.

Intake point location

Make sure the ROWPU site and intake point is 100’ upstream and away from the camp site. You do not want sewage or waste drainage from the kitchens flowing towards the raw water intake of the ROWPU.

Intake point security

Choose a site where the intake point can easily be guarded from the enemy. You should not make it easy for an enemy to infiltrate the intake point and pollute the water you are going to treat. At the very least, you should have an unobstructed view of the raw water pumps and hoses.

Types of water sources

There are three general types of water: seawater, brackish water, and fresh water. Some knowledge of the characteristics of each of these types will play an important role in the site selection. Again, the source and type of water will also affect operations during water treatment. We will briefly discuss the three major types of water.

Seawater

Of course, seawater is what the ROWPU was designed to treat. Seawater can contain up to 35,000 ppm TDS, but this is an exception rather than the norm. Of course, seawater is very salty and may contain a high amount of suspended solids (from sand), depending on the intake location. In addition, seawater usually contains a fair amount of bacteria depending again on the intake location. Choosing seawater will affect the ROWPU treatment process in terms of the amount of gal. produced per RO element. This is because the higher TDS content in the water will force a more frequent element-cleaning interval.

This will mean more down time for the unit and more work for you—the ROWPU operator. Keep in mind, seawater will cause corrosion of ROWPU components such as fittings, clamps, brackets, and panels.

Brackish water

The term “brackish” water is used to denote surface waters (from lakes) and groundwater (from wells) containing between 500 and 15,000 ppm in TDS. Even though the TDS content is lower than seawater, it is still high enough to give this kind of water a salty taste. Brackish water is usually very high in mineral content (hardness). In terms of desalination, it is much easier for the ROWPU to treat brackish water than to treat seawater.

Freshwater

Freshwater contains less than 500 ppm TDS and has no apparent salty taste. This type of water is usually found on the surface (stream, river, or oasis) and may contain a fair amount of suspended solids, dissolved solids, fecal matter, bacteria, and other disease-producing organisms. Although it is the easiest type of water to treat with the ROWPU, it may not always be the ideal type of water source depending on local conditions. When obtained from local municipalities, freshwater may appear clean with no significant odor. Despite this relatively clean appearance, local freshwater may contain bacteria and high amounts of dissolved solids.

ROWPU location

Now that you have selected the appropriate water source, you need to decide exactly where to locate the ROWPU. Proper location of the ROWPU is important because it will help you as operations progress. You must consider these conditions when selecting the location for the unit:

- Terrain elevation.
- Camouflage and concealment.
- Mechanical considerations.
- The whole picture.

Terrain elevation

Consider what would happen if it rained a lot. Be sure to locate the unit on high ground to prevent the ponding or flooding of water near the ROWPU. Also, standing water around the unit will create unsanitary conditions, and you do not want these to develop around a water purification unit. You want to locate the ROWPU a minimum of 100 yards upstream from latrines, showers, laundry areas, or other places where unsanitary conditions may occur. In low areas, mud puddles will quickly form, and water trucks will have a hard time getting close enough to load water. In either case, you will be forced to move the unit to higher ground. Most importantly, a huge loss of water production time will occur.

Camouflage and concealment

Take advantage of any natural camouflage by locating the unit under forest cover and close to natural geological formations. Although cover and concealment are of secondary importance, nothing is lost by at least *trying* to take advantage of the concealment provided by the relief of mountain formations, trees, or rock ledges. In all cases, use camouflage equipment to conceal the ROWPU unit from observation by air once operations are well underway.

Mechanical considerations

Be sure to consider the feasibility of accessing the raw water source once the unit is in place. In this regard, the raw water pump #1 must be as close to the source as possible—preferably at a point that does not require more than 20’ of suction lift. Additionally, keep in mind the raw water pump hoses and electrical cables will not go beyond 250’. If you do not consider this factor, you may have to relocate the unit to a location where the electrical cables and pump hoses will reach the raw water pumps. Poor planning in this stage of operations will prove time consuming.

Look at the whole picture

Your last step is to consider the site as a whole. Some important questions to answer during this step are as follows:

1. Where will all of the equipment be positioned?
2. Will the terrain be level throughout?
3. Will the bladders be on level terrain?
4. Will one tank get in the way of accessing the site?
5. Can a generator also fit on the site?
6. What if the mission is expanded?
7. Can more ROWPUs be easily located on the same site?
8. Can more bladders, pumps, and generators be easily located on the same site?

All of these factors are major considerations that should not be ignored.

606. Setting up the ROWPU

Once the site selection process is completed, you may proceed to set up the unit. To do this properly, position the ROWPU so the front of the unit (control panel side) faces the water to be treated and the operator’s back is toward the source. One of the very first things you must do during the initial set up of the ROWPU is to unpack (remove) all of the unit’s components from within the enclosure and from the top of the ROWPU. These components include the raw water pumps and distribution pump located within the enclosure, the suction and discharge hoses, and all of the storage boxes that are located on top. After unpacking the ROWPU, we will discuss how each auxiliary piece of equipment is set up to make the ROWPU operational. We will now discuss these set-up procedures systematically.

NOTE: Some items are heavy/difficult to handle. To prevent injury or damage to equipment, a minimum of two people should be used to unpack the 1500 ROWPU and to move the pumps.

Unpacking the ROWPU

As stated previously, two people are required for unpacking the ROWPU. Some BIIs are heavy and difficult to handle. Start by loosening the carabineers from the top of the cargo net on top of the unit. Remove the cargo net and all of the BII from the top of the unit. After unpacking everything, it is always a good idea to perform an inventory of all BII items to ensure accountability and serviceability. If any items are missing or damaged, immediately notify your chain of command.

Cargo straps

You are now ready to loosen the three cargo straps (fig. 1–29) that hold down the inner components of the ROWPU. To loosen the straps, pull down on the ratchet release and pivot the ratchet handle to the full open position. The tension on the strap will now be released. You can now lift the keeper and disconnect the hook from the trailer.

Hold down straps

Loosen the hold down straps (fig. 1–30) that keep the pumps from shifting during shipment. To remove the hold down straps, press in on the latch and pull the end of the hold down strap through the buckle. Next, pull the strap out of the anchor on the ROWPU frame.

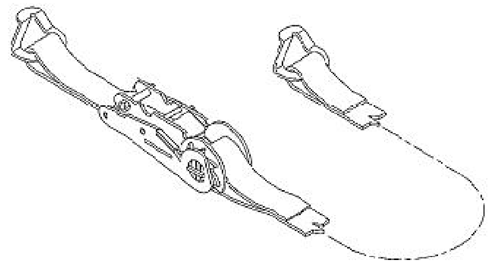


Figure 1–29. Cargo straps.

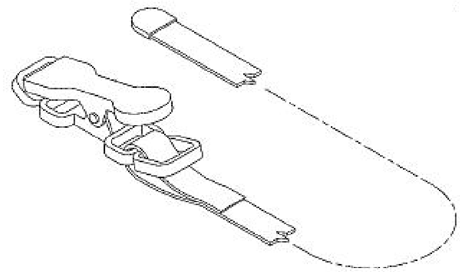


Figure 1–30. Hold down straps.

Accessory removal

Remove the raw water pumps and the distribution pump from the interior of the 1500 ROPWU frame and all components from the top of the ROWPU. As you remove all of the accessories from the ROWPU, arrange them about 15 to 20' behind the ROWPU (the side opposing the control panel). Make sure they are all together and out of the way while you prepare each subsystem of the unit for operation. QDs are used to aid in assembly and disassembly, the QD couplings (fig. 1–31) are installed on the raw water pumps, backwash pump, distribution pump, gate valves, and the control panel. Pay close attention to which QD fitting you are installing on the pumps. Some take both male and female couplings while others use only female coupling installation.

NOTE: Some items are heavy and or difficult to handle. To prevent injury or damage to equipment, a minimum of two people should be available to unpack the 1500 ROWPU and to move the pumps.

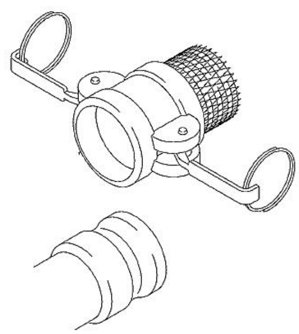


Figure 1–31. QD.

Raw water pumps

Two identical raw water pumps come with the 1500 ROWPU. Take one of the raw water pumps from behind the ROWPU, close the drain and vent valves on raw water pump (if both pumps are used, this will be considered raw water pump #1) and install a 2-inch (") male QD coupling on the raw water strainer. Relocate the pump and the strainer as close as possible to the water source. If you need a second pump, connect it in series closer to the ROWPU (this is considered raw water pump #2). If you do not need both pumps, the pump you will use is considered raw water pump #2 as it will plug in directly into the ROWPU. Raw water pump #2 is also used as the backwash pump. A three-way valve (backwash valve assembly) is included in the storage boxes to connect the brine bladder and raw water source to the pump. Refer to figures 1–32 and 1–33.

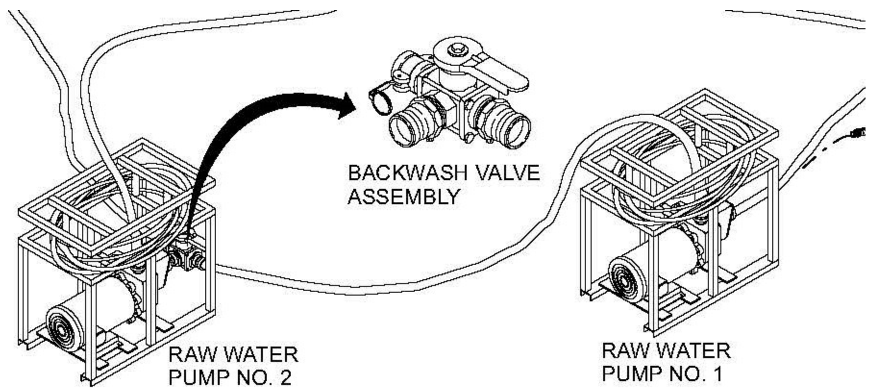


Figure 1–32. Raw water pumps used in series.

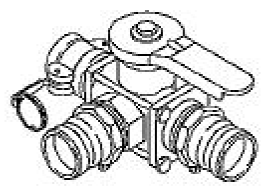


Figure 1–33. Backwash valve assembly.

Distribution pump

The distribution pump (fig. 1–34) is used to pump water from the product tanks and deliver it to a tanker using the nozzle. The distribution pump is electrically driven and is a centrifugal pump with a capacity of 30 gpm. The distribution pump is turned on at the control panel box of the ROWPU.

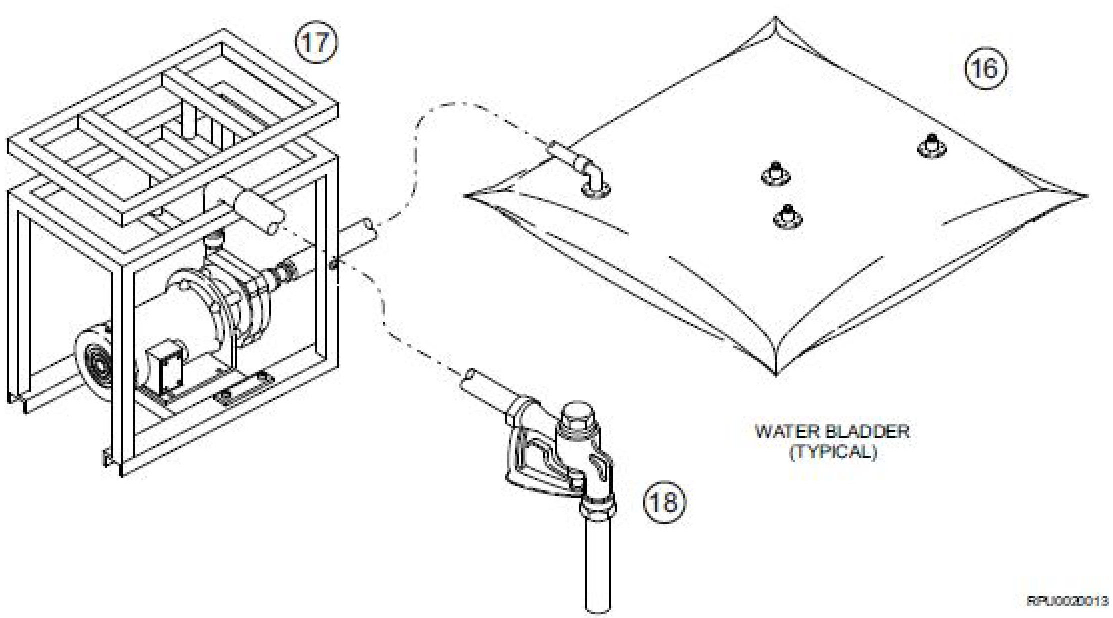


Figure 1–34. Distribution pump and nozzle.

Gate valves

Manufacturers assemble gate valves, illustrated in figure 1–35. These valves are used throughout the ROWPU setup to control and isolate tanks during operation. Various sizes of couplings, adapters, and reducers are supplied with the unit to meet operational requirements.

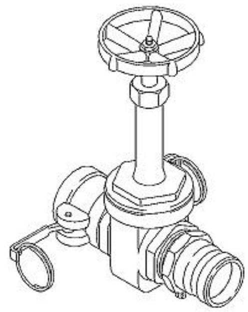


Figure 1–35. Gate valve.

TDS meter

The Ultrameter (fig. 1–36) is used to measure TDS and temperature.

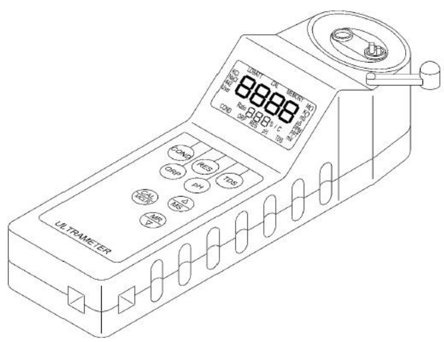


Figure 1–36. Ultrameter.

Setting up the raw water pumps with float and strainer

To this point, all of the preliminary assembly steps have been completed and you are ready to start making the unit come alive. Your first step is to set up the raw water pumps as illustrated in figure 1–37. To do this properly, start the set up from the control panel and work towards the intake source. Before you study specific set-up procedures, a few caveats are in order:

1. Do not use hoses marked with a blue stripe—they are intended for the product water system.
2. Position the hoses so a tripping hazard does not exist in front of the unit.
3. Use the minimum number of hoses required to set up the raw water system.

Make sure gaskets are in place and QD couplings are locked. Proceed to set up the raw water system using the following steps:

1. Install a 2” gate valve at the raw water inlet on the ROWPU.
2. Unravel the electrical cables from both of the raw water pumps and connect raw water pump #2 electrical plugs (pump closest to the ROWPU) to the control panel. Once the ring around the cannon plug has been installed finger tight, try to push the cannon plug into the receptacle to verify that it is fully inserted. You may have to repeat this procedure several times until the cannon plug cannot be inserted any further.
3. Place raw water pump #1 as close as possible to the water source.

4. Then connect raw water pump #1 to raw water pump #2. Once the ring around the cannon plug has been installed finger tight, try to push the cannon plug into the receptacle to verify that it is fully inserted. You may have to repeat this procedure several times until the cannon plug cannot be inserted any further.

NOTE: Fully insert electrical cables into the cannon plug socket or the thermal overload switch will disable the pump. This applies to all cannon plug receptacles.

5. Connect the canvas discharge hoses between the raw water coupling on the control panel and raw water pump #2.
6. Connect the discharge hoses between the suction coupling of raw water pump #2 and the discharge coupling of raw water pump #1.
7. Connect three hard rubber suction hoses from the suction coupling of raw water pump #1 to the intake point.
8. At the intake point, connect the suction strainer and float to the suction hose of raw water pump #1. Make sure the rope on the float is not shorter than 1'.
9. Toss the suction strainer and float as far as possible (into the deepest area of the intake point) making sure the strainer is not stuck on the bottom (in sand).

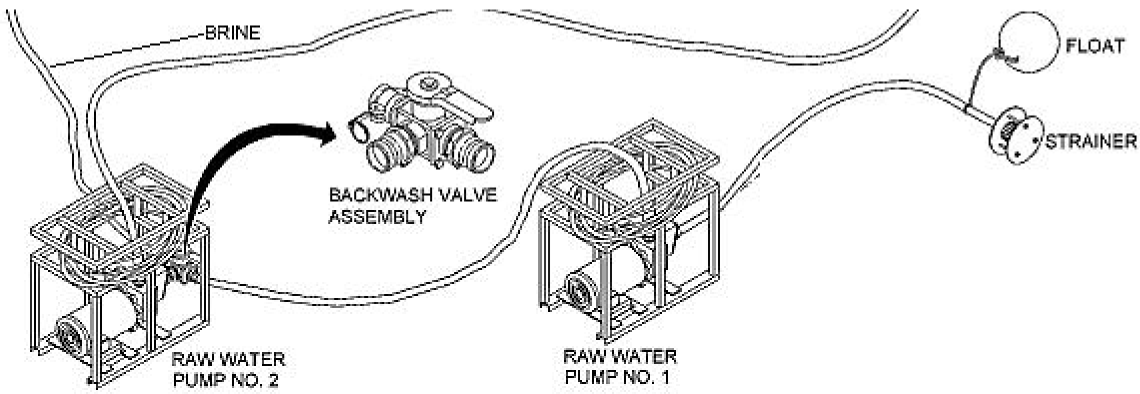


Figure 1–37. Raw water set up.

Setting up the raw water pumps with ocean intake structure

The ocean intake structure is used in place of the strainer and float. Refer to figure 1–38 during set-up procedures.

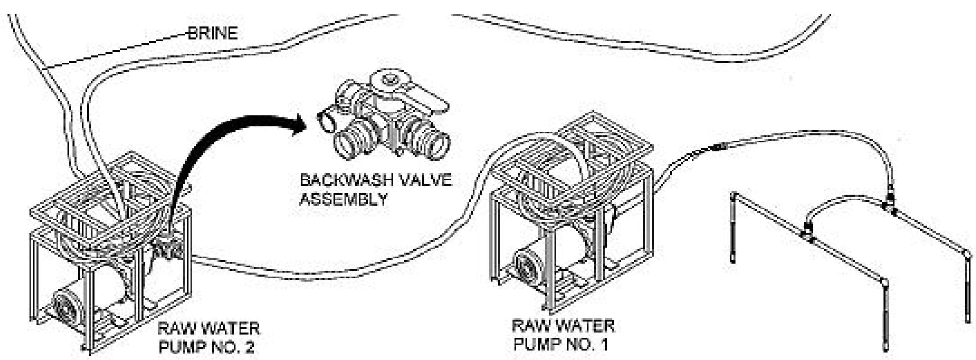


Figure 1–38. Ocean intake structure.

Listed below are the basic precautions during initial set-up:

1. Do not use hoses marked with a blue stripe—they are intended for the product water system.

2. Position the hoses so a tripping hazard does not exist in front of the unit.
3. Use the minimum number of hoses required to set up the raw water system.
4. Ensure gaskets are in place and QD couplings are locked.
5. Perform the installation of the ocean intake structure at maximum low tide. This should eliminate the need to move the wellpoints as tides change.

Following are the steps for setting up the ocean intake structure:

1. Connect canvas discharge hose between the raw water coupling on the control panel and discharge coupling of raw water pump #2.
2. Connect canvas discharge hose between suction coupling of raw water pump #2 and discharge coupling of water pump #1.
3. Install pump adapter fittings on the inlet and outlet of raw water pump #1.
4. Attach the 1½” pipe nipple, 2” gate valve, and adapter fitting to the outlet of raw water pump #1.

NOTE: During initial installation, one of the two wellpoints is used for source water when jetting the other wellpoint. The wellpoint used for source water may either be laid flat on the ocean floor (beach) or attached to a vertical metal stake while jetting operation is conducted. Make sure that the source wellpoint, whether laid flat or attached to stakes, is completely submerged. Refer to figure 1–38.

5. Assemble both wellpoints by attaching the 36” long nipples to the top of the wellpoint. Then install bushing, elbow, and QD fitting.

NOTE: Install check valve so that water flows from tee.

6. Assemble tee by attaching the male QD fittings to opposite ends. Attach the check valve and female QD fitting.
7. Attach the male end of one 10’ suction hose to the source wellpoint.
8. Attach the female end of the 10’ source wellpoint suction hose to the tee assembly.
9. Attach the 2” cam-lock cap to the tee assembly.
10. Attach the male end of 50’ suction hose to the female cam-lock fitting on the tee assembly.
11. Add additional 50’ lengths of suction as needed.
12. Attach the female cam-lock of the 50’ suction hose to the inlet adapter of the ROWPU raw water pump #1.
13. Attach one or more lengths of 50’, 2” suction hose to the gate valve at the discharge of the pump. Attach the other end of the hose to the wellpoint to be drilled.

WARNING: When installing the wellpoint, the area near the hole may fluidize creating a wide hole. This could result in loss of solid footing and the operator could fall into the hole being drilled. This could result in death by drowning. Ensure that there is someone nearby who may render assistance while wellpoints are being drilled.

14. Remove cover from raw water pump #1 receptacle on junction box. Connect raw water pump #1 electrical cable to the receptacle.
15. Check security of all hose coupling connections.
16. At this time, fill the suction hose, pump with water, and start the pump. Depending on the amount of water in the suction hose, the pump should prime within a few minutes. Once the pump has been primed, water will begin gushing from the jetting shoe of the first wellpoint.
17. With water flowing from the jetting shoe and while holding the wellpoint in the vertical position, proceed to drill the wellpoint into the ocean floor by gently pushing the wellpoint downward. The wellpoint will drive itself down because of the water pressure.

NOTE: An up-and-down as well as a turning motion may ease the drilling of the wellpoint. Depending on ocean floor conditions, it may be necessary to support the wellpoint and riser because of the fast drilling action of the wellpoint as it goes downward through the ground.

18. Drill the wellpoint until the elbow fitting on the end of the riser is approximately 1’ above the ocean floor.

NOTE: The first wellpoint will be used as the source of water for the installation of the second wellpoint.

19. Disconnect the 10’ length of 2” suction hose from the 50’ length of hose on the driven wellpoint.
20. Disconnect the 2” cam-lock cap that is on the tee assembly and the hose opposite it.
21. Attach the 10’ length of 2” suction hose from the driven wellpoint to the tee assembly.
22. On the opposite end to the tee, attach the 2” cam-lock cap.
23. Connect the hose from the discharge of the pump to the 10’ hose on the second wellpoint.
24. Prime and energize the pump. Depending on the amount of water in the suction hose, water will start pumping and begin gushing from the jetting shoe of the second wellpoint.
25. Position the second wellpoint in the vertical position, at least 10 to 20’ from the first wellpoint.
26. Drill the second wellpoint into the ocean floor using techniques performed in the installation of the first wellpoint.

NOTE: An up-and-down as well as a turning motion may ease the drilling of the wellpoint. Depending on ocean floor conditions, it may be necessary to support the wellpoint and riser because of the fast drilling action of the wellpoint as it goes downward through the ground.

27. Position the second wellpoint so that the elbow fitting on the end of the riser is approximately 1’ above the ocean floor.

NOTE: After both wellpoints have been positioned, hoses must be repositioned to use wellpoints for a raw water source.

28. Remove cap from tee assembly.
29. Remove the 10’ length of 2” suction hose that is connected to the second wellpoint and attach it to the opposite end of the tee assembly.
30. Remove and store the hose from the outlet of raw water pump #1. Remove and store the quick-disconnect fitting, the gate valve and pipe nipple.
31. Attach a $1^{1}/_{2}$” male QD fitting to the outlet of raw water pump #1.
32. Connect a canvas discharge hose from the discharge side of raw water pump #1 to raw water pump #2, which is already connected to the ROWPU.

Setting up the backwash system

Set up the backwash water system as illustrated in figure 1–39. Again, a few precautionary statements are in order:

1. Do not use blue striped hoses for the backwash system; these are intended for the product water system.
2. Keep in mind you will be using 2” hoses to set up the backwash system. Proceed to set up backwash system using the following steps: The ROWPU uses brine water for backwashing. Brine water is stored on site in bladders as site operation dictate. Refer to TO 40W4–21–1, *Basic Expeditionary Airfield Resources* (*BEAR) Water System*, for further guidance. Raw water pump #2 supplies water to the ROWPU during backwash operations. The only

operation involvement is turning the valve on the backwash valve assembly to select the brine water source.

3. Connect the discharge hoses from the brine outlet on the ROWPU to the brine storage.
4. Connect the suction hoses (maximum three) between the brine storage and the backwash valve assembly on raw water pump #2.
5. Check the security of all coupling connections.
6. Setup the brine water bladder according to TO 40W4–20–1.

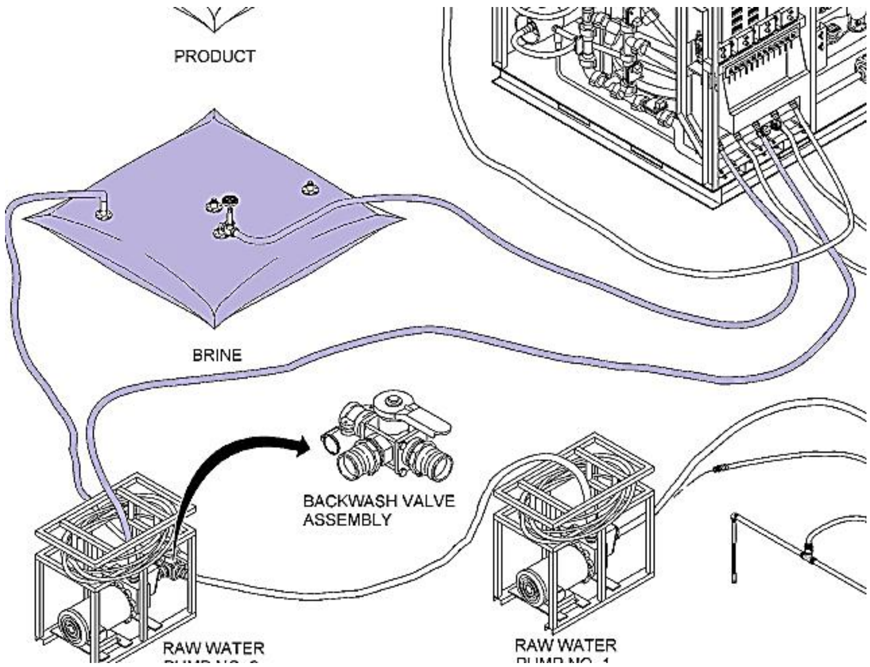


Figure 1–39. Backwash system.

Setting up the product water system

The most important sub-system set up of the ROWPU is the product water system set up. Since the product water system will contain purified water when set up, you must be very careful to make sure no components become unsanitary during the setup process. Set up the product water system as illustrated in figure 1–40. The hoses on the product water system will have a blue stripe running the length of the hose. Do not use any hoses without the blue stripe for the product water system. Proceed to set up the product water system using the following steps:

1. Set up the two product water tanks no more than 25’ away from the ROWPU. Make sure the product tanks are not more than 10’ apart.
2. Connect a 10’ length of 1½” hard rubber suction hose from the product water coupling on the control panel of the ROWPU to one length of canvas discharge hose. The other end of this canvas discharge hose goes into the product water tank #1 (tank closest to the ROWPU).
3. Connect 2” female × 1½” male adapters to both product water tanks as shown in figure 1–40.
4. Connect a 1½” suction hose between product tank #1 and product tank #2, being sure to install a 1½” gate valve at the inlet of product water tank #2.
5. Connect the suction hose from the discharge of product tank #2 to the suction port of the distribution pump.
6. Connect the canvas discharge hose from the discharge port of the distribution pump to the distribution nozzle.

7. Connect the electrical cable from the distribution pump to the ROWPU control panel.

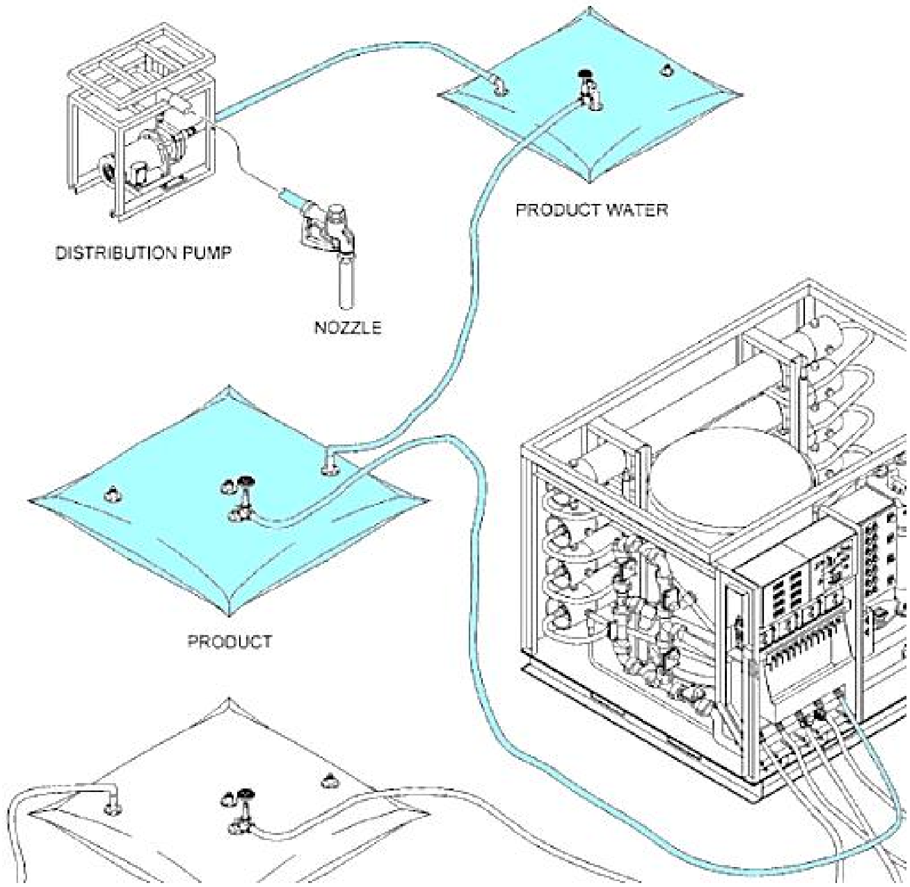


Figure 1–40. Product water system.

Setting up the waste system

Set up the waste system as illustrated in figure 1–41. As you would expect, the waste system discharges wastewater from the ROWPU. Two important precautionary statements are in order here. These are as follows:

1. Make sure both the vent vessels hose and the waste hose discharge are as far away from the ROWPU as possible and at least 25 yards downstream from the raw water intake.
2. Be sure you do not use a hose with a blue stripe—these are reserved for the product water system.

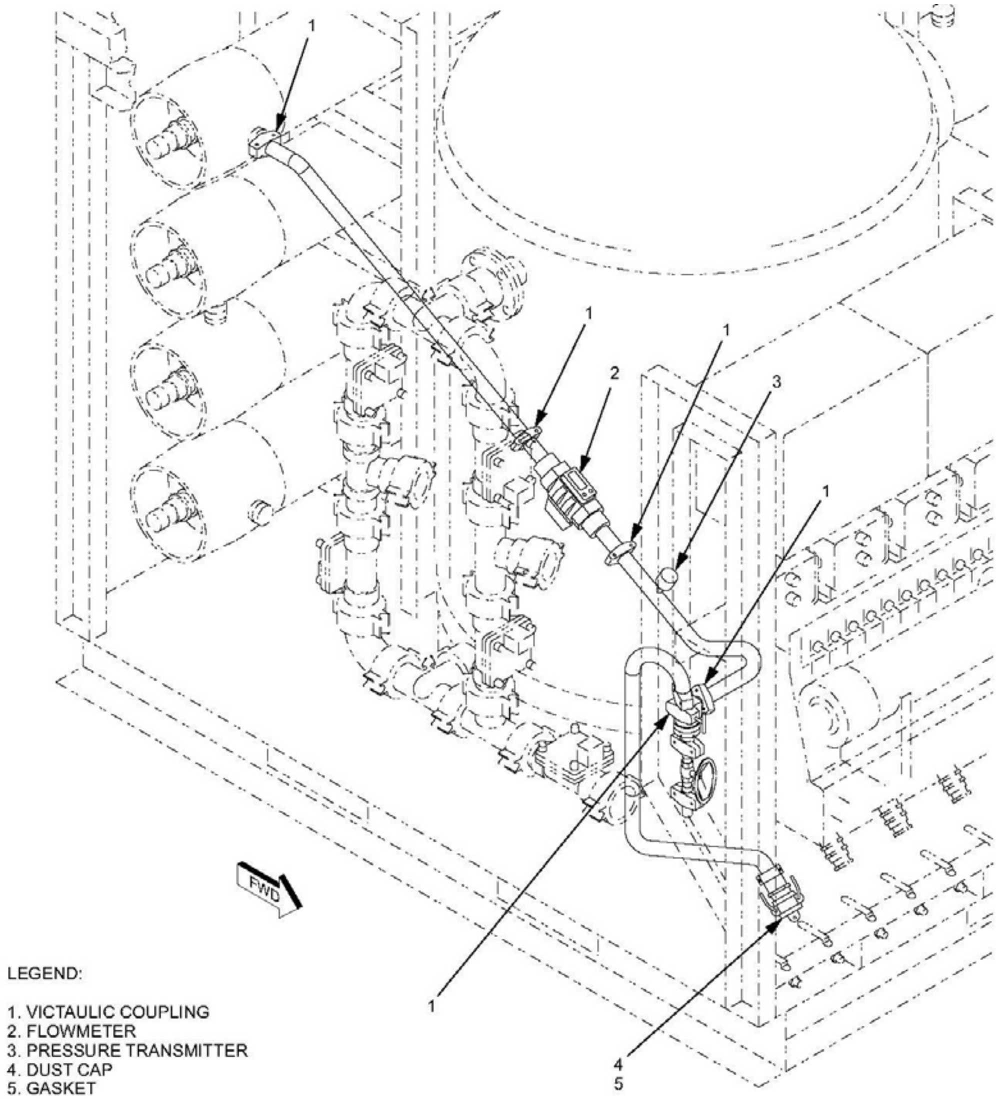


Figure 1–41. Waste system.

Preparing chemical solutions

At this point, all the subsystems of the ROWPU are set up and you are ready to mix chemicals. As we discussed earlier, the ROWPU uses four separate chemicals during operations. Since the proper operation of the ROWPU depends on the correct mix of chemicals, you must be very careful when you dispense and measure these chemicals into solution. A few precautionary statements are in order:

1. Always wear protective clothing (apron, rubber gloves, and face shield) when mixing chemicals.
2. If the ROWPU is being set up for the first time, use raw water to mix in the chemicals. Otherwise, always use brine water. NEVER use chlorinated water to mix chemicals.
3. Use the utility pails (3 gal. buckets) provided to mix the chemicals into solution—then pour the mixture into the chemical feed cans shown on figure 1–42.
4. Use the stirring paddles to mix the chemicals and water in the utility pails.

5. Mark four utility pails for the chemical mixed in them. Do not mix utility pails.
6. Use the measuring devices in the storage chests to dispense the proper amount of each chemical.

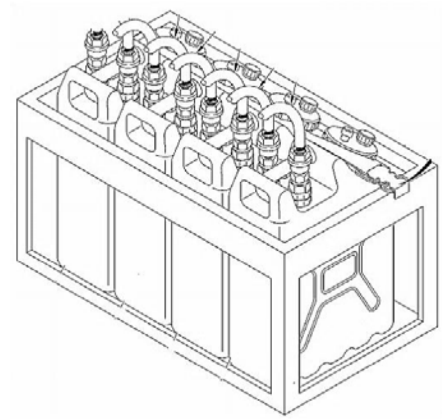


Figure 1–42. Chemical feed cans.

Proceed to mix chemicals using the following steps:

1. Collect raw water (or brine water) in the unmarked utility pail and fill the four utility pails to the 3 gal. mark.
2. Fill the 107-milliliter (ml) polymer beaker about half full of polymer and dispense it into the polymer pail. Mix thoroughly with a wooden paddle. Pour the mixture into polymer feed can.
3. Fill the calcium hypochlorite measure with 0.2 pounds (lb.) (91 grams) of calcium hypochlorite and pour it into the Cl2 pail. Mix thoroughly and pour the mixture into the Cl2 chemical feed can.

NOTE: White speckles of undissolved chemical are normal.

4. Fill the sodium hex measure with 0.1 lb. (45 grams) of sodium hex and pour it into the sodium hex pail. Mix thoroughly and pour the mixture into the sodium hex chemical feed can.
5. Fill the citric acid measure with 0.75 lb. of citric acid and pour it into the citric acid pail. Mix thoroughly and pour the mixture into the citric acid feed can.

NOTE: Citric acid is fed into the ROWPU after 20 hours of continuous operation or whenever the pH of the product water is above 8.

Connecting the chemical feed lines

All the needed chemicals are now mixed. Your next step is to connect the chemical suction and feed lines as illustrated in figures 1–43 and 1–43a. Your first step is to insert all four chemical feed cans into the rack provided and position the rack next to the chemical feed pump. Next, connect suction and return feed hoses to the feed cans according to the following color designation:

- Polymer—blue.
- Sodium hex—green.
- Cl2—red.
- Citric acid—yellow.

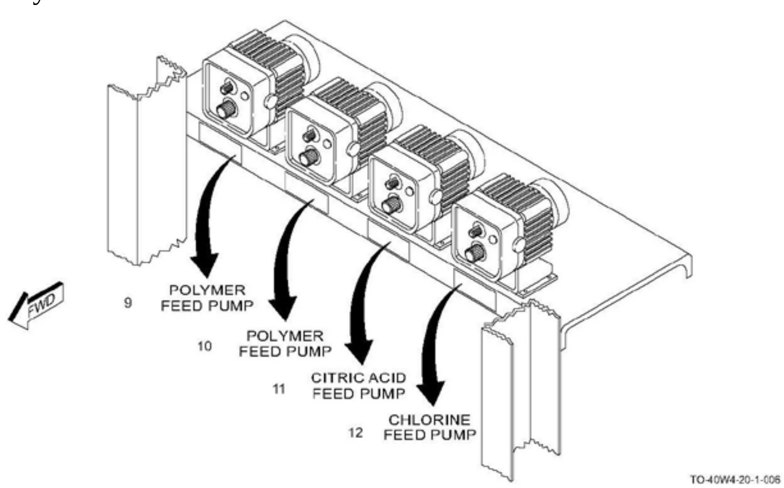
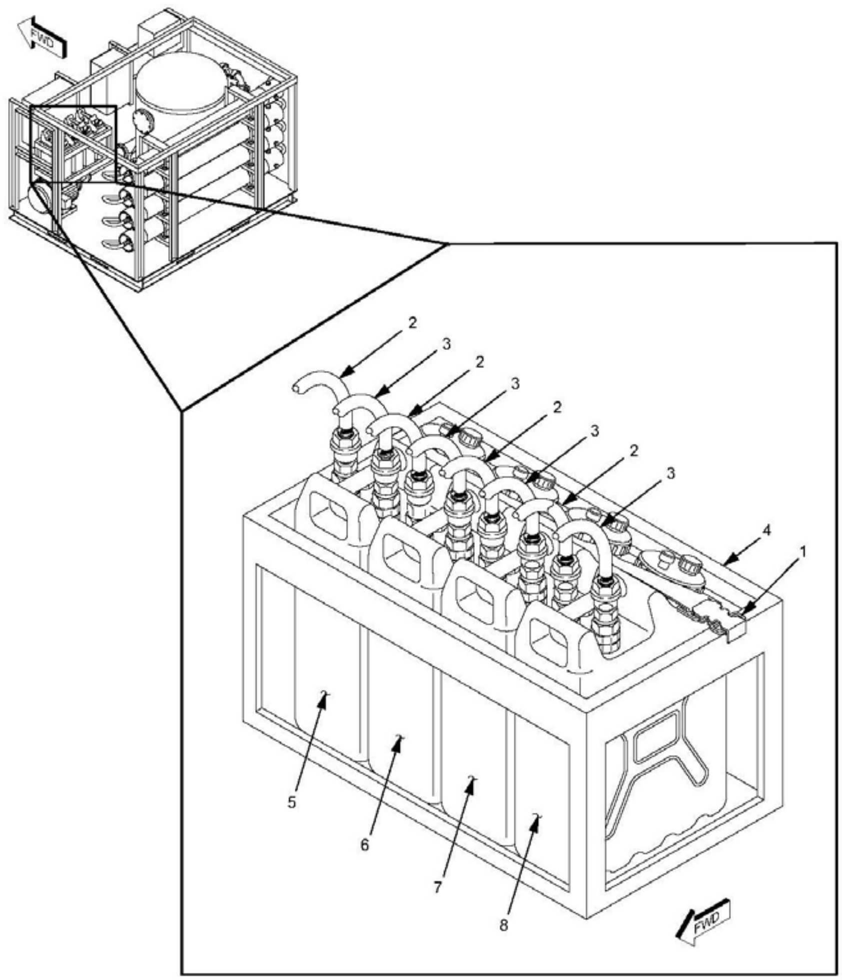


Figure 1–43. Chemical feed can connections.



LEGEND:

1. STRAP
2. SUPPLY HOSE
3. RETURN HOSE
4. CHEMICAL CAN RACK
5. CHLORINE CAN
6. POLYMER CAN
7. SODIUM HEX CAN
8. CITRIC ACID CAN

Figure 1–43a. Chemical feed can connections.

Note that the suction hose from the chemical feeder goes to the male quick-connect coupling on the feed cans while the return feed hose to the chemical feed goes to the female quick-connect coupling on the feed can (fig. 1–43). Another way to distinguish this is by looking at the chemical feeder. The suction hose is at the bottom of the feeder head while the return hose is above the feeder head.

Installing the grounding rod

As we discussed earlier, the grounding rod is installed to prevent operating personnel from getting shocked. Before power is applied to the unit, the grounding rod must be installed. The grounding rod consists of three 3’ sections. For the unit to be grounded properly, at least 8’ must be in the ground. For hard soil areas, this may be a chore in itself. To make the job easier, wet the area to be used as a location for the grounding rod with raw water. This will soften the soil. If needed, use alternative soil soakings as you hammer the grounding rod sections into the ground. Install the grounding rod-using figure 1–44 and these steps:

1. Remove the three sections of the grounding rod by loosening the securing plates enough to retrieve the rod from its stowage location on the front of the control panel.

2. Attach a drive bolt to the coupler and screw the coupler onto the first section of the grounding rod. Drive this first section into the ground with the 8 lb. hammer.
3. Continue to drive the remaining two sections in similar fashion (using the drive bolt and coupler) until at least 8’ of the rod is in the ground.

Next, install grounding strap to the grounding rod using the grounding lug and nut. Secure the other end of the strap to the location pointed out in figure 1–45.

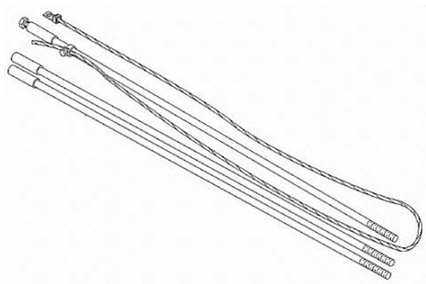


Figure 1–44. Grounding rod.

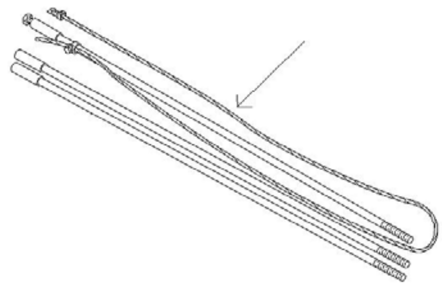


Figure 1–45. Ground strap.

Connecting power

Your final step in the ROWPU set up is connecting the power source to the junction box illustrated in figure 1–46.

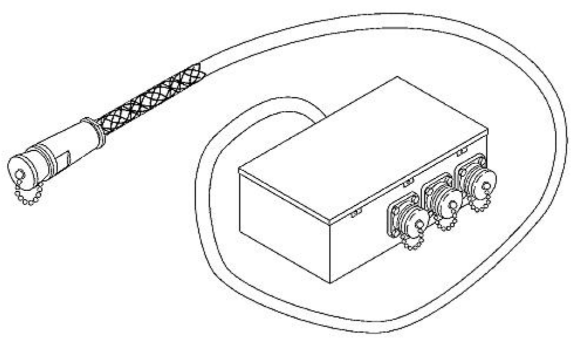


Figure 1–46. Junction box.

607. Purifying water

We have discussed a lot of material so far, mostly centered on setting up the ROWPU. We have now arrived at the heart of ROWPU operations—purifying water. Setting up the ROWPU is the hardest part of making water in the field. It has been noted by many war veterans that they spent a considerable amount of time just trying to set up the unit. They also stated that once the set up was complete, the rest was “gravy.” This is true if you follow the set-up procedures systematically. If you do not follow the proper procedures, you cannot properly operate this complicated unit. Any time you are working with the unit, be sure to use the procedures outlined in TO 40W4–20–1. Not properly setting up this machine will cost you—the operator—hours of lost time and potentially hampering the mission. This is the main reason we spent so much time discussing the setup of this unit—so you can be confident on how to correctly set up the unit—without fail. Now, let us prepare the ROWPU to make water. This instruction will be fast-paced.

Operating sequence

During the initial run up of the ROWPU, a valve and switch setting sequence occurs. This is done not only to establish a sequence of steps towards purifying water but also to prevent you from damaging the unit. You must follow the procedures to the letter.

Close the drain valves

The 1500 ROWPU is shipped with all drain valves open. Drain valves are used to dewater the unit before shipping. Next, close the drain valves (fig. 1–47). The closed position is indicated when the handle is parallel to the unit.

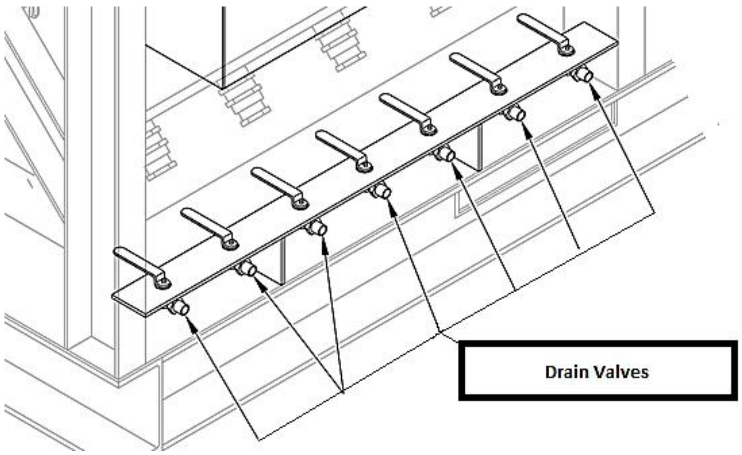


Figure 1–47. Drain valves.

Open the vent valves

Figure 1–48 illustrates where all the vent valves are located on the control panel. This location allows you to easily operate the valves. Vent valves are used to prevent air from accumulating inside the ROWPU; you must make sure all the vent valves are opened during the initial startup. Start valve opening procedure as follows:

1. Set the vent vessels knob/switch to vent (fig.1–48).
2. Set all vents (fig. 1–49) to open.

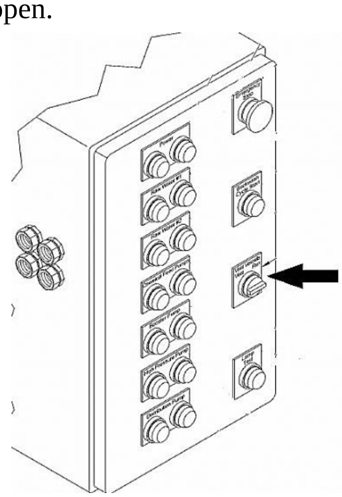


Figure 1–48. Vent valves switch.

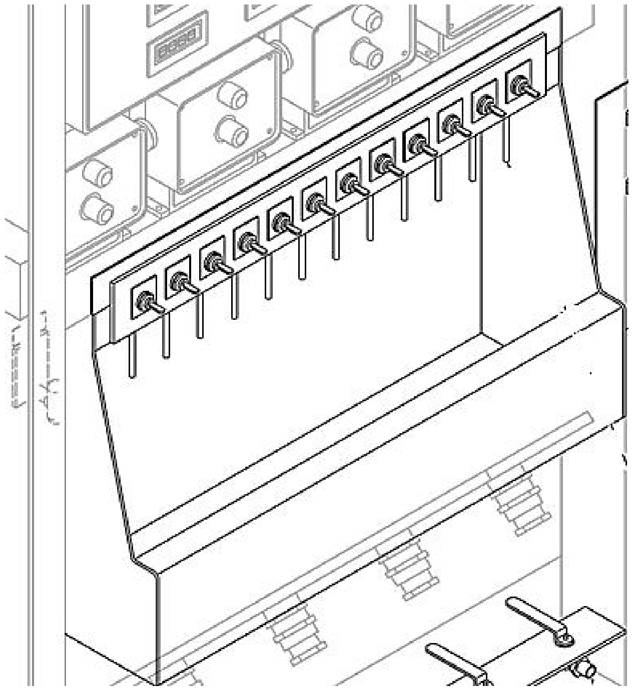


Figure 1–49. Vessels vent location.

Control box switches

With the exception of the “emergency stop” button, each control box switch has an indicator light.

Chemical feed valves

Your next step is to check to make sure all four chemical feed valves are in the “prime” position; the arrow ends of the valves should point to the prime position. The initial “prime” setting of the valves ensures these two important points:

1. The correct amount of chemical will be delivered after a sufficient priming period of the chemical feed pump.
2. That no air will be introduced into the ROWPU.

Priming the raw water pumps

You are now ready to prime the raw water pumps. To do this, remove the priming plug from the top of the raw water pump using a wrench from tool kit. Next, fill the volute of raw water pump until water comes out of the hole. To prevent air from being sucked into the volute, apply a small layer of Teflon tape to each priming plug. Now, replace the priming plug onto volute body of pump. Make sure the vent and relief valves on each pump are closed.

Applying electrical power

Using applicable procedures, establish power at the source. Push the ROWPU Main Disconnect upwards to engage (fig.1–50). Pull out the E-Stop Button on the control Panel. Depress the Main Power Button. Indicator lights should light after a short delay.

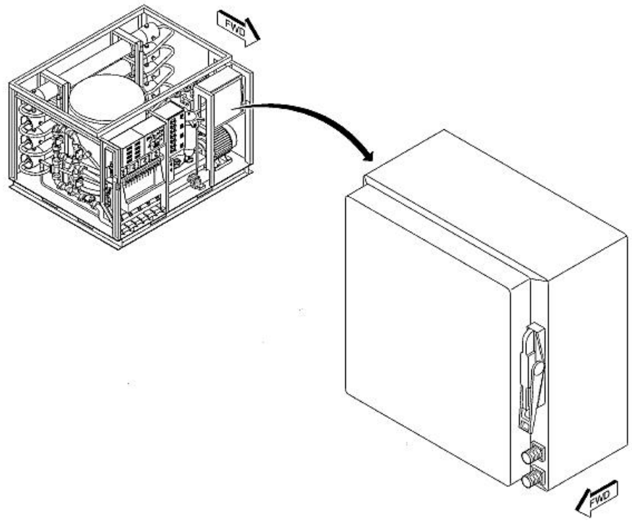


Figure 1–50. Junction box cover.

Start the chemical feed pumps

Make sure chemical feed valves are in the PRIME position. Turn on the pumps by depressing and releasing the Start Chemical Feed Pumps pushbutton (fig. 1–51). With the pumps operating, adjust the speed and stroke to 100 percent for all Chemical Pumps (fig. 1–52).

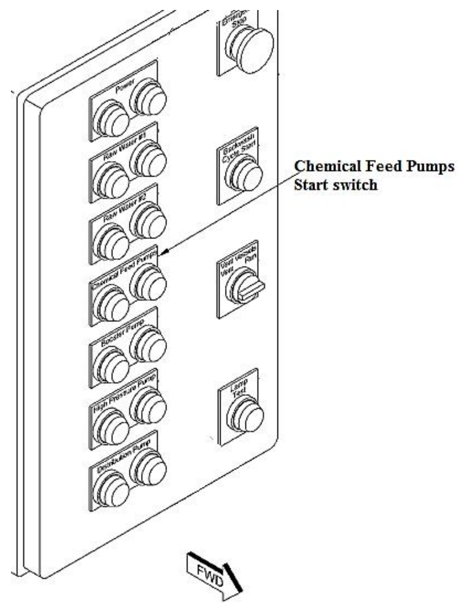


Figure 1–51. Chemical feed pumps start switch.

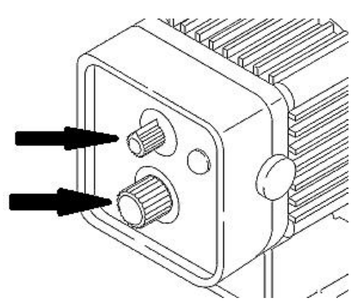


Figure 1–52. Chemical feed pump adjustment.

NOTE: During all of these procedures, the chemical feed valve must remain in the PRIME position. Do not turn to RUN until ROWPU operation dictates**.** Use the 100 ml graduated cylinder to complete these adjustments.

Allow the chemical pump to operate until a full solution flow is established in the return lines to each chemical feed can. Your primary interest here is priming the chemical pump and removing any air from the suction tubes coming from the chemical feed cans. When flow is established (flow returning to the can through the PRIME line) on the pumps, adjust the flows per the following:

- **Adjust polymer**—Turn the control knob for stroke and speed to 45 percent for turbid waters or 30 percent for clear water. Remove the prime hose from the chemical feed can and using the graduated cylinder collect the flow for 1 minute. The flow should be approximately 60 ml/min on turbid waters or 20 ml/min for clear water.
- **Adjust sodium hex—**Sodium hex flow is adjusted in the same manner, begin at 45 percent for your speed and stroke. Remove the prime hose from the chemical feed can and using the graduated cylinder collect the flow for 1 minute. Capture the flow and adjust as necessary to achieve 60 ml/min. Leave the chemical valve in the PRIME position.
- **Adjust Cl2 feed—**Cl2 feed is adjusted the same as sodium hex.
- **Adjust citric acid feed—**If citric acid is to be used, the pump will be set to maximum speed and stroke during operation. No other adjustments are necessary.

Start raw water pump #1

Locate the pushbutton for raw water pump #1 on the control box and depress and hold the button until the raw water pump #1 lamp comes on. Release the pushbutton switch. At this point, verify that raw water pump #1 is pumping. A good indication of this is that the discharge hose of this pump will expand under water pressure. If it does not expand, pinch the discharge hose of this pump (creating head backpressure) until it starts to pump. If this does not work, re-prime the pump. (If raw water pump #1 is not used, you will still need to depress the pushbutton to start the pump in order for the ROWPU to work properly.)

Start raw water pump #2

Locate the pushbutton for raw water pump #2 on the control box and depress and hold the button until the raw water pump #2 lamp comes on (just like raw water pump #1). Release the pushbutton. It will set itself to the run position. Again, verify that raw water pump #2 is pumping by looking for an expansion of the discharge hose under water pressure. You should not have any problem with raw water pump #2 pumping as long as raw water pump #1 is pumping. Check the hose connected to the gate valve on the raw water coupling on the control panel; it should be fully expanded. Next, adjust raw water gate valve to achieve a raw water flow of 45–52 gpm. Verify the pressure on the raw water flow gauge located on the control panel shown in figure 1–53. If it does not, shut down both raw water pumps and re-prime raw water pump #1. Continue this procedure until you get a flow of 45–52 gpm.

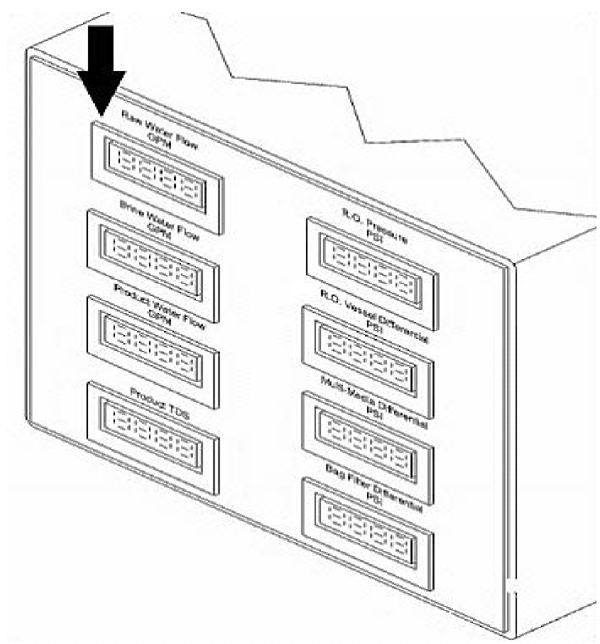


Figure 1–53. Raw water flow gauge.

Closing the vent valves and making water

When a stream of water flows from all the vents, you will close the vents (fig. 1–54). Turn the Chemical Feed valve for the polymer to RUN and allow the unit to run for approximately 10 minutes.

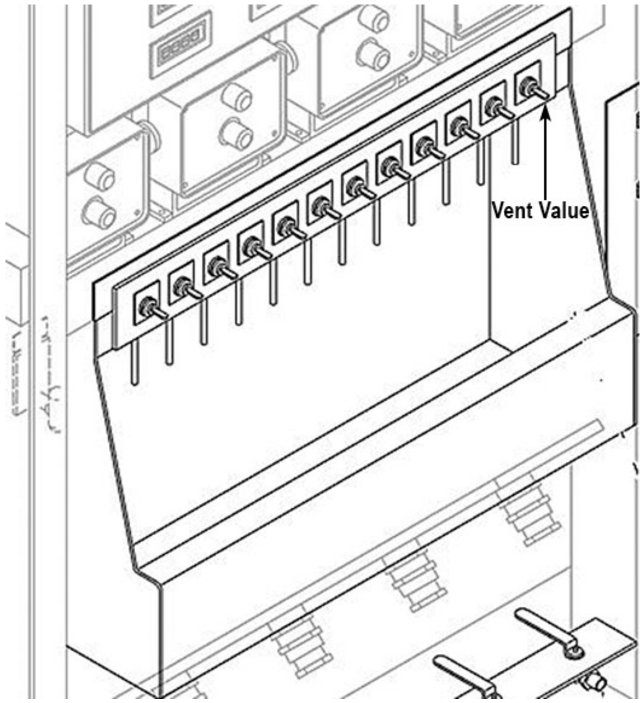


Figure 1–54. Vent valves.

Checking water clarity

At this point, water is being processed through the multimedia filter. Now you need to check for water clarity before you allow the water leaving the RO pump to go towards the RO vessels. As we discussed in a previous lesson, the water quality entering the RO vessels must be low in turbidity. Although this exercise is time consuming, it must be accomplished correctly to prevent the RO elements from plugging up prematurely. Using the graduated cylinder, draw a sample from the filtered water sample valve. Try not to trap any air in the sample because air bubbles can interfere with the accuracy of the Turbidity Meter. Transfer a portion of the sample to the Turbidity Meter and perform a turbidity test. Your goal should be a turbidity reading of less than 2 Nephelometric Turbidity Units (NTU). In water that is very turbid, you may be above 2 NTU, but always try for the best water you can achieve. If the water is above 2 NTU adjust the POLYMER chemical feed pump STROKE and SPEED up 5 percent from where you were. Allow the unit to run for 10 minutes and repeat turbidity test. Continue to adjust polymer feed until you achieve an acceptable water quality.

Final adjustments

By now, the water is clear enough to introduce into the RO vessels. You do this by forcing water to go to the RO vessels using the RO pump. Proceed as follows:

1. Set the sodium hex chemical feed valve to the run position.
2. Make sure the vent product water valve is open. This will allow trapped air to escape from the product water line.
3. Check and make sure the regulate product flow valve is quarter of a turn open.
4. Turn the selector switch for the vent vessel valve from the VENT position to the RUN position. The valve takes approximately 30 seconds to switch positions. This will force filtered water to go to the RO vessels. Make sure that the light on the display panel indicates the valve is in the "run" position.
5. Open the raw water gate valve fully. When in normal ops the valve should be fully open. It is only used to regulate flow in the vent and backwash cycles.

6. Start booster pump by depressing the pushbutton labeled Booster Pump. Make sure that the light for the booster pump illuminates.
7. If all the lights on the indicator panel are green, depress the pushbutton to start the high-pressure pump (RO pump).
8. *Slowly* adjust the regulate product water flow valve. When it starts up, this valve should be approximately half way open. By closing or opening until the desired RO vessel pressure is attained (freshwater 500 pounds per square inch [psi] and seawater 960 psi maximum). Using the “regulate feed water” valve, adjust the raw water flow to approximately 48–50 gpm. Allow the unit to stabilize, and when water flow is established from the other vent valves, close them. Note your product water flow. Nominal conditions are that on fresh or brackish water you should be targeting 30 gpm and on seawater 25 gpm. Use the regulate pressure boost valve to fine-tune your PRODUCT water flow. If you are making too much PRODUCT water, close the “regulate feed water” valve slightly. The 50 gpm is just a target.
9. Set the Cl2 chemical feed valve to the “run” position.
10. After 2 minutes of operation, check Cl2 levels in a sample from the sample product water valve. Using the photometer from the kit, and follow TO instructions. The water should have a Cl2 level of 2.0 ppm or other level as directed by command. Check the pH using the meter from the kit. It should be between 5 and 8 units.

The ROWPU is now in full operation. You are now producing purified water after a very long set-up, and run-up procedure. If you have done everything correctly, the ROWPU will not shut down prematurely.

At this point, we need to discuss specific parameters of operation. Carefully maintain parameters by diligently observing all ROWPU gauges and indicators for proper operation. The table below specifies the limits of each gauge or indicator:

Normal And Trouble Point Indications		
Gauge or indicator	***Normal reading***	***Trouble reading***
Bag filter	1–20 psid.	Above 20 psi.
Multimedia filter	10 psid or less, not to exceed 5 psid from original start up.	Over 10 psid or within 5 psid of initial startup reading.
Raw water flow	45–52 gpm	Drop to 30 gpm or less for fresh or brackish water, 25 gpm or less for salt water.
Brine flow	16–24 gpm	Below 15 gpm
Product water flow		
Saltwater	6–12 gpm	Below 6 and above 12 gpm
Fresh water	Up to 16 gpm	Over 16 gpm
Brackish water	Up to 16 gpm	Over 16 gpm
RO pressure		
Saltwater	960 psi	Above 960 psi
Fresh water	500 psi	Above 500 psi
Brackish water	500 psi	Above 500 psi
RO vessels	50–100 psid	Above 100 psid
TDS of product water	0–1,000 ppm	1,500 ppm or above

608. Maintaining normal operations

By now, you have successfully started up the ROWPU and you are making water. You have now completed the hardest part of ROWPU operations. If you started this unit, properly it will not have already shut down and you have done a good job of following procedures to the letter. This has been an arduous task indeed—but you are not able to rest yet. All you have done so far is get the unit ready to do the job you are responsible for. This is just the beginning. Now, you must make sure the ROWPU *continues* to operate properly in order for you to provide the troops with water. In a sense, your real job has just begun. You are now ready to operate the ROWPU. During the operation of the ROWPU, you, the operator, must have these specific goals in mind:

- Maintain the appropriate Cl2 dosage at *all* times.
- Fill the product water tanks and large storage bladders as needed for troop operations.
- Fill the brine tank so you can backwash.
- Prevent unauthorized personnel from loitering around.
- Monitor the ROWPU components for trouble and gauges for indications of a change in water quality.

Chlorine dosage

While the ROWPU is in operation, check the Cl2 residual of the product water entering the #1 product water tank every hour on the hour. The Cl2 residual of the product water *must* be at least 2 ppm of free available Cl2 unless specified otherwise by medical authorities—usually the site surgeon.

Here are a few factors you must consider before determining the appropriate Cl2 level:

- How long will the water sit in a tank before consumption?
- What is the outside temperature? The hotter the temperature, the faster Cl2 will dissipate.
- How much product water are you introducing into the tanks or bladders? Will it be enough to raise the residual back up?

Filling the brine tank

While treating product water, the brine tank will fill up. You are unable to backwash the multimedia filter or clean the RO elements without brine water. Remember, you can only use brine water to accomplish this task. Chlorinated product water will instantly destroy the RO elements and raw water is too dirty. You should fill the brine tank. When brine water bladder is full, remove the brine discharge hose and put it on the ground. Allow brine water to go to waste until you use up the brine water in the tank. Make sure the brine hose waste discharges at least 25 yards downstream from the raw water intake point.

Filling the product water tanks

This is the most important goal during water treatment operations. Above all, you must fill the product water tanks to keep troop operations going. The success of your job depends on those and other product water tanks being full at all times, as much as possible. During the initial set up of the ROWPU, you probably will only have the two onion bladders to fill. This may not always be so. You are provided larger tanks (bladders) to fill up, when the operational mission increases in personnel numbers. Be prepared to have personnel working day and night until all tanks are full of potable water. As you fill up the tanks, keep the following things in mind:

1. Always try to use tank #1 as Cl2 contact chamber. This will allow the Cl2 enough detention time with the treated water and help prevent bacteriological problems.
2. It is more important to fill product water tank #2 than product tank #1. This is because you want to be able to deliver as much water as possible to the user at any one time. When product tank #1 is full, open the gate valve (fig. 1–55) to allow water to flow to tank #2.

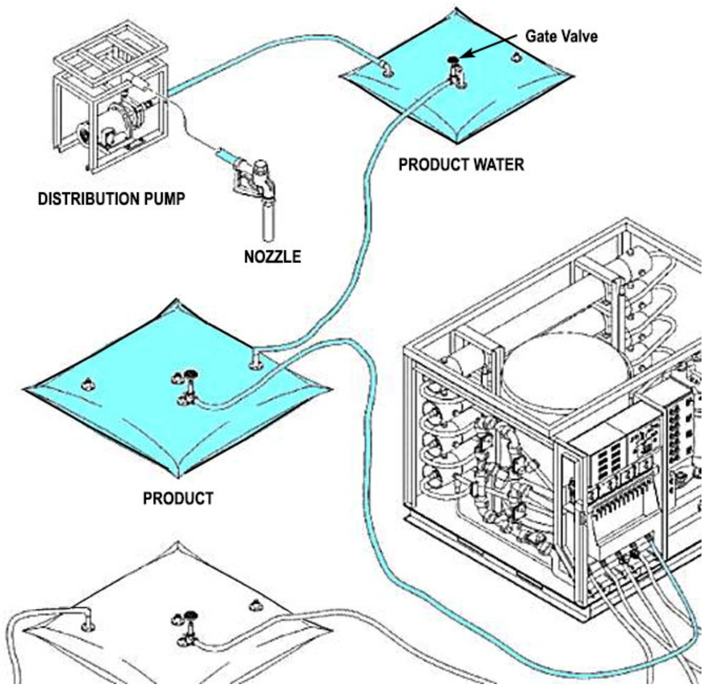


Figure 1–55. Product water tanks.

3. Keep both product water tanks covered at all times. You do not want airborne contaminants and rain entering these tanks.
4. Do not fill the product water tanks until the TDS of the product water is less than 1,000 ppm and the Cl2 residual is at least 2 ppm or limits established by base surgeon. The operator must keep the Cl2 residual high enough to ensure that a residual of sorts exists a while after production. To prevent consumers from getting sick in remote areas, make sure there is enough Cl2 residual in the tank so it stays sterile in the tank.
5. Shut down the ROWPU when product water tanks, storage bladders, and water buffaloes are completely filled.

Monitoring the polymer feed rate

Keep a good eye on the polymer feed rate. Every hour on the hour, you must perform the turbidity test on the cartridge filter influent to determine whether or not you need to increase the polymer feed rate or backwash the multimedia filter. The higher the turbidity of raw water, the higher the polymer feed rate. In all cases, it should never be necessary to increase the polymer feed rate above 5. Do not continue to run the ROWPU if the turbidity test is not satisfactory. In this case, backwash the multimedia filters. If you continue to run the ROWPU, you will be forced to change the cartridge filter elements prematurely as well as backwash the multimedia filter.

Monitoring RO pump pressure

Keep a very close watch on RO pump pressure. Remember, you must never exceed 980 psi (seawater) and 550 psi (freshwater and brackish water). The RO pump pressure will increase as solids build up on the RO elements even though the regulate product water valve is not touched after its initial setting. As solids build up on the RO vessels, the differential pressure from the inlet to the outlet of the vessel will increase. This will, in turn, increase the RO pump pressure because the RO pump will also have to work harder to push the same amount of water through the vessels. Be prepared to adjust the product regulate flow valve when the RO vessels gauge is above 150 psid. This act will give you a little longer production run as long as TDS is within parameters.

Pressure versus product

The last thing we need to discuss in this section is the relationship of RO pressure and product water flow as it relates to removal of TDS. It is very important you understand this relationship because it defines the fullest understanding possible of any ROWPU. Let us look at this relationship a little closer:

1. The higher the RO pressure, the less product water you will produce and the more brine water you will produce.
2. The TDS of the product water coming out of each vessel should always remain equally the same—from vessel to vessel.
3. The TDS of the brine water will increase, from top vessel downwards, as the rejected brine water flows to the next lower vessel.

Saltwater operations

After a saltwater production run, you must rinse the ROWPU of all salt before any shut down for more than 24 hours, or whenever the unit is to be shipped back to the depot location. If you do not rinse the ROWPU, the salt remaining in the ROWPU will corrode the internal piping and most importantly, it will damage the piston pump due to encrustation of salt particles. Salt will also ruin the filtering media in the multimedia filter after it dries. To rinse the ROWPU, follow these procedures:

1. While the unit is still producing water, turn all chemical feed pump valves to prime.
2. Drain all the brine water from brine tank and place brine hose on the ground.
3. Fill brine tank with at least 2,000 gal. of unchlorinated product water.
4. Shut the unit down and set up the raw water pumps to pump out of the brine tank.
5. Turn the unit back on and process the 2,000 gal. of product water out of the brine tank.
6. Perform normal shutdown procedures when the brine tank is completely drained of product water. The unit is now free of all salt in the system.

This concludes our discussion on operating the ROWPU. We have discussed many procedures and principles. In the next section, we will explain how you maintain the ROWPU.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

605. Site selection

1. Who normally decides the set up location of the ROWPU?

2. What are the three types of water sources?

3. What is the TDS content of brackish water?

4. Explain how the selection of a site in low-lying areas could affect your operations?

5. What is the maximum amount of suction lift that may be exerted on raw water pump #1?

606. Setting up the ROWPU

1. Where should the control panel of the ROWPU be facing when you position the ROWPU?

2. To prevent injury or damage to equipment, how many people are required to unpack the 1500 ROWPU and to move the pumps?

3. Where are all the BIIs packed on the ROWPU?

4. How far away from the water source should you position raw water pump #1?

5. Why do you need someone nearby while self-jetting the wellpoints for the ocean intake structure?

6. Which hoses are only intended for use with the product water system?

7. Where should you locate the waste discharge hose?

8. How far into the ground should you drive the grounding rod?

607. Purifying water

1. What is the purpose of the drain valves?

2. What is the purpose of the prime/run valves on the chemical feed pump?

3. When priming the chemical feed pumps, what is the maximum setting of the control knob for each chemical on the chemical?

4. Which instrument do you use to calibrate the chemical feed pumps?

5. How will you be able to tell raw water pump #1 is pumping once the switch is engaged?

6. What should the raw water flow be once both raw water pumps are on?

7. What do you use to check for turbidity?

8. What nominal conditions should you target for on fresh or brackish water and on seawater?

608. Maintaining normal operations

1. Explain your responsibilities towards the ROWPU once the unit is up and running.

2. Why must you always have the brine tank full?

3. What should you do when the brine tank is full?

4. What is the minimum allowable Cl2 residual on product water? Why?

5. Explain the relationship of polymer feed rate and turbidity removal.

6. Explain the relationship between RO vessel differential pressure and RO pump discharge pressure.

1–4. Maintaining the ROWPU

Earlier we stated that the ROWPU is a very complicated piece of equipment, and a lot of money was invested into the designing and building of it. Like any piece of mechanical equipment, the ROWPU is not maintenance free. To operate the ROWPU efficiently for any extended length of time, you must also be able to perform the required maintenance actions that will enable the unit to do its job effectively. Keep in mind here we are not talking about repair. That is an altogether different job. The word “maintain” means to keep up; keep in existence or continuance. In this section, we will discuss these maintenance actions in depth.

609. Backwashing the multimedia filter

During the production run, the multimedia filter will build up with suspended solids to such an extent that an increase of polymer feed will no longer help in removing turbidity. This event will occur long before a physical indication of the need to backwash materializes. By this, we mean, the physical indication of pressure differential from the inlet to the outlet of the filter. The multimedia filter must be backwashed when indicated to prevent the cartridge filter from clogging prematurely. As the multimedia filter run progresses, the media surface area will become plugged up. Eventually, water will find the path of least resistance through the filter bed by developing “cracks” allowing suspended solids to pass through the multimedia filter and plug up the bag filter prematurely. This becomes a dangerous precedent. It is for this reason the multimedia filter needs to be backwashed as soon as it is indicated.

When to backwash

Mainly the media filter is backwashed whenever system dictates (Media Filter Plugged Light on) or before long-term shutdown or storage. What are the indications for backwashing the multimedia filter? The TO officially dictates when to backwash; however, there are also other indications that you learned through experience. We will discuss the important indications in this lesson. As a rule, you should backwash the multimedia filter when any one or a combination of these events occurs:

1. 20 hours of continuous operations have elapsed.
2. Multimedia filter gauge indicates a reading of over 10 psid.
3. Multimedia filter gauge indicates a 5 psi reading above the initial start-up reading.
4. ROWPU will be shut down for more than 24 hours.

As we stated, you learn other indicators through experience. When these occur, you should be prepared to backwash the multimedia filter. They are listed here in order of occurrence:

1. Raw water flow starts to decrease slowly (indicating the plugging up of multimedia filter surface).
2. You notice the turbidity test is no longer satisfactory and an increase in polymer feed no longer reduces turbidity.
3. Raw water flow rises suddenly (indicating a crack in the filter bed).
4. Cartridge filter pressure gauge indicates a higher than normal pressure differential, indicating the filter load has been transferred to the cartridge filter.

Shutdown procedures

The ROWPU must be shut down before it is backwashed. You shut the unit down in the reverse order that it was started. There is a short-term and a long-term procedure for shutting down the unit. Let’s look at the steps you need to take for both:

SHORT TERM—less than a day.

1. Depress high-pressure pump STOP pushbutton.
2. Depress booster pump STOP pushbutton.
3. Depress chemical feed pumps STOP pushbutton.
4. Depress raw water pump # 2 STOP pushbutton.
5. Depress raw water pump #1 STOP pushbutton.

LONG TERM—more than one day

1. Before long-term shutdown when running on seawater it is necessary to flush the system with non-chlorinated product water for at least 30 minutes. Do not store the unit with seawater in it! While flushing the system also flush the chemical feed systems as well.
2. Depress high-pressure pump STOP pushbutton.
3. Depress booster pump STOP pushbutton.
4. Depress chemical feed pumps STOP pushbutton.
5. Depress raw water pump # 2 STOP pushbutton.
6. Depress raw water pump #1 STOP pushbutton.
7. Turn vent vessel selector switch to vent.

8. Perform media filter backwash.
9. Depress main power OFF pushbutton.
10. Depress emergency STOP.
11. Flip main breaker switch to OFF.

