

TECHNICAL MANUAL

**OPERATOR, UNIT, DIRECT SUPPORT
AND GENERAL SUPPORT
MAINTENANCE MANUAL
(INCLUDING REPAIR PARTS AND
SPECIAL TOOLS LIST)**

FOR

**WATER PURIFICATION BARGES
(NSN 1930-01-234-2165)
VOLUME 3
REVERSE OSMOSIS WATER PURIFICATION UNIT
(ROWPU) SYSTEM**

This technical manual is an authentication of the manufacturer's commercial literature and does not conform with the format and content requirements normally associated with the Army technical manuals. This technical manual does, however, contain all essential information required to operate and maintain the equipment.

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

*This manual supersedes TM 55-1930-209-14&P-3-1 and TM 55-1930-209-14&P-3-2, 30 January 1989.

WARNINGS AND SAFETY NOTICES

WARNING

**DANGEROUS VOLTAGES AND HAZARDOUS MATERIALS
ARE USED IN THIS EQUIPMENT
DO NOT TAKE CHANCES!
GENERAL WARNINGS**

- Always redtag electrical equipment, controls, circuits, and switches before beginning repairs.
- Do not service or adjust high voltage electrical equipment when alone.
- Do not overload circuits.
- Always use authorized, insulated tools and test equipment when working on electrical equipment.
- Remove all jewelry before working on or around electrical equipment with exposed current-carrying areas.
- Do not wear clothing with exposed metal fasteners when working on electrical equipment.
- Always use approved breathing apparatus when working with chemicals.
- Avoid chemical contact with eyes, skin, and clothing.
- Always wear safety glasses, gloves, and rubber aprons when handling chemicals.
- Wear protective clothing and safety glasses as required when working on barge equipment.
- Always wear approved ear protection in noise hazard areas.

SPECIFIC WARNINGS

- Do not connect any new circuit to an existing circuit.
- Do not energize circuits if water condensation is present.
- If any sparks are seen, stop operation immediately. Determine cause and take corrective action.
- Never touch radio antennas of fixed-base radio transmitters. When transmitting, antennas contain high voltage.
- Always use approved breathing apparatus when handling material in multimedia filters and chlorination unit descaling acid crystals. Do not breathe dust from these materials.
- Avoid breathing vapors from coagulant aid chemicals. Use in a well-ventilated area. In case of chemical contact with skin, wash with water. For eyes, immediately flush at eyewash station and obtain medical help as soon as possible.
- Always wear work gloves and shirts with full length buttoned sleeves when handling fuel oil and gasoline.

- Do not smoke or have open flames within 10 feet when handling fuel oil or gas Only minimum number of personnel necessary to conduct fueling operation is permitted In area.
- Before starting any repairs on compressed air system, always release pressure from air receiver and compressor and open and redtag circuit breakers.
- On air compressor, do not adjust automatic regulator switch (pressure switch) and pilot valve settings.
- To avoid flying particles lodging in eyes, do not use compressed air to "dust-off" clothing or workspace.
- Stay clear of anchor cables when operating anchor winches.
- Always wear safety glasses or face shield when using power tools.
- Always wear lifevests when on weatherdeck and throughout the barge during storm conditions.
- Lifevests are to be worn at all times aboard workboat.
- Only qualified persons will operate and maintain arc and fuel gas welders.
- When welding, always make sure those working with or near the welder wear proper clothing. heavy, hole-free gloves, heavy shirt, cuffless trousers, high shoes, and cap Keep clothing dry and free of oil and other flammable substances.
- Use dry heavy canvas drop cloth to cover work area and adjacent deck when arc welding.
- Before welding on bulkheads, deck plating and similar surfaces, always check carefully to make sure that the other side of the surface to be welded does not hide fuel or compressed gas tanks, flammable or hazardous materials, or electrical equipment or wiring.
- When welding, keep your head out of the fumes and make sure area is well ventilated.
- Before welding on surfaces which have been cleaned with cleaning solutions containing chlorinatedhydrocarbons, always wash with water, dry and ventilate area thoroughly.
- Use shield with proper filter lens when welding Do not allow others near welding operations to assist or observe without proper eye protection. This must include side shields during slag chipping operations Warn personnel In area during welding operations not to look at arc or expose themselves to hot spatter or metal.
- In an extreme emergency, when welding is required In void 2 port, shut down chlorination system. Close all valves Cover the parts of chlorination system not being welded with a heavy canvas drop cloth Turn on vent 8 and, If available, provide additional forced air ventilation.

- Before welding on fuel oil or sludge tank, make sure tank is gas-free by' 1) removing all liquid from tank, 2) cleaning tank thoroughly, 3) seeing that tank is thoroughly dry, and 4) force ventilating tank
- Connect arc welding work cable as close to welding area as possible. Work cables connected to barge framework or other locations far from welding site increase the possibility of the welding current passing through lifting chains, crane cables or other possible circuit paths This can create fire hazards or weaken lifting chains or crane cables until they break or fall
- Always weld with all doors, portholes, and hatches propped open and necessary ventilation systems operating.
- Take frequent breaks away from the area where you are welding
- Do not take oxygen and acetylene tanks into confined areas when welding
- Always use a friction lighter to start oxyacetylene torch.
- Always maintain all welding equipment in proper working condition If you have any doubts about the safety of any welding equipment, do not use the welder

ELECTRICAL SHOCK SAFETY STEPS

Five safety steps to follow If someone is the victim of electrical shock

1. Do not try to pull or grab Individual
2. Turn off electrical power when possible
3. If you can not turn off electrical power, pull, push, or lift person to safety using a wooden pole, rope, or some other insulating material
4. Get medical help as soon as possible
5. After the injured person is free of contact with the source of electrical shock, move the person a short distance away and, if needed, start CPR immediately

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INTRODUCTION TO

TM 55-1930-209-14&P-3

You can help improve this manual If you find any mistakes or if you know of a way to improve the procedures, please let us know Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located In the back of this manual direct to. Commander, US Army Troop Support Command, ATTN AMSTR-MMTS, 4300 Goodfellow Blvd, St Louis, MO 63120-1798 A reply will be furnished directly to you.

1. SCOPE

TM 55-1930-209-14&P covers the Reverse Osmosis Water Purification Barges, Models 300-WPB-1, 300-WPB-2 and 300WPB-3, NSN 1930-01-234-2165 This manual consists of twenty-one volumes

2. REVERSE OSMOSIS WATER PURIFICATION BARGES

The Reverse Osmosis Water Purification Barges provide up to 300,000 gallons of drinking water per 24 hour period The drinking water, converted from seawater or brackish water, Is for use by a Rapid Deployment Force In a forward area When needed, the drinking water can be pumped to a shore facility or to another vessel This manual provides operation and maintenance procedures for all the component systems on the barges

3. VOLUME 1 -- NORMAL OPERATIONS

This volume provides Information and procedures on normal Reverse Osmosis Water Purification Barge operations, including barge movement and deployment, communications and electrical power systems, drinking water production, shutdown, and required operational maintenance. Emergency shutdown procedures are also provided

4. VOLUME 2 -- SEAWATER SYSTEM

This volume describes operation and maintenance of the seawater system which supplies seawater to the Reverse Osmosis Water Purification Units (ROWPUs) for processing to the air conditioning unit for cooling to the ballast tank for barge trimming to the chlorination unit for priming and cooling, and to the diesel generators for cooling.

5. VOLUME 3 -- REVERSE OSMOSIS WATER PURIFICATION UNIT (ROWPU) SYSTEM

Volume 3 provides operation and maintenance procedures for the ROWPU System which processes seawater or brackish water to produce drinking water Normally, this system processes seawater supplied by the seawater system (TM 55-1930-209-14&P-2) to create product water. Chlorine is then added to this product water by the chlorination system (TM 55-1930-209-1 4&P-4) The resultant drinking water Is discharged into four storage tanks that are part of the drinking water system (TM 55-1930-209-14&P-5)

6. VOLUME 4 -- CHLORINATION SYSTEM

Operation and maintenance procedures for the chlorination system onboard the Water Purification Barges are contained In this volume. This system produces chlorine in a sodium hypochlorite solution, upon demand, to water processed by the ROWPU system just before the water enters the four drinking water storage tanks.

7. VOLUME 5 -- DRINKING WATER SYSTEM

The drinking water system provides storage for water produced by the ROWPUs and includes pumps and valves to move this water from onboard storage tanks to the shore discharge system, to another vessel, or overboard. The drinking water system also provides a pressurized water supply for drinking and washing onboard the barges.

8. VOLUME 6 -- SHORE DISCHARGE SYSTEM

This volume provides operation and maintenance procedures for the shore discharge system which transfers drinking water from barge storage tanks to holding/storage facilities ashore.

9. VOLUME 7 -- COMPRESSED AIR SYSTEM

Volume 7 describes the operation and maintenance of the compressed air system which provides compressed air to five air stations in the ROWPU space, one in the workshop, and one on stern weatherdeck. This system also provides compressed air to two air stations for blowdown of seachests in void 2 starboard and void 4 port. Compressed air is used on the barges to operate air-powered impact tools, to propel air through the shore discharge hose, to blowdown seachest, and for general cleaning blowdown.

10. VOLUME 8 -- FUEL OIL SYSTEM

This volume provides operation and maintenance procedures for the fuel oil system which functions as a centralized receiving storage and distribution system for diesel fuel used for barge operations. This onboard fuel system provides fuel for two 155 kW diesel ship service generators, a 20 kW ship auxiliary generator, two ROWPU high-pressure pump diesel engines, and a fueling station for the barge workboat.

11. VOLUME 9 -- ELECTRICAL POWER SYSTEMS

Operation and maintenance procedures for the two electrical power systems installed aboard the Water Purification Barges are contained in Volume 9. The normal electrical power system generates, controls and distributes all electrical power for operating the water purification system and its auxiliary systems. The emergency electrical system supplies 24 Vdc from a battery bank to 24 Vdc equipment and converts to 24 Vdc through an inverter to 120 Vac to power emergency lighting and equipment.

12. VOLUME 10 -- LIGHTING SYSTEM

Volume 10 contains operation and maintenance procedures for the onboard lighting systems for the Water Purification Barges. This system supplies interior and exterior lighting. Normal and emergency interior lighting is provided in the deckhouse ROWPU space, dayroom, workshop, and voids. Exterior lighting consists of searchlights and floodlights for use at night or during reduced visibility. Lights on the weatherdecks and standard navigation and status lights are for use during operation and towing.

13. VOLUME 11 -- EQUIPMENT MONITORING SYSTEM

This volume provides operation and maintenance procedures for the equipment monitoring system which monitors the operation of several equipment components onboard the Water Purification Barges. This system monitors operating conditions such as amount of drinking water in storage tanks and temperature of diesel engine cooling water. Sensors detect unacceptable operating conditions, the main processor flashes at double intensity and remote alarms (horns, strobe lights and buzzer) alert crew members that corrective action is necessary.

14. VOLUME 12 -- COMMUNICATIONS SYSTEM

Operation and maintenance procedures for the communications system are provided in Volume 12 This system consists of three separate communications methods, radio communications, foghorn and intercom telephones

15. VOLUME 13-- HANDLING EQUIPMENT

This volume contains operation and maintenance procedures for handling equipment used for lifting, transporting and repositioning equipment and materials onboard the barges The system includes a bridge crane, bow crane and a void 4 trolley hoist.

16. VOLUME 14 -- ANCHOR, MOORING, AND TOWING EQUIPMENT

Volume 14 describes the operation and maintenance procedures for the anchor mooring, and towing equipment on the Water Purification Barges This equipment provides a method to hold (anchor) the barges in a fixed position offshore, at dockside, or next to another vessel and a method to move the barges from one location to another

17. VOLUME 15 -- MISCELLANEOUS EQUIPMENT (DAYROOM, WORKSHOP, ACCESSES, AND SANITATION SYSTEMS)

Volume 15 addresses operation and maintenance procedures for miscellaneous equipment installed on the Water Purification Barges This equipment includes the dayroom on the forward starboard side of deckhouse, the workshop on the forward portside of deckhouse, accesses such as deckhouse doors and portholes and various accesses to and from the voids, and two separate sanitation systems (toilets and bilge) Additional equipment addressed in this volume includes guard rails, rubber fendering, removable rubber floor mats, eyewash stations, component labels, caution, warning and danger signs, and storage areas.

18. VOLUME 16 -- VENTILATION, HEATING, AND AIR CONDITIONING SYSTEMS

This volume contains operation and maintenance procedures for the deckhouse and voids ventilation systems and the heating and air conditioning (HAC) system installed on the Water Purification Barges The ventilation system provides fresh air circulation in the deckhouse and voids with 17 hatches and 10 ventilation fans The HAC controls the temperature in the dayroom and deckhouse.

19. VOLUME 17 -- WORKBOAT, LIFESAVING, AND FIREFIGHTING EQUIPMENT

Volume 17 includes procedures for the operation and maintenance of.

- a. Workboat -- provides water transportation for crew members and visitors, small cargo items, transportation of the messenger line for the shore discharge hose and similar work-related tasks associated with operating the Water Purification Barges.
- b. Lifesaving Equipment -- installed on the barges and consisting of 2 liferafts, 15 Type II and 24 Type V lifevests and 4 lifesaving rings.
- c. Firefighting Equipment -- Installed on the barges and consisting of Halon 1301 system, 2 CO₂ hose reel units, a smoke detector system, 17 portable CO₂ fire extinguishers, 5 dry chemical fire extinguishers, 5 self-contained breathing apparatuses, and a portable, engine driven firefighting pump The workboat also has a 1 O-pound, portable, dry chemical fire extinguisher.

20. VOLUME 18 -- SUPPORTING APPENDICES FOR VOLUMES 1-17

Volume 18 contains the Maintenance Allocation Chart, Components of End Item List, Tools and Test Equipment List, Expendable/Durable Supplies and Materials List and the Repair Parts and Special

All of the Information contained In this volume is common to volumes 1-17 and does not appear In each individual volume

Appendix A in volumes 1-17 provides information unique to each volume Appendix B in volumes 1-17 provides manufacturers manuals and Instructions unique to the system described In each volume Appendixes C-G are located In Volume 18

21. **VOLUME 19 -- PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)**

Volume 19 contains PMCS pertinent to all onboard systems for the Reverse Osmosis Water Purification Barges

22. **VOLUME 20 -- SUPPLEMENTAL DATA**

Volume 20 contains the Basic Issue Items List, and additional Authorization List for all onboard systems for the Reverse Osmosis Water Purification Barges.

23. **VOLUME 21 -- WINCH, DOUBLE DRUM, DIESEL**

This volume contains operation and maintenance procedures for the 20-ton double drum diesel engine winch used on the Water Purification Barges Appendix B of Volume 21 contains the Maintenance Allocation Chart and the Repair Parts and Special Tools List for the winch

TECHNICAL MANUAL
NO 55-1930-209-14&P-3

HEADQUARTERS
DEPARTMENT OF THE ARMY,
WASHINGTON D C, 15 OCTOBER 1992

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VOLUME 3
REVERSE OSMOSIS WATER PURIFICATION UNIT
(ROWPU) SYSTEM**

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help Improve this manual. If you find any mistakes or if you know of a way to Improve the procedures, please let us know Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual direct to: Commander, US Army Troop Support Command, ATTN: AMSTR-MMTS, 4300 Goodfellow Blvd., St Louis, MO 63120-1798 A reply will be furnished directly to you

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NOTE

The following appendices, common to all TM's in this series, are in TM-55-1930-209-14&P-18

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 TOOLS AND TEST EQUIPMENT LIST (TTEL)
 EXPENDABLE /DURABLE SUPPLIES AND MATERIALS LIST (ESML)
 REPAIR PARTS AND SPECIAL TOOLS LIST (RPSTL)
 REPAIR PARTS LIST TO FIGURE NUMBER CROSS-REFERENCE LIST

NOTE

The following appendices, common to all TM's in this sense, are in TM 55-1930-209-14&P-20
 COMPONENTS OF END ITEM LIST (COEIL) and BASIC ISSUE ITEMS LIST (BIILL)
 ADDITIONAL AUTHORIZED ITEMS LIST (AAL)

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CHAPTER 1 INTRODUCTION

Section I. General information

1-1 Purpose. This Technical Manual (TM) describes the operation and maintenance of the water purification system Installed onboard Water Purification Barges Information on other systems and equipment Installed onboard is in TM 55-1930-209-14 & P-1 and P-2, and P-4 thru P-17 TM 55-1930-209-14 & P-1 8 contains appendices common to all TM's. Location of major barge components is shown in Figure NO TAG.

NOTE

Additional operation, maintenance and parts Information may be found In the following technical manuals which cover the 150,000 Gallon Per Day(GPD) Reverse Osmosis Water Purification Unit (RO WPU):

TM 10-4610-229-10, Operator's Manual for 150,000 GPD ROWPU

TM 10-4610-229-24, Unit, Direct and General Support Maintenance Manual for 150,000 GPD ROWPU

TM 10-4610-229-24P, Repair Parts and Special Tools List for 150,000 GPD ROWPU

1-2 Scope. The Reverse Osmosis Water Purification Unit (ROWPU) system processes seawater or brackish water into drinking water Normally, this system processes seawater supplied by the seawater system (TM 55-1930-209-14 & P-2), and creates product water Chlorine Is then added to this product water by the chlorination system (TM 55-1930-209-14 & P-4) The resultant drinking water is discharged into four storage tanks that are part of the drinking water system (TM 55-1930-209-14 & P-5)

1-3 Warranties and guarantees The ROWPU system is government furnished equipment. This TM, therefore, contains no applicable warranty/guarantee Information

1-4 Maintenance forms and records. Maintenance forms and records are explained In DA PAM 738-750, The Army Maintenance Management System (TAMMS)

1-5 Destruction of Army materiel to prevent enemy use. This shall be as directed in TM 750-244-3.

1-6 Storage. For storage of this equipment, refer to Chapter 5

Section II. Description and data

1-7 System description. The ROWPU system has two identical units, ROWPU 1 and ROWPU 2, that process feedwater (seawater or brackish water from a river or lake) provided by the seawater system (TM 55-1930-209-14 & P-2). This ROWPU system produces two products through reverse osmosis (RO). brine water or dirty water that Is dumped overboard and highly filtered non-saltwater called product water. The product water, with the addition of chlorine from the chlorination system (TM 55-1930-209-14 & P-4), becomes drinking water. Drinking water is pumped into the drinking water system's four drinking water storage tanks or directly overboard (TM 55-1930-209-14 & P-5)

Components of the ROWPU system are listed in Table 1-1. Location of ROWPU 1 components is shown in Figure NOTAG and ROWPU 2 components In Figure NOTAG A block diagram of the ROWPU system is shown In Figure NO TAG ROWPU system installation Is shown on drawings referenced In Appendix A

1-8 Component description. The ROWPU system main components are described below. Main components are shown in Figure NO TAG. Valves, controls, and indicators are discussed in paragraph 3-1.

1-8.1 Pretreatment skid assembly. The pretreatment skid assembly controls water flow and monitors water processing from the seawater pumps through various cleaning procedures before water is delivered to the high pressure (HP) pumps. This assembly consists of a control station, two chemical metering pumps for adding coagulant and inhibitor, four water pressure gauges, a cartridge filter assembly, interconnecting piping, and valves. Seawater pumps, part of the seawater system, establish the required flow rate through the pretreatment skid, the cartridge filter assembly, and the media filters.