When performing a long-term shutdown, the media filter must be backwashed. During the shutdown after completing step 7 (turn vent vessel selector switch to vent) for long-term shutdown, close the raw water gate valve attached to the ROWPU raw water inlet. Turn the backwash valve assembly on raw water pump # 2 to the backwash water source. Verify that there is at least 600–800 gal. of water available. Depress Backwash Pushbutton Slowly to open the raw water gate valve to attain a flow of no more than 50 gpm. (DO NOT EXCEED 50 gpm at any time.) Monitor your flowmeter and your waste stream. You may have to slow the backwash rate down if media is being removed (for instance if on seawater or very warm water). The backwash cycle is automatic and lasts for 12 minutes. The times are as follows:

1. Backwash 8 minutes.
2. Rinse 4 minutes.

The system is now ready for long-term shutdown. During a required backwash, you would turn the backwash valve assembly on raw water pump # 2 to the raw water source and resume operations with normal start-up procedures.

610. Feeding citric acid

Recall during the setup of the ROWPU, citric acid (weak acid) was mixed in one of the chemical cans. So far, in our discussion of the operation of the unit, we have not mentioned feeding this chemical. Citric acid feeding during the production run is used as a “maintenance” dose to prolong the production run before the thorough cleaning required of the RO vessels, which we have not yet discussed. As the production run progresses, solids will build up on the RO elements. Consequently, citric acid is added to the water at the multimedia filter effluent line going to the bag filter in order to break up the buildup of scale (dissolved solids) built up on the surface of the RO elements. The buildup of scale on the RO elements will cause the product water pH to increase—a telltale sign of the need to feed citric acid. You must feed citric acid whenever the pH of product water rises above 8 and/or when 20 hours of production time have elapsed. Keep in mind, feeding citric acid will not stop production. Take a sample of product water and record TDS reading. Since you have already mixed the citric acid solution, you are ready to feed it when required. Feed citric acid as follows:

1. Make sure the citric acid control knob on the feeder is set maximum speed and stroke.
2. Set the citric acid chemical feed valve to run and feed this chemical for 10 minutes.
3. Draw a water sample from the brine discharge hose (going into the brine tank).
4. Check the pH of the sample. When it is between 5 and 8, set the citric acid chemical feed valve to prime and mix up a new solution of this chemical if you have depleted the contents or if the contents are low in the Citric Acid chemical can.

If you have done this procedure correctly, you will have extended your production run. You should also notice a drop in pH when compared to the sample taken before you fed citric acid. You should continue normal operations until the pH raises above limits or the pH starts rising again. Furthermore, regular feeding intervals of citric acid in this fashion (every 20 hours or when pH of brine is above 8) will prolong the need for an element cleaning procedure (discussed later).

611. Cleaning the reverse osmosis elements

The RO elements will eventually need cleaning as mineral deposits, dirt, silt, and salts encrust the outer surface of the RO elements. This encrustation will cause the RO pump discharge pressure to rise and product water flow to decrease. You cannot continue to purify water when these conditions develop. In fact, without corrective actions, the ROWPU will eventually shut itself down anyway.

You clean the RO elements to prolong their operational life inside the RO vessels. RO elements are expensive; thus, it is imperative that you, as the operator, take good care of the elements and clean them regularly rather than replace them prematurely wasting money. The RO vessels must be cleaned when any one or a combination of the following occurs:

1. Product water TDS is over 1,000 psid.
2. RO vessels gauge reads a differential pressure of over 100 psid.
3. RO pressure gauge reads 980 psi and the product water flow gauge indicates less than 25 gpm (saltwater).
4. RO pressure gauge reads 550 psi and the product water flow gauge indicates less than 30 gpm (brackish water).

There are two methods of cleaning the RO vessels—low pH and high pH. The low pH cleaning method is used to remove mineral deposits such as calcium carbonate (CaCO3), calcium sulfate (CaSO4), barium sulfate (BaSO4), iron (Fe), and other metal oxides. The high pH cleaning method is more effective for removing silt, colloids, biofilms and other organic contaminants. Cleaning is most effective if time and conditions permit doing both a low and high pH.

Setting up the unit for cleaning

Remove all components from the storage bag and verify the inventory with the parts list. Select your location. You will need space on the left of the unit to attach components to the ROWPU, space for the tanks, and space for the raw water pump. Also keep in mind the necessity to collect/drain spent cleaning solutions. Avoid tripping hazards with the hoses. Open drain valves on the ROWPU to drain the pressure vessels and to relieve any system pressure. Prepare the tank. Connect a valve assembly to both fittings on the tank (the lower - or supply, and the upper - or return). Ensure that the valves are closed. Fill the tank with product water and de-chlorinate. Fill to approximately 6” from the top of the tank. Add ½ teaspoon (tsp.) of Cl2 neutralizer to remove any Cl2 present in the water.

WARNING: The use of water containing Cl2 will permanently damage the RO elements. Always check the residual Cl2 level in any cleaning solution before using. If necessary, add more than a ½ tsp. of Cl2 neutralizer.

Disconnect the raw water hoses from raw water pump #2. Disconnect the power cable for raw water pump #1 from raw water pump #2. Reposition raw water pump #in proximity to the cleaning tank. Place the heater assembly on top of raw water pump #2. The heater power cord connects to the utility receptacle on the ROWPU (do not plug in the heater until ready to use). Install the adapter on the inlet of raw water pump #2 and the other adapter on the outlet of raw water pump #2. Initially connect the cleaning hoses as follows. Connect the medium length hose from the supply valve on the tank (the bottom) to the inlet of raw water pump #2. Connect the short hose from the outlet of the raw water pump #2 to the inlet of the heater assembly, then connect the remaining valve assembly to the end of a long hose. Connect the end of that hose (without the valve) to the outlet of the heater assembly, and the other end (with the valve) to the female x female adapter and then to the valve assembly at the return valve (the top) on the tank. Adjust the valve on the heater assembly to 20 percent flow. Open all valves on the cleaning tank and the tank return hose.

NOTE: Cleaning efficiency is enhanced by using warm water; however, it is possible to perform a cleaning without using warm water. The optimum water temperature to begin a cleaning is approximately 80–90º F. The heater will take time to heat the water up, so plan for this time in your workload.

Begin to re-circulate the water and mix. Start raw water pump #2. Observe the water flow and check for leaks. Energize the heater assembly by plugging the cable into the utility outlet. Continue to re-circulate and heat the water while performing the following procedures.

Locate the feed and return lines to the pressure vessels. The feed line is the lower line, and the return line is at the top. There are multiple connection points on each line. For the cleaning/preservation feed, disconnect the Victaulic coupling on the feed line, which is located just in front of the media filter. Install a 1¼" elbow assembly on the feed line going to the pressure vessels (the pipe section to the left of the break point). Reuse the Victaulic coupling and bolts that were removed. For the cleaning/preservation return, disconnect the Victaulic coupling that is located at the outlet of the upper pressure vessel. Connect the 1½" elbow assembly directly to the pressure vessel. Reuse the Victaulic coupling and bolts that were removed. Remove the ROWPU product water line from the product water supply. Discard any product water produced during the cleaning operations. CLOSE any drain valves opened to relieve pressure or drain the system When ready to proceeded with cleaning (pH and temperature are suitable) turn off both raw water pump #2 and the heater. Close the two valves on the tank and the valve on the return hose. Disconnect the return hose from the tank and connect the valve assembly on the hose to the elbow assembly on the supply line to the pressure vessel (the lower line near the media filter). Remove the adapter from the valve on the tank fitting. Connect the other long hose from the upper pressure vessel elbow assembly (the pressure vessel return) to the return valve on the tank (the upper valve). Open the two tank valves and the valve located on the feed line to the pressure vessels (fig. 1–56).

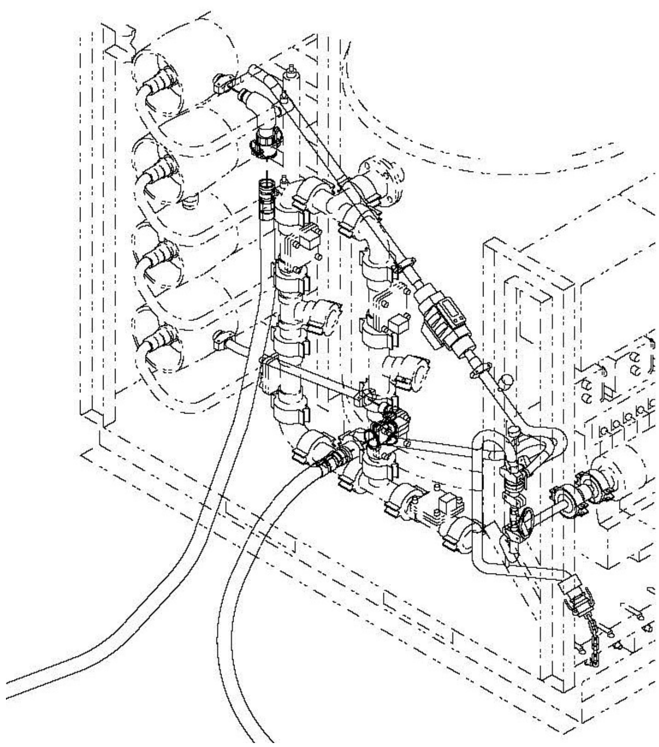


Figure 1–56. Citric acid cleaning hose set up.

WARNING: At no time during any cleaning or preservative operation should the temperature of the water exceed 110º F. Permanent membrane damage will occur.

Process

Once the element cleaning cycle is initiated, the acid solution will circulate in and out of the RO vessels by way of the tank provided. It is at this point that cleaning action will really take place. As the acid in the water starts to dissolve deposits from the elements, the acidity of the solution does the job of dissolving and removing the deposits from the elements.

Cleaning procedure

This procedure assumes that the water has been dechlorinated and that the proper low pH cleaner or high pH cleaner has been added to the tank and prepared according to the procedures above. As mentioned in the “warning” box, at no time during any cleaning or preservation operation should the temperature of the water exceed 110º F, or permanent membrane damage will occur. By using heated water, cleaning becomes more efficient. Periodically check your solution for conformance. Always check the pH of the cleaning solution before using. At no time should the pH be below 2.0 or above 10.5 because you can permanently damage the membrane. The use of water containing Cl2 will permanently damage the RO elements. Always check the residual Cl2 level in any cleaning solution before using. If necessary, add more than a ½ tsp. of Cl2 neutralizer. Before completing the following steps, make sure you drain the water from the pressure vessels and that no pressure remains in the system (verify this on the main pressure gage). Serious injury could occur if you try to remove components under pressure.

1. Turn on raw water pump # 2 and plug in the Heater. Adjust the flow control valve on the heater assembly to 20 percent and allow the system to circulate at this flow rate for 15 minutes. It may be necessary to add more cleaning solution to maintain desired pH. Specific directions are included with the cleaning solution.
2. Shut down the raw water pump # 2 and unplug the Heater and allow the system to soak for 10 minutes.
3. Restart raw water pump # 2 and plug the heater back in.
4. Adjust the valve on the heater assembly to 50 percent and allow the system to operate for 30 minutes.
5. At the end of the 30 minutes unplug the heater. Turn off the raw water pump # 2.
6. Disconnect the return hose to the tank. This will allow the pump to be used to pump the spent cleaning solution to the appropriate location. Additional dechlorinated product water can be added to the tank as needed to completely remove all cleaning compound from the pressure vessels (no foaming and approximately neutral pH).
7. If desired, the unit can now be returned to normal operations or additional cleaning or preservation methods can occur.

CAUTION: Used cleaning and preservation solutions must be disposed of in accordance with MAJCOM directives or local base directives.

Rinsing the RO vessels

When the RO vessels are returned to service, after any cleaning or preservation operation, the product water should be discarded for an hour or as otherwise directed. Full clearance of produced water must be attained before distribution. There may be cases where the elements are so fouled up that even after cleaning, the TDS level will still be above 1,000 ppm. Completely replace RO elements if the TDS reading does not drop below 1,000 ppm (fig. 1–57).

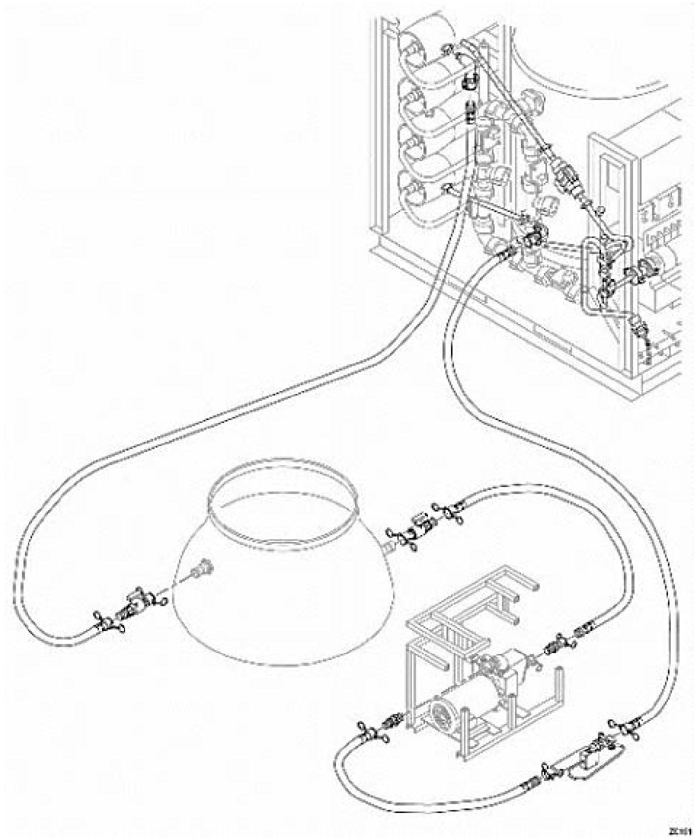


Figure 1–57. RO vessels rinse set up.

Return to service

Once the TDS is lower than 1,000 ppm, turn the Cl2 feed valve to “run” and wait 5 more minutes before you take a Cl2 residual and pH reading. During this time, you should be producing product water away from the setup site in such a way that it does not create muddy conditions. Before you collect the sample, pick up the end of the product water hose and hold the end vertical in such a way that mud, dirt, and acid is washed away from the nipple of the hose. This will prevent contamination of the sample. When the pH and Cl2 levels are within limits (pH 5 to 8 and 2 ppm Cl2 or Cl2 level dictated by bioenvironmental), connect the product water hose back into product water tank #1.

612. Replacing bag filter

Replacing the bag filter is the simplest maintenance task performed on the ROWPU. Bag filter replacement is indicated when the differential pressure of this filter exceeds 20 psid.

Removal

Your first step in replacing a bag filter is to do a normal shut down and turn off the main power. Release pressure and drain then disconnect the coupling connecting the bag filter vent connector to the cover of the bag filter housing. Remove the bag filter cover and internal framework. Remove the fabric filter bag from the bag filter housing and clean the components to remove debris. Inspect the components for damage that can prevent them from functioning properly. Take advantage at this time to perform gasket maintenance on the O-ring by inspecting for damage and lubricating with glycerin provided in one of the ROWPU storage chests (fig. 1–58). The bag filter can be washed and re-used. After 6 washes, discard the bag filter.

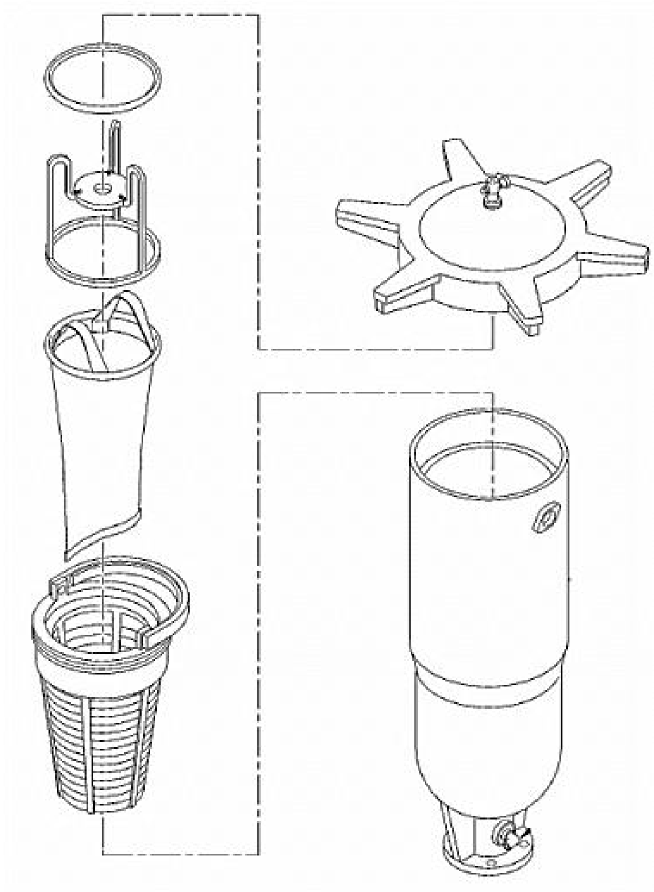


Figure 1–58. Bag filter element removal.

Installation

Install the fabric filter bag in the bag filter housing. Insert the internal support framework and attach the cover to the bag filter housing. Connect the coupling connecting the bag filter vent connector to the cover of the bag filter housing. Operate the ROWPU to check for leaks and correct operation.

613. Replacing reverse osmosis elements

The RO elements are replaced when it is no longer possible to lower the TDS of product water below 1,000 ppm using citric acid feeding and the element cleaning method. When element cleaning no longer works, it can be said:

1. The individual RO element is defective (damaged).
2. The preformed packing (brine seal) around each element(s) is worn or damaged, preventing water from being forced through the element.
3. The end connectors and O-rings are leaking through, failing to seal brine water from product water.

Earlier in this unit, we discussed the natural process of osmosis—a lower concentration of salt will naturally move towards a high concentration until equilibrium occurs. This is what happens when the interconnectors and end connectors are damaged due to high temperatures and pressures (general wear and tear).

Procedure

First, take the few minutes it takes to confirm which element(s) (and hence, vessel) is defective by doing a TDS test on the product water from each vent/sample valve. If you are short on time and are low on water, you can just replace the defective element for now and perform a complete element replacement later. Use the table below to determine the defective elements:

RO Vessel Troubleshooting Table			
	Measured TDS		
Condition	***Front sample***	***Rear sample***	***Cause***
1	Normal	Normal	Vessel and element operation okay.
2	High	Normal	Leak at front end connector/preformed packing of RO element.
3	Normal	High	Leak at rear end connector/preformed packing of RO element.
4	High	High	Leak at front and rear end connector/preformed packing of RO element and/or RO element interconnector O-ring

On the other hand, if you have plenty of time and water available, it is *always* a good idea to replace all the elements (eight total). This is because it is very likely the remaining good elements could also be nearing the point where they need to be replaced. Furthermore, it is better to start with a completely new set—that way pressure is applied evenly across the entire element O-rings and connectors.

Direction of removal and installation

On the1500 ROWPU, the RO elements are always removed and installed in the direction of flow. As figure 1–59 illustrates, the flow pattern of the four RO vessels alternate in direction at every vessel. Because of this, you must use great care when removing and installing RO elements. Installing the RO elements in the direction of flow helps seat the brine seals of the elements.

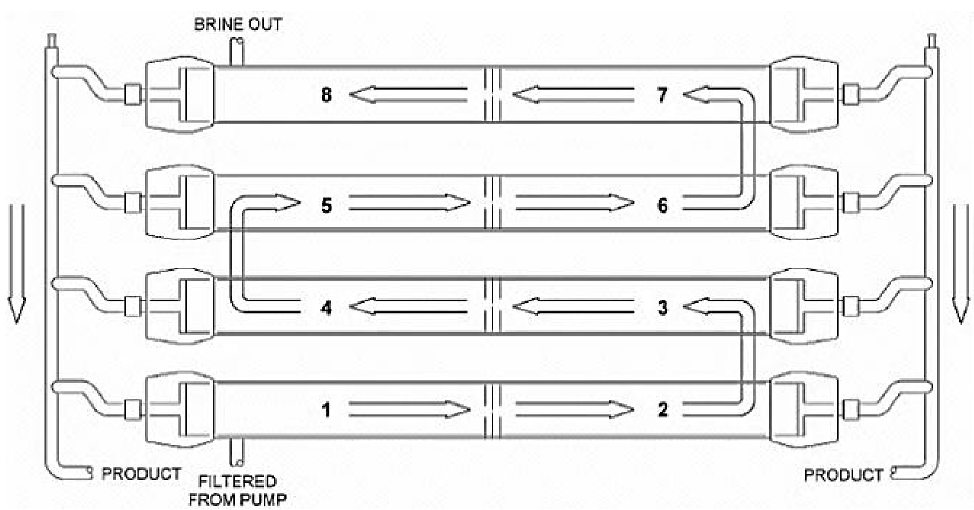


Figure 1–59. RO vessel water flow pattern.

Now that you understand this very important principle, we will discuss specific procedures for element replacement. First and foremost, perform a normal unit shutdown procedure as discussed previously. Next, relieve all pressure from the RO vessels to prevent injury.

Head assembly removal

Remove the product water outlet hose from the end of the adapter on the head assembly at the end of the pressure vessel. Remove the securing ring then grasp the product water adapter and pull the head assembly free from the vessel. Next, remove the head seal (large diameter seal) from the vessel.

Element removal

Remove two elements from each RO vessel, paying special attention to the direction of flow we discussed earlier. Proceed as follows:

1. Remove the head assemblies from both ends of the pressure vessel.
2. Remove the thrust ring from the downstream end of the vessel.
3. Remove the elements by pushing in the direction of flow.
4. Using 2 people, one on each end, detach elements from each other (they are attached in center) by holding one and turning the other counterclockwise.
5. Your final step is to clean the inside of the RO vessel with brine water and inspect the tube for nicks, cracks, and gouges.

Element installation

Install the thrust ring into the DOWNSTREAM end of the pressure vessel. Position the ring so the gap is over the port in the side of the vessel. Slide the first element into the unit leaving about 12” hanging out, then using two people, secure the second element on the first element by turning it clockwise to lock it in place. Finally, slide the elements into the vessel.

Head assembly installation

Install a head seal on the sealing plate of the head assembly. Lubricate the seal with glycerin, then install the head assembly into the pressure vessel. Take care to ensure that the head seal enters without pinching. Next, push firmly until the head fully seats into the pressure vessel and install the securing ring. Finally install the product water outlet hose on the adapter. The RO element replacement procedure is now complete.

This unit on the ROWPU was thorough; it had to be. This piece of equipment is so critical to the application of aerospace power that I felt it was very important to treat the subject thoroughly and seriously. This closes our study of ROWPU operations and maintenance. In the next unit, we will discuss the BEAR water distribution system—an equally important component used in the deployment of aerospace power.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

609. Backwashing the multimedia filter

1. What happens when filter cracks are allowed to develop in the multimedia filter?

2. How many hours can you operate the ROWPU without backwashing the multimedia filter?

3. How much differential pressure across the filter is acceptable before the multimedia filter needs backwashing?

4. What is the quickest indicator of a crack in the filter bed of the multimedia filter?

5. What action must be performed before the multimedia filter is backwashed?

6. What is the last step performed during short and long-term shutdown procedures?

7. How long is the backwash cycle?

610. Feeding citric acid

1. Where is the citric acid feed injection point located?

2. What is the "telltale" sign of the need to feed citric acid?

3. When do you stop feeding citric acid?

611. Cleaning the reverse osmosis elements

1. What is the result of regularly cleaning the RO elements safely?

2. What are the two element cleaning methods?

3. Which cleaning method should you use when the raw water source is high in dirt and silt?

4. Explain how the citric acid solution cleans the elements.

5. Citric acid solution should not exceed what temperature reading? Why?

6. What is the lowest pH value allowed for the citric acid solution?

7. How long do you operate the ROWPU when rinsing acid out of the RO vessels?

8. What is the maximum amount of TDS allowed, and the minimum amount of Cl2 needed, prior to filling the product water tanks?

612. Replacing bag filter

1. When should you replace the bag filter?

2. What step is taken after removing the fabric filter bag from Bag Filter Housing and cleaning the components?

3. How many times can the bag filter be washed before it is discarded?

613. Replacing reverse osmosis elements

1. When are the RO elements changed?

2. What should you do before even attempting to replace the elements?

3. What would be the cause of a high front TDS reading and normal rear TDS reading from their respective sample/vent lines?

4. In what direction are the top RO elements removed and installed?

Answers to Self-Test Questions

601

1. The 1,500 gph model.
2. All ROWPU models have colored bands on the unit piping. These bands are installed so you will be able to identify the stage of treatment of the water each pipe carries.
3. Black.
4. 1,500 gph.

602

1. It is a turbo charger that takes the discharge from the RO Pump and increases the pressure using energy recovered from the brine water discharge.
2. BII.
3. Self-jetting wellpoints.
4. 20,000 gal.
5. To remove NBC contaminants from product water.
6. Two.

603

1. Reverse osmosis.
2. Four. Multimedia filtration, bag filtration, RO (desalination), and chemical disinfection.
3. Water that has become saturated with salts. It’s a waste by-product of the reverse osmosis process.
4. Cl2.
5. Polymer.
6. To prevent scale and corrosion.

604

1. The control panel.
2. The “product regulate flow” valve.
3. The pushbutton control box.
4. Forces water to go towards the RO vessels.
5. The chemical feed pumps.
6. The pocket photometer.

605

1. Proper medical authorities.
2. Seawater, brackish water, and freshwater.
3. Between 500 to 15,000 ppm TDS.
4. A ROWPU set up on terrain with a low elevation could cause standing water around the unit after rainfall. If flooding were to occur, the unit would have to be relocated. In all cases, unsanitary conditions will develop. Muddy conditions will hamper delivery of water to trucks.
5. 20’.

606

1. Towards the water source.
2. Two.
3. On top.
4. As close to the water source as possible.
5. The area near the hole may fluidize creating a wide hole that could result in a loss of solid footing causing the operator to fall into the hole being drilled, and possibly drowning.
6. Hoses with a blue stripe running the length of the hose.
7. As far away from the ROWPU as possible and at least 25 yards downstream of the intake point.
8. At least 8’.

607

1. To dewater the unit prior to shipment.
2. To prevent air from entering into the ROWPU and to feed the correct amount of chemicals.
3. 100 percent speed and stroke.
4. 100 ml graduated cylinder.

5. The discharge hose will expand.
6. 45–52 gpm.
7. Turbidity meter.
8. 30 gpm for fresh or brackish water and 25 gpm for seawater.

608

1. Maintain the appropriate Cl2 dosage at all times. Fill the product water tanks and large storage bladders as needed for troop operations. Fill the brine tank so you can backwash. Prevent unauthorized personnel from loitering around. Monitor the ROWPU components for trouble and gauges for indications of a change in water quality.
2. You are unable to backwash the multimedia filter or clean the RO elements without brine water.
3. Remove the brine hose from the tank and lay it on the ground as far away from the unit as possible and at least 25 yards downstream of the raw water intake point.
4. 2 ppm free available Cl2. The operator must keep the Cl2 residual high enough to make sure that a residual of sorts exists a while after production. To prevent consumers from getting sick in remote areas away from the ROWPU from a depletion of residual.
5. The higher the turbidity of raw water, the higher the polymer feed rate—up to a point. The polymer feed rate should never need to be increased over 5. Do not continue to run the ROWPU if the turbidity test is not satisfactory. In this case, backwash the multimedia filters.
6. As solids build up on the RO vessels, the differential pressure from the inlet to the outlet of the vessel will increase. This will, in turn, increase RO pump pressure because the RO pump will also have to work harder to push the same amount of water through the vessels.

609

1. Suspended solids pass through the multimedia filter and plug up the bag filter prematurely.
2. 20 hours, provided the other indicators are within parameters.
3. 10 psid.
4. Raw water flow rises suddenly.
5. The ROWPU must be shut down.
6. For short-term shutdown, depress raw water pump #1 STOP pushbutton. For long-term shutdown, flip main breaker switch to OFF.
7. 12 minutes.

610

1. Multimedia effluent line, going to the bag filter.
2. Rise in product water pH above 8 and/or when 20 hours of production time has elapsed.
3. When the pH is back to 5 to 8.

611

1. Prolong the operational life of the RO elements inside the RO vessels.
2. High and low pH method.
3. High pH method.
4. Once the element cleaning cycle is initiated, the acid solution will circulate in and out of the RO vessels by way of the brine tank. It’s at this point that cleaning action will really take place—as the acid in the brine water starts to dissolve deposits from the elements. The acidity of the solution does the job of dissolving and removing the deposits from the elements.
5. 110º F; permanent membrane damage will occur.
6. 2.0 pH.
7. 10 minutes.
8. TDS is below 1,000 ppm and the Cl2 is at 2 ppm or Cl2 level dictated by bioenvironmental.

612

1. When the pressure differential across the filter exceeds 20 psi.
2. Inspect components for damage that can prevent them from functioning properly.
3. 6 times.

613

1. When it is no longer possible to lower the TDS of product water below 1,000 ppm using citric acid feeding and the element cleaning method.
2. First, take the few minutes it takes to confirm which element(s) (and hence, vessel) is defective by doing a TDS test on the product water from each vent/sample valve.
3. Leak at front end connector; preformed packing of RO element.
4. Always in the direction of flow.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (601) Which color band designates reverse osmosis water purification unit (ROWPU) piping that carries raw water?
   a. Yellow.
   b. Black.
   c. Green.
   d. Blue.

2. (601) Which color band designates reverse osmosis water purification unit (ROWPU) piping that carries filtered water?
   a. Yellow.
   b. Black.
   c. Green.
   d. Blue.

3. (601) Which color band designates reverse osmosis water purification unit (ROWPU) piping that carries product water?
   a. Yellow.
   b. Black.
   c. Green.
   d. Blue.

4. (601) How many gallons per hour (gph) does the 1500 reverse osmosis water purification unit produce (on the average)?
   a. 600.
   b. 1,000.
   c. 1,250.
   d. 1,500.

5. (601) How many hours per day is the reverse osmosis water purification unit (ROWPU) designed to operate?
   a. 24.
   b. 20.
   c. 12.
   d. 8.

6. (602) What is attached to the suction hose connected to the raw water pump that prevents the intake of damaging objects?
   a. Float.
   b. Strainer.
   c. Gate valve.
   d. Distribution pump.

7. (602) What is an electrically driven centrifugal pump used to pump water from the product water tanks to the end user?
   a. Reverse osmosis (RO) pump.
   b. Chemical feed pump.
   c. Distribution pump.
   d. Raw water pump.

8. (602) What is another term used to refer to the backwash water tank?
   a. Raw water tank.
   b. Product tank.
   c. Filtered tank.
   d. Brine tank.

9. (602) How many gallons of water does the backwash water tank hold?
   a. 20,000.
   b. 15,000.
   c. 10,000.
   d. 5,000.

10. (602) How many reverse osmosis (RO) elements are in each reverse osmosis water purification unit (ROWPU) RO vessel?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

11. (603) What is the *first* stage of purification in the reverse osmosis water purification unit (ROWPU) process?
    a. Bag filter.
    b. Backwash filter.
    c. Multimedia filtration.
    d. Chemical disinfection.

12. (603) What is the fourth and final stage of treatment that completes the reverse osmosis water purification unit (ROWPU) water treatment process?
    a. Multimedia filtration.
    b. Chemical disinfection.
    c. Bag filtration.
    d. Desalination.

13. (603) Sodium hex is fed by the reverse osmosis water purification unit (ROWPU) chemical feed pump at the
    a. multimedia filter pump.
    b. multimedia filter influent.
    c. reverse osmosis element pump.
    d. reverse osmosis element influent.

14. (603) What chemical is fed to reduce scale and corrosion inside the pipe network of the reverse osmosis water purification unit (ROWPU)?
    a. Polymer.
    b. Chlorine.
    c. Citric acid.
    d. Sodium hex.

15. (604) How many drain valves are installed on the reverse osmosis water purification unit (ROWPU)?
    a. 5.
    b. 6.
    c. 7.
    d. 8.

16. (604) What is the *maximum* allowable total dissolved solids (TDS) level on the reverse osmosis water purification unit (ROWPU)?
    a. 850 parts per million (ppm).
    b. 1,000 ppm.
    c. 1,250 ppm.
    d. 1,500 ppm.

17. (604) What process lasts for 4 minutes and completes the backwash cycle?
    a. Backwash.
    b. Cleaning.
    c. Rinsing.
    d. Draining.

18. (605) What *must* you do *first* before you set up and operate the reverse osmosis water purification unit (ROWPU)?
    a. Inventory all components.
    b. Assemble the ROWPU.
    c. Unpack the ROWPU.
    d. Select the proper site.

19. (605) How many feet upstream and away from the campsite should the reverse osmosis water purification unit (ROWPU) intake point be located?
    a. 50.
    b. 100.
    c. 150.
    d. 200.

20. (606) How many people are required for unpacking the reverse osmosis water purification unit (ROWPU)?
    a. 2.
    b. 3.
    c. 4.
    d. 5.

21. (606) How many *identical* raw water pumps are included with the 1500 reverse osmosis water purification unit (ROWPU)?
    a. 2.
    b. 3.
    c. 4.
    d. 5.

22. (606) What is used to measure total dissolved solids (TDS) and temperature?
    a. Thermometer.
    b. Volt meter.
    c. Ultrameter.
    d. Multimeter.

23. (606) Once operational, what water source is used to mix the chemical used in the reverse osmosis water purification unit (ROWPU)?
    a. Raw.
    b. Brine.
    c. Product.
    d. Brackish.

24. (606) What type of water may *never* be used to mix chemicals?
    a. Raw.
    b. Product.
    c. Brackish.
    d. Chlorinated.

25. (606) For the unit to be grounded properly, how many feet of the grounding rod *must* be in the ground?
    a. 3.
    b. 8.
    c. 9.
    d. 12.

26. (607) What is the target flow for brackish water?
    a. 20 gallons per minute (gpm).
    b. 25 gpm.
    c. 30 gpm.
    d. 35 gpm.

27. (607) When forcing water to go to the reverse osmosis (RO) vessels using the RO pump, what is the target flow for seawater?
    a. 20 gallons per minute (gpm).
    b. 25 gpm.
    c. 30 gpm.
    d. 35 gpm.

28. (607) The *normal* raw water flow reading should be between
    a. 35–38 gallons per minute (gpm).
    b. 38–42 gpm.
    c. 45–52 gpm.
    d. 55–58 gpm.

29. (607) The *normal* reading of reverse osmosis (RO) pressure for saltwater is
    a. 900 pounds per square inch (psi).
    b. 920 psi.
    c. 940 psi.
    d. 960 psi.

30. (607) The *normal* reading of reverse osmosis (RO) pressure for freshwater is
    a. 5 pounds per square inch (psi).
    b. 50 psi.
    c. 500 psi.
    d. 5,000 psi.

31. (607) The *normal* reading of reverse osmosis (RO) pressure for brackish water is
    a. 5 pounds per square inch (psi).
    b. 50 psi.
    c. 500 psi.
    d. 5,000 psi.

32. (608) You are *unable* to backwash the multimedia filter without which type of water?
    a. Brackish.
    b. Brine.
    c. Fresh.
    d. Sea.

33. (608) In *all* cases, it should *never* be necessary to increase the polymer feed rate above what?
    a. 2.
    b. 3.
    c. 4.
    d. 5.

34. (608) The reverse osmosis (RO) pump pressure should *never* exceed
    a. 920 pounds per square inch (psi) (seawater) and 540 psi (freshwater/brackish water).
    b. 940 psi (seawater) and 540 psi (freshwater/brackish water).
    c. 960 psi (seawater) and 550 psi (freshwater/brackish water).
    d. 980 psi (seawater) and 550 psi (freshwater/brackish water).

35. (609) As a rule of thumb, the multimedia filter should be backwashed when how many hours of continuous operations have elapsed?
    a. 20.
    b. 21.
    c. 23.
    d. 24.

36. (609) As a rule of thumb, the multimedia filter should be backwashed when the multimedia filter gauge reads
    a. 5 pounds per square inch (psi) above initial start-up reading.
    b. 10 psi above initial start-up reading.
    c. 15 psi above initial start-up reading.
    d. 20 psi above initial start-up reading.

37. (609) When performing long-term shutdown, what needs to be backwashed?
    a. Reverse osmosis (RO) vessels.
    b. Bag filter.
    c. Multimedia filter.
    d. No backwash needs to be done.

38. (610) In which capacity is citric acid feeding used during the production run of the reverse osmosis (RO) vessels?
    a. Initial dose.
    b. Recording dose.
    c. Maintenance dose.
    d. Descaling dose.

39. (610) Citric acid is fed when product water potential of hydrogen (pH) rises above
    a. 8 and/or 20 hours of production time has elapsed.
    b. 2 and/or 20 hours of production times has elapsed.
    c. 8 and/or 24 hours of production time has elapsed.
    d. 2 and/or 24 hours of production has elapsed.

40. (611) What needs to happen if the product water total dissolved solids (TDS) is over 1,000 pounds per square inch differential (psid)?
    a. Replace the reverse osmosis (RO) vessels.
    b. Backwash the multimedia filter.
    c. Replace the bag filter.
    d. Clean the RO vessels.

41. (611) During cleaning operation, water temperature should *never* read above
    a. 100º F.
    b. 110 ºF.
    c. 115º F.
    d. 120º F.

42. (611) Replace the reverse osmosis (RO) elements after they have been cleaned and if the total dissolved solids (TDS) readings *do not* drop below
    a. 100 parts per million (ppm).
    b. 500 ppm.
    c. 800 ppm.
    d. 1,000 ppm.

43. (612) When *must* you replace bag filter?
    a. After the unit has been running for more than 50 operational hours.
    b. When the differential pressure exceeds 10 pounds per square inch differential (psid).
    c. When the differential pressure exceeds 20 psid.
    d. After every backwash cycle.

44. (612) What *must* you accomplish *first*, before you replace the bag filter?
    a. Complete a normal shutdown only.
    b. Complete the backwash cycle.
    c. Turn off the regulate product flow valve.
    d. Complete a normal shutdown and turn off the main power.

45. (612) You discard the bag filter after this many washes?
    a. 4.
    b. 6.
    c. 8.
    d. 10.

46. (613) When do you replace the reverse osmosis (RO) elements?
    a. After every backwash cycle.
    b. When it's time to add new chemicals.
    c. After 20 hours of continuous operation.
    d. When it's no longer possible to keep the total dissolved solids (TDS) of product water below 1,000 parts per million (ppm).

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Expedient Beddown Methods

OPERATING AND MAINTAINING the ROWPU is not your only responsibility as a WFSM journeyman. You will find there are several collateral responsibilities that emerge after a potable water system is set up. Where does the water go? How is the water distributed? How water is used and collected are collateral responsibilities. The task of setting up a bare base begins with potable water treatment and ends with wastewater collection. In a bare base situation, you are responsible for providing the air wing with the same utilities and services they enjoy at your home base—only more rudimentary. World War II was the first war in history where deaths from combat exceeded deaths from other causes. We can directly attribute this paradigm shift to improvements in field sanitation, water treatment, and wastewater disposal. In this unit, we will discuss your collateral responsibilities. Always remember that your primary job during contingency operations is to provide potable water and safely dispose of wastewater.

2–1. BEAR Subsystems

In the 1950s, military planners developed prepackaged base support equipment. This equipment consisted mainly of World War II tents, field kitchens, medical facilities, power generators, cots, desks, and other equipment. It was bulky and heavy and required excessive time to position and erect. This first true deployment package was called *Gray Eagle.* In the early and mid–1960s, the AF added more equipment and redesigned the package for air transportability. At this time, the package was renamed *Harvest Eagle.* The *Harvest Eagle* package saw significant use during the Vietnam conflict. Still, the equipment was not adequate for the mission. Much of the equipment was too heavy or too flimsy for use in the field. Harvest Eagle underwent design changes over the next few years, but it still did not meet the requirements of the newer aircraft. Under a new project, the equipment was redesigned to support 6,000 people and five squadrons of fighter aircraft, and was entirely C–130 transportable. This new package was named Harvest Bare. The Harvest Bare package was designed to allow air operations to commence within 72 hours after arrival at the deployed location. The Harvest Bare package was later renamed Harvest Falcon with modifications made to the old package. Within the last few years, the modular approach concept to deployment, known as Expeditionary Falcon (*E-Falcon, or Falcon lite*), was developed for the air and space expeditionary force (AEF). E-Falcon was a means of providing equipment incrementally to support deploying forces. The E-Falcon concept is now formalized into the current deployment package named Basic

Expeditionary Airfield Resource (BEAR). We will now look at the total picture of the BEAR package as it relates to your specific responsibilities during force beddown.

614. BEAR water system capabilities and set-up

The BEAR water system is modular in design and scalable to meet a variety of user deployment needs. The BEAR water system can draw water from a natural source and purify, store, and distribute the water while maintaining sufficient pressure, quantity, and quality for an entire base. Depending on the selected modular configuration, the water system can supply 30 gallons of water per person per day (gpppd) for a 1,100-person camp and maintain enough storage capacity to sustain the camp with 30 gpppd for 5 days with no new water production. The BEAR water system consists of a series of piping, pumping, fluid control, and water storage equipment that comprises five distinct subsystems as shown in foldout (FO) 1. A cold weather kit is also available as an option for each subsystem, which provides components to sustain operation of the water system when subjected to operating environments as low as –25º F. The BEAR system is designed primarily for temporary deployments, but it can be geared toward applications that are more permanent by replacing the soft-wall hose system with buried rigid piping.

The BEAR water system contains five distinct subsystems:

1. Source Run.
2. Water Production with 600 or 1500 ROWPUs.
3. 550 Initial.
4. 550 Follow-On.
5. Industrial Operations and Flightline Extension.

The BEAR water distribution system is used in conjunction with the field equipment items listed in the table below. All TO references reflect the current equipment items assigned to the utilities part of the BEAR package. Study FO 1 for a detailed layout of each subsystem system and its component locations.

TO Number	Field Equipment
TO 40W4–21–1	*Basic Expeditionary Airfield Resources (BEAR) Water System*
TO 40W4–20–1	*1500 Reverse Osmosis Water Purification Unit (ROWPU)*
TO 35E35–5–1	*Field Deployable Latrine*
TO 35E7–4–27–1	*Heater, Water, Liquid Fuel M–80/M–85*
TO 35E35–4–1	*Shower Facility, Bare Base*
TO 35E35–3–1	*Shave Stand, Bare Base*
TO 50D1–4–1	*Self-Help Laundry*

When all of the preceding assets are connected to the BEAR water system, a formidable utility support system can be established.

Color coding

All components of the BEAR subsystems are color-coded to prevent contamination of the different water subsystems.

- Green stripe—raw water.
- Purple stripe—wastewater.
- Red stripe—ROWPU wastewater.
- White stripe—potable water.

Strictly follow color codes to avoid cross-contamination of water and wastewater systems. Always refer to the BEAR water system TO during set-up and maintenance of the system.

Initial bare base set-up

Your first task when arriving at a bare base will be to ensure the local water source will support the anticipated base population and projected mission. This requires you to do the following:

- Establish water points.
- Set-up purification and treatment operations.
- Set-up storage capability.
- Set-up water distribution system.

Complicating the situation is the fact that you will probably not receive the total water distribution system package all at one time. The initial items received should be the source run subsystem and the ROWPU package.

Later on, additional assets will arrive that enable the complete installation of the soft-wall hose loop system. Initial set-up involves several concurrent activities supporting water production at a bare base that start immediately upon arrival. The source of water must allow pumping into storage bladders and eventually pipelines. This could involve clearing a road to the source, setting up an expedient water intake system, or even building a temporary dam to create an expedient reservoir.

Start water production as soon as possible. Be sure that electrical and power production crews installing generators are aware of the water plant location(s) and power requirements. Also, make sure that the brine, waste, and vent vessel discharge lines from the ROWPUs lead to an area that can accommodate a large volume of water, or more ideally, back to the source itself.

Setting up the BEAR water and wastewater system

Once the ROWPUs are in operation, you will have to dedicate manpower to water plant and water-hauling operations. During water plant and tank farm setup, other WFSM crews are busy laying out the soft-wall, hose-looped water distribution system to key facilities requiring potable water. These include the kitchen, showers, latrine areas, laundry, hospital, and selected shop facilities. Establish fill points for potable and non-potable water to support fire department and remote location requirements. Start upgrades and improvements when the remaining components of the water distribution system arrive.

When it is determined that sustained operations will take place, the above-ground, soft-wall hose needs to be replaced by rigid piping and buried after all other higher priority tasks are completed. You will have to acquire hard-wall piping and use the transition fittings provided with the BEAR water system to connect the two piping systems. Besides providing protection from damage, burying the pipelines decreases the heat gain from solar radiation. Experience has shown that water in above-ground pipelines can reach temperatures of up to 160º F. If the water temperature is too hot, you will have very unhappy personnel throughout the camp, so plan ahead before you get to that point.

Remember, while you are getting the water system established, you must focus on what to do with the waste discharged from the facilities. The BEAR water system uses a wastewater collection system similar to that of an Air Force base (AFB). The wastewater is discharged from the facilities and pumped through a series of lift stations to a 25,000 gal. aerated holding tank. The holding tank keeps the wastewater fresh before final disposal. Either you will have a contractor dispose of the wastewater or you will have to construct stabilization or evaporation ponds. We will discuss designing stabilization and evaporation ponds in a later section.

Disinfecting the water system

All components of newly installed potable water systems must be disinfected prior to putting them into use. To do this, you will need to superchlorinate the entire potable water system with enough chlorine to obtain a residual dosage of 10 ppm of chlorine after the components stand for 24 hours. Keep in mind during this procedure, the treated water from the ROWPU will already have been disinfected to no less than 2 ppm. Consequently, you will have to adjust your initial superchlorination dose with this in mind.

Again, we will stress the point that you must disinfect *all* components of the system that contain potable water. To do this properly, follow these procedures:

1. Calculate, mix, and add calcium hypochlorite (hth) or bleach to the potable water storage tank. Use the pounds formula learned previously in volume two of this CDC to calculate the needed amounts.
2. Fill all parts of the potable water system with potable water.
3. Circulate the water through the loop system for 2 hours.
4. After 30 minutes, open the valves to all usage points and allow them to fill. Flush the system if needed. Allow the system to sit for 24 hours. Then, have the medical authorities run a bacteriological test to ensure the water if safe.
5. Do not drain the entire potable water system, as this would be a waste of good water. Simply reduce the chlorine dosage from the ROWPU to such a point that an eventual equilibrium of 2 ppm arises in the entire potable water subsystem.

Once the equilibrium has been reached, continue to monitor the chlorine residual at the farthest point in the distribution network. The chlorine residual should never be less than 1 ppm at the point of use. To maintain this residual throughout normal operations, properly mix an hth solution in the dual-pump chemical feed tank. You will then be able to maintain the minimum required 1 ppm chlorine residual at the end user points.

615. BEAR water subsystems and components

As discussed earlier, the BEAR water system contains five distinct subsystems that are modularized to complement each other as the deployment package requirements increase. In this next lesson, we will discuss each subsystem and the individual components that make up these subsystems.

Source run subsystem

The source run subsystem (SRS) is a modular raw-water distribution subsystem. When used to supplement the BEAR water system (fig. 2–1), the SRS provides the raw-water input for the system. The SRS is capable of drawing water from a raw-water source (i.e., pond, lake, stream, sea, or ocean) up to 100’ away and 20’ below the pumping station. The SRS can pump this water for a distance of up to 6,000’ and to a height of 150’ to a storage tank. In the event the water distribution routing requires crossing roadways or similar heavy vehicular traffic areas, the SRS provides protection ramps (fig. 2–1, callout 6) and a hose-to-hard-wall pipe transition kit as options to the user to either bury the pipe or run it on the roadway or traffic area. The SRS consists of a series of piping, plumbing, fluid control, and water storage equipment that comprise the subsystem major components. Next, we will discuss the individual components of the SRS.

4” strainer and float assembly

The 4” strainer and float assembly (fig. 2–1, callout 1) provides a coarse filter as the input to the SRS to prevent impurities such as trash, twigs, and debris from entering the SRS. The float buoy, with cable, keeps the strainer end of the suction hose from lying on the bottom of the raw water source where dirt and gravel could enter the SRS.

400 gpm diesel pump assembly

The 400 gpm diesel pump assembly (fig. 2–1, callout 2) is a trailer-mounted, diesel-driven, centrifugal, self-priming pump. It is capable of producing 400 gpm of water at 300’ maximum head from a raw-water source to the SRS storage tank. The trailer, which enables ease of movement of the pump, allows towing speeds up to 20 miles per hour (mph). There is a pintle hook at the rear of the trailer for towing additional units of similar weight.

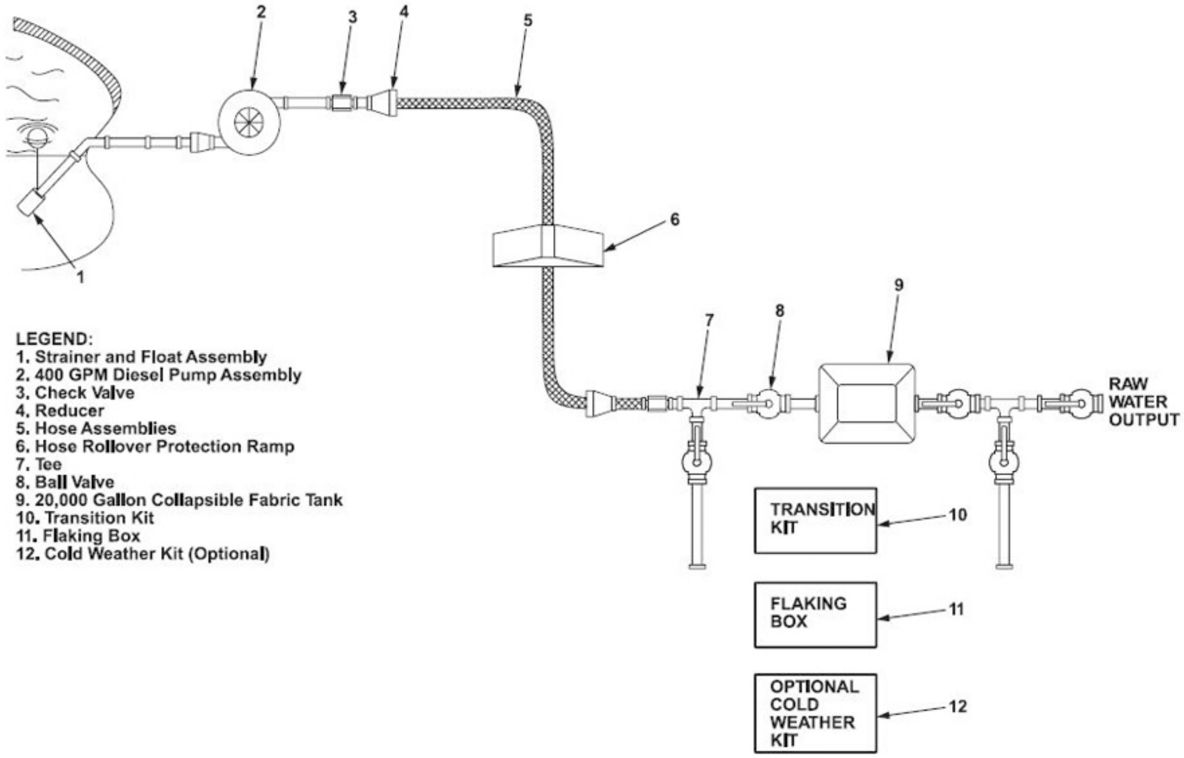


Figure 2–1. Source run subsystem.

20,000 gal. collapsible fabric tank

The 20,000 gal. collapsible fabric tank, color-coded green, (fig. 2–1, callout 9) is used for raw-water storage.

Hoses

The SRS includes a variety of hose and hose assemblies (fig. 2–1, callout 5) of various lengths and diameters. These color-coded green hoses route the raw water from the source to the storage tank.

Ball valves

Ball valves (fig. 2–1, callout 8) control raw-water input flow, output flow, and draining of the SRS storage tank.

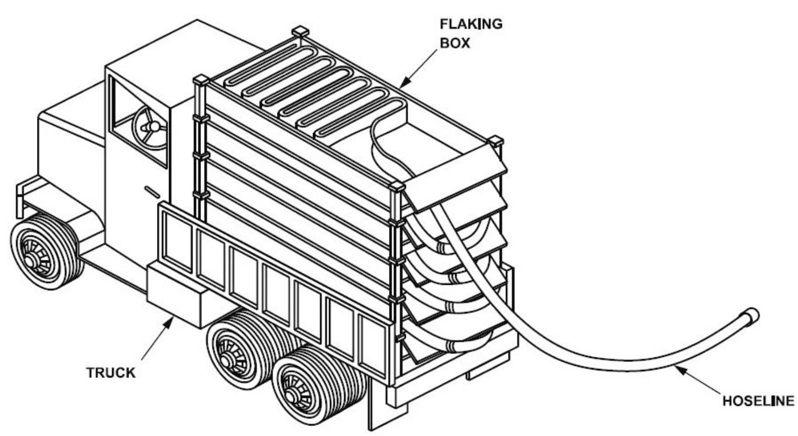


Figure 2–2. Flaking box.

Flaking boxes

A flaking box (fig. 2–2) contains four 150 ft. lengths of 6” hose. The flaking boxes serve as storage space for the hoses when not in use and allow for deployment during system installation.

1,500 gph ROWPU water production subsystem

The 1,500 gph ROWPU water production subsystems (WPS) as shown in figure 2–3, generates potable water for distribution to user facilities within the BEAR water system. Water purification is accomplished by two 1,500 gph ROWPUs (fig. 2–4), set up in single or tandem configuration allowing for continuous water production capabilities during maintenance and repair. Each ROWPU is capable of producing 1,500 gal. of potable water per hour. A 125 gpm diesel pump distributes raw water for storage in 20,000 gal. storage tanks. Then the raw water is distributed through a series of hoses and fittings configured to interface with the ROWPUs.

The potable water generated by the ROWPUs is distributed through another series of hoses and fittings configured to interface with 20,000 gal. potable water storage tanks. The byproduct from the water purification process includes both wastewater and brine water, which are distributed separately. Brine water is distributed to a 20,000 gal. storage tank and wastewater to a 3,000 gal. storage tank. Output of the brine water tanks may be optionally selected for user purposes (i.e., washing vehicles, decontamination [DECON], firefighting, wetting dusty roads); otherwise, both brine water and wastewater are introduced to a 35 gpm electric pump for distribution to a waste disposal area. An optional 125 gpm diesel pump is available if prime power is not available or is inadequate.

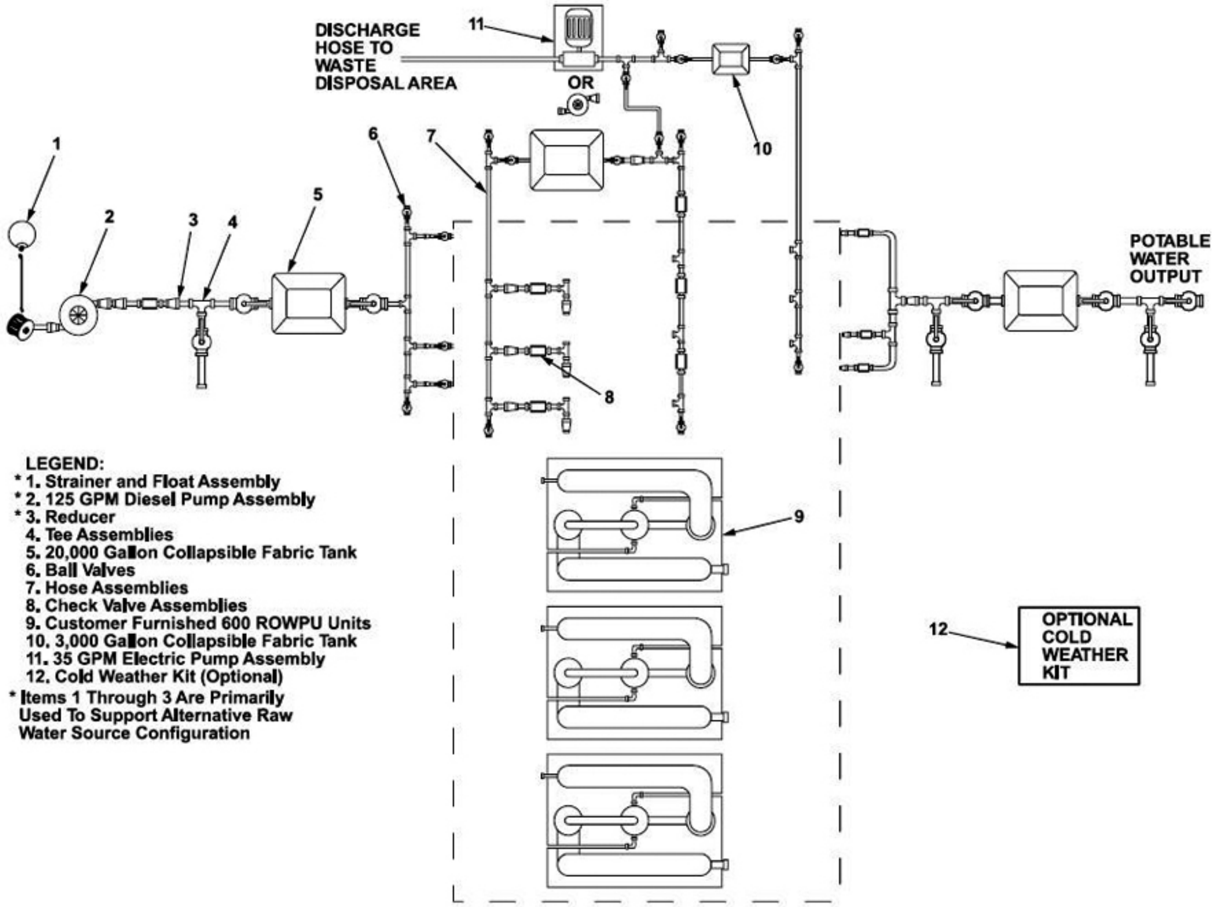


Figure 2–3. Water production 1500 gph ROWPU subsystem.

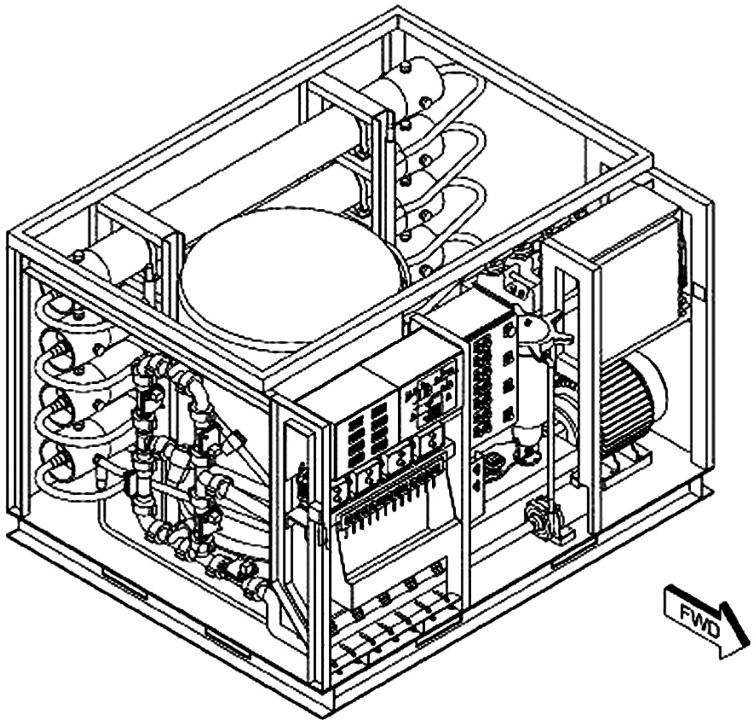


Figure 2–4. 1500 ROWPU unit.

550 initial subsystem

The 550 initial subsystem is the primary potable water distribution subsystem of the BEAR water system. The 550 initial subsystem may be deployed as a stand-alone potable water distribution subsystem; however, it is designed for expansion and build-up to meet varying user deployment and operational needs. The 550 initial subsystem (fig. 2–5) normally receives potable water input from a water production 1500 subsystem. The 550 initial subsystem can draw potable water from other similar potable water sources with supplied adapters. The potable water input is distributed to three 20,000 gal. collapsible fabric tanks for storage. The storage tanks, in tank farm configuration, distribute the potable water to a variable-speed, dual-pumping station. The two pumps are parallel configured enabling either dual- or single-pump operation or single-pump isolation for maintenance or repair purposes. The remaining operational pump maintains water pressure in the distribution line. Output from the pumping station flows to a looped pressurized distribution feed line. User facilities such as latrines, showers, and laundries are branch fed from the pressurized feed line. Wastewater from facilities is processed by a series of lift station pumps and wastewater lines that are pumped to a wastewater collection tank for disposal. Hose rollover protection ramps are provided in the event the potable water distribution and wastewater distribution requires crossing roadways or similar heavy vehicular traffic areas. Next, we will discuss the components provided with the 550 initial subsystem package.

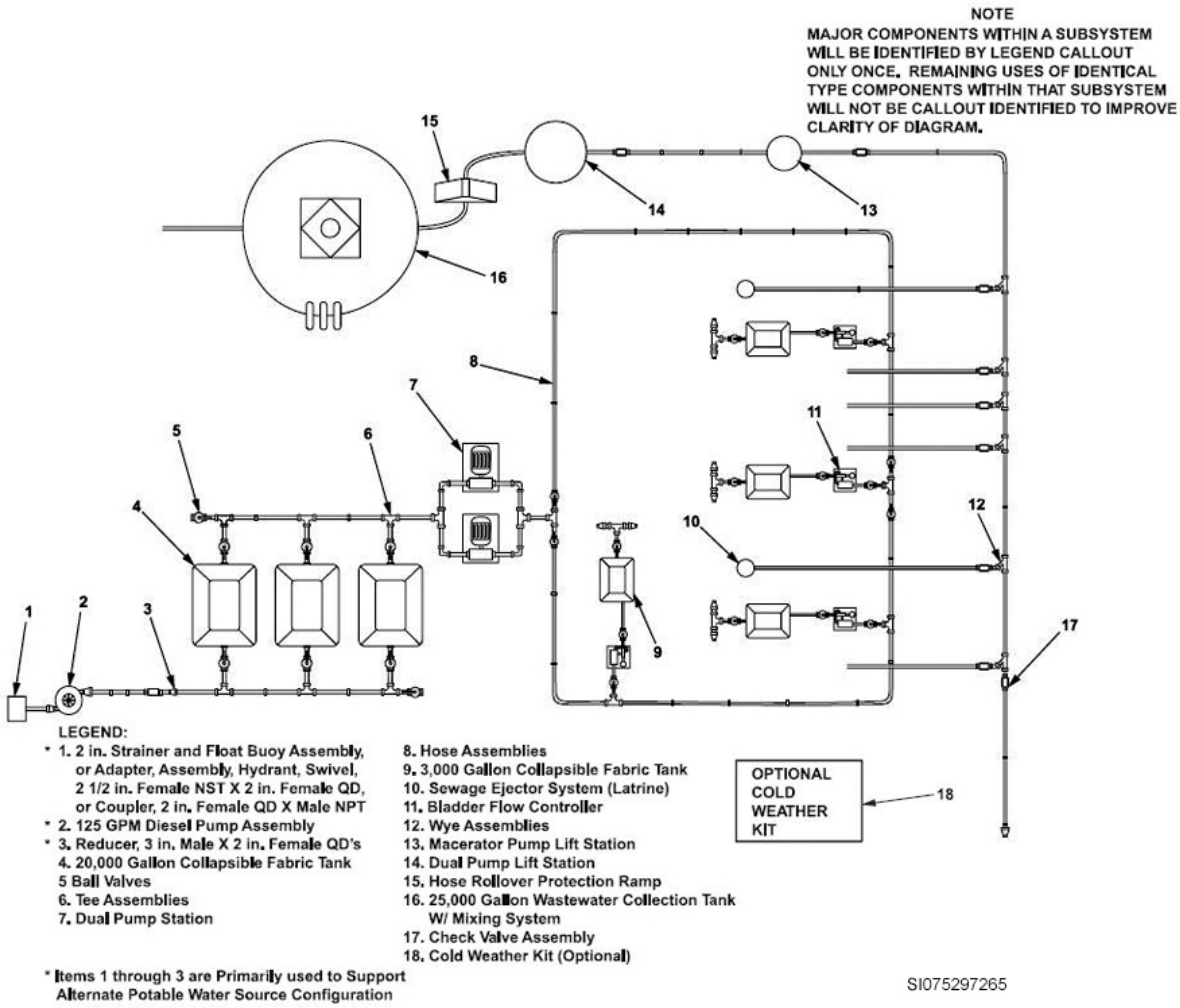


Figure 2–5. 550 initial subsystem.

Adapters

The adapters (fig. 2–6) supplied for the 550 initial subsystem include a hydrant swivel adapter assembly and a 2” coupler with female QD X male national pipe threads (NPT). The adapters support alternate potable water source configurations.

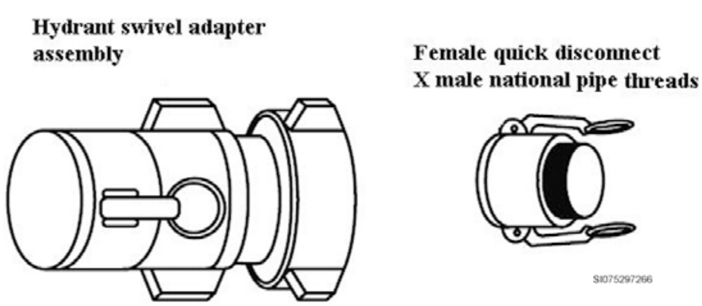


Figure 2–6. Adapter.

125 gpm diesel pump assemblies

The 125 gpm diesel pump assembly (fig. 2–7) is a centrifugal, self-priming pump. It is color-coded white for use in potable water input distribution to fill three 20,000 gal. collapsible fabric tanks.

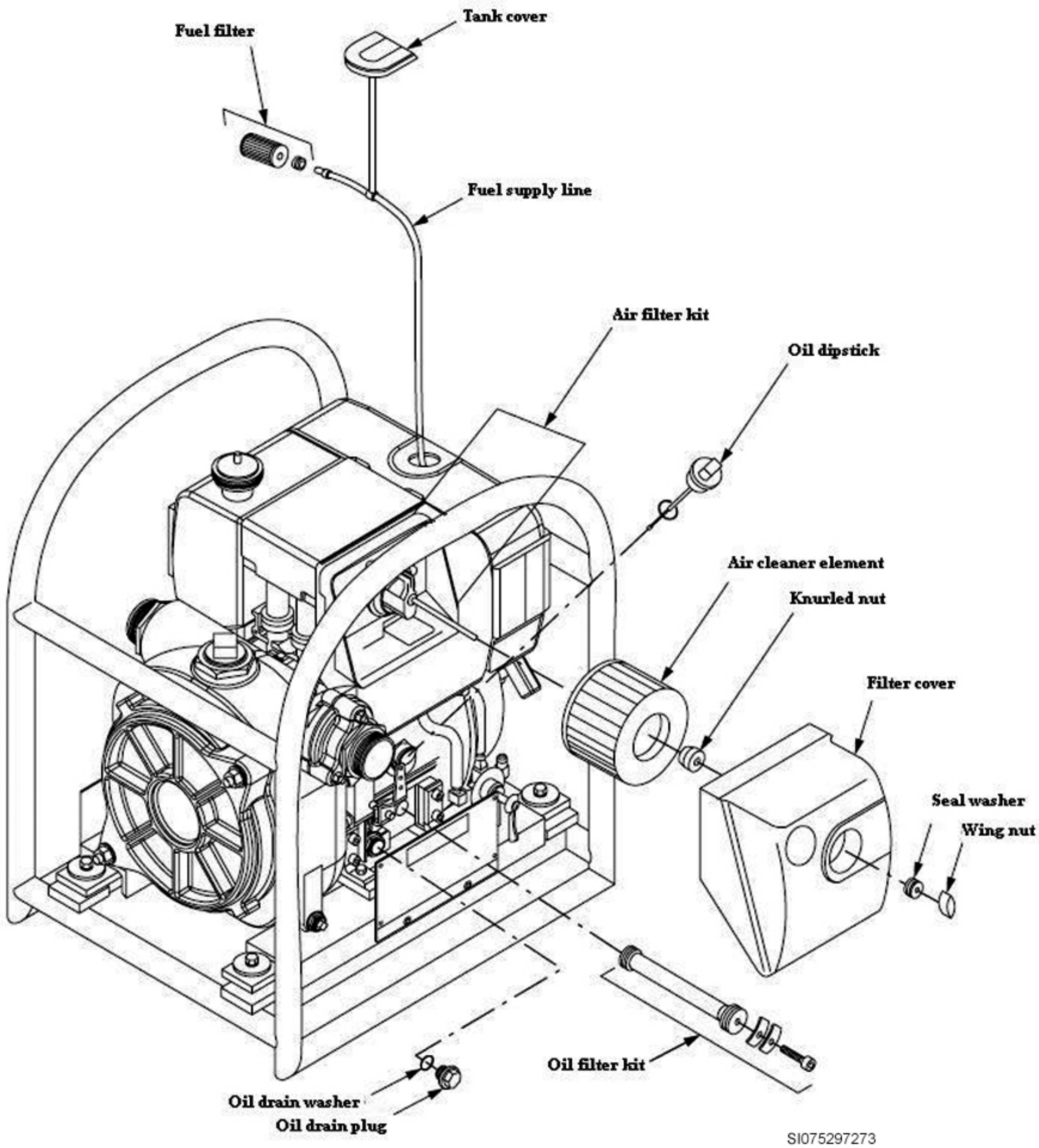


Figure 2–7. Diesel pump assembly.

20,000 gal. collapsible fabric tanks

The three 20,000 gal. collapsible fabric tanks (fig. 2–8), color-coded white, are used for potable water storage.

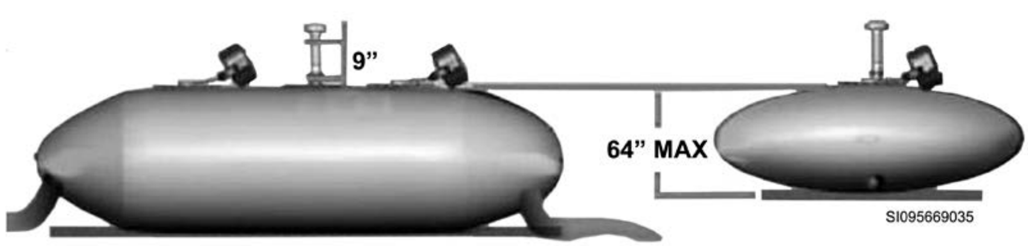


Figure 2–8. 20,000 gal. collapsible fabric tanks.

Dual-pump station

The dual-pump station (figs. 2–9, 2–9a, and 2–9b) is used to pressurize the potable water distribution lines between 40–50 psi up to 400 gpm, and maintain chlorination of the water system through chemical feed pumps. The two pumps can operate in either dual- or single-pump configuration to support maintenance repair actions while maintaining pressure in the potable water distribution feed lines. All required parameters have been factory preconfigured, and there is no requirement to change or set these parameters. Only the chemical feed pumps will need periodic adjustments.

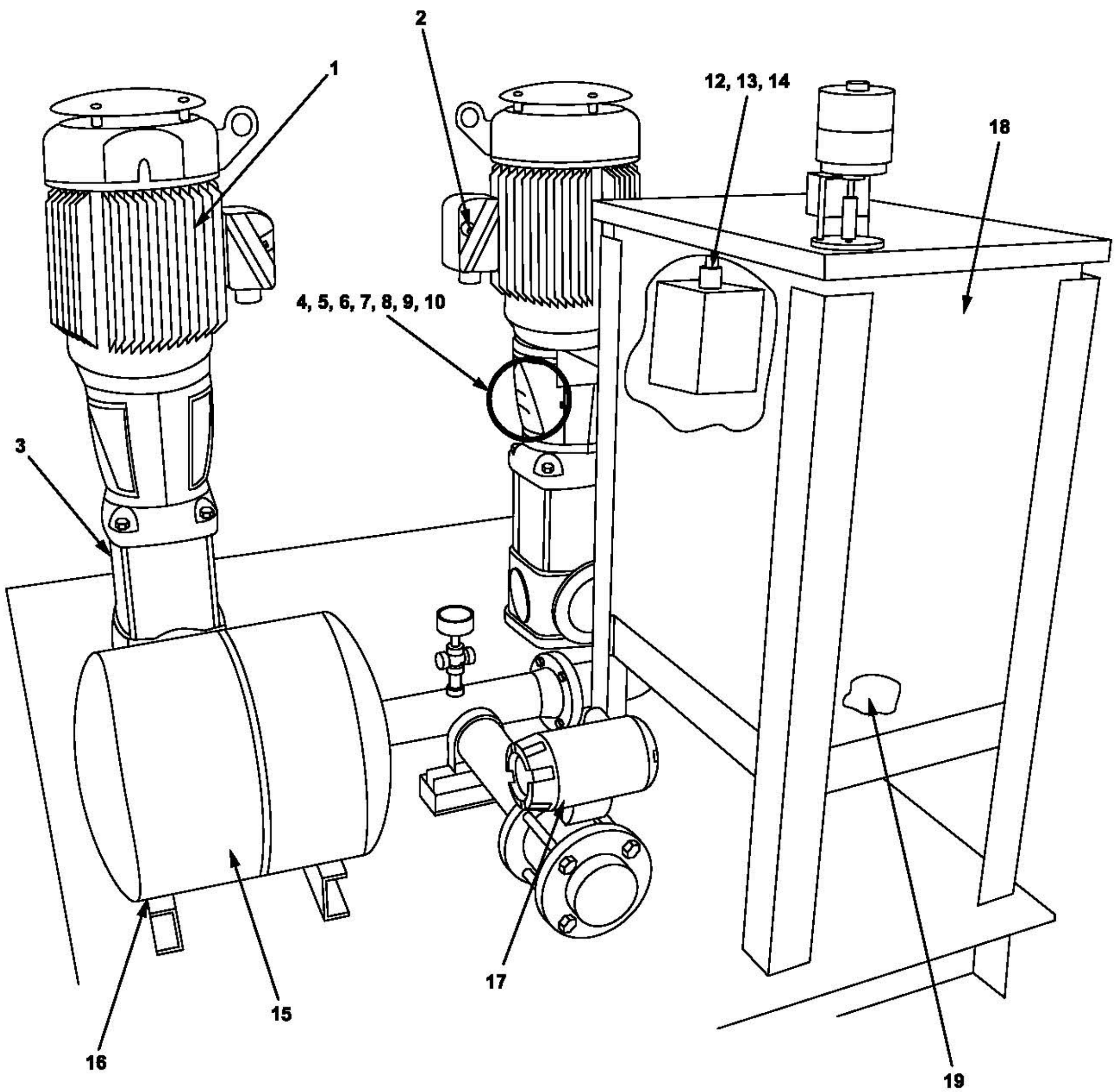


Figure 2–9. Dual-pump station.

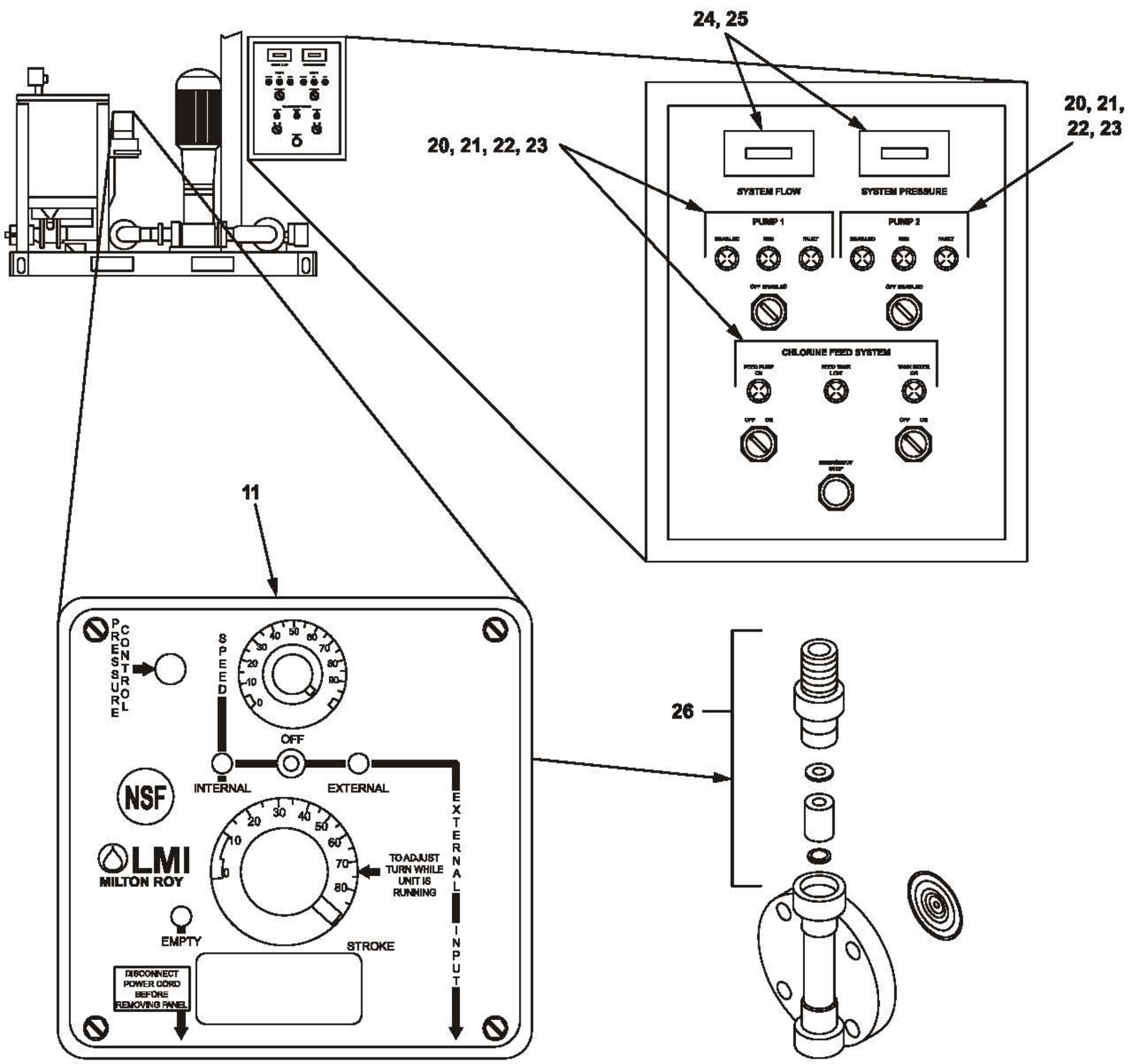


Figure 2–9a. Dual-pump station.

FIGURE & INDEX/ SHEET NO.	PART NUMBER	CAGE	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY	USABLE ON CODE	SMR CODE
27	3030140-1	61125	DUAL PUMP STATION, WHITE STRIPE	REF		
1	507-1037-20	0AK83	. MOTOR	2		
2	COMM	0AK83	. . ELECTRICAL JUNCTION BOX HEX SCREWS 5/16 - 18 x 1-1/2 IN.	4		
3	404-1037-17-REP	0AK83	. PUMP ASSEMBLY	2		
4	410-1037-91	0AK83	. . PUMP SEAL KIT	2		
5	4L515	0AK83	. . COUPLING GUARD KIT	2		
6	4L553	0AK83	. . SHAFT COUPLING KIT	2		
7	1L83	0AK83	. . SEAL HOUSING	2		
8	1L628	0AK83	. . STATIONARY SEAT	2		
9	410-1037-91	0AK83	. . SEAL HOUSING O-RING	2		
10	13K44	0AK83	. . MOTOR BOLTS	8		
11	701-1037-6-REP	0AK83	. CHEMICAL FEED PUMP	1		
12	10299	0AK83	. . THREADED NUT	1		
13	26136	0AK83	. . CLAMP RING	1		
14	409-1-00-02	0AK83	. . POLYETHYLENE TUBING 3/8	1		
15	410-1037-45	0AK83	. ACCUMULATOR	1		
16	COMM	0AK83	. . NYLON LOCKNUT NUT 5/16 - 18 STANDARD GRADE,SS	4		
17	410-1037-7	0AK83	. FLOWMETER	1		
18	701-1037-13229EO447	0AK83	. MIXER ASSEMBLY	1		
19	507-13229EO0310	0AK83	. . LEVEL SWITCH	1		
20	TBD506-AB-800T-QSH24R	0AK83	. RED LED	9		
21	TBD506-AB-800T-QSH24W	0AK83	. WHITE LED	9		
22	TBD506-AB-800T-QSH24G	0AK83	. GREEN LED	9		
23	507-1037-87	0AK83	. 120 VAC BULB	4		
24	506NP558-B	0AK83	. PANELMETER	2		
25	507-1037-85	0AK83	. . LENS FOR PANELMETER	2		
26	RO781RK	0AK83	. . PUMP REBUILD KIT	1		
			-END OF FIGURE-			

Figure 2–9b. Dual-pump station.

NOTE: Parameters should not be changed or altered on the dual-pump station’s centrifugal pump control (CPC). Changing any CPC parameter could cause the dual-pump station to become inoperable.

3,000 gal. collapsible fabric tanks

Use the provided 3,000 gal. collapsible fabric tanks (fig. 2–10) color-coded white for potable water storage for the user facilities.

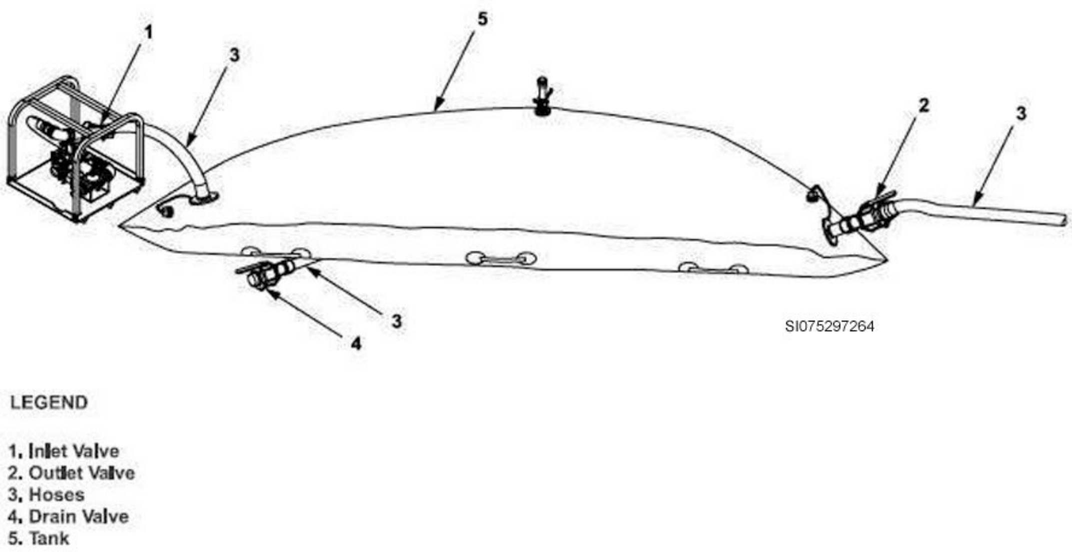


Figure 2–10. 3,000 gal. collapsible fabric tank.

Bladder water level controllers

The four bladder water level controllers provided (fig. 2–11) maintain a preset maximum volume of water in the 3,000 gal. collapsible fabric tanks.

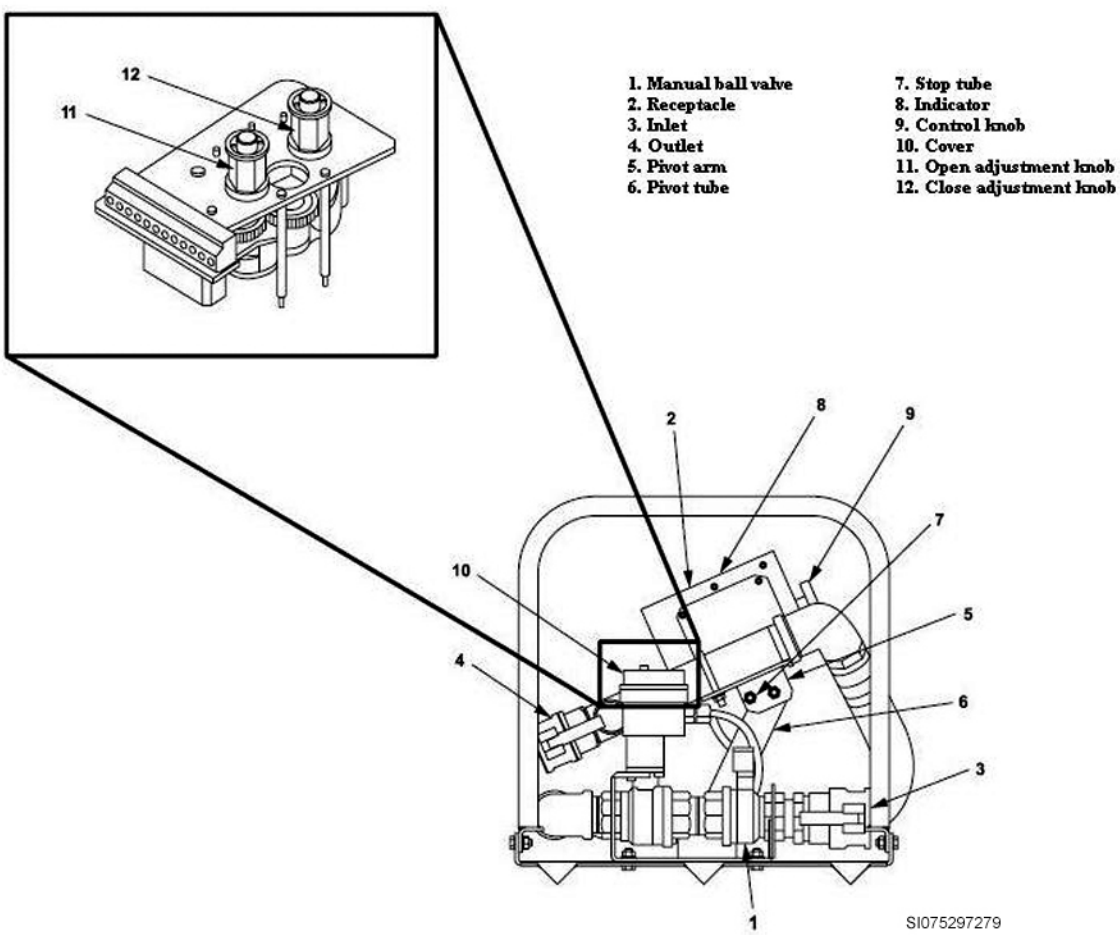


Figure 2–11. Bladder water level controllers.

Sewage ejector system (latrine)

The two sewage ejector systems (latrines) (fig. 2–12) are wet-pit sump pumps, used to pump raw sewage from the latrines for output distribution to the wastewater collection tank.

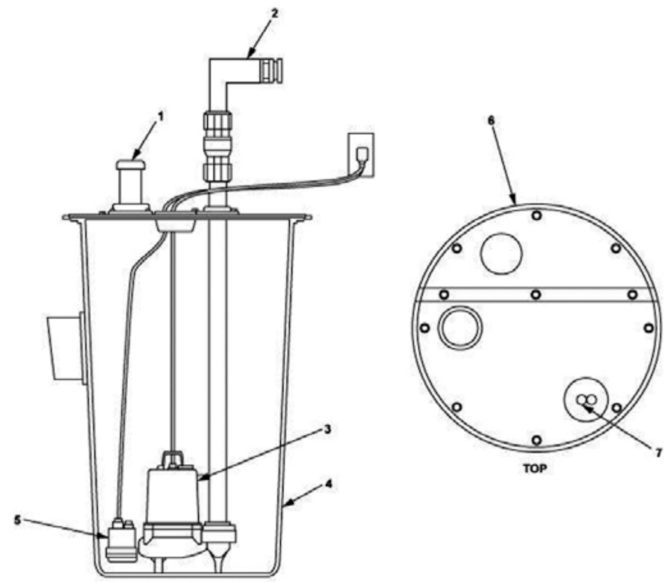


Figure 2–12. Sewage ejector system.

Macerator pump lift station

The macerator pump lift station (fig. 2–13) is used for a wet-pit sump, predigestion of raw sewage, and pumping of wastewater to the dual-pump lift station.

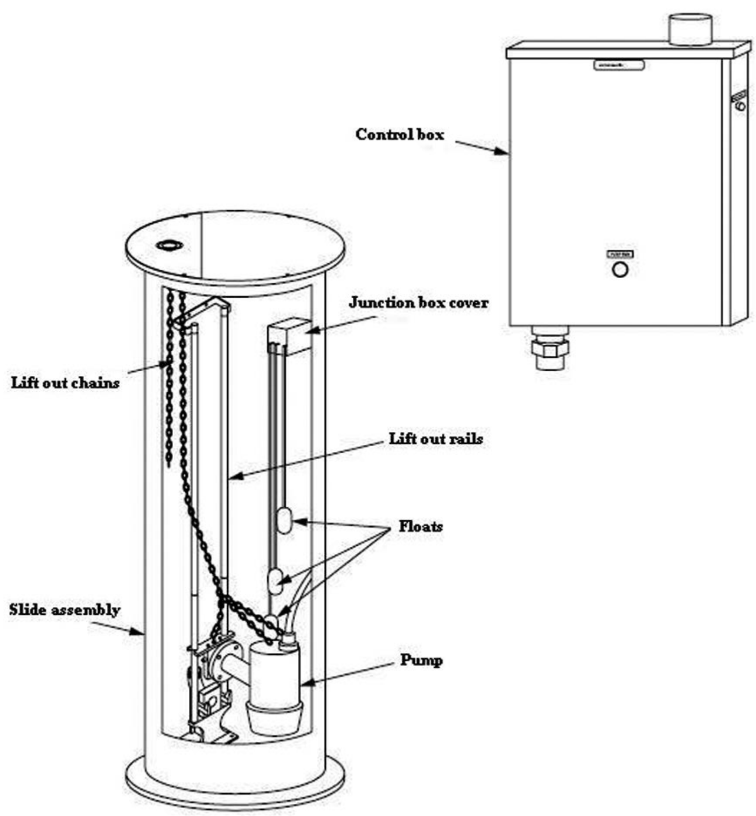


Figure 2–13. Macerator pump lift station.

Dual-pump lift station

The dual-pump lift station (fig. 2–14) is used for a wet-pit sump, predigestion of raw sewage, and pumping of wastewater to the wastewater collection tank. The two pumps can operate in either dual- or single-pump configuration. For personnel safety reasons, terminate pump operations during maintenance and repair actions.

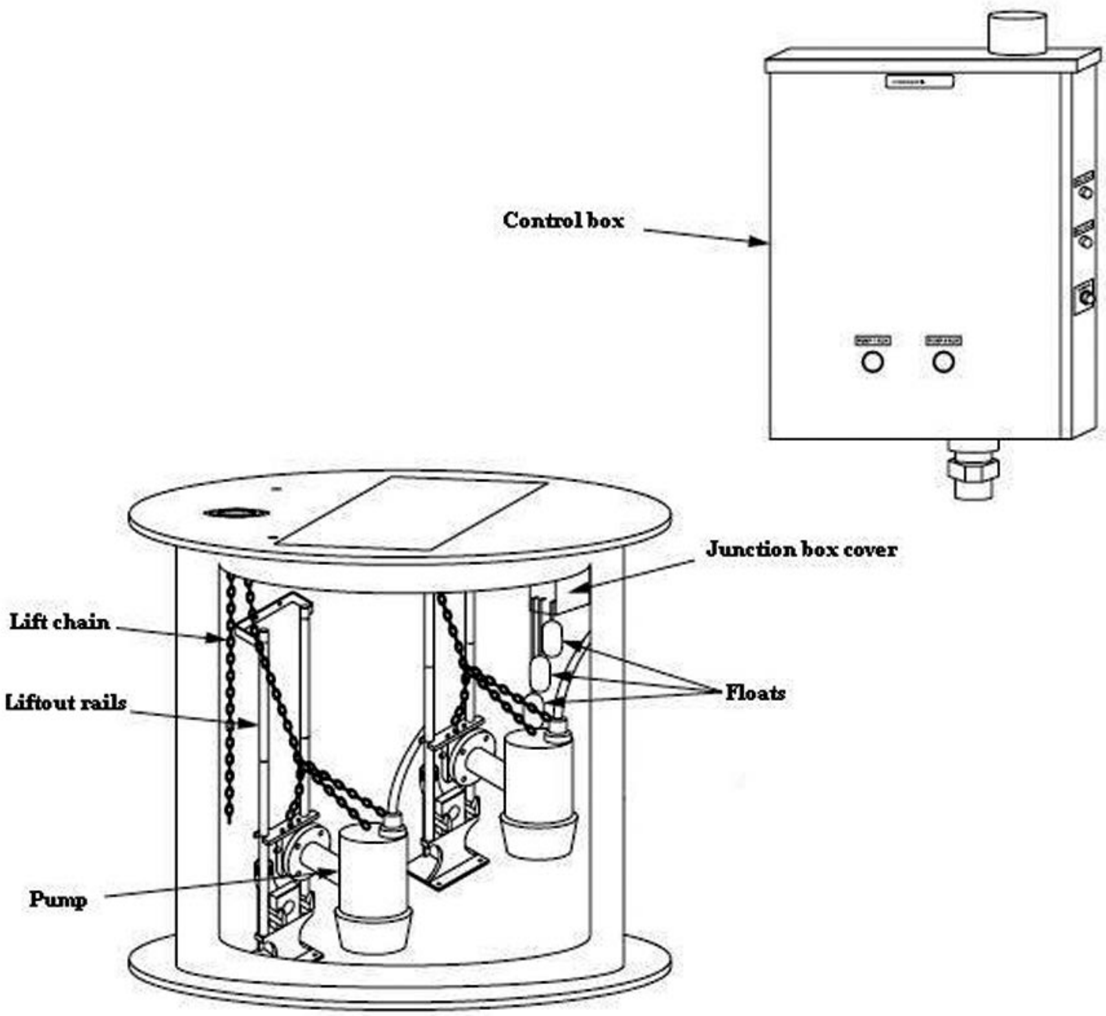


Figure 2–14. Dual-pump lift station.

25,000 gal. wastewater collection tank with mixing system

The 25,000 gal. wastewater collection tank (fig. 2–15) provides a 25,000 gal. storage capacity and includes an aerator and pump assembly to mix and aerate wastewater. Aeration of wastewater keeps raw sewage fresh and in a liquid state until final disposal.

Hoses

The 550 initial subsystem includes a variety of hose and hose assemblies of various lengths and diameters. Use these hoses to route the potable water (hoses color-coded white) for storage, distribute potable water to user facilities for storage, and collect wastewater (hoses color-coded purple) for disposal.

Ball valves

Ball valves control the flow of water and isolate the system for maintenance and repair actions.

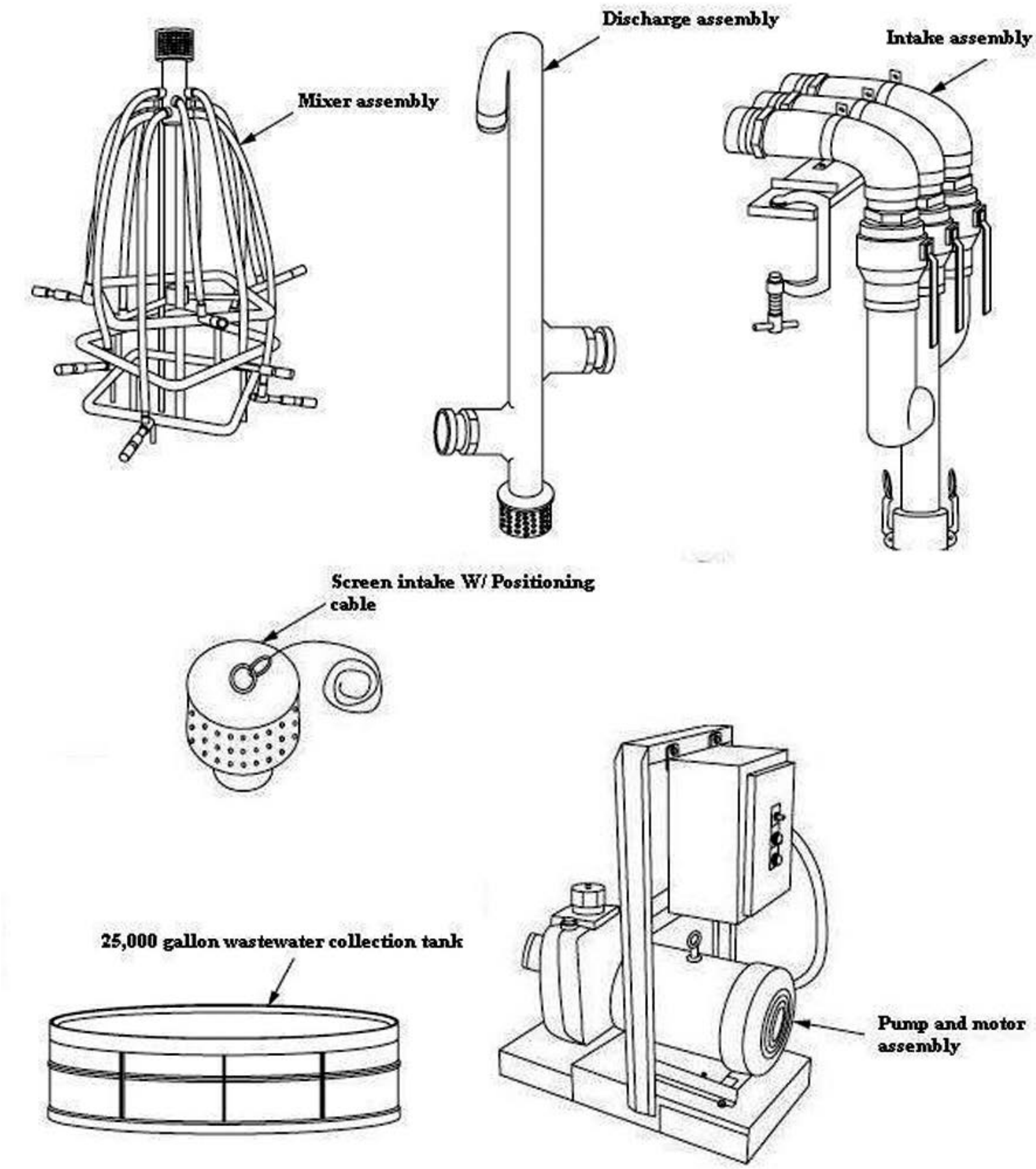


Figure 2–15. 25,000 gal. wastewater collection tank with mixing system.

550 follow-on subsystem

The 550 follow-on subsystem is designed for expansion and build-up of the 550 initial subsystem. The 550 follow-on subsystem *is not* intended to function alone. The 550 follow-on subsystem (fig. 2–16), when used as an expansion to the 550 initial subsystem, operates functionally identical to the 550 initial subsystem. User facilities such as latrines, showers, laundries, and kitchen are branch fed from the pressurized feed line. Waste output from the user facilities is processed by various lift stations and hoses that distribute the wastewater to the 25,000 gal. wastewater collection tank for disposal. Next, we will discuss the components provided with the 550 follow-on subsystem package.

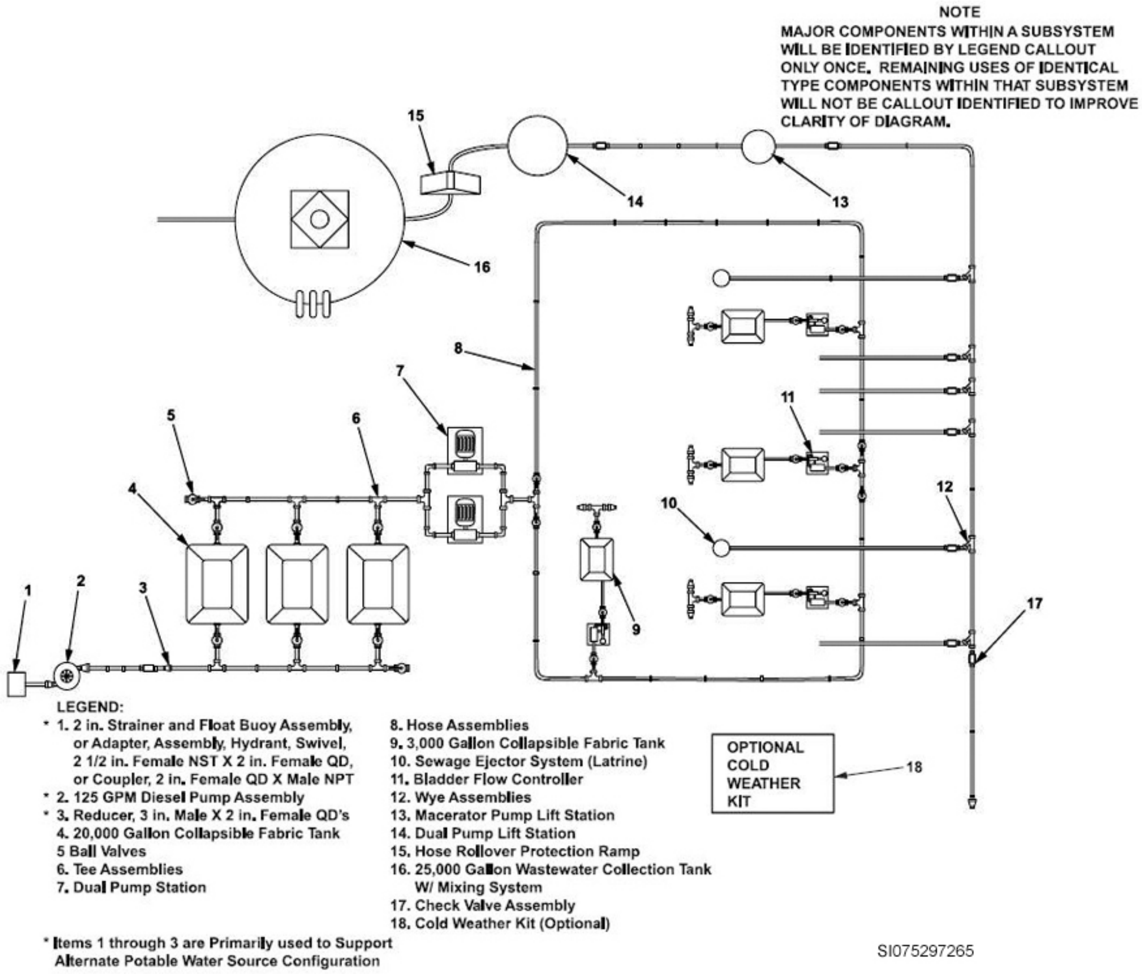


Figure 2–16. 550 Follow-on subsystem.

20,000 gal. collapsible fabric tanks

The three 20,000 gal. collapsible fabric tanks (fig. 2–16, callout 4), color-coded white, are configured for tank farm expansion and used for potable water storage.

3,000 gal. collapsible fabric tanks

The four 3,000 gal. collapsible fabric tanks (fig. 2–16, callout 9), color-coded white, are used for potable water storage for the user facilities.

Bladder water level controllers

The four bladder water level controllers (fig. 2–16, callout 11), color-coded white, are used to maintain a preset maximum and minimum volume of water in the 3,000 gal. collapsible tanks.

Latrine sewage ejector system

The two-latrine sewage ejector systems (fig. 2–16, callout 10) are wet-pit sump pumps used to pump raw sewage from the latrines for output distribution to the wastewater collection tank.

Macerator pump lift station

Use the macerator pump lift station (fig. 2–16, callout 13) for wet-pit sump, pre-digestion of raw sewage, and flow of wastewater distributed to the wastewater collection tank.

Dual-pump lift station

The dual-pump lift station (fig. 2–16, callout 14) is used for a wet-pit sump, predigestion of raw sewage, and pumping of wastewater to the wastewater collection tank. The two pumps can operate in either dual- or single-pump configuration. For personnel safety reason, terminate pump operations during maintenance and repair actions.

Hose

The 550 follow-on subsystem includes a variety of hoses and hose assemblies (fig. 2–16, callout 8) of various lengths and diameters. Use the hoses to route the potable water input for storage, distribute potable water to user facilities for storage, and wastewater for disposal. The hoses and hose assemblies are color-coded white and purple respectively, for their distribution function.

Ball valves

Use the provided ball valves (fig. 2–16, callout 5) for water flow control. This includes potable water input for storage, storage tank isolation for maintenance and repair actions, and isolation of each user's facility branch feed from the distribution line.

Industrial operations and flightline extension subsystem

The industrial operations and flightline extension subsystem (fig. 2–17) is designed as a potable water expansion subsystem for the 550 initial, 550 follow-on, or water production subsystems of the BEAR water system. The extension subsystem can branch off any part of the 3" pressurized feed line for the 550 initial and 550 follow-on subsystems, or potable water line from the water production subsystems. When used to supplement the BEAR water system, the extension subsystem supplies potable water to isolated user facilities (i.e., latrines, showers, and kitchens). Hose rollover protection ramps are provided in the event the potable water distribution requires crossing roadways or similar heavy vehicular traffic areas.

Next, we will discuss the components provided with the industrial operations and flightline extension subsystem package.

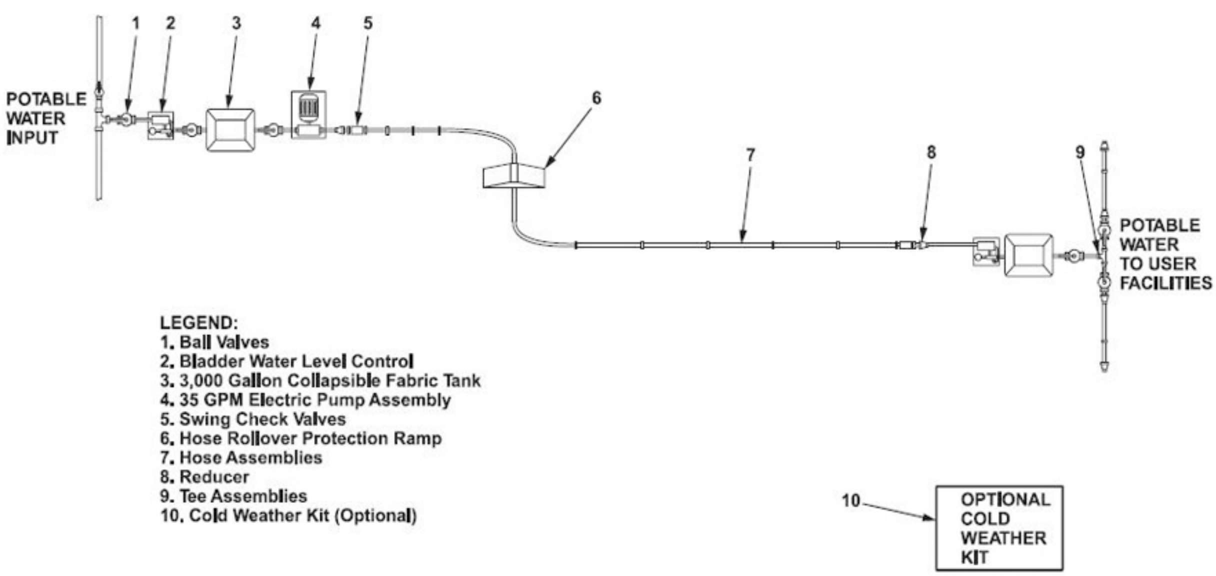


Figure 2–17. 550 industrial operations and flightline extension subsystem.

Bladder water level controllers

The two bladder water level controllers (fig. 2–17, callout 2) are used to maintain a preset maximum and minimum volume of water in the 3,000 gal. collapsible fabric tanks.

3,000 gal. collapsible fabric tanks

The two 3,000 gal. collapsible fabric tanks (fig. 2–17, callout 3) are color-coded white. One is used for input potable water storage and the other as output potable water storage for distribution to the user facilities.

35 gpm electric pump assembly

The 35 gpm electric pump assembly (fig. 2–17, callout 4) is powered by an electric motor coupled to a centrifugal, self-priming pump. The 35 gpm pump assembly is used to pump potable water up to 2,500’ to fill the facility potable water storage tank. An accumulator tank and pressure switch at the pump outlet is set to control pump operation for output flow regulation between 20 and 40 psi.

Hoses

Hose assemblies (fig. 2–17, callout 7) of various lengths and diameters are used to route the potable water input for storage, potable water output for storage, and for distribution to user facilities. The hose assemblies are color-coded white for their distribution function.

Ball valves

Ball valves (fig. 2–17, callout 1) are used for water flow control of input and output water distribution and isolation of the pump assembly for maintenance and repair actions.

616. BEAR water system components’ troubleshooting and repair

Repairing the BEAR water system components can range from the simple task of repairing a pinhole leak in the water hose to replacing a pump in the dual-pump lift station. In this lesson, we will discuss the major components of the BEAR water system and the basics of troubleshooting and repairing these components. Remember, always use the appropriate TO for the equipment you are operating or working on.

Dual-pump station

Maintenance and repair of the potable water system’s dual-pump station (fig. 2–18) consists of removal and replacement of the motor, seal, accumulator tank, chemical feed pump, and repair of tubing. During your deployment, the main problem you will most likely experience is hoses cracking due to sunlight and chemical exposure. Periodically inspect hoses for discoloration and cracking, and make repairs when needed. The design of the dual-pump station allows one pump to be under repair while the other pump maintains system pressure. Before you begin to operate, check the motor for proper rotation by applying electricity.

NOTE: Do not alter the factory parameters on the dual-pump station’s CPC or the pump station could become inoperable.

Accumulator

The accumulator (fig. 2–18, callout 15) controls the length of the cycling of the pump by maintaining pressure against the system through a factory pre-set pressurized air bladder. When the pump turns on, it applies pressure against the bladder until the system reaches pressure, then the pressure switch or device shuts off the pump. As water use increases in the system, the pressurized bladder maintains pressure against the water system until it drops to a preset pressure and then it cycles on again. If you notice long pump runs, check the accumulator air pressure to see if the bladder has become water logged by depressing the air valve. If water discharges out of the air valve, then replace the accumulator. Release the pressure from the accumulator before removal. The accumulator cannot be repaired; it must be replaced.

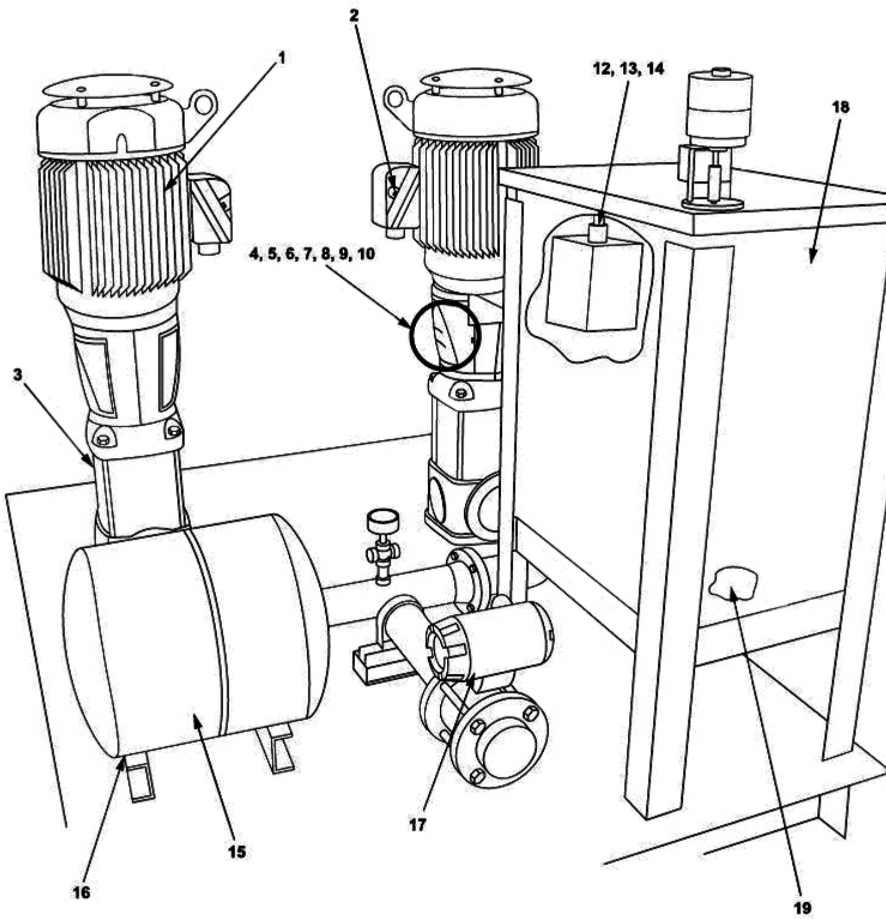


Figure 2–18. Dual-pump station.

Accumulator and pressure switch

The accumulator (fig. 2–19, callout 10) and pressure switch (fig. 2–19, callout 4) operate in unison on the 35 gpm electric pump assembly. The accumulator allows the pump to maintain pressure in the system when the pump is off, and the pressure switch turns the pump on and off to apply the system pressure as needed. The pressure switch is factory set to maintain the system pressure between 20 to 40 psi. One of the disadvantages of the pressure switch is that it has electrical contacts that are highly susceptible to dirt and sand which interfere with the operation. If the pump starts to rapidly cycle off and on, check the electrical contacts; clean them first and replace if needed. It is always a good idea to have extra pressure switches on hand for a quick repair to the system. Always disconnect power before repairing or replacing the pressure switch.

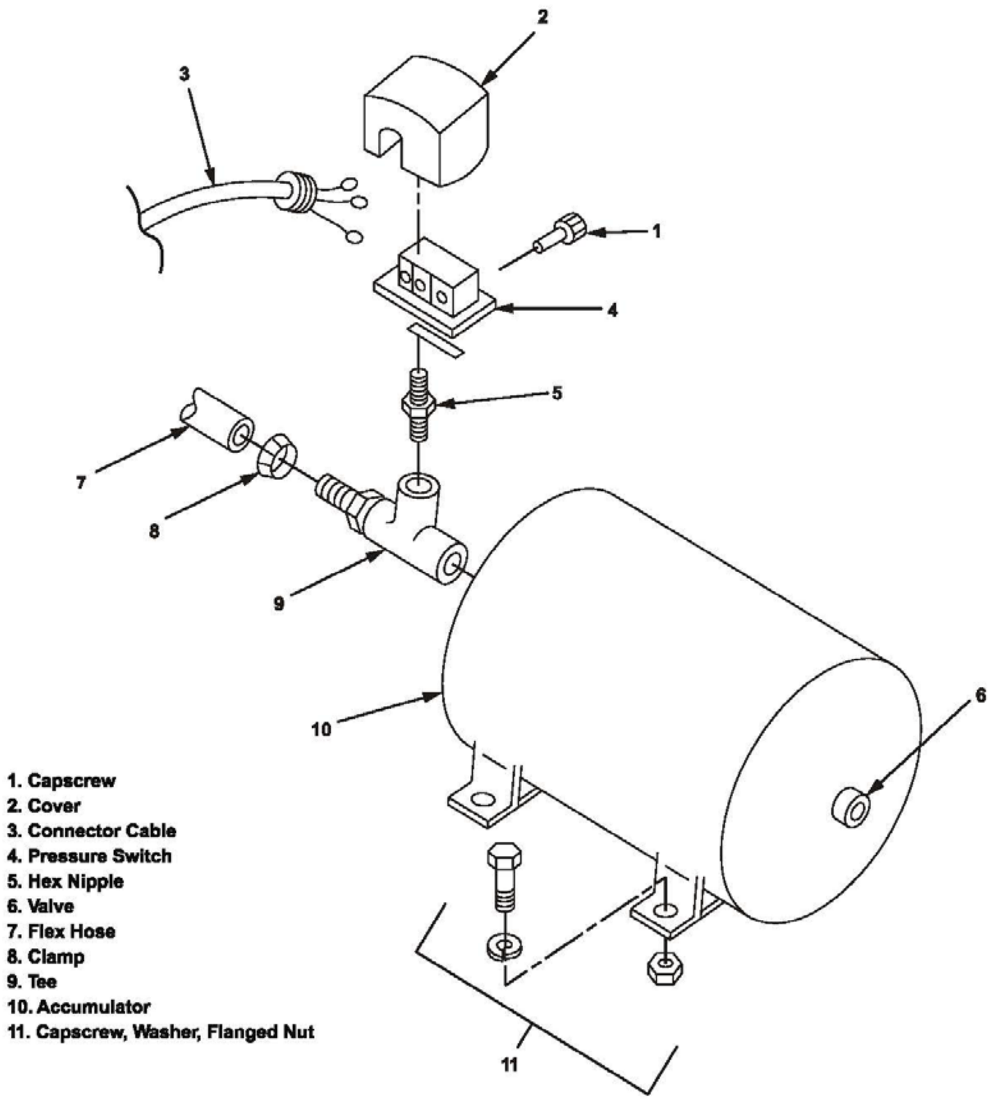


Figure 2–19. Exploded view of accumulator and pressure switch.

Chemical feed pump

The chemical feed pump is adjusted to maintain the desired chlorine residual in the BEAR potable water distribution system. If you are experiencing problems maintaining chlorine residual in the system, check the chemical feed pump for proper operation. The chemical feed pump repair will primarily consist of replacing the pump diaphragm (fig. 2–20, callout 9) or the pump itself. Make sure to follow the BEAR water system TO instructions for replacement of the diaphragm.

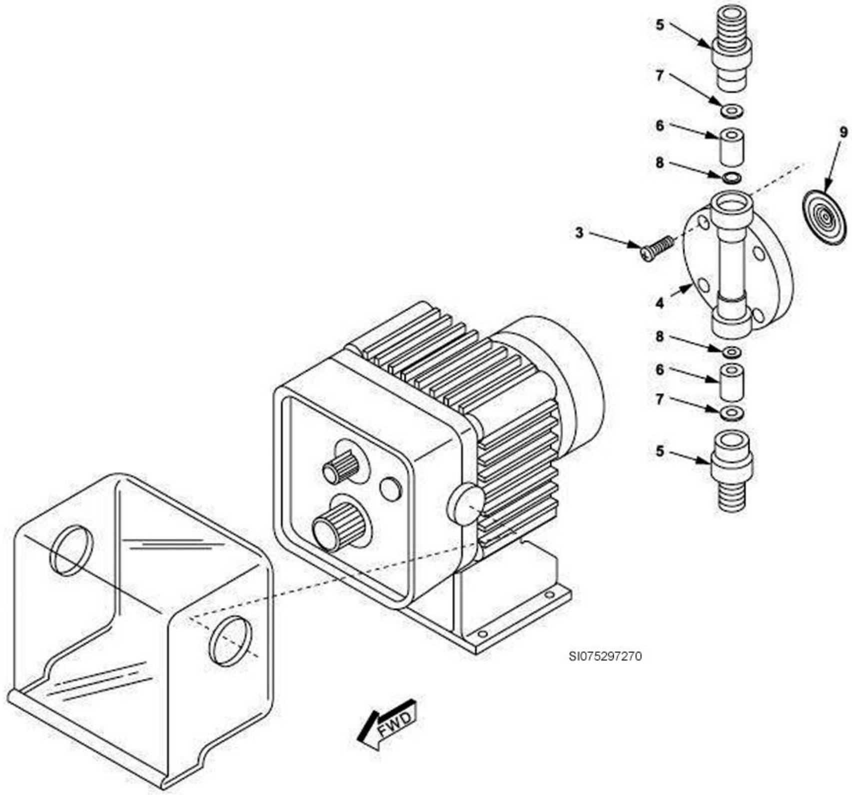


Figure 2–20. Chemical feed pump.

35 gpm electric pump assembly (potable)

Maintenance of the potable water system's 35 gpm electric pump assembly (fig. 2–21) consists of removal and replacement of the pump, pressure switch, and accumulator. The electric pump will require periodic adjustment to maintain the desired pressure range of 20 to 40 psi. Follow procedures discussed above for accumulator maintenance. Always check the pump for proper rotation.

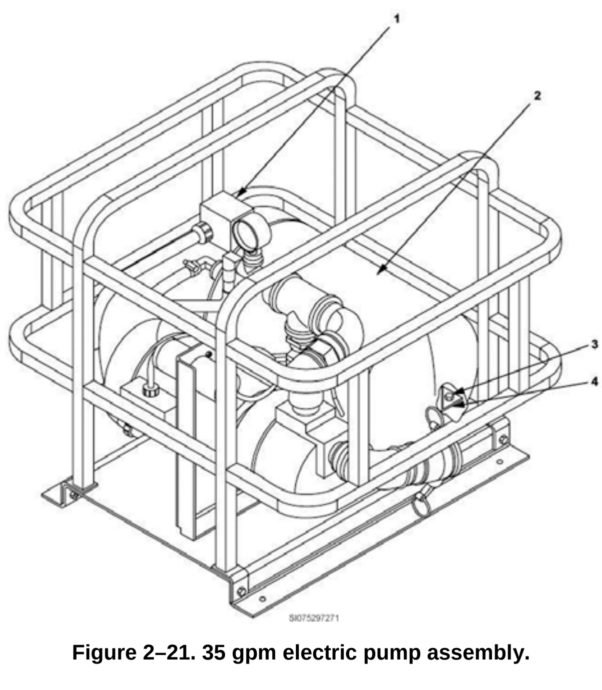


Figure 2–21. 35 gpm electric pump assembly.

35 gpm electric pump assembly (wastewater)

The 35 gpm electric pump assembly is a typical centrifugal self-priming pump. This pump is used to pump ROWPU waste away from the water treatment area. Pump air lock and incorrect phase voltage are your primary troubleshooting concerns.

125 gpm and 400 gpm diesel pump assemblies

The 125 gpm (fig. 2–22) and 400 gpm (fig. 2–23) diesel pumps require basic engine maintenance. Check all fluid levels before start-up. Change fuel, oil, and air filters according to the maintenance procedures outlined in the applicable TO. Never allow the centrifugal pump to run dry because damage may occur. Always follow the applicable TO for operation, maintenance and repair.

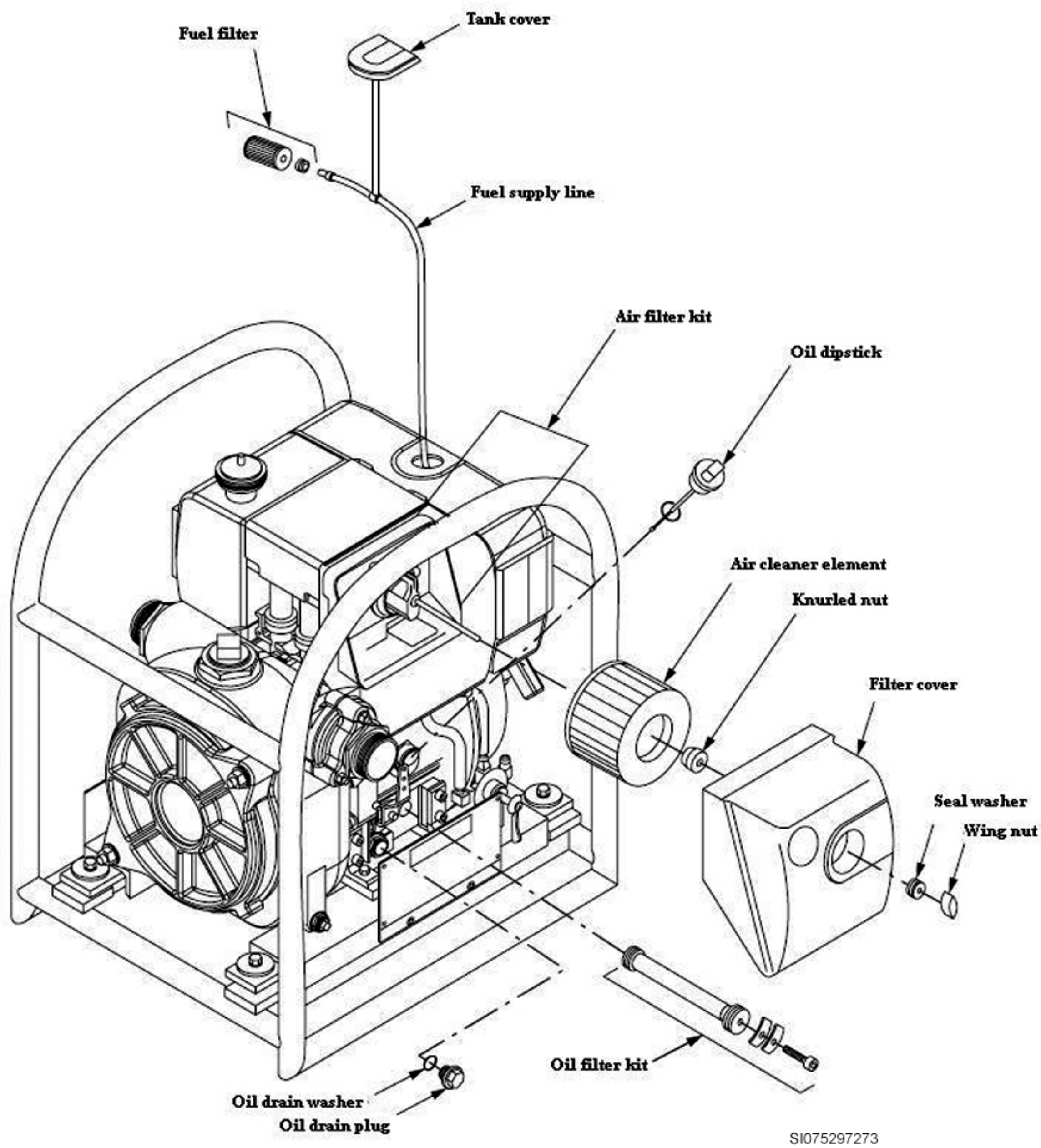


Figure 2–22. 125 gpm diesel pump.

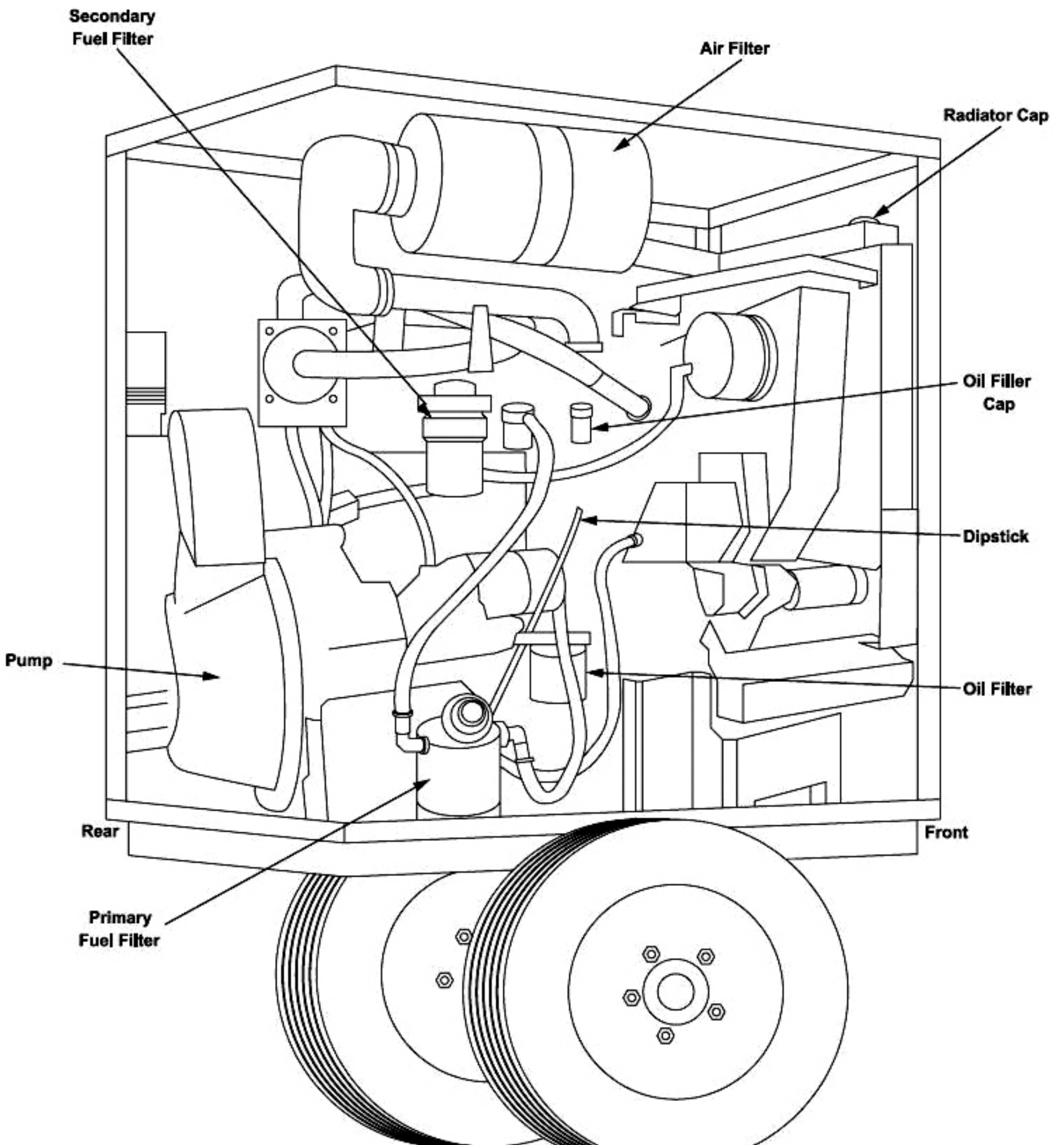


Figure 2–23. 400 gpm diesel pump.

BEAR sewage lift stations

The wastewater collection system is a series of four lift stations that collect the wastewater at user facilities and deliver it to a 25,000 gal. aerated collection tank. The lift stations are as follows:

1. Sewage ejector lift station kitchen.
2. Sewage ejector lift station latrine.
3. Macerator lift station.
4. Dual-pump lift station.

Sewage ejector lift station kitchen and latrine

The sewage ejector lift station (fig. 2–24) is almost identical for the kitchen and latrine; the only difference is the type of wastewater it receives. This lift station has a single submersible centrifugal pump and single float switch. Follow the procedures in the TO for removal of the pump assembly, and always ensure power is off before doing any maintenance on the lift station.

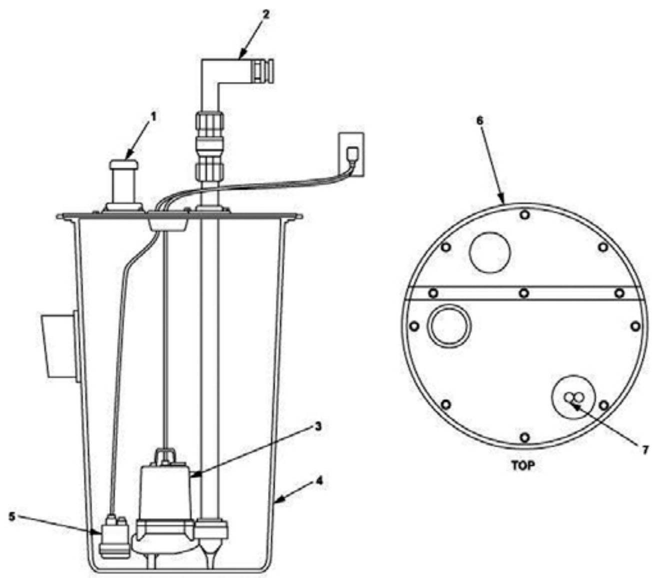


Figure 2–24. Sewage ejector lift station kitchen and latrine.

Macerator pump lift station

The macerator pump lift station (fig. 2–25) consists of a submersible macerator pump, sewage tank, pump lift-out assembly, three floats, and associated plumbing and electrical box. The lift-out assembly and rails allow you to easily remove and replace the pump for repair and replacement. Follow the procedures in the TO for removal of the pump assembly. The impellers on this type of pump have a cutting edge designed to grind waste materials as they are being pumped out.

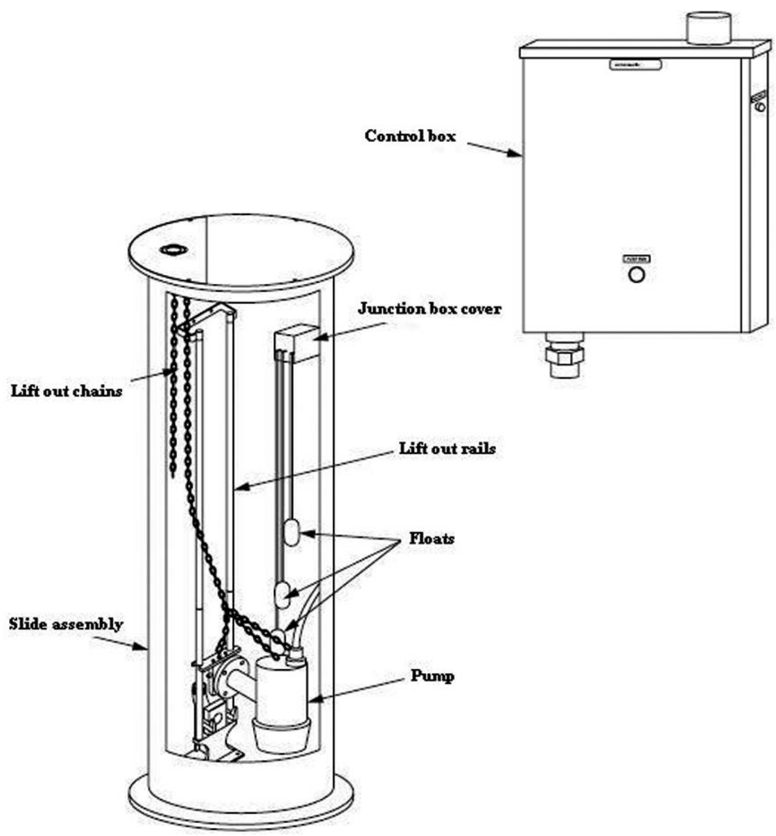


Figure 2–25. Macerator pump lift station.

Dual-pump lift station

The dual-pump lift station (fig. 2–26) contains two submersible macerator pumps, a sewage tank, a pump lift-out assembly, four floats, and associated plumbing and electrical box. Removal and replacement of the pump assembly is almost identical to the macerator pump lift station; the only difference is that you can remove one pump and still allow the other pump to operate.

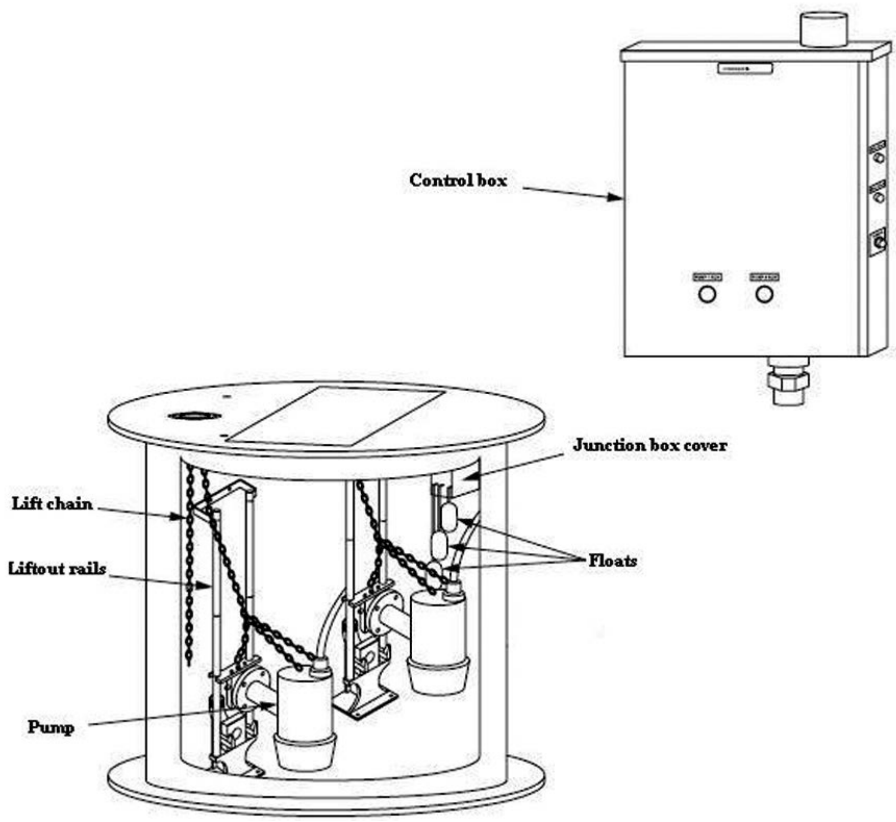


Figure 2–26. Dual-pump lift station.

BEAR lift station maintenance and repair

The BEAR lift stations have submersible centrifugal pumps that require little maintenance. These pumps are controlled by a float or series of floats that turn the pumps on and off at the correct levels. Below we will discuss some basic maintenance and repair actions to ensure the proper operation of the lift stations. Always use the applicable TOs to install, operate, and maintain these lift stations.

Trouble shooting and repairing floats

If you notice the lift station water level is too high or that the pump will not turn off, then you will need to check the operation of the float(s). The floats control the on and off operation of the lift station, and they can cause problems in a number of ways. First, try to clean the float(s) and put them back into operation. If cleaning does not correct the problem, watch the floats operate through a pumping cycle. Sometimes you will find a float getting hung-up on something inside the lift station. If you determine that the floats are not visibly the problem, then have an electrician check the floats and determine if they are in need of replacement.

Repairing clogged pumps

If you experience problems with the discharge from the lift station, you will most likely need to pull the pump and check the impeller for foreign debris clogging the pump. First, make sure there is no power to the pump. While wearing appropriate gloves, pull the pump and remove any debris from the pump impeller, being careful of sharp objects lodged in the impeller. After the impeller is clear, inspect the pump for proper rotation before placing the pump back into the lift station. If pump rotates backwards, have an electrician check the phase voltage to the pump. If the pump fails to operate after completing the troubleshooting procedures, check the force main for obstructions. Lastly, inspect the check valve and ensure that it is operating properly. If you determine the force main and check valve are not the problem, then you need to replace the pump.

Pump rotation

Incorrect pump rotation is a common problem in the field. If you have determined the pump is operating and the force main is clear, then pull the pump to inspect the impeller rotation. You can see if the pump is running backwards by briefly jogging the pump's electrical on/off and observing the rotation of the impeller. You can identify the proper rotation by locating the directional arrow on the pump casing. If the pump is running backwards, have an electrician check the phase voltage to the pump motor. It is common that the phase voltage is not installed correctly during bare base set-up causing the pumps to run backwards.

25,000 gal. wastewater collection tank with mixing system

The 25,000 gal. wastewater collection tank mixing system (fig. 2–27) has an electric pump that recirculates the wastewater to keep it fresh until final disposal. As with any other electric pump, check the rotation, hoses, and impeller when troubleshooting the system.

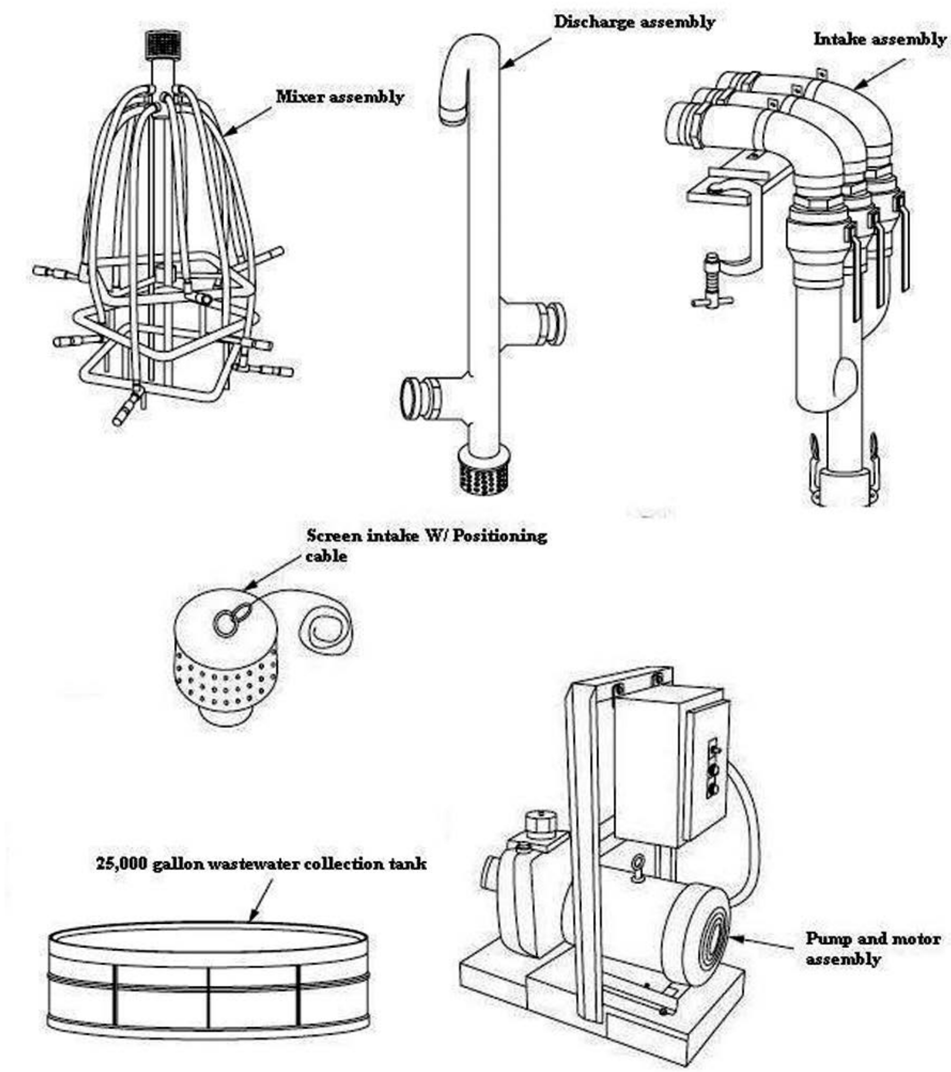


Figure 2–27. 25,000 gal. wastewater collection tank with mixing system.

Bladder water level controller

The bladder water level controllers (fig. 2–28) maintain the water level in the 3,000 gal. potable water storage tanks. Adjust the water level control devices with the control knobs to reach the desired level. When you can no longer control the water level with the control knobs, replace the controller.

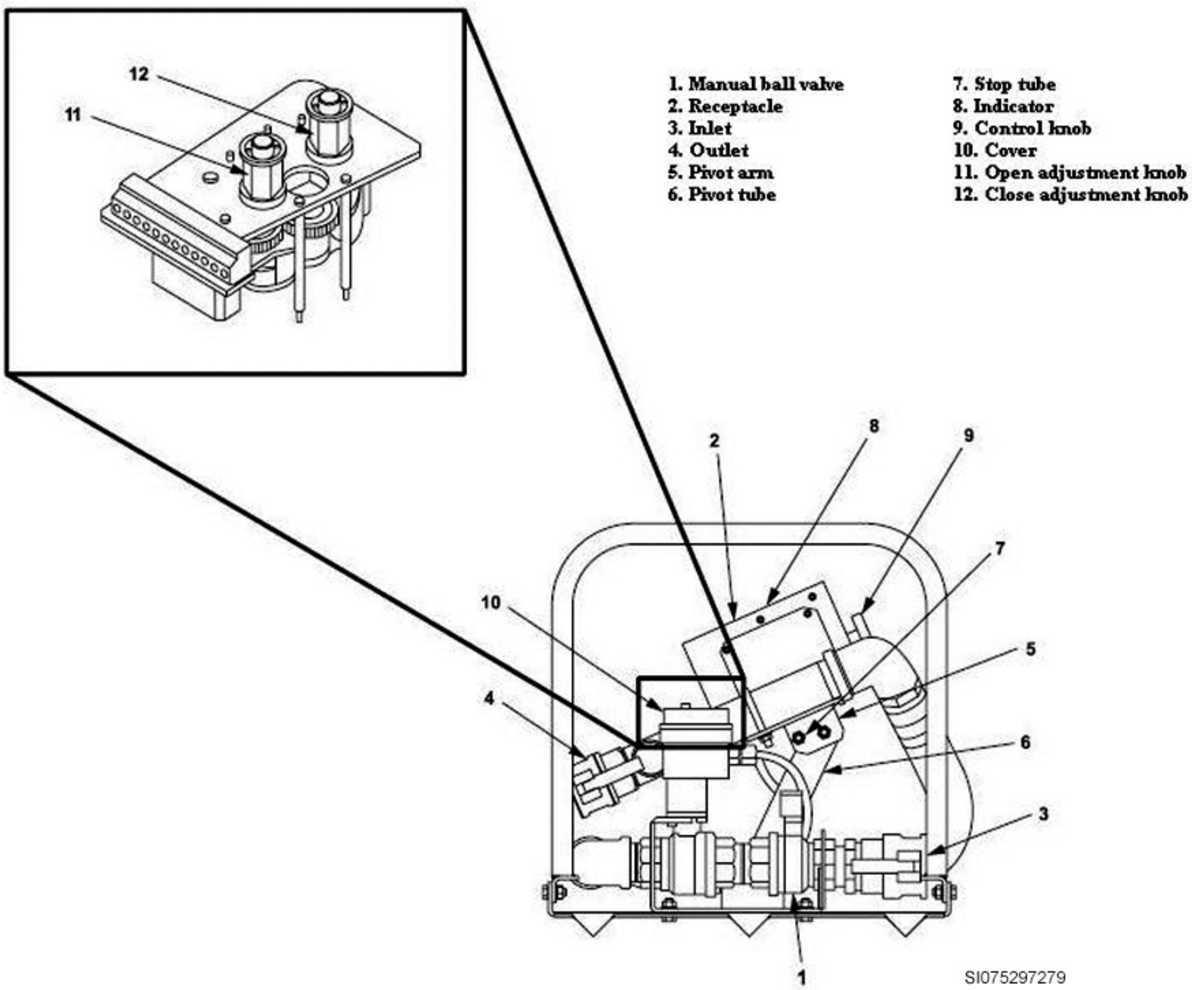


Figure 2–28. Bladder water level controller.

Hose and fittings

The BEAR water system is connected by a series of hoses, quick-connect couplings, and threaded and polyvinyl chloride (PVC)-glued connections and fittings. Be sure to follow specific TO instructions on hose connections and repair. You will tailor-fit the water system to meet your specific installation's needs with the hose strap installation tool. Remember, once you have successfully installed the BEAR water system, start preparing to convert the hose to a rigid pipe to allow burying the pipe for thermal and security protection.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

614. BEAR water system capabilities and set-up

1. How many gpppd is the BEAR water system designed to support?

2. How many days can the BEAR water system maintain enough water storage capacity to sustain the camp with no new water production?

3. What are the five distinct subsystems that make up the BEAR water system?

4. What color code is used to denote components used in the wastewater system?

5. What temperature can water reach in above-ground pipelines?

6. The BEAR water system should never be less than how many ppm chlorine residual at the point of use?

615. BEAR water subsystems and components

1. What is the *main* purpose of the source run subsystem?

2. How many feet can the source run subsystem pump water?

3. What is the 550 initial subsystem's primary purpose?

4. How many 20,000 gal. water bladders are part of the water production subsystem, and what are their designated uses?

616. BEAR water and wastewater system components troubleshooting and repair

1. How do you repair the accumulator on the dual-pump station?

2. What actions can you take to repair an electrical pressure switch on the 35 gpm electric pump?

3. What problem may occur if you run a centrifugal pump without water?

4. What lift stations are used in the BEAR wastewater collection system?

5. If you notice the pump impeller running backwards, what should you do to correct the problem?

6. How do you maintain the correct water level in the 3,000 gal. potable water storage tanks?

2–2. BEAR Assets

Discussing the BEAR base set-up would not be complete without providing a detailed overview of the various systems supported by it. As a WFSM Journeyman, you are a vital asset to any forward deployed contingency. Without proper laundry, dining, latrine, or shower facilities, morale can quickly dwindle and ultimately affect the mission. In this section, we discuss the set-up and operation of these critical support facilities essential to the overall success of the mission.

617. Set-up and maintenance of the self-help laundry

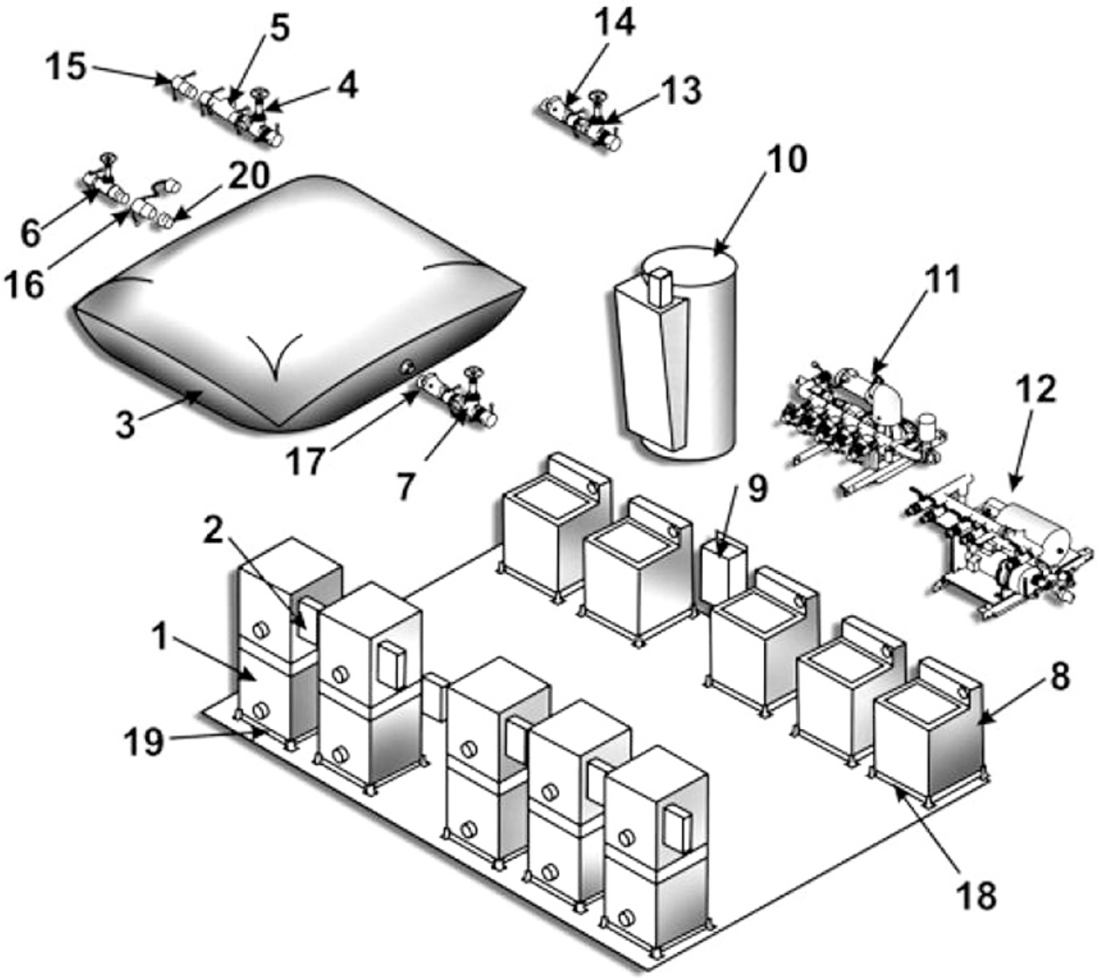
Imagine being deployed and not having the ability to clean your clothes on a regular basis. The BEAR deployment concept incorporated a self-help laundry into the base infrastructure to make sure you have clean clothes even while deployed to remote locations. As WFSM personnel, your contingency jobs are to set-up and maintain the self-help laundry for base personnel.