The control station contains electrical circuitry for operating one seawater pump and two chemical metering pump motors. It also mounts the seawater pump OFF/ON/START switch, OFF/ON switch for each chemical metering pump, BACKWASH TIMER, and POWER ON, CARTRIDGE FILTER OK, and MEDIA FILTER OK indicator lights

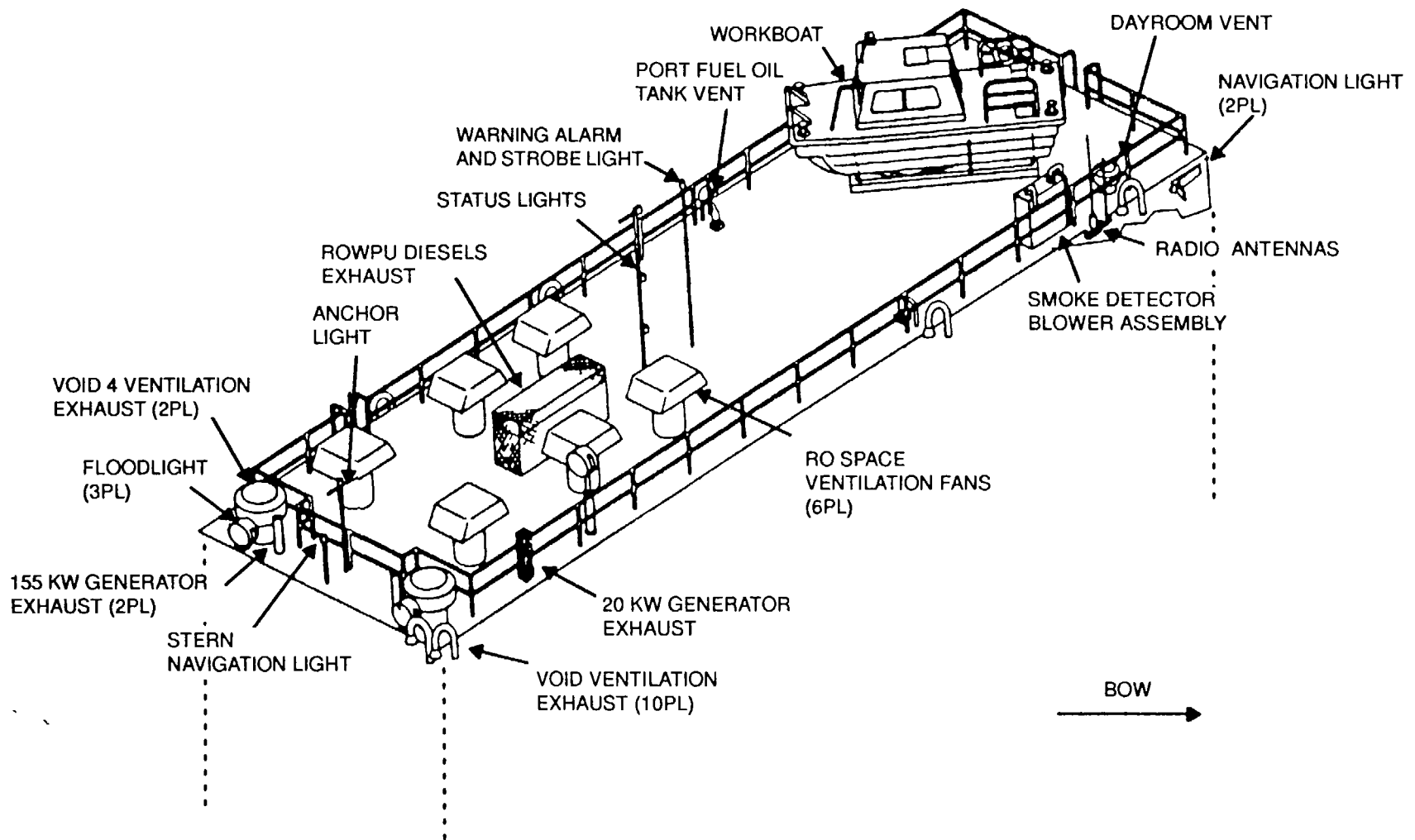


Figure 1-1. Major Components of ROWPU Barge Systems and Equipment - Deckhouse Roof
(Sheet 1 of 3)

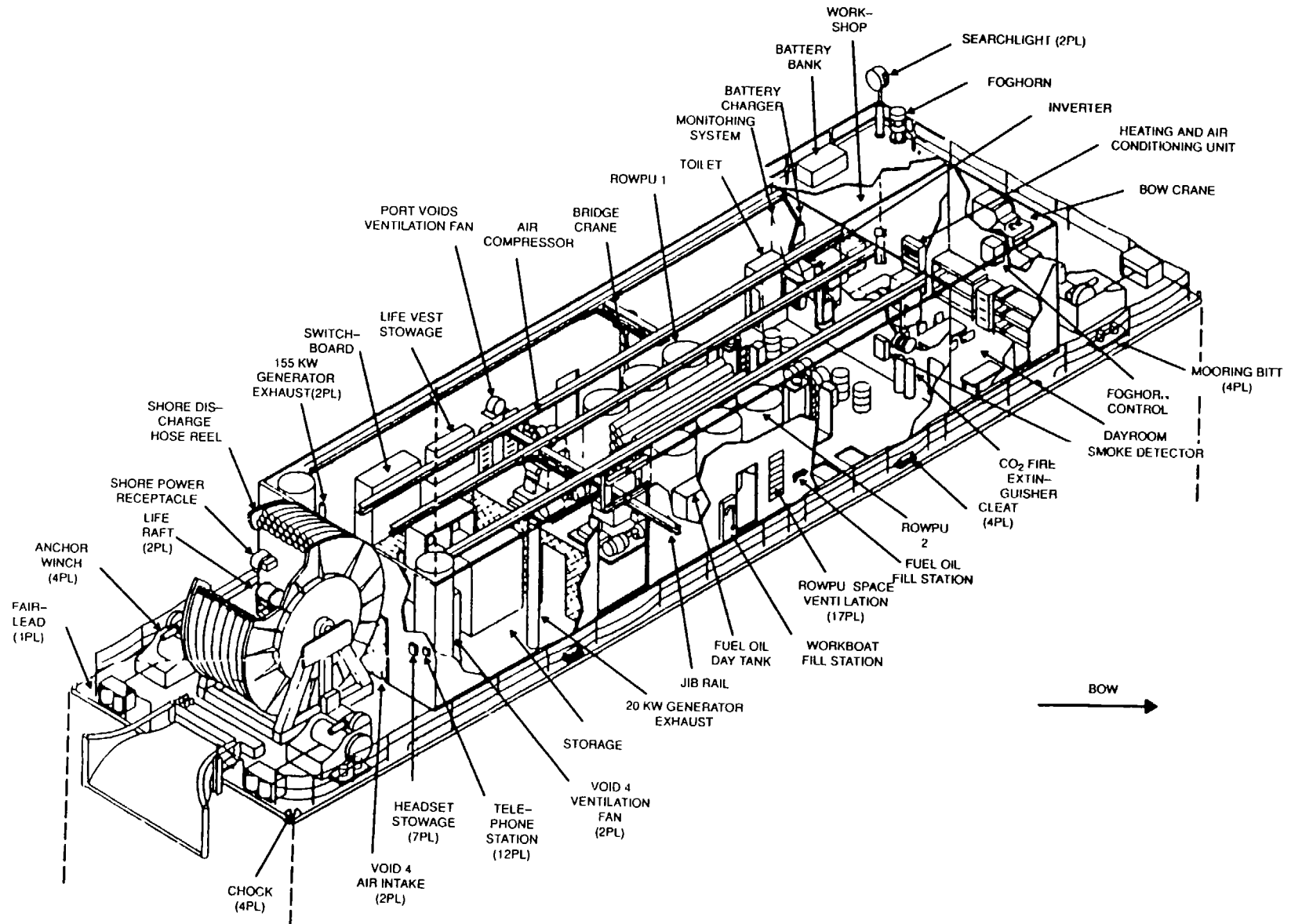


Figure 1-1. Major Components of ROWPU Barge Systems and Equipment - Deckhouse Roof
(Sheet 2 of 3)

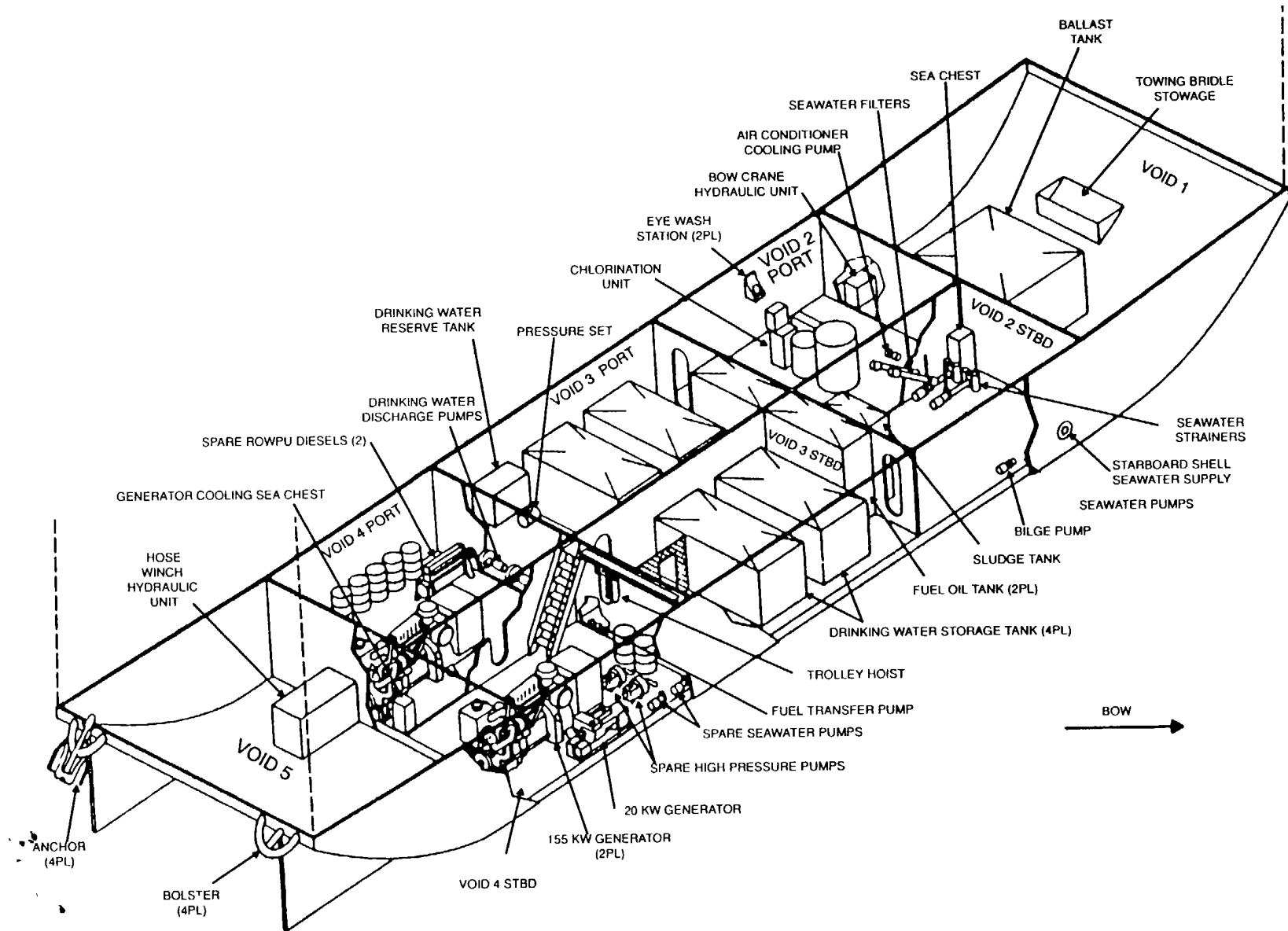


Figure 1-1. Major Components of ROWPU Barge Systems and Equipment - Deckhouse Roof
(Sheet 3 of 3)

The coagulant metering pump is a reciprocating, positive displacement unit designed to move specific volumes of liquid against positive or negative pressure. The pump delivers a manually adjusted dosage of coagulant (Hydrapol-50) into the feedwater stream before the raw water enters the seawater filter (part of the seawater system) The metering pump is on top of the pretreatment skid and the ON/OFF switch is on the control panel Output capacity is adjustable by a micrometer handknob located on the pump head.

The scale inhibitor metering pump delivers a manually adjusted dosage of scale Inhibitor (Hydrapol-1 00) into the feedwater stream before the filtered water enters the RO block. Pump description, location, and characteristics are the same as the coagulant pump.

Four water pressure gauges across the top of the control station monitor feedwater pressure at critical points In its passage from the seawater pumps to the HP pumps Pressure gauge P1 indicates pressure going into the media filters. Pressure gauge P2 indicates pressure coming out of the media filters and going into the cartridge filter assembly Pressure gauge P3 indicates pressure coming out of the cartridge filter assembly. Pressure gauge P5 indicates brine water pressure as it leaves the RO block Pressure gauge P4, located on the HP pump outlet, measures feedwater pressure In the HP pump discharge line

The cartridge filter assembly removes any suspended particles that may escape the media filters The filter assembly housing is constructed of fiberglass and polyvinyl chloride, and contains 12 polypropylene filter elements whose filtration rating is 10 microns During operation, the differential pressure drop across the cartridge filter assembly may be monitored by subtracting the reading of P3 from P2. A pressure difference of 12 pounds per square Inch (psi) or more Indicates the need to replace the filter cartridges. Filter replacement is also indicated when the green CARTRIDGE FILTER OK light on the control panel goes out.

1-8.2 Media filters. Three identical media filters are provided for each ROWPU Each filter has a capacity of 120 gallons per minute (gpm) and all filters are used constantly during water processing Inlet water is pumped into the top of the filters where it is spread out across the filter media and forced downward through four different kinds of media to the outlet The top layer consists of a layer of relatively coarse, high density anthracite coal Below the anthracite is a layer of medium fine silica sand The next layer is fine garnet and below that is a layer of coarse garnet which covers the radial laterals of the bottom distributor These four media rest upon a supporting bed of gravel placed in the bottom of the filter body Media filters require periodic backwashing to remove minute particles collected from the seawater during normal operation. The need for backwashing is indicated when the difference between pressure gauges P1 and P2 exceeds 35 psi or when green MEDIA FILTER OK light on control panel goes out Valves on the pretreatment skid control backwashing and flushing Drinking water production must be stopped while backwashing media filters Because media materials are progressively denser from top to bottom, they rearrange themselves after backwashing to the original layers for correct filtering.

1-8.3 HP pump skid. The HP pump skid consists of a steel skid frame with a diesel engine, an HP pump, and a multiple V-belt drive mounted on it The diesel engine drives the HP pump through the V-belt drive system. The HP pump, in turn, boosts feedwater pressure from the pretreatment skid to the higher pressure required for the reverse osmosis process in the RO block assembly. The skid carries all engine accessory equipment such as batteries, exhaust system, and alternator Diesel engine controls are mounted on top of the V-belt housing.

1-8.4 RO block assembly. The RO block assembly is a steel skid and frame that supports 16 pressure tube assemblies and their associated manifolds and piping. The pressure tubes each hold five RO membrane elements Sample valves are located at the end of each pressure tube for monitoring water quality A product water sample valve is also located in the piping leading to the drinking water tanks. A flowmeter measures product water flow. A throttling valve in the brine discharge piping provides a means of controlling product water flow and is adjusted in conjunction with the HP pump output pressure. The HP pump output is adjusted by varying diesel engine speed to increase or decrease seawater pressure flowing to the RO block.

Table 1-1. ROWPU System Components *

<u>Component</u>	<u>Quantity</u>	<u>Function</u>	<u>Location</u>
Pretreatment skid assembly	1 per ROWPU	Controls flow of seawater and chemicals to media filters and cartridge filter assembly, indicates status of pretreatment filters	Forward of media filters
Seawater pump flow rate indicator FI	1 per ROWPU	Monitors flow rate of incoming seawater	On pretreatment skid
Pressure gauge P1	1 per ROWPU	Indicates pressure of media filter inlet water (seawater pump discharge)	On pretreatment skid top panel
Pressure gauge P2	1 per ROWPU	Indicates pressure of media filter outlet water and cartridge filter assembly inlet water	On pretreatment skid top panel
Pressure gauge P3	1 per ROWPU	Indicates water pressure at cartridge filter assembly outlet	On pretreatment skid top panel
Pressure gauge P4	1 per ROWPU	Indicates HP pump discharge pressure	On HP pump outlet
Pressure gauge P5	1 per ROWPU	Indicates brine discharge pressure	On pretreatment skid top panel
Temperature gauge T1	1 per ROWPU	Monitors incoming seawater temperature	Between RO18 and FI
Product water flowmeter F2	1 per ROWPU storage tanks	Measures flow of product water to	Aft of RO block assembly
Sight glass flow indicator	1 per ROWPU	Indicates presence of water flow from RO block	Brine discharge line
Media filter	3 per ROWPU	Filters water from seawater pump before entering cartridge filter assembly	Between pretreatment skid cartridge filter assembly and HP pump skid
Cartridge filter assembly	1 per ROWPU	Filters water from media filters before it enters HP pump	Mounted on pretreatment skid

Table 1-1. ROWPU System Components *

<u>Component</u>	<u>Quantity</u>	<u>Function</u>	<u>Location</u>
HP pump assembly	1 per ROWPU	Boosts pressure of chemically treated seawater to high level required for RO block processing	Aft of media filters and RO block assembly
RO block assembly	1 per ROWPU	Processes chemically treated seawater from HP pump	Inboard of media filters
Hydraldeen-20 (55-gallon cleaning agent drum)	1 per ROWPU	Cleans RO membrane elements	Inboard of Hydrapol- 50 drum
Chemical metering pumps	2 per ROWPU	Adds measured amounts of chemicals (coagulant aid and Inhibitor) to feedwater	On top of pretreatment skid
Hydrapol-50 (55-gallon coagulant drum)	1 per ROWPU	Added to seawater as a coagulant aid before entering media filters	Forward of pretreatment skin
Hydrapol-100 (55-gallon inhibitor drum) filter assembly	1 per ROWPU	Added to seawater as a scale Inhibitor before entering cartridge	Outboard of Hydrapol- 50 drum

*See Table 3-3 for listing of ROWPU system valves.

1-9 System capabilities

24-hour production (per ROWPU)	150,000 gallons
24-hour production (total)	300,000 gallons

The above figures are for a production cycle of 10 hours of operating time followed by 2 hours of non-operating time to accomplish backflushing, cartridge changing, and other maintenance.

1-10 Limitations. Seawater (feedwater) must be free of chlorine, detergents, and other contaminants. In addition, the ROWPU cannot be operated in sea conditions that exceed Sea State 3.