Self-help laundry package

The self-help laundry is designed for rapid deployment and continuous operation as a complete field laundry. The system consists of five washers; five double-stacked dryers; floor-anchoring brackets for the washer and dryers; 80 gal. water heater; 3,000 gal. water tank; supply pump; drain pump; electrical distribution panels; hoses; valves; filters; and electrical cables. The washer, dryers, and electrical connection boxes are designed to be operated within a user-furnished tent at least 32’ long by 20’ wide. Anchor washers and dryers to the floor using the supplied anchor brackets. Position the pumps, water heater, and tank outside the tent. Major components of the self-help laundry are shown in figure 2–29. Next, we will discuss the equipment items associated with the self-help laundry.

System inlet

The system inlet (fig. 2–29, callouts 4 and 5) consists of a gate and check valve assembly. The gate valve controls the flow of water from the base supply into the storage tank. The check valve prevents tank water from flowing back into the base supply line if base supply pressure is lost.



KEY

1. Double Stacked Dryer	11. Supply Pump Assembly
2. Dryer Electrical Connection Box	12. Drain Pump Assembly
3. Storage Tank	13. Gate Valve Assembly
4. Gate Valve Assembly	14. Check Valve Assembly
5. Check Valve Assembly	15. Base Adapter
6. Tank Inlet Valve	16. Tank Inlet Fitting
7. Tank Outlet Valve	17. Tank Outlet Fitting
8. Washing Machine	18. Washer Locator Bracket
9. Washer Pump Electrical Connection Box	19. Dryer Locator Bracket
10. Water Heater Assembly	20. Bushing

Figure 2–29. Self-help laundry.

Storage tank inlet and outlet valves

The storage tank inlet valve (fig. 2–29, callout 6) controls the flow of water to the storage tank. The inlet valve may be left closed to isolate the tank from the base system or left opened allowing the storage tank to fill from the base supply. The storage tank outlet valve (fig. 2–29, callout 7) controls water flow from the storage tank to the supply pump.

Storage tank

The storage tank (fig. 2–29, callout 3) is a 3,000 gal. collapsible-type bladder tank.

Supply pump assembly

The supply pump (fig. 2–29, callout 11) draws water from the storage tank and pressurizes and sends the water to the cold-water inlets of the washing machines and to the water heater.

Water heater assembly

The 80 gal. water heater (fig. 2–29, callout 10) uses electric elements to raise the temperature of the water to 180ºF. The heated water from the water heater flows through the thermostat. Adjust the thermostat to regulate the water to 110ºF for the washing process.

Base adapter

The base adapter (fig. 2–29, callout 15) is a female reducer fitting used to adapt a 2” base supply line to the 1½” diameter system inlet valve assembly.

Washing machines

The washing machines (fig. 2–29, callout 18) provide three choices of washing processes, a variable water level selector, and three choices for wash and rinse cycle.

Drain pump assembly

The drain pump (fig. 2–29, callout 12) draws wastewater from the washing machines and sends it to the designated disposal system.

Discharge valve

The discharge valve controls the flow of wastewater from the laundry piping system into the base disposal system. The check valve prevents wastewater from the base system from backing up into laundry.

Dryers

The dryers (fig. 2–29, callout 1) are standard commercial-grade, tumble-type dryers. An adjustable timer is provided to set the amount of time the dryers will run. A permanent lint trap is part of the dryer door assembly.

Tank inlet and outlet fittings

These fittings, along with the bushing, adapt the QD inlet and outlet valve assemblies (fig. 2–29, callouts 16 and 17) to the threaded fittings installed on the tank. Once the inlet and outlet fittings and bushing are installed on the tank, they need not be removed.

Power distribution panels

The washer pump power distribution panel (fig. 2–29, callout 9), within the washer pump electrical connection box, contains the circuit breaker (CB) switches used to activate and protect the individual washing machine and pump assembly electrical circuits. Electrical connectors are provided to distribute electrical power from base supply to the individual washing machines and pump assemblies.

Each of the dryer distribution panels (fig. 2–29, callout 2) contains two CB switches to activate and protect the electrical circuits of one pair of dryers. Electrical connectors are provided to distribute base electrical power to the pair of dryers.

Setting up the self-help laundry for use

The self-help laundry may be set up to operate with or without the water heater. Always use TO 50D1–4–1 to perform the following procedures to assemble the self-help laundry and prepare it for general use.

1. Place washers and dryers in user-furnished shelter and securely anchor them to the floor.
2. Install and connect the electrical boxes to the washers and dryers.

3. Position the supply pump assembly, drain pump assembly, water heater, and storage tank outside the BEAR shelter. Connect gate and check valves where applicable.
4. Attach dryer exhaust ducts to dryers and secure with the clamp. Route ducts out of the shelter. Connect dryer electrical connection boxes using supplied electrical cables.
5. Connect the drain assembly to the washing machines to include all hoses, gates, and check valves. Connect the drain assembly to the base drain system.
6. Connect the supply assembly to the water heater to include all hoses, gates, and check valves. Then connect the water heater to the washing machines.
7. Connect the water supply and drain lines, and ensure electrical is connected to all equipment.
8. Connect the storage tank to the base water system and fill the tank.
9. Turn the power on to the system (except water heater) and allow the supply pump to fill the system. Open the water heater relief valve to relieve air from the water heater tank.
10. After all the air is relieved from the system, apply power to the water heater. The laundry facility is now ready for operation.

These steps are the general set-up order for the self-help laundry. Use the TO for the exact set-up instructions of the self-help laundry.

Wastewater disposal

Careful thought must go into the disposal of the wastewater generated by the self-help laundry. Keep in mind that civil engineering (CE) planners estimate that the field laundry will generate 2 gal. per day of wastewater for each person in the camp. If the total deployment is 550 persons and they all wash their laundry every day, this means you would have to dispose of 1,100 gal. of wastewater per day (minimum). For the most absolutely crudest of field conditions, you could drain all the wastewater generated by the laundry to a point away from the laundry and downstream from any water treatment facilities (back into the stream). Also, be sure that the drainage site is downwind from billeting areas. In most cases, you should pipe the field laundry into the BEAR wastewater collection system for final disposal to an evaporation bed or lagoon.

Troubleshooting and repair

The purpose of the troubleshooting chart is to aid maintenance personnel in isolating the causes of malfunctions, therefore allowing them to accomplish repairs necessary to restore the unit to operational condition. The troubleshooting chart lists problems that can occur during operation. Each problem lists the probable cause and repair.

Problem	Probable Cause	Remedy
Water too hot or not hot enough	Mixing valve malfunction.	Refer to the TO for procedures to test and service mixing valve.
No hot water	1. Water heater CB tripped. 2. Heater connector cable not connected or defected. 3. Mixing valve malfunction.	1. Find cause for tripped CB and repair malfunction. Reset CB. 2. Connect cable. If heater still does not operate, substitute a different cable to determine if original cable is defective. 3. Refer to the TO for procedures to test and service mixing valve.
Supply pump runs continuously	Pressure switch malfunction.	Replace pressure switch.
Supply pump cycles on and off rapidly and continuously	1. Accumulator precharge low. 2. Pressure switch malfunction.	1. Service accumulator. 2. Replace pressure switch.
Supply pump does not operate	1. CB tripped. 2. Electrical cable not connected or defective.	1. Determine cause of tripped CB and repair problem. Reset CB. 2. Connect cable. If pump still does not

Problem	Probable Cause	Remedy
	3. Pressure switch defective. 4. Pump motor defective.	operate, substitute a different cable to determine if original cable is defective. 3. Refer to TO for procedures to test and replace pressure switch. 4. Replace motor.
Drain pump does not operate	1. CB tripped 2. Electrical cable not connected or defective. 3. Defective drain pump toggle switch. 4. Load sense unit in washer/pump electrical connection box defective. 5. Pump motor defective.	1. Determine cause of tripped breaker and repair problem. Reset CB. 2. Connect cable. If pump still does not operate, substitute another cable to determine if original is defective. 3. Replace switch. 4. Replace load sense unit and set control settings as described in TO. 5. Replace motor.
Drain pump runs but does not pump	1. Defective flapper valve. 2. Defective diaphragm.	1. Replace flapper valve(s). 2. Replace diaphragm.
Drain pump transmission noisy	1. Level of lubricant low. 2. Bearings and/or gears worn.	1. Service transmission lubricant. 2. Replace worn parts.
Drain pump runs continuously	Load senses unit in washer/pump electrical connection box defective.	Replace load sense unit and position control settings as described in the TO.

This troubleshooting chart does not cover every possible malfunction that may occur, but does cover those that are most likely to occur. Refer to the TO for specific equipment troubleshooting and repair procedures.

618. Electric kitchen

Napoleon Bonaparte of France once said, “An army moves on its stomach.” Subsequent historical events have proven this to be true. In view of this, kitchens designed to *move* with United States (US) armed forces have been designed. These kitchens are made to be expedient and efficient. As a WFSM journeyman, you will install the utilities required to operate the equipment in these kitchens. The main pieces of equipment that concern you are the dishwasher, scullery sink, and the water heater.

Potable water supply

The equipment in the BEAR electric kitchen is used for food preparation and cleaning. The dishwasher, scullery sink, and water heater all require potable water. Plastic piping and flexible hose connect the BEAR water supply to the equipment and to each other. An electric water pump supplies potable water between 20–40 psi. The potable water source can come from various sources (e.g., BEAR water system, water buffalos, and numerous sizes of bladders and onion tanks).

Wastewater disposal

CE planners estimate that the electric kitchen will use up to 3 gpppd to provide meals for the deployed force. This estimate is based on a usage of 0.65 gallons per day (gpd) for food preparation and 2.35 gpd for kitchen clean up. As you can imagine, keeping kitchen waste disposed of in any field environment is paramount for sanitation reasons. The kitchen equipment connects to the BEAR wastewater disposal system that includes 4” plastic piping, a septic tank, and an oxidation lagoon. When the BEAR wastewater system is not used, drain the kitchen into a series of evaporation beds. As figure 2–30 illustrates, you are to make seven beds—one for each day of the week. Each bed should be about 1’ deep and allow for 1’ of freeboard once the berms are formed. To determine the area required for all the beds, allow 3 square feet per person per day of use. Divide the total square footage by 7 to determine the individual size of each bed.

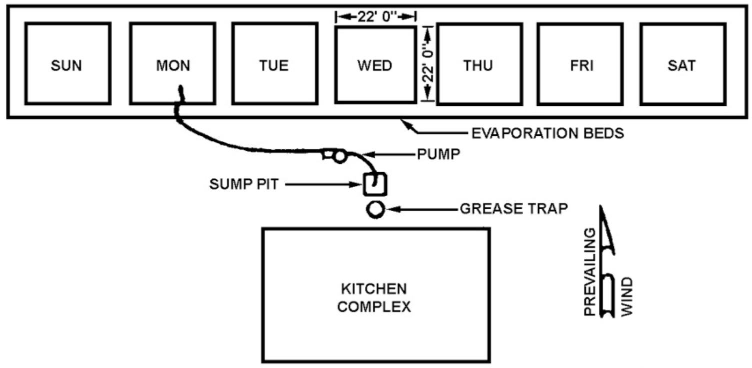


Figure 2–30. Expedient methods for kitchen wastewater disposal.

Grease trap requirements

Construct grease traps to prevent grease from entering the evaporation beds. The reason for this is threefold:

1. Grease will slow the evaporation process.
2. Grease will prevent water from leaching into the soil.
3. Most importantly, grease will provide food for insects, which could create a serious health hazard.

There are various ways to construct a grease trap—some being rather rudimentary and troublesome, while other designs are superior and trouble-free.

The simplest type of grease trap to build is a drum grease trap (fig. 2–31) using a standard 55 gal. drum that has the top cut out. Multiples of these may be constructed in series or in parallel, depending on usage requirements. Probably the best type of grease trap to construct is a concrete one. This type will be much more permanent and will not give you as much trouble. The important thing to remember about building a grease trap is to size it correctly. You do not want the trap so small that the grease fills up faster than you are prepared to remove it.

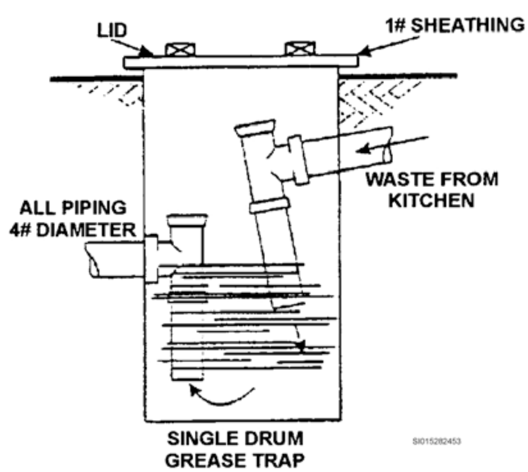


Figure 2–31. Drum grease trap.

Additionally, the grease trap should be large enough so that hot greasy water drained into the trap does not heat the congealed grease already formed on the surface. If the grease trap is not large enough, the congealed grease will liquefy and be carried to the evaporation beds. Remember to install inverted tees at the inlet and outlet of the trap. Kitchen grease traps should be maintained daily by services personnel and inspected weekly by CE personnel.

619. Setting up liquid storage bladders

BEAR assets include water and fuel storage bladders. As a WFSM journeyman, you may be required to assist in erecting water and fuel bladders.

Water bladders

There are presently two *main* sizes of water storage bladders used in the BEAR water distribution system:

- 3,000 gal.
- 20,000 gal.

The 20,000 gal. water bladder is part of the BEAR water system package. Follow the procedures outlined in the appropriate TO or technical manual (TM) when setting up water bladders. For proper set-up of the 20,000 (K) water bladder, use TM 5–5430–216–ET, *Operation & Organizational Maintenance Instructions, Tank, Fabric, Collapsible, 20,000 Gallon, Water*. Always locate your bladders where there is the least chance of damage from enemy attack or where bursting could potentially cause damage to your tent city. Use camouflage netting to mask your facility from the enemy and to reduce excessive heat gain. The 20K bladders are a highly desirable commodity when mission requirements expand. If possible, set up 20K bladders at isolated high-use facilities, such as a camp shower area. This will prevent you from making daily trips to fill up these storage sites. The water bladders have quick-connects that allow you to fill them from a water truck or an established distribution system.

Set-up

The first step to setting up a water bladder is to make sure the site is free of rocks and debris that may puncture the bladder. If the location is rocky or uneven, then install bladders on a 2” bed of sand for protection. If possible, surround the bladder or bladder farm with a berm to contain potential spills from bursting and causing damage. One 20K bladder can cause extensive damage to any nearby base infrastructure.

Before filling bladders, make sure hose connections are all connected and tight, and then begin filling bladders. 20K water bladders are at their maximum capacity when they reach 64” in height. To take the guesswork out of filling bladders, drive stakes into the ground near each side of the bladder and run a string across the top no higher than 64” tall (fig. 2–32). This will provide a visual gauge for filling the bladders to their capacity without bursting them due to overfilling.

Figure 2–32. 20,000 gal. water bladder maximum height.

The 3K water bladder requires the same attention to detail during set-up to avoid rupture by rocks or sharp debris, but it has a bladder water level controller to maintain the proper level without overfilling the bladder beyond its capacity. You will need to occasionally check the water level indicators to ensure they are operating according to the TO.

When all bladders are set-up, the last step you need to accomplish is to protect the bladders from heat gain or camouflage them for force protection reason. Camouflaging can be a fix for both problems, so it is probably the best protection for both situations. Remember, the last thing you want is to take a shower in 140°F water! If that happens then you will have the entire camp upset with the unbearable conditions. You will often find that we are appreciated when we first provide water, showers, and latrines to personnel; all other recognition typically comes from a failure to properly maintain the systems to the comforts of the base populace. Planning and implementing appropriately will eliminate headaches down the road.

620. Setting up the field deployable latrine

The field deployable latrine (fig. 2–33) consists of two latrine units and a pumping unit. Each latrine unit consists of two batteries of three toilets mounted back-to-back above a 360 gal. waste tank. A urinal trough is hung onto one of the sides of the latrine. This also drains into the waste tank. Mount the two sinks on the side opposite the urinal, facing the pumping unit.

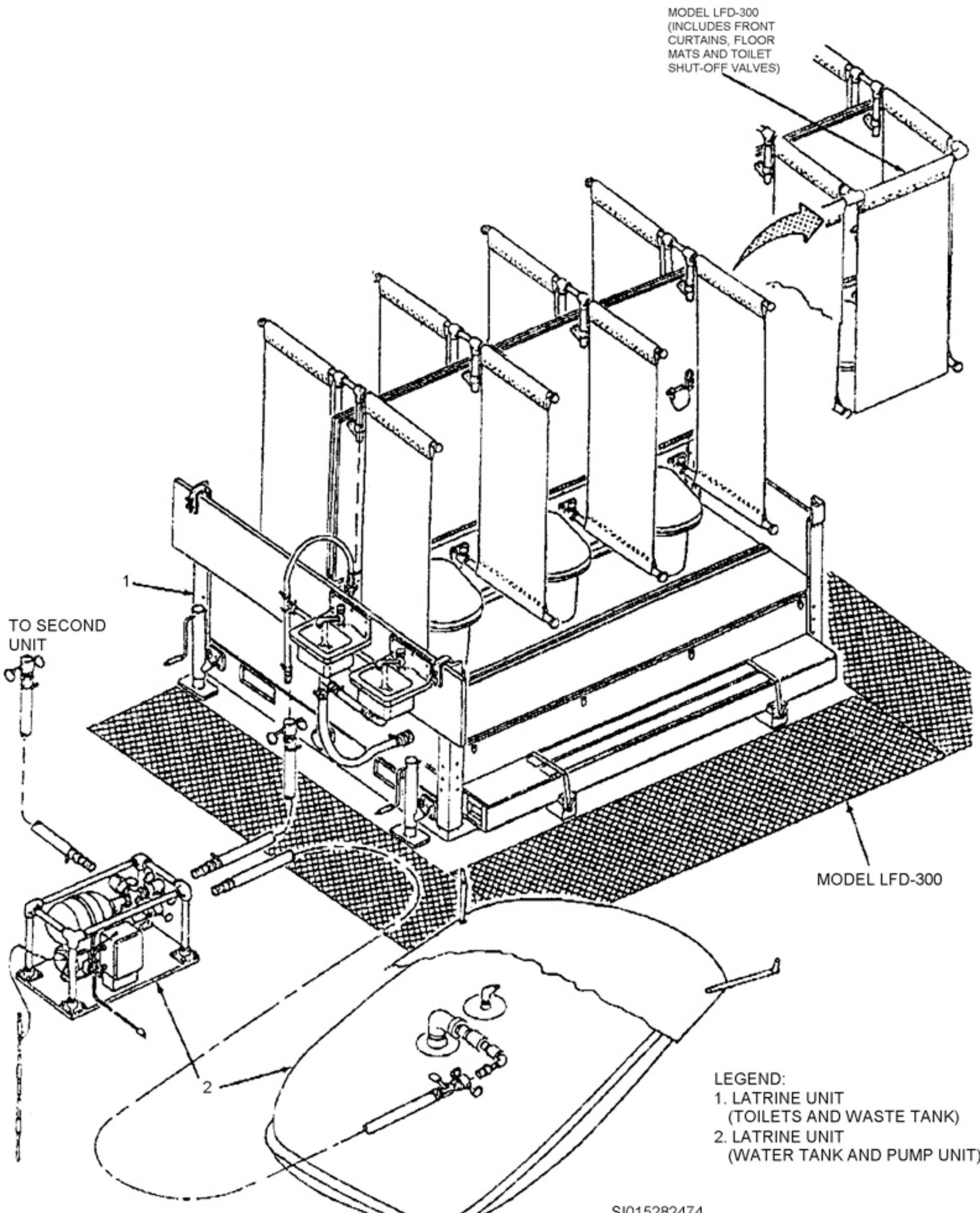


Figure 2–33. Field deployable latrine unit.

The sink faucets, urinal, and toilet flush valves are timed devices, dispensing only a measured amount of water with each activation of the push button/push valves. The pumping unit consists of a 1/3-horsepower 115-volts, alternating current (VAC) centrifugal pump and motor; check valve; pressure switch; pressure gauge; suction hose; and two supply hoses.

The pumping unit is supplied with water from a 500 gal. nylon pillow bladder. A pressure switch ensures the centrifugal pump cycles on and off to provide a constant operating pressure of 20–40 psi to the toilets, urinal, and sinks. The pressure gauge allows external monitoring of system pressure. The 360 gal. waste tank is supported by an aluminum frame and plywood partitions. The vent pipes, curtains, and frame dismantle, and the urinal board folds down to provide a shipping package measuring 84” long by 96” wide and 42” high. All metal components in contact with water are stainless steel, brass, or copper.

The unit is self-packaging with panel closures. It can be forklifted and is stackable. Tie down and lifting eyes are provided. The double-stacked unit is air transportable on 463L pallets. The unit weighs 1,530 pounds dry. One field deployable latrine serves 70 male or 52 female personnel. Normally, two latrine units are set up inside a tent or small building, thus providing some degree of privacy towards the front or the rear. Use TO 35E35–5–1 to guide you during the assembly of the unit.

Installation

With the outer bands and shipping covers removed, make the unit ready for use as follows:

1. Raise both lid assemblies to the vertical position and support each lid cover with braces. Lift the urinal trough board assembly and sink board assembly (fig. 2–34) from the front and back of the unit. Hang the sink board assembly and the urinal board assembly on the sides of the unit using the reversible swing hooks (fig. 2–35, callout 11). Connect the water supply and waste disposal hoses for the sink and urinal boards.

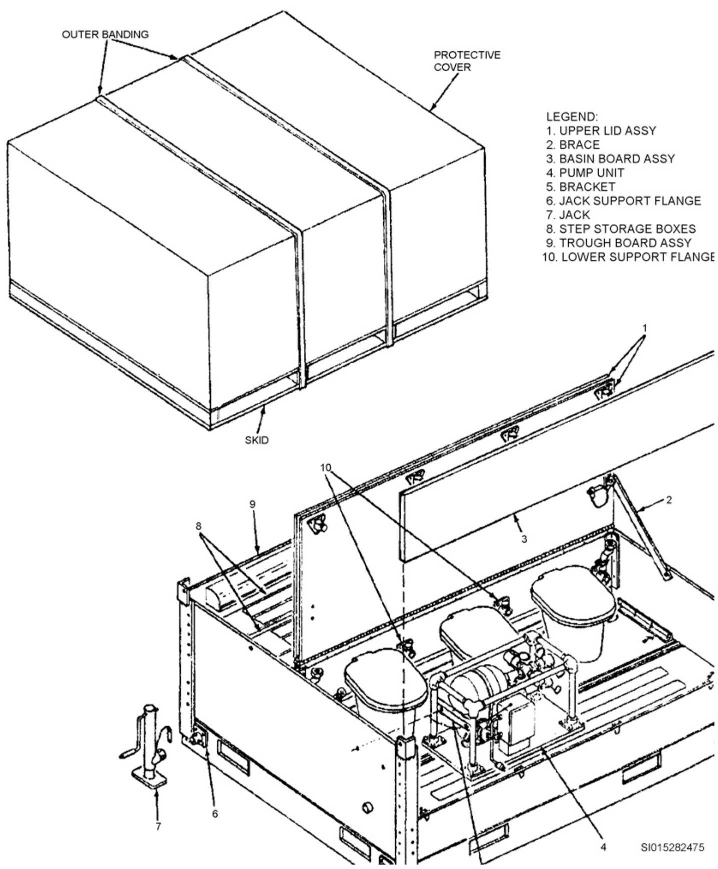


Figure 2–34. Unpacking the latrine unit.

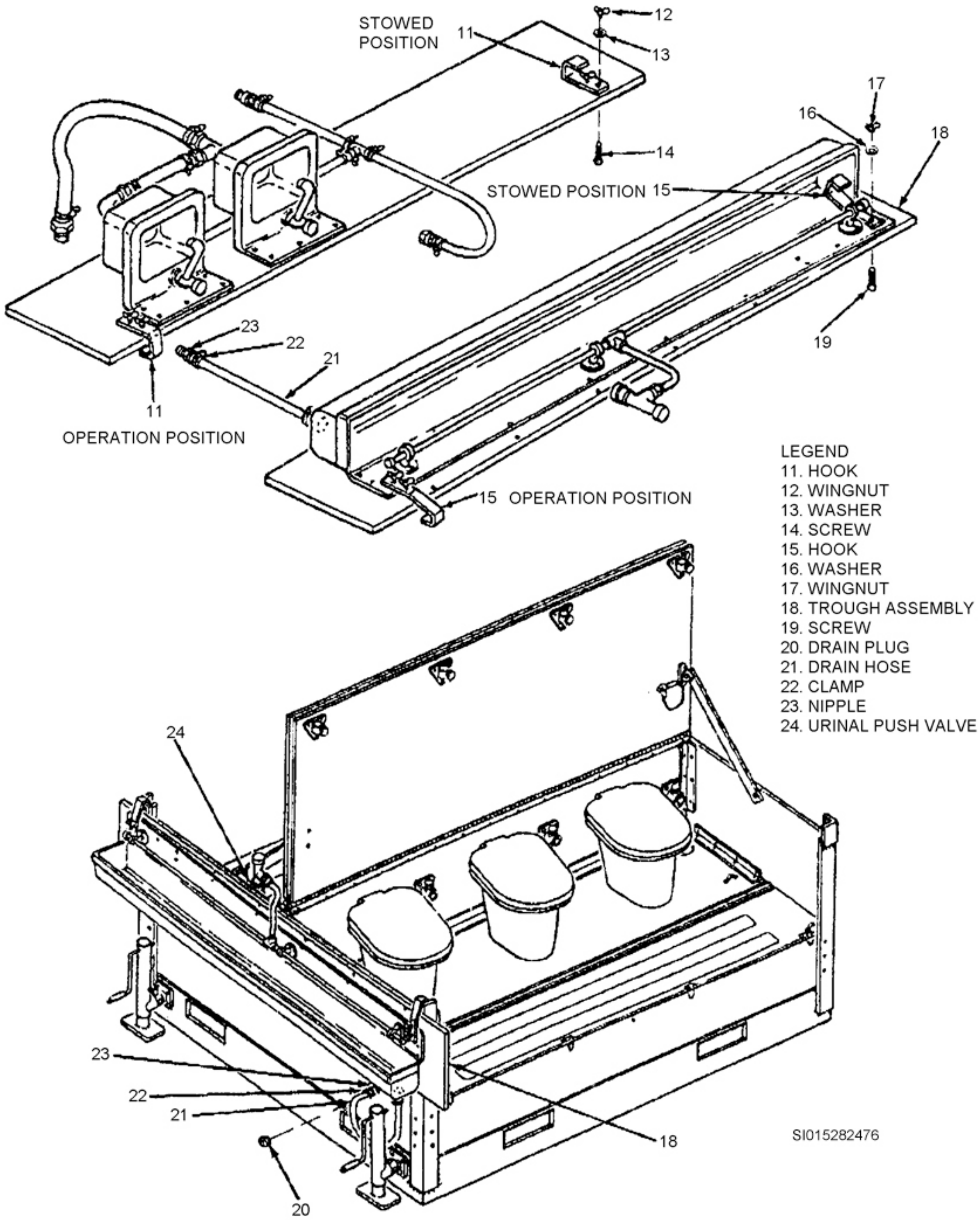


Figure 2–35. Setting up trough board and sink basin.

2. Pull out the two step/boxes (fig. 2–36, callouts 26–29) from the front and rear of the unit, and secure them with leveling blocks and straps.
3. Remove the two screws in the center of each step/box lid and remove the lids.
4. Figure 2–37 details how to install the upper and lower curtain support tubes and slide privacy curtains on the tubes. Be sure to remove any slack from the curtains by pushing up on the upper curtain support tube assemblies (fig. 2–36, callouts 37 and 38) and tightening the knobs. Finally, install the vent tube to the floor of the latrine unit.

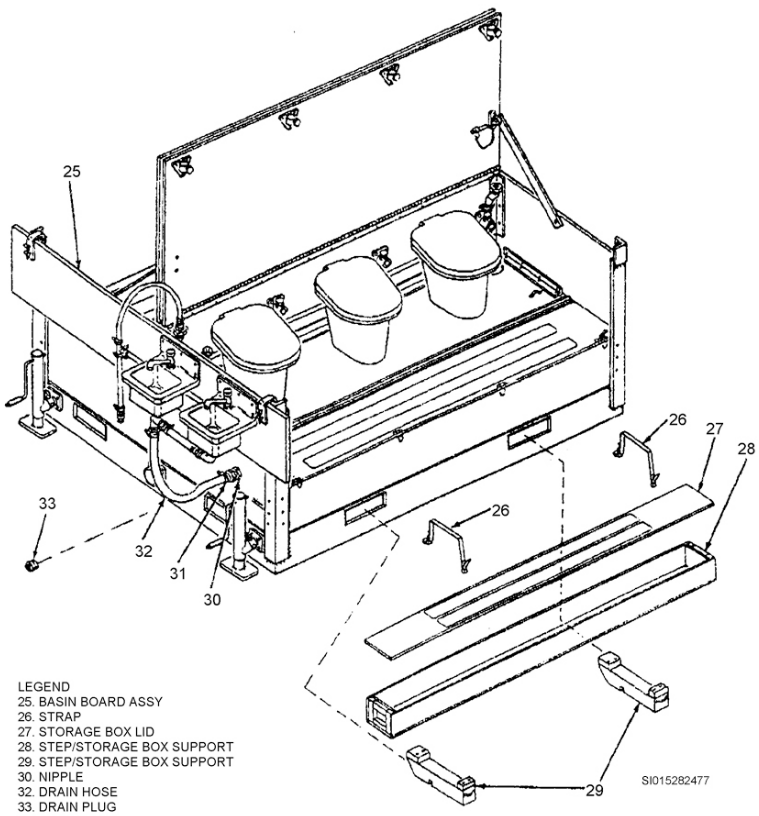


Figure 2–36. Step boxes.

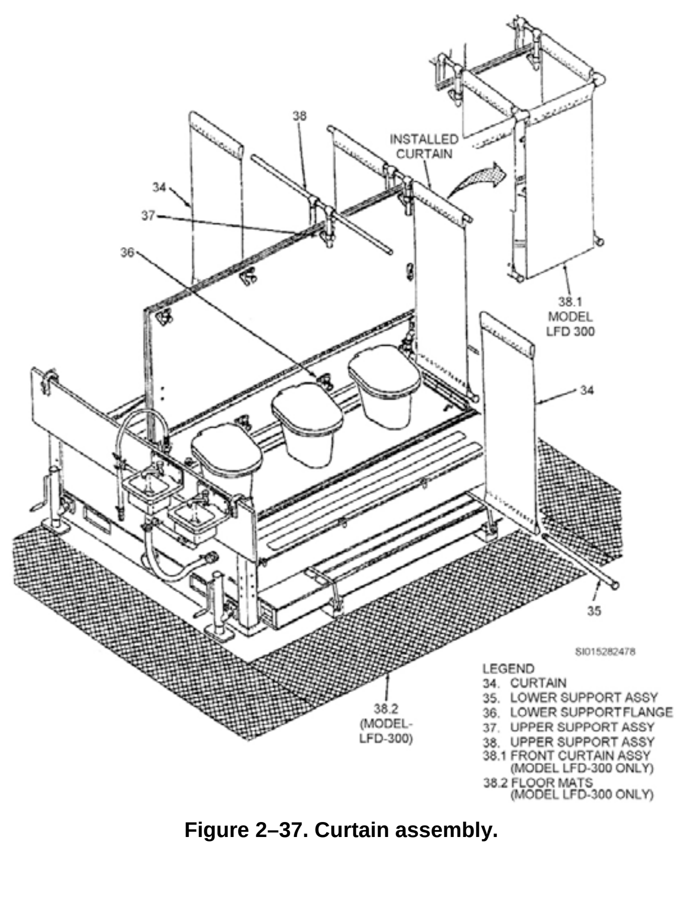


Figure 2–37. Curtain assembly.

Preparation for use

After erection, prepare the latrine for use as follows:

1. Position the water bladder 10’ from the pumping unit and fill the 500 gal. water bladder until it is 24” high (full).
2. Electrically ground the pumping unit to the top of the CB enclosure and grounding rods.
3. Connect the hard suction hose (fig. 2–38, callout 40) from the water bladder to the pumping unit. Connect the supply hose from the pumping unit to the latrine (side with the sinks, fig. 2–33). Prime the pump with approximately 3 quarts of water. (After the initial priming, the pump is self-priming.)

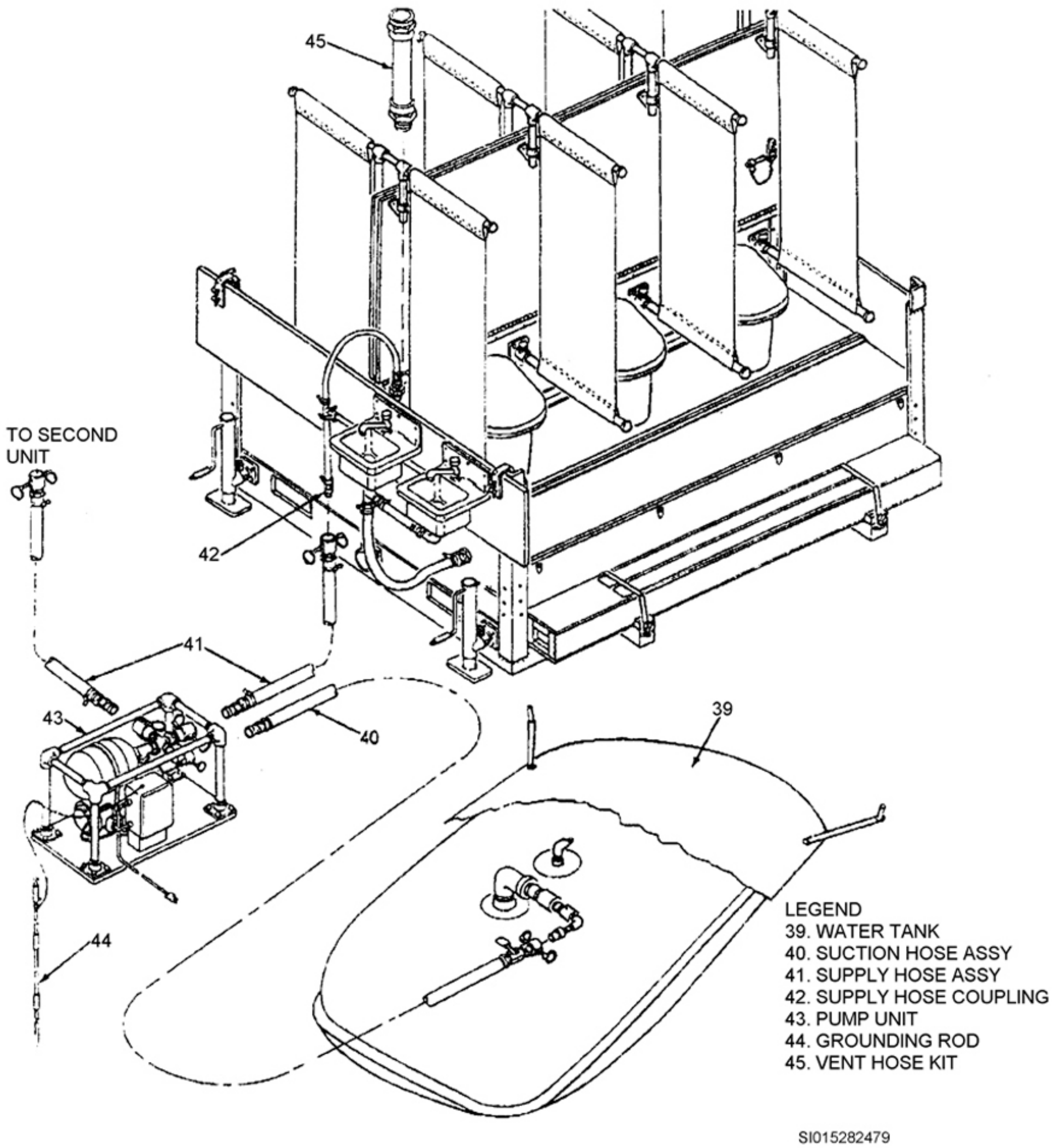


Figure 2–38. Connecting water supply.

4. Connect the power cord to a 115-volt, single-phase power supply.
5. After priming, raise the lever on the side of the pressure switch only enough to operate the motor.
6. When the pressure builds past 20 psi, the operation of the switch is automatic and cycles the pump between the high- and low-operating pressure. (The pump motor can be shut off by raising the lever to a vertical position.)
7. Operation of the pump without priming or without supply water may damage the pump. If the pressure drops below 20 psi (due to loss of water supply), the switch turns off the motor. After you refill the tank, repeat the starting procedure.
8. Open the faucet over the trough to bleed air from the line.
9. On the toilet farthest from the pump, pull the white rinse lever slowly to bleed air from the system.

Use of toilets

Before each use, rinse the bowl and add a little water by pulling on the white lever located at the rear of the stool. After you use the toilet, pull the black lever that opens the discharge valve and operates the white lever to provide flush water.

Disposal of wastes

Each time a full tank of supply water is used, drain the waste tank. Disposal of accumulated wastes may be accomplished by:

1. Removing the tank by forklift and dumping the contents into a designated waste disposal site (least preferable method).
2. Suction-draining by a sewer sucker trailer (SST) unit.
3. Discharging into the BEAR sewage disposal system (most preferable method).

BEAR disposal method

When connected to the wastewater disposal system, insert the plug on the waste valve into the drain hole beneath the opening in the floor. Turn the round knob clockwise to expand the rubber plug, and then turn the start knob to expand the rubber cover. When the waste tank is ready for dumping, insert the cleaning wand in the inspection hole and agitate the waste with a full flow of water. Direct the jet towards the area under the stools. After a few minutes of agitation, release the plug on the waste valve by turning the round knob counterclockwise; then pull up the plug. Continue to rinse until an inspection through a stool opening indicates the waste is cleared. Then reinstall the plug valve.

Forklift dumping

Although forklift dumping is a cumbersome process, it can be accomplished in a similar method as for the sewer system. Since there are no baffles in the tank, tilting, caused by one wheel going over a bump, could dislodge the lids and send a geyser of waste several feet into the air.

Sewer sucker trailer unit

When the latrine tank is to be suction-drained by a wastewater trailer, use the following procedures:

1. Place the cap on the drain nipple to close the drain.
2. Exchange the cover (with the waste valve in it) with the plain inspection cover at the opposite corner.
3. Agitate and rinse the tank with the wand as previously described.
4. Draw out the waste from the opening in the drain area by means of the suction hose.

Disassembly

The disassembly of a BEAR latrine is not difficult. To disassemble the BEAR latrine, use the reverse order of installation. Refer to TO 35E35–5–1 before you perform disassembly procedures.

621. Using the bare base shower facility and shave stand

You will find that one of the biggest morale boosters for deployed personnel is the ability to take a nice hot shower after working extremely long hours. Even though WFSM troops provide the equipment and personnel to run the showers, CE takes overall credit for this convenience, just as they take the credit for providing air conditioning in tent areas. CE is valuable in the field because they provide the niceties of “back home” as much as are possible.

Showering facilities (buildings) may or may not exist at the deployed location. If already provided, your primary responsibilities will be to make sure that all the installed plumbing in the shower area is initially working properly and maintained on a regular basis. More than likely, you will have to set up a shower facility using specially made equipment designed for field use.

In this lesson, we discuss the procedures used to set up, operate, and maintain the bare base shower and shave unit.

The bare base shower and shave unit is an actual semi-permanent showering structure erected inside a BEAR tent. Of course, the best and most permanent type of showering facility in the field would be an actual permanent building constructed for the expressed purpose of being used as a showering facility.

General characteristics

The bare base shower/shave unit is comprised of three separate pieces of equipment—the shower facility, four shave stands, and one M–80 boiler. When assembled, the shower facility is the largest component of the shower/shave unit. Here, we discuss the shower/shave unit and its components.

The shower facility component itself is made up of six, two-man shower stalls (base assemblies) that are joined together to form a complete “walk-in” type facility (fig. 2–39). These six individual shower units are assembled to form the 12-man facility. Use TO 35E35–4–1 when setting up the shower component of the shower/shave unit. The 12-man shower facility itself consists of the base assembly, shower support framework, pump assembly, hoses, and wiring harness. Let us discuss each of these sub-components of the bare base shower.

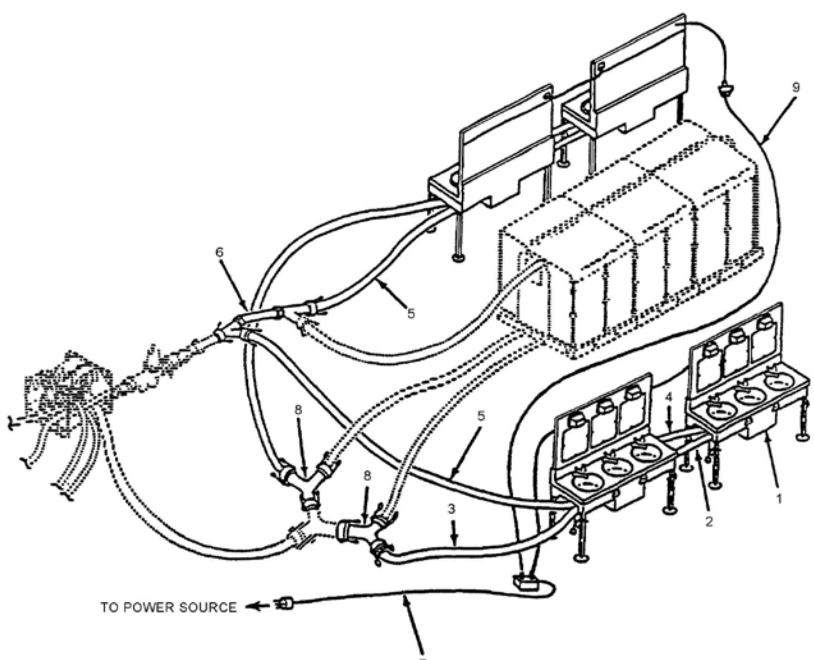


Figure 2–39. Bare base shower assembly.

Base assembly

Each base assembly is 46” wide, 72” long, 86” high, and weighs approximately 100 lb. Each base assembly consists of a base that supports two stalls, a top frame assembly with attached showerheads, side supports, and fabric cover. Made of fiberglass, the base assembly (fig. 2–40) has a built-in central drain and reinforced side sockets for the support poles that make up the shower frame. The drain is provided with male quick-connect couplings for connection to the drain hoses.

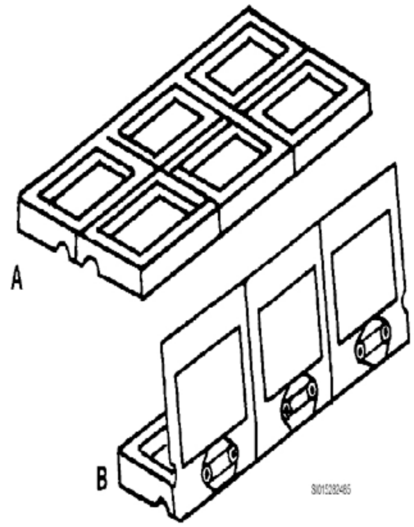


Figure 2–40. Base assembly, shower support, and top assembly.

Shower support framework

For each base assembly, the shower support consists of an aluminum top frame fitted with a shower supply manifold (with shower heads) and two attached soap dishes. The top frame is supported by six side support poles that fit into sockets in the base assembly.

Pump assembly

This unique pump assembly consists of one centrifugal supply pump, one diaphragm drain pump, a temperature regulator, and an electrical switch-box for connection to the power supply (bare base) all on the same platform (frame). One side of the pump assembly frame (fig. 2–41, left) shows the supply pump. Notice that the electrical switch-box and temperature regulator outlet are on the side that has the supply pump. There is a “Y”-strainer on the inlet side of the supply pump. On the side opposite of the supply pump is the drain pump (fig. 2–41, right). Having the two pumps on the same platform does have one advantage—you have less equipment to move.

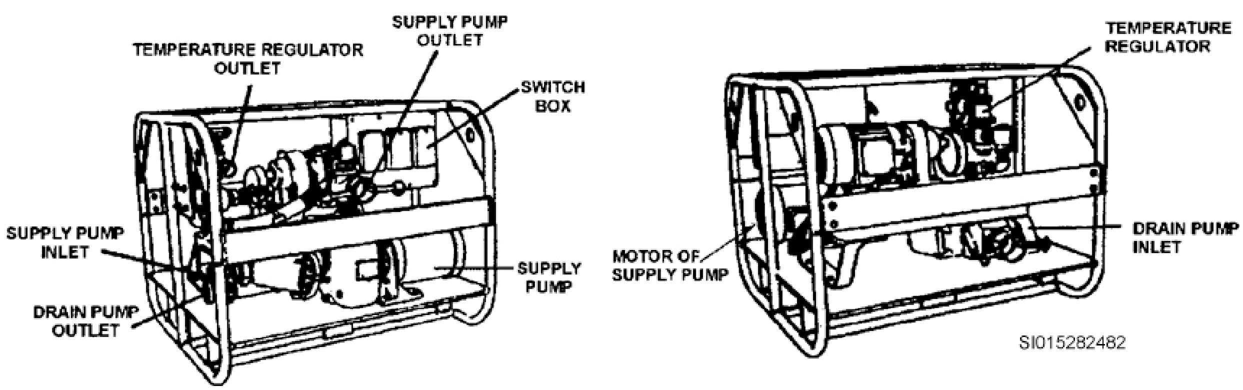


Figure 2–41. Pump assembly.

Supply water (from the source) is pumped to an M–80 boiler using the centrifugal supply pump. Heated water from the M–80 boiler is returned by pump pressure to the pump assembly and mixed by the temperature regulator using cold water direct from the supply pump. The drain (diaphragm) pump (fig. 2–41, right) provides drain suction for the shower facility and connected shave stands.

Hoses

The main 1” supply hose is used to connect the boiler to the shower facility itself (fig. 2–42, callout #4); while six 2.5’ long, 1” diameter supply hoses (fig. 2–42, callout #2 are used to connect each top frame supply manifold to each other. They also make the “end-around” connection between the two straight lines of top frame manifolds. The drains on each base assembly are interconnected in similar fashion as the water supply with the exception that the drainage hoses are 2” in diameter and are connected *within* the base assemblies. These six, 5’ long, 2” diameter hoses are used to connect the six base assemblies to each other. Using a 2” “Y” connector, the two drainage runs from the shower are tied into one and fed into the drainage pump (in the pump assembly). After the two drainage runs are tied into the “Y” connector, one drain hose 35’ in length is used to convey shower drainage to the diaphragm pump (located in the pump assembly), and another 35’ long, 2” drainage hose is used to convey pumped drainage to an approved drainage area.

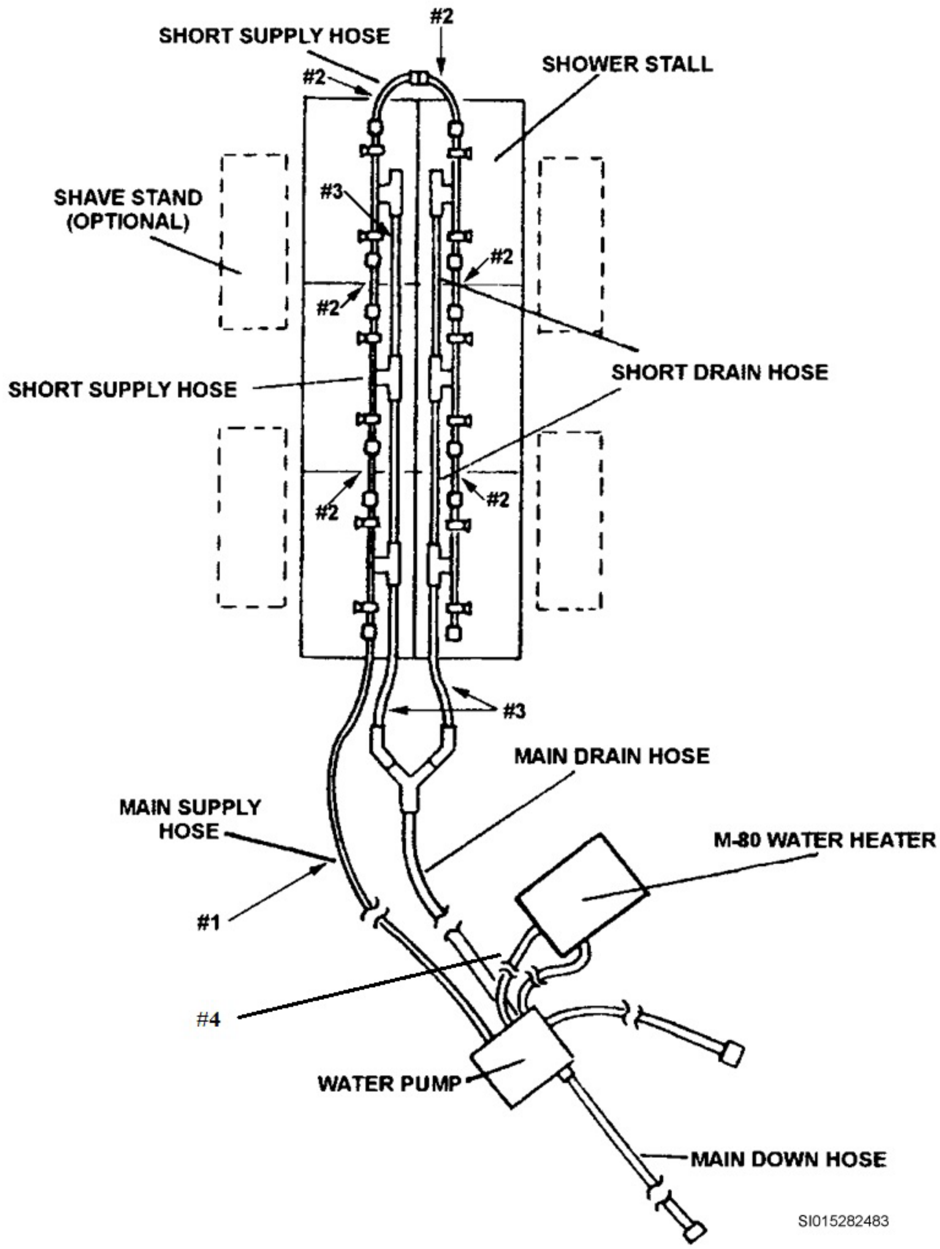


Figure 2–42. Hose placement in assembled shower facility.

Wiring harness

Electrical wiring harnesses are provided with the shower unit to connect power to the pump assembly and the electrical circuits on the bare base shave stands. The electrical components of the shower facility have a power requirement of 115 VAC, 60 hertz (Hz). Power used may either be commercial power or power from bare base power production systems.

Principles of operation

Product water is pumped from the storage bladder to an M–80 boiler. As the boiler heats up the water, and a preset desired temperature in the boiler is reached, the shower heads are opened and water is allowed to flow from the boiler out to a temperature regulator on the supply pump. At the temperature regulator, cold supply water is mixed in with heated water to ensure a constant temperature when flow demand is increased or decreased, as shower heads are opened and closed. From the temperature regulator, water travels under pressure through a long 1” diameter supply hose to the first top-frame assembly supply manifold of the facility. Each of the remaining five top frame supply manifolds are connected to each other by short sections of 1” diameter supply hoses. The two shower heads located in each top frame supply manifold are opened and closed as showering occurs.

Wash water is collected as wastewater through the drains of each base assembly. The base assembly drains are interconnected using 2” diameter hoses. Six, 2” drain hoses running parallel to each other (3 on each side) connect all six base assemblies to a “Y” connector, which conveys wastewater from both drain runs into one main-drain hose. The main-drain hose from the facility is connected to a drain pump. The diaphragm action of the drain pump ensures that wastewater does not build up in the base assemblies. Because the drain pump is a diaphragm pump, it can be operated with little or low flow for short periods (during lag times of showering) without damaging the pump. The drain pump is turned on as soon as personnel start showering and is left on until all personnel have finished showering.

Setting up the shower facility

Before you set up the bare base shower, you need to think about where to place the facility. Establish the facility on a site with adequate overall size to accommodate the shower facility, shave stand, and BEAR shelter. The site should be as level and well-drained as possible and be within easy hookup distance of BEAR water supplies and electrical systems. The set-up procedures for the shower facility consist of unpacking the unit, setting up the unit, and operating the components of the unit.

Site preparation

You also need to think about what type of flooring will be used for the shower area. Hasty site preparation during this consideration may lead to the campsite having a mud hole for a shower area. The shower/shave can be set up in one of three ways. The easiest set-up is erecting a BEAR shelter and using the supplied flooring. The supplied flooring is for temporary set-ups, and should not be used for long deployments. A wood floor is ideal for deployments that have a moderate duration, and they provide a good surface for personnel. Lastly, if concrete is readily available and the duration of deployment will be much longer, get all the necessary materials together to mix, pour, and form concrete pads. Remember, always slope the floor to ensure adequate drainage.

If needed, get help from the structures personnel to assist you for installing the flooring. Finally, place the boiler between the water source and the shower area, no more than 5’ from where the water pump will be located. Make sure to have some form of vestibule or fabricated entry to provide privacy for personnel.

Unpacking the shower

You will find that the BEAR shower is rather easy to set up. To begin with, open all the packing crates and remove the shower components from them. Be careful to avoid damaging fiberglass or painted surfaces when removing the components from the crates. Remove and inspect all components for damage during shipment. Set all the components aside from the packing crates and replace any packing material back in the crates.

Connecting the drain system

First, position the base assemblies (fig. 2–43, view A) with the drain hose cutouts towards the centerline. Make sure you have enough space between the base assemblies to facilitate the installation of the 2” drain hoses underneath the base assemblies.

Next, tilt three of the base assemblies upwards from the outer side of the facility toward the centerline of the shower to expose the drain manifolds under each base assembly (fig. 2–43, view B). Tilting the base assemblies in this way allows you to connect the short 2” drain hoses in between each assembly with relative ease. Now that the undersides of the three base assemblies are exposed, remove the two quick-connect caps from each of the six drain manifolds by opening the cap locking levers.

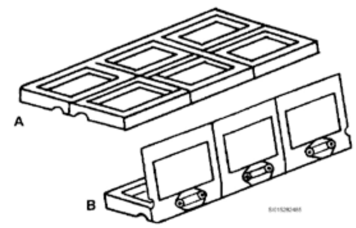


Figure 2–43. Exposing undersides of base assemblies.

Once the manifold drain caps are removed, install six, 2” drain hoses (fig. 2–44, callout 2) in between the base assemblies. This will form the drain system of the shower—interconnecting each drain in the base assemblies into one common drain line. Lower these three base assemblies back down and repeat the same procedure just described for the remaining three base assemblies. Once the drain hoses of the other three base assemblies are set up, you may slide (push) all six base assemblies together so their facing sides are touching.

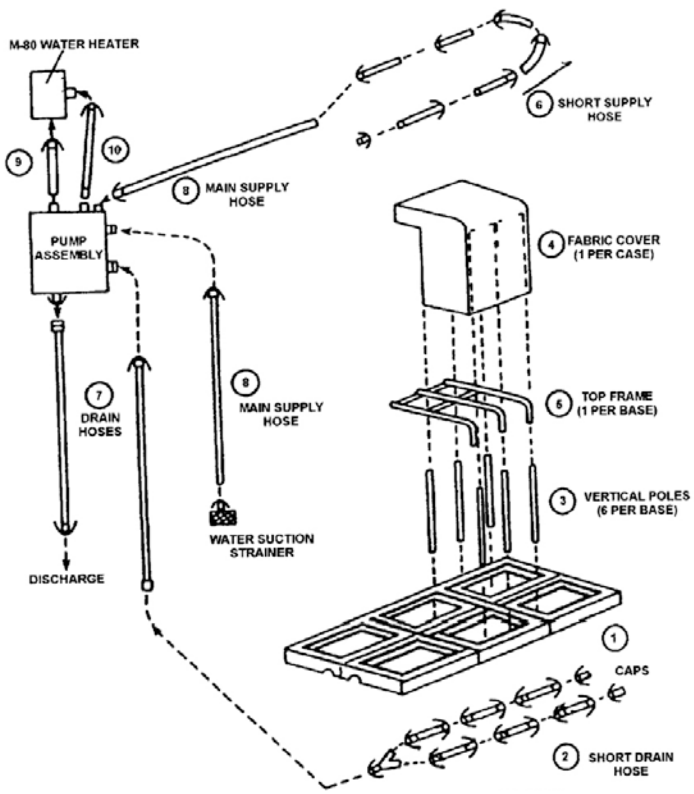


Figure 2–44. Shower facility assembly.

Setting up the framework of the shower

Now that the base assemblies are put together, you are ready to construct the framework of the shower. This will consist of all the procedures necessary to construct the shower from the base assembly up. Begin by installing five of the support poles that will hold the top frame manifolds (fig. 2–45, callout 4). Do not install the sixth (outer center) support pole (fig. 2–45, callout 20) at this time. Next, fit a top frame manifold assembly (fig. 2–45, callout 4) into a fabric cover (fig. 2–45, callout 2), making sure that the outer legs of the top frame assembly extend through the holes of the fabric cover.

Position the top frame assembly with cover over the five support poles and lower the assembly on to the poles. Keep the fabric cover overhang inside the support poles. Finally, insert the sixth support (outer center) pole by lifting the middle outer top frame assembly elbow just high enough to snap it down. Pull the remaining fabric cover over the support framework and secure the poles with Velcro straps. The finished individual shower assembly will look as shown in figure 2–45. Now, repeat the above support framework construction procedures for all 5 remaining base assemblies.

Once you have finished constructing the framework and covers for the remaining five base assemblies, position the three shower floor covers (fig. 2–45, callout 0) over the central walkway and secure it using Velcro strips on floor edges. Position the door (fig 2–45, callout 1) over the opening and secure it using Velcro straps.

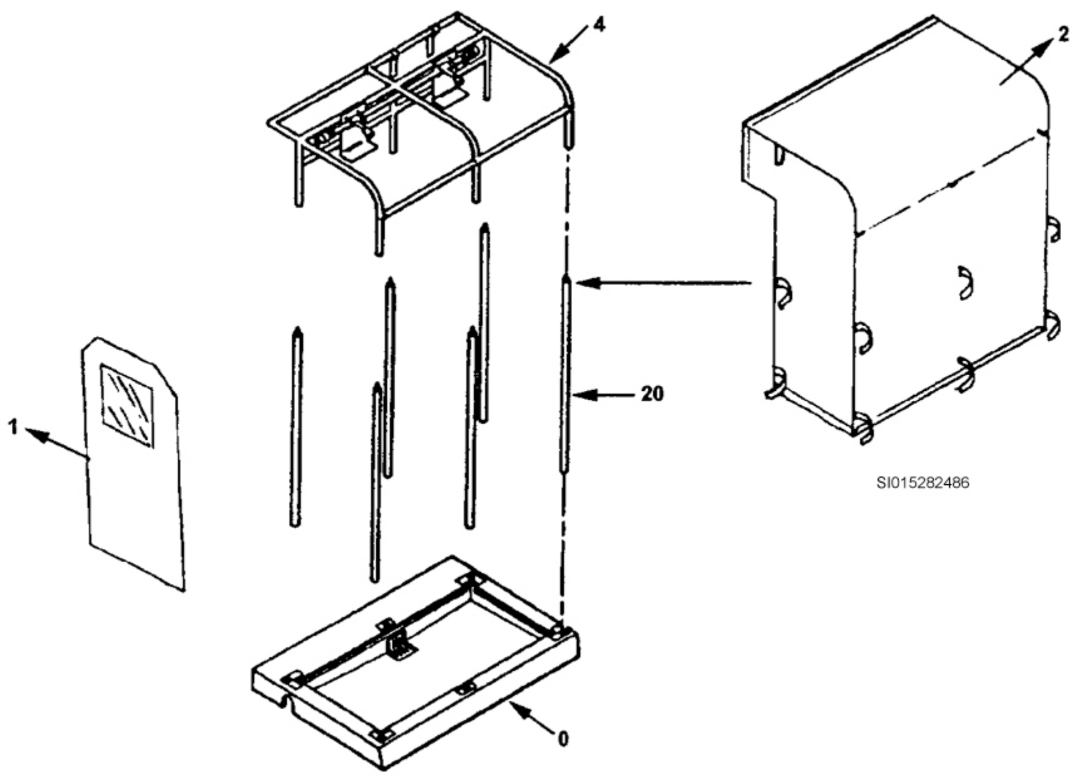


Figure 2–45. Finished base assembly with fabric cover installed.

Providing water to the top frame manifolds

At this point, you have assembled the shower floor and sub-drainage systems. You have also constructed the framework for the shower and installed the shower fabric. Your next step is to connect the water supply to the supply manifolds in each of the top frame assemblies (fig. 2–46).

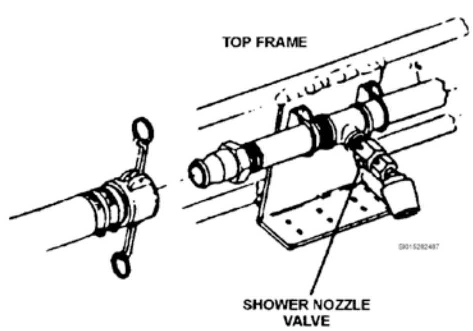


Figure 2–46. Supply manifold in top frame assembly.

To do this, you connect the six short 1” water supply hoses from each quick-connect on the supply manifolds in (fig. 2–47). Connect these hoses from end to end until a loop of supply hoses is formed.

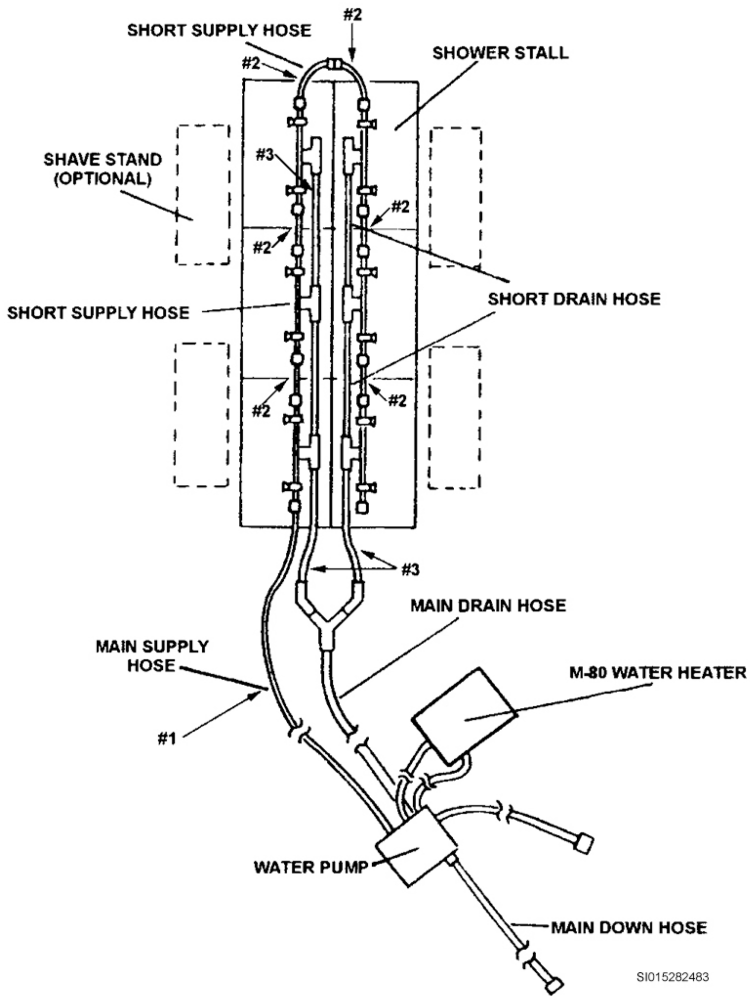


Figure 2–47. Completed supply manifold loop.

Connecting water pump assembly to the shower

So far, you have connected the drain system and supply systems. What remains is to connect the supply and drain hoses from the pump assembly to the shower facility itself. You also will need to connect the main supply hose from the source to the pump assembly as well as the main-drain hose from the pump assembly to an area lower in elevation from the supply intake. Later, you will connect the boiler to the pump assembly.

Follow the remaining steps for completing the assembly of the shower facility. When you finish, it will look like the one shown in figure 2–48.

1. Route one end of the long main water supply hose (fig. 2–48, callout 9) through the canvas cover, and connect it to the first supply manifold. Connect the opposite of this hose to the quick-connect fitting on the effluent side of the temperature regulator (fig. 2–48, callout 21).
2. Lay the other long main water supply hose (fig. 2–48, callout 9) from the water source to the pump assembly and install the strainer (fig. 2–48, callout 16) onto the end that will go into the water supply. Put the strainer into the water supply and connect the opposite end of hose to the suction inlet of the water pump (in the pump assembly frame).

3. Install the "Y" adapter (fig. 2–48, callout 2) on to the two main-drain runs coming out of the shower floor. Route one main-drain hose (fig. 2–48, callout 15) from the "Y" adapter to drain pump inlet on pump assembly. Connect the appropriate end of the other main-drain hose (fig. 2–48, callout 15), from the drain pump discharge, and lay the hose to the point of discharge, downstream from the water supply intake.

Connect the pump assembly to the boiler by connecting the water supply hose from the water pump discharge to the M–80 boiler inlet (fig. 2–48, callout10). This is the hose that will supply the boiler with cold water. Finally, close the loop by connecting the water supply hose from the boiler discharge valve to the temperature regulator inlet in the pump assembly (fig. 2–48, callout 13). This hose provides heated water back to the temperature regulator, which will blend the heated water with some cold supply water (diverted from the water pump) to provide blended water to the shower.

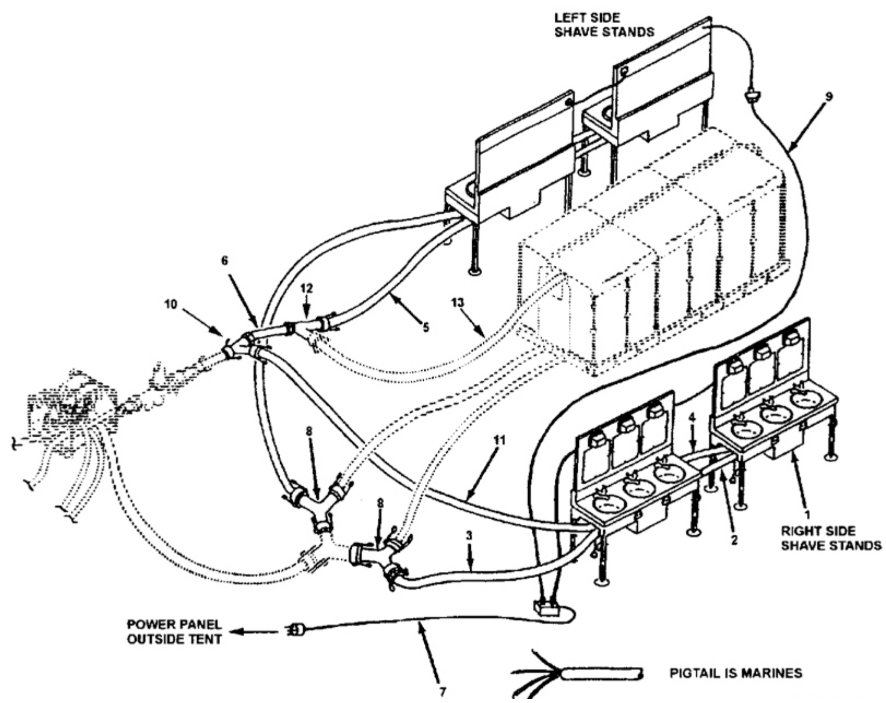


Figure 2–48. Completed facility.

At this point, the bare base shower facility is completely set up. All that remains to be done is to set up the boiler, connect the power to the units, and start up the facility. The first thing you start after power has been applied is the water supply pump in the pump assembly.

Setting up the M-80 boiler

Now that the water lines are properly connected to the M–80 boiler (fig. 2–49), we will discuss how to connect the fuel system and properly operate the M–80 boiler according to TO 35E7–4–27–1.

NOTE: Keep in mind during set-up of the M–80 boiler, that heating, ventilation, and air conditioning (HVAC) personnel are ultimately responsible for the maintenance of the M–80 boiler.

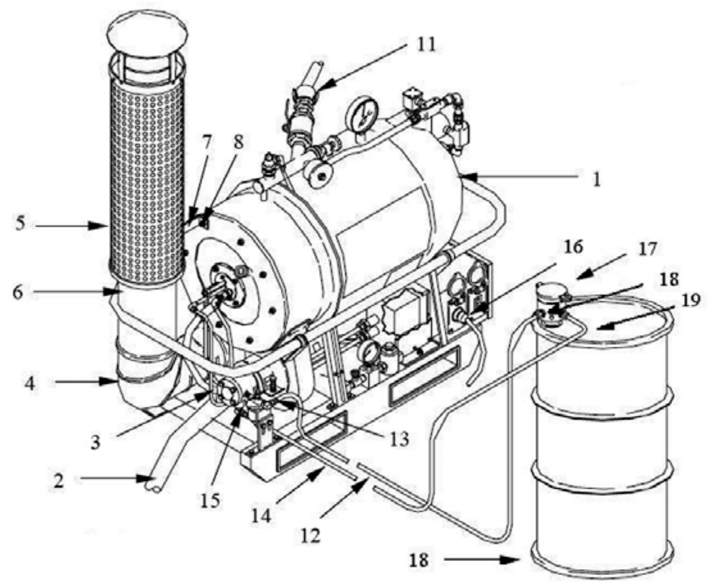


Figure 2–49. M–80 boiler.

Boiler exhaust system

Once the water connections are complete, install the boiler exhaust system. To do this, install the elbow (fig. 2–49, callout 4) onto the boiler and twist the elbow to the right to snap the retaining pin in place. Next, insert the smoke stack and guard assembly (callout 5) through the bracket (callout 7) and onto the exhaust elbow (callout 4). Tighten the screw (callout 8) onto the bracket (callout 7). You are now ready to connect the fuel system to the boiler.

Boiler fuel system

Begin this procedure by placing the fuel container (fig. 2–49, callout 18) 5’ from the boiler. Next, screw the drum fill adapter (callout 17) into the fuel container. Then, connect the fuel supply and return lines from the fuel container to the fuel pump on the boiler. Remember that excess fuel pressure must be relieved back into the fuel container. Continue by connecting the fuel pump supply fuel line (callout 12) from the fuel pump intake (callout 15) to the suction fitting (callout 18) on the drum fill adapter assembly (callout 17). Finally, connect the fuel return line from the pump (callout 14) to the return fitting on the drum fill assembly (callout 19).

NOTE: Some of the fuels that can be used with the boiler are extremely flammable. Once tightened, be sure to *recheck* all fuel fittings during the time the water heater is operating to make sure there are no fuel leaks with the system under pressure.

Starting the boiler

Make sure the boiler is full of water at this point. With the water pump running, open the faucet on top of the water heater (fig. 2–49, callout 11), turn off the pump, and close the faucet as soon as water starts to flow from the faucet. After determining the boiler is full of water, the last step in the setup of the boiler is to apply power to the unit. Do this by connecting the power cable (fig. 2–49, callout 16) to the water heater from the power source.

Ignition sequence

You must test the ignition and combustion process of the boiler before you actually put the boiler into full service. This is just a pre-operational checklist-type item that is done to check the ignition system and regulate the type of exhaust gases coming from the stack by making air band (air flow) adjustments (fig. 2–50, callout 8). The latter is primarily to burn fuel at the most economical rate possible by optimizing the amount of oxygen consumed during combustion.

With the water pump off, open the fuel valve (callout 2) and turn on the load-limit switch (callout 3), and power source. At this time, the fuel pressure gauge (callout 12) should indicate 100 psi. Look for ignition spark through the ignition sight tube (callout 4) after the power is on. After 7 seconds, look for the presence of combustion through the combustion sight tube (callout 13).

NOTE: If combustion fails to occur after an additional 12 seconds (total of 19 seconds), a buzzer will sound, and the ignition source will be turned off automatically. If this happens, wait 2 additional minutes, then press the safety reset button (callout 6) located behind the panel of the load limit switch, and restart the boiler.

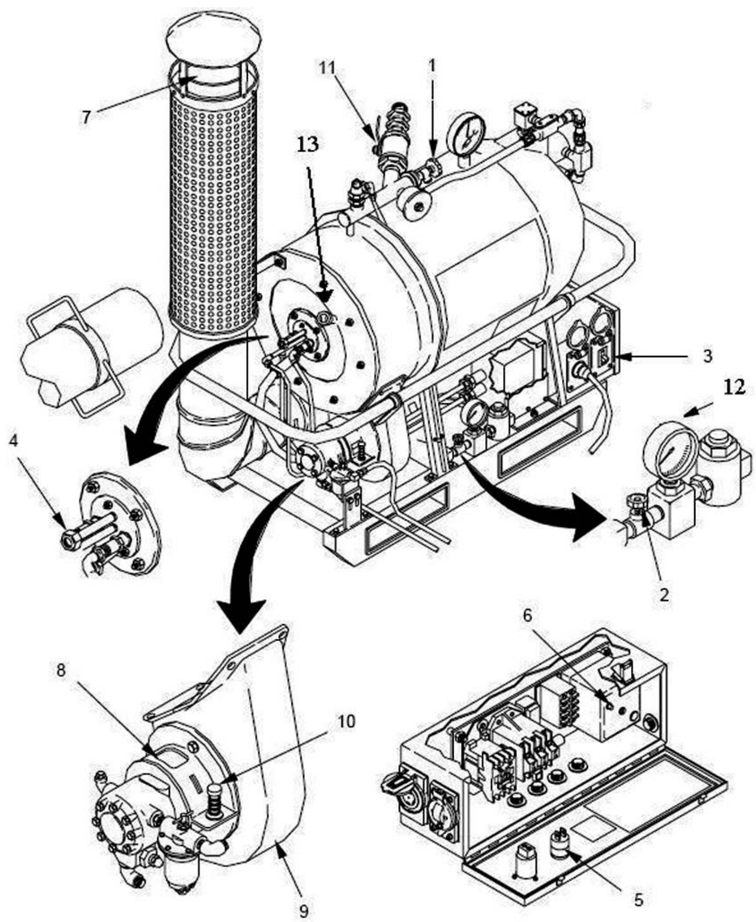


Figure 2–50. Location of ignition components.

Right after start-up, look for exhaust gases emitting from the exhaust stack. These gases should be transparent and smokeless. If this is not the case, the fuel/air mixture is not set properly. Varying the air band position will adjust your fuel/air mixture—thus preventing smoke. To correct this, slowly *open* the air band (fig. 2–51, callout 12) on the blower assembly until the exhaust gases are transparent and smokeless. The boiler is now operating on automatic. Turn off the load limit switch. The boiler will shut down.

NOTE: Normal vibrations of the boiler during operation may change the air band adjustment. Because of this, you should frequently check the presence of smoke. If smoke is present due to air band movement from vibrations after normal operations have begun, you should adjust the air band. To do this, press the rivet (fig. 2–51, callout 14) on the air band (fig. 2–51, callout 12). Then shift the air band adjustment tab (fig. 2–51, callout 15) downward while observing smoke. Next, open the air band (fig. 2–51, callout 12) until smoke is no longer visible.

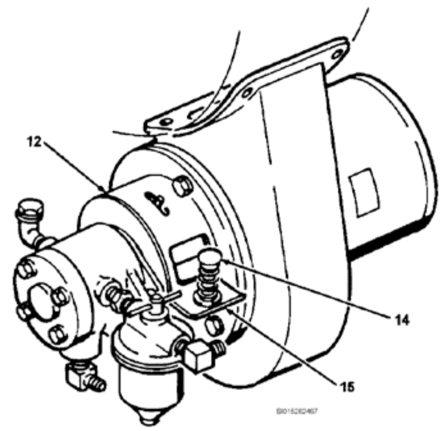


Figure 2–51. Adjusting exhaust gases.

Normal operating procedures

Now that you have set up the shower/shave unit and properly tested and prepared all related equipment, we are ready to move on to the normal operating procedures for the shower. Remember that during field operations, this unit is likely to be off most of the day. Turn the unit on after duty hours, when troops want to take a shower. In this sense, the procedures that follow infer that the unit has been set up properly, tested properly, and previously operated at length.

To begin, close the boiler outlet valve (fig. 2–52, callout 18) and open the fuel valve (callout 20). Turn on the load limit switch (callout 3). The unit will start up as usual (check for ignition and combustion). Next, turn on the water pump and wait until the water temperature gauge (callout 19) on the boiler indicates 160° F (71° C). Open the boiler outlet valve (callout 18) and open one shower nozzle. Observe the temperature gauge on the shower/shave temperature regulator, and set it to 105° F (never more than 115° F). The shower/shave unit is now fully operational.

Shutdown procedures

When all the showering is complete, you will need to shut down the unit. This procedure is rather simple. Close the fuel valve (fig. 2–52, callout 20), shut off the load limit switch (callout 3) and water pump, and quickly close the boiler outlet valve and shower valves (keeps water pump primed). If the weather is cold, take additional steps and drain the boiler, water hoses, and water pump.

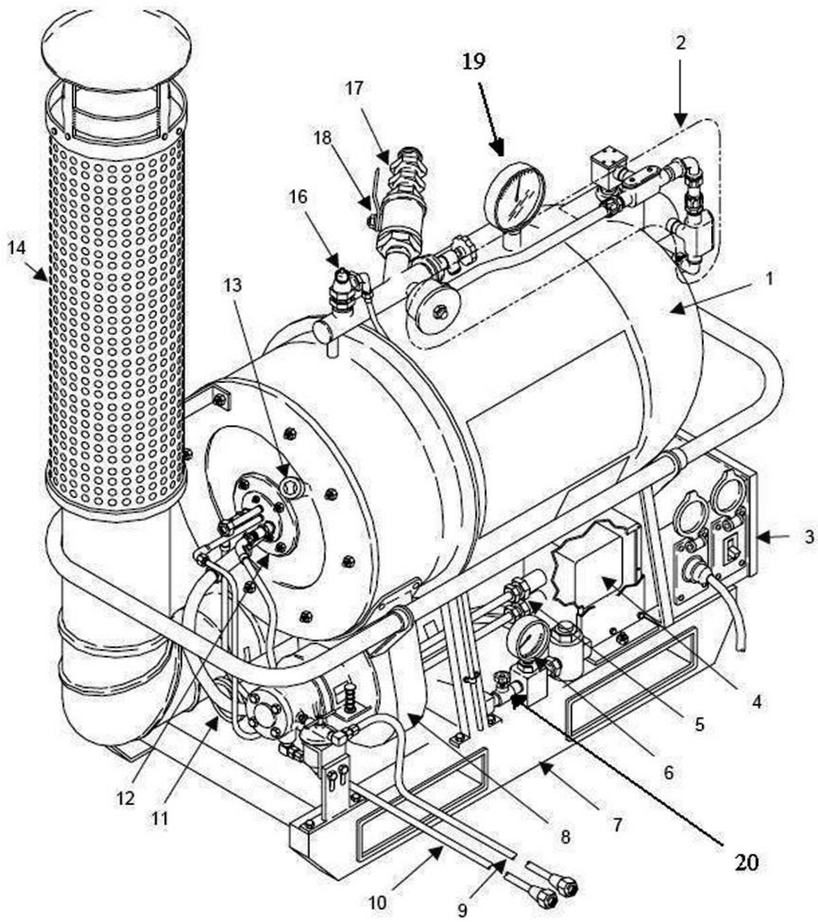


Figure 2–52. Location of all components used during normal start-up.

Setting up the shave stands

You may remember from an earlier discussion that a separate TO is used during the set-up of the shave stands. Use TO 35E35–3–1, when mating the shave stands to the shower facility. At this point, you have completed all the groundwork for operating the shower itself. Next, you will set up the four shave stands with the shower facility. The shave stands themselves are rather easy to set up because they are already constructed. All you have left to do is to connect the water and drainage hoses to the stands and provide power to them as well. Let us study the general characteristics of these shave stands before we discuss how to set them up. After we have done this, we will discuss how to set the shave stands up, and you will finally see how to operate the shower/shave facility.

General characteristics

Four shave stands are provided for use with the shower facility. Each shave stand consists of:

1. A base unit with three sinks (fig. 2–53).
2. A mirror-back with three mirror surfaces.
3. Electric light and 115 VAC outlets.
4. Wiring harness to connect the shave stand to the power supply.
5. Hoses to connect the shave stand plumbing with the water supply and wastewater disposal.
6. From the numbers above, you can deduce that the shave stands are designed to handle 12 people at any one time (just like the shower).

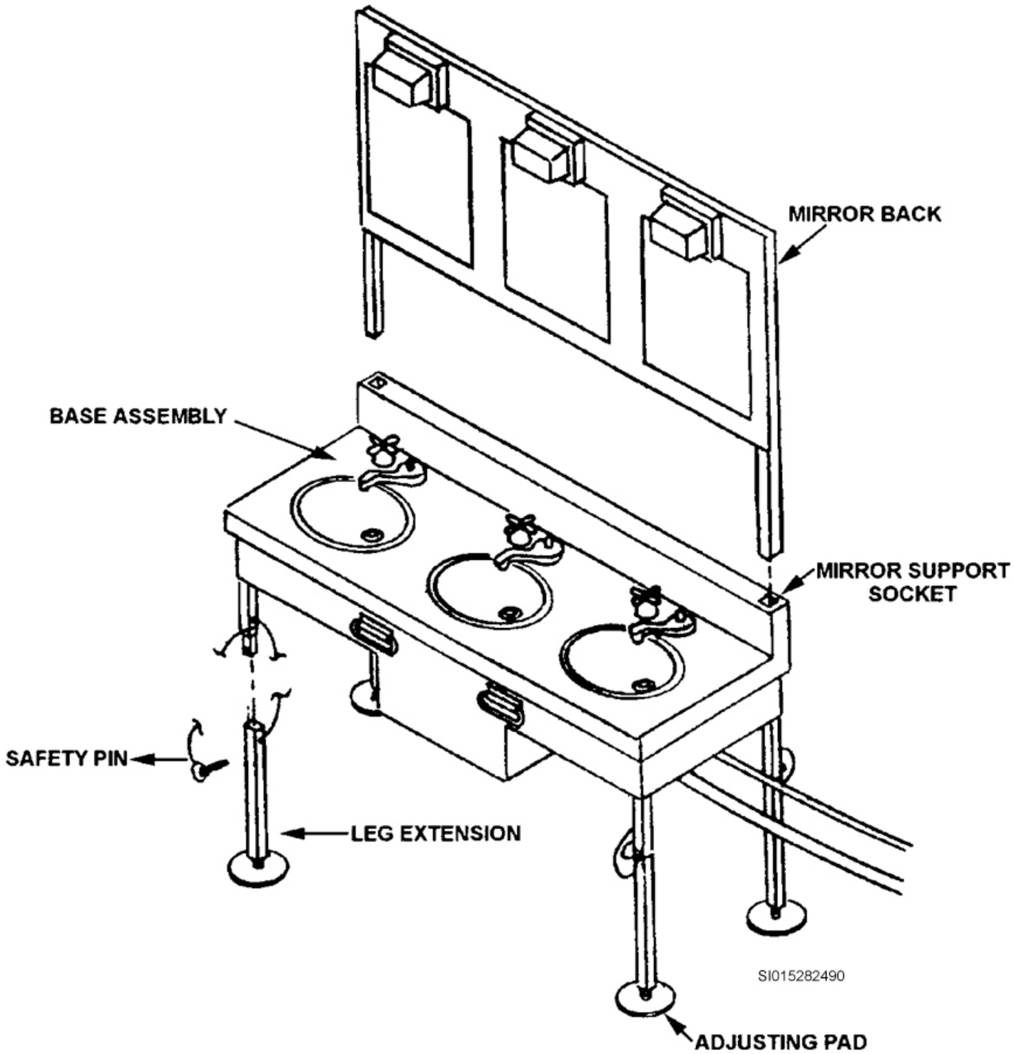


Figure 2–53. Shave stand.

Base unit

The shave stand base assembly, or base unit as it is normally referred to, consists of a stainless steel cabinet with three sink/faucet stations. Each base unit has mounting sockets for the mirror support assembly, removable legs, and four handles for ease of movement (two handles on each long side). The sinks themselves are also stainless steel, and each sink has a single on/off faucet. Each sink also has QD fittings for the water supply to the faucets and drains from the sinks. Straps are also provided on the underside of each base unit to store the legs during shipment. Safety pins (fig. 2–53) are used to lock the legs in place when the unit is set up.

Mirror support assembly

The mirror support assembly is a stainless steel unit with two legs that slide into the sockets in the back of the shave stand unit. Each mirror assembly contains three polished stainless steel mirrors with three electric light/outlet fixtures.

Hoses

One-inch hoses are provided for water supply to the base units while 1½" hoses are used to connect the sink drains to the shower facility's drainage system. Both sizes of hoses are designed to connect to the shower facility's water supply and drainage system.

Power supply

Extension cords with 110-volt receptacles and plugs are used to supply power to the light fixtures and the shave outlets only. The harness has ground fault protection built into it. The wiring harness is designed to be plugged into the power panel provided with a typical BEAR shelter.

NOTE: No special tools are required to assemble the shave units. A multimeter may be required for the maintenance of the outlets on the shave stand.

Setting up the shave stands

Unpack the shave stands from the shipping containers. Check shave stand components for damage during shipment. Use caution when removing the mirror assembly to prevent damaging the mirror surfaces. Position the shave stands with base assemblies lying on their back, *around* the shower facility as shown in figure 2–54. With the undersides of the shave stands exposed, release the retainer straps securing the leg extensions to the underside of the base assemblies. Remove the leg extensions and insert them into the respective sockets (callout 4) so that the holes line up. Insert locking pins. Lift the base assemblies (with leg extensions attached) and stand them up. You may now level each stand by turning the adjuster at the bottom of each extension. You are now ready to connect the drainage hoses and water supply to the shave stands.

Drainage hoses

Look at figure 2–54 as we discuss these procedures. Two different lengths of 1½” drainage hoses are used to remove wastewater from the sinks and tie into the main drain of the shower. The shorter (54”) hoses are connected in between the shave stands (one on each side), while the longer (120”) hoses are used to connect the two shave stands on each side to the main-drain “Y” connector. The drainage hoses are connected in “runs” just as you connected the drainage hoses to the base assemblies of the shower units.

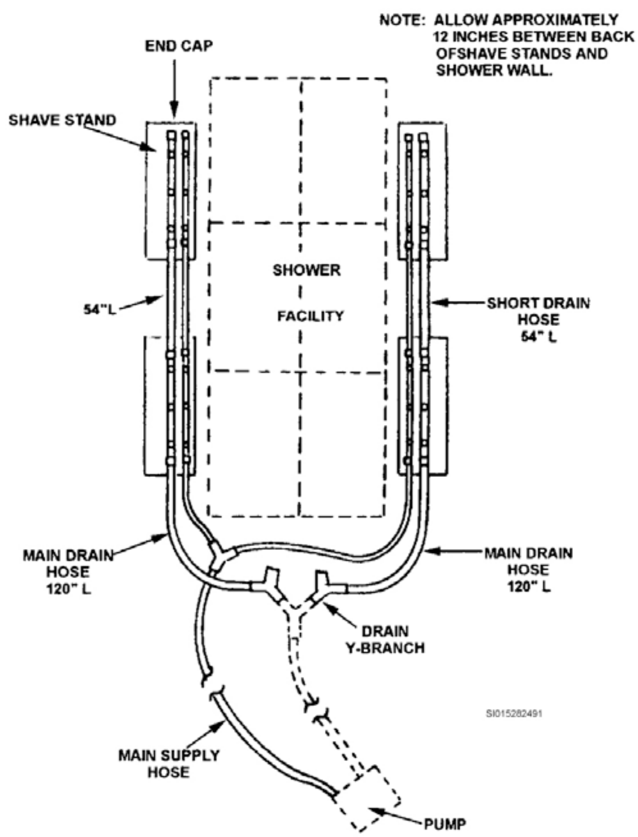


Figure 2–54. Shave stand configuration around shower.

The drainpipe under each shave stand is a fixed pipe that has quick-connect couplings attached on each end (fig. 2–55). A single drain hose connects both shave stands on each side of the shower facility. The water supply manifold is next to the drain manifold. Connect the shorter 1½” drain hose between the shave units and install two caps on the drain manifold quick-connects of the far shave stands (sides facing away from pump assembly).

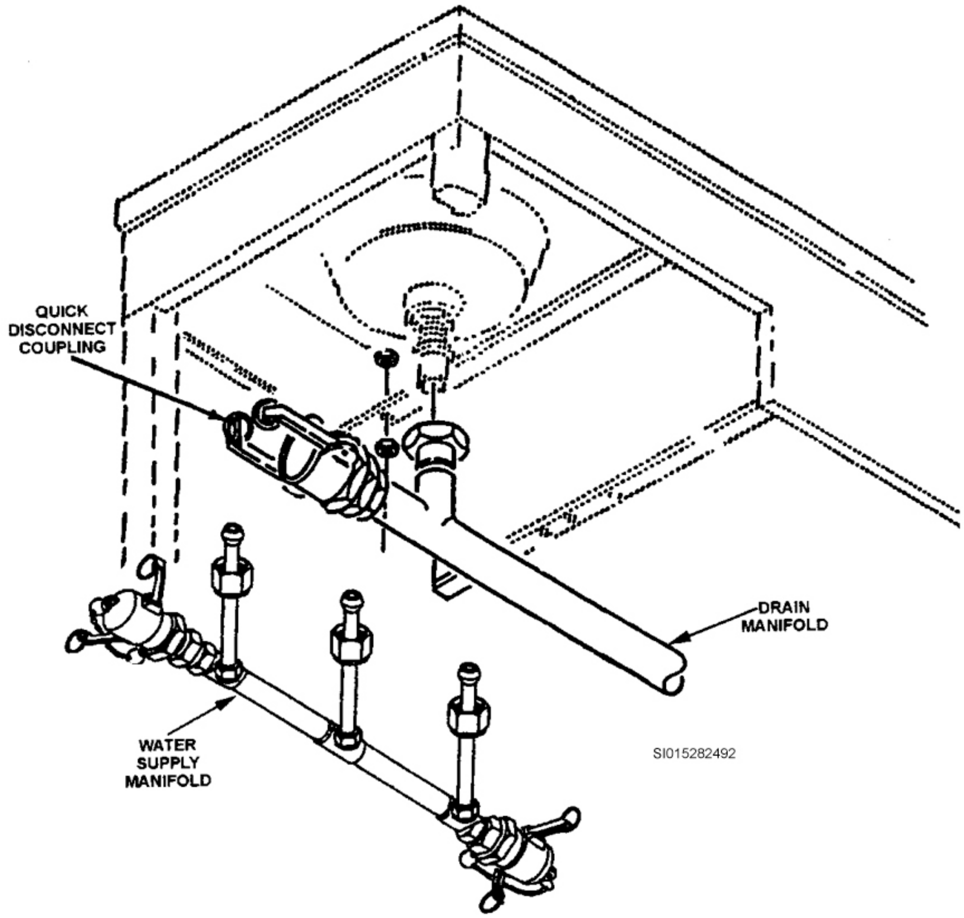


Figure 2–55. Underside view of countertop.

Water supply

You install the short 1” water supply hoses between the shave stands (fig. 2–56, callout 2) just as you did with the drainage hoses (fig. 2–56, callout 4). Connect the long 1” water supply hoses to the temperature regulator’s quick-connect discharge fitting as shown in figure 2–56. Notice that you will have to first install a wye (fig. 2–56, callout 10) on the temperature regulator to branch off towards the right-side shave stands (fig. 2–56, callout 11). Also notice that a short section of hose (fig. 2–56, callout 6) is used to connect yet another wye fitting (fig. 2–56, callout 12), this time to branch off to the shower water supply manifolds (fig. 2–56, callout 13). The run of the last wye fitting (fig. 2–56, callout 5) goes directly to the left shave stand water supply manifold.

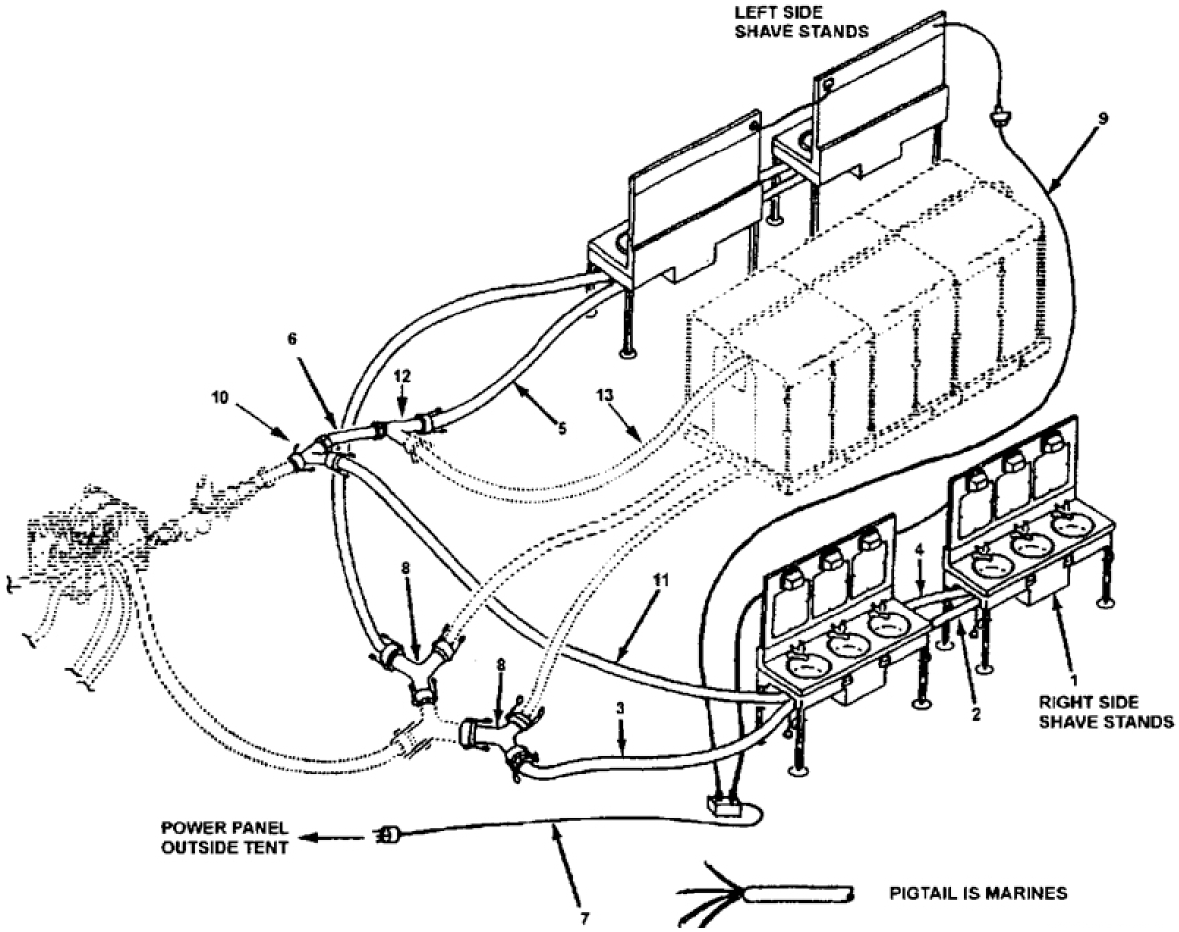


Figure 2–56. Final shave stand connections.

To finish setting up the shave stands, connect power to them using the extension cords as shown in (fig. 2–57). We discussed earlier that the shower/shave facility is set up inside a BEAR shelter. These tents come with, among many things, a power distribution panel that hangs outside the door panel side of the tent. The plug for the mirror outlets and lights on the extension cord is plugged into a 110-volt outlet on this panel.

WARNING: Do not lay outlets on the ground next to the shower or shave stands where they may be exposed to water. Instead, securely fasten them to the back of the mirror assemblies or to the BEAR shelter itself.

Applying power to the shower/shave facility

At this point, you are ready to connect the wiring harnesses to the bare base power distribution system. You have already connected power to the shave stands. We still need to discuss in more detail how to connect the bare base electrical to the pump assembly and the M–80 boiler. Three types of wiring harness connectors are used to do this. The three types of connectors used to power the pump assembly and the boiler are the “T” cable connector, Marine Corps “pig tail” and the AF cable adapter assembly (fig. 2–57).

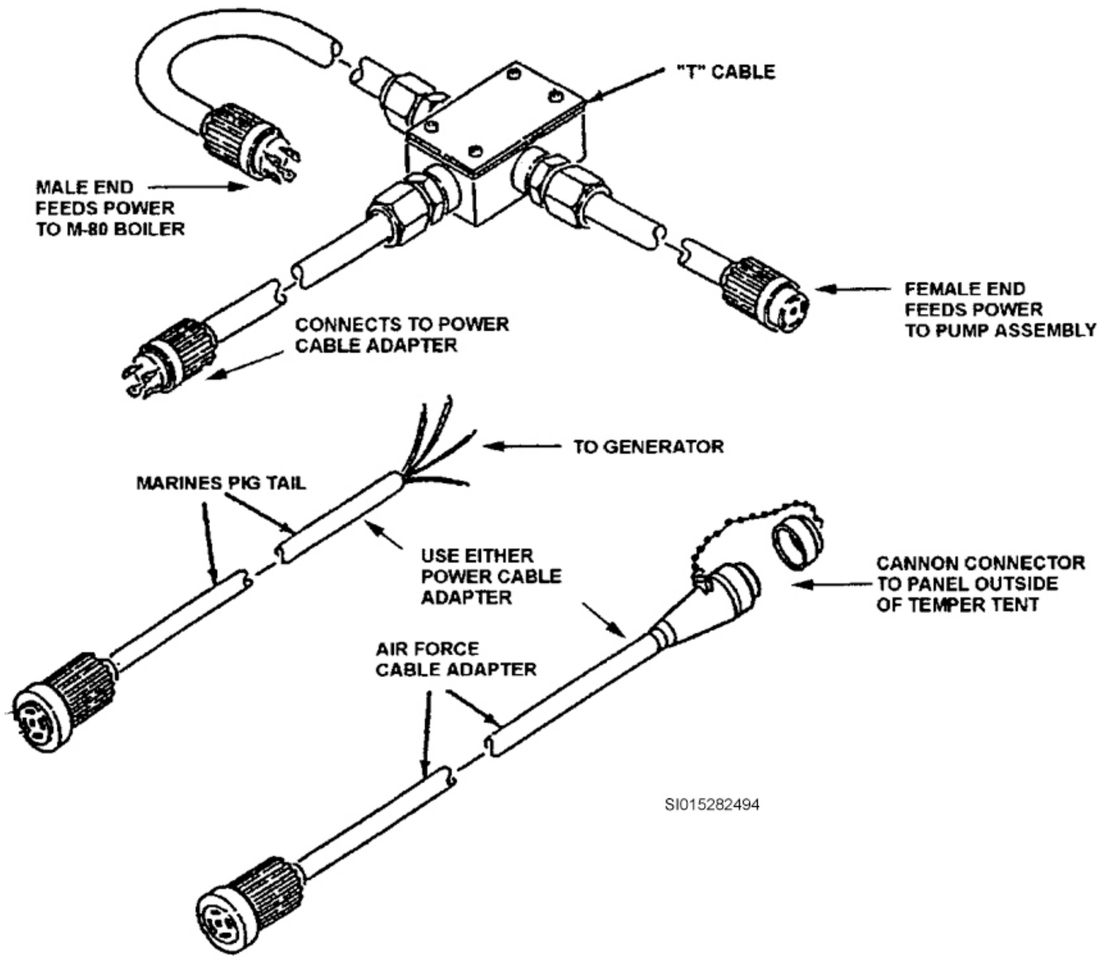


Figure 2–57. Types of power cables.

Keep in mind that the wiring harness used to power the pump assembly and the M–80 boiler is different from the extension cords used to power the shave stands. The main difference is that the extension cords for the shave stand lights and outlets are standard 110-volt receptacles while the connectors for the pump assembly and M–80 boiler are the bare base-type “cannon” connectors (same as on the ROWPU). The “T” cable is used to branch off power to the water pump assembly and the boiler (fig. 2–57). The pigtail and the “cannon-type” cable adapters (fig. 2–57) are used to connect the cable from the “T” cable connector to the power supply. You may use either the pigtail or the “cannon-type” cable adapter—depending on your particular situation. If a generator is providing the power, or you want to hardwire it into an electrical panel, you will have to use the Marine Corps “pig tail.” If the power is from the bare base distribution system, you will use the “cannon-type” cable adapter.

Connect the other end of cable adapter (socket) into the four-prong outlet on the pump assembly power switch (fig. 2–58). Power is now applied to every component used with the shower/shave facility.

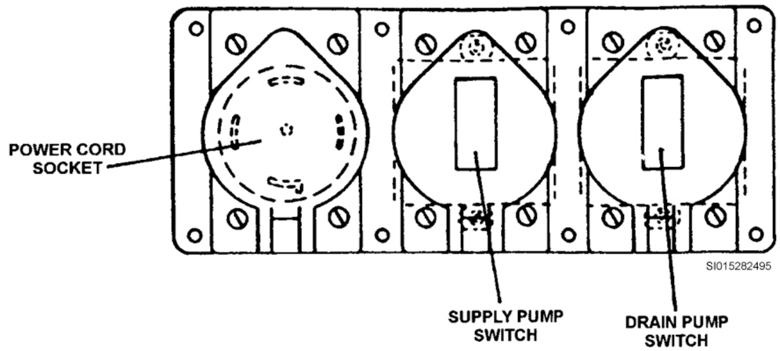


Figure 2–58. Pump assembly power switch.

WARNING: Hook up of pig tail-type power cable adapter involves equipment with high voltage that could result in severe electrical shock. Only qualified electricians should attempt the hook up of the pig tail power cable adapter.

Operating the shower/shave facility

You are now ready to begin the start-up procedures for the shower facility. This procedure is rather quick and easy.

1. Check all hose and power connections. Ensure the main water supply hose is submerged *in* or connected *to* the water supply. Prime the water supply pump.
2. Make sure the main drainage hose (drainage pump discharge) is routed to an area/tank approved for wastewater. The drainage pump is self-priming.
3. Start the water supply pump using the switch in the pump assembly and allow the M–80 boiler to fill. Release trapped air from the boiler by gently pulling the ring from the pressure relief valve on top of boiler. After all the air has been released from the boiler vessel, it is time to start the boiler.
4. Check all water supply hose connections for leaks after water starts to drip from the shower heads. Fix any leaks found. Turn all showerhead control valves to the fully open position. Open faucets on shave units and ensure they all work properly.
5. Turn on the drainage pump using the control switch on the pump assembly. Allow at least two minutes to flush the shower water supply manifolds and hoses. Observe temperature gauge on the temperature regulator assembly. It should be at 105°F and never more than 115°F. Adjust the temperature regulator as needed. Turn the showerhead valves to the fully closed position. Showerheads will still drip. This is normal.
6. Shower is now ready to use.

NOTE: In desert environments, you may not need to start the boiler for evening showering when supply water for the shower has been stored in bladders all day long. The water in the bladders is warm enough for showering as it is.

Shutdown procedures

First, you must shut down the boiler as instructed in the TO. Next, shut off the water supply pump. Lastly, shut down the drainage pump. The shower is ready for normal startup when you need it again.

Service and periodic maintenance

During field conditions, equipment tends to be used rather harshly. This is why it is very important to keep your equipment in good working condition. There are a few preventative measures that you can take to accomplish this. First, you will study these preventative measures for the shower/shave facility. Then, you will look at some troubleshooting and minor maintenance procedures.

Preventative maintenance

The table below illustrates some of the daily, weekly, monthly, and quarterly checks you should make on the shower/shave facility. A little attention here will lower the amount of troubleshooting and maintenance you might have to do later.

Preventive Maintenance Chart	
Item	***Procedure***
DAILY	
Shower base assembly	Check drain for debris or blockage.
	Check surface for soap or dirt buildup.
Pump assembly	Check pump for dirt or debris—clean as required.
	Check suction strainer for clogging.
Shave stand basins	Check faucets for correct operation.
	Check drains for correct operation.
Shave stand lights/outlets	Ensure lights and outlets work when they are energized.
WEEKLY	
Framework/manifolds	Check showerhead for correct operation.
	Inspect tubing for damage.
Frame covers	Inspect fabric covers for damage or dirt buildup.
Pump assembly	Ensure outlet has power when circuits are energized.
	Inspect pump cover for damage or debris.
	Inspect pumps for debris, leakage, or damage.
Electrical harnesses	Inspect all electrical harnesses and extension cords for damage.
Supply & drainage hoses	Inspect for damage, loose connections.
Shave stand drain manifolds	Remove hoses and caps; inspect for dirt accumulations.
MONTHLY	
Velcro fasteners	Inspect Velcro fasteners on fabric covers and door assemblies for adequate grip strength.
Shave stand mirrors	Inspect mirrors for scratches or distortion.
QUARTERLY	
Wiring harnesses	Remove control box cover and inspect switch/outlet wiring for damage or corrosion.
Shave stand faucet/drain	Inspect drain mechanism for excessive play or leakage.

In each of the preventative maintenance checks done on the shower/shave, you clean, repair, or replace something when an item is found to be out of compliance. You can also expect the shower facility to be extremely messy after hundreds of people use it each day. For this reason, you should arrange for someone to prepare a detail roster for shower cleanup for each day of use.

Troubleshooting

There are occasions when equipment will fail for some reason even though people operating the equipment have been very diligent in upkeep and preventative maintenance. Except for the shower/shave facility, the equipment is not hard to maintain or troubleshoot.

Listed below are four problems you may experience with the shower shave facility:

1. No water.
2. No drainage.
3. No power.
4. Incorrect temperature of water.

These problems are not difficult to fix. Use the skills you have now to discover the root cause of a problem with the shower/shave facility and repair it quickly. The troubleshooting table below will help you diagnose these common problems.

Troubleshooting the Shower/Shave Facility		
Symptom	***Probable Cause***	***Probable Remedy***
No water at shower/shave	Supply pump off	⇒ Turn pump on
	Water supply dry	⇒ Refill/replace
	Leak in supply hose	⇒ Repair/replace
	Supply pump broken	⇒ Repair/replace
Water does not drain	Drain manifold clogged	⇒ Clean manifold
	Drain pump off	⇒ Turn pump on
	Drain pump broken	⇒ Repair replace
No power to pumps or outlets	Power supply off	⇒ Turn supply on
	Power harness/cord broken	⇒ Repair/replace
No power to pump(s)	Power switches off	⇒ Turn switch on
	Power switch defective	⇒ Repair/replace
Water temperature incorrect	Temperature regulator setting incorrect	⇒ Set to correct temperature
	Temperature regulator defective	⇒ Repair/replace
	M–80 boiler defective	⇒ Replenish fuel ⇒ Check ignition system ⇒ Refer to heating, ventilation, and air conditioning/refrigeration (HVAC/R)

Maintenance/repair

Only four separate components used with the shower/shave facility are likely to require actual repair in the field. These are the M–80 boiler (for which you are not responsible to repair), pump assembly (to include the supply pump and drainage pump), temperature regulator, and the showerhead and faucet valves.

Maintenance and repair during field conditions is not always an exact science. You will need special parts and tools to repair some of the components of the shower/shave unit that may fail. Additionally, there is not always enough time to repair such things as pumps and other mechanical equipment. People usually want a quick fix of the component, and this is not always possible within the time and manpower constrains of field conditions. Because of this, you are more likely to replace a defective unit with a like kind rather than repair it on site. Therefore, you will discuss just how to improvise using “like” equipment in the field when equipment fails. For detailed repair procedures, you should refer to the TO for step-by-step procedures.

For example, let us say that you determined the diaphragm of the drain pump has a pinhole in it large enough to prevent the pump from sucking. Obviously, the diaphragm must be replaced for the pump to work correctly. Guess what? You do not have a diaphragm in stock, and it will take a month for a new diaphragm to arrive on site. What do you do now? Think a minute.

The easiest thing to do is to find another pump assembly from a shower/shave that is not yet installed and put it in place of the existing pump assembly. That way you also have a new supply pump. If this is not possible, try using a 3” mud-hog instead by adapting/reducing from 3” connections to 2” connections and hose. If needed, purchase a similar pump from the local area. If all else fails, try lowering the drainage hose to such an extent that drainage occurs naturally, even if it is a little slower. The main thing to remember here is use your engineering skills to make things work.

622. Expandable Bicon Shelter Hygiene System

A new addition to WFSM is the Expandable Bicon Shelter (EBS) Hygiene System (fig. 2–59). It is designed to modernize the current latrine and shower/shave system design we have in our inventory. Although you may still deal with the old one, the EBS Hygiene system will eventually phase it out. The EBS hygiene system consists of four EBSs and a storage container with a connectivity kit. Two of the Bicon shelters are the expandable showers that, when combined, include 12 shower stalls with curtains and mats, 12 sinks with shelves and mirrors, 24 towel hooks, and four sets of self-adjusting stairs. The other two Bicon shelters are the expandable latrines that, when combined, include 12 toilets with double paper holders and privacy doors, eight urinals, four sinks with mirrors and shelves, and four sets of self-adjusting stairs. Each EBS has a storage compartment with tools and equipment necessary for system set-up and operation (refer to table 2–1, Storage Compartment Contents*)*. EBS hygiene system also includes one storage Bicon including a connectivity kit (refer to table 2–2, Storage Bicon Including Connectivity Kit). In addition, each Bicon contains spare parts cartons labelled “FRAGILE” (refer to table 2–3, Spare Parts Carton Contents). The EBS hygiene system also includes four Alaskan 10´ x 10´ privacy shelters that attach to showers and provide space for changing.

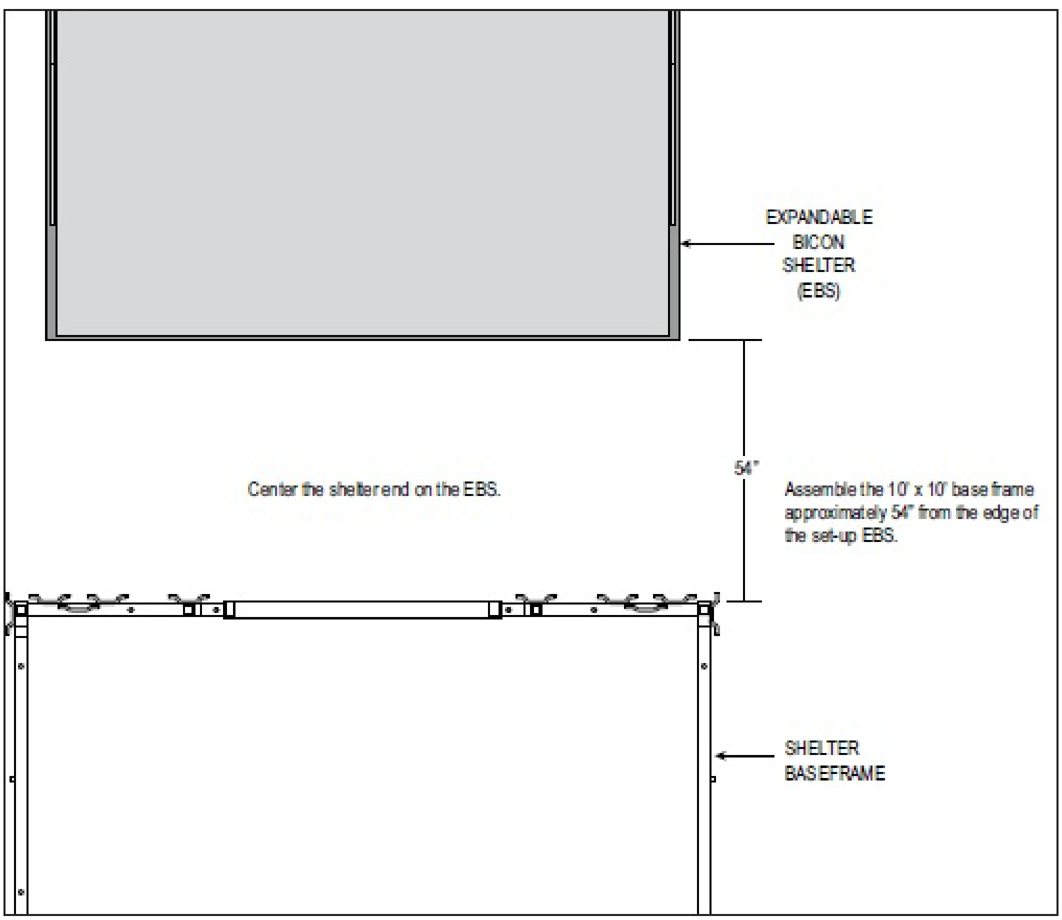


Figure 2–59. EBS Hygiene System.

Latrine Unit #1	Latrine Unit #2	Shower Unit #1	Shower Unit #2
(4) Leveling Jacks	(4) Leveling Jacks	(4) Leveling Jacks	(4) Leveling Jacks
(4) Jack Brackets	(4) Jack Brackets	(4) Jack Brackets	(4) Jack Brackets
30 mm socket wrench		30 mm socket wrench	
(2) Twist locks	(2) Twist locks	(2) Twist locks	(2) Twist locks
Support pole		Support pole	
Extension $^{3}/_{8}$”		Extension $^{3}/_{8}$”	
Bubble level		Bubble level	
Winch		Winch	
Speed wrench		Speed wrench	
(4) Ratchet Straps *	(4) Ratchet Straps *		
¾” Wrench		¾” Wrench	
¾” Socket		¾” Socket	
$^{7}/_{8}$” Wrench		$^{7}/_{8}$” Wrench	
$^{3}/_{8}$” Adaptor		$^{3}/_{8}$” Adaptor	
$^{5}/_{32}$ “T” handle Allen wrench		$^{5}/_{32}$ “T” handle Allen wrench	
Commercial Manual	Commercial Manual	Commercial Manual	Commercial Manual

Table 2–1. Storage Compartment Contents.

Item in Bicon	Quantity
Shoring Beams	6
Shelves 46 ½” W x 104 $^{7}/_{16}$” L	2
Plastic Folding Benches	12
Cables 100’ - , 60A, 120/208v, 3PH with military plug and connector on each end	4
25’ CABLE FOR AHW-400 BOILER, 120/208V,20A, 3 PH	1
Spare Parts Boxes labeled “Fragile”	3
HVAC DUCT (16" X 7')	8
HVAC Duct (16” x 5’)	4
Reducer adaptor for 130K Cold Weather Heater (16” to 12”)	4
HVAC Inlet/Outlet Housing (Wyes) (Assembled with covers and inserts)	4
DRAIN PUMP ASSEMBLY, part number (P/N) SBI-P12.10	1
SHOWER SUPPLY PUMP ASSEMBLY, P/N SBI-P12.2	1
LATRINE SUPPLY PUMP ASSEMBLY, P/N SBI-P12.3	1
SEWAGE EJECTOR PUMP ASSEMBLY, P/N SBI-P12.9	1
2” x 25’ White Stripe Hose	7
1 $^{1}/_{2}$” x 25’ White Stripe Hose	1
1 $^{1}/_{2}$” x 15’ White Stripe Hose	4

Item in Bicon	Quantity
1” x 15’ White Stripe Hose	2
1” x 25’ White Stripe Hose	1
2” x 25’ Purple Stripe Hose	5
4” x 5’ Black Discharge Hose	2
2” x 5’ Grey Discharge Hose	2
Ratchet Straps securing items for transport	5
1" Brass Wye (to connect AHW-400 Boiler to Showers)	1
2" Brass Wye (to connect Latrine & Shower Drain Hoses)	1
Packing List stored inside Spare Parts Carton #1	1

Table 2–2. Storage Bicon Including Connectivity Kit.

Carton #1	
Spare Part	**Quantity**
Shower Curtain	1
Faucet Aerator	2
Cross-linked polyethylene (PEX) Clamps – $^1/_2$”	2
PEX Clamps – $^3/_4$”	2
PEX Clamps – 1”	2
Brass Tube Fittings for PEX Clamps – $^1/_2$”	1
Brass Tube Fittings for PEX Clamps – $^3/_4$”	1
Brass Tube Fittings for PEX Clamps – 1”	1
Crimper Tool	1
Electric Water Heater Heating Element for Eemax EX8208T	1
Urinal Flushometer Replacement (Sloan A-36-A)	1
S-trap	1
P-trap	1
Sliding Door Partition Rollers	2
Shower Head	1
Carton #2	
Grounding Rod and Cable (no hammer)	1
Carton #3 (Bundled)	
2’ light-emitting diode (LED) Light (in original package)	1
4’ LED Light (in original package)	1
Gas Piston Strut	2

Table 2–3. Spare parts carton contents.

Site selection

When selecting a site, an area as close to level as possible is preferable. Each shelter is equipped with four leveling jacks to allow users to deploy on a site that has a maximum grade of 6.5 percent (~4 degrees) though other system components may not function properly on such grades. The overall footprint of the entire system is approximately 90 x 60’. These dimensions should be considered when selecting a site to ensure no obstructions hinder the proper layout. The site should have well-drained, hard-compacted, level soil. The immediate area should be free from obstructions and permit access to equipment needed for unloading the shelter from its conveyance device. The area should accommodate the personnel and support equipment necessary for accomplishing the objective. If there are questions regarding suitability, contact either in-house staff or an architectural engineering firm for a consultation.

Setting up the EBS hygiene system

The four EBSs (two shower and two latrine) should be moved by forklift and positioned according to the system drop layout shown in figure 2–60.

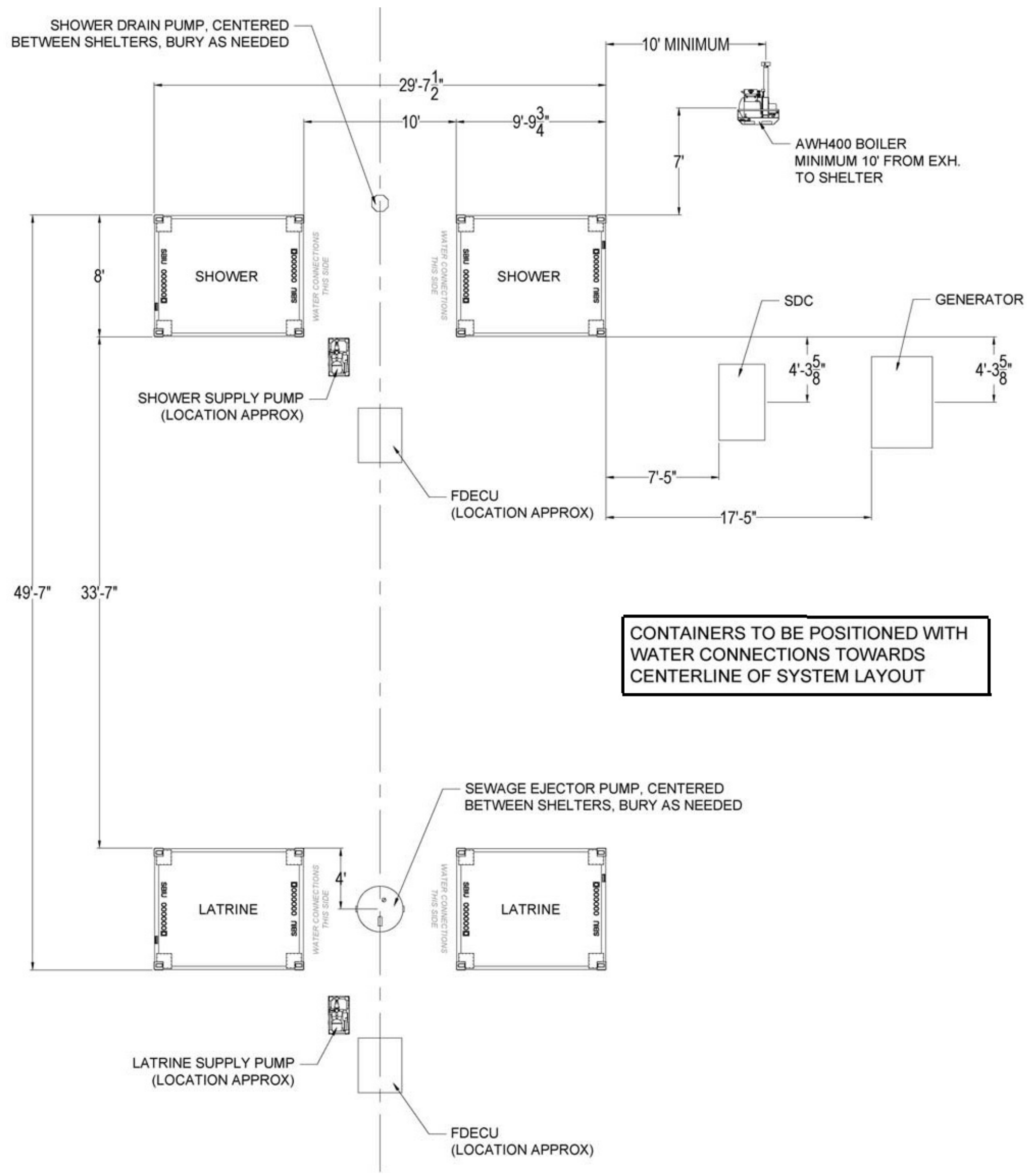


Figure 2–60. Drop layout.

The Storage Bicon should be placed outside of the system footprint shown. Do not expand shelters until all containers have been properly positioned.

For proper operation and deployment, the Bicon must be level. Leveling jacks are located in the storage compartment. It is preferable to level containers while they are on the forklift and suspended above the ground. The suggested elevation for the containers is approximately 6” to ensure the floor drains, discharge pipes, and adjustable steps work properly. After all containers are properly positioned, remove the four leveling jacks and support brackets from the storage compartment along with the 30 millimeter (mm) socket wrench. Attach the support bracket to the arm of the jack. If there is a forklift or other suitable lifting device present during setup, proceed with the following leveling instructions:

- Preset each jack to an expanded height of approximately 6”.
- Using the forklift, lift the shelter approximately 12” from the ground.
- While the shelter is suspended, insert and lock one jack into each of the four corner castings.
- The jacks should be placed in the hole that is on the 8’ side of the container (non-expandable side) to allow for proper clearance around the expandable sections while deployed.

WARNING: USE EXTREME CAUTION WHILE SHELTER IS BEING SUSPENDED BY FORKLIFT. DO NOT PLACE ANY BODY PARTS UNDER SHELTER.

- After the all four jacks have been installed, the container can be set back on the ground and leveled by raising the low side or corners to match the highest side or corner. This means that no corner of the shelter should be lower than 6” before deploying the expandable sections.
- Make sure the container is level by placing a bubble level (found in storage compartment) at the center of each bottom rail.

If there is NOT a forklift or crane present during site setup (i.e., the shelters were placed before camp habitation and/or setup), the following instructions are applicable:

- After retrieving the jacks from the storage compartment and installing support brackets, make sure that all are retracted completely.
- Insert and lock one retracted jack assembly into each of the four corner castings.
- The jacks should be placed in the hole that is on the 8’ side of the container (non-expandable side) to allow for proper clearance around the expandable sections while deployed.
- Extend each of the four jacks, working around the shelter from one corner to the next lifting the entire shelter in 1” increments until the each jack has been extended 6”.
- The shelter can then be leveled as needed by raising the low side or corners to match the highest side or corner.
- No corner of the shelter should be lower than 6” before deploying the expandable sections.
- Make sure the shelter is level by placing a bubble level (found in storage compartment) at the center of each bottom rail.

Once the shelter has been leveled, it can be expanded. After the shelter is expanded, the jacks should be inspected and adjusted to compensate for any shifting that may have occurred. Each shelter should be checked weekly or after significant rainfall and adjusted to compensate for any shifting that may have occurred. For illustration purposes, only one side of the Bicon is shown. Both sides of the Bicon are identical (fig. 2–61).

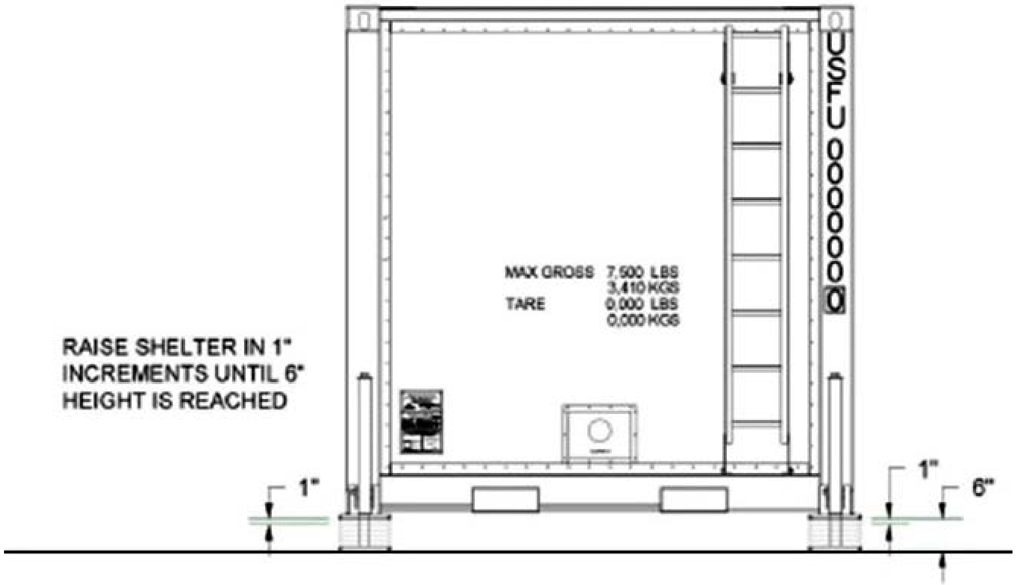


Figure 2–61. Bicon leveling jacks.

Four people are needed to expand the Bicon shelter. First, retrieve the two-piece support pole from the storage compartment. Fully extend the lower pole section and connect the top extension. Remove the safety clip, lift and remove the cam lock pin, and raise the cam lock lever on ends of the of the expandable side of the Bicon (fig. 2–62). Raise the roof (panel 1) using the gas struts for assistance. Position the support pole to temporarily support the roof panel (fig. 2–63).

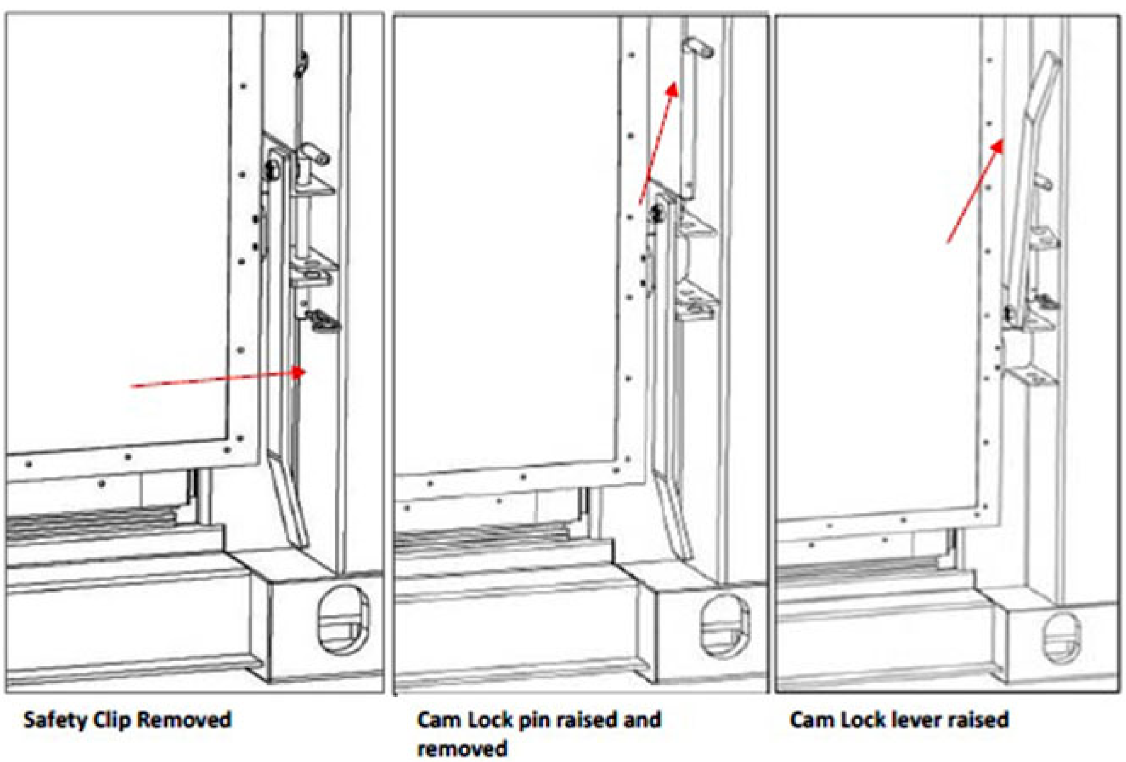


Figure 2–62. Bicon Safety clip, cam lock pin and cam lock lever.

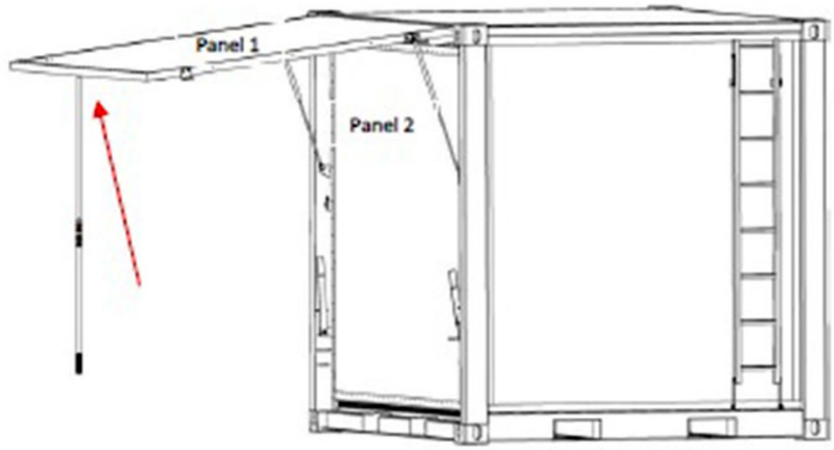


Figure 2–63. Support pole.

Locate the safety chain at the upper side left side of the container. Remove the safety chain from the D-ring and connect it to the lug mount. Slowly pull down Panel 2 until the safety chain is stretched and engaged. Get the winch from the storage compartment, and bring it to the roof by climbing the ladder. To deploy the ladder, slide back the retainer bar to release the ladder, and pull it out and down. Insert the winch into the corner casting of the side that is being opened. Attach the winch strap belt to the lug mount by placing it around the OUTSIDE of the gas strut (fig. 2–64).

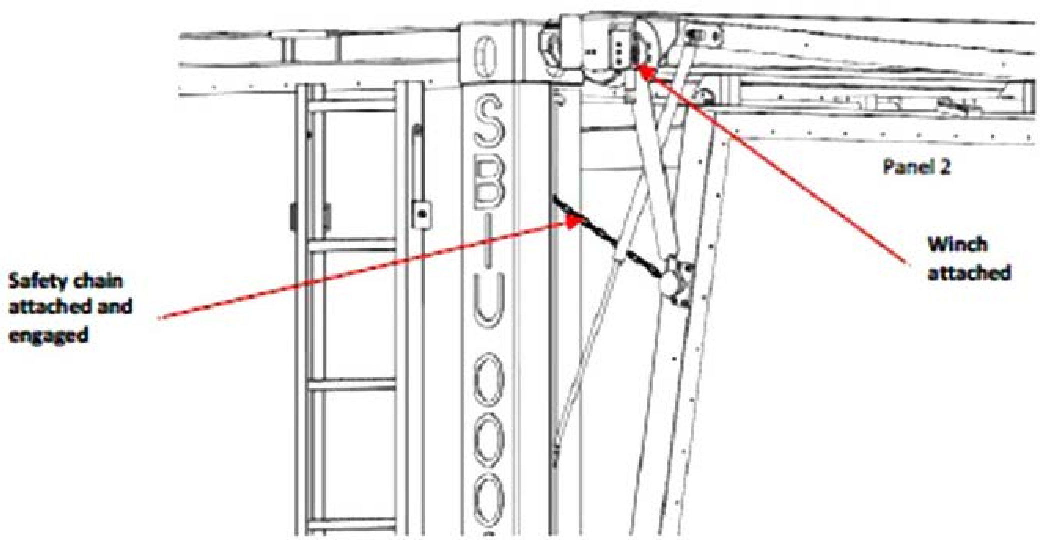


Figure 2–64. Winch strap.

Using a ¾” drill with extension bar (from the storage compartment), tighten the winch strap to ease the load until the safety chain can be removed. It may be necessary to push slightly on the panel to remove the safety chain. If a drill is not available, a speed wrench is provided in the storage compartment as a back-up. After ensuring that the area around Panel 2 is clear, lower the panel using the winch and drill (fig. 2–65). When completely lowered, unhook the winch strap and reel it back into winch. Remove the winch and place it on the diagonal opposite side of the shelter in preparation for deploying the second side of the Bicon. When the second side is opened, return the winch to the storage compartment.

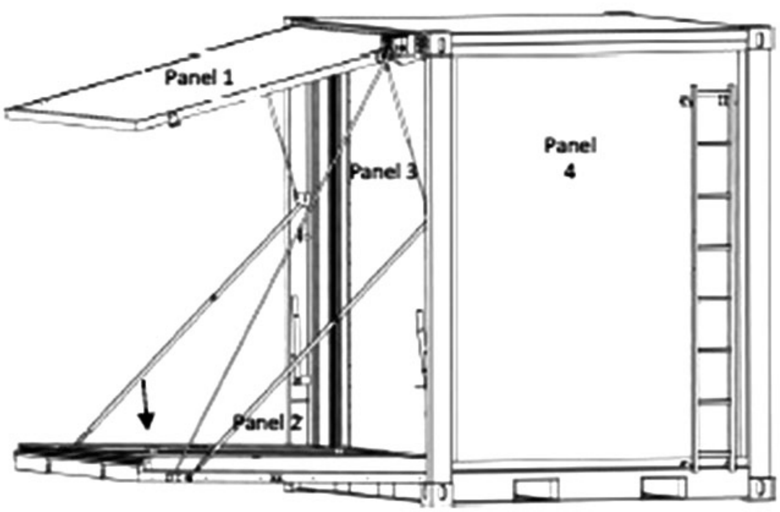


Figure 2–65. Panel 2 lowering.

With two people on each side, manually lift Panel 3 upward into place. While two people hold Panel 3 in place, a third person can remove support pole. The pole can be moved to other side of the Bicon for deployment or lowered and returned to the storage compartment. Ensure the upper corner of Panel 3 is flush with spacer. If it is not, adjust it using the turnbuckle with the wrench (located in the storage compartment) (figs. 2–66 and 2–67).

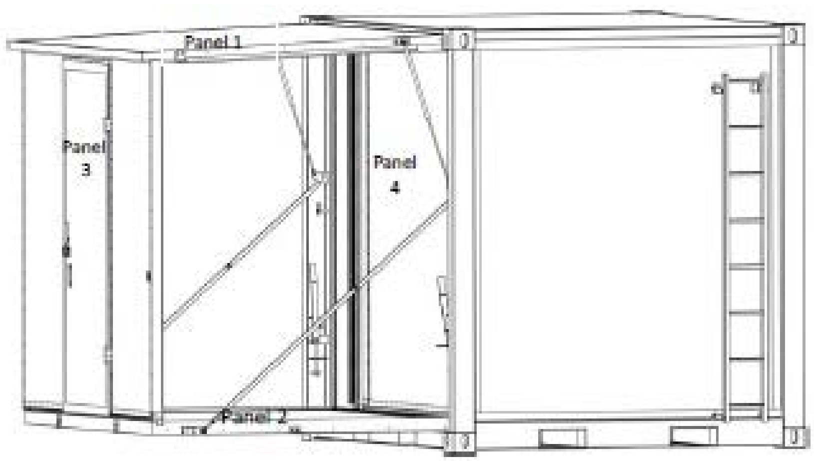


Figure 2–66. Bicon Panel 3.

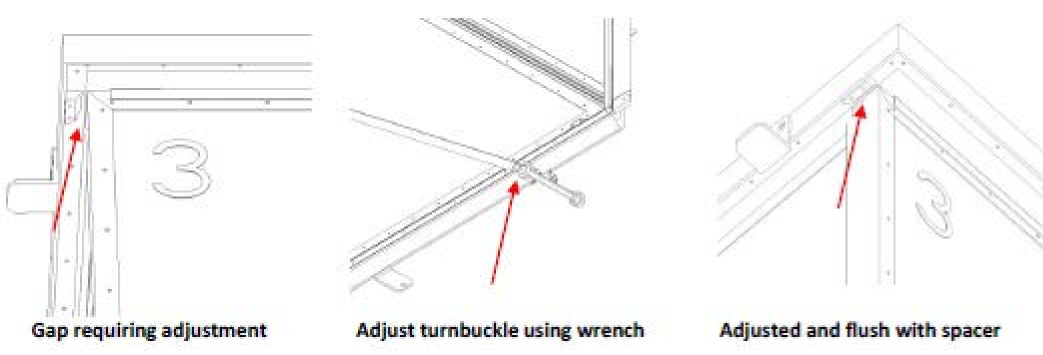


Figure 2–67. Bicon turnbuckle, wrench flush with spacer example.

Lock the two latches on the inside of Panel 3 to the roof (panel 1) and secure them with the safety strap. Ensure that the rubber gaskets on the roof panel are pulled out. Enter the container frame and unlock Panel 4 (lock is on inside floor). Open the exhaust fan panel in upper corner. Pull and swing out Panel 4. Lock two safety latches on the inside wall. Unlock Panel 5 and pull it out the same way as Panel 4. Secure with safety latches. If there is not enough space below the ceiling to fully extend Panel 4 or Panel 5, re-adjust the turnbuckle until it can be pushed into place. Once locked, re-tighten the turnbuckle until the end walls and floor are sealed. Make sure that the rubber gaskets on the bottom of both walls are on the outside of the floor panel (fig. 2–68).

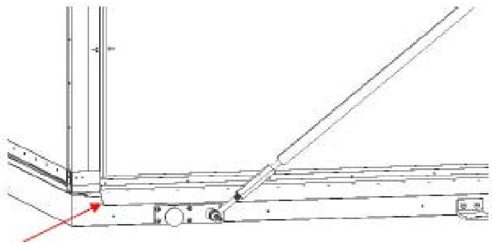


Figure 2–68. Bicon rubber gasket.

Once all the sides are deployed and all the panels are secure, check for level. Observe the two arrows—one on the side panel and one on the end (fig. 2–69). The arrows should align. If they don't align, adjust the turnbuckle in either direction as necessary to achieve this. The Bicon is now deployed (fig. 2–70).

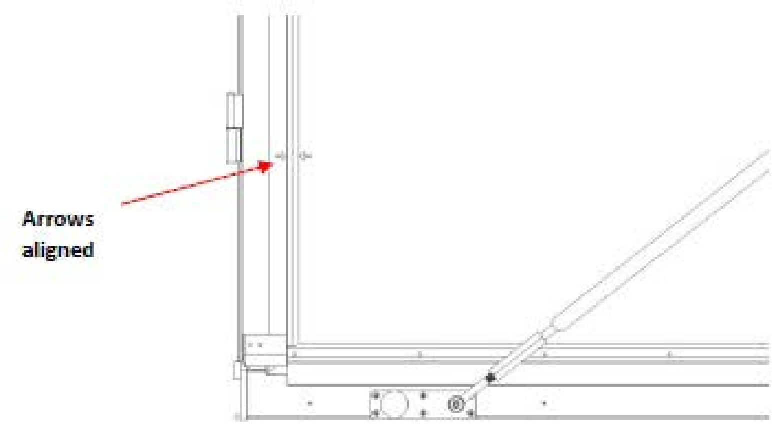


Figure 2–69. Bicon arrows.

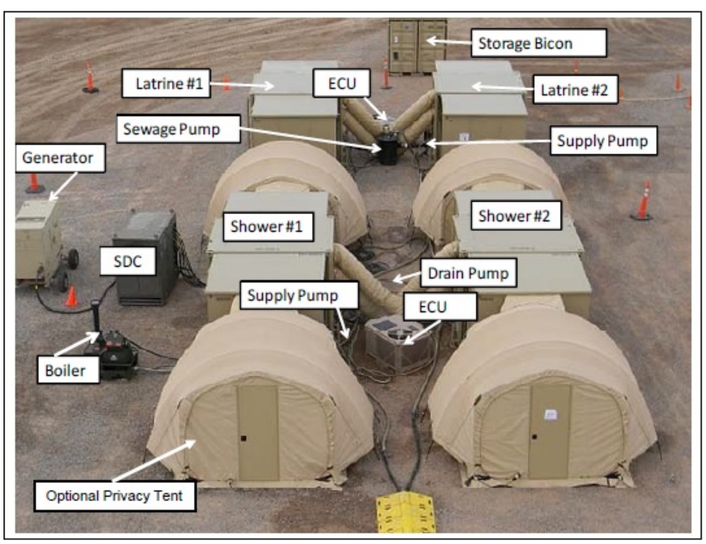


Figure 2–70. Deployed Bicon.

Shower interior set-up

The stairs are screw-mounted (¼-20 bolts) on the center shower stall partition during transport. Retrieve a $^{5}/_{32}$ “T” handle Allen wrench from the storage compartment and use it to unscrew and remove the stairs. Bring the stairs outside the shelter and hook them into the two mounting pegs beyond the width of the exterior side of the personnel door. The screws should be properly stored in the storage compartment. Remove the benches from the Storage Bicon; un-bundle the benches and unfold each one. The ratchet straps should be stored in the Storage Bicon. One bench is placed inside each shelter below the towel hooks, the others are for use outside or in the optional privacy tent. Connect the pipe union, hot and cold water lines, and the drain under the sink on both sides of the container.

Alaska 10’ x 10’ privacy shelter

The set-up location for the privacy shelter will be on either side of the shower Bicon shelters, and the area must be at least 16' wide × 15' long. Clear all debris and make the area as smooth and level as possible. Locate the containers or crates in which the shelter has been packed. After unlatching and removing the top, the shelter may be unpacked directly from the containers. Inspect for any damage or missing parts. When the shelter and accessories have been removed from the container, replace the container top for storage. The container should be stored in this manner until it is needed again.

Connector boot to EBS installation

Locate the connector boot end panel. While the EBS entry end wall is laying down, install the keder on the end panel into one end of the keder track above the EBS door. Make sure to center the keder in the track over the door so that there is an equal amount of keder on each side. Insert the bottom end of the keder into the top of the keder track on one side of the door. Pull the keder down the track until it reaches the bottom. Repeat for the opposite side of the door. Allow the boot to remain in place until the EBS entry end is raised and the shelter frame assembly is complete (fig. 2–71).

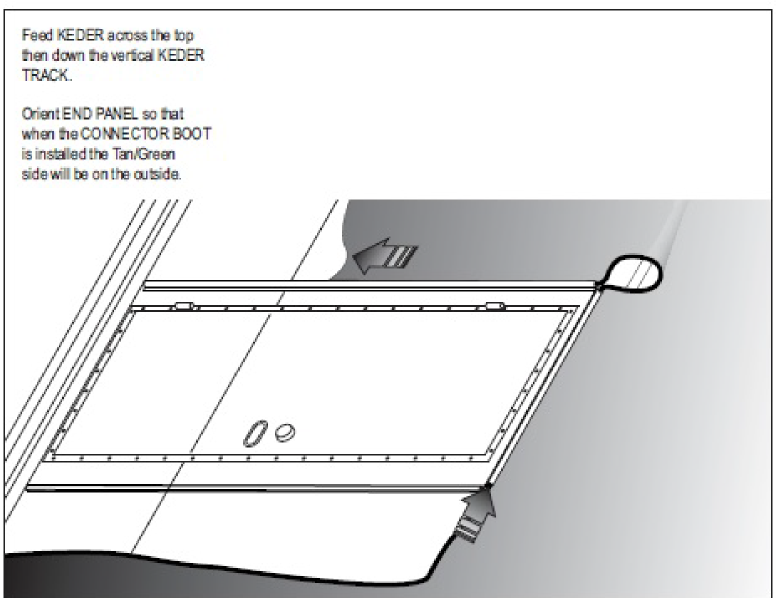


Figure 2–71. EBS entry.

Connector boot arch installation

Locate the (2) bottom tensioning arch sections, with base pads, and the (1) top tensioning arch section. Assemble the arch sections and attach to the connector boot end panel, while the entry end wall is laying down (fig. 2–72). Prop the connector boot end panel up on the connector arch, between the EBS and the shelter end, when the EBS entry end is raised.

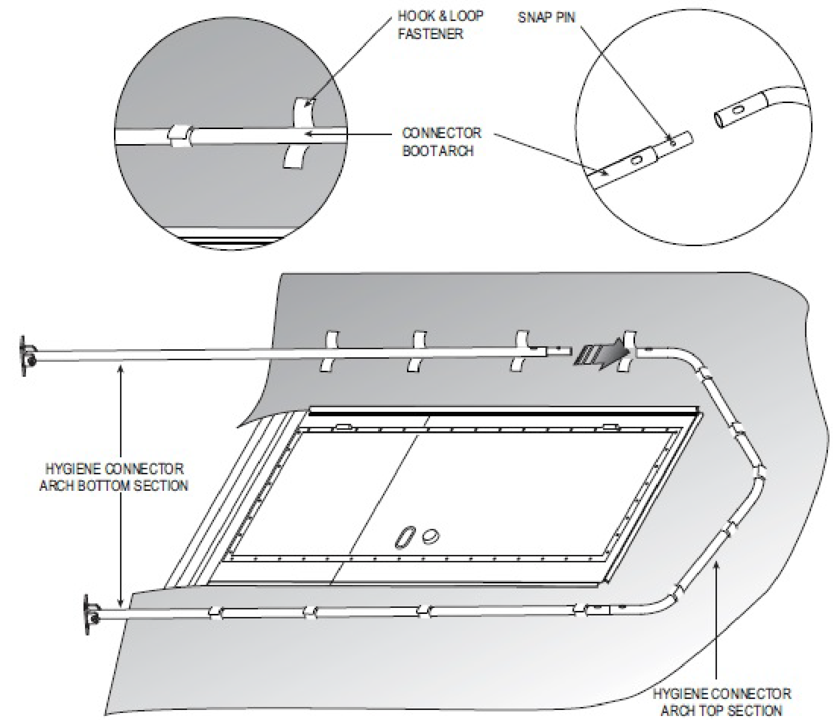


Figure 2–72. EBS arch sections.

Base frame

Lay out and identify base frame pieces for your shelter (fig. 2–73). Near the end of the EBS, assemble base sections in sequence as shown (fig. 2–74). Use white throw ropes or a tape measure for diagonal measurements. Place all base pieces with base hooks on the outside of the shelter with the hooks facing down. Ensure all sections are completely and securely slip-fitted together.

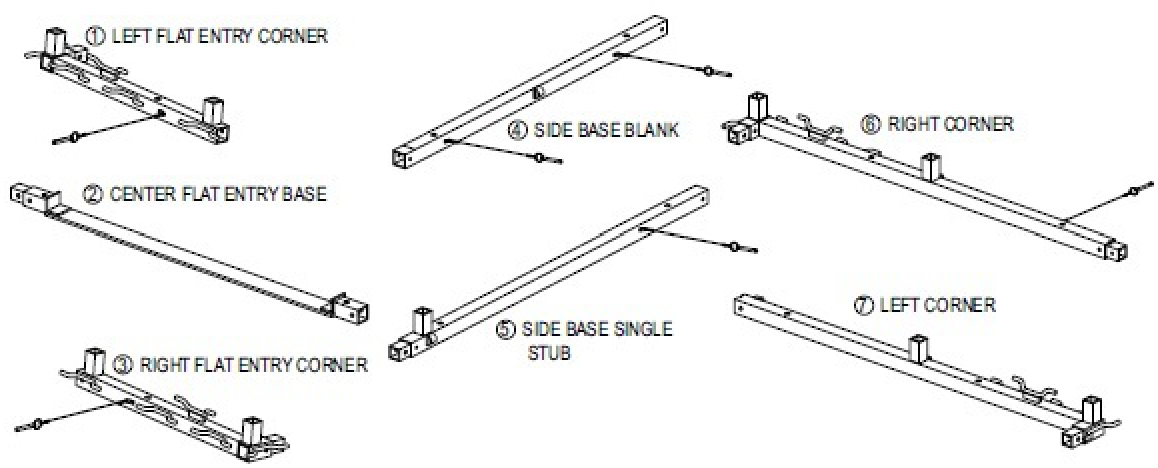


Figure 2–73. EBS base frame.

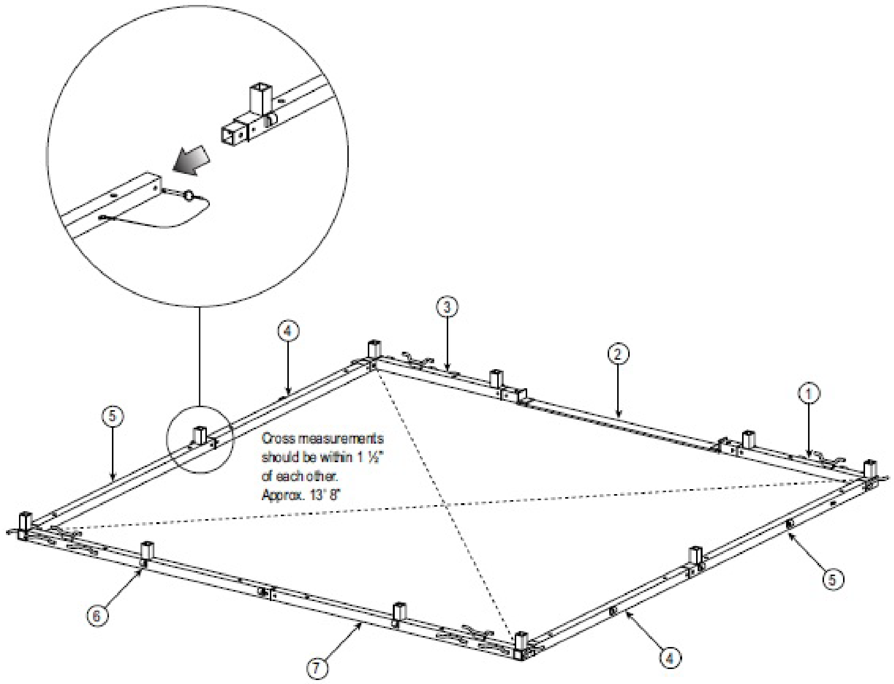


Figure 2–74. EBS base frame sequence.