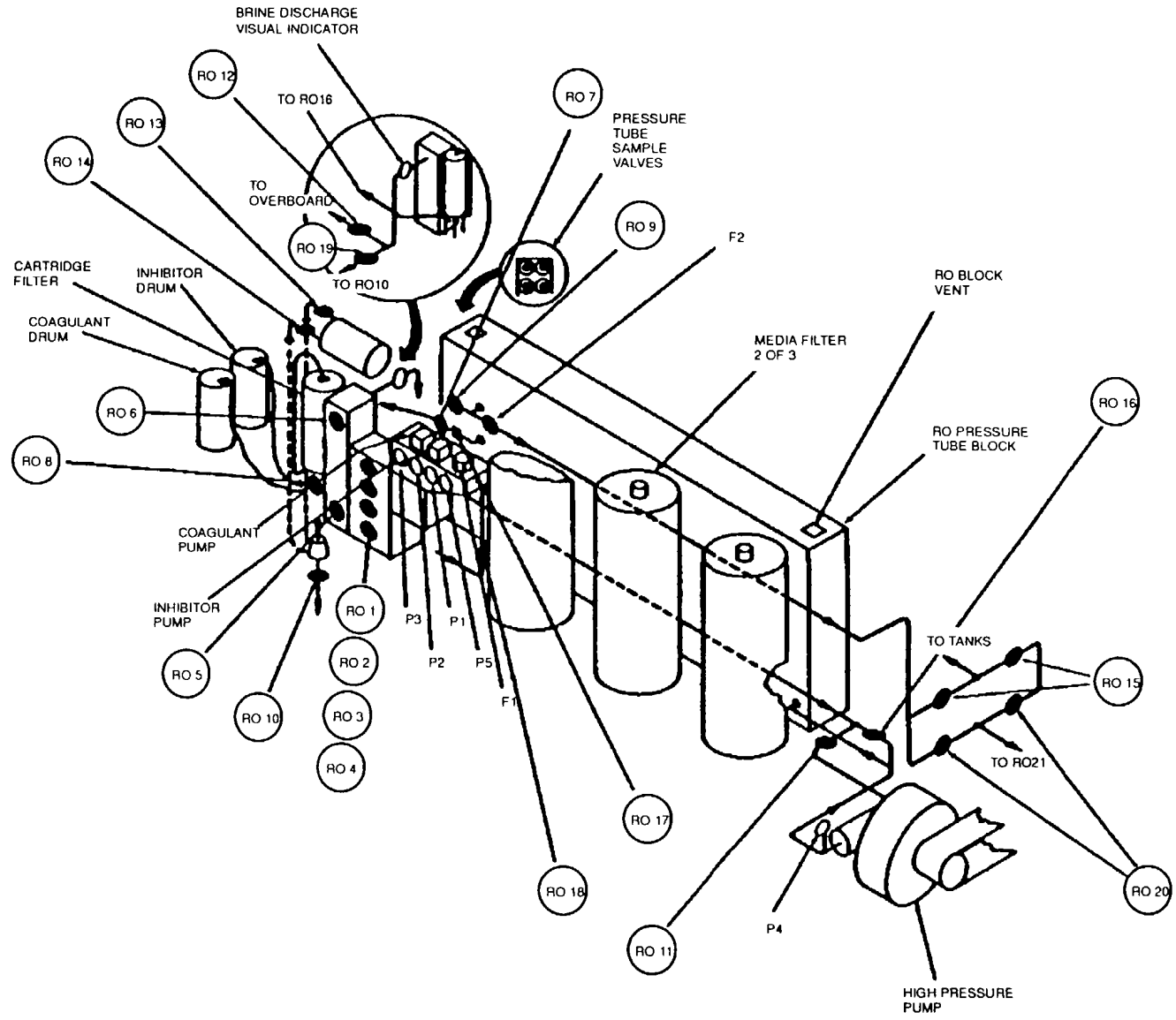


Figure 1-2. ROWPU 1 Installation

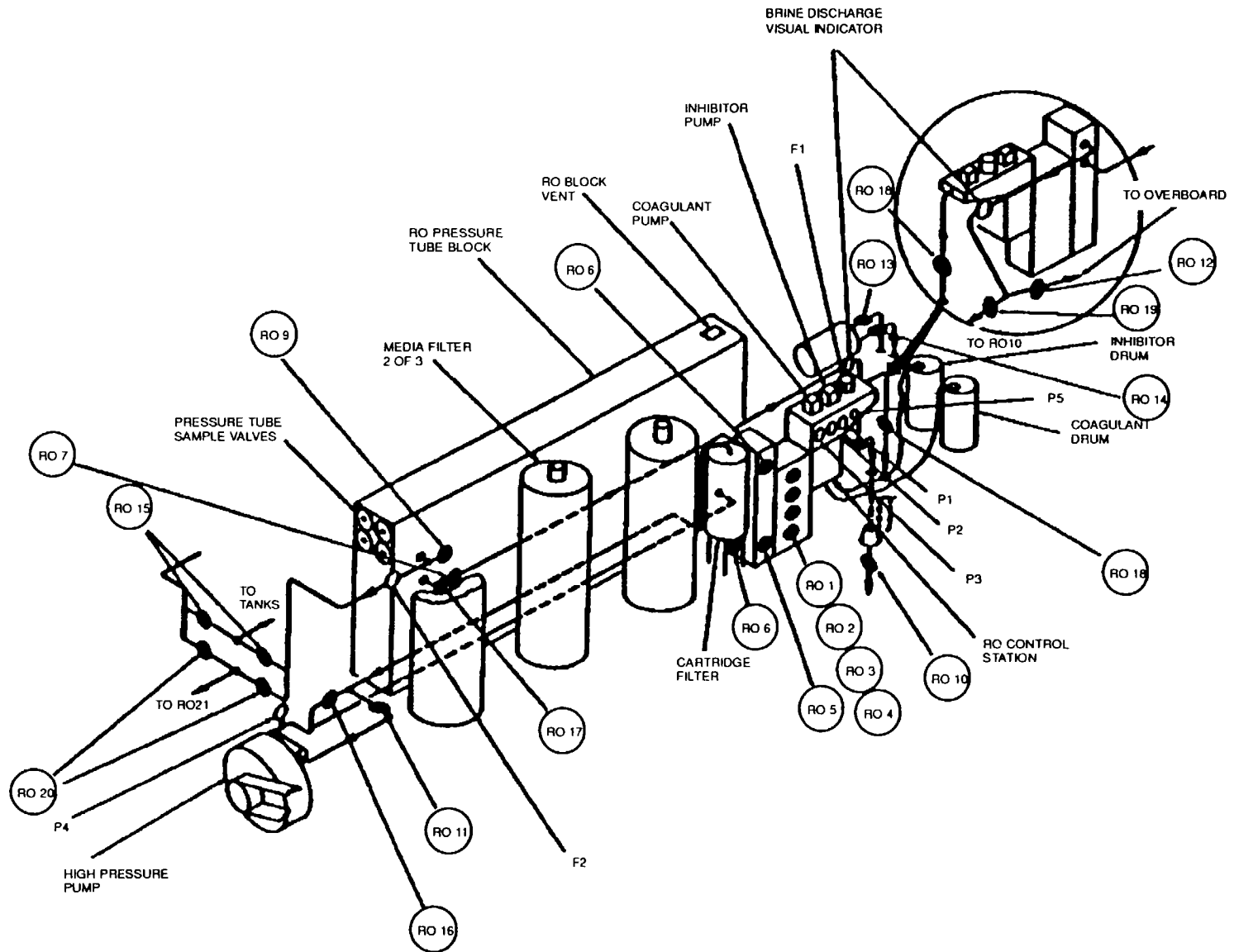


Figure 1-3. ROWPU 2 Installation

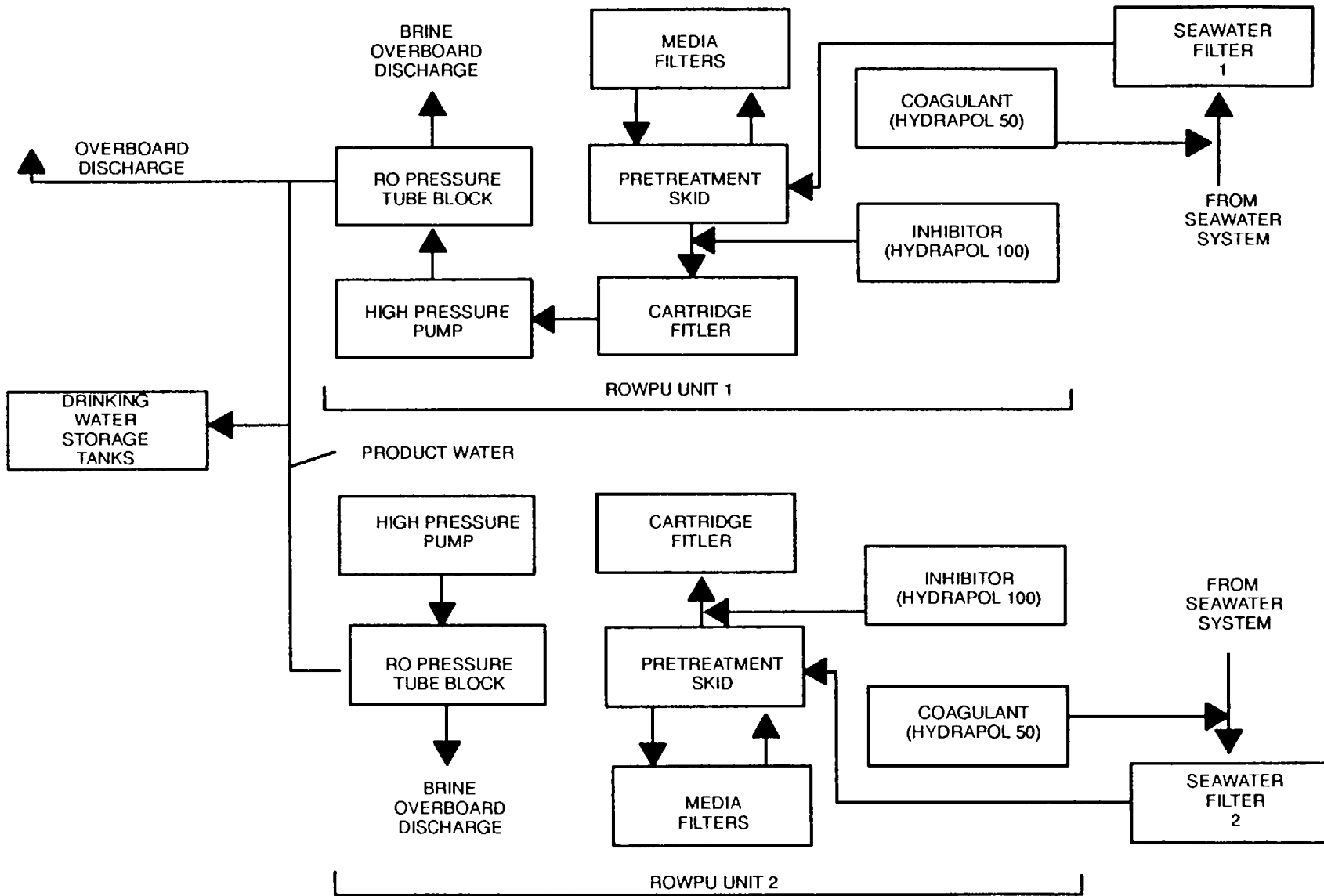


Figure 1-4. ROWPU System Block Diagram

NOTE
3 WAY VALVE DESIGNATION
A B AND C DENOTE VALVE
HANDLE POSITIONS

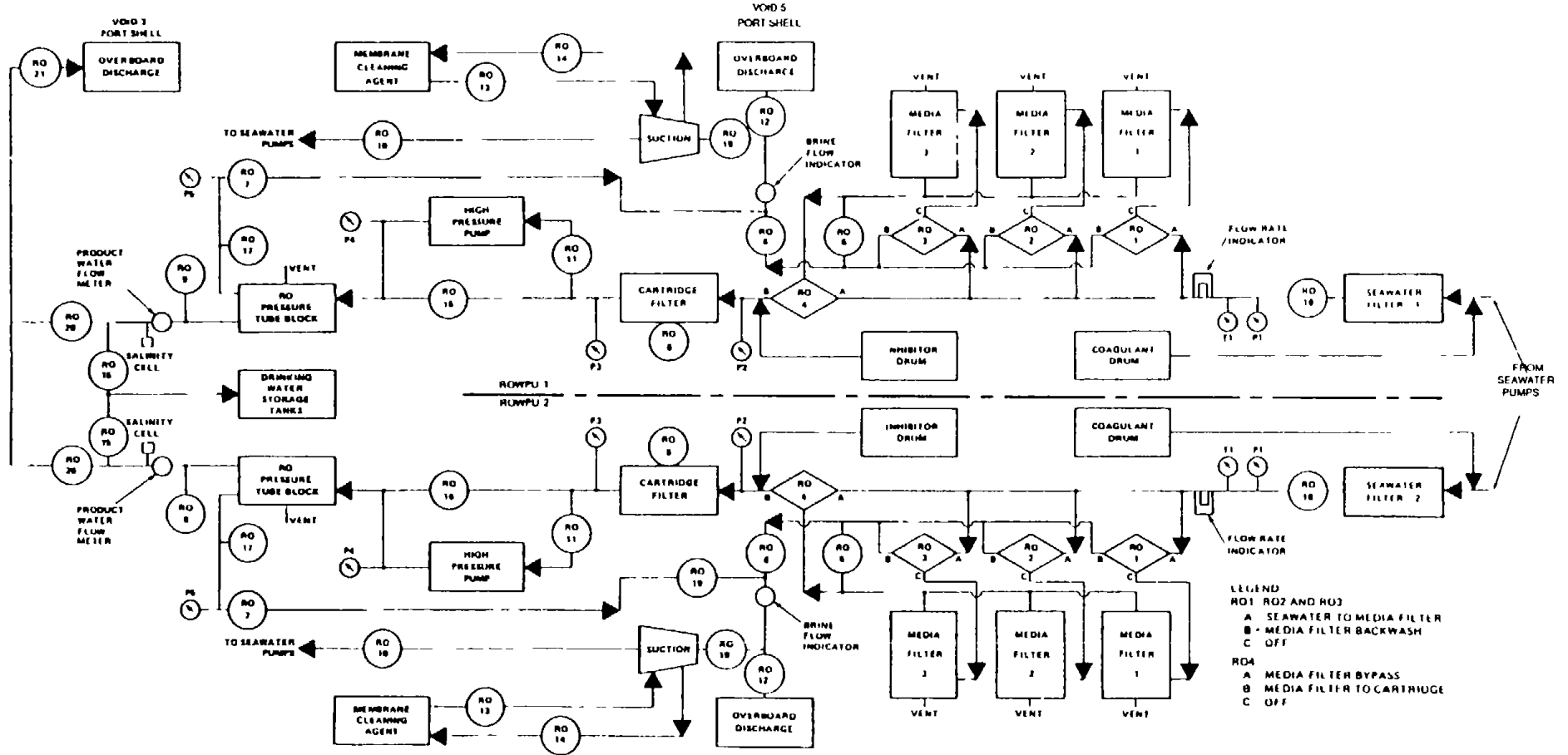


Figure 1-5. ROWPU System Block Diagram

1-11 Performance characteristics

- | | |
|--|----------------------|
| a. Seawater flow rate from seawater pump
Each ROWPU | 350 gpm |
| b. Product water flow rate from RO block
Each ROWPU | 108 gpm |
| c. Brine flow rate from RO block
Each ROWPU | 242 gpm |
| d. Power required
Each ROWPU | 440 Vac, 3 ph, 60 Hz |

1-12 Equipment specifications

- | | |
|----------------------|-----------------------|
| a. Media filter | |
| Manufacturer | Hydranautics |
| CAGEC | 52487 |
| Drawing number | 52034 |
| Capacity | 120 gpm |
| Size | 56 in Lx48 n Wx82 n H |
| Weight | |
| Empty | 1168 lb |
| Dry | 5052 lb (media added) |
| Wet | 9217 lb |
| Quantity | 3 per ROWPU |
| b. RO block assembly | |
| Manufacturer | Hydranautics |
| CAGEC | 52484 |
| Drawing number | 52001 |
| Size | 229 In Lx53n Wx92 n H |
| Weight: | |
| Dry | 4000 lb |
| Wet | 6144 lb |
| Quantity | 1 per ROWPU |

- c. Pretreatment skid
 - Manufacturer Hydranautics
 - CAGEC 52484
 - Part number (P/N) Drawing number 52003
 - Size 111 in L x 38in Wx71 in H
 - Weight
 - Dry 1518 lb
 - Wet 1672 lb
 - Quantity 1 per ROWPU

- d. Metering pump
 - Manufacturer Hydranautics
 - CAGEC 52484
 - P/N52054-1
 - Type Piston-diaphragm
 - Rating 0 7 gallons per hour (gph) and 145 psi
 - Power requirement 115 Vac, 1 ph, 60 Hz
 - Weight 13.9 lb
 - Quantity 2 per ROWPU

- e. HP pumpskid
 - Manufacturer Cosmodyne, Inc
 - CAGEC 11243
 - Drawing number 2914301
 - Size 101 In L x 75 In, W x 82 In H
 - Weight dry 5760 lb
 - Quantity 1 per ROWPU

- f. HP pump
 - Manufacturer KOBE, Inc.
 - CAGEC 26404
 - Model number ROB-300
 - P/N 2914352-1
 - Type Roto-jet, V-belt driven
 - Rating 350 gpm at 850 psi (1940 ft TDH)
 - Horsepower (Hp)/ rotations per minute (rpm) 260 brake horsepower at 4380 rpm
 - Quantity 1 per HP pump skid

g. Engine	
Manufacturer	Caterpillar
CAGEC	11083
Model number	3406T1
P/N	2914356-1
Type	6-cylinder, 4 stroke-cycle diesel
Bore	54 in
Stroke	6 5 in.
Displacement	893 cu In.
Power rating	325 Hp at 2100 rpm (intermittent) 250 Hp at 1800 rpm (continuous)
Quantity	1 per HP pump skid
h. Membrane cleaning agent (Hydraldeen-20) drum	
Manufacturer	Hydranautics
CAGEC	52484
Drawing number	52063
Capacity	55 gallons
Quantity	1 per ROWPU
i. Scale inhibitor (Hydrapol-100) drum	
Manufacturer	Hydranautics
CAGEC	52484
Drawing number	52052
Capacity	55 gallons
Quantity	1 per ROWPU
j. Coagulant (Hydrapol-50) drum	
Manufacturer	Hydranautics
CAGEC	52484
Drawing number	52053
Capacity	55 gallons
Quantity	1 per ROWPU
k. Gate valve	
Manufacturer	William E. Williams Valve Co
CAGEC	79342
P/N	141F
Size	3 In nominal
Rating	150 lb
Connection	Flanged
Material	Bronze
Quantity	12

- l. Sight glass
 Manufacturer Ernst Gage Co
 CAGEC 72256
 P/N Figure E-57-4
 Type Ball action
 Size 3 In nominal
 Material Bronze
 Quantity 1 per ROWPU

- m. Suction adapter assembly
 Manufacturer Cosmodyne Inc.
 CAGEC 11245
 PIN 2914160-A
 Quantity 2

- n. Salinity cell w/cable
 Supplier Tracor Marcon, Inc
 CAGEC 1 U276
 P/N 23236-01
 Size 3/4 in NPT w/cable
 Quantity 1 per ROWPU

- o. Hose assembly
 Manufacturer Aeroquip Corporation Industrial Division
 CAGEC 01276
 P/N 2652-412-48-190016-3-48-24
 Size 3 in nominal
 Rating 150 lb
 Connection Bronze flange with male NPT adapter
 Quantity 2

- p. Gate valve
 Manufacturer Crane Co
 CAGEC 89814
 P/N 66176-AM
 Size 3 In. nominal
 Connection Flanged
 Class 600
 Material Stainless steel
 Quantity 2

- q. Plug valve
 - Manufacturer Nupro Co
 - CAGEC 18034
 - P/N SS-4P4T1
 - Size 1/4 in nominal
 - Connection 1/4 In male NPT x 1/4 in swagelock
 - Material Corrosion resistant steel
 - Quantity 2 per ROWPU

- r. Pressure relief valve
 - Manufacturer Tayler-Parker Co
 - CAGEC 59349
 - P/N 230/SP
 - Size 2 In nominal
 - Rating 150 psi
 - Connection Flanged
 - Material Bronze
 - Quantity 2

- s. Swing check valve
 - Military specification MIL-V-18436
 - Type Group A, Type III
 - Size 3 in nominal
 - Rating 150 lb
 - Connection Flanged
 - Material Bronze
 - Quantity 4

- t. Hose assembly
 - Manufacturer Aeroquip Corporation Industrial Division
 - CAGEC 01276
 - P/N 150901-48-42
 - Size 3 in nominal
 - Length 42 In
 - Connection Bronze flange w/NPT adapter
 - Rating 900 lb
 - Quantity 2

- u. Globe valve
 Manufacturer Walworth Co
 CAGEC 63686
 P/N 3095
 Size 3 In
 Connection Silver braze
 Material Bronze
 Quantity 2

- v. Ball valve
 Manufacturer Pittsburgh Brass Manufacturing Co
 CAGEC 92021
 P/N MPB-19-SB2/POC1 (Patt 10)
 Type 3 way
 Size 3 In nominal
 Connection Silver braze
 Material Bronze
 Quantity 8

- w. Ball valve
 Manufacturer Pittsburgh Brass Manufacturing Co
 CAGEC 92021
 P/N 3"-SPB-19-SB2
 Size 3 In nominal
 Connection Silver braze
 Material Bronze
 Quantity 2

- x. Gate Valve
 Manufacturer William E William Valve Co
 CAGEC 79342
 P/N 141 F
 Rating 150 lb
 Size 4 In nominal
 Connection Flanged
 Material Bronze
 Quantity 3

- y. Victaulic coupling
 - Manufacturer Victaulic Co of Amenca
 - CAGEC 79154
 - P/N HP-70ES
 - Size 3 In nominal
 - Material Galvanized steel
 - Quantity 2

- z. HP adapter
 - Manufacturer Victaulic Co. of Amenca
 - CAGEC 79154
 - Type High pressure, 90 degree
 - Size 3 in nominal
 - Connection Victaulic coupling one end, buttweld other end
 - Material Stainless steel
 - Quantity 2

- aa. Quick disconnect half coupling
 - P/NMS27024-16
 - Type Female
 - Size 3 in. nominal
 - Material Bronze
 - Quantity 2

- ab. Engine crankcase filter system
 - Manufacturer Oildex Corporation
 - CAGEC 31714
 - P/N XCAD-14T
 - Quantity 2

1-13 Items furnished

- 1-13.1** Components installed as part of the ROWPU system are listed on the parts lists of drawings referenced in Appendix NO TAG and in the Components of End Item List in Appendix F of TM 55-1930-209-14 & P-18
- 1-13.2** Common and bulk items are listed in the Expendable Supplies and Materials List in Appendix E of TM 55-1930-209-14 & P-18.
- 1-13.3** Repair parts and special tools are listed In the Repair Parts and Special Tools List In Appendix G of TM 55-1930-209-14 & P-18.

1-14 Items required but not furnished. All required items are furnished.

1-15 Tools and test equipment. Use existing tools and equipment A complete list of tools and test equipment is in the Tools and Test Equipment List In Appendix D of TM 55-1930-209-14 & P-18.

CHAPTER 2 DESCRIPTION OF OPERATION

NOTE

Additional operation, maintenance and parts Information may be found In the following technical manuals which cover the 150,000 Gallon Per Day (GPD) Reverse Osmosis Water Purification Unit (ROWPU):

TM 10-4610-229-10, Operator's Manual for 150,000 GPD ROWPU

TM 10-4610-229-24, Unit, Direct and General Support Maintenance Manual for 150,000 GPD ROWPU

TM 10-4610-229-24P, Repair Parts and Special Tools List for 150,000 GPD ROWPU

2-1 RO process. The RO process separates dean water from salt water or brackish water. During the natural osmosis process, pure water and saltwater can be separated by a semipermeable membrane in a container at atmospheric pressure. Because of the difference In salt concentration, pure water will naturally diffuse through the membrane and raise the water level In the saltwater side as though pressure were being applied to it The effective driving force causing this flow Is called osmotic pressure. The magnitude of osmotic pressure depends upon the concentration of dissolved solids in the saltwater and the temperature of the water The greater the concentration of salt In the saltwater and the higher the water temperature, the higher the osmotic pressure. To reverse the natural osmosis process, therefore, pressure is applied to the saltwater side (Figure 2-1). When the applied pressure is greater than the osmotic pressure, purified water diffuses through the semipermeable membrane from the saltwater side to the freshwater side Thus the term reverse osmosis. To use this principle, feedwater is cleaned by several types of filters and pumped under pressure across semipermeable membranes in the RO block assembly. The resulting purified water, called product water, flows to the storage tanks. The water on the outside of the membrane that now has a higher salt concentration, called brine concentrate, is discharged overboard.

2-2 ROWPU system operation. As shown in Figure NO TAG, seawater (feedwater) to be processed by the ROWPU's flows from seawater filters (part of the seawater system) to the pretreatment skid A flow rate Indicator on top of the pretreatment skid monitors the feedwater's degree of cloudiness and flow rate. In addition, incoming water temperature may be read on a gauge (T1) located In the line on the supply side of the pretreatment skid three-way valves.

The coagulant pump adds coagulant (Hydrapol-50) to the seawater before it enters the seawater filter Seawater containing coagulant then flows through the seawater filter to three media filters .The coagulant helps the media filters to remove fine partides and colloids (clouds of fine particles suspended In water). Normally, a dose of 1.0 parts per million (ppm) is adequate Dosage can be increased, however, if a seawater sample taken at valve R08 contains more Impurities than usual Dosage Is increased by manually adjusting metering pump stroke length and speed.

In the media filters, seawater flows from the top downward Fine particles and colloids are thus removed from the seawater so It is suitable for processing by the RO block assembly.

Scale Inhibitor (Hydrapol-100) is added to the seawater as It Is discharged from the media filters and collected into a single stream. Scale inhibitor limits formation of scale on the RO block membranes . A dose of 40 ppm is added to the seawater by a small, diaphragm type, positive displacement pump similar to the coagulant metering pump. If necessary, however, dosage can be manually adjusted by changing metering pump stroke length and speed.

Seawater containing scale inhibitor then flows through the cartridge filter assembly on pretreatment skid. The cartridge filter assembly removes any particles not removed by the media filters that would be harmful to the HP pump. This filtered seawater then flows to the HP pump where pressure is increased to the 835 psi (maximum) required for reverse osmosis, processing in the RO block.

Pressurized seawater enters RO block inlet manifold which divides the water flow among 16 pressure tubes. Each pressure tube separates seawater by reverse osmosis into a high purity product water and a brine concentrate stream. Product water from each pressure tube flows to a common manifold, through a flowmeter, and then through piping to drinking water tanks or overboard. Normal flow rate as indicated on the flowmeter is 108 gpm. The brine stream from each pressure tube also flows to a common manifold from which the brine flows through a throttling valve. This throttling valve allows adjustment of pressure and flow. The adjusted pressure is shown on pressure gauge P5 on the pretreatment skid. Brine is then discharged overboard through the void 5 port shell.

While ROWPU is operating, the following items are monitored on designated gauges or on the Equipment Monitoring System (EMS).

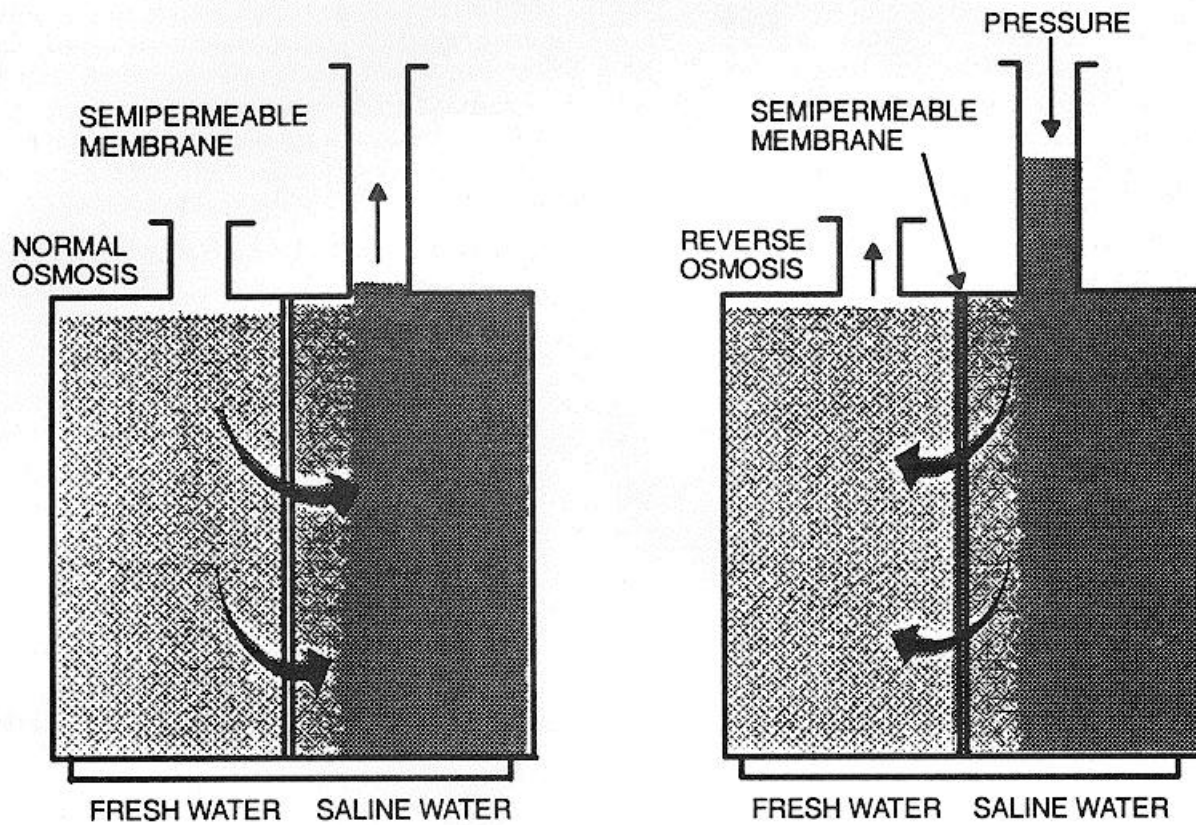


Figure 2-1. Reverse Osmosis Demonstration

<u>Indication</u>	<u>Gauge no.</u>	<u>Indicator</u>
Product water salinity	--	EMS monitor SALINITY display page
Seawater pump (feedwater) flow rate	F1	Flow indicator
Product water flow rate	F2	Flowmeter
Seawater pump (feedwater) temperature	T1	Temperature gauge
Seawater pump discharge pressure	P1	Pressure gauge
Brine discharge pressure (RO block discharge)	P5	Pressure gauge
Media filters output pressure	P2	Pressure gauge
Cartridge filter assembly output pressure	P3	Pressure gauge
HP pump discharge pressure (RO pressure tube block inlet pressure)	P4	Pressure gauge
HP pump diesel engine low oil pressure PUMPS display page	--	EMS monitor HIGH PRESSURE WATER
HP pump diesel engine high cooling water temperature	--	EMS monitor HIGH PRESSURE WATER PUMPS display page

CHAPTER 3 OPERATING INSTRUCTIONS

Section I. Operating controls and indicators

NOTE

Additional operation, maintenance and parts information may be found in the following technical manuals which cover the 150,000 Gallon Per Day (GPD) Reverse Osmosis Water Purification Unit (ROWPU):

TM 10-4610-229-10, Operator's Manual for 150,000 GPD ROWPU

TM 10-4610-229-24, Unit, Direct and General Support Maintenance Manual for 150,000 GPD ROWPU

TM 10-4610-229-24P, Repair Parts and Special Tools List for 150,000 GPD ROWPU

3-1 Operating controls and indicators. Information about ROWPU system operating controls and indicators is in Table 3-1. Information about ROWPU system valves, shown in Figure 1-2, figure 1-3, and figure 1-5, is in Table 3-3.

NOTE

ROWPU 1 controls, indicators, and valve number designators, such as RO1 or F2, are identified as 1-RO1 or 1-F2. ROWPU 2 component numbers are preceded by 2-, such as 2-RO1 or 2-F2.

Section II. Prestart procedures

3-2 Prestart procedures

NOTE

Chlorination system injects chlorine into ROWPU product water before water enters drinking water storage tanks. If starting ROWPU from a storage or travel status, 4 hours are required for chlorination system to develop sufficient supply of chlorine to treat output from both ROWPU units.

a. Make sure chlorination system is operating and has sufficient chlorine stored in its tanks to treat product water from ROWPU system. If not operating, start up chlorination system according to TM 55-1930-209-14&P-4.

Table 3-1. Operating Controls and Indicators

<u>Control/Indicator</u>	<u>Figure</u>	<u>Location</u>
Control station	3-1	Pretreatment skid
Seawater pump discharge pressure gauge P1	3-1	Pretreatment skid, above control panel
Media filters output pressure gauge P2	3-1	Pretreatment skid, above control panel
Cartridge filter assembly output pressure gauge P3	3-1	Pretreatment skid, above control panel
Brine discharge pressure gauge P5	3-1	Pretreatment skid, above control panel
Seawater pump flow rate indicator FI gauges	3-1	Pretreatment skid, above pressure
HP pump discharge pressure gauge P4	3-2	HP pump discharge line

Table 3-2. Operating Controls and Indicators (continued)

HP pump diesel engine controls and indicators	3-2	HP pump
---	-----	---------

Product water flow rate meter F2	3-3	RO block, product water discharge line
Seawater temperature gauge T1	3-4	Pretreatment skid, between Ro18 and F1
Coagulant (Hydrapol-50) metering pump controls	3-5	Pretreatment skid, above pressure gauges
Inhibitor (Hydrapol-100) metering pump controls	3-5	Pretreatment skid, above pressure gauges
Monitoring system SALINITY display page	3-6	ROWPU space forward bulkhead
Monitoring system HIGH PRESSURE WATER PUMPS display page	3-7	ROWPU space forward bulkhead

Table 3-3. ROWPU System Valves

<u>Type</u>	<u>Valves</u>	<u>Location</u>	<u>Label Identification and Valve Function</u>
3-in. 3-way ball valve	RO1	ROWPU space -on pretreatment skid ball valve	MEDIA FILTER 1 FLOW; allows seawater to flow to media filter 1 when making product water and when backflushing media filter 1
3-in. 3-way ball valve	RO2	ROWPU space -on pretreatment skid	MEDIA FILTER 2 FLOW; allows seawater to flow to media filter 2 when making product water and when backflushing media filter 2
3-in. 3-way ball valve	RO3	ROWPU space -on pretreatment skid	MEDIA FILTER 3 FLOW; allows seawater to flow to media filter 3 when making product water and when backflushing media filter 3
3-in. 3-way ball valve	RO4	ROWPU space -on pretreatment skid	MEDIA FILTERS FLOW; allows seawater from media filters to flow to cartridge filter assembly and HP pump when making product water
2-in. globe diaphragm valve	RO5	ROWPU space -on pretreatment skid	MEDIA FILTER BACKWASH; allows waste water to flow through RO6 and RO12 directly overboard during media filter backflushing
3-in. 2-way ball valve	RO6	ROWPU space -on pretreatment skid	MEDIA FILTER BACKWASH FLOW; allows adjusting media filter backflushing water flow to obtain optimum flow

Table 3-4. ROWPU System Valves (continued)

2-in. 2-way throttling valve	R07	ROWPU space -in brine discharge line	BRINE THROTTLE VALVE; adjusts brine flow rate so that product water is 1/3 of seawater flow. Product water flow is controlled by adjusting valve R07 and HP pump diesel engine speed
3/4-in. 2-way ball valve	R08	ROWPU space -bottom of cartridge filter assembly	CARTRIDGE FILTER DRAIN; for taking filtered seawater samples and draining cartridge filter assembly
3/4-in. 2-way ball valve	R09	ROWPU space -on end of each pressure tube	PRODUCT WATER SAMPLING; for sampling product water in RO block pressure tube
4-in. gate valve	R010	Void 2 starboard - above seawater pump	MEMBRANE CLEANING SOLUTION RECIRCULATION; allows membrane cleaning solution to recirculate through seawater pumps
<u>Type</u>	<u>Valves</u>	<u>Location</u>	<u>Label Identification and Valve Function</u>
3-in. gate valve	R011	ROWPU space -in HP pump suction line	CARTRIDGE FILTER TO HIGH PRESSURE PUMP; Allows filtered seawater from cartridge filter assembly to flow to HP pump
3-in. gate valve skid	R012	ROWPU space -in- board of pretreatment	BRINE TO OVERBOARD DISCHARGE; allows brine to flow overboard from RO block when making product water
3/4-in. 2-way ball valve	R013	ROWPU space -near membrane cleaning solution drum	MEMBRANE CLEANING SOLUTION RETURN; allows flow of membrane cleaning solution back to drum
3/4-in. 2-way ball valve	R014	ROWPU space -near membrane cleaning solution drum	MEMBRANE CLEANING SOLUTION INPUT; allows membrane cleaning solution to flow from drum
3-in. gate valve	R015	ROWPU space -be- tween RO block and HP pump	PRODUCT WATER TO STORAGE TANKS; allows product water from RO block to flow to drinking water storage tank
3-in. gate valve	R016	ROWPU space -between RO block and HP pump	HIGH PRESSURE PUMP BYPASS; allows flow of membrane cleaning solution to RO block bypassing HP pumps
1/4-in. 2-way ball valve	R017	ROWPU space -in brine discharge piping near valve R07	BRINE SAMPLING; for taking samples of brine output from RO block
3-in. gate valve	R018	ROWPU space -in pretreatment skid seawater input piping	SEAWATER TO ROWPU; allows flow of seawater to ROWPU pretreatment skid

Table 3-2. ROWPU System Valves (continued)

3-in. gate valve	RO19 (Barges 2 and 3 only)	ROWPU space -in- board of pretreatment skid	MEMBRANE CLEANING SOLUTION RECIRCULATION; during RO block membrane cleaning, allows cleaning solution to recirculate through seawater pump
3-in. gate valve	RO20 (Barges 2 and 3 only)	ROWPU space -between RO block and HP pump	PRODUCT WATER TO OVERBOARD; allows flow of product water from RO block to overboard
4-in. gate valve	RO21 (Barges 2 and 3 only)	Void 3 port shell	PRODUCT WATER OVERBOARD DISCHARGE; allows product water from RO block and RO20 to flow overboard

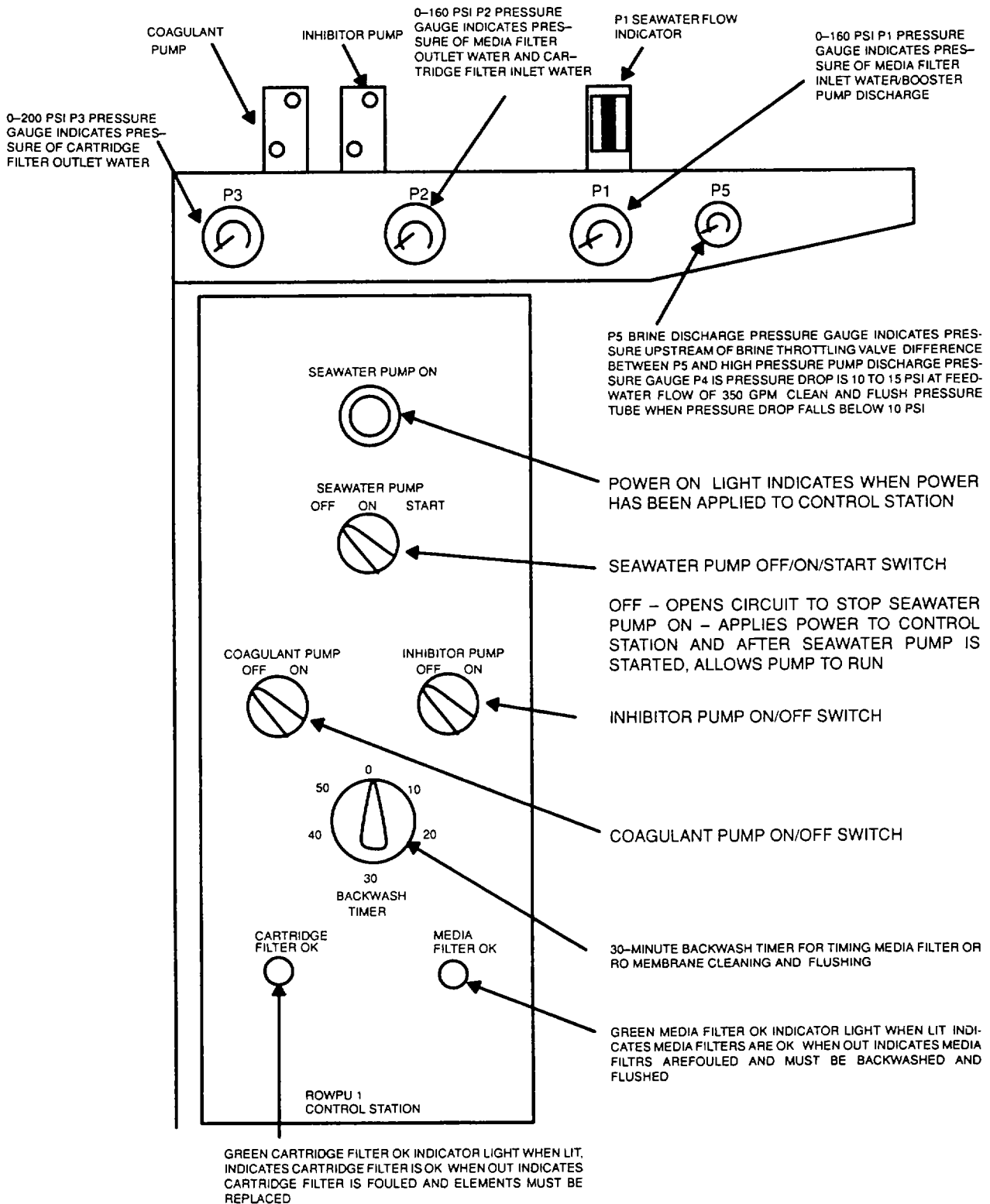


Figure 3-1. ROWPU Control Station (ROWPU 1 Station Shown)