Place the assembled base frame's end section approximately 54" from the end of the EBS. Center the frame at the end of the EBS where the connector boot is located (fig. 2–75). Place the end with the center flat entry base section nearest the EBS System. Unfold the non-slip floor with the black side facing the ground. Slip the floor cutouts over the base stubs (fig. 2–76).

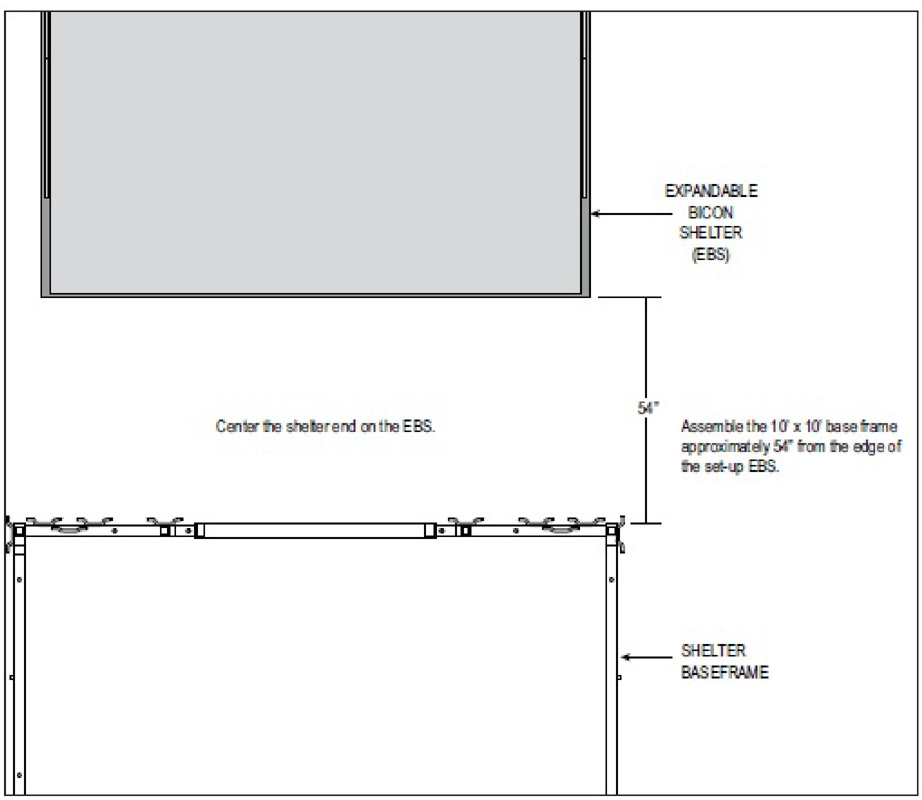


Figure 2–75. EBS centering.

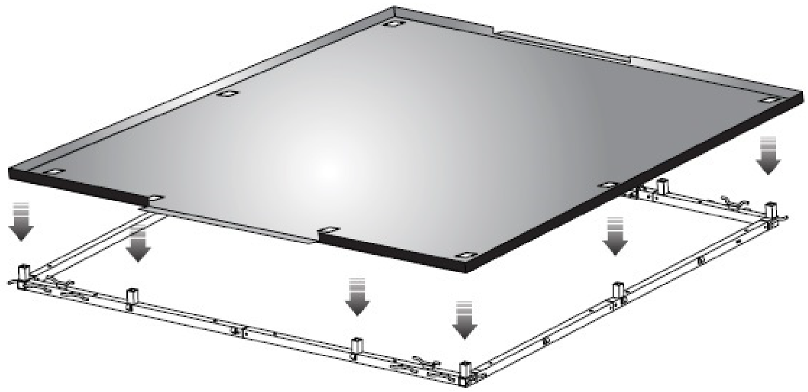


Figure 2–76. Floor cutouts.

An alternate method of squaring the base sections, which eliminates the need for diagonal measurements, can be done as follows:

- Assemble the base sections in sequence as shown (fig. 2–76).
- Align the base sections until they are straight, and install the non-slip floor.
- The non-slip floor will square the base frame sections.

Assemble the arches on the ground and keep all the joints completely slip-fitted together (fig. 2–77). Stand the assembled arch. Set the first side of the arch onto the appropriate arch stub on the base frame. Holding the assembled arch firmly, spring the opposite end onto the corresponding arch stub (fig. 2–78). Repeat this process for each remaining arch.

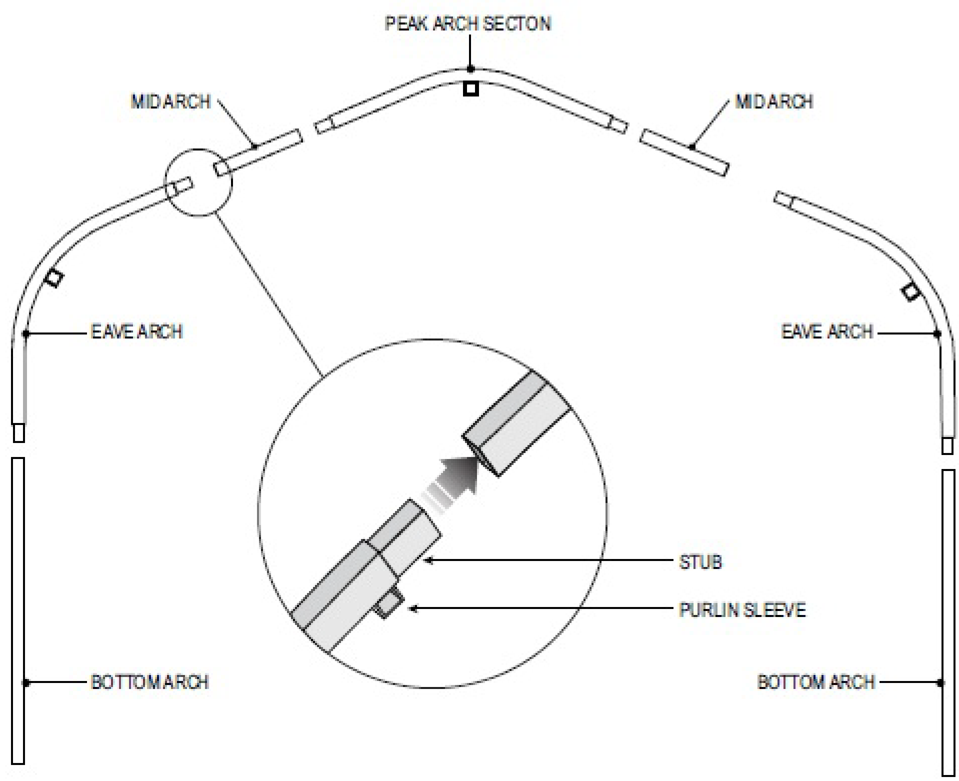


Figure 2–77. EBS arch section assembly.

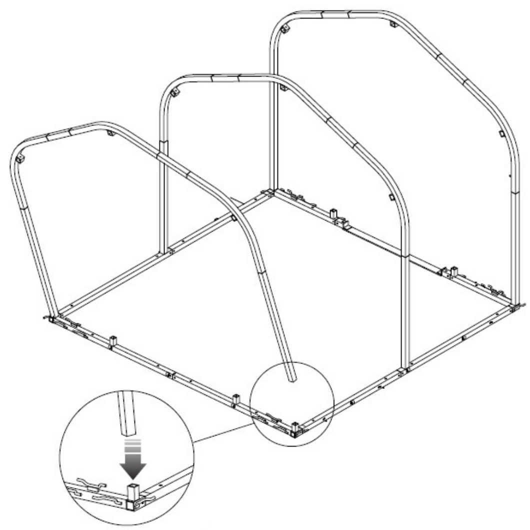


Figure 2–78. EBS arch stub.

There are three rows of purlins that connect the arches. Begin with the RED coded start purlins, inserting one end into the first purlin sleeve and securing it with the attached pin. Make sure that the pins are fully inserted at each purlin connection site. The pins should be inserted from the top of the purlin toward the ground. Install YELLOW coded end purlins in the next bay. Locate the uprights and upright inserts with J-hooks. Install (2) uprights at each end of the shelter. Place an upright insert into the top of the upright (fig. 2–79). Lift the upright, with the open end of the J-hook facing the shelter arch. Slip the J-hook on the insert over the end arch. Place the bottom of the upright down onto the appropriate base stub (fig. 2–80). Pay attention to the instructions stenciled on the upright. Plumb the upright, and ensure that the upright insert is oriented so that the bolt head is facing away from the shelter.

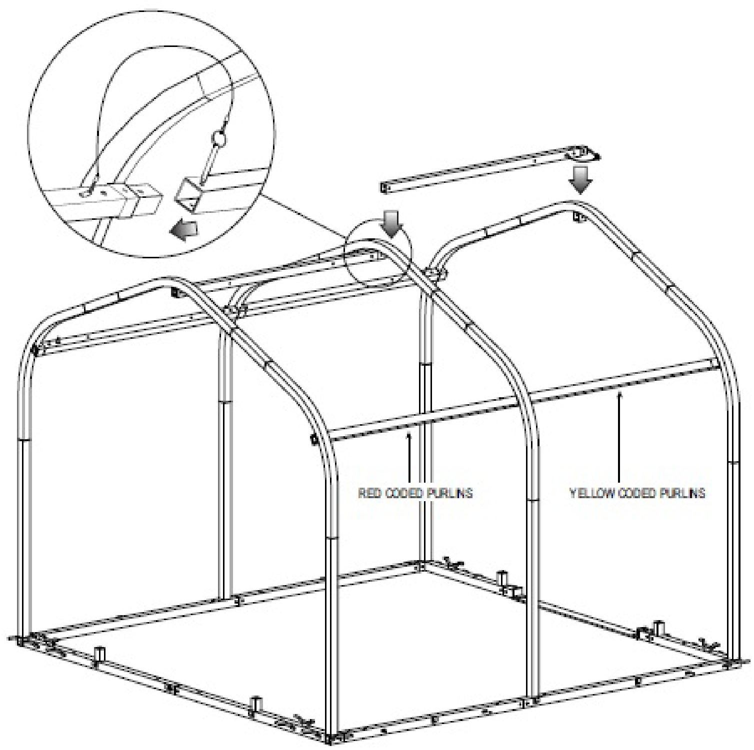


Figure 2–79. EBS purlins.

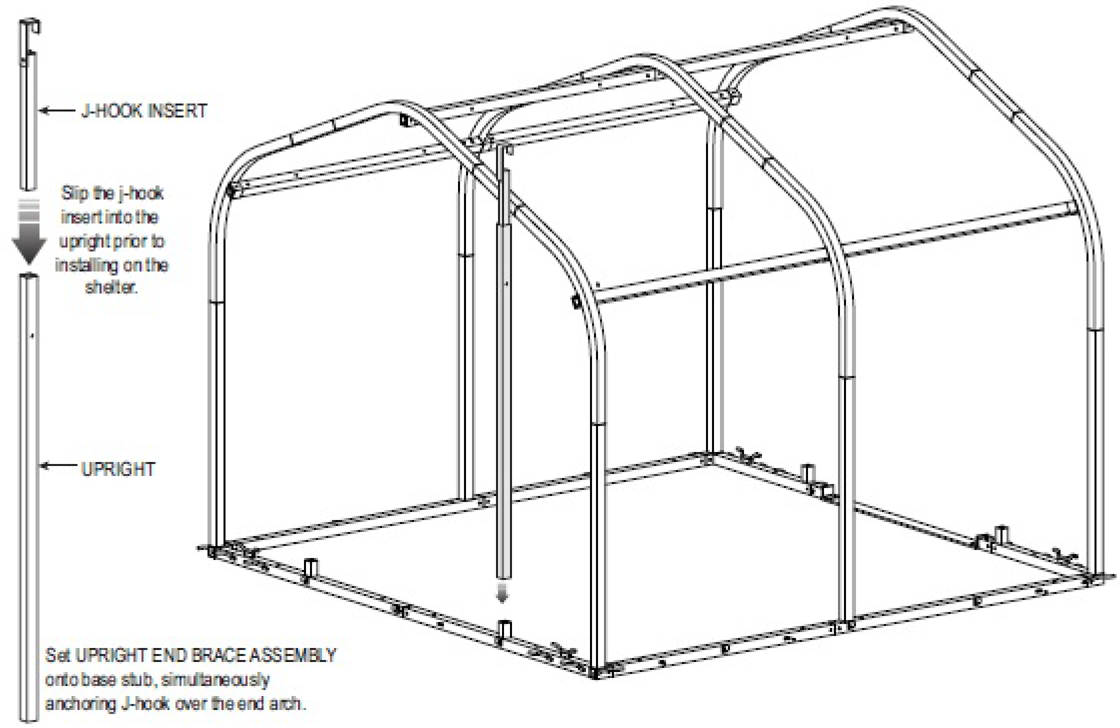


Figure 2–80. EBS uprights and J-hooks.

Stretch the connector boot end panel from the EBS over the tensioning arch to the end arch of the shelter. Tie off one end of the left YELLOW base rope to the left YELLOW cleat on the left flat entry corner section. Pull tightly on the opposite end of the base rope, towards the flat section, and tie it off to the YELLOW cleat. Repeat to secure the base rope to the right flat entry corner section. Remove the purlin pins at the connection to the end arch, so that the purlins can be separated from the purlin sleeves. Lift the end panel from the center portion, working the contour edge over the end arch (fig. 2–81). Slip the contour rope underneath the purlin at each cutout. Insert the purlins back into the purlin sleeves and pin them securely into place before continuing to tension the end panel.

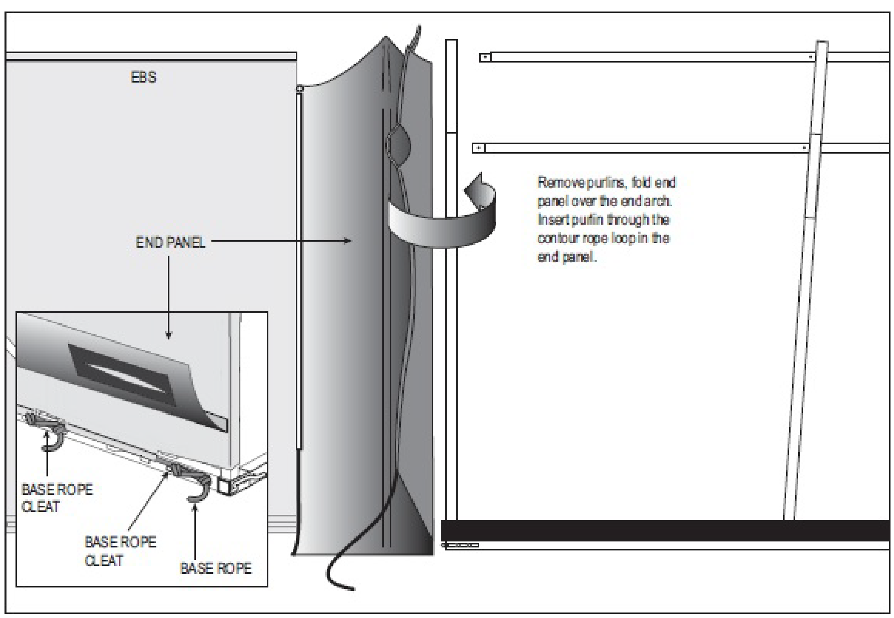


Figure 2–81. Contour edge.

Keeping the end panel centered, tension both ends of the contour rope tightly using a foot for leverage. Continue working the edge of the end panel over the end arch while tensioning contour rope. When the end panel is snug and the rope is tightly tensioned, secure the contour rope to the rope cleat on the base frame (fig. 2–82). The end panel should overlap the end arch by 4–6”. Tension the connector boot by moving the entire assembled shelter frame slightly away from the EBS end. Make sure the shelter remains centered on the EBS. Move the shelter towards the EBS slightly to relieve overtensioning if the connector boot is pulled too tightly.

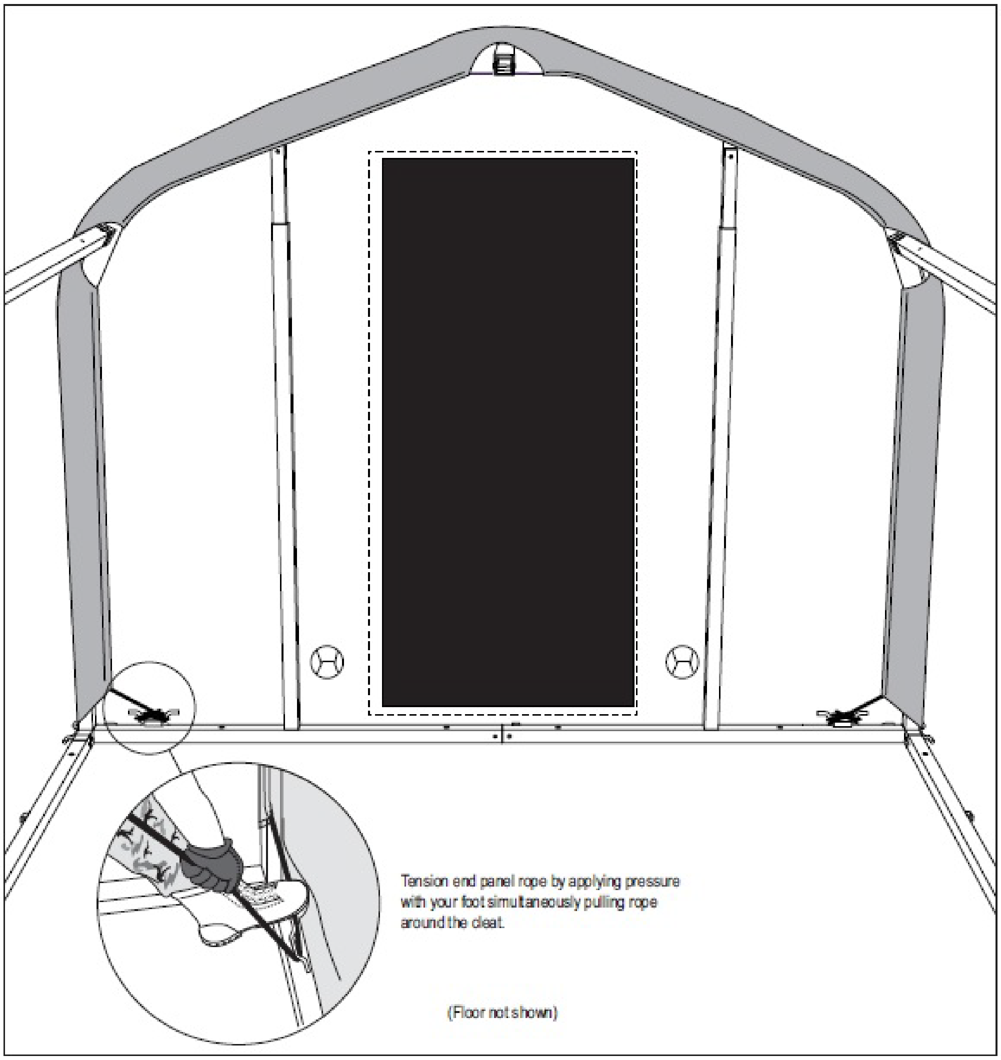


Figure 2–82. Contour rope.

After assembling the shelter frame at the end of the EBS and tensioning the connector boot, make sure the shelter is centered and correctly positioned. Drive the double-headed spikes through the pre-drilled anchor holes in the base frame and tensioning arch into the ground using a sledge hammer (fig. 2–83). Take care to not strike or damage the base frame when anchoring. For asphalt, a hole may have to be drilled through the asphalt. For concrete, drill a hole in the concrete using a ½” masonry drill bit. Drive the concrete anchors (through the pre-drilled anchor holes) into the concrete using the sledge hammer.

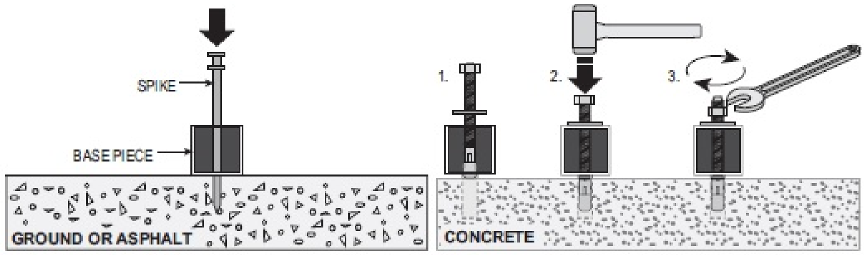


Figure 3-14. Base Anchoring Options

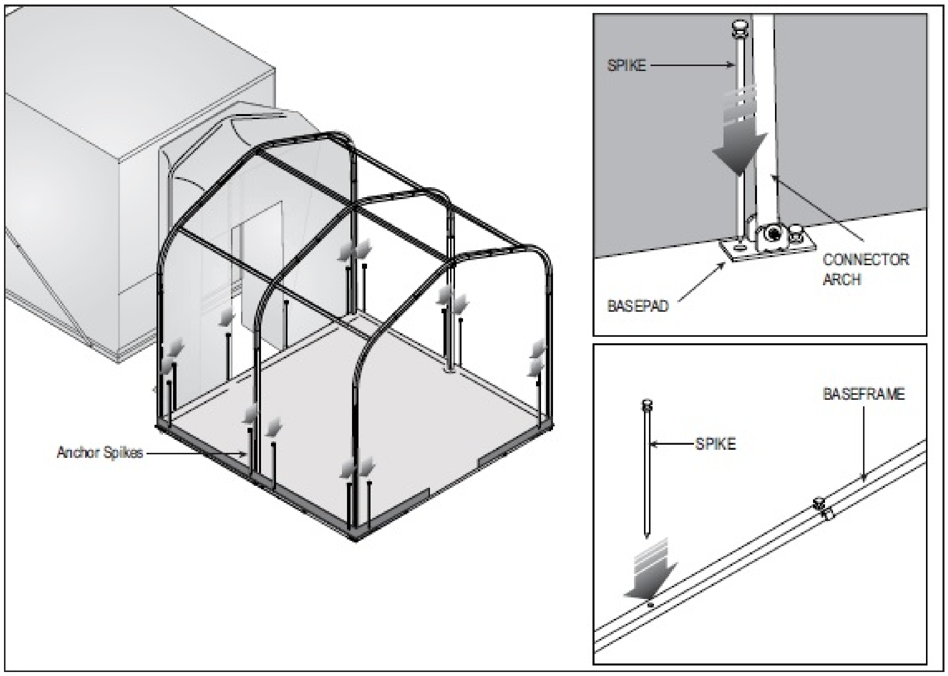


Figure 2–83. Double headed spikes.

Unfold the non-slip connector floor, with the black side facing the ground. Slide the keder edge of the floor into the keder track, below the door, on the EBS. Connect the opposite end to the shelter floor using the hook and loop (H&L) on the edge. Connect the sides of the floor to the sides of the connector boot. Secure with the H&L. Lay out the hard door end panel in front of the end base where the uprights were installed, with the WHITE side facing up. Align the cutouts along the base with the base rope hooks on the end base frame. Tie one end of the YELLOW base rope to the YELLOW base rope cleat on the shelter end base. Stretch the other end of the rope until taught and tie it off to the YELLOW tie-off cleat on the opposite end of the shelter end base (fig. 2–84).

Remove the purlin pins at the connection to the end arch, so that the purlins can be separated from the purlin sleeves. Lift the end panel from the center portion, working the contour edge over the end arch. Slip the contour rope underneath the purlin at each cutout. Insert the purlins back into the purlin sleeves and pin them securely into place before continuing to tension the end panel (fig. 2–84). Keeping the end panel centered, tension both ends of the contour rope tightly using a foot for leverage. Continue working the edge of end panel over the end arch while tensioning the contour rope. When the end panel is snug and the rope is tightly tensioned, secure the contour rope to the rope cleat on the base frame (fig. 2–85). The end panel should overlap the end arch by 4–6”. Using the hook tools, lever the end panel base rope under the base hooks. Secure the end panel uprights using the flaps with H&L fasteners attached to the end panel. Secure the end panel to the uprights using the upright sleeves on the end panel.

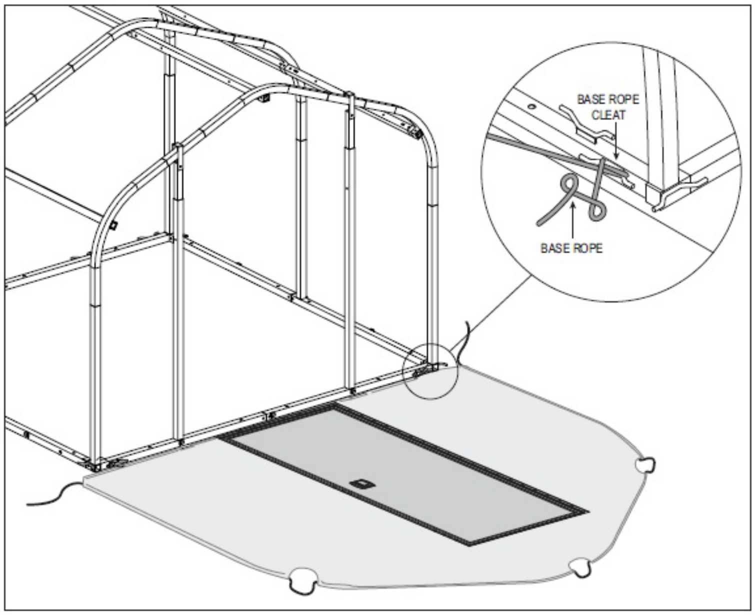


Figure 2–84. Yellow base rope.

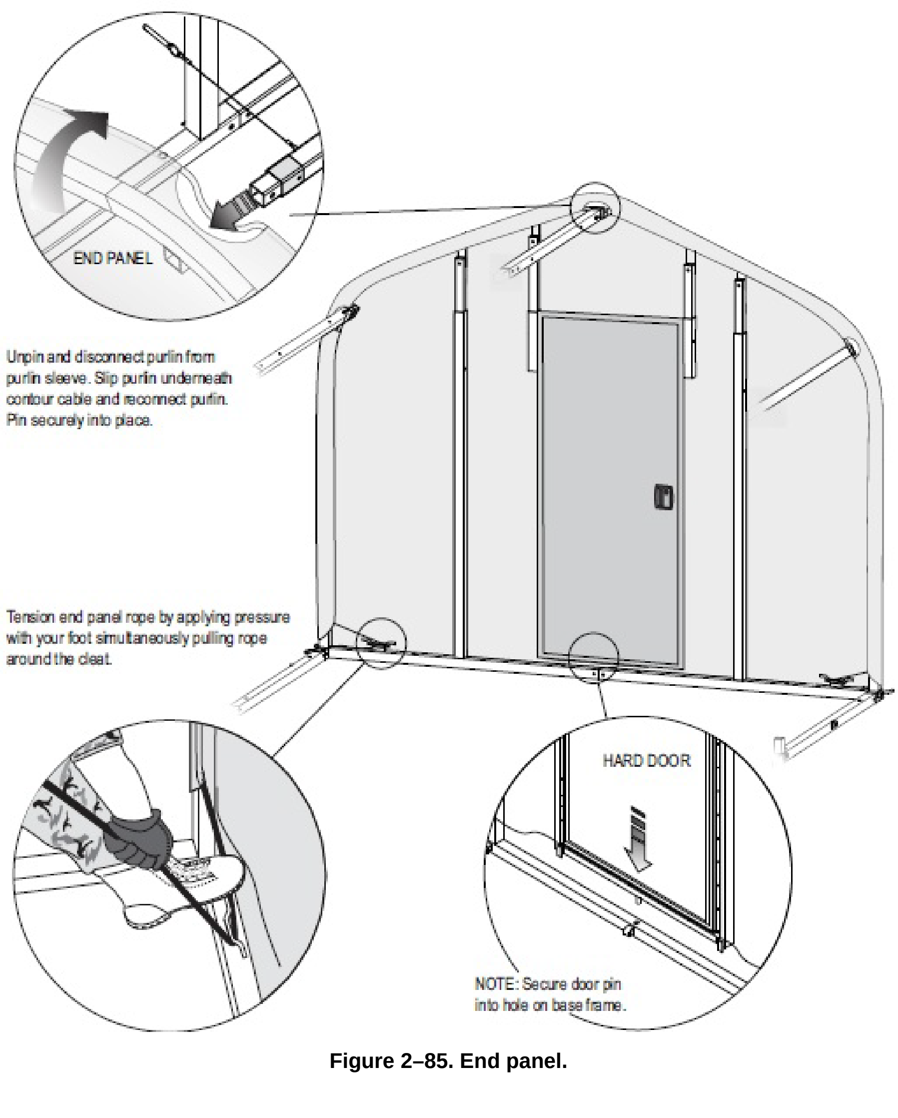


Figure 2–85. End panel.

Lay out the main cover alongside of the shelter (fig. 2–86) so that when the cover is pulled over, the ground flap will be on the outside of the shelter and the BLACK side to the inside of the shelter. Tie off the end of the cover base rope to the GRAY tie-off cleat on the side base frame near the end of the shelter. Align the exposed portions of the base rope with the hooks on the base frame. Extend the other end of the rope and secure this end to the GRAY tie-off cleat at the opposite end of the shelter. From the opposite side of the shelter, throw two white ropes over the shelter frame and attach the rope snaps to the web loops along the base edge of the cover. To pull the cover over the frame, pull in unison on the throw ropes. Draw the cover up and over the shelter. The GREEN/TAN color should now be on the outside of the shelter. Secure the base rope on the second side of the unit in the same manner as the previous base rope. Align exposed portions of the base rope with the base hooks. Pull the ends of the cover over the end arches; the cover should overlap the ends by 4 to 5”. Make sure the overlap of the cover is the same at each end of the shelter. Guy O-rings should be aligned directly over each arch.

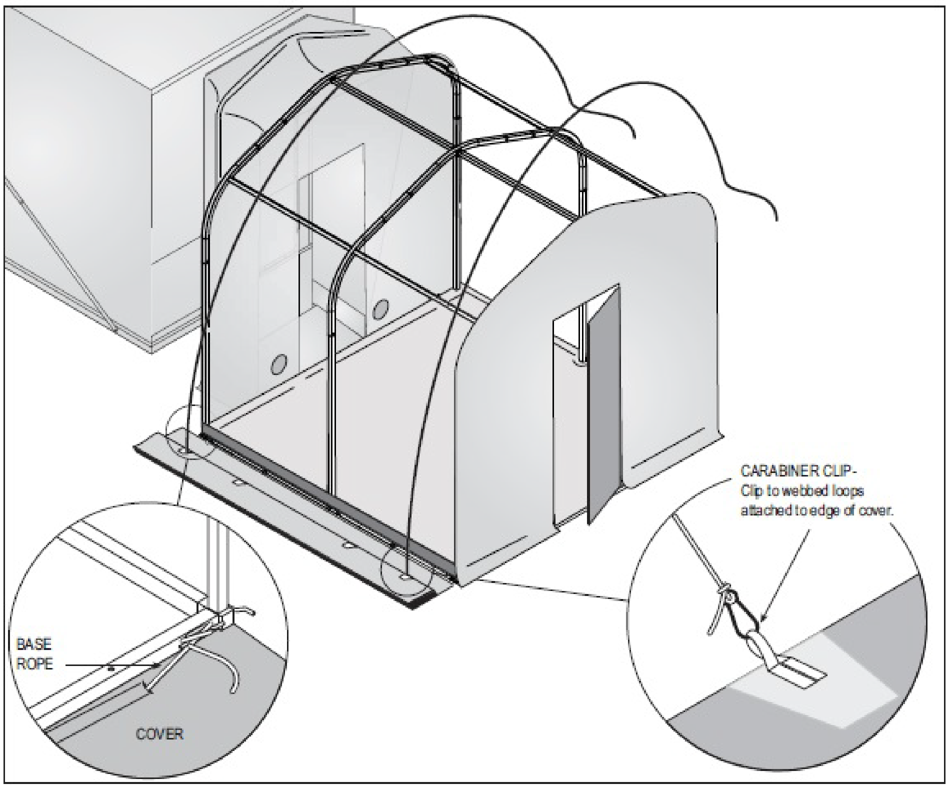


Figure 2–86. Main cover.

Starting at one end of the cover, slip the cover contour ropes through the slits in the end panel ground flap (fig. 2–87). Run the contour rope under the RED-coded contour cleat on the base frame. Tension until the cover is taught and overlaps the end arches by approximately 5”. Make sure that the guy-rings are aligned with the shelter arches. Once the cover is tensioned, secure the contour rope ends to the RED-coded contour cleats. Repeat for opposite end of the cover. Secure the base rope along each side of the cover to the base hooks using the hook tools.

Locate the (2) EnerLayer panels. Place the first EnerLayer panel over the peak purlin. Pass the EnerLayer behind each of the two bottom purlins. Unfold the panel and stretch it across the bay, between the end arch and middle arch. Ensure that the liner is centered between the shelter sides and the purlin cutouts are located at each purlin. Secure the panel to the end arch using the H&L on the end panel overhang and the H&L on the EnerLayer panel. Secure the panel to the middle arch using the H&L straps located along the edge of the liner (fig. 2–88). Repeat for the second EnerLayer panel installation. Secure the second liner to center arch by pressing the H&L on the panel edge onto the H&L on the edge of the first end panel.

Figure 2–87. Ground flap.

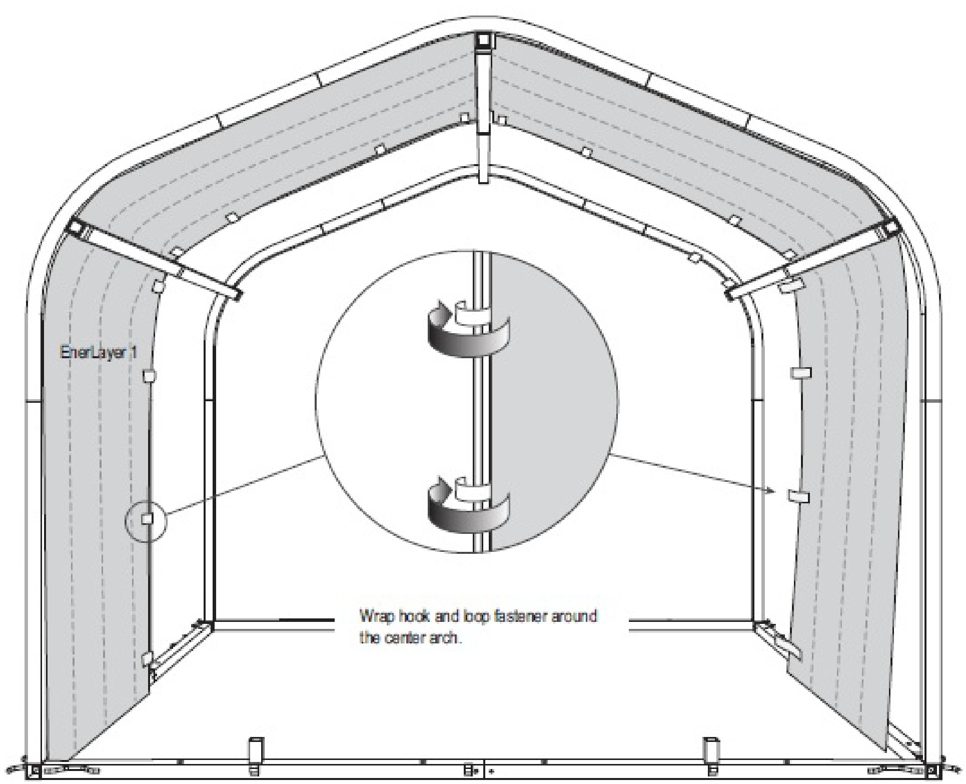


Figure 2–88. H&L straps.

Locate the (2) cover liner panels, and (1) boot liner. Place the first cover liner panel over the peak purlin. Pass the liner behind each of the two bottom purlins. Unfold the liner so that the SILVER side is up. Make sure the liner is centered between the shelter sides and the purlin cutouts are located at each purlin. Secure the liner panel to the EnerLayer panel at the middle arch, using the H&L located along the edge of the liner (fig. 2–89). Stretch the liner across the shelter bay and secure the liner to the end arch using the H&L on the end panel overhang and the H&L on the liner panel. Repeat for second cover liner panel installation.

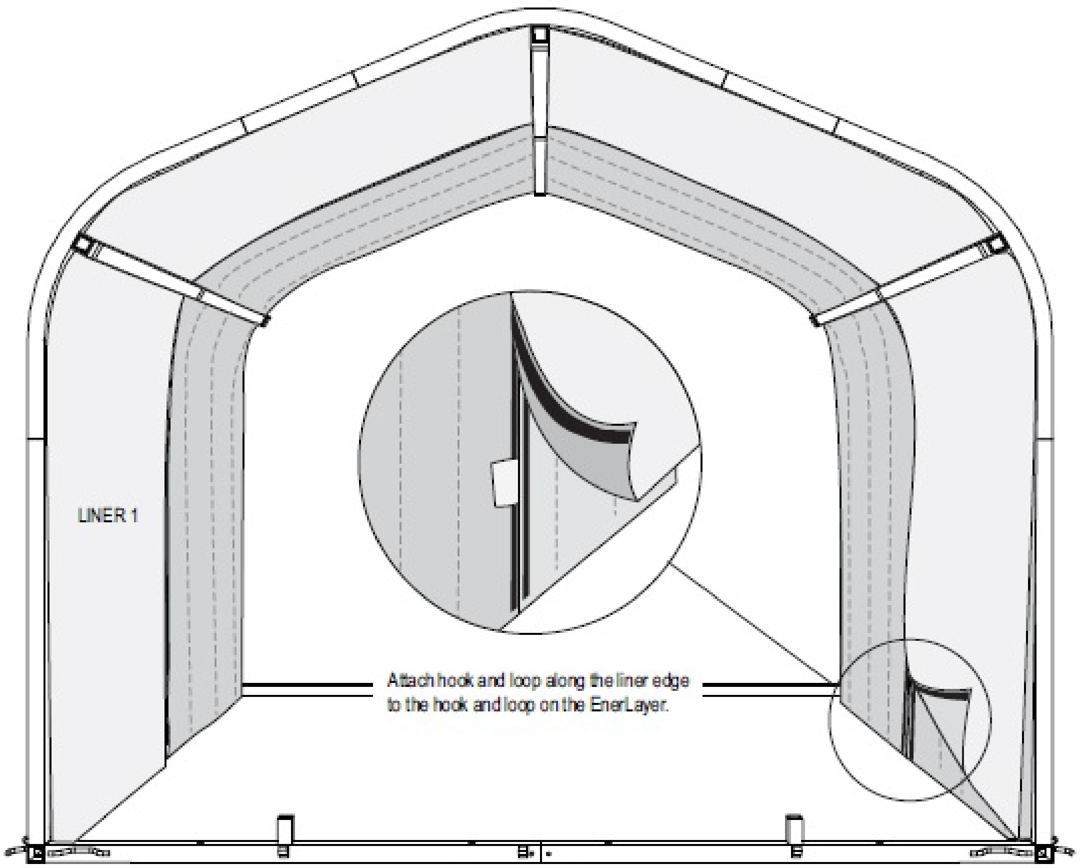


Figure 2–89. EnerLayer liner.

Locate the (1) hard door end panel liner, and (1) connector boot end panel liner. After the two cover liners have been installed over the two EnerLayer panels, install the end panel liners to complete the shelter EnerLayer System (fig. 2–90). Attach the end panel liner to the H&L around the connector boot entry. Stretch the end panel liner out towards the top and sides of the end arch. Secure the end panel liner to the end panel using the H&L. Attach the end panel liner to the H&L along the sides of the hard door frame. Stretch the end panel liner out towards the top and sides of the end arch. Secure the end panel liner to the end panel using the H&L.

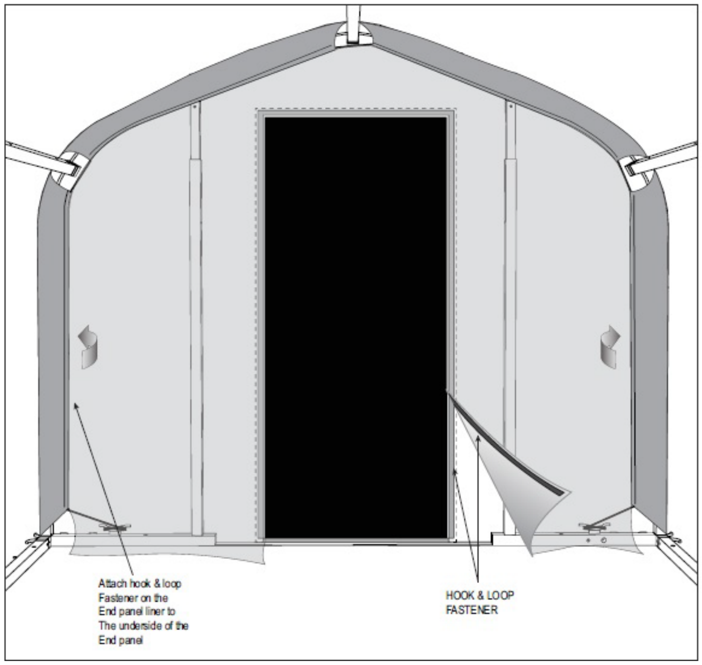


Figure 2–90. End panel liners.

Locate the two fluorescent lights (fig. 2–91) included with this shelter system. Secure the first light to the first center purlin, near the personnel entrance, using H&L straps. Ensure that the male connector is towards the personnel door. Repeat to install the second light onto the next center purlin. Connect the male connector on the second light to the female connector on the first light. Attach the light switch to the upright and secure it with the pin. Run the female end of the cable up the upright and over to the peak purlin row. Connect the male end of the first fluorescent light to the female end of the switched power cable (fig. 2–91). Secure any loose cable to the upright using H&L straps. Run the male end of the switched power cable, down the upright, under the end panel liner, and towards the side of the shelter. Continue down the side of the shelter, behind the cover liner panels. At the rear end of the shelter, feed the cable through the electrical boot in the end panel, nearest the power source. Connect the male end of the cable to an appropriate power source.

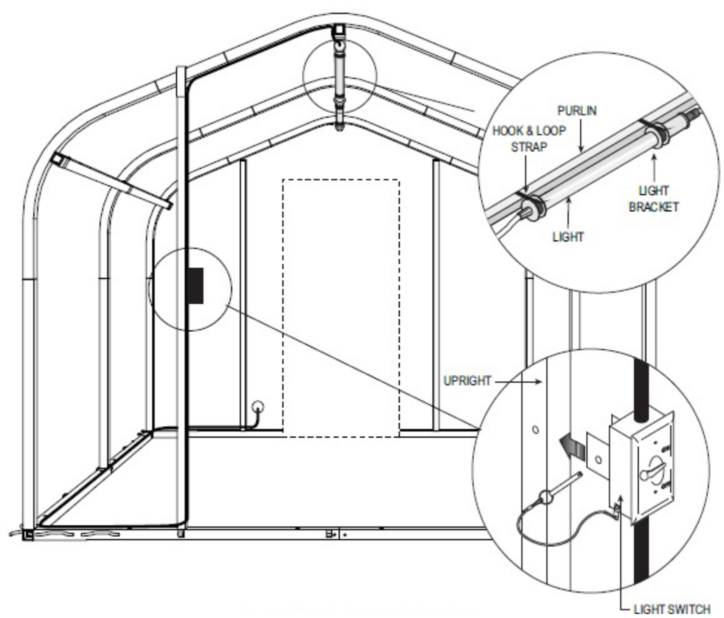


Figure 2–91. Fluorescent lights and light switch.

Install the guy ropes by driving the guy anchor into the ground, approximately 36” out from the side of the shelter. Angle the top of the anchor away from the shelter and attach the other end to the guy anchor. Pull the tent slip down toward the ground until taught (fig. 2–92).

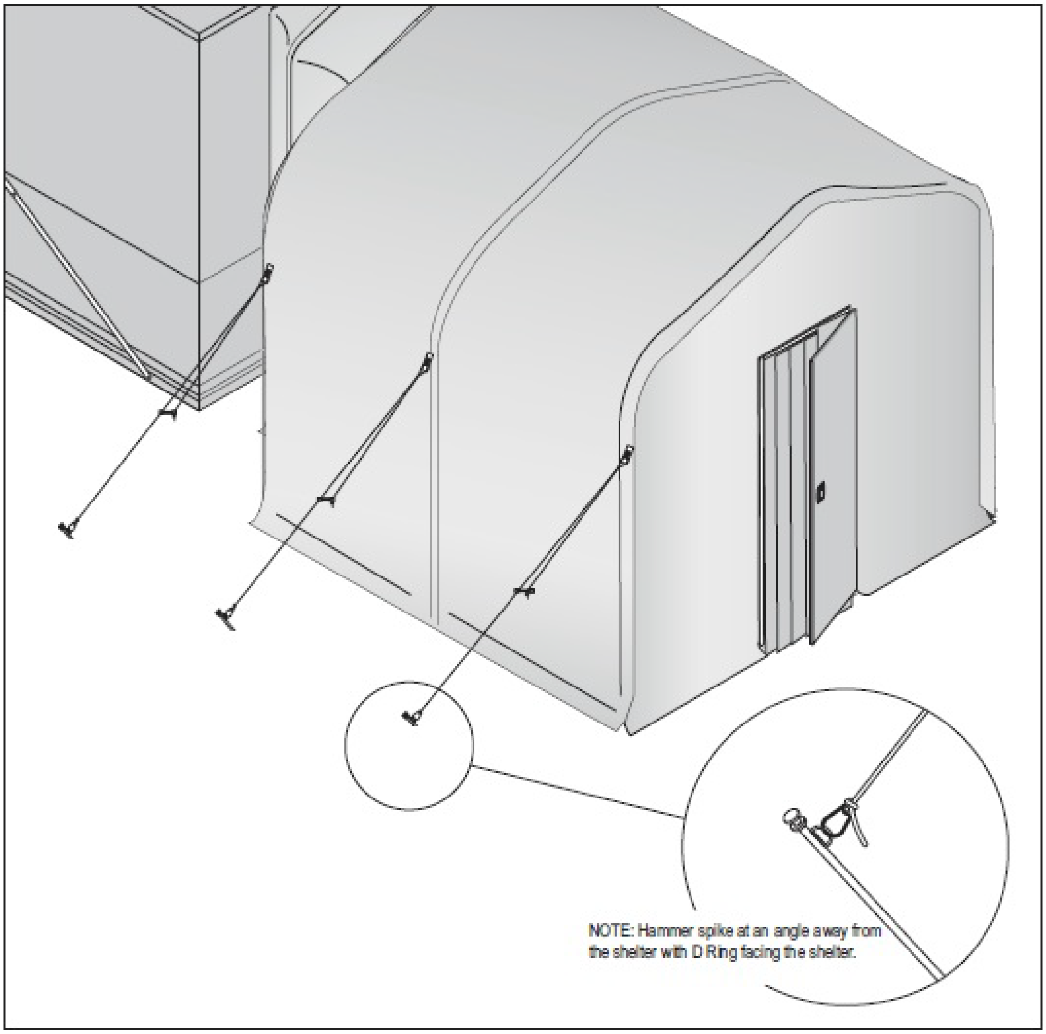


Figure 2–92. Guy ropes.

Locate the Solar Fly base pads (fig. 2–93). Install the four base pads along each side of the shelter, and align the base pads, two on each side (fig. 2–94). Place each pad approximately 36” from the shelter side base frame and anchor with two double-headed spikes. Orient each base pad so that the long edge of the pad is parallel with the shelter side base. Pull the Solar Fly fabric over the shelter so that it is centered from side to side and each sleeve is centered over a shelter bay. Make sure that the sleeves are located on the bottom face of the fabric. Locate and assemble the two poles. Unfold the shock-corded poles and slip-fit the pole sections together (fig. 2–94). Make sure that each section is fully seated in the next section. Insert one end of the first pole into one sleeve on the underside of the Solar Fly. Push the pole through its sleeve, up and over the shelter, making sure that the pole passes completely through the sleeve (fig. 2–94). Continue passing the pole through the sleeves until you can reach the end of the pole from the ground on the opposite side of the shelter. Repeat for the second pole. Secure each end of one pole in the base pad so that the Solar Fly is lifted off the surface of the shelter cover. Repeat for the remaining Solar Fly pole.

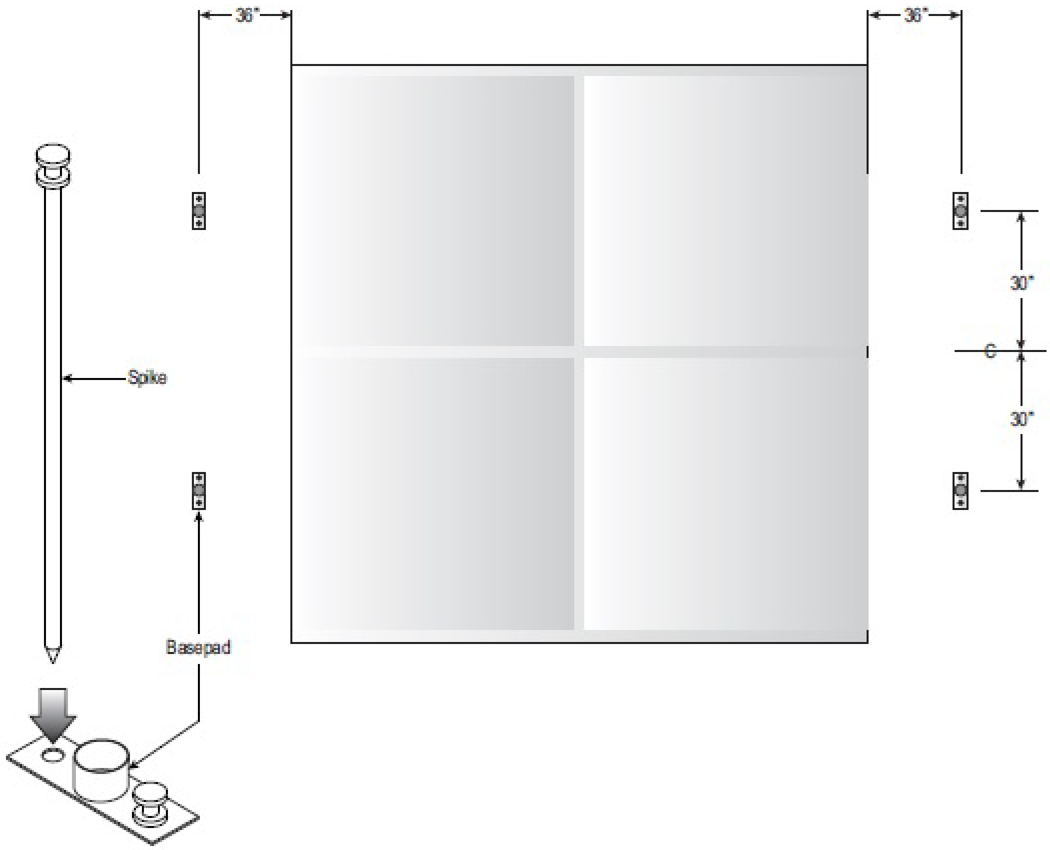


Figure 2–93. Solar Fly.

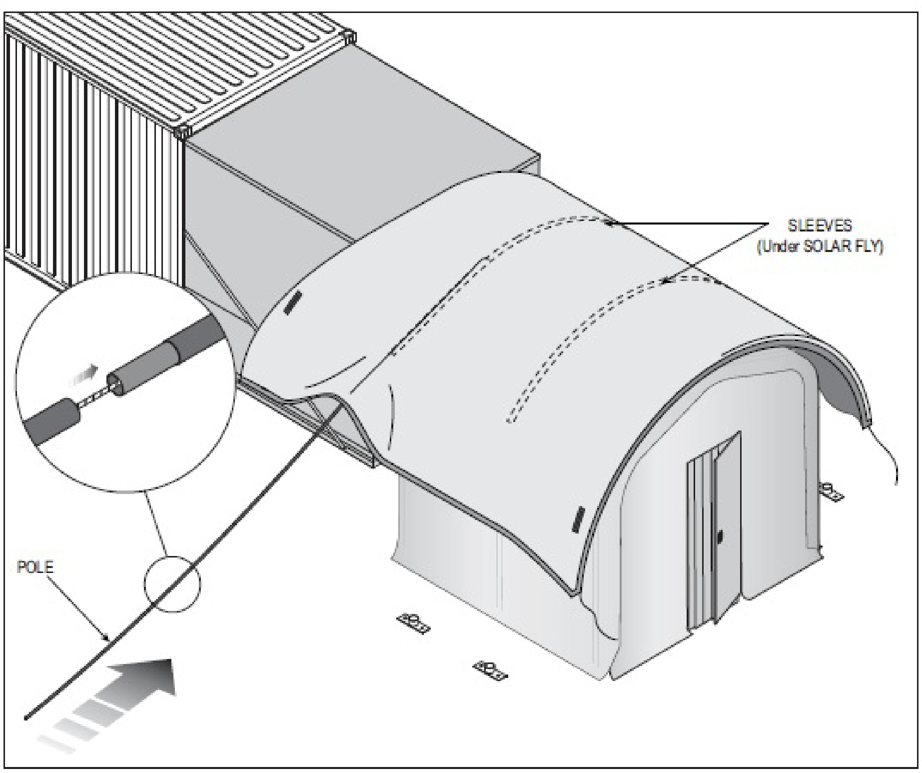


Figure 2–94. Sleeves under Solar Fly.

Work the ends of the Solar Fly fabric over the end arches with two people from the ground level. The cover should overlap the end arch by 6 to 10”. Make sure the overlap of the Solar Fly is the same at both ends of the shelter. Starting at one end of the shelter, slip the Solar Fly contour ropes through the slits in the end panel ground flap. Raise the ground flap, and tension the Solar Fly contour rope to the RED contour cleat on the shelter base frame (fig. 2–95). Use a foot for leverage to tension the contour rope until the Solar Fly is tight and overlaps the end arches by about 5” on each end of the shelter. Once the cover is tensioned securely, attach the contour rope ends to their cleats. Repeat for the other end of the cover. Attach one Solar Fly guy rope to the ring on the side edge of the Solar Fly cover, and clip the opposite end of the guy rope to the center guy anchor on the side of the shelter. Repeat for the guy rope on the opposite side of the shelter.

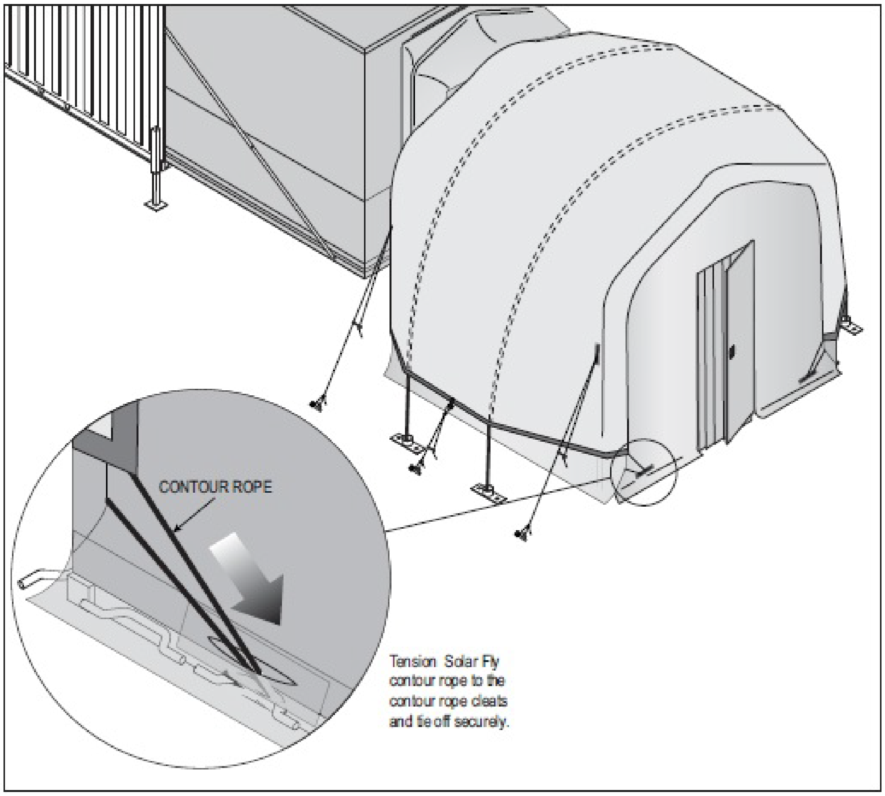


Figure 2–95. Solar Fly contour rope.

Latrine interior set-up

Stairs are screw-mounted (¼-20 bolts) inside each latrine on a stall partition during transport. Retrieve a $^{5}/_{32}$ “T” handle Allen wrench from the storage compartment and use it to unscrew and remove the stairs. Bring the stairs outside the shelter and hook them into the two mounting pegs beyond the width of the exterior side of the personnel door. The screws should be properly stored in the storage compartment. Remove the shelf and sink that are screw mounted to the far stall wall. Carry them to the sink wall and re-use thumb screws to mount them into place under mirror. Locate the drain assembly mounted in the same toilet stall. Unscrew the two screws on the top bracket and two on the bottom bracket. Carry the pipe, brackets, and screws to the opposite wall for installation under the sink.

Enter the toilet stall on the opposite end (sink wall side). Unscrew the two thumbscrews and lift and remove the stainless steel cover plate to expose the plumbing connection. Connect the drain pipe and reuse the brackets and screws to secure the pipe to the wall at the specified mounting points. Reinstall the plumbing cover plate once it is connected. Attach the trap to the bottom of the sink and union at the end of the drain to the main drain. The S-trap under the sink may have to be adjusted/moved slightly from right to left to allow for proper pipe connection. Connect the hot and cold water lines and drain under the sink. Unscrew the two thumb screws at the top of the urinal located closest to the end wall. Loosen the trap knot/drain connection on the drain and slide the urinal toward the interior of the center of the container. Re-mount using the same thumbscrews into the pre-drilled holes. Tighten the knot/drain connection. On the urinal wall, remove the top of the drain pipe from the wall storage bracket and attach it to the drain pipe at the lower wall. Locate the cold water line behind the partition wall and connect. Remove the ratchet straps that are around the doors and partition walls during shipping. Store the straps in the storage compartment. To install partitions between the stalls, unscrew the top and unlock the bottom of the stall partition walls. Slide it forward into place and secure it using the top thumbscrews and bottom locks. Stall privacy doors are hook mounted to the back wall during transport. To deploy, remove them from the wall hooks and move them to the front of the stalls. Slide the upper and lower pegs into place to secure.

Shower system water connection

All pumps and connection equipment are located in the Storage Bicon. “Potable” hoses have white stripes. “Grey Water” hoses have purple stripes. Remove the Drain Pump from the Storage Bicon and position it between the shower shelters. Dig a 12” hole into ground and place the pump inside to achieve the proper drainage pitch. Remove the Shower Supply Pump and hoses marked for potable water from the Storage Bicon and inventory them according to the table below. Position them in accordance with the layout in figure 2–96. Connect the Bladder (government supplied) to the Shower Supply Pump using hoses A1, A2, and A3. Connect one end of hoses B1 and B2 to the Shower Supply Pump and the other ends to the shower container connections marked “Cold Potable.” Connect the Supply Pump to the AHW–400 Boiler (government supplied) using hose C. Connect the AHW–400 Boiler to the Hot Water Line Splitter (Tee) using hose D. Connect one end of hoses E1 and E2 to the Tee and the other ends to the container connections marked “Hot Potable.” Connect one end of hoses F1 and F2 to each container connection labeled “Grey Water” and the other end of the hoses to the Drain Pump. Connect the Drain Pump to the Wastewater Loop using hoses G1, G2, and G3. Hose G3 will connect to the wye which is attached to Hose K3 from the Latrine System. It is important that all hoses lay flat and are not twisted or kinked in any way.

Origin	Termination	Hose Reference	Hose Stripe Color	Hose Dimensions	Hose Ends	QTY
Bladder #2	Shower Supply Pump	A1, A2, A3	White	25’ x 2”	2” Male x 2” Female	3
Supply Pump	Shower Containers (Cold Water)	B1, B2	White	15’ x 1 ½ ”	1 ½” Male x 1 ½” Female	2
Supply Pump w/ PSI Reducer	AHW-400 Boiler	C	White	25’ x 1 ½ “	1 ½” Male x 1 ½” Female	1
AHW-400 Boiler	Hot Water Line Splitter (Tee)	D	White	25’ x 1”	1” Male x 1” Female	1
Hot Water Line Splitter (Tee)	Shower Containers	E1, E2	White	15’ x 1”	1” Female x 1” Female	2
Shower Containers	Drain Pump	F1, F2	Grey	4-1/2’ to 5’ x 2”	2” Female x 2” PVC Union	2
Drain Pump	Wye connecting to K3 from Latrine System	G1, G2, G3	Purple	25’ x 2”	2” Male x Female	3
				TOTAL		14

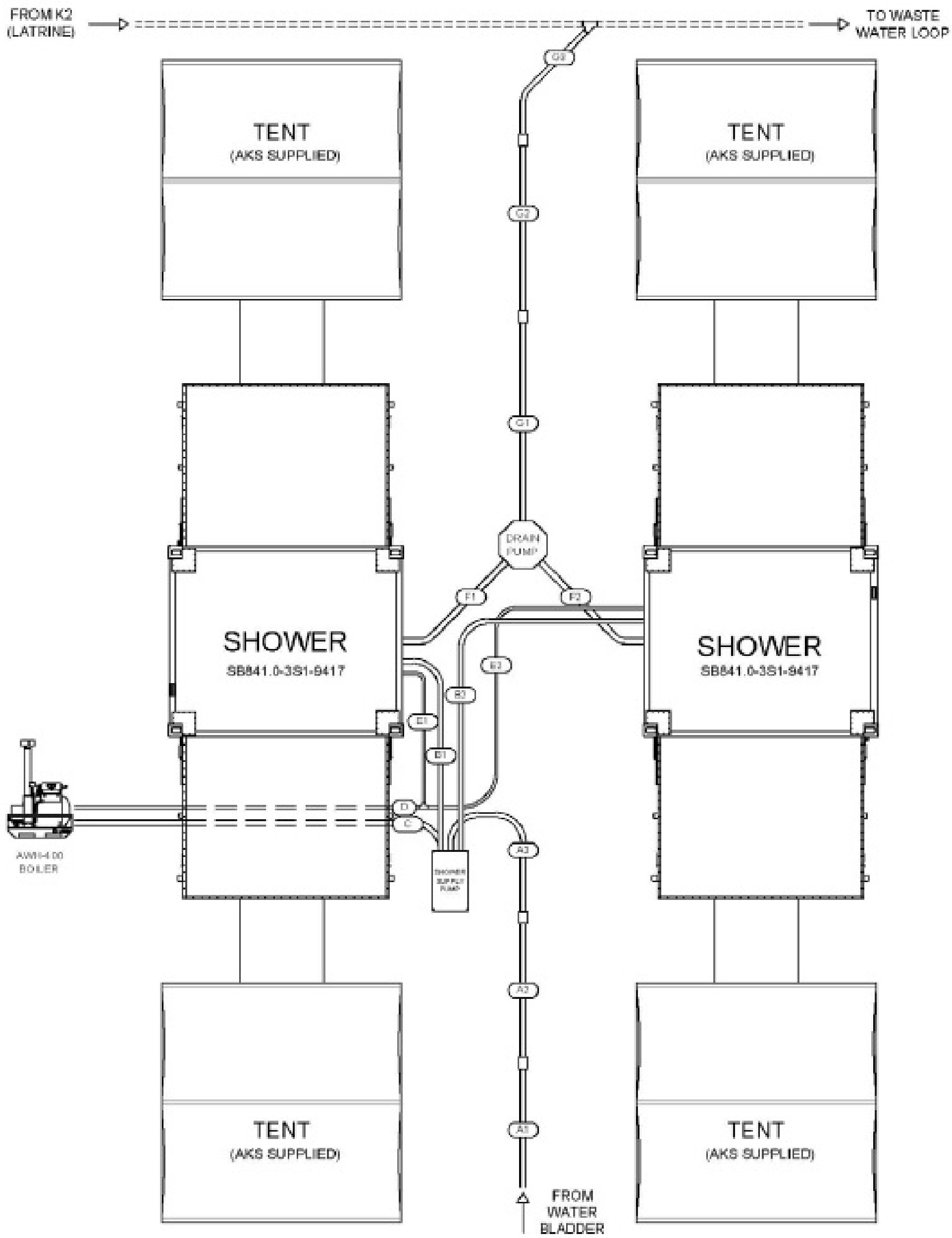


Figure 2–96. Shower supply pump and potable water hoses.

Latrine water connection

Remove the Sewage Ejector Pump from the Storage Bicon and position it centered between the two latrine shelters (fig. 2–97). The pump should be buried as required to attain proper pitch. Remove the Latrine Supply Pump and hoses from the Storage Bicon. For clarification on the positioning of pumps and pipe layout, refer to the following table and figure 2–97. Connect the bladder (government supplied) to the Latrine Supply Pump using Hoses H1, H2, H3, and H4. Connect one end of hoses I1 and I2 to the Latrine Supply Pump and the other ends to the latrine container connections marked “Cold Potable.” Connect one end of hoses J1 and J2 to each of the container connections marked “Black Water.” Connect the other ends of each hose to the Sewage Ejector Pump. Connect the Sewage Ejector Pump to the Wastewater Loop using Hoses K1 and K2. K2 will connect to a Wye that connects with hose G3 from the Shower System.

Origin	Termination	Hose Reference	Hose Stripe	Hose Length and Diameter	Hose Ends	QTY
Bladder #1	Latrine Supply Pump	H1, H2, H3, H4	White	25’ x 2”	2” Male x 2” Female	4
Supply Pump	Latrine Containers	I1, I2	White	15’ x 1 ½ ”	1 ½” Male x 1 ½” Female	2
Latrine Containers	Sewage Ejector Pump	J1, J2	Black	4-1/2’ to 5’ x 4”	4” Female x 4” Female	2
Sewage Ejector Pump	Wye that connects with Hose G3 (from Shower System)	K1, K2	Purple	25’ x 2”	2” Male x 2” Female	2
				TOTAL		10

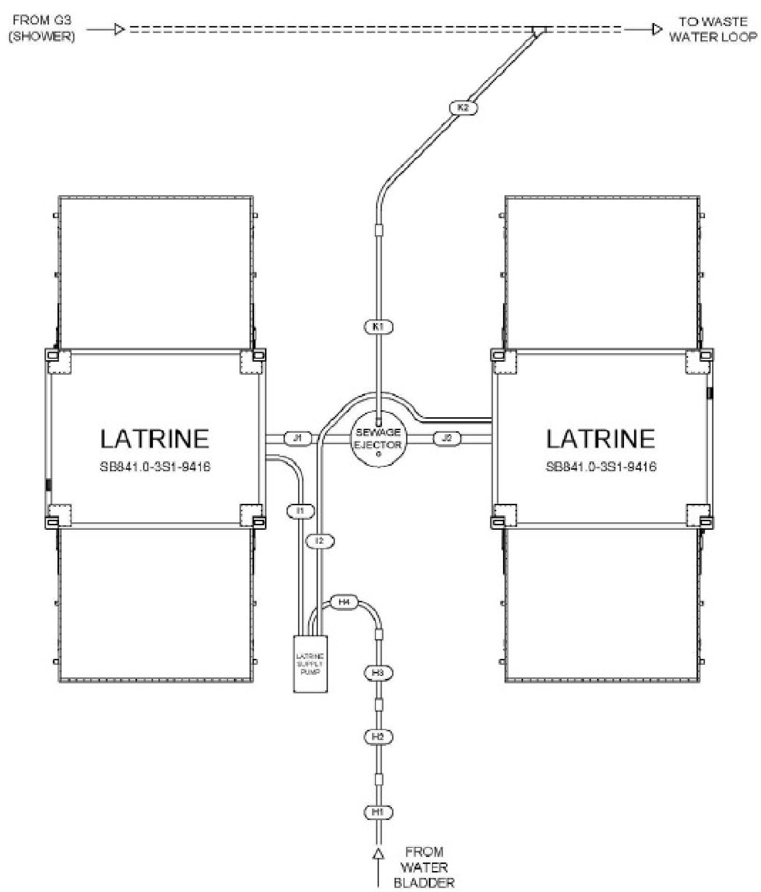


Figure 2–97. Sewage ejector pump and sewage hoses.

It is important that all hoses lay flat and are not twisted or kinked in any way.

HVAC system set-up

Although we are not required to set up the HVAC system, you will, at times, be required to work outside of your skills set. Getting familiar with the set-up of the HVAC system will speed up the entire set-up process. Do not install the HVAC system if you do not feel confident to do so. Ask for help from a technician from the HVAC career field.

The protective cover of the duct connection is held in place by two clips and a tether. Remove the cover and store. Remove the ducts and wyes from the Storage Bicon. Connect all ducts to wyes; then connect 7’ ducts to the HVAC feed and return ports on the containers. When connecting, make sure all four latches are first loosely engaged with the flange and then tightened. Connect 5’ ducts to the environmental control unit (ECU) (government supplied). If a 130K cold weather heater is being used instead of an ECU, connect the reducer/adaptor to the 5’ duct first, and then connect the adaptor to the heater (figs. 2–98 and 2–99).

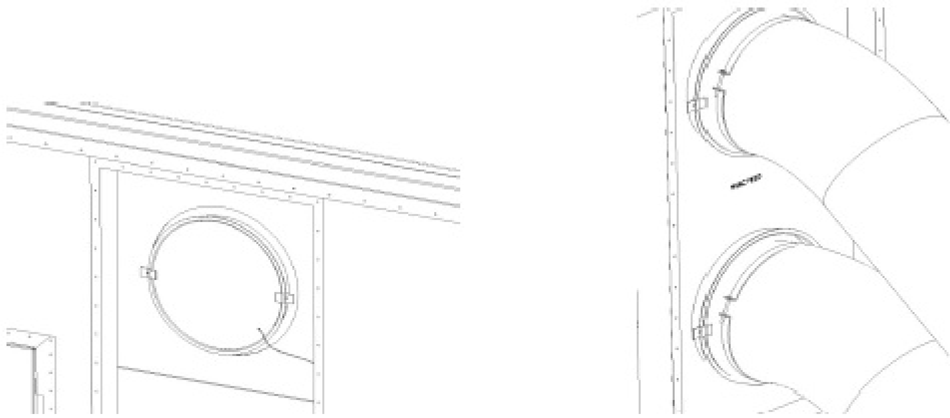


Figure 2–98. HVAC ducts.

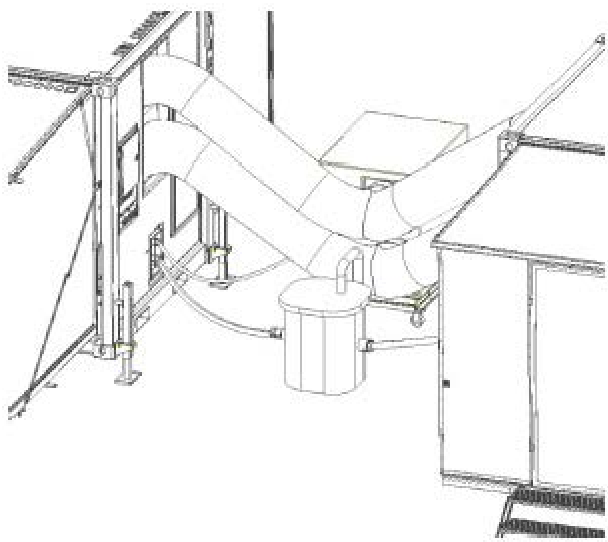


Figure 2–99. HVAC set-up.

Electrical system set-up and power on

Similar to the HVAC system, we are not required to set up the electrical system; however, as a WFSM technician, you will at times be required to work outside of your skills set. Getting familiar with the set-up of the electrical system will speed up the entire set-up process. Do not install the electrical system if you do not feel confident to do so. Ask for help from a technician from the electrical career field.

The grounding rod and hammer are stored inside one expandable end of each shelter behind the end partition wall. To ground the unit, attach one end of the cable to the ground rod and the other end of the cable to the ground stud next to the incoming power cable. Pound the grounding rod into the earth a minimum of 80”. The hammer used to drive the grounding rod is shown in the interior storage position in figure 2–100. Installation of the provided ground kit and its connection to the shelter’s ground stud located in the power entry Z-panel must be completed before turning on power! See figures 2–100 and 2–101.

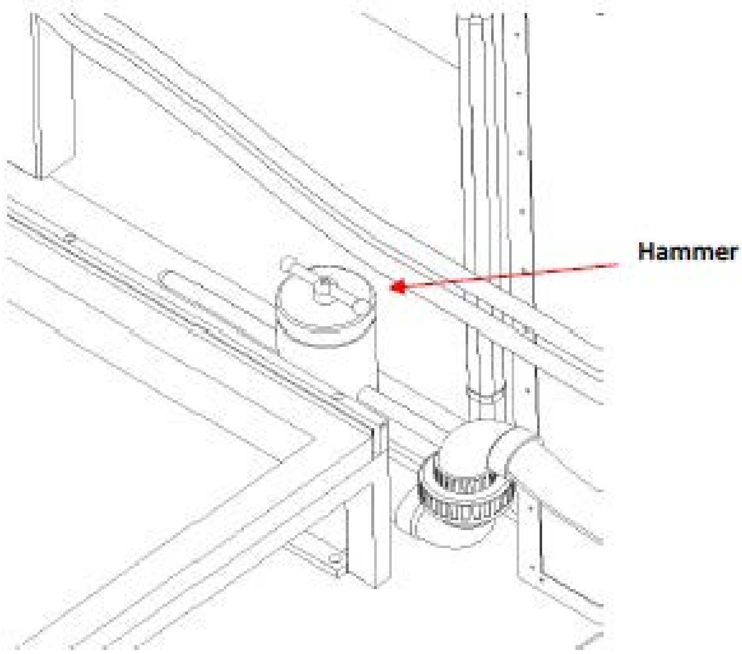


Figure 2–100. Grounding rod hammer.

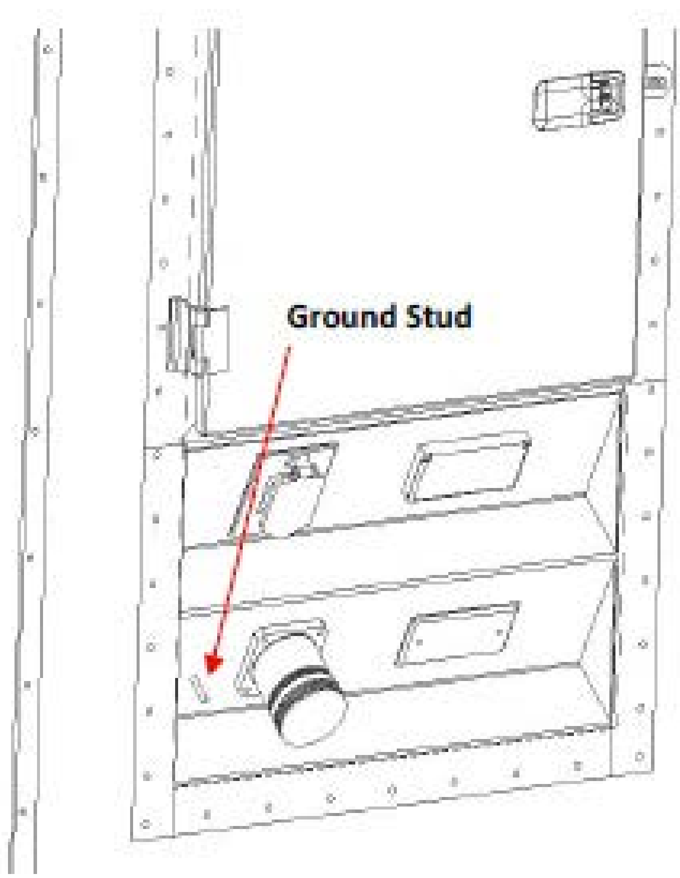


Figure 2–101. Ground stud.

The following tables detail the power panel and cable connections. Refer to figure 2–102 for the proper layout of the electrical system. Shower Shelters are S1 and S2; Latrine Shelters are L1 and L2.

SHOWER Power Panel Input/Output (I/O)			LATRINE Power Panel I/O	
Power Panel Reference # for S1 & S2	As Marked on Power Panel		Power Panel Reference # for L1 & L2	As Marked on Power Panel
1	CB 4, 120/208 (volt) V, 20 ampere (A)		6	CB 6, 208V 20A
2	CB 8, 208V, 20A		7 Convenience Outlet	CB 10, 120V, 20A, ground fault circuit interrupters (GFCI)
3	Ground (GND)		8	GND
4	120/208V, 3 phase (PH), 60A power inlet		9	120/208V, 3 PH, 60A power inlet
5 (Duplex)	CB 7, 120V, 15A		10	BLANK

	Power Panel Reference #'s			
To From	S1	S2	L1	L2
Secondary distribution center (SDC) – (4) 100' cables	4	4	9	9
AHW–400 boiler – (1) 25'cable	1			
Supply pumps – hard-wired	2			6
Drain pump – hard-wired		2		
Tents – Cables are ground fault equipment (GFE)	5	5		
Grounding cable	3	3	8	8
Sewage ejector pump – hard-wired			6	
Cables between SDC and ECUs or 130K Cold Weather Heaters are GFE				

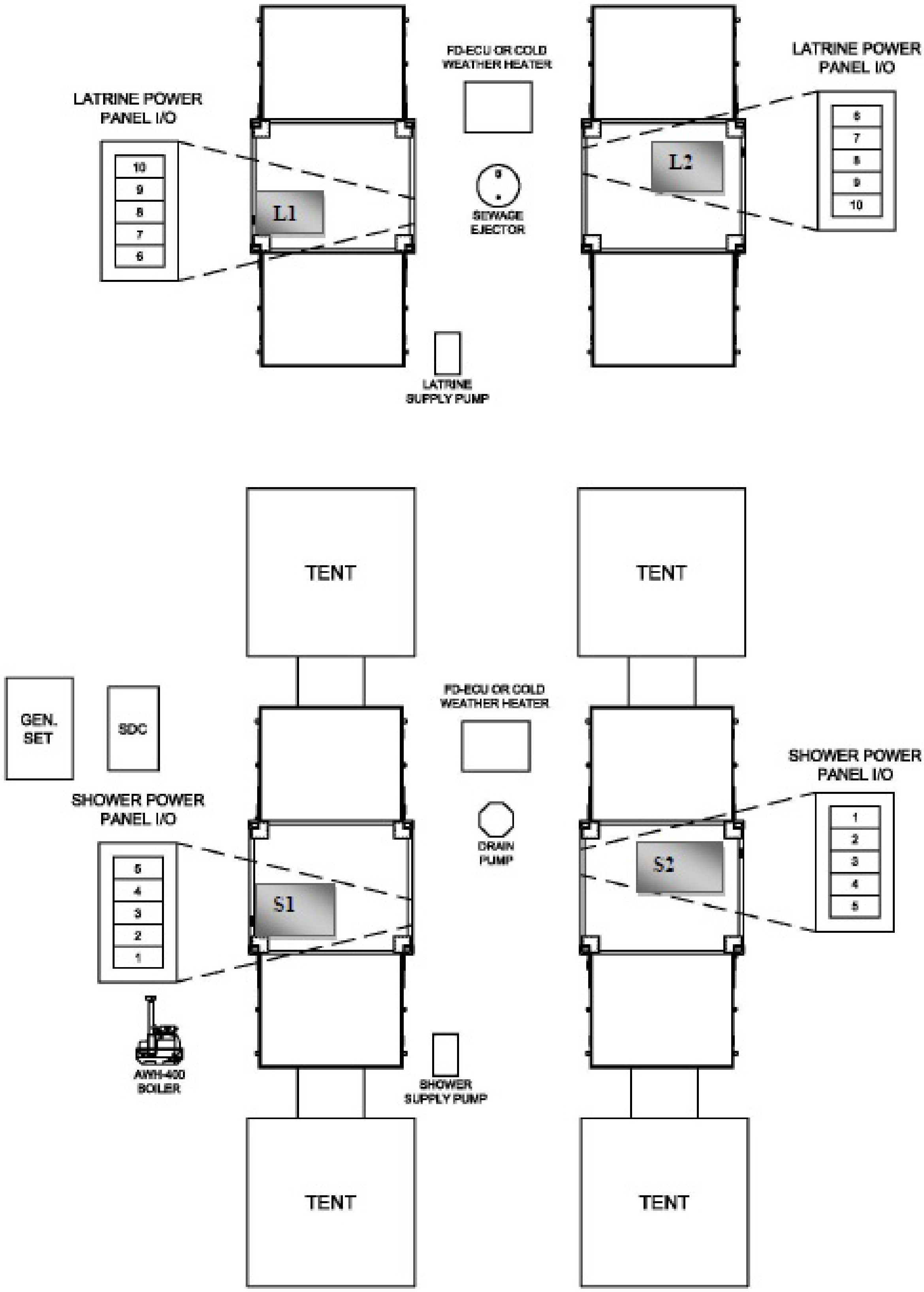


Figure 2–102. Electrical system.

Shower system power on procedure

Before turning on the power, the following items must be completed:

- Grounding cable has been connected to the ground stud on the containers and to grounding rod.
- Grounding rod has been anchored into the ground by at least 8’.
- All plumbing connections to supply and drain water must be completed.
- All feeders’ breakers in the distribution center must be in the OFF position.
- All shelters main breakers must be in the OFF position.
- ECU supply and return ducts must be installed to shelters.

Shower power entry:

- Connect 60A, 120/208V, 3-phase military cable to the military male inlet located in the shelter’s power entry Z-panel.
- Connect cable to military secondary distribution center.
- Turn ON corresponding breaker in secondary distribution center.
- Turn ON shelter’s main breaker.
- Turn ON lighting and receptacles breakers CB7, CB9 and CB11.

Repeat this procedure for the 2nd shower container.

ECU unit:

- Connect 60A, 120/208V, 3-phase cable to ECU’s military male inlet.
- Connect cable to secondary distribution center.
- Turn ON corresponding breaker in secondary distribution center.
- Turn ON ECU on correct mode as needed following manufacturer operation manual.

Shower supply pump:

- Connect shower supply pump’s cable to 20A, 208V, 1-phase exterior receptacle CB8 located z-panel.
- Turn ON CB8 breaker in shelter’s distribution panel.

AHW–400 Boiler (M–80 boiler replacement):

- Connect 20A, 120/208V, 3-phase cable to AHW–400 boiler. (**NOTE:** This cable configured for 120/208V, 3-phase, has its female connector wired for 120V since the water heater has a matching 120/208V, 3-phase male inlet wired for 120V).
- Connect cable to 120/208V, 3-phase exterior twist lock receptacle CB4 located in z-panel.
- Turn ON CB4 breaker in shelter’s distribution panel.

Grey water drain pump:

- Connect drain pump’s cable to 20A, 208V, 1-phase exterior receptacle CB8 located in the next shower’s z-panel.
- Turn ON CB8 breaker in shelter’s distribution panel.

The shower system electrical schematic is provided in figure 2–103.

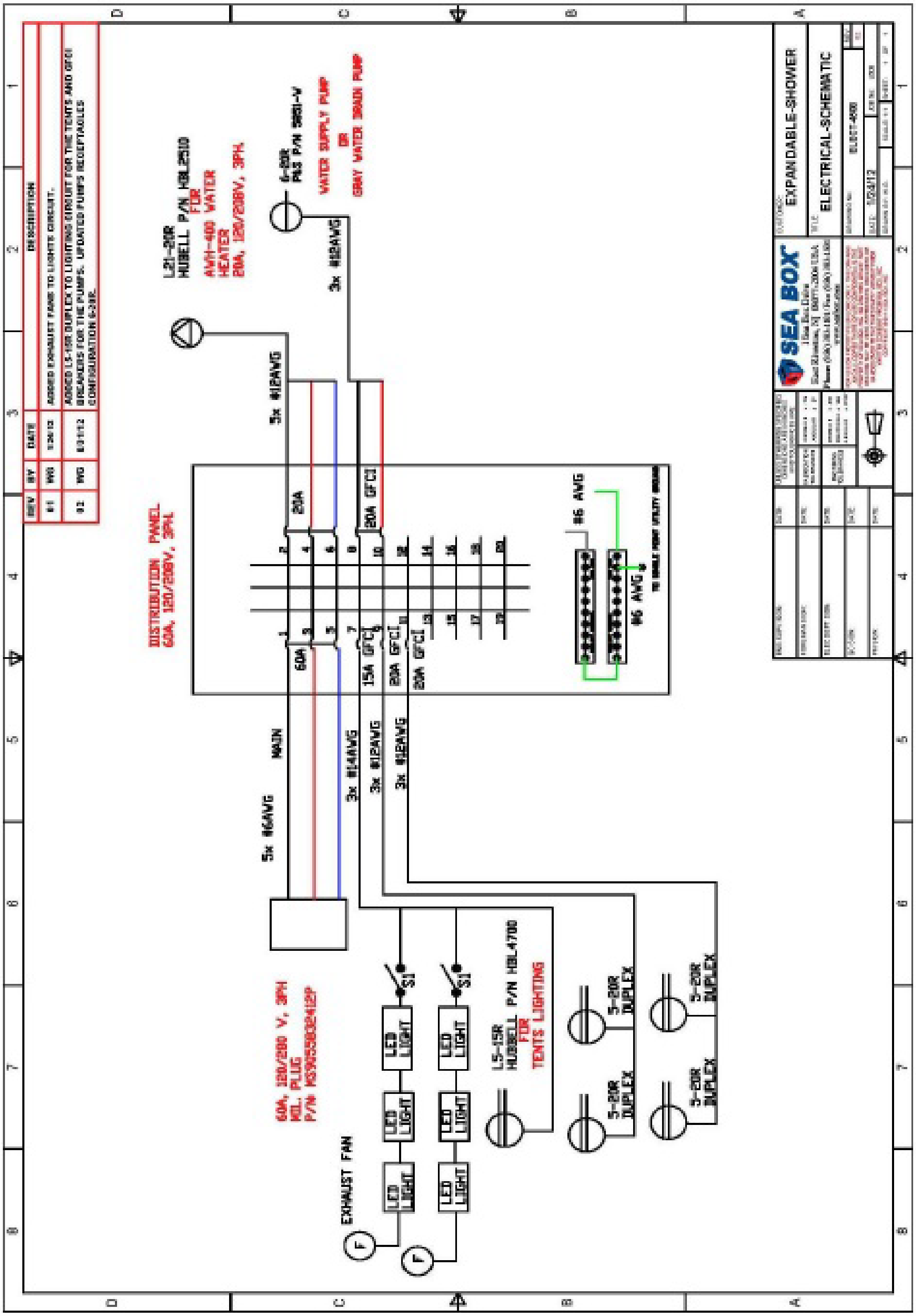


Figure 2–103. Shower system electrical schematic.

Shower system water on procedure

You should inspect that all exterior connections are complete and secure. Enter the shelter and locate the main valve which will be on the same side as the discharge. Main water valves are behind the shower partition wall. The wall can be easily moved if needed by removing the two thumbscrews then lifting the wall panel and pulling it out from the bottom. Turn the valve to the “on” position. Check for leaks. If no leaks are found, run the faucet for one minute to remove air from the line. After the air is removed, turn off the faucet and re-check the connections on the interior and exterior of the container to make sure all are secure and no leaks are present (fig. 2–104).

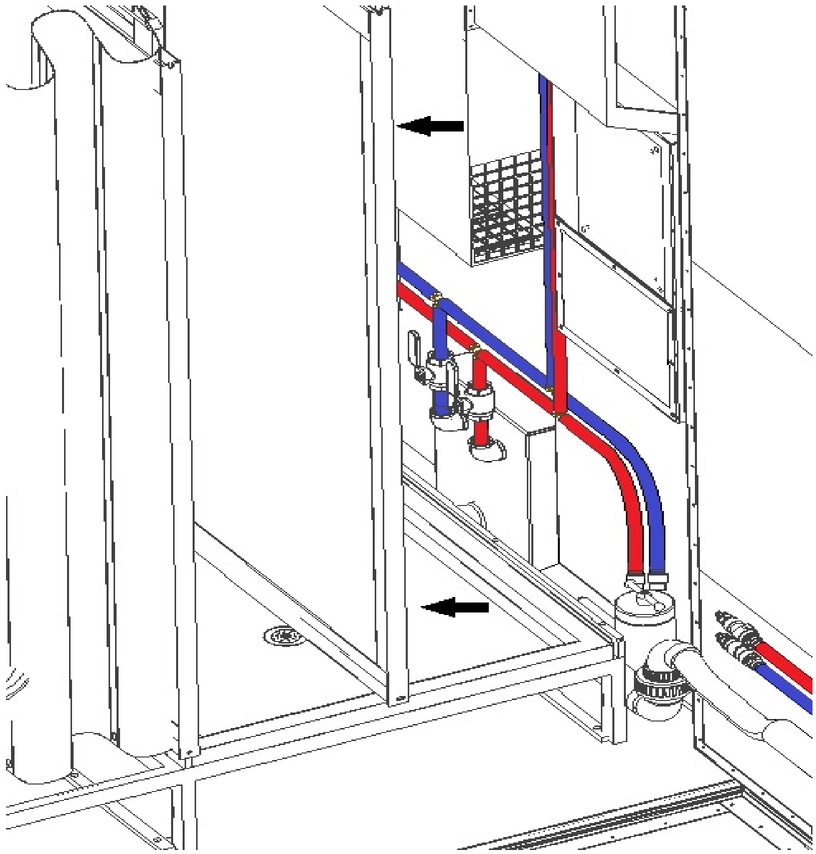


Figure 2–104. Shower system water.

Latrine system power-on procedure

Follow these procedures to power-on these latrine system components (Latrine System Electrical Schematic is provided in figure 2–105):

Latrine Power Entry:

- Connect 60A, 120/208V, 3-phase military cable to military male inlet located in shelter’s power entry Z-panel.
- Connect cable to military secondary distribution center.
- Turn ON corresponding breaker in secondary distribution center.
- Turn ON shelter’s main breaker.
- Turn ON Eemax EX8208T water heater, lighting, and receptacles breakers CB2, CB7, CB9 and CB10.

Repeat this procedure for the 2nd latrine container.

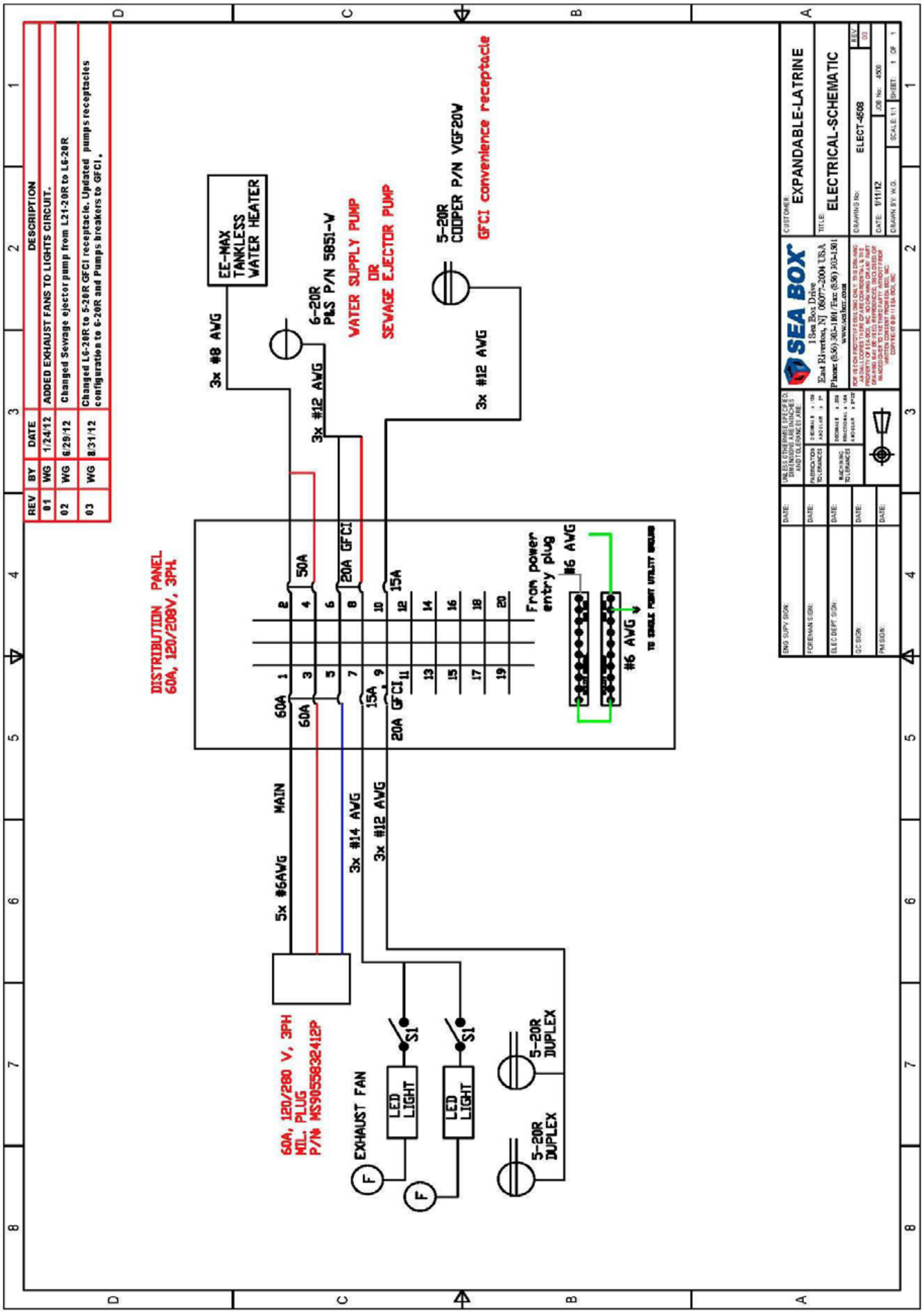


Figure 2–105. Latrine system electrical schematic.

ECU unit:

- Connect 60A, 120/208V, 3-phase cable to ECU's military male inlet.
- Connect cable to secondary distribution center.
- Turn ON corresponding breaker in secondary distribution center.
- Turn ON ECU on correct mode as needed following manufacturer operation manual.

Latrine supply pump:

- Connect latrine supply pump's cable to 20A, 208V, 1-phase exterior receptacle CB6 located z-panel.
- Turn ON CB6 breaker in shelter's distribution panel.

Sewage ejector pump:

- Connect sewage ejector pump's cable to 20A, 208V, 1-phase exterior receptacle CB6 located on the next latrine's z-panel.
- Turn ON CB6 breaker in shelter's distribution panel.

Latrine system water on procedure

After you inspect all exterior connections, walk inside the shelter and locate the main valve which will be on the same wall as the discharge. Turn the valve on and check for leaks. Tighten connections if leaks are discovered. Run the faucet for one minute to remove air from the line. Shut off the faucet and flush the toilet three times. Walk outside the container and check and secure any leaks or lose connections on exterior of container.

General maintenance and repair

This section is a general guide for shelter maintenance, skin inspection, and repair procedures for expandable type of insulated shelters. The shelters are basically a steel frame/substructure with insulated panels to form the walls, floor, and roof. The foam is protected from moisture and other contaminates by metal cladding and the use of sealant to all joints.

Each shelter should be checked for level weekly or after significant rain fall and adjusted to compensate for any shifting that may have occurred. Shelters should be cleaned on a regular basis. A non-abrasive soap can be used on the exterior of the Bicons and an antiseptic non-abrasive soap should be used to clean the interior. Struts should be cleaned regularly and especially before opening or closing to keep dirt from entering the mechanism. The system has been designed so that components can be isolated to allow maintenance and repair to be performed without shutting down the system. Each shelter has four floor drains for ease in cleaning. There is a main drain that exits to the exterior of the shelter for efficient cleanout. Interior and exterior connections including pipes, hoses, cables, HVAC ducts and wyes and pumps should be inspected daily. All connections should be tight and no water leakage should be visible. Every 3–6 months, shelter turnbuckles should be checked for lubrication and greased if necessary. Every 6 months, it is recommended that all seams and rivets that have been caulked be examined for damage and new caulk applied if needed. Silaprene SolidSeal high solids-low volatile organic compound (VOC) adhesive/sealant is recommended. Container-matched color is available from Sea Box. The system is equipped with a spare parts kit located in the Storage Bicon. The following table lists the spare parts along with a description of the replacement process.

Spare Part	Quantity Per System		Process for Replacement
	Shower	Latrine	
Shower Head	1		Removed damaged shower head and replace with new.
Shower Curtain	1		Removed damaged shower curtain and replace with new. Replacement curtain can be used in any stall on either side of the container.

Spare Part	Quantity Per System		Process for Replacement
	Shower	Latrine	
Faucet Aerator		2	Unscrew and remove damaged part. Replace with new.
PEX Clamps –½”	1	2	Remove a damaged ring and replace with new using a crimping tool.
PEX Clamps –¾”	1	1	Removed damaged ring and replace with new using a crimping tool.
PEX Clamps –1”	1		Removed damaged ring and replace with new using a crimping tool.
Crimper Tool	1		Use for replacing PEX rings. See above.
Brass Tube Fittings for PEX Clamps–½”	1		Remove damaged tube fitting and replace with new.
Brass Tube Fittings for PEX Clamps–¾”	1		Remove damaged tube fitting and replace with new.
Brass Tube Fittings for PEX Clamps–1”	1		Remove damaged tube fitting and replace with new.
Grounding Rod and Cable	1		Discard damaged rod and/or cable and replace with new.
2’ LED Light, P/N SBI–E2.1	1		Turn off lighting CB. Open access plate on light fixture and disconnect fixture’s wires. Drill out rivets and remove damaged LED light. Replace with new LED light fixture. Reinstall rivets and reconnect light fixture wires as they were previously. Turn on lighting CB.
4’ LED Light, P/N SBI–E2.2		1	
Electric Water Heater (Eemax EX8208T) Heating Element		1	Instructions included with replacement part.
Gas Piston Strut	1	1	While Bicon is fully deployed or while roof panel is opened and supported by extension pole, unbold upper and lower clevises. Remove from container. Unscrew clevises from damaged strut and re-screw onto new. Bolt to Bicon.
Urinal Flushometer Replacement (Sloan A-36-A)		1	Instructions included with replacement part.
S-trap		1	Loosen and remove damaged part. Replace with new.
P-trap		1	Loosen and remove damaged part. Replace with new.
Sliding Door Partition Rollers		2	Unscrew and remove damaged roller and replace with new.

Special procedures to be performed during long-term storage of shelters to prevent damage or deterioration of shelter include:

- Clean shelter interior to avoid growth of fungus, etc.
- Clean shelter exterior to avoid corrosion from salt, etc.

Inspection/temporary repair-exterior skin

The tolerances for deciding whether a repair is necessary or not can be determined by inspecting the skin to ensure that is not compromised and all functionality can be operated safely.

- It is only necessary to repair if the cladding is broken by cracks or grooves. Otherwise, only paint has to be refurnished.
- **IMPORTANT:** If the insulation is exposed due to cracks, etc., a proper sealing has to be done IMMEDIATELY. As a temporary repair, the cracks can be covered by self-adhesive tape (weather resistant) or covered by sealing compound. If there is not a proper seal, the water continuously enters the sandwich panel and causes delaminating between the skin and foam. In wintertime, frost will cause damage.

- Damage to the interior or exterior wall panels can be repaired by installing riveted overlaying patches.

PEX pipe repair

To repair a puncture to the PEX pipes, follow these procedures. Locate the puncture. Shut off the main water supply to the container. Cut entirely through the PEX pipe directly at the puncture location using a PEX cutting tool. Trim any rough edges on severed pipe edges to ensure both sides are smooth. Install a PEX coupling onto one side of the severed pipe. Slide a PEX ring onto the same side of the pipe. Install a PEX ring onto the other side of the severed pipe. Join the pipe to the coupling. Crimp the final PEX ring using crimping tool. The pipe is now repaired (fig. 2–106).

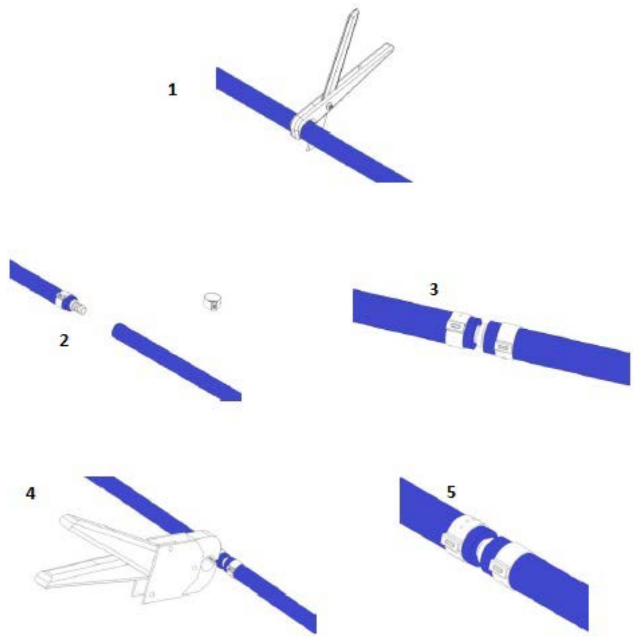


Figure 2–106. PEX pipe.

Shower layout

The internal layout of the shower is shown in figure 2–107.

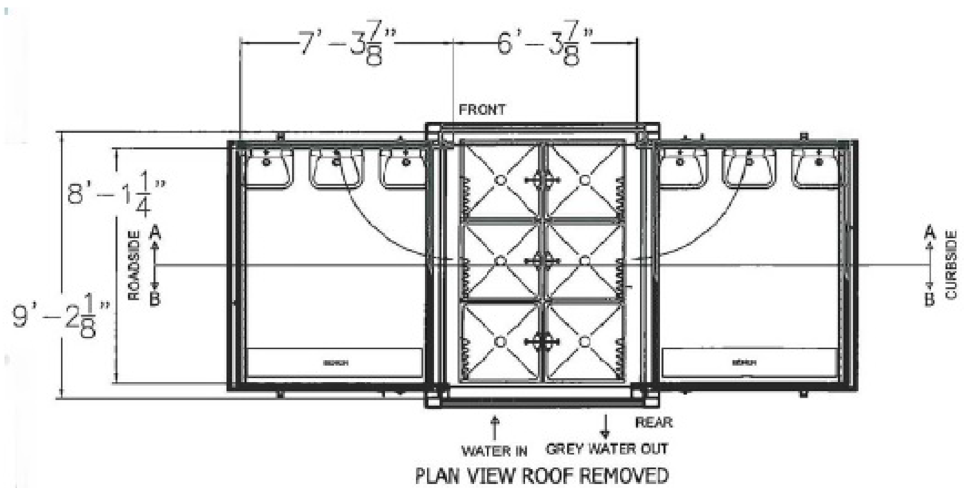


Figure 2–107. Shower layout.

A diaphragm-type vent is installed at the farthest sink; at the right of figure 2–108, you see a close-up view. The sink has shut off valves for hot (red) and cold (blue) water connections under the sink drain. This type of connector can be disconnected with water pressure present (figs. 2–109, 2–110, and 2–111).

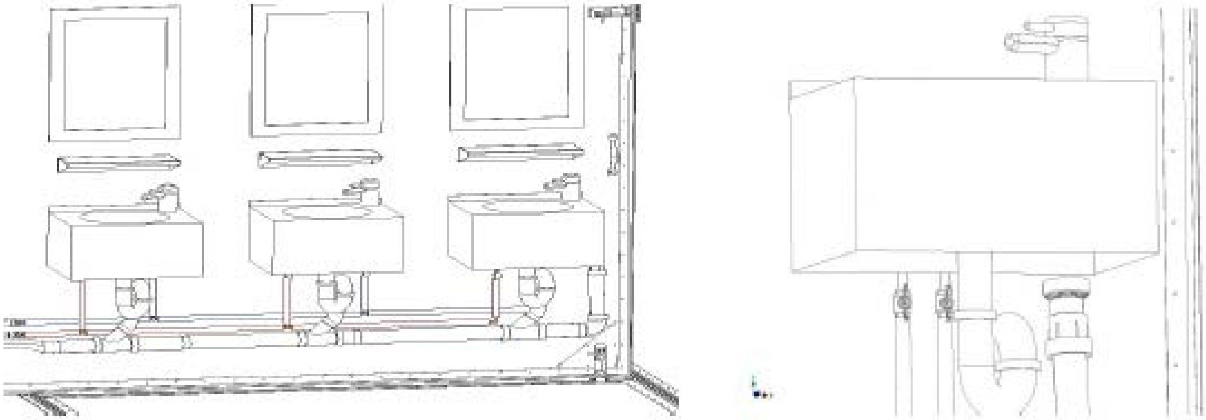


Figure 2–108. Diaphragm vent.

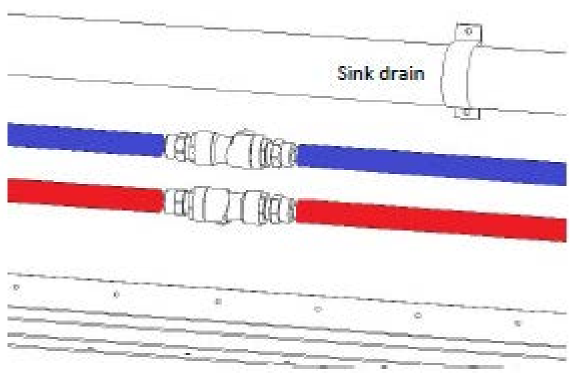


Figure 2–109. Shut off valves.

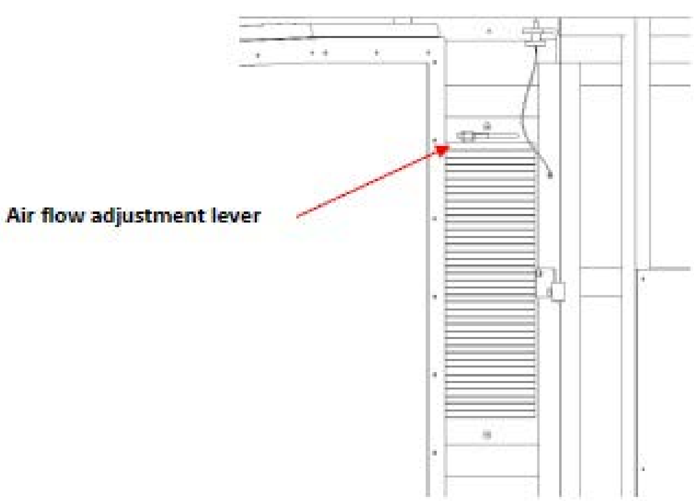


Figure 2–110. Air flow adjustment lever.

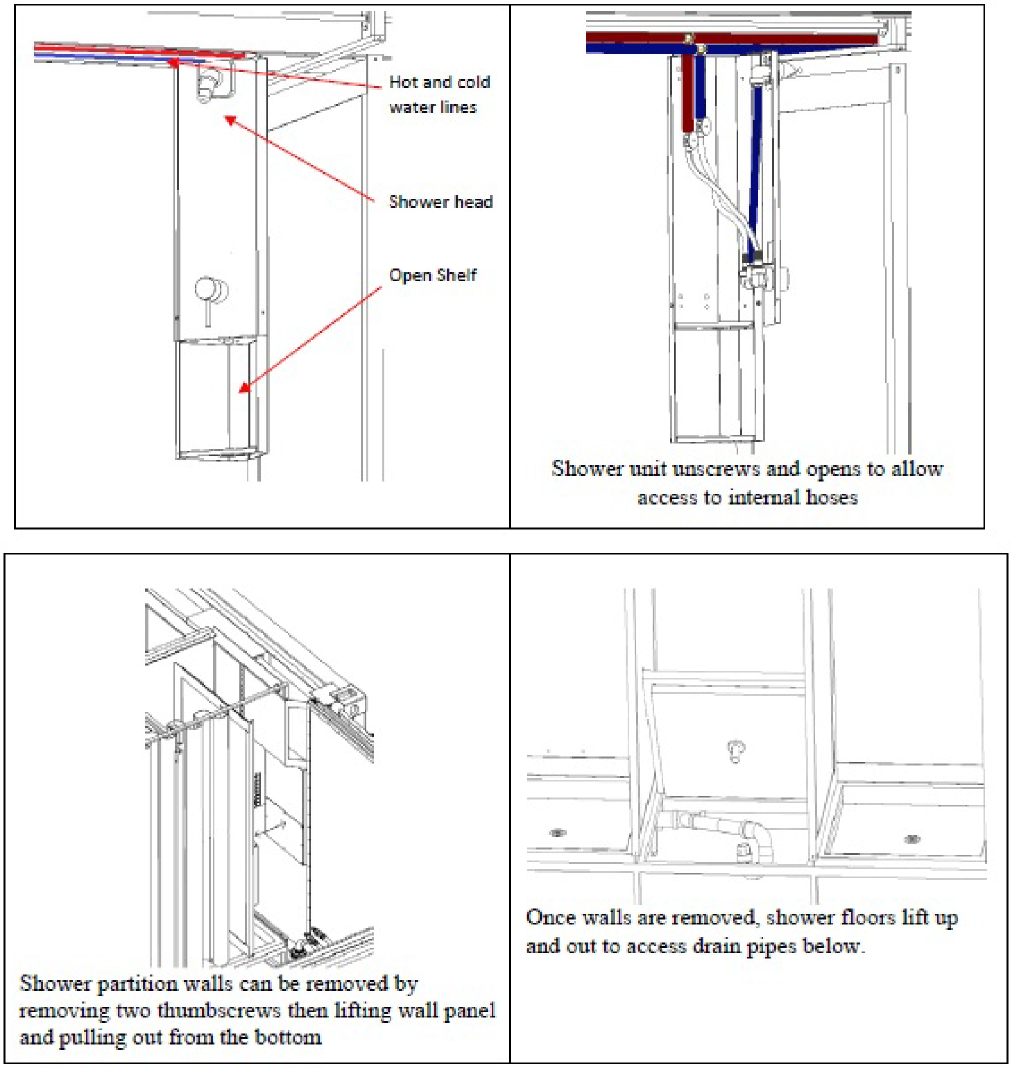


Figure 2–111. Shower internal hoses access.

Latrine layout

The internal layout of the latrine is illustrated in figure 2–112. Wherever possible, QD tool-free fittings are used.

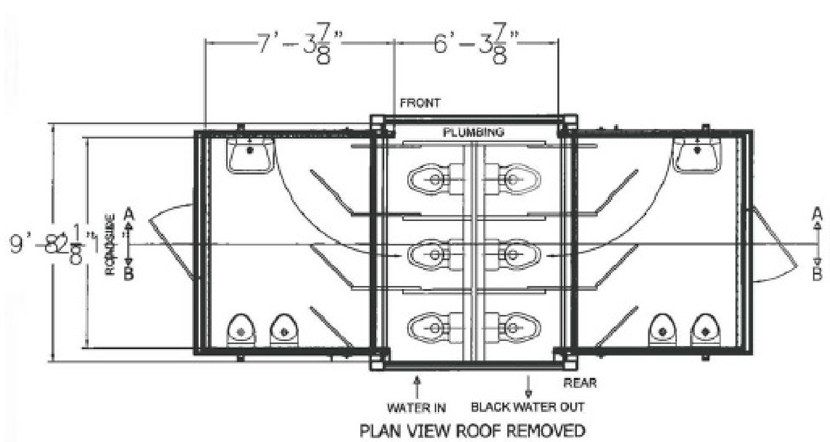


Figure 2–112. Latrine layout.

Urinals

Urinals are fixed mounted with two bolts, flush valve, drains for two-into-one, and water supply QD fitting (fig. 2–113).

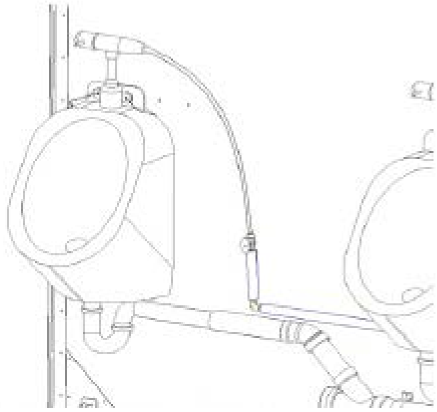


Figure 2–113. Urinal.

The urinal fixtures are identical. They each have their own shut-off valves, drains, and water supply lines. The two left side fixtures (on either side of the latrine) move to facilitate movement necessary for positioning into the transport mode. The two sides of the latrine shelters are mirror images of each other. The urinals' water supply lines and valves are ½". The supply lines are PEX ½" flexible lines.

NOTE: For service and/or repair, it is recommended that a PEX crimping tool and crimp rings are used along with PEX ratchet clamp and cutting tool and the stainless steel clamps. The shelter has a drain clean-out, found on the opposite side of the shelter from the main drain below the incoming water line. The cleanout drain can be used, if necessary, to flush out the system or remove clogs.

623. Medical facility support

The AF has developed a number of deployable medical treatment facilities to treat combat casualties. Your involvement with these facilities is limited to providing facility erection and utility support. These bare base medical facilities are as follows:

1. Air transportable clinic (ATC).
2. Expeditionary medical support system/Air Force theater hospital (EMEDS/AFTH).

ATC

The ATC consists of one air-transportable pallet, one tent, and the medical supplies necessary to support one flying squadron for 30 days. The ATCs provide only outpatient services; they have no messing facilities or quarters and require base element support. Increasingly, the ATCs are the first medical support sent into a deployed location, and they become the flightline clinic when medical capability is increased during a site build-up.

EMEDS/AFTH

EMEDS/AFTH is put together in a building-block configuration designed to provide care in deployed locations to meet the needs of the population at risk; therefore, they use as small a footprint in the transportation system as possible. EMEDS are aircraft-palletized configurations housed in a combination of tent expendable modular personnel (TEMPER) and Alaskan tents. The EMEDS are designed to support a number of contingency types, including the AEF, war operations, deterrence and contingency operations, peacetime engagement, crisis response, and humanitarian relief operations. Stateside EMEDS are assigned primarily to AEF-aligned bases and large medical centers. Staffing for an EMEDS comes primarily from the base medical facility that maintains the modules during peacetime, although personnel may be requested to augment in urgent home station staffing situations. As WFSM personnel, you will be responsible to provide the required amount of water for the ATC and the EMEDS/AFTH and provide support during initial set-up.

624. Contingency equipment

Depending on location and availability of contract support, you may find yourself providing water and removing wastewater from the facilities you maintain. Next, we will briefly cover some types of equipment you might use to accomplish these tasks.

Sewer cleaning trailer and operational principles of a vacuum truck

The sewer cleaning trailer, otherwise known as the SST is a vital asset during contingency operations. Many WFSM personnel have been deployed to contingency areas and have had to use this piece of equipment. Unfortunately, many people have had problems operating this trailer because they did not understand its capabilities or expected much more than was possible from it, considering its design. In this section we will look at the SST's operating principles.

General operational theory

There are a few general principles you must understand before operating the SST. Knowing a little about the design of this machine should preclude you from becoming frustrated during its operation.

General theory of vacuum loading (truck or trailer)

A vacuum condition is introduced into an enclosed cylinder or tank using a vacuum pump. This high-speed pump draws air from the outside of the tank through the suction port (hose) of the tank and *discharges* the same volume of air through an exhaust port. A "wind tunnel" condition exists inside the tank when this vacuum pump is on. The vacuum created inside the tank will be more or less, depending on the revolutions per minute (rpm) setting of the pump. A vacuum gauge mounted on the tank will indicate the vacuum or pressure gradient inside the tank. The rotating fan in the vacuum pump may have speeds as high as 10,000 rpm and move air as much as 1,000 cubic feet per minute (cfm). This is vital in any commercial sewer cleaning truck or trailer unit. The high performance of the vacuum pump enables the tank to be under 8–15" of vacuum at all times when the pump is on. Most commercial sewer cleaning trucks or trailers are built this way. These types of units can easily vacuum rocks, sludge, grit, sand, and small objects. They never lose vacuum as long as the pump is on, and they can be left on with the boom valve open.

SST theory of operation

The one exception for this general design theory we just discussed is the way that our SST is designed. The SST is designed so that the vacuum pump draws air from *inside* the tank and expels it to the atmosphere (fig. 2–114). A vacuum condition is first created inside the tank during this procedure by closing the boom suction valve. Once the proper amount of vacuum is obtained (usually 10"), the boom suction hose is lowered into the container to be drained, and the boom valve is opened allowing fluids to be sucked into the tank. The boom valve, which is located at the end of the boom hose assembly must be closed before the container to be sucked is completely drained. If this is not done, air will enter the tank and the vacuum condition will be lost as the inside of the tank equalizes with the outside atmosphere. This is the major disadvantage of this sewer trailer. The main culprit of this failure is the type and size of the vacuum pump. The vacuum pump on this trailer is a rotary vane, 175 cfm pump. It is really not designed to be used in the way it is installed on the sewer trailer. A 500 cfm positive displacement (blower) pump would have done a much better job of keeping air moving in the tank with the boom valve opened. Yet, we must work with the equipment on hand, no matter how poor the design. Commercial vacuum trucks have a large enough cfm blower to operate the vacuum with ease of operation.

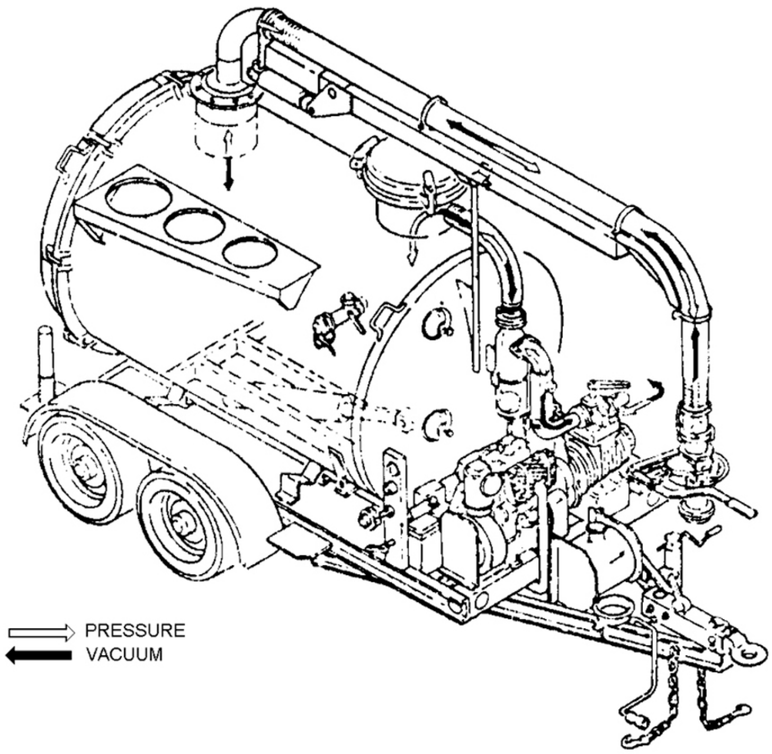


Fig. 2–114. Sewer trailer flow pattern.

As with any AF equipment, you should always study the appropriate TO before operating the equipment. For the specific procedures for the use and operation of the sewer-cleaning trailer, consult TO 36A11–18–24–1, *Trailer, Sewer Cleaning, Model JV1000A F.*

Water distribution truck

The water distribution truck is used extensively during contingency deployments. You will find it common that some bare base facilities are not connected to the BEAR water distribution system due to the isolated location of the facility. Typically, these isolated facilities will have a storage tank for the potable/non-potable water supply and a storage tank for wastewater collection. Clearly mark the trucks for their intended purpose—potable or non-potable—to eliminate cross-contamination.

As WFSM personnel, you are responsible to fill and maintain these isolated water storage tanks. The typical water truck is nothing more than a commercial water tank truck with a gas-operated centrifugal pump to fill the water tanks. Operating the water truck is straight forward, but there are a few things to keep in mind during water truck operations.

1. Fill water trucks at the end of each shift. Having trucks ready for the next day allows you to be ready for the late night stand-by call.
2. Establish a well-planned route and filling schedule for each facility with a water storage tank.
3. At the start of each shift, properly fill out the AF Form 1800, Operator’s Inspection Guide and Trouble Report. Good maintenance is the key to an efficient water truck operation.
4. Pass on good operational instructions for the next rotations that will follow you. You should always strive to leave the air base better off than you found it for the next rotation.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

617. Set-up and maintenance of the self-help laundry

1. What does the self-help laundry package consist of?

2. What level do you adjust the water heater temperature to for washing clothes?

3. How do you relieve air from the water heater tank?

4. How many gal. of wastewater per day will the self-help laundry generate if the camp totals 150 personnel?

5. What problems can cause the supply pump to continuously cycle on and off?

618. Electric kitchen

1. What pressure does the potable water electric pump maintain the electric kitchen’s water distribution system?

2. How much water per person per day for food preparation is needed?

3. When designing an evaporation bed, how many square feet are factored in for each person per day?

4. Why is a grease trap installed on the drain of the kitchen?

5. What is the simplest type of grease trap to build?

619. Setting up liquid storage bladders

1. What are the two main sizes of water bladders used in the field?

2. What do you use to mask your facility from the enemy and to reduce excessive heat gain on a water bladder?

3. When filling the 20,000 gal. water bladder, what is the maximum height they can be filled?

620. Setting up the field deployable latrine

1. How large is the waste tank of a field deployable latrine?

2. How much water is needed to prime the pump?

3. When should the waste tank be drained?

4. What methods can you use to dispose of waste from the waste tank?

5. When you use a forklift to drain the waste tank, why should the lids be secure?

621. Using the bare base shower facility and shave stand

1. How many personnel can shower at any one time in the shower/shave facility?

2. What are the major pieces of equipment in the bare base shower/shave facility?

3. What components are included in the pump assembly?

4. What piece of equipment heats the water in the shower/shave facility?

5. What is the size of the water supply hoses and the drainage hoses in the shower facility itself?

6. How far should you place the fuel container from the boiler?

7. How long should you wait before resetting the boiler if combustion fails?

8. Right after start up, what should the M-80 boiler exhaust gases look like coming from the exhaust stack?

9. At what temperature should the temperature regulator be set at and what is the maximum allowable temperature for showering?

10. How many sinks are included in each shave stand?

11. What is used to lock the legs of each shave unit in place?

12. What is the diameter of the drain hoses for the shave units?

13. What is the purpose of the “T” cable in the wiring harness of the shower shave unit?

14. What action should you take if the shower heads drip after turning them off?

15. How often do you inspect pumps for debris, leakage, or damage?

16. What four problems are likely to occur with the shower shave facility?

17. What four separate components used with the shower/shave facility are likely to require actual repair in the field?

622. Expandable Bicon Shelter Hygiene System

1. With the EBS Hygiene system, how many showers, sinks, toilets, and urinals are there?

2. When setting up the latrines what size T-handle Allen wrench do you need?

3. Why do you have to dig a 12” hole for the shower drain pump?

4. How often do check the shelter turnbuckles and what do you check for?

623. Medical support

1. Which bare base medical facility provides outpatient clinic services?

2. Which medical facility is housed in a combination of TEMPER and Alaskan tents?

624. Contingency equipment

1. Explain the usual principle of operation of a vacuum truck or trailer.

2. What must be closed before the container being vacuumed is completely dry?

3. How much air does the vacuum pump on the SST displace?

4. How do you ensure there is no cross-contamination between the potable and non-potable water trucks?

2–3. Fuel System Repair and Recovery

In this section, you will learn the basics for the petroleum, oils, and lubricants (POL) rapid utility repair kit (RURK) system. If you need more information, refer to TO 35D26–9–2–1, *POL Rapid Utility Repair Kit System (POL RURK)*. The POL RURK can be used as a water RURK if the kit has *never* had fuel through it. All the concepts are the same for the POL RURK as it is for water RURK.

625. RURK I concepts and fundamentals

This lesson covers several general areas concerning the rapid utility repair process, including safety, manpower, support, delivery, and peacetime and attack issues. The rapid utility repair process begins during peacetime. Peacetime training, planning, and preparation are critical. Pre-attack preparations must be identified, coordinated, and completed before hostilities commence.

Description

The RURK I is used to make temporary repairs to fuel pipelines and valve pits. The RURK I configuration consists of an open-bed trailer, collapsible fabric tank, air compressor, four trailer containers, and a variable number of supplemental containers. Each RURK I provides the capability to perform one in-crater repair, three bypass repairs, and one 4-way valve pit repair for 4”, 6”, and 8” pipe. Supplemental packages are provided for site-specific requirements for extra components to support additional repairs of 4”, 6”, or 8” pipe. Supplemental packages for 10” and 12” pipe and puncture repair for 4–12” pipe are also available. The kit contains equipment and material to remove damaged sections of pipeline, evacuate fuel from pipelines, repair damaged pipe, dress pipe ends, and attach temporary hoses and valves as needed to resume fuel flow.

Types of repairs

There are five types of repairs that can be made by using the RURK I: in-crater, bypass, valve pit, pipe end cap, and puncture. Keep in mind that even though these repairs are temporary, they have to be done well enough to last until permanent repairs can be completed.

In-crater repair

To make this repair, you must enter the crater, saw off damaged pipe ends, and attach various hoses and pipes to re-establish flow and pressure. Three team members can make an in-crater repair of a 4”, 6”, or 8” pipeline in 45 minutes, or a 10” or 12” pipeline in 60 minutes. Figure 2–115 depicts an in-crater repair.

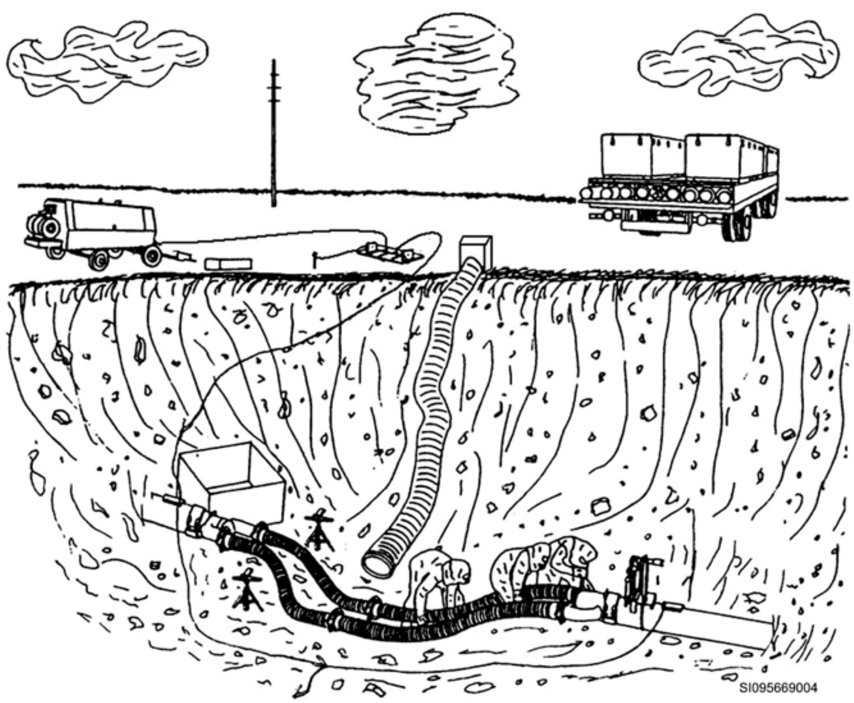


Figure 2–115. In-crater repair.

Bypass repair

This repair serves the same purpose as the in-crater repair but is done by exposing undamaged pipe on each side of, but away from, the crater edge. Three people can make a bypass repair of a 4”, 6”, or 8” pipeline in 1 hour and 45 minutes, or a 10” or 12” pipeline in 2 hours. Figure 2–116 shows a bypass repair.

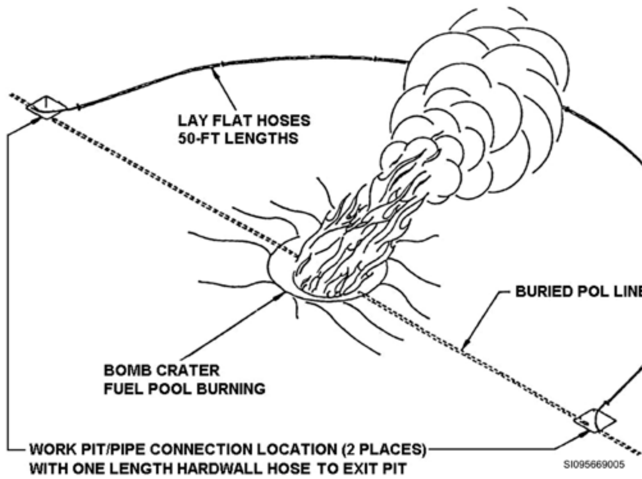


Figure 2–116. Bypass repair.

Valve pit repair

This repair can be used independently or in conjunction with either in-crater or bypass repairs. Butterfly valves are included so that fuel can be controlled and/or directed. It is important to note that in a valve pit/in-crater repair (depicted in fig. 2–117), the valve manifold should be located outside the crater and upwind to make it more assessable and to avoid vapor hazards or any hazards within the crater.

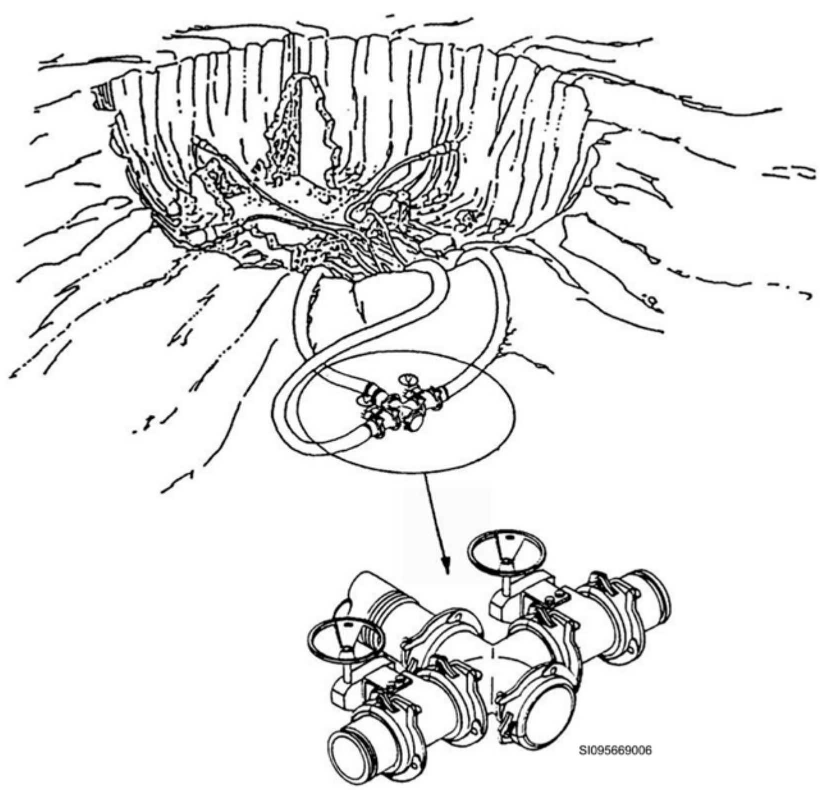


Figure 2–117. Valve pit repair.

Pipe end-cap repair

This type of repair is used to isolate one end of a pipe or any leg of a cross piece (fig. 2–118). This can be a quick repair of a damaged looped system or to isolate fuel system sections.

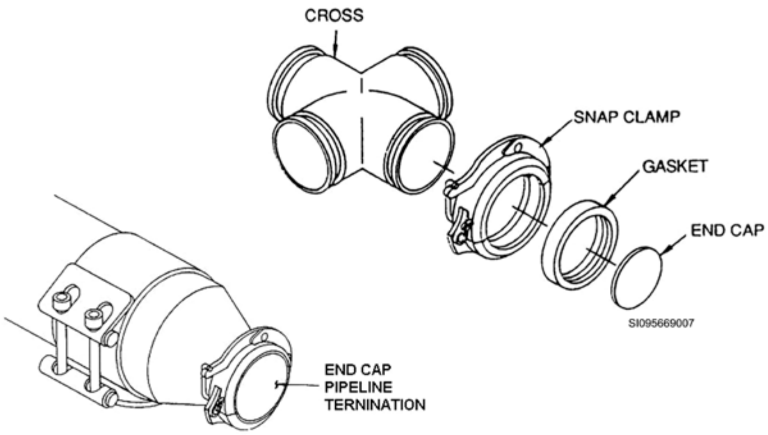


Figure 2–118. End cap repair.

Puncture repair

To repair a puncture, you use a repair clamp (full-circle clamp) to cover a hole in a pipeline small enough not to require removing a section of pipe. Figure 2–119 shows a pipe puncture and full-circle clamp.

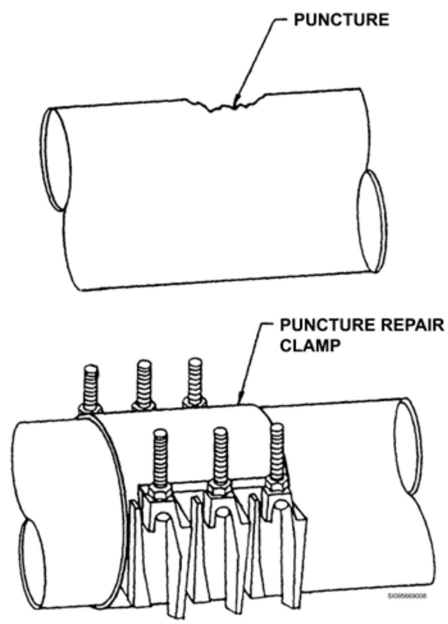


Figure 2–119. Puncture repair.

Manpower

Each air base should have a primary and a backup RURK team. Each team must have a minimum of three people. The team will consist of a team chief with fuel system maintenance experience and two other WFSM helpers.

Support

The RURK I is not self-contained. POL pipeline repairs require additional support equipment and personnel. A tow vehicle is needed for the trailer and compressor. It should have a capacity of at least 2 ½ tons and a cargo bed large enough to carry additional repair materials. A backhoe or excavator is required to remove debris and expose undamaged pipeline ends. A large-capacity pump may be needed if fuel and/or water is in the crater and exceeds the capacity of the RURK pump.

An explosive ordnance disposal (EOD) team may be required to remove any unexploded explosive ordnance (UXO) that may hinder system repair. A fire truck and team may be necessary to extinguish existing fuel system fires and/or be on site if there is a considerable amount of fuel in the repair area.

Safety

As always, personnel safety is a priority even in a wartime environment. When using the RURK I, safety considerations fall into three categories: before, during, and after operation.

Before operation

Safety practices must begin *before* operation begins. Giving the kit's equipment, a thorough inspection during the initial inventory is a must to ensure a safe work environment when you are tasked to make system repairs.

Even the task of driving to the repair site has some safety guidance. Exceeding the allowable towing speed of the RURK trailer can be hazardous. Tow the trailer no faster than 25 mph on dirt or gravel roads, and no faster than 45 mph on paved surfaces.

In addition to chemical, biological, radiological, nuclear, and high-yield explosives (CBRNE) hazards, the RURK team may encounter conditions at the repair site that complicate or delay repair efforts. Examples include fire, burning fuel, saturated soil, pooling fuel, breathing hazards, and/or a contaminated repair site. The existence and timely mitigation of any of these hazards must be dealt with before repairs can be made.

During operation

Do not enter a work site until the team chief tells you to enter. Pooling fuel and fuel mist/vapors are the most serious hazards associated with RURK I operations. If no respiratory equipment is available, repair team members will not enter the work area if the lower explosive limit (LEL) is above 1 percent. Additionally, when work is being accomplished and no respiratory equipment is being used, they must leave the work area if the LEL goes above 1 percent. If elevated LEL conditions occur, ventilate and keep workers out of the area until the LEL is < 1 percent.

If air-purifying respirators (APR) are available, they can be used safely if the fuel vapors are ≤ 10 percent of the LEL and the oxygen levels in the air are between 19.5–23.5 percent. Since APRs only filter fuel vapors out of air, they cannot be used in atmospheres with less than 19.5 percent oxygen.

If supplied air respirator (SAR) equipment is available, it can be used when oxygen levels are below 19.5 percent. But, if the vapor levels rise above 20 percent of the LEL, stop work, leave the area, and ventilate until the LEL levels are safe.

Besides preparing the site for repair operation, the excavating equipment can be used to mitigate fuel hazards by removing saturated soil. Always keep clear of heavy equipment when in motion and direct their operations from a safe location.

Do not allow your NBC protection clothing to come in contact with fuel or fuel-saturated soil. Contact will render the NBC protection clothing ineffective and a chemical attack could seriously injure or kill you.

Whenever possible, use fuel resistant personal protective equipment (PPE) (boots, gloves, etc.) to prevent skin contact with fuel. Wear goggles, face shields and ear plugs or muffs to protect your eyes, face, and hearing. Take care around work sites as well to avoid tripping hazards.

Keep fire extinguishers near access and exit points and keep these areas clear. Remove spark-producing materials, such as keys, matches, lighters, watches, and so forth, to prevent a possible explosion or fire, and ensure all equipment is grounded and bonded. Never make power or grounding/bonding cable connections in the crater or around fuel-saturated areas. Fuel vapors that could be present could cause an explosion or fire. Further, never connect power cables to GFCIs or to a generator outlet until the generator is operational.

For night operations, place area floodlight stands no closer than the height of the floodlight from the edge of the crater. If an operating lamp falls in the crater, an explosion could occur.

Don’t stand downwind of an operating vaneaxial fan. Doing so could cause you to be overcome by toxic vapors from the crater. Monitor LEL until the repair is completed. Disconnect all air lines before moving the hacksaw, fan, and pump.

After operation

Maintain communication with persons responsible for pressurizing pipeline while testing is in progress. Stand at least 50’ away from the pipeline when it is being pressurized.

Survivability and rapid recovery of air base utility systems are essential elements of air base wartime capabilities to provide a fighting platform for air warfare. In wartime, significant damage from air attack is predicted, and air base utility systems are not expected to survive. Key elements of the utility systems will likely have to be repaired or replaced to support critical base missions. The POL rapid utility repair kit I provides CE forces with the equipment, tools, materials, and procedures to rapidly make temporary repairs that quickly restore the flow of jet fuel to support air base operability and base recovery after attack.

Delivery

The RURK I is delivered to user organizations as an open-bed trailer pre-loaded with four component containers (fig. 2–120). When put to use, the RURK requires unpacking and preparation. When you receive the RURK, you must make an initial inventory and inspection. Use the shipping documents to conduct a complete inventory. You must know what assets you have in order to up-channel repair capabilities.

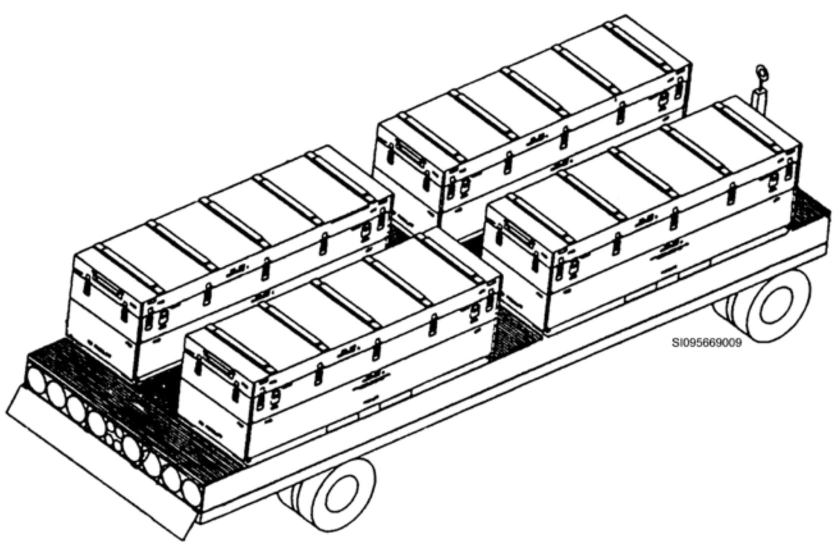


Figure 2–120. RURK I trailer.

RURK I containers are sealed for long-term storage. Do not open containers unless humidity indicators are pink, seals are broken, or there is evidence of damage. If one of these conditions exists, inspect the contents and repair/replace damaged or missing items. Repair or replace the rubber seal around the container lid if necessary. Store the RURK I as a WRM asset.

Peacetime preparation

To ensure the RURK will operate when put into use, you must periodically inspect and service some components. During periodic inspections, conduct an inventory using TO 35D26–9–2–1. At the 5-year inspection, you must inspect, service, and/or operationally check certain RURK I components, specifically, the compressor, generator, portable hacksaw, floodlights, vaneaxial fan, and reciprocating pump. Check all shelf-life items and replace them if they are past the disposal date. Procedures are provided in TO 35D26–9–2–1.

Pre-attack preparation

Get the POL system maps and drawings from the damage control center (DCC) to familiarize yourself with the system key facilities and isolation points. Connect at least a 2½-ton tow vehicle to the trailer. Inspect and service the trailer and connect a compressor to it.

Get a serviced flightline type of fire extinguisher, and ensure all team members can operate it. Check consumable items like batteries, cleaning rags and solvents, wire brushes, lubricating and motor oils, safety wire, and soft grease needed for RURK I equipment and operations.

Tow the trailer and compressor to the pre-attack preparation site. Disconnect the trailer and the compressor, position ramps to the trailer bed, and open the containers. Using TO 35D26–9–2–1, make a complete inventory of the RURK I. Replace missing or damaged components. Service and operationally check the compressor, generator, portable hacksaw, portable and mast floodlights, reciprocating pump, tapping and fuel suction tool, and portable ventilator. Replace all items that are not satisfactory.

NOTE: If an air motor fails to rotate when air is applied, manually rotate the motor shaft to make sure the shaft rotates freely.

Refer to TO 11H5–35–1, *Operation and Maintenance Instructions, Combination Gas and Oxygen Indicator*, *Automatic*, when you prepare the vapor detector for use. Then, using the owner's manual, prepare a utility line tracer for use. Calibrate the primary and spare torque wrenches and place the vapor detector in a position for immediate access.

Now inspect, service, and operationally check the components of the essential tool set, critical spares kit, and packages "B" through "E." Using correct socket and torque wrenches, tighten the lay-flat hose coupling nuts to 40 foot-pounds. Reset the torque wrenches to the lowest setting, and inspect and service pipe cutters, coating removal tool (CRT), air line manifold, deicer assembly, hand winch, pipe stand, puncture repair clamps, and reinforcement sleeves.

Reload the component consolidation containers and replace their lids, and then re-connect the compressor to the trailer. Advise the DCC of any deficiencies or shortages.

Post-attack actions

In a post-attack environment, damage assessment response teams (DART) will assess, prioritize, and report damage to POL pipelines. RURK teams will be dispatched to make repairs. The CE DCC is assigned to use this information, along with other inputs, to make an overall damage assessment. If sufficient POL pumping assets remain, the DCC will direct RURK teams to repair the damaged pipelines so you can resume dumping the jet fuel.

Inspect the compressor, trailer, and tow vehicle, and advise the DCC of equipment condition. Make sure an excavator/backhoe and operator are available. Make sure impressed cathodic protection is turned off. When directed by the DCC, move the equipment to the repair site over preplanned routes. Watch for UXOs. If UXOs block the route, use an alternate route and advise the DCC. To save some time, the team can remove the vapor detector from the kit before departing for the repair site since it will be the first piece of equipment used when approaching the damaged area.

At the crater

If possible, approach the crater site from upwind and uphill, and stop no closer than 50’ from the crater. Use the vapor detector to approach and circle the crater on foot. Position the vapor detector’s sampling hose as far into the crater as possible. Survey crater damage from a safe LEL (less than 1 percent) position, and monitor LEL until repair is complete. Assess work site conditions, advise the DCC, and await instructions. Once permission to perform work is given, and after the work of the heavy equipment is done, staging the equipment around the crater begins. Always keep the wind direction in mind when performing this operation (fig. 2–121).

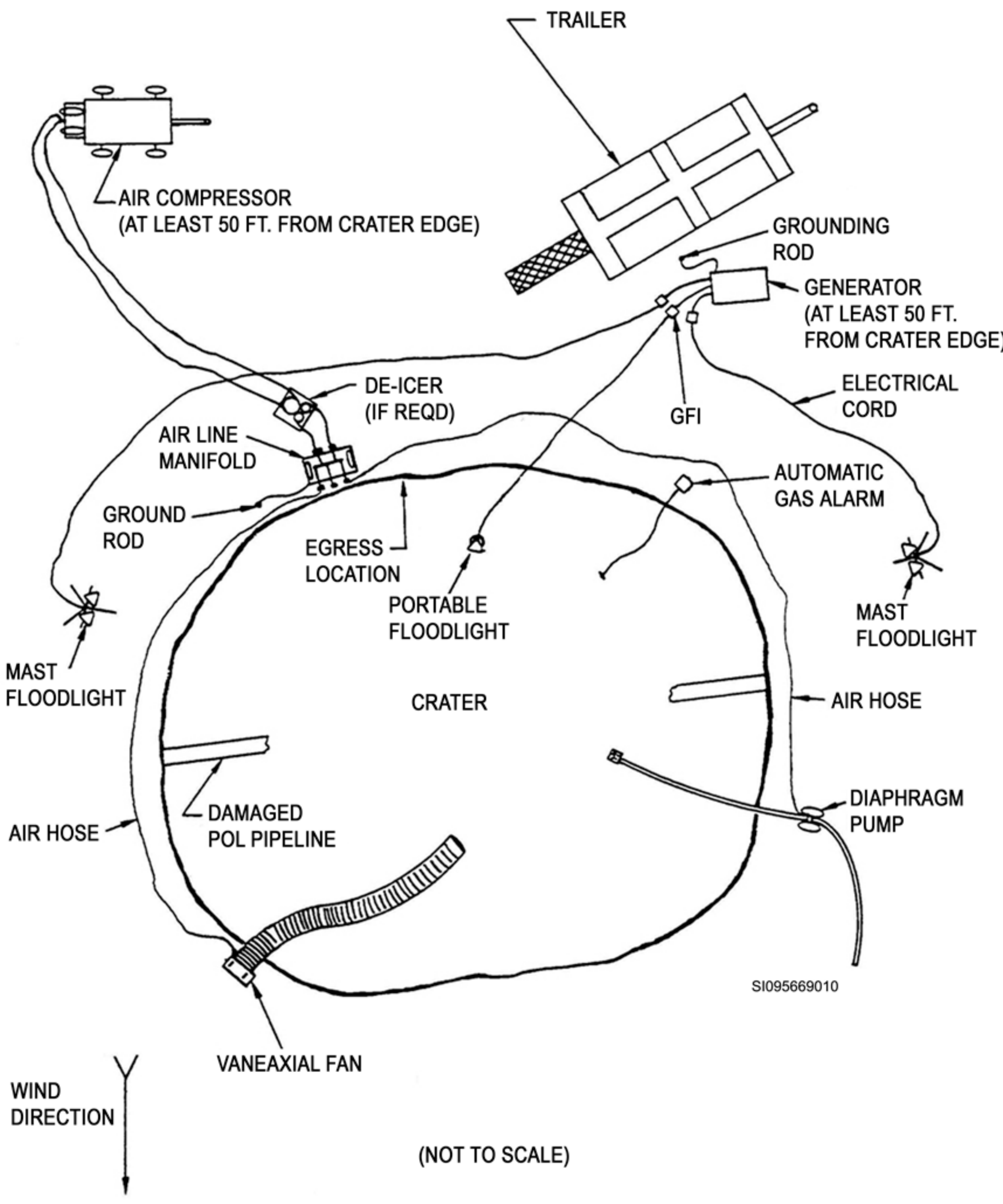


Figure 2–121. RURK I setup (typical).

Pipe clamps and expedient repairs

Leaks in a pipe system require either temporary or permanent repairs. You may stop small or slow-flowing leaks with temporary repairs. Make permanent repairs as soon as possible. Once the permanent repair is complete, the system should be as good as it was when it was installed originally. Before you make any kind of repairs on plumbing systems, be sure to block, lock out, and tag out the damaged section of the fuel system to prevent others from pressurizing the system while you are working on it.

Full-circle (saddle) pipe clamps

There are many different types of breaks that can cause fuel lines to leak. Lines that have holes, splits, or full-circle breaks usually are temporarily repaired with a full-circle clamp. A permanent repair will require welding or replacing the pipe. Full-circle clamps are available for pipe sizes of 1¼ to 24”, and will cover pipe lengths of 6 to 36”. This type of clamp has a specially ribbed one-piece rubber gasket that goes around the inside of the band, wrapping itself around the pipe without a “gasket break”—hence the name full-circle. The ends of the gasket are oppositely tapered so that gasket thickness is uniformly maintained at the closure point of the gasket. The band or “panel” is usually made of ductile iron or stainless steel. The stainless steel band is preferred for corrosive “warm soil” applications. Pipes that have been buried for years and constructed long ago do not have a perfect outside diameter. For this reason, full-circle clamps are constructed with a variance of either 0.4” or 0.8”, depending on the design. Single-panel, full-circle clamps, such as the one in figure 2–122, view A, have a 0.4” variance on the outside diameter (OD) of the pipe.

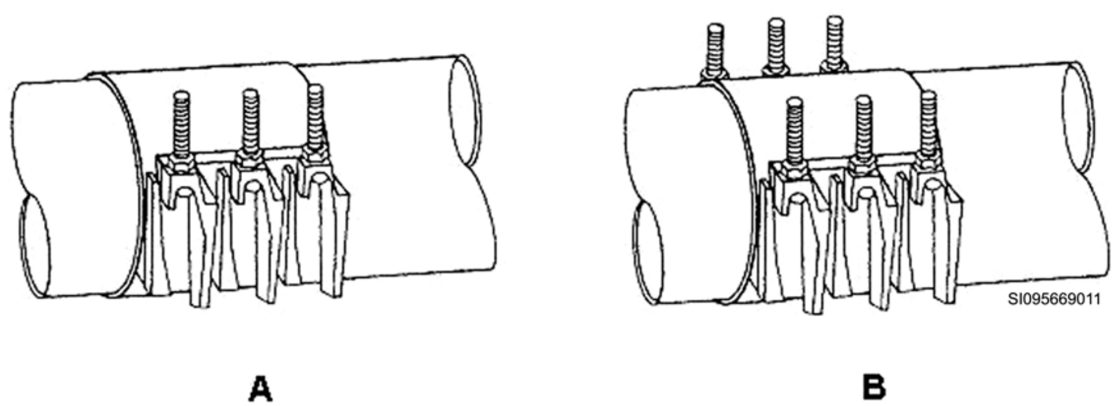


Figure 2–122. Full-circle (saddle) clamps.

The double-panel, full-circle clamp in figure 2–122, view B, has the same gasket configuration as the single-panel, full-circle clamp with the exception of the number of panels or “bands.” Because of the double-panel design, this full-circle clamp has a 0.8” variance—a great advantage when ordering. The double-panel, full-circle clamp is preferred because of the leverage in variance. Specially configured triple-panel, full-circle clamps are used for pipe sizes larger than 24”. The ends of the panel or “band” all have lugs attached. These lugs have holes in them for the bolts. Some clamps have slots in place of the holes on one of the lugs, which make installing the bolts easier.

Installation procedure

Circle clamps are an easy way to temporarily fix a leaking pipe until a more permanent fix can be made. Follow these steps to install a circle clamp:

1. Before you begin to install the clamp, thoroughly clean the pipe where the clamp will be installed.
2. Lubricate the full-circle gasket to reduce friction and evenly distribute clamping force.