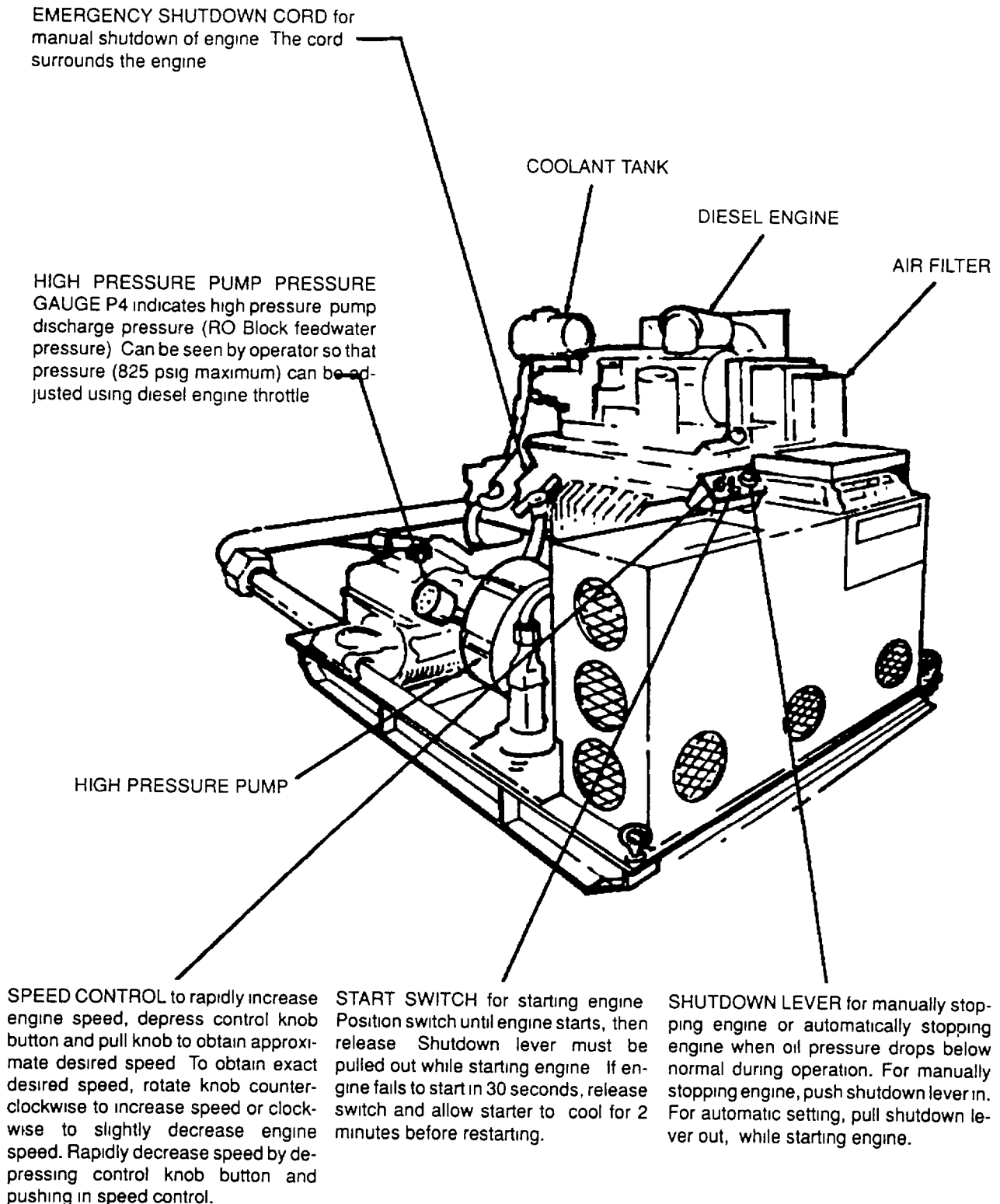


Figure 3-2. HP Pump Diesel Engine Controls and Indicators (Sheet 1 of 2)

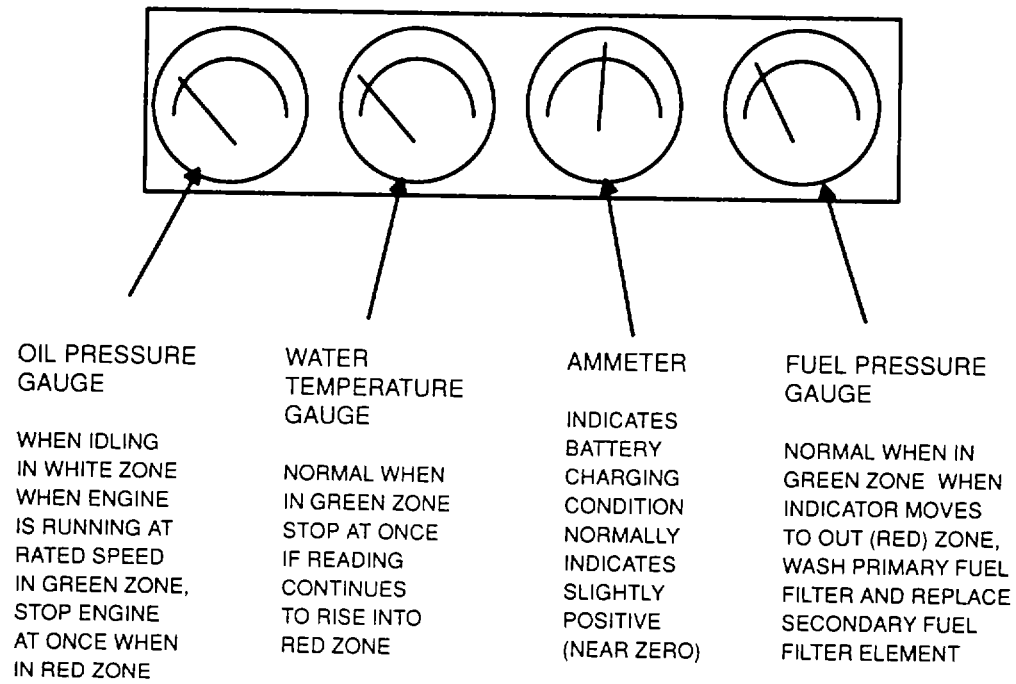
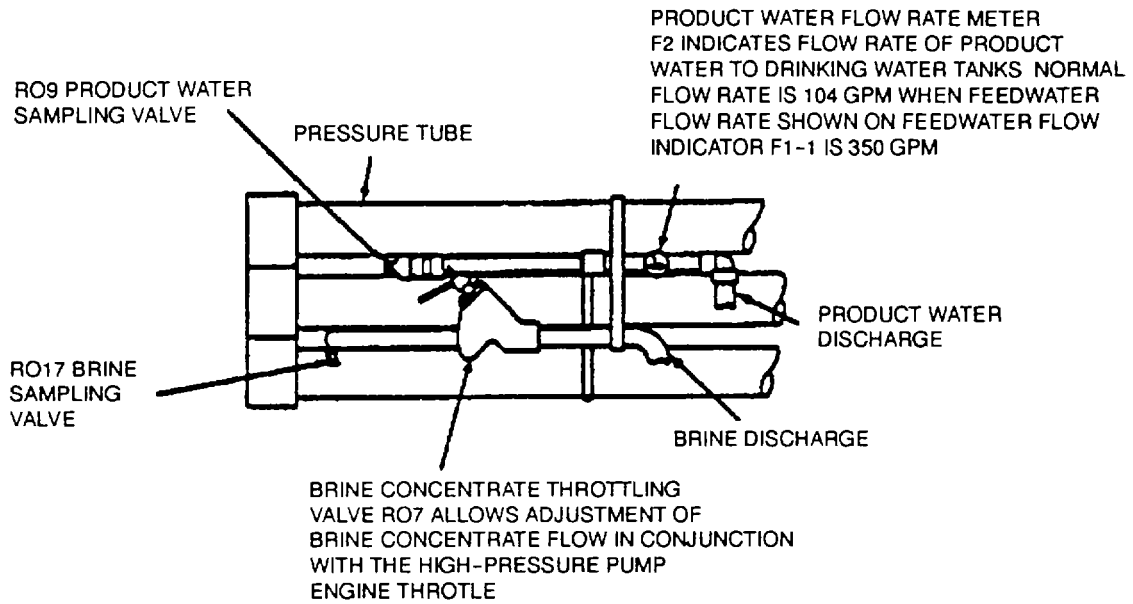
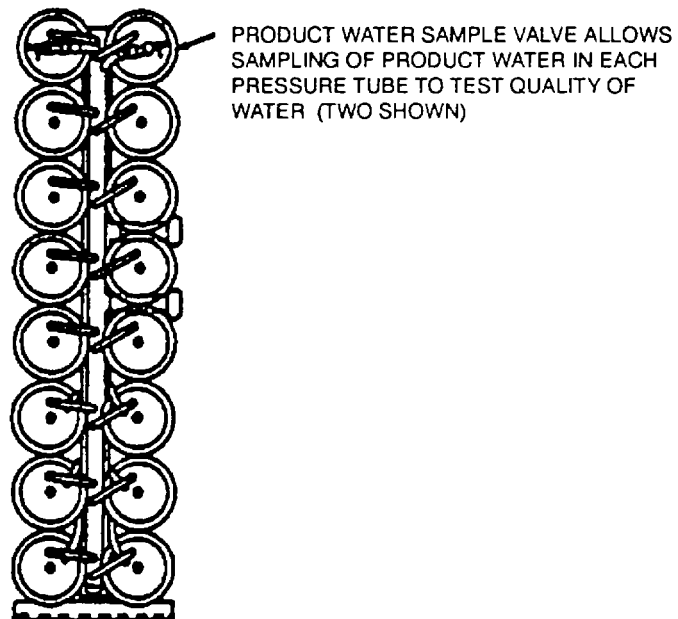


Figure 3-2. HP Pump Diesel Engine Controls and Indicators (Sheet 2 of 2)



RO BLOCK - LOOKING OUTBOARD FROM CENTERLINE



ROWPU 1 RO BLOCK - FORWARD END LOOKING AFT
 ROWPU 2 RO BLOCK AFT END LOOKING FORWARD

Figure 3-3. RO Block Valves and Indicators

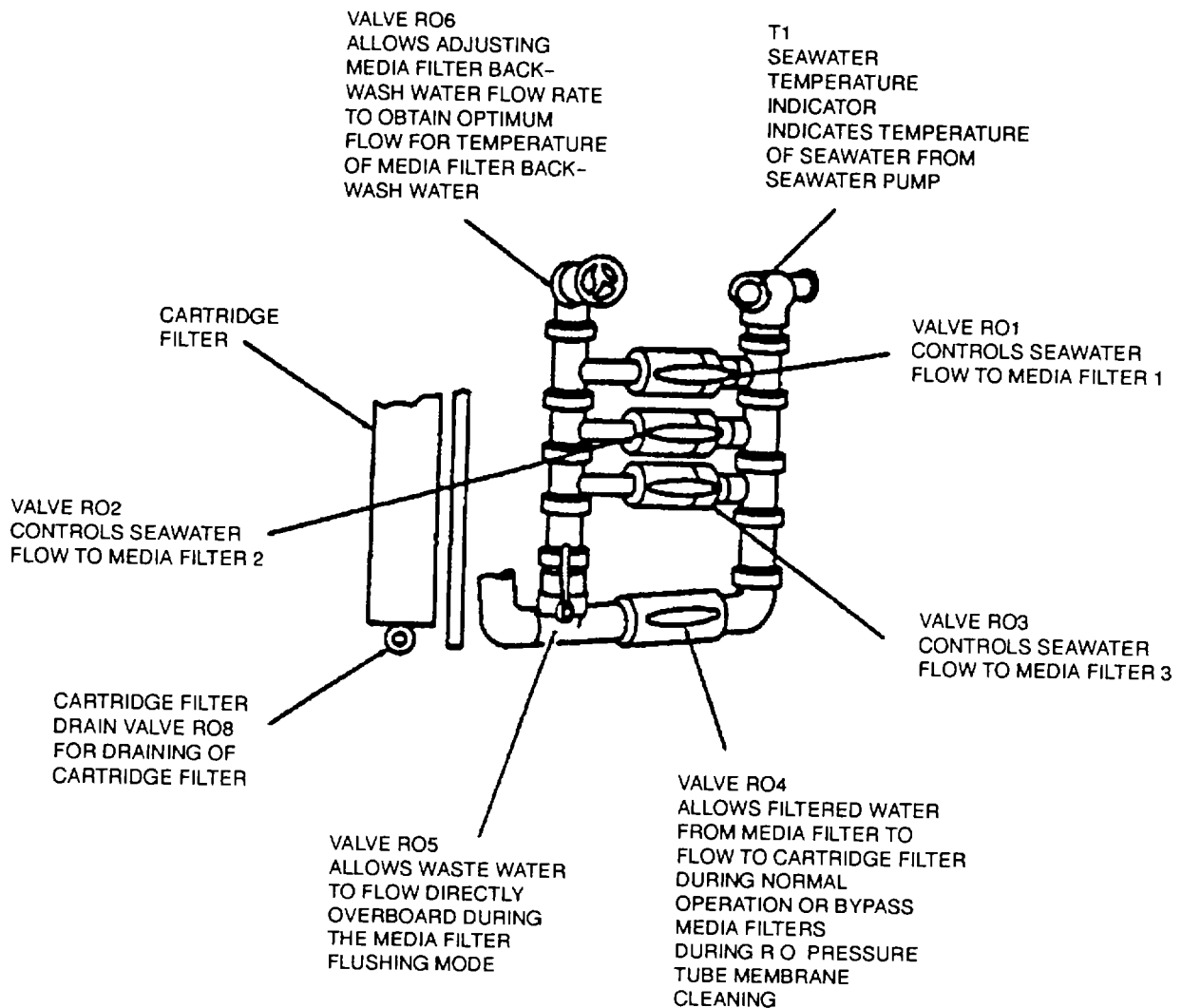


Figure 3-4. Pretreatment Skid Valves and Temperature Indicator

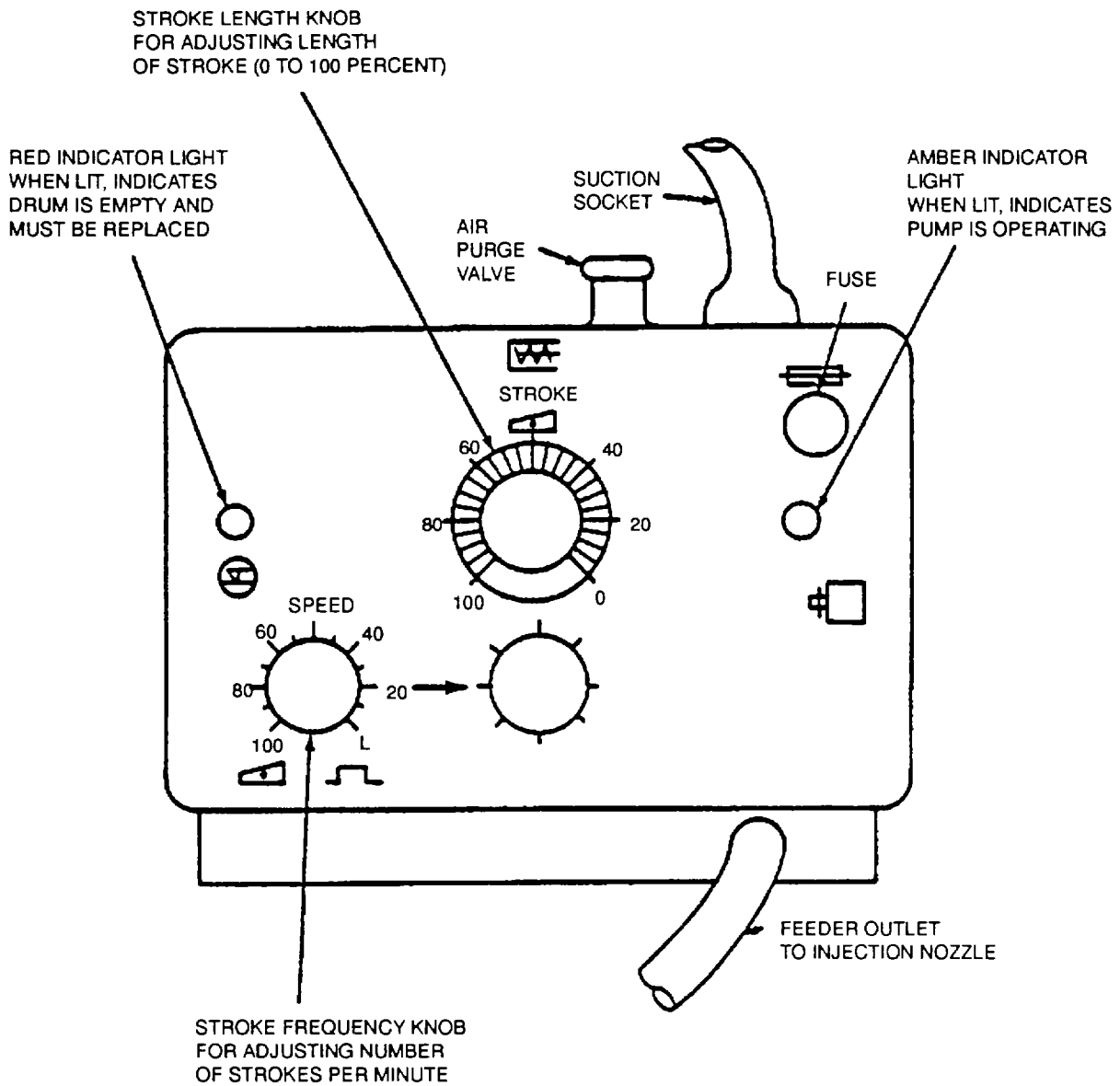


Figure 3-5. Coagulant and Inhibitor Pump Controls (Sheet 1 of 2)

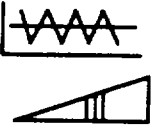

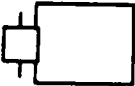



LEGEND FOR SYMBOLS	
	STROKE LENGTH, ADJUSTMENT
	STROKE FREQUENCY
	METERING PUMP OPERATION
	TANK LEVEL ZERO
	HAND OPERATION
	AUTOMATIC OPERATION

Figure 3-5. Coagulant and Inhibitor Pump Controls (Sheet 2 of 2)

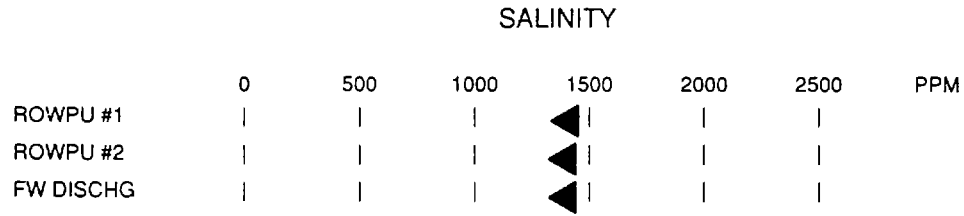


Figure 3-6. Monitoring System SALINITY Display Page

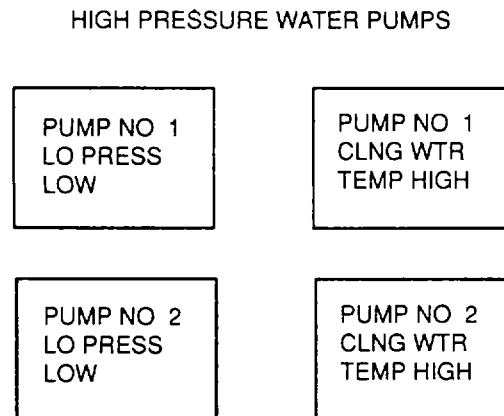


Figure 3-7. Monitoring System HIGH PRESSURE WATER PUMPS Display Page

- b. Before operating ROWPU system, check system for damage and perform before operation preventive maintenance procedures (paragraph 4-3).

NOTE

Seawater system provides seawater (feedwater) to ROWPU's 1 and 2 for processing into product water.

- c. Make sure seawater system is ready for operation by ensuring strainers are clean and filters have been drained. Set seawater system valves to provide seawater to either ROWPU 1 or 2 or both (TM 55-1930-209-14 & P-2).

NOTE

The EMS monitors ROWPU's 1 and 2, product water salinity, and HP pump diesel engine cooling water temperature and oil pressure.

- d. Make sure EMS is operating normally (TM 55-1930-209-14 & P-11).

Section III. Operating procedures

3-3 General. ROWPU's 1 and 2 are normally started on a staggered schedule with at least a 2 hour interval separating start up of the two units. After each unit operates for 10 hours, it is shut down for 2 hours for required maintenance such as membrane cleaning, media backflushing, and cartridge filter changing. This staggered startup keeps product water flowing ashore and keeps the barge workload within the capabilities of crews required to maintain a continuous 24 hour operation.

3-4 Startup procedures

- a. Perform prestart procedures (paragraph 3-2).

NOTES

Valves are positioned initially to bypass the HP pump and to discharge seawater (feedwater) overboard. As soon as the flow is satisfactory, flow is directed through HP pump.

The RO valves are identified in Figures 1-2, 1-3, and 1-5 is in Table 3-3.

- b. Position ROWPU RO valves as shown in table below. Make sure valve RO7 is fully open.

o = open	x = closed										A = position A					B = position B					
RO valve no.	1	2	3	4	5	6	7	8	9	10											
Valve position	A	A	A	B	x	x	o	x	x	x											
RO valve no.	11	12	13	14	15	16	17	18	19	20	21										
Valve position	x	o	x	x	x	o	x	o	x	o	o										

CAUTION

Do not start seawater pumps until seawater valves are positioned to supply seawater to ROWPU's and RO valves are positioned to bypass HP pump and discharge feedwater through void 5 port overboard discharge.

- c. Start seawater pump by turning OFF/ON/START switch (Figure 3-1) to START. When pump starts, release switch. Switch will return to ON position.