3. Loosen nuts to the end of bolts and place the clamp around the pipe—centered over the break or damaged area with the gasket flap at the top.
4. Tuck the gasket flap in place, close the bolt lugs, engage the center-most bolts and nuts, and finger-tighten.
5. Rotate the clamp to flatten the tapered end of the gasket, and position the bolts and nuts for convenient tightening.
6. Evenly tighten bolts working from *center outward*. Maintain an even gap between bolt lugs when installing double and triple-panel clamps by alternating from side to side while tightening the nuts.
7. Allow the gasket to fully compress and recheck bolt tightness. Finally, torque the bolts to the manufacturer's specifications.

When fully compressed, the gasket protrudes slightly beyond the edge of the stainless steel band, providing extra protection against galvanic corrosion. After installing the clamp, check for leaks.

Expedient repairs

Expedient repairs are for emergency situations only. Make them only when correct repair parts are not immediately available. Never consider a job as being complete when temporary repairs have been made. Temporary repairs usually are made with the use of resilient pads, duct tape, metal or wooden plugs, sheet-metal screws, epoxy, and pipe clamps. After any of these types of expedient repairs are used, they must be checked on a daily basis to ensure they remain effective.

Resilient pads

Holes in pipe or fittings may also be repaired temporarily by covering the hole with a resilient pad. The pad must be of a fuel-resistant material such as buna-n, cork gasket material, or even a piece of automatic valve diaphragm. Otherwise, the fuel will start to dissolve the pad and leak out of the repair. Hold the pad in place with a piece of sheet metal and a suitable clamp.

Tape

If the pipe is never under significant pressure and a clamp is unavailable, you can use duct tape or another similarly strong tape to secure the pad to the pipe. The pipe must be completely clean and dry of fuel in order for the tape to stick. Start the tape at least the width of the tape past the end of the pad. Wrap the tape so that each wrap overlaps the last one halfway. The tape should go past the end of the pad at least the width of the tape. Then rewrap the repair in the opposite direction. A fuel-resistant pad must be used, as fuel will dissolve the adhesive on the tape and cause the repair to fail.

Plugs

You can sometimes fill small holes with metal or wooden plugs. Metal repair plugs will be tapered and threaded their entire length. A wooden plug should be tapered and smooth or threaded like a metal repair plug, or may just be a piece of wood a slightly larger diameter than the hole it is to fill. Drive the plug into the hole after you drill or ream the diameter. Hardwood is the best wood to use for making the plug.

Sheet-metal screws

The use of sheet-metal screws is an easy way to close very small holes in pipes, tanks, and similar equipment temporarily. To make a repair with a metal screw, place a small metal washer and then a rubber washer on the screw and turn the screw into the hole with a screwdriver. Make sure the rubber washer is against the surface of the pipe. The screw forms its own threads as it is screwed into the metal. Screw it into the wall of the pipe or tank far enough so that the rubber washer makes a seal.

Epoxy

Small holes or cracks in pipes can be filled with a fuel-resistant epoxy. Epoxies can be solid or liquid and usually come in two parts. After mixing the parts in the required ratio, you have a limited amount of time to apply the epoxy before it hardens and sets—a process called *curing*. You must wait until the epoxy is fully cured before the fuel system can be pressurized. If fuel is leaking out of the hole, a backing material such as a piece of sheet metal must be held against the repair until the epoxy sets.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

625. Rapid utility repair kit I concept and fundamentals

1. What is the RURK I used for?

2. What 5 types of repairs are possible with the RURK I?

3. What are the manpower requirements for a RURK I team?

4. What additional support equipment and personnel may be needed for the RURK I?

5. What is the maximum tow speed for the RURK I trailer on paved surfaces?

6. Team members cannot be in the work area without respiratory equipment if the LEL is above what percent?

7. How many containers are on the RURK I trailer?

8. What specific items in the RURK I must be operationally checked during the 5-year inspection?

9. What are two methods of permanent pipe repair?

10. Match the characteristic in column A with the expedient repair techniques in column B. Items in column A may have more than one correct answer. Items in column b may be used once, more than once, or not at all.

Column A

____ (1) Can be screwed into a hole to stop a leak.
____ (2) Cannot be used by itself to stop a leak.
____ (3) Used to hold a resilient pad in place.
____ (4) Allows for greater pipe deformity.
____ (5) Needs time to cure for before the pipe can be used.
____ (6) Threaded the length of its body.
____ (7) Should be tapered and smooth or threaded.
____ (8) Has one set of bolts along the length of its body.
____ (9) Completely surrounds the pipe to repair it.

Column B

a. Single-panel, full-circle clamp.
b. Double-panel, full-circle clamp.
c. Resilient pad.
d. Duct tape
e. Metal plug.
f. Wooden plug.
g. Sheet metal screw.
h. Epoxy.
i. Sheet metal and clamp.

Answers to Self-Test Questions

614

1. 30.
2. Five.
3. Source run, water production with 600 or 1500 ROWPUs, 550 initial, 550 follow-on, and industrial operations and flightline extension.
4. Purple.
5. 160 degrees.
6. 1 ppm.

615

1. Provide raw water for the system.
2. 6,000’.
3. Potable water distribution.
4. Three. Two for potable water and one for raw water storage.

616

1. The accumulator cannot be repaired.
2. Clean or replace.
3. Damage may occur.
4. Sewage ejector kitchen, sewage ejector latrine, macerator, and dual-pump lift station.
5. Have an electrician check the phase voltage to the pump motor.
6. Adjust the bladder water level control devices control knobs to maintain the desired level.

617

1. Five washers, five double-stacked dryers, floor-anchoring brackets for the washer and dryers, 80 gal. water heater, 3,000 gal. water tank, supply pump, drain pump, electrical distribution panels, hoses, valves, filters and electrical cables.
2. Adjust the thermostat to regulate the water to 110ºF for the washing process.

3. Open the water heater relief valve to relieve air from the water tank.
4. 300 gal.
5. Accumulator precharge is low or the pressure switch has malfunctioned.

618

1. 20-40 psi.
2. 3 gal.
3. 3’ per person per day.
4. To prevent the grease from slowing the evaporation process in the evaporation beds.
5. Drum grease trap.

619

1. 3,000 and 20,000 gal.
2. Camouflage netting.
3. 64”.

620

1. 360 gal.
2. Approximately 3 quarts.
3. Each time a full tank of supply water is expended.
4. Removal of tank by forklift and dumping of contents into a designated waste disposal site, suction-draining by a wastewater trailer, or discharge into the BEAR sewage disposal system.
5. A bump on the road could dislodge the lids and send a geyser of waste several feet into the air.

621

1. 12.
2. Base assembly, shower support framework, pump assembly, hoses, and wiring harness.
3. One centrifugal supply pump, one diaphragm drain pump, a temperature regulator, and an electrical switch-box.
4. M-80 boiler.
5. 1” water supply hose and 2” drainage hose.
6. 5’.
7. Two minutes, 19 seconds.
8. Transparent and smokeless.
9. Normally set at 105°F, and never more than 115°F.
10. 3.
11. Safety pins.
12. 1½”.
13. To branch off power to the water pump assembly and the boiler.
14. Nothing. It is normal for the showerheads to continue dripping.
15. Weekly.
16. No water, no drainage, no power, and incorrect water temperature.
17. The M–80 boiler (for which you are not responsible to repair), pump assembly (to include the supply pump and drainage pump), temperature regulator, and the showerhead and faucet valves.

622

1. The hygiene system consists of four expendable Bicon shelters. Two of the shelters include 12 shower stalls with curtains and mats, 12 sinks with shelves and mirrors, 24 towel hooks, and 4 sets of self-adjusting stairs. The other two shelters include 12 toilets with double paper holders and privacy doors, 8 urinals, 4 sinks with mirrors, and 4 sets of self-adjusting stairs.

2. $^5/_{32}$.
3. For proper drainage slope.
4. Every 3–6 months check for lubrication and grease if necessary.

623
1. ATC.
2. AFTH.

624
1. Outside air is drawn into the tank by a vacuum pump. The same amount of air is expelled outwards, out of the tank. Consequently, the tank is always under a vacuum condition.
2. The boom valve.
3. 175 cfm.
4. Clearly mark the trucks for their intended purpose?

625
1. To make temporary repairs to fuel pipelines and valve pits.
2. In-crater, bypass, valve pit, end cap, and puncture.
3. Each air base should have a primary and a backup RURK team. Each team must have a minimum of three people. The team will consist of a liquid fuels maintenance specialist as team chief and two helpers. The helpers may be utilities personnel.
4. Tow vehicle, backhoe or excavator, large capacity pump, EOD team, and fire truck and team.
5. 45 mph.
6. 1%.
7. Four.
8. The compressor, generator, portable hacksaw, floodlights, vaneaxial fan and reciprocating pump.
9. Welding and pipe replacement.
10. (1) e, f, g.
    (2) c, d.
    (3) d, i.
    (4) b.
    (5) h.
    (6) e, f, g.
    (7) f.
    (8) a.
    (9) a, b, d.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet AFCDA.

47. (614) With no new water production, how long is the Basic Expeditionary Airfield Resources (BEAR) water storage capacity designed to sustain a 1,100-person camp, and how many gallons (gal.) are allotted for each person per day?
    a. 3 days and 20 gal.
    b. 4 days and 25 gal.
    c. 5 days and 30 gal.
    d. 6 days and 35 gal.

48. (614) What color stripe identifies hoses that are intended for use with the potable water subsystem of the Basic Expeditionary Airfield Resources (BEAR) water distribution system?
    a. Blue.
    b. Green.
    c. White.
    d. Yellow.

49. (614) What is the *best* way to protect hard wall piping from solar radiation?
    a. Bury piping.
    b. Paint piping.
    c. Keep water constantly moving.
    d. Cover pipe with camouflage material.

50. (614) Under normal conditions, what are the proper parts per million (ppm) and hours needed for chlorine to disinfect the Basic Expeditionary Airfield Resources (BEAR) water distribution system?
    a. 20, 12.
    b. 20, 24.
    c. 10, 12.
    d. 10, 24.

51. (614) The chlorine residual of a Basic Expeditionary Airfield Resources (BEAR) water distribution system should *never* be lower than
    a. 1 part per million (ppm) at the point of use.
    b. 5 ppm at the point of use.
    c. 1 ppm at the point of injection.
    d. 5 ppm at the point of injection.

52. (615) How many feet can the source run subsystem pump water, and how many feet can it pump to a water storage tank?
    a. 3,000 and 75.
    b. 4,000 and 100.
    c. 5,000 and 125.
    d. 6,000 and 150.

53. (615) What Basic Expeditionary Airfield Resources (BEAR) water distribution subsystem is the *primary* potable water distribution system?
    a. 550 initial subsystem.
    b. Source run subsystem.
    c. 550 follow-on subsystem.
    d. Industrial operations and flightline extension subsystem.

54. (615) What pressure range does the dual-pump station maintain the Basic Expeditionary Airfield Resources (BEAR) water distribution system to?
    a. 20–30 pounds per square inch (psi).
    b. 30–40 psi.
    c. 40–50 psi.
    d. 50–60 psi.

55. (615) The 550 follow-on subsystem, when used as an expansion, is functionally identical to what other water distribution subsystem?
    a. 550 initial subsystem.
    b. Source run subsystem.
    c. 500 follow-on subsystem.
    d. Industrial operations and flightline extension subsystem.

56. (616) What components make up the Basic Expeditionary Airfield Resources (BEAR) package macerator pump lift stations?
    a. Submersible centrifugal pump, pump lift-out assembly, and three floats.
    b. Two submersible centrifugal pump, pump lift-out assembly, and four floats.
    c. Submersible macerator pump, pump lift-out assembly, and three floats.
    d. Two submersible macerator pumps, pump lift-out assembly, and four floats.

57. (616) If the pressure switch on the 35 gallons per minute (gpm) electric pump is *not* operating properly, what is the *first* step you should take to correct the problem after de-energizing the unit?
    a. Clean the contacts.
    b. Replace the contacts.
    c. Replace the pressure switch.
    d. Tap on the pressure switch housing.

58. (616) What could cause extensive damage to the centrifugal pump on the 400 gallons per minute (gpm) diesel pump?
    a. Too little water flow.
    b. Too much water flow.
    c. No water flow to pump.
    d. Restricted discharge line.

59. (616) When a float is *not* working properly in the dual-pump lift station, and you have cleaned it and observed that it is not getting hung up in the lift station itself, what is your *next* course of action?
    a. Replace the float.
    b. Have an electrician check the float.
    c. Check the voltage to the lift station.
    d. Shake the float to knock the contacts loose.

60. (616) What is the *first* thing you should do before pulling a pump out of one of the Basic Expeditionary Airfield Resources (BEAR) lift stations?
    a. Notify your supervisor.
    b. Put on the appropriate gloves.
    c. Turn the power off to the pump.
    d. Read the local operating instructions.

61. (617) How many washer and dryers are provided with the self-help laundry?
    a. Three washers and three double-stacked dryers.
    b. Four washers and four double-stacked dryers.
    c. Five washers and five double-stacked dryers.
    d. Six washers and six double-stacked dryers.

62. (617) For planning purposes, how much wastewater should you expect to be generated from the field laundry?
    a. 12 gallons (gal.) per load.
    b. 8 gal. per load.
    c. 4 gallons per person per day (gpppd).
    d. 2 gpppd.

63. (617) What technical order (TO) action do you follow to correct the self-help laundry's water heater if the water is too hot?
    a. Contact heating, ventilation, and air conditioning (HVAC) personnel.
    b. Test and service the mixing valve.
    c. Partially close the gate valve.
    d. Adjust the thermostat.

64. (618) How many evaporation beds are used in a field kitchen waste disposal system?
    a. 1.
    b. 3.
    c. 5.
    d. 7.

65. (618) What effect does grease have on the electric kitchen's evaporation beds?
    a. Attracts beneficial bacteria.
    b. Slows the evaporation process.
    c. Enhances the bacteriological process.
    d. Grease does not affect the evaporation process.

66. (619) How many inches of sand is required when a 20,000-gallon water bladder is placed on rocky or uneven surfaces?
    a. 2.
    b. 3.
    c. 4.
    d. 5.

67. (619) What is the *maximum* allowable height you can fill a 20,000-gallon (gal.) water bladder?
    a. 34 inches (“).
    b. 44”.
    c. 54”.
    d. 64”.

68. (620) Each Basic Expeditionary Airfield Resources (BEAR)-deployable latrine unit consists of
    a. four toilets and two urinal troughs that drain into a 360-gallon (gal.) waste tank.
    b. five toilets and one urinal trough that drain into a 180 gal. waste tank.
    c. six toilets and one urinal trough that drain into a 360 gal. waste tank.
    d. seven toilets and two urinal troughs that drain into a 180 gal. waste tank.

69. (620) How many males and females does one field deployable latrine service?
    a. 50 males and 22 females.
    b. 60 males and 32 females.
    c. 70 males and 52 females.
    d. 80 males and 52 females.

70. (620) How much water is required to prime the pump on the Basic Expeditionary Airfield Resources (BEAR) latrines deployable pump?
  a. 3 quarts.
  b. 12 quarts.
  c. 3 gallons.
  d. 12 gallons.

71. (621) How many people can use the shower at any one time?
  a. 12.
  b. 4.
  c. 3.
  d. 1.

72. (621) The temperature of delivered water is *primarily* controlled in the shower/shave facility by the
  a. individual users manually adjusting shower valves to their need.
  b. thermostat of the boiler controlling the temperature according to need.
  c. thermostat setting on the pump assembly adjusting according to need.
  d. temperature regulator mixing in more or less cold supply water when demand is increased or decreased.

73. (621) What action during operation will prevent the boiler from emitting heavy smoke from the exhaust stack?
  a. Opening the air band.
  b. Closing the air band.
  c. Increasing fuel pressure.
  d. Decreasing fuel pressure.

74. (621) What is the *highest* allowed temperature of “mixed” water from the shower/shave pump assembly’s temperature regulator?
  a. 99.5° F.
  b. 105° F.
  c. 115° F.
  d. 160° F.

75. (621) What is the diameter, in inches, of the drainage hoses for the shave stands?
  a. ¾.
  b. 1.
  c. 1½.
  d. 4.

76. (621) What are the four *most common* problems that will likely occur to the shower/shave unit?
  a. No water, no drainage, no power, leaking pipes.
  b. No water, no drainage, no power, incorrect temperature.
  c. No water, no power, leaking pipes, clogged faucet aerator.
  d. No water, leaking pipes, clogged faucet aerator, leaking shower heads.

77. (622) How many sinks and showers does the Expandable Bicon Shelter (EBS) contain?
  a. 16 each.
  b. 14 each.
  c. 12 each.
  d. 10 each.

78. (622) Approximately how big of area do you need to set up the Expandable Bicon Shelter (EBS) system?
    a. 40 feet (´) x 40´.
    b. 90´ x 60´.
    c. 60´ x 80´.
    d. 50´ x 50´.

79. (623) Which bare-base medical facility provides outpatient clinic services?
    a. Aeromedical staging facility.
    b. Air transportable hospital.
    c. Air transportable clinic.
    d. Contingency hospital.

80. (623) Which medical facility is housed in a combination of tent expendable modular personnel (TEMPER) and Alaskan tents?
    a. Air transportable clinic.
    b. Air Force theater hospital.
    c. Air transportable hospital.
    d. Aeromedical staging facility.

81. (624) Which technical order (TO) should you consult before operating the sewer sucker trailer (SST)?
    a. 36A11–18–24–1.
    b. 36A18–11–24–1.
    c. 35E35–5–1.
    d. 35E5–35–1.

82. (624) How do you eliminate the possibility of cross-contamination with the water distribution truck?
    a. Paint the truck key red or blue.
    b. Clearly mark the trucks potable or non-potable.
    c. Make sure the AF Form 1800 states the type of water required.
    d. Have operating instructions that states which truck is potable or non-potable.

83. (625) The supplemental packages for the rapid utility repair kit (RURK) I contain the components to repair what size pipes?
    a. 2- and 4-inch (“) pipe.
    b. 6” and 8” pipe.
    c. 10” and 12” pipe.
    d. 14” and 16” pipe.

84. (625) When performing a valve pit repair in conjunction with an in-crater repair, where should the valve manifold be located?
    a. In the crater and upwind.
    b. In the crater and downwind.
    c. Outside the crater and upwind
    d. Outside the crater and downwind.

85. (625) During night repair operations with the rapid utility repair kit (RURK) I, how close to a crater’s edge can flood light stands be positioned?
    a. 20 feet (‘).
    b. 50’.
    c. No closer than the height of the floodlight.
    d. No closer than twice the height of the floodlight.

86. (625) What size towing capacity *must* the tow vehicle have to be used for the rapid utility repair kit (RURK) I?
    a. Two and a half ton.
    b. One and a half ton.
    c. Two ton.
    d. One ton.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Expedient Field Construction and Repair

DURING WARTIME an air base is a prime target and could come under attack. If this occurs, aircraft, runways, and facilities could be damaged or destroyed. In addition, utilities such as water mains and sanitary sewer systems supporting the base could also be damaged. Additionally, you are also responsible for operating and maintaining landfills during field conditions as well as determining and developing alternate water sources of supply should the primary sources become damaged. This valuable information will help you when tasked with these responsibilities during wartime.

3–1. Waste Disposal Systems and Storm Drain Repairs

Poor sanitation and improper waste disposal under wartime conditions greatly increases the disease-vector potential of such common pests as flies and rodents. Even in mobile situations where ground forces move frequently, these “camp followers” historically amplify sanitation problems and often cause epidemics of diarrhea diseases that, in turn, result in many casualties. This threat is even greater at bare-base or theater of operations’ airfields that have been converted to temporary or semi-permanent use. In these situations, the deployed force, unlike the infantry, does not move every day to a different, cleaner area. Yielding to the temptation to relax sanitation standards can cost the health of the deployment force, no matter how primitive the facilities or endangering the combat situation may be. In this section, you will study the types and construction of latrines and wastewater disposal systems.

626. Expedient field latrine construction

Expedient field latrines are needed for some wartime situations, especially during highly mobile operations. Most of the latrines are simple to construct but must be constructed correctly to make sure waste is disposed of quickly and safely. The types of field latrines you will encounter are:

- Deep-pit.
- Straddle trench.
- Ventilated improved pit (VIP).
- Burnout latrine/pail.
- Mound.

Deep-pit latrines

The deep-pit latrine is illustrated in figure 3–1. Construct deep-pit latrines for prolonged stays. As you can see, this latrine uses a standard-type latrine box with four seats. The deep-pit latrine is considered sufficient for 50 personnel. The holes are covered with flyproof lids, and all cracks are made flyproof with strips of wood or tin.

A metal deflector inside the front of the box prevents the wood from becoming soaked. If a pipe ventilator is installed, it must be screened at both ends and should extend upwards at least 6’ above ground level.

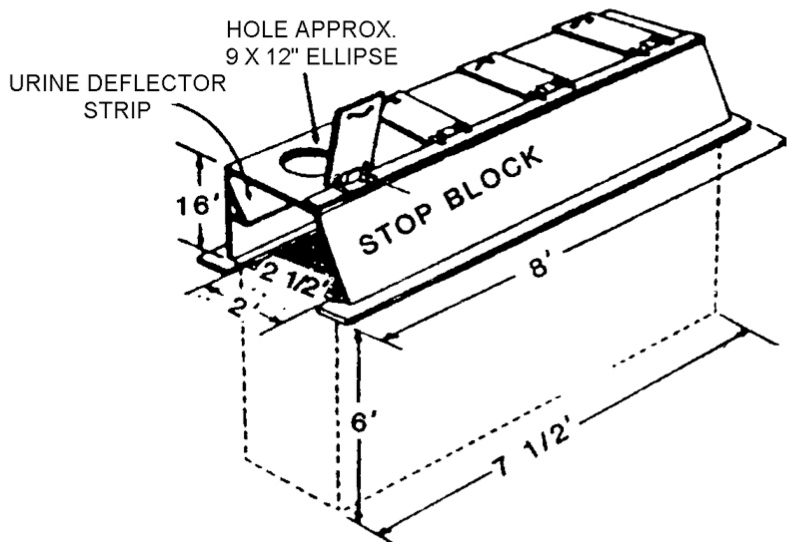


Figure 3–1. Deep-pit latrine.

The pit is 2’ wide by 7½’ long. This allows 3” of support on all sides of the box. As a guide to the depth of the pit, allow 1’ for each week you expect the facility is going to operate at full capacity. It is not desirable to dig the pit more than 6’ deep. Pack dirt tightly around the bottom edges of the latrine. This will seal any openings and prevent flies from getting into the pit. In addition, surround the latrine with a ditch to prevent flooding. You are also required to spray the latrine with a residual spray twice a week to control flies. The procedure for closing and marking the deep-pit latrine is identical to the straddle trench latrine we will now discuss.

Straddle trench latrine

The basic saddle trench latrine is illustrated on figure 3–2. To make the latrine, you dig a trench 1’ wide, 2½’ deep, and 4’ long. A trench this size can accommodate two people at the same time. The number of trenches depends on the size of the unit being served. The general rule is that you need 16’ of trench for 100 people. As you can see in figure 3–2, a canvas wall provides an entrance as well as a screen for privacy. Toilet paper is placed on a suitable holder by each trench and may be covered with an empty tin can to protect it from the weather. The dirt removed from the trench is piled at each end. A shovel or paddle is provided so each person can promptly cover any excreta and toilet paper with dirt. Water for washing hands is provided in two containers located near the entrance of the latrine.

During construction, dig a drainage ditch around the latrine at the edge of the screen. The ditch must be deep and wide enough to prevent rainwater from flowing over the ground and flooding the trenches. Spray the shelter and the pits twice a week with a residual insecticide to control flies from breeding. The use of lime or similar chemicals isn’t recommended as a means of controlling flies.

When the trench is filled to within 1’ of the surface or when the site is to be abandoned, close the latrine properly. To do so, spray the trench, sidewalls, and the ground 2’ around the latrine area with a residual insecticide. Then fill the trench to ground level with 3” layers of earth. Pack down each layer and spray it with insecticide before you add the next layer. Mound the trench over with dirt piled at least 1’ above ground level. Identify the location plainly with a dated sign stating “CLOSED LATRINE.” Follow this complete procedure whenever you close a pit or trench-type latrine.

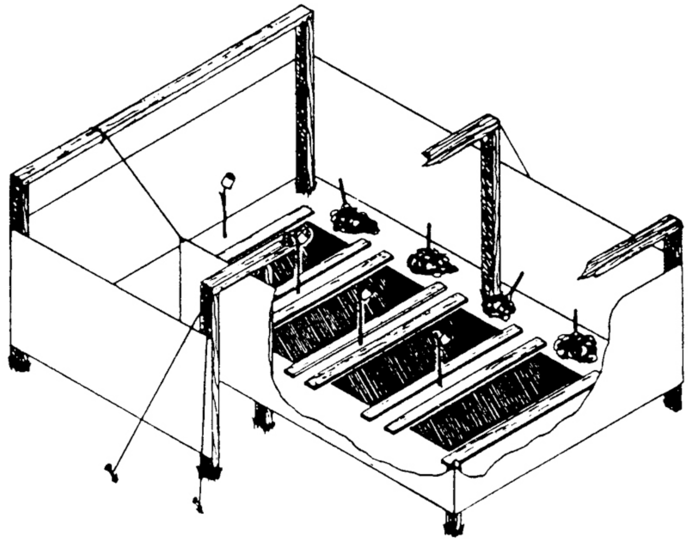


Figure 3–2. Straddle trench latrine.

VIP latrine

The construction features of the VIP latrine are shown in figure 3–3. The VIP latrines are the best method for disposing of human wastes in the absence of a sewage system. Housed in a Temper tent or Alaskan shelter, the VIP latrine supports approximately 270 personnel. It has 12 latrine seats and 2 trough urinals.

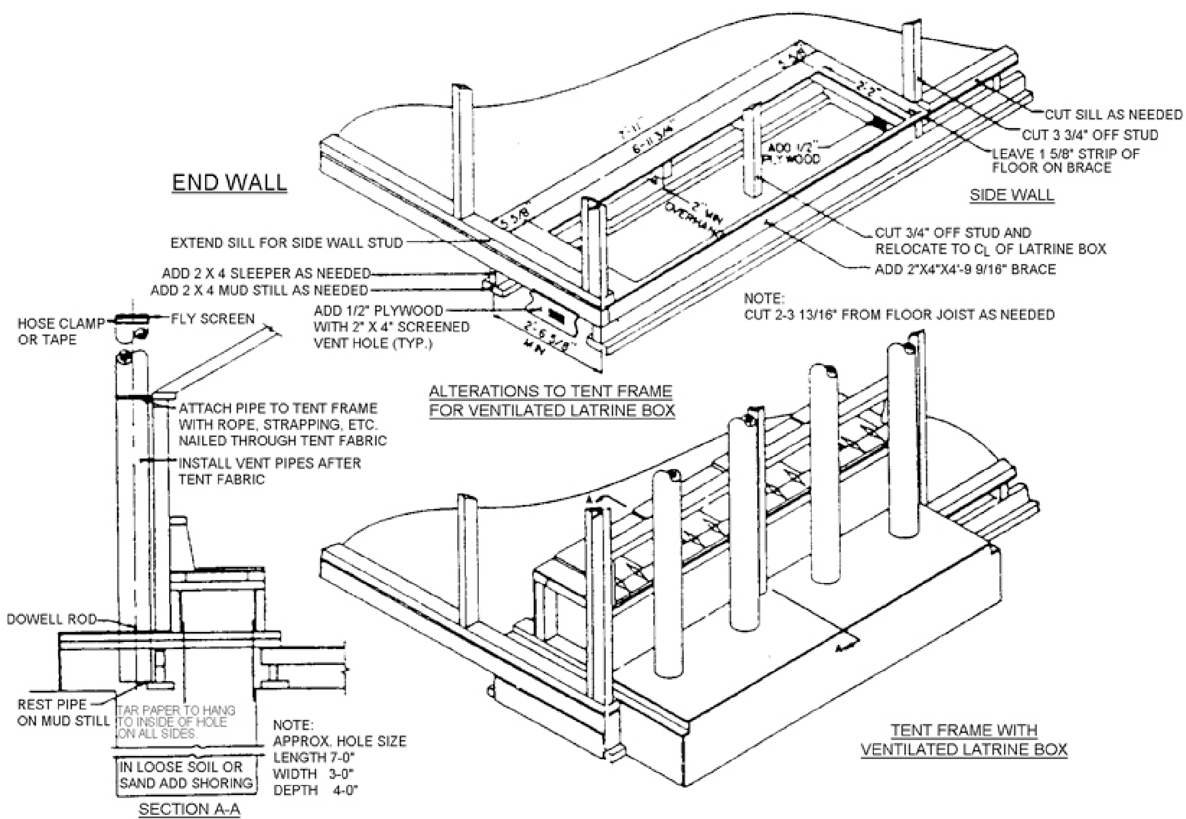


Figure 3–3. VIP latrine.

When VIP latrines are properly designed and constructed, they are sanitary and devoid of odor and insects. There are various designs of VIP latrines. They all differ from traditional pit latrines by the presence of a vertical vent pipe. This pipe leads directly from beneath the pit to above the tent roof. The vent pipe generates a strong updraft and maintains a flow of air down through the latrine pedestal. Proper design of the vent pipe is essential for the VIP latrine to function correctly. Under design normally causes problems in odor and insect control, while over design increases cost unnecessarily. The vent pipe has a fly screen at its top. This screen is constructed of plastic-coated glass fiber mesh only.

Airflow

The effect of the vent pipe airflow is to minimize odors in the superstructure and to discourage insects from breeding (flies and mosquitoes) in the pit. Most flies approaching a latrine are attracted to the top of the vent pipe by the fecal odors discharged there. Although they congregate at this point, the fly screen prevents them from entering the pit. Moreover, if the superstructure is kept reasonably dark, any flies that hatch in the pit are attracted to the daylight at the top of the vent pipe. These are prevented from leaving by the fly screen and eventually fall back into the pit and die.

Venting process

You should orient the latrine so the maximum amount of direct sunlight reaches the black vent pipes. On calm days, proper ventilation of the pits relies on the air inside the vent pipes heating up, rising and sucking the foul air upwards. Facing vent pipes to the south aids in this process. When this is impossible, try facing vent pipes east or west—avoid facing the north.

Controlling insect migrations

Urine and small amounts of water entering the pit eventually evaporate or soak into the soil. Do *not* allow personnel to empty excessive amounts of water from bathing or cooking into the pits. If you do, this water will accumulate and harbor breeding insects. When the latrine is not in use, keep the pedestal seat cover closed. This discourages insects from entering the pit and keeps the pit dark. In this way, insects are forced to travel up the vent pipes toward the light and are trapped by the fly screen. Air continues to enter the pit through the gap under the seat, thus, maintaining the ventilation of the pit. Be sure you inspect the fly screens at the top of the vent pipes and the cover slabs over the pit periodically to make sure they are properly secured and in good condition.

Burnout latrine/pail latrine

One of the simplest and most effective latrines to construct is the burnout latrine shown on figure 3–4. Its ease of construction, portability, and maintenance make it one of the best latrines to use in field conditions. You should provide the burnout latrine when soil conditions (hard, frozen, or rocky) make digging a deep-pit latrine difficult. It is also particularly suitable to jungle areas having high water tables.

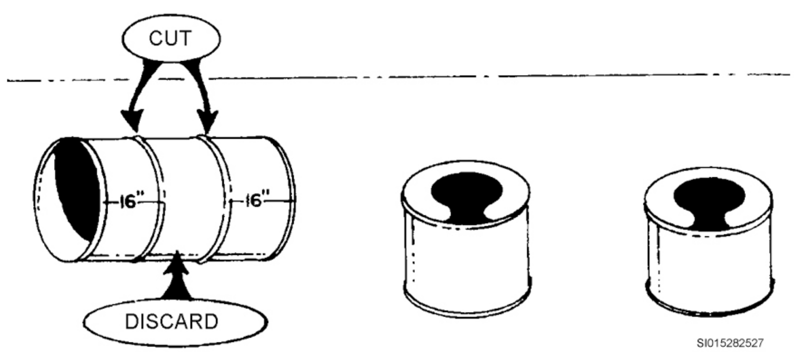


Figure 3–4. Burnout latrine.

Construction procedure

Place a 55 gal. drum into the ground, but leave enough of the drum above the ground for a comfortable sitting height. Place a wooden seat with a flyproof self-closing lid on top of the drum. Cutting the drum in half makes two latrines of less capacity. The most efficient method of burning is:

1. Put ½ gal. of fuel oil in the empty can before use.
2. Before the first burning, add an additional ½ gal. of fuel. Mix with the waste and burn the mixture.
3. After the waste is burned, mix ½ gal. of fuel with the resultant ash and reburn.
4. Bury any remaining dry ash.

Considerations

Build a pail latrine (fig. 3–5) when conditions such as populated areas, rocky soil, and marshes prevent you from constructing any of the other types of latrines. To do this, convert a standard-type latrine box for use as a pail latrine by placing a hinged door on the rear of the box, adding a floor, and placing a pail under each seat. If the box is located in a building (if possible) fit it into an opening you make in the outer wall. In this way, the rear of the box can be opened from outside the building. Make the seats and rear door self-closing and the entire box flyproof. Slope the floor towards the rear enough to facilitate rapid drainage of any water used to clean the box.

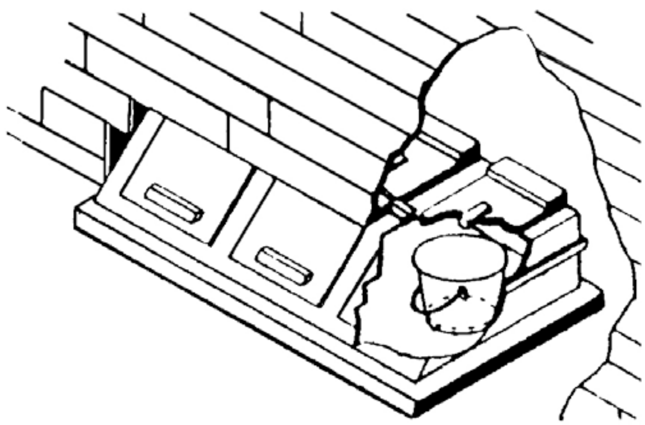


Figure 3–5. Pail latrine in a building.

You may also install a urinal in the latrine enclosure, which has a drain pipe leading to an outside pail. Enclose this pail in a flyproof box. Dispose of the waste in pails by burning it or by hauling it to a suitable area and burying it. Use plastic bag liners for pails to reduce the risk of spilling the content accidently. Tie the tops of the filled bags and then dispose of them by burning or burying them.

Mound latrine

Construct the mound latrine when a high groundwater level or a rock formation near the ground surface prevents you from digging a deep pit. A dirt mound makes it possible to build a deep pit and still not have it extend into the groundwater or rock. Construct the mound from 1’ increments of compacted soil.

Form a mound of earth with a top at least 6’ wide and 12’ long so you can place a four-seat, flyproof latrine box on top of it. Make the mound high enough to meet the pit’s requirements for depth. Allow 1’ from the base of the pit to the water or the rock level. It may be necessary to brace the walls with wood, sandbags, or other suitable material to prevent cave-ins.

627. Constructing wastewater disposal systems

Many gal. of wastewater can be created daily during wartime situations. If this wastewater is disposed of in an inappropriate manner, breeding areas for disease carrying pests will surely be created. Your job is to make sure this does not happen by constructing disposal systems that quickly and safely rid the area of any wastewater generated. In this lesson, you will study the following wastewater disposal systems:

- Urine soakage pit.
- Stabilization ponds.
- Evaporation ponds.
- Septic tanks.
- Leach fields.
- Grease traps.

In addition to these subjects, we will also look at piping.

Urine soakage pit

The urine soakage pit is a hole dug 4' square by 4' deep. It is filled with large stones at the bottom, small stones next, and then fine gravel. You should place a ventilation pipe in a corner of the pit to allow air to enter. In addition, construct a trough urinal box like that shown in figure 3–6 so it drains into the pit.

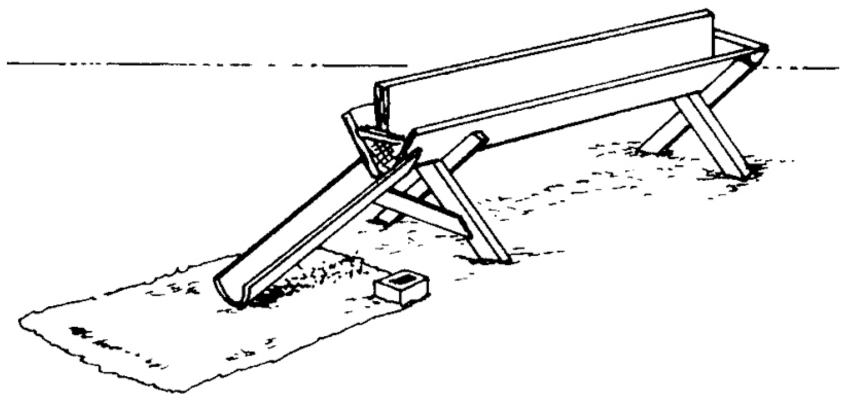


Figure 3–6. Trough urinal and soakage pit.

Stabilization ponds

In areas where sufficient natural drainage exists to carry wastewater away from the base, construct stabilization ponds or lagoons (terms normally used interchangeably) to provide treatment of the wastewater before discharge. These lagoons may be classified as *aerobic*, *anaerobic*, or *facultative*. Aerobic lagoons are frequently called *oxidation ponds*. In facultative ponds, both aerobic and anaerobic bacteria work to reduce incoming wastes. Bacteria and protozoa metabolize waste organics in a lagoon. When the lagoon bottom is anaerobic (without oxygen), solids are digested. Nutrients released by bacteria are used by algae in photosynthesis.

The degree of stabilization produced in a lagoon is significantly influenced by climatic conditions. During warm, sunny weather, decomposition and photosynthetic processes flourish and result in rapid and complete stabilization of the waste organics. Stabilization lagoons are designed large enough to allow long liquid retention times, usually 20 to 120 days.

A lagoon is a flat-bottom pond enclosed by an earth dike. The operating liquid depth has a range of 2 to 5' with 3' of dike freeboard. A minimum depth of 2' is required to prevent roots from aquatic plants from growing. Operating depths greater than 5' can create odorous conditions because of anaerobic bottom conditions.

Detention times

The square foot size of a pond is usually so large their size is normally specified in acres. There are 43,560 square feet in one acre; consequently, a 5-acre pond 3’ deep contains 653,400 cubic feet. Since there are 7.48 gal. in a cubic foot, you can multiply 653,400 by 7.48 to find the gal. capacity of your 3’ deep pond (4,887,432 gal.). To calculate detention time, divide the average daily flow into this pond by the total capacity of the pond (full). In this case, 4,887,432 divided by an average daily flow of 7,700 gal. (based on 550 people) is a detention time of 634 days. You can see a 3’ deep, 5-acre pond is too big for a small deployment of 550 persons. Yet, if your bare base explodes to 5,000 people, your detention time for this same lagoon becomes 69 days!

Flow

Influent lines discharge near the center of the pond, and the effluent usually overflows in a corner on the windward side to minimize short-circuiting. Where multiple lagoons are used, they should be capable of being operated individually, in series, or in parallel. If the soil is porous, it may be necessary to seal the dikes. If a producing aquifer underlies the lagoon, it may also be necessary to seal the bottom of the lagoon. A commonly used sealing agent is bentonite. Flexible membranes also may be used. Since most lagoons emit odors occasionally, locate the lagoons as far as practicable from the base and on the leeward side so the prevailing winds are away from the base.

Evaporation ponds (beds)

In areas where it is impossible to discharge wastewater off base, you should construct evaporation ponds. Because of the large construction requirements, use evaporation ponds only as a last resort. Evaporation is dependent upon the net evaporation rate and the surface area available for evaporation.

The chart in figure 3–7 shows the time required for each of the eight lagoons to fill. The time varies because as the lagoon area increases, the amount of water being evaporated increases, thus decreasing the net flow rate. For the 750-person base, the first lagoon fills in 45 days but the eighth lagoon does not fill for 892 days. Obviously, you do not construct lagoons if they are not going to be used during the anticipated deployment time frame. Follow the lagoon construction sequence in figure 3–8 to minimize construction requirements.

DAYS REQUIRED TO FILL LAGOON #

BASE SIZE	1	2	3	4	5	6	7	8	9
750	45	96	155	223	312	426	591	892	-
1500	48	103	167	243	337	467	647	977	-
2250	50	108	176	255	354	485	677	1036	-
3000	52	111	180	262	364	499	699	1050	-
3750	52	112	181	264	367	502	700	1072	-
4500	53	114	185	270	376	516	724	1126	-
5250	53	114	185	270	376	516	728	1130	-
6000	54	116	188	274	381	523	733	1140	-
6750	54	116	188	275	383	526	738	1146	-
7500	54	116	188	275	383	526	738	1146	-
8250	55	117	190	277	385	528	740	1148	-
9000	55	118	191	278	387	531	744	1156	-
12000	56	120	194	283	394	541	760	1189	-
15000	56	120	194	283	394	541	760	1189	-

NOTES: BASED ON 14 GALLONS OF WASTEWATER PER PERSON PER DAY.
NET EVAPORATION RATE OF 45" PER YEAR.
LAGOONS ARE 5'DEEP WITH DIKE WALLS THAT SLOPE AT 3:1.

Figure 3–7. Evaporation pond time chart.

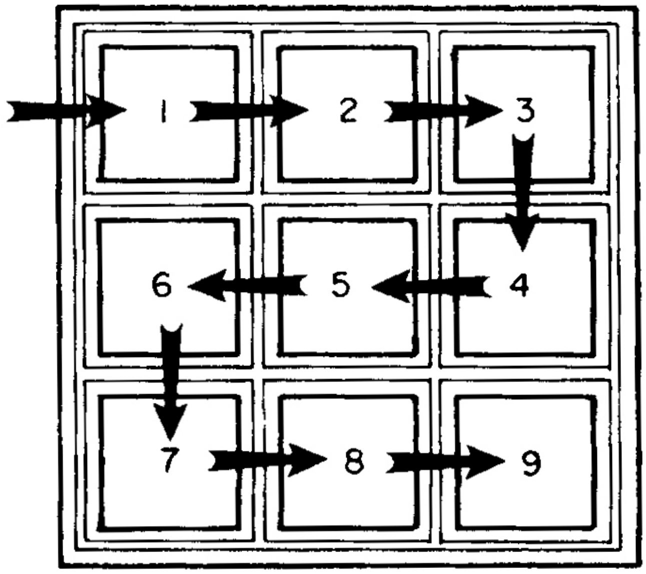


Figure 3–8. Construction sequence.

Septic tanks

The septic tank (when properly designed) holds the sewage long enough for bacterial action to reduce most of the solids to liquids. The liquids are then disposed of in a leaching field (tile field). Figure 3–9 shows a typical septic tank.

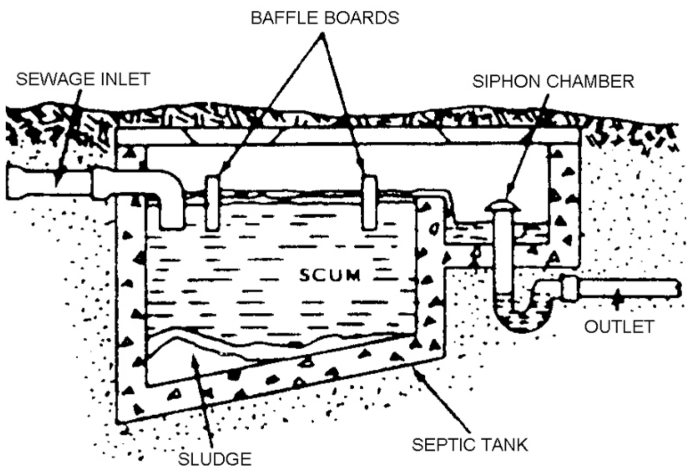


Figure 3–9. Cross-section of a septic tank.

The raw sewage entering the tank contains bacteria. These are tiny forms of life on which the operation of the tank depends. These anaerobic bacteria thrive in the absence of air. They obtain oxygen from the organic sewage by reducing the sewage to gases, liquids, and mineral solids. The bacteria act strongly on the animal and vegetable waste, but cannot act on the metal or mineral substances that settle to the bottom of the tank in the form of sludge.

If given enough time, the bacteria reduces most of the animal and vegetable solids to liquid form. Twenty-four hours is usually enough time for this action to take place. Even such things as leather and bones are reduced to liquids in time. It is essential to design the tank so it is large enough to provide this needed time.

As figure 3–9 illustrates, the septic tank is simple in design, yet effective in operation. The siphon chamber is not absolutely necessary for the operation of the septic tank, but the installation of a siphon chamber ensures a positive flow of liquid. The baffle boards reduce the agitation of the layer of scum on the surface of the tank by slowing the water currents caused by solids splashing from the inlet, through the tank. The baffle boards are usually made of 2” oak planks and run entirely across the tank. They are suspended from hangers and set to extend several inches below the surface of the sewage. You should locate one board 10” from the inlet end of the tank and the other about 4” from the outlet partition.

Install the septic tank as close to the fixture group as possible. Before you install the tank, consider the slope of the land. Install the septic tank with the flow in the proper direction. Sewage should enter the tank at a low velocity in order to prevent it from agitating the scum in the tank. To produce slow flow, the drain (sewage inlet) to the septic tank should run nearly level before it reaches the tank. The inlet should enter the tank above the sewage level and turn down in order to direct the solid matter towards the bottom of the tank. This also prevents agitation and consequently breaks up the scum accumulating at the surface. The partition between the two tank chambers should be perfectly level so sewage flows over it evenly along its entire length.

The bottom of the septic tank should pitch down towards the inlet end. This is where the heaviest part of the sewage is naturally deposited when it enters the tank. Cleaning the tank is thereby made easier. You should provide both the tank and the siphon chamber with a manhole and cover to give access for cleaning and repair purposes.

Leach field

At the effluent end of any septic tank is a subterranean leach field. This is a network of pipes (3”) branching off a lateral header at the outlet of the septic tank. The leach field allows wastewater to percolate through the ground. By the time the wastewater reaches the water table, most of the impurities in the sewage have been removed by the natural filtering action of the ground. The perforated pipe typically has ½” holes drilled at 6” intervals to allow the wastewater to flow down the pipe and percolate through the rock. The gravel bed beneath the pipe allows for an even distribution of the wastewater into the ground, and most importantly, it prevents the holes from plugging up with soil. Paper or straw is placed over the gravel to prevent fine soil particles from migrating into the gravel. A minimum topsoil cover is placed over the gravel to protect the leach field, prevent contact with the wastewater, and reduce infiltration from rain. The location of a leach field is discovered by looking for unusually green patchy areas of grass at the effluent end of the septic tank. Sometimes a depression is also clearly visible because of settling.

Piping

Piping is used when you need to convey waste from a disposal device to a distant soakage pit or lagoon. Almost any type piping could be used but plastic is preferred because of its lightweight and ease of installation. Four-inch plastic is the best type of piping to use on an expedient waste disposal piping system. It is strong, durable, and easy to install. The 4” diameter minimizes the chances of a stoppage.

The installation of the piping may vary from operation to operation. Here are two general rules to follow:

1. Lay main lines at a slope of 1’ per 100’.
2. Lay lateral lines on slopes that are sufficient to provide velocities of no less than 2’ per second and no more than 10’ per second when waste is flowing.

Grease traps

As we previously discussed in the electric kitchen section, grease traps must be constructed to prevent grease from entering the wastewater disposal beds. Grease will slow the evaporation process, clog the soil and prevent water from leaching into the soil, and provide food for insects. Several types of grease traps are sufficient to do a good job of removing the grease from liquid wastes in the field. Some are superior to others in that they are easier to construct and last longer. The important thing about any grease trap is that it should be of sufficient capacity so that the hot, greasy water being added will not heat the cool water already present in the trap. Otherwise, the grease will remain uncongealed and pass through the trap. Figure 3–10 depicts the two types of expedient grease traps that are easiest to construct.

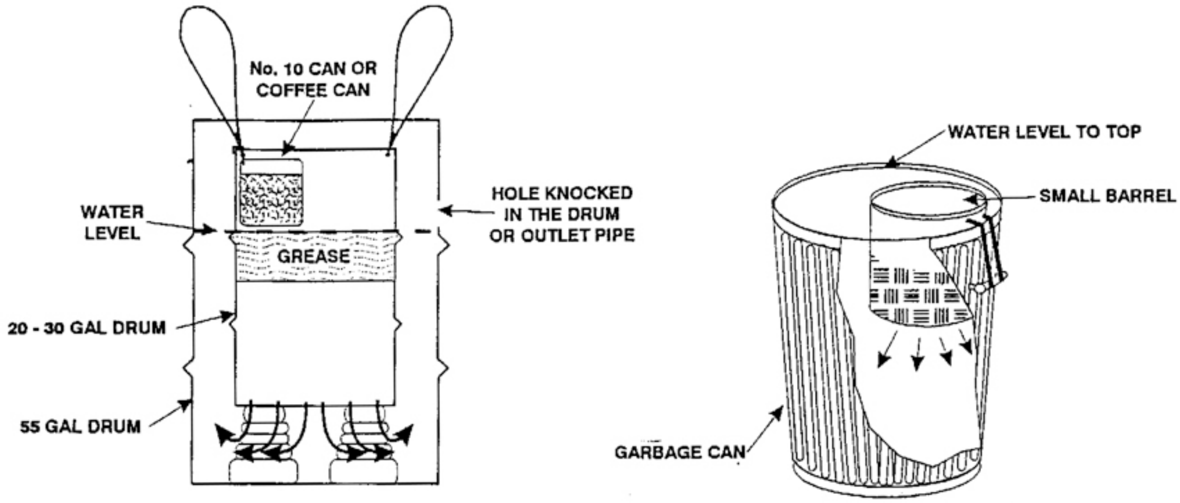


Figure 3–10. Expedient grease traps.

Safety

Since any contingency or wartime situation is stressful, be sure you are aware of what is happening around you at all times. Building expedient storm sewers requires both manual and heavy equipment. If you are not careful around this equipment, you could injure yourself and others. It is also very important you heed this warning: Do *not* operate any equipment you are not qualified to use.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

626. Expedient field latrine construction

1. What do you install in a latrine box to prevent soakage of the wood?

2. Why do you pile dirt at the end of the straddle trench?

3. What is the difference between a VIP latrine and other pit latrines?

4. What should you install on the top of a burnout latrine’s drum?

5. How wide do you make a mound latrine?

627. Constructing wastewater disposal systems

1. What do you place at the bottom of a urine soakage pit?

2. What influences the degree of stabilization in a stabilization lagoon?

3. What can you use to seal a stabilization lagoon?

4. When should you construct evaporation lagoons?

5. What is the purpose of baffle boards in a septic tank?

6. Why should you provide a manhole for a septic tank?

7. What problem occurs when grease is not allowed to cool down in the trap?

8. How many inches apart are ½” holes drilled in leach field piping?

9. Why is plastic pipe preferred in expedient wastewater systems?

3–2. Alternate Water Sources

In an ideal world, US forces would always be deployed to a location where an established water supply was already developed. Even better, we would always have at our disposal water treatment distribution systems we could install in a relatively short amount of time. In a perfect world, these systems would never be destroyed by enemy action, and we would never worry about having a backup plan. Yet, we know things do not always work out this way. In a contingency environment, all things are possible—planned and unplanned. For this reason, you—the WFSM Journeyman, must be knowledgeable in how to develop alternate water sources.

628. Expansion of water facilities

Surface waters from rivers, streams, lakes, or springs are the most common source of water supply and are usually satisfactory for use (after treatment) by the means available in the field. Both the quality and the yield of water from these sources may be subject to extreme variation because of seasonal changes in rainfall; therefore, you should base the selection of the source on careful investigation of average and minimum flow, contamination, and pollution. The capacity of small streams to meet requirements may be increased by the construction of small dams and reservoirs. These should be capable of impounding at least the total daily flow. Some suitable structures for this purpose are shown in figure 3–11.

Various intake structures are required to capture surface water. Locate the piping inlets in deep water with the elevation being at least 1' below the freezing level. Piping inlets should have strainers or screens with sufficient openings to preclude excessive head loss. Some typical intake structures are shown in figure 3–12.

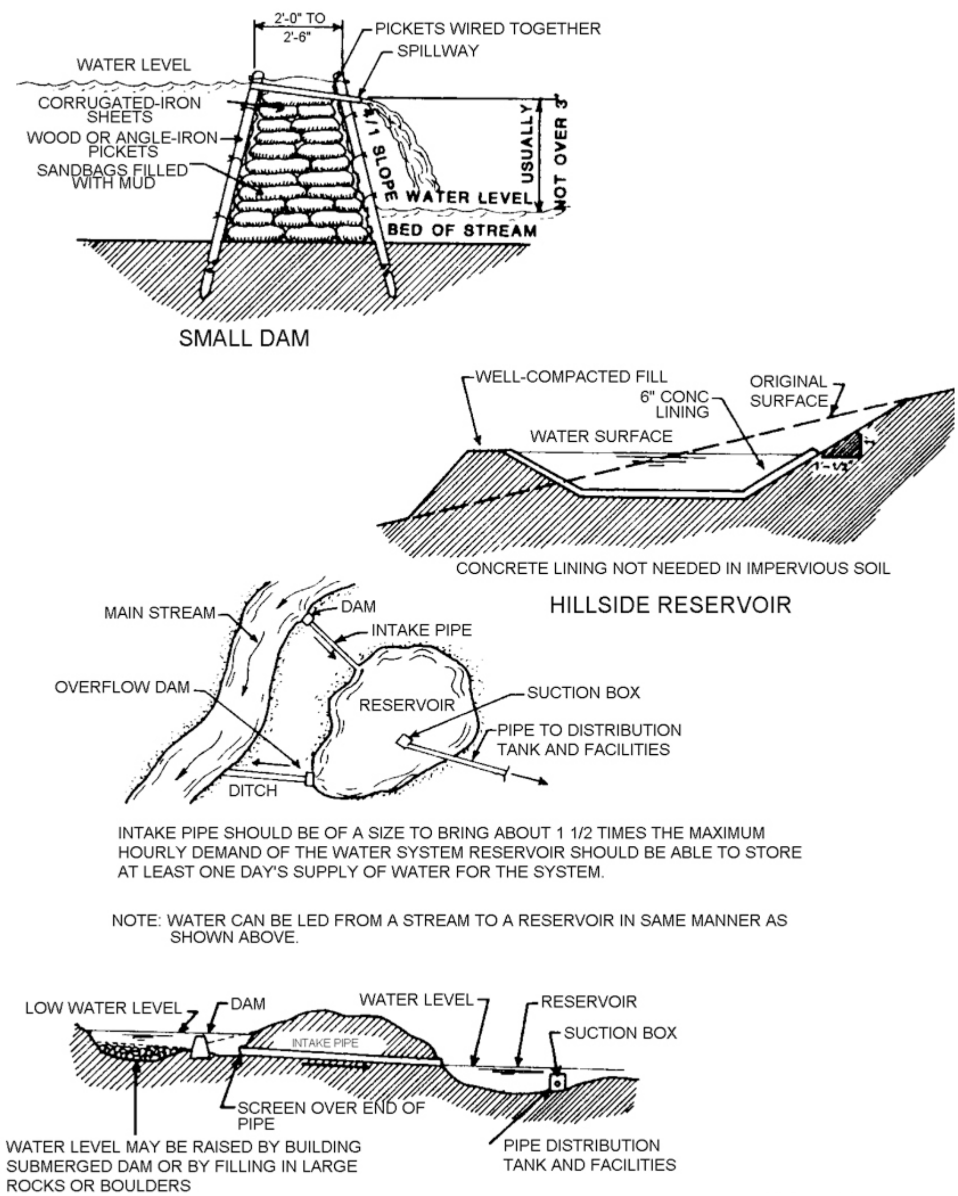


Figure 3–11. Expedient dams and reservoirs.

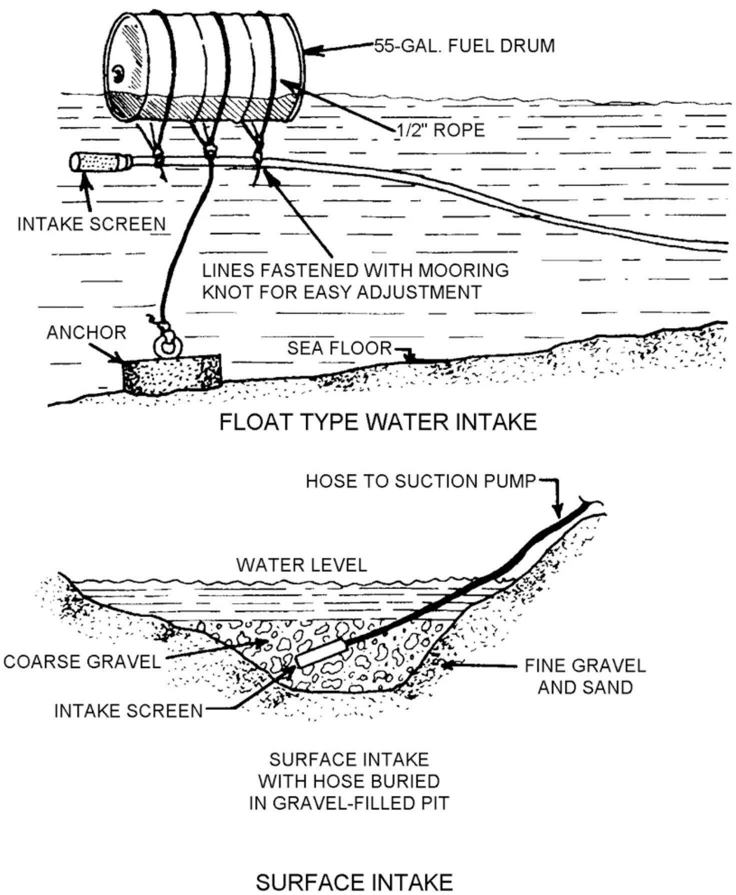


Figure 3–12. Water intakes.

Infiltration galleries

Water from muddy streams can be improved by digging infiltration galleries along the bank as illustrated in figure 3–13. To make an infiltration galley, dig a trench along the bank deep enough so water from the stream percolates into it or it intercepts ground water flowing towards the stream. Fill the trench with gravel to prevent the sides from collapsing and place an intake screen in the gravel below the water level. Infiltration galleries are even possible next to a seawater source (1,000 to 1,500' from a beach) provided the pumping rate is not too much.

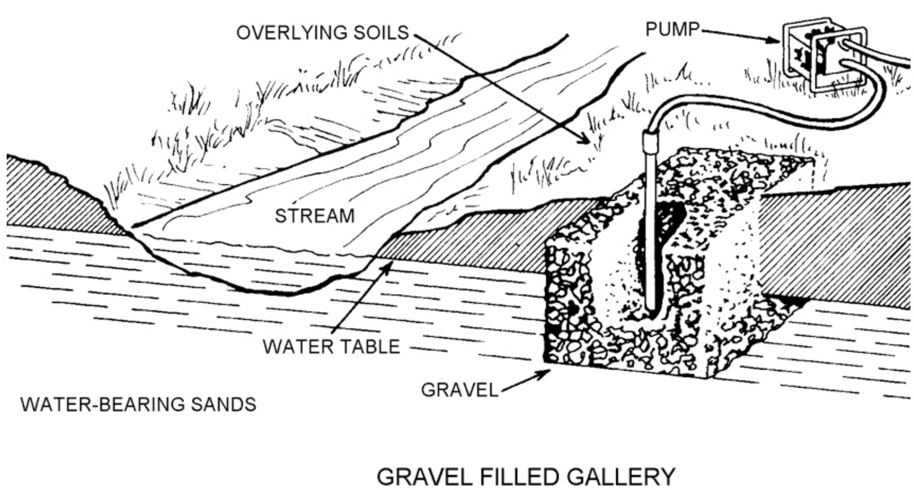


Figure 3–13. Infiltration galleries.

Rainwater

In regions such as the tropical islands where there is abundant rainfall and rapid surface runoff, rainwater is the primary source of water for the inhabitants. Rainwater as a source may be sufficient for small units during limited operations. A collecting surface may be constructed from tarpaulins supported by wood, metal, or concrete. The collected water may then be transferred to storage tanks for treatment.

Snow

In cold weather regions, snow can be collected and heated. The resulting water can then be collected into storage tanks until a sufficient amount of water is available to justify a treatment production run. An even better idea would be to melt ice. Ice is preferred over snow because it yields more water by volume when melted.

Springs

In mountain areas, natural springs of water may be located during a thorough reconnaissance of an area. These springs provide an abundant source of cool, clear water rarely needing anything more than disinfection. Spring water may be collected by constructing wooden troughs that dump water into storage tanks. The water can then be transferred into a water tanker truck and brought to the camp area for treatment.

Wells

Shallow wells are used in many areas of the underdeveloped countries. The local inhabitants of the area usually collect water from these wells with buckets. If you use a shallow well, also use available pumping equipment to transfer water out of the well and into a storage tank. This water can then be trucked to the water treatment site. Existing shallow wells are by far the easiest source of water.

629. Shallow well development

Before modern well-drilling equipment was developed, it was common to dig an open pit in the earth for use as a well. This method is still used in many underdeveloped nations and in areas where well-drilling equipment is not reasonably available.

Dug wells are necessarily shallow and are used where the water table is fairly close to the ground surface. The diameter may range from 3 to 20’. Depths of 10 to 40’ are common. The principal advantage of dug wells is they can be constructed with hand tools. Secondly, their large diameter provides a fairly large reservoir of water within the well itself. However, dug wells are subject to contamination by surface seepage, windblown material, or debris falling into them. To prevent cave-in, dug wells are curbed or lined with wooden staves, masonry curbing, or metal curbing. Most of the water flows into the well through the open bottom, and is removed by using a suction pump like the pitcher pump shown on figure 3–14.

A raw water pump from the BEAR subsystems can be used instead of the pitcher pump. When using the raw water pump, be sure to throttle the pump using the effluent gate valve if the withdrawal rate from the well is too high.

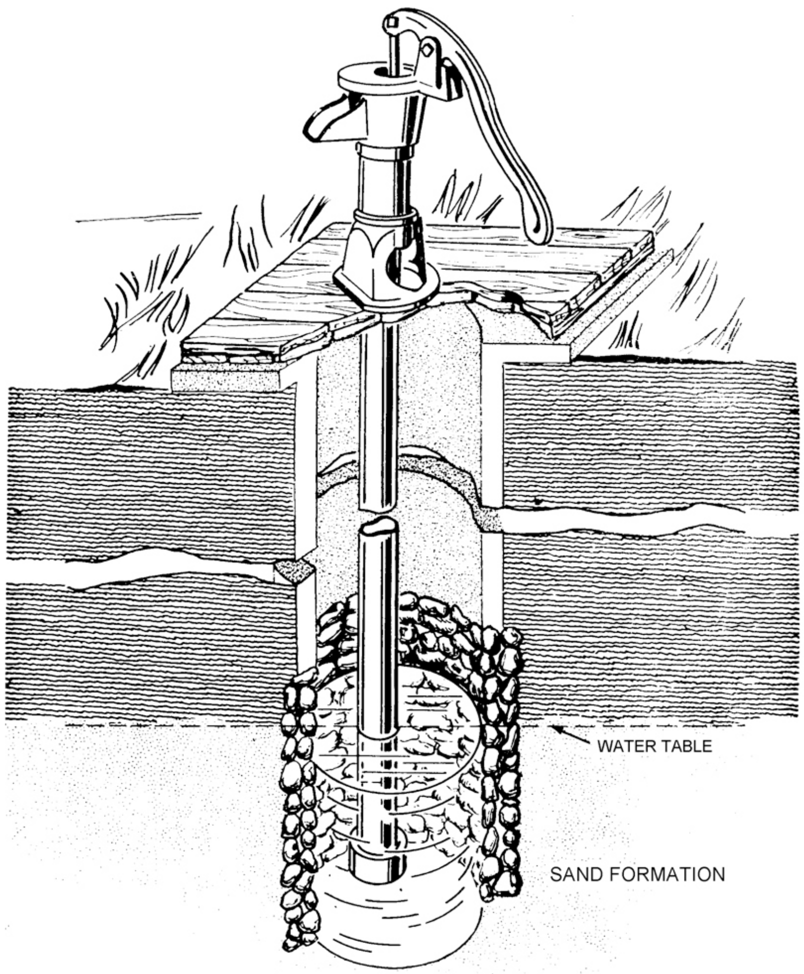


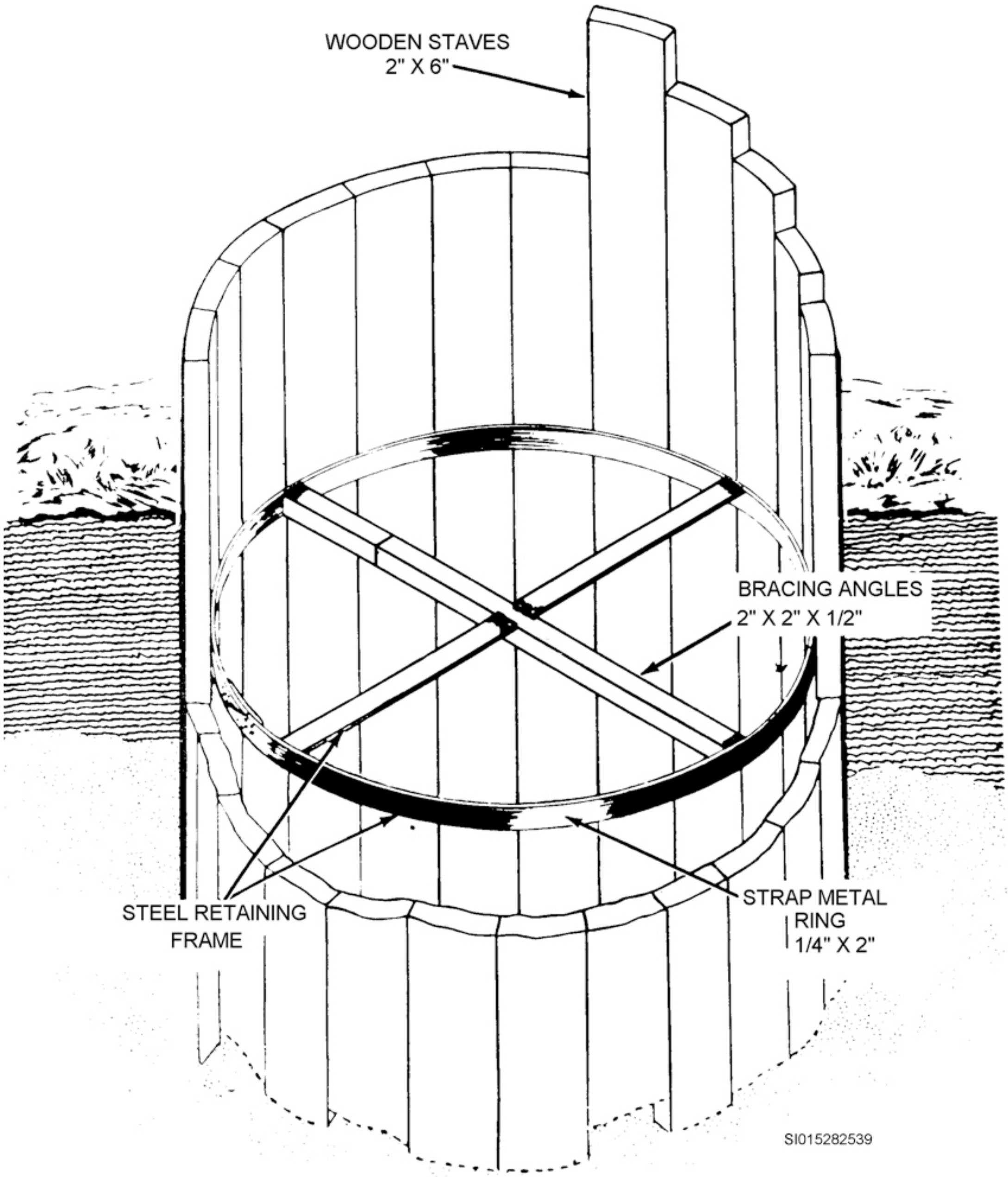
Figure 3–14. Dug well.

Excavation

Dug wells are commonly constructed in circular shape, since a circular hole has fewer tendencies to cave-in. The well material is usually excavated with a pick and a shovel. When digging by hand, a windlass or hoist with a bucket and rope is used to lift the excavated material from the hole.

Curb installation

As the well is being dug deeper, a curb or lining is laced in the excavation before the danger of cave-in develops (3' maximum) because of the depth of the hole. In soft or sandy soil the curb must be started as soon as the digging is begun and moved downward as the pit is deepened (fig. 3–15). As the well becomes deeper, water must be pumped from the well so digging can continue. Once the digging is terminated, the well curbing is extended 1' above the surface to prevent surface runoff from entering the well. After the medical authorities have tested the water, the well can be used as a source of water.



NOTE: RETAINING FRAME SPACED 5 FEET APART FOR AVERAGE GROUND FORMATIONS.

Figure 3–15. Installing wooden staves

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

628. Expansion of water facilities

1. What are the most common sources of water supply?

2. How can you increase the water yielding capacity of small streams?

3. How can you tap water flowing in a muddy stream?

629. Shallow well development

1. Which well development method is still used in many underdeveloped countries?

2. How does water flow into a dug well?

3. What's the principal advantage of a dug well?

4. What component of a dug well prevents cave-ins?

Answers to Self-Test Questions

626

1. A metal deflector inside the box.
2. So each user can cover their excreta and toilet paper with dirt.
3. The VIP has a vertical vent pipe with a fly screen at the top.
4. A flyproof self-closing lid.
5. At least 6' wide.

627

1. Large stones.
2. Climatic conditions.
3. Bentonite.
4. When it is impossible to discharge wastewater off base.

5. They reduce agitation of the layer of scum on the surface of the tank by slowing the water currents through the tank.
6. To allow access for cleaning and repair.
7. The grease remains uncongealed and passes through the trap.
8. 6”.
9. Because of its light weight, strength, and ease of installation.

628

1. Surface waters.
2. By building dams and reservoirs.
3. By building an infiltration gallery.

629

1. The dug well.
2. Through an open bottom.
3. It can be constructed with hand tools.
4. Curbing.

Complete the unit review exercises.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

87. (626) Which expedient latrine is used if a prolonged deployment is planned?
    a. Pail.
    b. Mound.
    c. Deep pit.
    d. Outhouses.

88. (626) How often should you spray a deep-pit latrine for fly control?
    a. Hourly.
    b. Daily.
    c. Weekly.
    d. Twice a week.

89. (626) The number of saddle trenches that you have to build in the field is determined by the
    a. size of the unit.
    b. location of camp.
    c. porosity of the soil.
    d. depth of the ground water.

90. (626) You should close a saddle trench expedient latrine when
    a. insects become a nuisance.
    b. the ground becomes saturated.
    c. it becomes filled to the surface.
    d. it becomes filled to within 1 foot of the surface.

91. (626) Which expedient latrine is *best* for disposing human wastes in the field?
    a. Ventilated improved pit.
    b. Straddle trench.
    c. Deep pit.
    d. Pail.

92. (626) The proper dimensions of the mound latrine are *at least*
    a. 3 feet (‘) wide and 6’ long.
    b. 4’ wide and 8’ long.
    c. 5’ wide and 10’ long.
    d. 6’ wide and 12’ long.

93. (627) To prevent the growth of rooted aquatic plants, how many feet is the *minimum* depth of an oxidation pond?
    a. 2.
    b. 3.
    c. 4.
    d. 5.

94. (627) What type of pond or lagoon should be used only as a last resort when disposing of wastewater?
    a. Aerated.
    b. Oxidation.
    c. Evaporation.
    d. Nonaerated.

95. (627) What reduces the agitation of the scum layer in the septic tank?
    a. Baffle boards.
    b. Deflector plates.
    c. A crimped inlet pipe.
    d. A slight water spray.

96. (627) What is used in a leach field to prevent fine soil particles from migrating into the gravel?
    a. Cloth.
    b. Plastic.
    c. Layer of tar.
    d. Paper or straw.

97. (627) You should design a lift station to have sufficient capacity so grease already in the trap is
    a. digested over time.
    b. stored for long periods.
    c. not heated by incoming hot grease.
    d. no more than 2 inches in thickness.

98. (628) When you expand water facilities, the capacity of any small dams and reservoirs you build should be capable of impounding *at least* the total
    a. daily flow.
    b. weekly flow.
    c. biweekly flow.
    d. monthly flow.

99. (629) How many feet is the diameter of a dug well?
    a. 1 to 3.
    b. 3 to 20.
    c. 25 to 35.
    d. 35 to 40.

100. (629) In a dug well, the water flows into the casing from the
    a. well screen.
    b. bottom.
    c. sides.
    d. top.

Glossary of Abbreviations and Acronyms

’	foot/feet
”	inch/inches
A	ampere
AEF	air and space expeditionary force
AF	Air Force
AFB	Air Force base
AFS	Air Force specialty
AFTH	Air Force theater hospital
APR	air-purifying respirator
ATC	air transportable clinic
BaSO4	barium sulfate
BEAR	Basic Expeditionary Airfield Resources
BII	basic issue item
CA(C1O)$_2$	calcium hypochlorite
CaCO3	calcium carbonate
CaSO4	calcium sulfate
CB	circuit breaker
CBRNE	chemical, biological, radiological, nuclear, and high-yield explosives
CE	civil engineering
cfm	cubic feet per minute
Cl2	chlorine
CPC	centrifugal pump control
CRT	coating removal tool
DART	damage assessment response team
DCC	damage control center
DECON	decontaminate
DI	deionization
DPD	diethyl-phenylene-diamine
EBS	Expandable Bicon Shelter
ECU	environmental control unit
E-Falcon	Expeditionary Falcon
EMEDS	expeditionary medical support team
EOD	explosive ordnance disposal

Fe	iron
FO	foldout
gal.	gallon
GFCI	ground fault circuit interrupters
GFE	ground fault equipment
GND	ground
gpd	gallons per day
gph	gallons per hour
gpm	gallons per minute
gpppd	gallons per person per day
H&L	hook and loop
hth	calcium hypochlorite
HVAC	heating, ventilation, and air conditioning
HVAC/R	heating, ventilation, and air conditioning/refrigeration
Hz	hertz
I/O	input/output
IPB	illustrated parts breakdown
K	thousand
kW	kilowatt
lb.	pound
LED	light-emitting diode
LEL	lower explosive limit
ml	milliliter
mm	millimeter
mph	miles per hour
NBC	nuclear, biological, and chemical
NPT	national pipe threads
NSN	national stock number
NTU	Nephelometric Turbidity Unit
OD	outside diameter
OISS	Ocean Intake Structure System
P/N	part number
PEX	cross-linked polyethylene
PH	phase
pH	potential of hydrogen

POL	petroleum, oils, and lubricants
PPE	personal protective equipment
ppm	parts per million
psi	pounds per square inch
psid	pounds per square inch differential
PVC	polyvinyl chloride
QD	quick-disconnect
RDF	rapid deployment force
RO	reverse osmosis
ROWPU	reverse osmosis water purification unit
rpm	revolutions per minute
RURK	rapid utility repair kit
SAR	supplied air respirator
SDC	secondary distribution center
SRS	source run subsystem
SST	sewer sucker trailer
TDS	total dissolved solids
TEMPER	tent expendable modular personnel
TM	technical manual
TO	technical order
tsp.	teaspoon
US	United States
USAF	United States Air Force
UTC	unit type code
UXO	unexploded ordnance
V	volt
VAC	volts, alternating current
VIP	ventilated improved pit
VOC	volatile organic compound
WFSM	Water and Fuel Systems Maintenance
WPS	water production subsystem

Student Notes

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