- d. Check appearance of feedwater in seawater pump flow rate indicator F1 (Figure 3-1).
 - (1) If feedwater is not too dirty (cloudy), go to step e.
 - (2) If water is very dirty, stop pumps. Make sure seawater strainer is clean and seawater filter has been drained.
 - (3) Repeat steps c and d.
- e. Start coagulant pump by turning coagulant pump ON/OFF switch (Figure 3-1) to ON.
 - (1) Set pump stroke to 50 and speed control to 35 on coagulant pump control panel (Figure 3-5).
 - (2) Make sure amber indicator light comes on (Figure 3-5). If amber indicator lamp on coagulant pump panel does not light, troubleshoot according to Table 4-1.
 - (3) Make sure red indicator light does not come on. If red indicator light comes on, replace coagulant drum (paragraph 4-7.1.3).
- f. Start inhibitor pump by turning inhibitor pump ON/OFF switch (Figure 3-1) to ON.
 - (1) Set pump stroke control to 100 and speed control to 46 (Figure 3-5).
 - (2) Make sure amber indicator light comes on (Figure 3-5). If amber indicator lamp on control panel does not light, troubleshoot according to paragraph 4-4.
 - (3) Make sure red indicator light does not come on. If red indicator light comes on, replace inhibitor drum (paragraph 4-7.1.3).

NOTE

As media filters fill up, vent valves on top of each filter may spew air and water until filters are filled with water. Valves automatically close when filters are full. These valves may open at any time during operation if air accumulates in media filters.

- g. Ensure vent valves close when media filters are full of water.
- h. Check MEDIA FILTER OK indicator light (Figure 3-1).
 - (1) If light is on, go to step i.
 - (2) If light is out, check pressure readings on seawater pump discharge pressure gauge P1 and media filters outlet pressure gauge P2.
 - (3) If pressure difference exceeds 35 psi, backwash and flush media filters (paragraph 4-7.2).
 - (4) If difference is less than 35 psi, check bulb. Replace if burned out.
- i. Check CARTRIDGE FILTER OK indicator light (Figure 3-1).
 - (1) If light is on, go to step j.
 - (2) If light is out, check pressure difference between media filters outlet pressure gauge P2 and cartridge filter assembly outlet pressure gauge P3.
 - (3) If pressure difference exceeds 12 psi, change cartridge cage assembly (paragraph 4-7.1.1).

- j. Check flow rate on seawater pump flow rate indicator F1 (Figure 3-1).
 - (1) If flow rate is near 350 gpm, go to step k.
 - (2) If flow rate is very much less than 350 gpm, make sure seawater valves are fully open or completely closed as specified in seawater system operating procedures (TM 55-1930-209-14 & P-2).
 - (3) Make sure seawater strainer and seawater filter are not clogged.
 - (4) Repeat step j.
- k. Open valve RO11 to allow feedwater from cartridge filter assembly to flow through HP pump.
- l. Close valve RO16 to prevent HP pump discharge water from flowing back to cartridge filter assembly.
- m. Make sure valves R020 and R021 are open to allow product water from RO block to flow directly overboard through port shell overboard discharge in void 3.
- n. Make sure valve RO15 is closed to prevent water from flowing to drinking water storage tanks.

CAUTION

The HP pump may be damaged if it is run dry. Since flow from the seawater pump primes HP pump, never start HP pump unless seawater pump is on and feedwater is flowing to HP pump. Cartridge filter assembly output pressure gauge P3 must show 20 psi minimum. Do not apply throttle when starting engine.

- o. Start HP pump (Figure 3-2).
 - (1) Set speed control to idle position (full forward).
 - (2) Pull shutdown lever out to start position and turn starter switch to START. Hold shutdown lever out until oil pressure builds up in engine and holds shutdown lever in out position.
 - (3) If engine does not start in 30 seconds, release starter switch and wait 2 minutes for starter to cool before trying again.
 - (4) After engine starts:
 - (a) Release starter switch.
 - (b) Continue to hold shutdown lever out until it stays in run position.
 - (c) Allow engine to idle for 3-5 minutes or until all systems reach operating temperatures.
 - (d) Check gauges for readings listed below:
- | <u>Gauge</u> | <u>Initial reading</u> |
|-------------------|--|
| Oil pressure | Out of red zone. (Oil pressure should rise within 15 seconds after engine starts). Will indicate normal (green) range when engine is running at rated speed. |
| Water temperature | Will rise out of white zone into green zone as engine continues to idle. |
| Ammeter | Slightly positive near zero. |
| Fuel pressure | Normal (green) range. If indicator registers below 20 psi (red zone), wash primary fuel filter and replace secondary fuel filter element. |
- p. When gauges indicate acceptable (normal) readings, slowly increase engine speed by turning speed control counterclockwise until seawater pump flow rate indicator F1 reads 350 gpm (Figure 3-1).

- q. Make sure seawater pump discharge pressure gauge P1 reads 100 psi and product water flowmeter F2 reads 0.
- r. Set up product water flow as follows:
 - (1) Gradually close brine throttling valve RO7 and increase engine speed until product water flowmeter F2 reads about 108 gpm.
 - (2) At the same time, make sure HP pump discharge pressure gauge P4 reading does not exceed 835 psi.
 - (3) Make sure brine discharge pressure gauge P5 reading does not exceed 820 psi.
- s. While closing valve RO7, ensure brine discharge flow is evident in brine flow indicator glass.
 - (1) If flow rate indicator FI reading drops below 350 gpm during this operation, slowly open RO7 and increase engine speed until F1 reads 350 gpm.
 - (2) Make sure readings do not exceed 108 at F2 and 820 psi at P5.

NOTE

During initial startup or after a shutdown longer than 3 days, product water should be discharged overboard until quality is acceptable.

- t. Allow product water from RO block to flow directly overboard through overboard discharge in void 3 port, for at least 15 minutes.
- u. While dumping product water overboard, perform the following checks:

- (1) Monitor pressure gauges and flow indicators for normal readings.

RO component	P1	P2	P3	P4	P5	F1	F2
Normal reading	About 100	More than 65	More than 53	No more than 835	No more than 820	About 350	About 108

- (2) Monitor MEDIA FILTER OK indicator light (Figure 3-1).
 - (a) If light goes out, check pressure difference between seawater pump discharge pressure gauge P1 and media filters output pressure gauge P2.
 - (b) If pressure difference exceeds 35 psi, backwash and flush media filters (paragraph 4-7.2).
 - (c) If difference is less than 35 psi, check indicator light. Replace bulb if necessary.
- (3) Monitor CARTRIDGE FILTER OK indicator light (Figure 3-1).
 - (a) If light goes out, check pressure difference between media filters outlet pressure gauge P2 and cartridge filter assembly outlet pressure gauge P3.
 - (b) If pressure difference exceeds 12 psi, change cartridge cage assembly (paragraph 4-7.1.1).
 - (c) If difference is less than 12 psi, check indicator light. Replace bulb if necessary.
- (4) Monitor difference between HP pump discharge pressure gauge P4 and brine discharge pressure gauge P5. If difference exceeds 25 psi, clean RO block membranes (paragraph 4-7.4.2).

CAUTION

Operating temperature is critical in diesel engines. Shut down HP pump diesels immediately if EMS indicates lubricating oil pressure is too low or cooling water temperature is too high.

- (5) Monitor EMS video monitor.
 - (a) SALINITY display page values (Figure 3-6) should read less than 1000 ppm.
 - (b) HIGH PRESSURE WATER PUMPS (Figure 3-7) display page should show in normal white (nonblinking, non double intensity) light.
- (6) Monitor HP pump gauges (Figure 3-2) as a backup to the EMS.
- v. After dumping product water overboard for 15 minutes, check water quality.
 - (1) Obtain product water sample at valve RO9.
 - (2) Manually check total dissolved solids (TDS), salinity, and pH of product water being discharged (TM 5-6630-215-12).
 - (3) Make sure salinity reading is less than 1000 ppm and pH factor is about 7.
- w. If quality of product water in step v is acceptable, proceed to paragraph 3-5.
 - (1) If quality of product water is not acceptable, continue to discharge water overboard for another 15 minutes.
 - (2) Repeat step v. Continue to discharge water overboard if water quality remains unacceptable.
 - (3) If water quality is not acceptable after an additional 15 minutes, troubleshoot according to paragraph 4-4.

3-5 Operating procedures

WARNING

Product water CANNOT be discharged to drinking water storage tanks until chlorination system is operational and providing sufficient chlorine additive to the product water. The only exception to this would be when chlorination system is not operational. As a temporary emergency measure, and with prior coordination with water unit ashore, product water may be stored in tanks and pumped ashore where chlorination can be added by the water unit on the beach.

- a. Make sure chlorine is being added to ROWPU product water before water enters storage tanks. If chlorination system is unable to provide proper amounts of chlorine, continue to pump product water overboard or suspend operation of seawater and ROWPU systems until chlorine is available. For chlorination system operation, see TM 55-1930-209-14 & P-4.
- b. Make sure drinking water system storage tank valve(s) in table below are open for tanks to be filled.

Tank	1	2	3	4
Valve no.	DW1	DW2	DW3	DW4

- c. Open valve RO15 and close valve RO20 to allow product water to flow to drinking water storage tanks.

NOTE

The EMS monitors salinity of output from each ROWPU, amount of chlorine in water entering the tanks, water level in the four storage tanks, and HP pump diesel engine lubrication oil pressure and cooling water temperature. Salinity is shown on SALINITY display page, Chlorine entering storage tanks is shown on CHLORINE STATUS display page, storage tank levels are shown on POTABLE WATER TANKS display page, and engine indicators are shown on HIGH PRESSURE WATER PUMPS display page.

- d. Monitor water level in each storage tank, total level in all four storage tanks, and the amount of chlorine entering tanks.
- e. ROWPU's will continue to operate and fill drinking water storage tanks until manually shut down (paragraph 3-6.1). Stop and restart units as often as needed to maintain flow of water into storage tanks.
- f. Perform during operation preventive maintenance procedures.
- g. While ROWPU's are operating, periodically perform the following eight steps:

(1) Monitor pressure gauges and flow indicators for normal readings listed below.

<u>RO component</u>	P1	P2	P3	P4	P5	F1	F2
Normal reading	About 100	More than 65	More than 53	No more than 835	No more than 820	About 350	About 108

- (2) Monitor MEDIA FILTER OK indicator light on control station. If light goes out, check difference between media filter output pressure gauge P1 and media filters output pressure gauge P2. If difference exceeds 35 psi, backwash media filters (paragraph 4-7.2). If pressure difference is acceptable, check indicator light. Replace bulb if necessary.
- (3) Monitor CARTRIDGE FILTER OK indicator light on control station. If light goes out, check pressure difference between media filters output pressure gauge P2 and cartridge filter output pressure gauge P3. If difference exceeds 12 psi, change cartridge filter assembly (paragraph 4-7.1.1). If pressure difference is acceptable, check indicator light. Replace bulb if necessary.
- (4) Monitor difference between HP pump discharge pressure gauge P4 and brine discharge pressure gauge P5. If difference exceeds 25 psi, clean RO block membranes (paragraph 4-7.4.2).
- (5) Monitor EMS salinity, HIGH PRESSURE WATER PUMPS, POTABLE WATER TANKS, and CHLORINE STATUS display pages for normal readings. Alarms are activated when parameters exceed normal limits. These indications should be periodically checked, however, in case of alarm failures. When alarms sound, turn off alarms according to TM 55-1930-209-14 & P-11.
- (6) Monitor coagulant pump and inhibitor pump amber and red indicator lights on pump control panel (Figure 3-5). When amber light goes out, pump may be malfunctioning. Troubleshoot according to paragraph 4-4. When red indicator light comes on, supply drum may be empty. Replace drum if necessary.
- (7) Monitor HP pump diesel engine gauges (Figure 3-2) for readings listed below. If not normal, troubleshoot according to paragraph 4-4.

<u>Gauge</u>	<u>Reading</u>
Oil pressure	Normal (green) zone
Water temperature	Normal (green) zone
Ammeter	Slightly positive near zero
Fuel pressure	Normal (green) range

- (8) Periodically check product water quality for TDS (salinity) and pH according to TM 5-6630-215-12. Obtain product water sample at valve R09. Make sure salinity reading is less than 1000 ppm and pH factor is about 7. If readings are not within these values, troubleshoot according to paragraph 4-4.

3-6 Shutdown

3-6.1 Normal shutdown

- a. Stop HP pump as follows:
 - (1) Depress inner button on speed control and push forward to idle setting.
 - (2) Open throttling valve RO7 and product water overboard valves RO20 and RO21 to allow product water to flow overboard through void 3 port overboard discharge. Close valves RO15 to stop product water from flowing to drinking water storage tanks.

CAUTION

Do not immediately stop engine. Operating engine for 5 minutes at low idle allows hot areas to cool and turbocharger to slow down while still maintaining oil pressure on the turbine shaft.

- (3) Idle engine for about 5 minutes.
 - (4) Push shutdown lever forward to stop engine (Figure 3-2).
- b. Stop coagulant pump by turning ON/OFF switch (Figure 3-1) to OFF.
 - c. Stop inhibitor pump by turning ON/OFF switch (Figure 3-1) to OFF.
 - d. Stop seawater pump by turning OFF/ON/START switch (Figure 3-1) to OFF
 - e. Perform after operation maintenance procedures.

3-6.2 Emergency shutdown

3-6.2.1 General. The barge has two emergency shutdown modes. One mode shuts down individual systems such as the ventilation system or a diesel HP pump, and the other shuts down all barge operating systems.

Both modes are activated by pushing a red button protected by a metal guard. On individual system shutdowns, either fuel or electrical power is shut off to that system only. On total shutdown, all fuel and electrical power is shut off to all operating systems.

Seven red system shutdown buttons are located on the ROWPU space starboard bulkhead just aft of the personnel door. These system shutdown buttons (Figure 3-8) control shore power, ventilation system, ROWPU 1 diesel HP pump, ROWPU 2 diesel HP pump, ship auxiliary generator, ship service generator 2, and ship service generator 1.

Six red total shutdown buttons are located as follow:

- (1) On ROWPU space starboard bulkhead aft of personnel door, above and forward of system shutdown buttons.
- (2) Outside ROWPU space starboard door on weatherdeck.
- (3) Outside ROWPU space port door on weatherdeck.
- (4) Inside ROWPU space port door to weatherdeck.
- (5) Outside dayroom door to weatherdeck.
- (6) Inside dayroom door to weatherdeck.

3-6.2.2 Emergency shutdown procedures

- a. Local emergency ROWPU shutdown. Pull emergency shutdown cord surrounding diesel engine (Figure 3-2) to stop engine and HP pump.
- b. Remote emergency ROWPU shutdown. Push appropriate system shutdown button, either "ROWPU 1 diesel HP pump" or "ROWPU 2 diesel HP pump" on starboard side of ROWPU space near personnel door. This stops the ROWPU HP pump but not the seawater pump feeding that ROWPU system. If this shutdown is used, immediate action must be taken to turn off the appropriate seawater pump.
- c. Remote total shutdown. Push any total shutdown button to stop all pumps.
- d. When the situation that caused the emergency has been corrected, reset emergency button by turning collar behind button one-quarter turn clockwise. Button will pop out and again be in the ready position.
- e. When emergency button is reset, any systems turned off by that emergency button must be restarted with their individual controls.

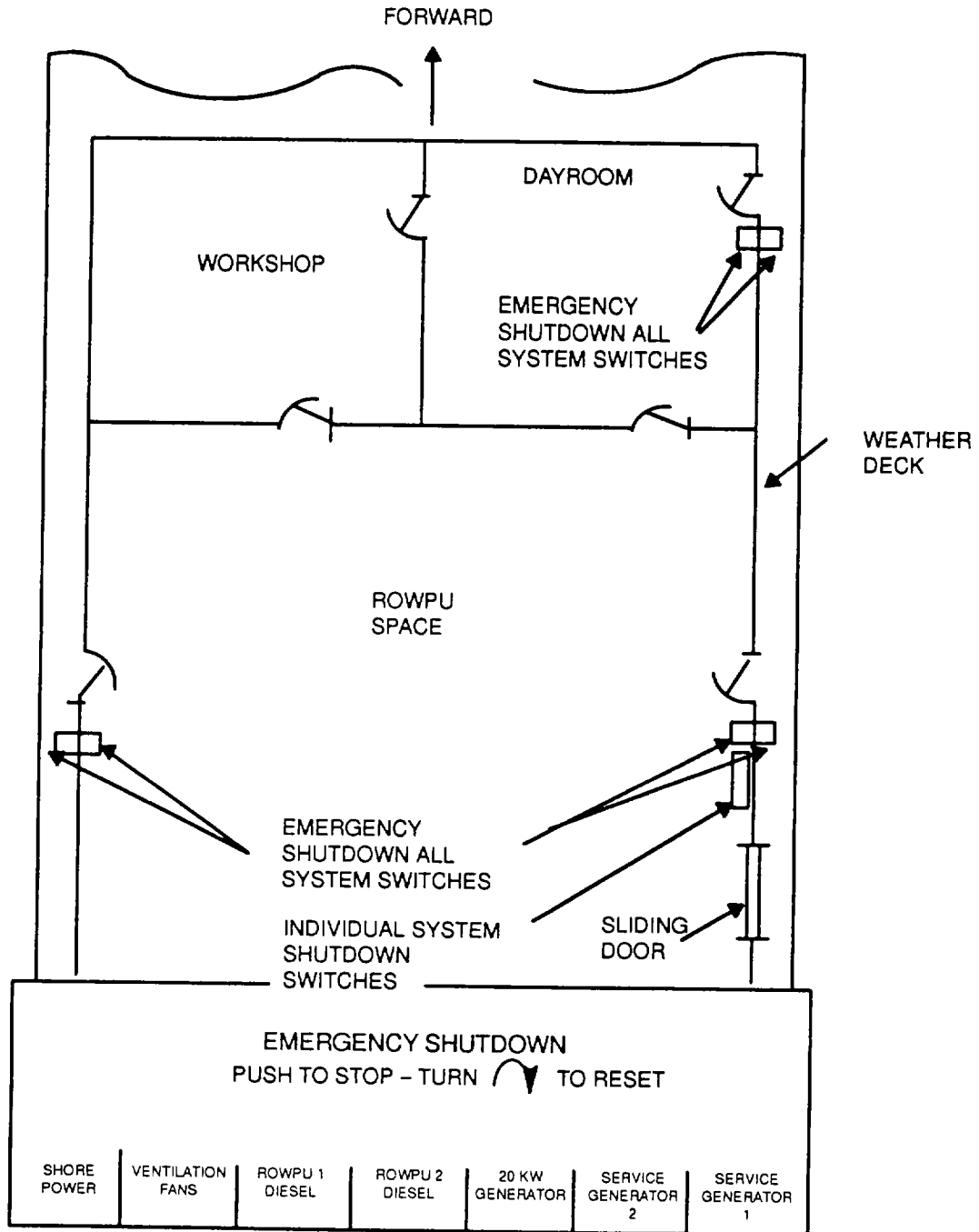


Figure 3-8. Location of Control Buttons for Emergency Shutdown Systems

CHAPTER 4 MAINTENANCE INSTRUCTIONS

Section I. General

NOTE

Additional operation, maintenance and parts information may be found in the following technical manuals which cover the 150,000 Gallon Per Hour (GPD) Reverse Osmosis Water Purification Unit (ROWPU):

TM 10-4610-229-10, Operator's Manual for 150,000 GPD ROWPU

TM 10-4610-229-24, Unit, Direct and General Support Maintenance Manual for 150,000 GPD ROWPU

TM 10-4610-229-24P, Repair Parts and Special Tools List for 150,000 GPD ROWPU

4-1 Maintenance concept

4-1.1 Unit level and Intermediate Direct Support and Intermediate General Support (IDS/IGS) maintenance on the ROWPU system is performed by barge crewmembers whenever possible.

4-1.2 Any IDS/IGS maintenance beyond capability of crewmembers is provided by a shore-based area support maintenance unit. This unit also determines if depot support maintenance is required.

4-1.3 Intermediate support maintenance is accomplished by replacement of components or major end items.

4-1.4 Unless other intermediate support procedures are directed, IDS/IGS maintenance is provided by an Army Transportation Corps floating craft intermediate support maintenance unit serving terminal operating area. Components to be disposed of are processed by this unit.

4-1.5 Maintenance Allocation Chart (MAC) is in Appendix C of TM 55-1930-209-14 & P-18. Consult appropriate manual for maintenance of other equipment onboard.

4-2 Maintenance instructions. Maintenance instructions are presented as follows: Section II, Preventive maintenance; Section III, Troubleshooting; and Section IV, Maintenance procedures.

Section II. Preventive maintenance checks and services

4-3 See TM 55-1930-209-14&P-3, Appendix B for Preventive Maintenance Checks and Services for the POWPU System. See TM 55-1930-209-14&P-1 9 for complete Preventive Maintenance Checks and Services for all ROWPU barge systems.

Section III. Troubleshooting

4-4 ROWPU system. Troubleshoot ROWPU system according to Table 4-1.

4-5 Trouble evaluation. Trouble should always be evaluated to determine if repair involving equipment shutdown should be made immediately. In many cases it may be wiser to wait until the next scheduled maintenance period before repairing. For a guide to trouble evaluation, refer to Table 4-2.

Section IV. Maintenance procedures

4-6 General. Maintenance for this system consists of servicing and repairing or replacing items listed in Appendix G of TM 55-1930-209-14 & P-18. No special tools are required. When performing maintenance, observe appropriate safety precautions and adhere to the following general shop practices:

- a. Always use new seals and gaskets before reassembling components disassembled for repair. Be sure to use only the correct seals and gaskets and install them carefully to avoid damage.
- b. When replacing O-rings, make sure all surfaces are clean and free of dirt, grit, or foreign material. Prior to installation, apply a thin coat of silicone grease to the O-ring. Protect O-rings by applying tape over threads, sharp corners, and edges.
- c. To ensure a leak-proof joint when replacing gaskets, make sure mating surfaces are clean and free of old gasket material, adhesive, oil, or grease.
- d. When replacing electrical components, follow proper procedures for soldering or crimping connections. Check all grounding. Make sure current-carrying members are properly insulated to avoid short-circuiting. Check for abrasions and chafing of insulation on wires and cables. Repair with tape or replace as necessary.

Table 4-1. ROWPU System Troubleshooting

<u>Condition</u>	<u>Possible Cause</u>	<u>Suggested Action</u>
1. Low flow of seawater at flow rate indicator F1	<ul style="list-style-type: none"> a. Valve RO18 not fully open b. HP pump engine speed not adjusted correctly with throttle valve R07 c. Seawater system not providing proper flow of seawater 	<ul style="list-style-type: none"> a. Open valve RO18 b. Adjust (paragraph 3-4 steps q-s) c. Troubleshoot seawater system (TM 55-1930-209-14&P-2)
2. Seawater appears very cloudy in seawater pump flow rate indicator FI	<ul style="list-style-type: none"> a. Seawater filters clogged or seawater strainers dirty 	<ul style="list-style-type: none"> a. Drain filters or clean seawater strainers (TM 55-1930-209-14&P-2)
3. MEDIA FILTER OK light on control station is out	<ul style="list-style-type: none"> a. Bulb burned out 4-8.1.7) b. Media filters clogged 	<ul style="list-style-type: none"> a. Replace bulb (paragraph 4-7.2) b. Backwash (paragraph 4-7.2)
4. Pressure difference between pressure gauges P1 and P2 exceeds 35 psi improperly positioned	<ul style="list-style-type: none"> a. Media filters clogged b. Valve RO4 	<ul style="list-style-type: none"> a. Backwash filters (paragraph 4-7.2) b. Open valve RO4
5. CARTRIDGE FILTER OK light on ROWPU control station is out	<ul style="list-style-type: none"> a. Bulb burned out b. Cartridge filter elements clogged 	<ul style="list-style-type: none"> a. Replace bulb (paragraph 4-8.1.7) b. Replace cartridge cage assembly (paragraph 4-7.1.1)
6. Pressure difference between pressure gauges P2 and P3 exceeds 12 psig	<ul style="list-style-type: none"> a. Cartridge filter elements clogged 	<ul style="list-style-type: none"> a. Replace cartridge cage assembly (paragraph 4-7.1.1)
7. Water sample taken at valve RO8 is cloudy	<ul style="list-style-type: none"> a. Inadequate dose of coagulant b. Coagulant pump off c. Coagulant drum empty 	<ul style="list-style-type: none"> a. Increase stroke on coagulant pump b. Start pump at control station by turning coagulant pump ON/OFF switch ON c. Replace drum (paragraph 4-7.1.3) and prime pump (paragraph 4-7.1.5)

Table 4-1. ROWPU System Troubleshooting (Continued)

<u>Condition</u>	<u>Possible Cause</u>	<u>Suggested Action</u>
8. Chemical metering pumps inoperative (amber indicator light not lit)	a. Pump switch off b. Red indicator light on pump control panel comes on indicating chemical drum empty	a. Start pump at control station b. Replace drum (paragraph 4-7.1.3) and prime pump (paragraph 4-7.1.5)
9. Chemical metering pump does not prime	a. Stroke length improperly set b. Check valves plugged	a. Set stroke length at 100 percent b. Clean (paragraph 4-7.1.4)
10. Chemical seeps out around metering pump head disc	a. Dosing head mounting loose b. Diaphragm defective	a. Tighten dosing head mounting screws (Table 4-3) b. Replace (paragraph 4-8.1.2)
11. Pressure difference between gauges P4 and P5 exceeds 25 psi	a. RO block membrane elements need cleaning b. RO block membrane elements need replacing	a. Clean membrane elements (paragraph 4-7.4) b. Remove and replace membrane elements (paragraph 4-8.4)
12. Discharge dirty at brine flow indicator	a. RO block membrane elements need cleaning b. Media filters need backwashing and flushing	a. Clean membrane elements (paragraph 4-7.4) b. Backwash and flush (paragraph 4-7.2)
13. High -TDS present in water sample taken at valve R09	a. Improper ratio of product water to brine b. RO block membrane needs cleaning	a. Adjust pump engine speed and valve R07 (paragraph 3-4, steps q-s) b. Clean membrane elements (paragraph 4-7.4)
14. The pH factor not acceptable in sample taken at valve R09	a. RO block membrane elements need cleaning	a. Clean membrane elements (paragraph 4-7.4)
15. HP pump engine running at normal speed, but pressure loss on pressure gauge P4	a. Valve RO11 not fully open b. Valve RO16 not fully closed c. Valve R07 open	a. Open valve RO11 b. Close valve RO16 c. Adjust pump engine speed and valve RO7 (paragraph 3-4, steps q-s)
16. HP pump vibrating (engine running normally)	a. Drive belts out of adjustment b. Mounting bolts loose	a. Adjust (paragraph 4-7.3.11) or replace (paragraph 4-8.3.11) b. Tighten bolts (Table 4-3)

Table 4-1. ROWPU System Troubleshooting (Continued)

<u>Condition</u>	<u>Possible Cause</u>	<u>Suggested Action</u>
17. Water runs from HP pump drain holes	a. Pump inoperative	a. Replace pump (paragraph 4-8.3.10)
18. HP pump diesel engine fails to start	a. Battery defective	a. Check and replace if necessary
	b. Battery cables loose	b. Tighten
	c. Starter motor defective	c. Check and replace if necessary (paragraph 4-8.3.8)
19. HP pump diesel engine does not run smoothly	a. Fuel line leaks	a. Tighten loose connectors
	b. Engine idle speed incorrect	b. Adjust
20. HP pump diesel engine does not develop full power	a. Throttle control linkage out of adjustment	a. Adjust
	b. Fuel leaks	b. Tighten loose connections
	c. Fuel filter clogged	c. Clean (paragraph 4-7.3.2) or replace (paragraph 4-8.3.7) fuel filter
	d. Air cleaner blocked	d. Clean or replace (paragraph 4-7.3.4)
21. HP pump diesel engine has low oil pressure	a. Oil level low	a. Add engine oil (See Appendix C)
	b. Oil lines leak	b. Tighten
22. HP pump diesel engine overheats	a. Oil level low	a. Add oil (See Appendix C)
	b. Coolant level low	b. Add coolant (paragraph 4-7.3.6)
	c. Cooling system leaks	c. Notify shift leader
	d. Expansion tank cap loose	d. Notify shift leader
23. HP pump diesel engine smokes excessively	a. Air filter blocked	a. Clean or replace (paragraph 4-7.3.4)
24. No electrical power with ignition switch in any position	a. Battery defective	a. Replace
	b. Battery cables loose or corroded	b. Clean and tighten. Replace if defective
25. Ammeter shows discharge with engine running	a. Wiring harness defective	a. Check for continuity. Replace if defective
	b. Alternator defective	b. Test (paragraph 4-8.3.2) and replace if necessary (paragraph 4-8.3.3)

Table 4-2. Trouble Evaluation

Question	Evaluation	Action
Is the trouble dangerous or likely to cause damage to the equipment	Yes	Repair
Can the repair be made without shut down	No	Repair
	Yes	Repair
	No	<ol style="list-style-type: none"> 1) Continue running equipment. 2) Make any temporary repairs you can without shut down. 3) Locate all tools and parts required for the repair. 4) Shut down and make repair when it is no longer critical to keep equipment running or when evaluation of questions, changes to indicate immediate repair.

e. Torque values for metal fasteners are shown in Table 4-3.

WARNING

Be sure electrical power is off before performing maintenance on this system. Open circuit breaker(s) P6 and/or P7 on switchboard. Redtag circuit breaker and/or motor controller with: "WARNING -DO NOT ACTIVATE. REPAIRS BEING MADE" Observe applicable safety precautions.

NOTE











Due to this vessel's mission and crew capabilities, maintenance normally assigned to intermediate support maintenance may be assigned to the crew.

4-7 Component servicing. The following paragraphs provide information on servicing major components of the ROWPU system.

- a. Pretreatment skid.
- b. Media filters.
- c. HP pump assembly.
- d. RO block.

Table 4-3. Torque Values for Fasteners (Sheet 1 of 2)











STANDARD TORQUE VALUE CHART

FASTENER	TYPE	M/N TENSILE STRENGTH	MATERIAL	BODY SIZE OR OUTSIDE DIAMETER OF FASTENER																	
				2	3	4	5	6	8	10	1/4	1/10	1/8	1/16	1/2	5/16	3/8	3/4			
	SAE 0-1-2	74 000 PSI	LOW CARBON STEEL									6	12	20	32	47	69	96	155		
	SAE 3	100 000 PSI	MEDIUM CARBON STEEL									9	17	30	47	69	103	145	234		
	SAE 5	120 000 PSI	MEDIUM CARBON HEAT TREAT STEEL									10	19	33	54	78	114	154	257		
	SAE 6	133 000 PSI	MEDIUM CARBON STEEL QUENCHED TEMPERED									12.5*	24	43	69	106	150	209	350		
	SAE 7	133 000 PSI	MEDIUM CARBON ALLOY STEEL									13	25	44	71	110	154	215	360		
	SAE 8	150 000 PSI	MEDIUM CARBON ALLOY STEEL									14	29	47	78	119	169	230	380		
	SOCKET HEAD CAP SCREW	160 000 PSI	HIGH CARBON CASE HARDENED STEEL	TORQUE VALUES All figures are foot-pounds except those marked with an asterisk (*) which are inch-pounds																	
	SOCKET SET SCREW	212 000 PSI	HIGH CARBON CASE HARDENED STEEL					9*	16*	30*	70*	140*	18	29	43	63	100	146			
	MACHINE SCREW YELLOW BRASS	60 000 PSI	COPPER (CU) 63% ZINC (ZU) 37%	2*	3.3*	4.4*	6.4*	8*	16*	20*	65*	110*	17	27	37	49	78	104			
	SILICONE BRONZE TYPE 'B	70 000 PSI	COPPER (CU) 96% ZINC (ZNI) 2% SILICON (SI) 2%	2.3*	3.7*	4.9*	7.2*	10*	19*	22*	70*	125*	20	30	41	53	88	117			

There is no difference in the above chart between the torque figures for fine or coarse threads. The torque figures for a finely-threaded fastener as compared to a coarsely-threaded fastener of the same diameter may be slightly higher but hardly worth mentioning.

Table 4-3. Torque Values for Fasteners (Sheet 2 of 2)

STANDARD TORQUE VALUE CHART

FASTENER	TYPE	MIN TENSILE STRNGN	MATERIAL	BODY SIZE OR OUTSIDE DIAMETER OF FASTENER													
				7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	2 3/4	3
	SAE 0-1-2	74 000 PSI	LOW CARBON STEEL	206	310	480	675	900	1100	1470	1900	2380	2750	3450	4400	7350	9500
	SAE 3	100,000 PSI	MEDIUM CARBON STEEL	372	551	872	1211	1624	1943	2660	3463	4695	5427	7226	8049	13450	17548
	SAE 5	120,000 PSI	MEDIUM CARBON HEAT TREAT STEEL	382	587	794	1105	1500	1775	2425	3150	4200	4550	6550	7175	13000	16000
	SAE 6	133 000 PSI	MEDIUM CARBON STEEL QUENCHED TEMPERED	550	825	1304	1815	2434	2913	3985	5189	6980	7491	10825	14983	20151	26286
	SAE 7	133 000 PSI	MEDIUM CARBON ALLOY STEEL	570	840	1325	1825	2500	3000	4000	5300	7000	7500	11000	15500	21000	27000
	SAE 8	150 000 PSI	MEDIUM CARBON ALLOY STEEL	600	900	1430	1975	2650	3200	4400	5650	7600	8200	12000	17000	23000	29000
	SOCKET HEAD CAP SCREW	160 000 PSI	HIGH CARBON CASE HARDENED STEEL	640	970	1520	2130	2850	3450	4700	6100	8200	8800	13000	18000	24000	31000
	SOCKET SET SCREW	212,000 PSI	HIGH CARBON CASE HARDENED STEEL														
	MACHINE SCREW YELLOW BRASS	60,000 PSI	COPPER (CU) 63% ZINC (ZU) 37%	160	215	325	400		595								
	SILICONE BRONZE TYPE "B"	70,000 PSI	COPPER (CU) 96% ZINC (ZNI) 2% SILICON (SI) 2%	180	250	365	450		655								

There is no difference in the above chart between the torque figures for fine or coarse threads. The torque figures for a finely-threaded fastener as compared to a coarsely-threaded fastener of the same diameter may be slightly higher but hardly worth mentioning.

4-7.1 Pretreatment skid

4-7.1.1 Changing cartridge cage assembly (filter elements). Perform this procedure when the pressure difference between media filter output pressure gauge P2 and cartridge filter assembly output pressure gauge P3 (Figure 3-1) exceeds 12 psi, or when the CARTRIDGE FILTER OK light goes out. Changing the cartridge cage assembly (filter elements) requires a minimum of three personnel and a bridge crane with a 2-ton hoist.

- a. Follow these preliminary procedures if HP pump diesel engine is operating:
 - (1) Close valve RO15 to prevent product water from flowing to drinking water tanks.
Open valves RO20 and RO21 to allow product water to flow directly overboard.

CAUTION

Do not immediately stop engine. Operating engine for 5 minutes at low idle allows hot areas to cool and turbocharger to slow down while still maintaining oil pressure on the turbine shaft.

- (2) Gradually reduce HP pump diesel engine throttle setting to idle (Figure 3-3). Leave engine idling.
 - (3) Open throttling valve RO7.
 - (4) Stop coagulant and inhibitor pumps at control station (Figure 3-1) by setting ON/OFF switches to OFF.
 - (5) After HP pump diesel engine has been running at idle for about 5 minutes, stop engine by pushing in on shutdown lever (Figure 3-3).
 - (6) Stop seawater pump by turning pump OFF/ON/START switch on control panel (Figure 3-1) to OFF.
- b. Remove cartridge cage assembly (filter elements) as follows:

NOTE

Item numbers referenced in these procedures are shown in Figure 4-1. Valves, shown in Figure 1-2, figure 1-3, and figure 1-5, are listed in Table 1-3.

- (1) Turn valve RO4 to position C (OFF) to prevent seawater flow to cartridge filter assembly.
- (2) Drain cartridge filter assembly by opening valve RO8.
- (3) Disconnect camlock coupling, item 3, on cartridge filter assembly output line.
- (4) Remove four hex nuts, item 4, on top end assembly, item 1.

WARNING

Do NOT manhandle heavy components. Operate bridge crane according to TM 55-1930-209-14&P-13.

- (5) Using bridge crane and 2-ton hoist, remove top end assembly from the filter housing, item 2, and place it out of the immediate work area.
- (6) Attach a lifting rig to the U-bolts, item 10, of cartridge cage assembly, item 9.

CAUTION

Cartridge cage assembly must be lifted vertically and slowly to prevent damage to assembly. Two crewmen should slightly rotate cartridge cage assembly to overcome O-ring resistance while the hoist applies a steady lift.

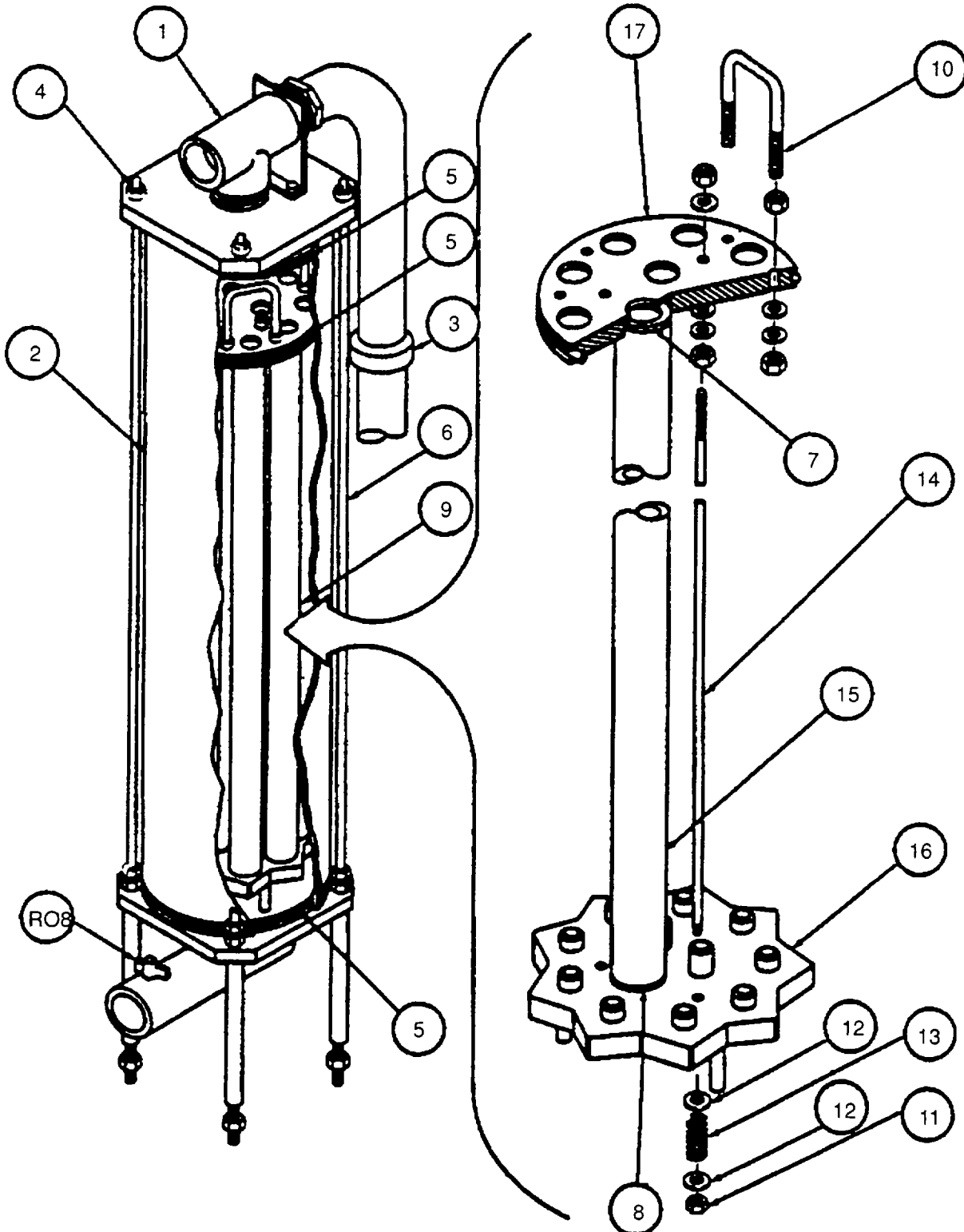


Figure 4-1. Cartridge Filter Assembly (Sheet 1 of 2)

KEY TO FIGURE 4-2

<u>Item Number</u>	<u>Quantity</u>	<u>Description</u>	<u>Hydranautics Part Number</u>
1	1	Top end assembly	52094
2	1	Filter housing	52083
3	1	Camlock coupling	_____
4	16	Nut	3/4-10 UNC-2BSS
5	3	O-ring	Parker 2-452C557-70
6	4	Tie rod	52082
7	12	Upper seal	52085
8	12	Lower seal	52084
9	1	Cartridge cage assembly (filter elements)	52092
10	3	U-bolt	52089
11	21	Hex nut 5/16-18	UNC-2B 316SS
12	18	Flat washer	5/16 316SS
13	3	Spring	52086
14	3	Tie rod, spiders	52087
15	12	Filter element	52088
16	1	Lower spider weldment	52090
17	1	Upper spider	52091

Figure 4-1. Cartridge Filter Assembly (Sheet 2 of 2)

- (7) Using bridge crane and 2-ton hoist, lift cartridge cage assembly while slowly rotating it to overcome O-ring resistance. As assembly clears the housing, attach lines to the assembly to control its movement. The assembly should be lifted vertically and slowly to prevent (damage). Move it away from the filter housing, lower it to the deck, and remove the hoist.
- (8) Remove and replace cartridge elements according to paragraph 4-7.1.2.
- c. Installing cartridge cage assembly (filter elements)
 - (1) Check that O-rings, item 5, on cartridge cage assembly are in their grooves and lightly lubricated with a silicone-based lubricant. Install new O-rings if existing ones are damaged.
 - (2) Attach lifting rig to cartridge cage assembly U-bolts. Using bridge crane with 2-ton hose, lift assembly and guide it over the filter housing.

CAUTION**Be careful not to damage O-ring when installing cartridge cage assembly.**

- (3) Carefully lower assembly into the filter housing. Rotate assembly slightly, if necessary, to get O-rings into filter housing without damage.
- (4) Attach a lifting rig to top end assembly and lower onto filter housing. Insert tie rods, item 6, into tie rod holes and align camlock connections.
- (5) Install hex nuts on tie rods and torque evenly to 10 ft-lb.
- (6) Connect camlock coupling.
- (7) Close valve RO8.
- (8) Prepare ROWPU's for normal operation (paragraph 3-3).

4-7.1.2 Cartridge filter elements replacement. The following equipment is required to replace cartridge filter elements on the cartridge cage assembly:

- 12 new filter elements (P/N 52088)
- Set of socket wrenches and torque wrench
- 12 upper seals (spare) (Hydranautics #52085)
- 12 lower seals (spare) (Hydranautics #52084)
- 3 O-rings (spare) (Parker 2-452C557-70)
- Stiff bristle brush and clean, lint-free cloths
- Clean workspace

NOTE

Item numbers referenced in these procedures are shown in Figure 4-1.

- a. Invert cartridge cage assembly and stand it on the three U-bolts.
- b. Remove three 5/16 hex nuts, item 11; six washers, item 12; and three springs, item 13. Lift and remove lower spider, item 16, from tie rods.

CAUTION

Do not attempt to remove upper or lower seals. If seals come loose, be sure to install upper seals on upper spider and lower seals on lower spider. Failure to install seals correctly may result in water leakage.

- c. Remove used filter elements, item 15. Keep upper seals, item 7, separate from lower seals, item 8.
- d. Examine used filter elements. If they contain large amounts of sand and frequency of replacement has been increasing, check media filters for possible internal damage.
- e. Discard used filter elements.
- f. Clean internal parts and inside of filter housing with a stiff bristle brush and clean water. Flush with clean water and dry with clean, lint-free cloths.
- g. Inspect upper and lower spiders, items 16 and 17. Check seals for damage and replace if nicked. Place new or reused upper seals in sockets on upper spider. Place lower seals on guide pins on lower spider.
- h. Place three new filter elements in three center sockets on upper spider. Make sure upper seals remain properly seated.

- i. Making sure that seals stay in sockets, place nine outer filter elements in outer sockets on upper spider. Make sure upper and lower seals are properly seated for each filter element.
- j. Slowly press lower spider down while aligning outer filter elements with guide pins.
- k. Install six washers, three springs, and three hex nuts on spider tie rod ends, item 14. Hand tighten until nuts contact top washers. Tighten hex nuts evenly another seven turns each to compress but not completely flatten spring.
- l. Record completion of this maintenance action in maintenance logbook.

4-7.1.3 Coagulant or inhibitor drum replacement

WARNING

Avoid exposure to coagulant (Hydrapol-50) and inhibitor (Hydrapol-100). Wear safety goggles or faceshield and rubber gloves when working around chemicals. If chemical is swallowed, do not induce vomiting. Drink water and seek medical attention. If chemical gets in eyes, flush with water and seek medical attention. If chemical contacts skin, wash with soap and water.

- a. Disconnect suction hose from chemical metering pump on top of pretreatment skid.

NOTE

Pump suction hose enters drum through the larger of two plastic bungs that are screwed into the drum.

- b. Remove suction hose, with suction foot valve and weight attached, from empty drum.

NOTE

Drum breather (vent) hose enters drum through smaller plastic bung and hangs over the side.

- c. Remove breather hose.
- d. Remove empty drum.

WARNING

Ensure that correct drum is removed and replaced.

Coagulant drum is normally painted black. Inhibitor drum is normally painted white.

- e. Obtain new drum using drum lifter and bridge crane with 2-ton hoist. Position and secure drum in rack.
- f. Install suction hose in drum through hole in large bung. Make sure foot valve is just above the drum bottom.
- g. Connect other end of suction hose to chemical metering pump.
- h. Insert breather hose into smaller bung in the drum. Make sure hose does not siphon chemical onto the deck.
- i. Prime chemical metering pump according to paragraph 4-7.1.5.

4-7.1.4 Chemical metering pump check valves cleaning. Check valves are located in the foot valve, suction inlet on dosing head, pressure outlet on dosing head, and injection valve on the process stream. These valves are all the same and are disassembled for cleaning as follows:

NOTE

The following procedures are the same for both chemical metering pumps.

- a. Remove chemical metering pump according to paragraph 4-8.1.1.
- b. Once pump is removed, disassemble dosing head (Figure 4-2) as follows:
 - (1) Remove four screws and flatwashers holding dosing head to pump. Remove dosing head, diaphragm, and disc head.
 - (2) Set pump stroke length knob (Figure 3-5) at 0 percent.
 - (3) Remove discharge valve body and C-ring. Remove valve ball and O-ring.
 - (4) Remove suction valve body and O-ring. Remove valve ball and O-ring.
 - (5) Remove bleeder valve and O-ring.
 - (6) Using small punch, press sleeve, valve ball, and two O-rings from discharge and suction valve bodies.
 - (7) Thoroughly wash parts and clean water to remove dry or caked media. Replace any damaged or worn O-rings or balls.
- c. Reassemble dosing head assembly as follows:
 - (1) Install O-ring and valve ball in discharge valve body. Press in O-ring and sleeve.
 - (2) Install O-ring on discharge valve body.
 - (3) Install valve ball in dosing head. Install O-ring in dosing head. Install discharge valve.
 - (4) Install O-ring and valve ball in suction valve body. Align hole in sleeve with hole in body. Press in O-ring and sleeve.
 - (5) Install O-ring in suction valve body.
 - (6) Install valve ball and O-ring in dosing head. Install suction valve.
 - (7) Install O-ring and bleeder valve in dosing head.
 - (8) Set pump stroke length knob at 0 percent.
 - (9) Set pump stroke knob at 100 percent.
 - (10) Rotate head disc down and align screw holes.
 - (11) Install diaphragm.
 - (12) Install dosing head with arrow pointing up. Install four screws and flat washers.
- d. Reinstall chemical metering pump in accordance with paragraph 4-8.1.1.

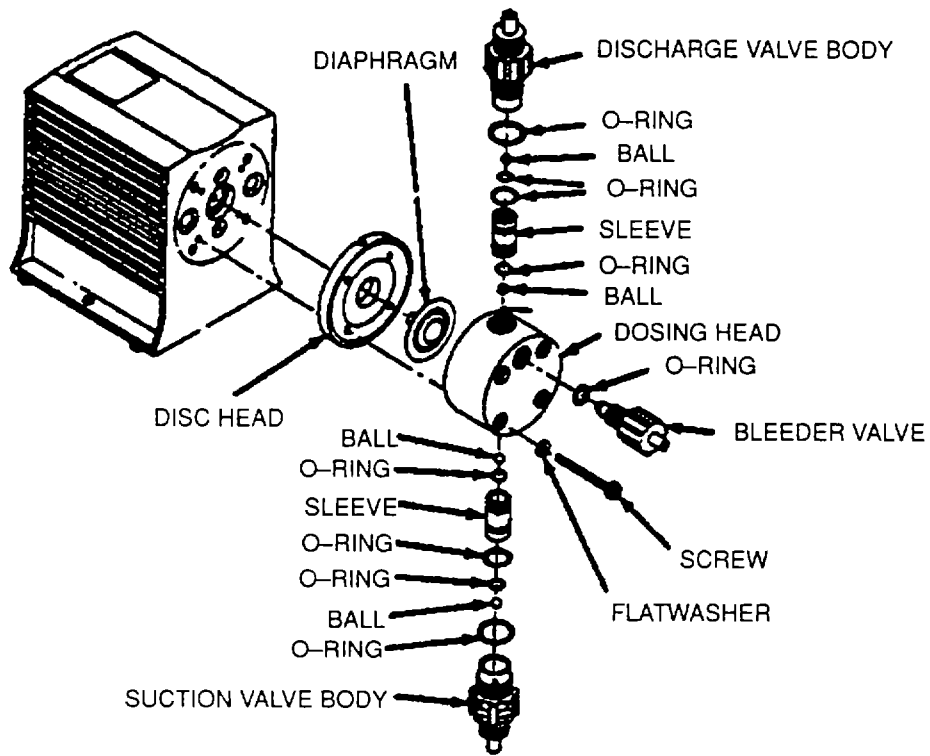


Figure 4-2. Chemical Metering Pump Maintenance

4-7.1.5 Chemical metering pump priming. Following coagulant or inhibitor drum replacement or pump maintenance, prime pump as follows:

- a. Set stroke and speed controls (Figure 3-5) to 100.
- b. Set pump ON/OFF switch on control station to ON.
- c. Connect piece of hose to air purge valve (Figure 4-3) to collect any air or liquid that may appear.
- d. While pump is priming, open air purge valve on back of pump.
- e. Close air purge valve when fluid is free of air.
- f. When pump is primed, turn pump ON/OFF switch on control station to OFF.
- g. Set chemical metering pump controls as follows:

	<u>Stroke Length</u>	<u>Stroke Frequency</u>
COAGULANT PUMP (P2)	50	35
INHIBITOR PUMP (P4)	100	46

- h. Record completion of maintenance action in maintenance logbook.

4-7.2 Media filters. Media filters need to be backwashed and flushed when pressure difference between seawater pump discharge pressure gauge P1 and media filters output pressure gauge P2 (Figure 3-1) exceeds 35 psig, when MEDIA FILTER OK light (Figure 3-1) goes out, or when water sample taken from cartridge filter assembly drain valve ROE is dirty. Filtered water from two of the filters is used to backwash the third one. In this procedure, a slow backwash is followed by a fast backwash followed by another slow backwash for each of the three media filters. All three media filters are then flushed simultaneously. Backwashing and flushing should normally take about 1 hour per ROWPU.

4-7.2.1 Preliminary procedures. If HP pump diesel engine is operating, perform the following- .

- a. Close valve RO15 to prevent product water from flowing to drinking water tanks. Open valves RO20 and RO21 to allow product water to flow directly overboard.

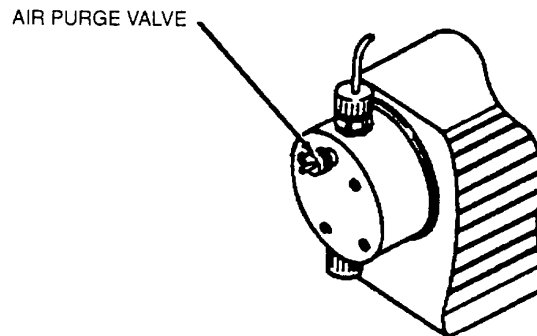


Figure 4-3. Chemical Metering Pump Priming.

CAUTION.

Do not immediately stop engine. Operating engine for 5 minutes at low idle allows hot areas to cool and turbo-charger to slow down while maintaining oil pressure on the turbine shaft.

- b. Gradually reduce HP pump diesel engine throttle setting to idle (Figure 3-2). Leave engine idling.
- c. Open throttling valve RO7.
- d. Stop coagulant pump and Inhibitor pump at control station by setting ON/OFF switches (Figure 3-1) to OFF.
- e. After HP pump diesel engine has been running at idle for about 5 minutes, stop engine by pushing in on shutdown lever (Figure 3-2).
- f. Stop seawater pump by turning pump OFF/ON/START switch on control station (Figure 3-1) to OFF.

4-7.2.2 Backwashing media filter 1.

- a. Position RO valves as indicated.

o = open
A = position A

x = closed 1/2
B = position B

o = 1/2 open.
C - position C.

RO valve no	1	2	3	4	5	6	7	12	18	19.
Valve position	B	A	A	C	x	1/2o	x	o	o	x.

- b. Start seawater pump by turning pump OFF/ON/START switch on control station to START and then to ON (Figure 3-1).
- c. Adjust valve RO6 to obtain a backwash flow rate of 162 gpm at seawater pump flow indicator F1 and a temperature reading of 80°F at seawater temperature gauge T1 Exact flow rate depends on actual temperature reading and should correspond to readings in table below Cooler water requires less flow.

Temperature T1 (F)	Slow backwash F1 flow rate (gpm)	Fast backwash. F1 flow rate (gpm).
55	115	180
60	125	200
65	135	220
70	144	240
75	153	255
80	162	270
85	170	285
90	177	300
95	184	315
100	191	325
105	198	334
110	204	342
115	210	350
120	216	355
125	222	360

- d. Observe condition of the water at the flow indicator After 5 minutes or when water is clear, open valve RO6 to obtain fast backwash flow rate corresponding to water temperature at T1 in the table above.
- e. After 2 minutes of fast backwash, partially close valve R06 to obtain slow backwash flow rate at FI.
- f. After 2 minutes of slow backwash, stop seawater pump by turning pump ON/OFF/START switch on control station (Figure 3-1) to OFF.

4-7.2.3 Backwashing media filter 2.

- a. Position RO valves as indicated In table below,.

	o = open		x = closed		1/2o = 1/2 open					
	A = position A		B = position B		C = position C					
RO valve no	1	2	3	4	5	6	7	12	18	19
Valve Position	A	B	A	C	x	1/2o	x	o	o	x

- b. Follow procedures in steps 4-7 2 2b thru f.

4-7.2.4 Backwashing media filter 3

- a. Position RO valves as indicated in table below.

	o = open		x = closed		1/2o = 1/2 open					
	A = position A		B = position B		C = position C.					
RO valve no	1	2	3	4	5	6	7	12	18	19
Valve Position	A	A	B	C	x	1/2o	x	o	o	x.

- b. Follow procedures In steps 4-7 2 2b thru f.

4-7.2.5 Flushing media filters. After each media filter has been backwashed, flush all media filters simultaneously as follows.

- a. Position RO valves as indicated in table below.

	o = open		x = closed		1/2o = 1/2 open					
	A = position A		B = position B		C = position C					
RO Valve No	1	2	3	4	5	6	7	12	18	19
Valve Position	A	A	A	C	o	o	x	o	o	x.

- b. Start seawater pump by turning pump ON/OFF/START switch on control station (Figure 3-1) to START and then ON.
- c. After 10 minutes of flushing, stop seawater pump by turning pump ON/OFF/START switch to OFF.
- d. Prepare ROWPU for normal operations (paragraph 3-3).

4-7.3 HP pump assembly.

4-7.3.1 Diesel engine oil and filter change Change diesel engine oil and filter quarterly or every 250 meter hours, whichever occurs first.

- a. Drain engine crankcase oil as follows.
- (1) Barge 1 - Open crankcase drain valve BD12 to drain ROWPU 1 engine and BD13 to drain ROWPU 2 engine.
 - (2) Barges 2 and 3 - Connect one end of a utility hose to quick disconnect at crankcase drain Connect other end to quick disconnect at crankcase drain oil disposal. Open valves BD12 and BD19 when draining ROWPU 1 engine and BD13 and BD19 when draining ROWPU 2 engine.
 - (3) Start bilge pump (TM 55-1930-209-14&P-15) and run until crankcase is empty Turn bilge pump off and close valve BD12 or BD13 and BD19 Disconnect utility hose, flush It clean, and return to stowage. .

- b. Remove and replace filter as follows.
 - (1) Wipe dirt from oil filter (Figure 4-4).
 - (2) Remove and discard filter.
 - (3) Clean the filter base and remove all old gasket material.
 - (4) Lightly coat filter gasket with engine oil.
 - (5) Install new filter Hand tighten an additional 3/4 turn after gasket contacts the base.
- c. Fill crankcase with 9 gallons of oil.
- d. Start and run engine to operating temperature Check for leaks.

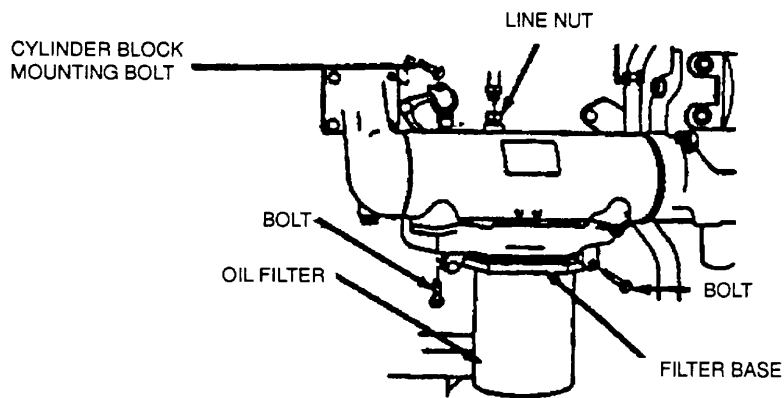


Figure 4-4. HP Pump Diesel Engine Oil Filter.

- e. Reduce engine speed to Idle Check oil level with dipstick. Add oil as necessary.
- f. Shut down engine.

4-7.3.2 Draining water from diesel engine fuel filter. Drain water and sediment from the fuel filter (Figure 4-5) at the start of each shift.

4-7.3.3 Diesel engine alternator fan belt adjustment. Adjust HP pump diesel engine alternator fan belt (Figure 4-6) as follows.

- a. Remove three nuts, bolts, lockwashers, and flat-washers Remove alternator guard.
- b. Place straight edge from vibration damper pulley to alternator pulley.
- c. Using a ruler, press down on fan belt halfway between pulleys Measurement should be 3/8 to 1/2 inch.
- d. If fan belt needs adjustment, proceed as follows.
 - (6) Loosen jam nut and bottom mounting nut.
 - (7) Use adjusting nut to adjust fan belt.
 - (8) When adjusted, tighten bottom mounting nut and jam nut.
- e. Install alternator guard Install three flatwashers, lockwashers, bolts, and nuts.

4-7.3.4 Diesel engine air filter cleaning and replacement. Service the air cleaner when the red band in the Indicator locks in the visible position. The air filter element can be cleaned approximately four times. Carefully inspect element after each cleaning. If exhaust smoke and/or loss of power continues after servicing the air cleaner, install a new element.

CAUTION.

Service the air cleaner with the engine stopped.

- a. Open six batches and remove the air cleaner cover and element (Figure 4-7).
- b. Cover the air inlet opening to prevent foreign objects from entering the engine.
- c. Wipe filter housing and cover clean.
- d. If filter will be reinstalled, tap it gently on a hard surface to remove dirt and debris.
- e. Remove covering from the air inlet opening.

CAUTION

Arrows on the side of the element indicate direction of air flow. Ensure element is installed correctly.

- f. Install either a new or cleaned filter element.
- g. Install the air cleaner cover and secure latches.
- h. Reset the service indicator by pushing in the reset button.

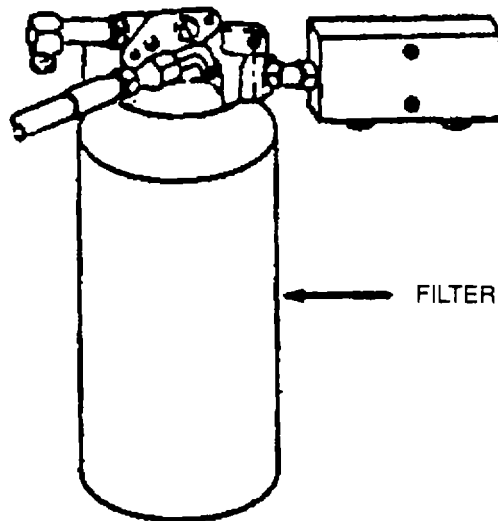


Figure 4-5. HP Pump Diesel Engine Fuel Filter.

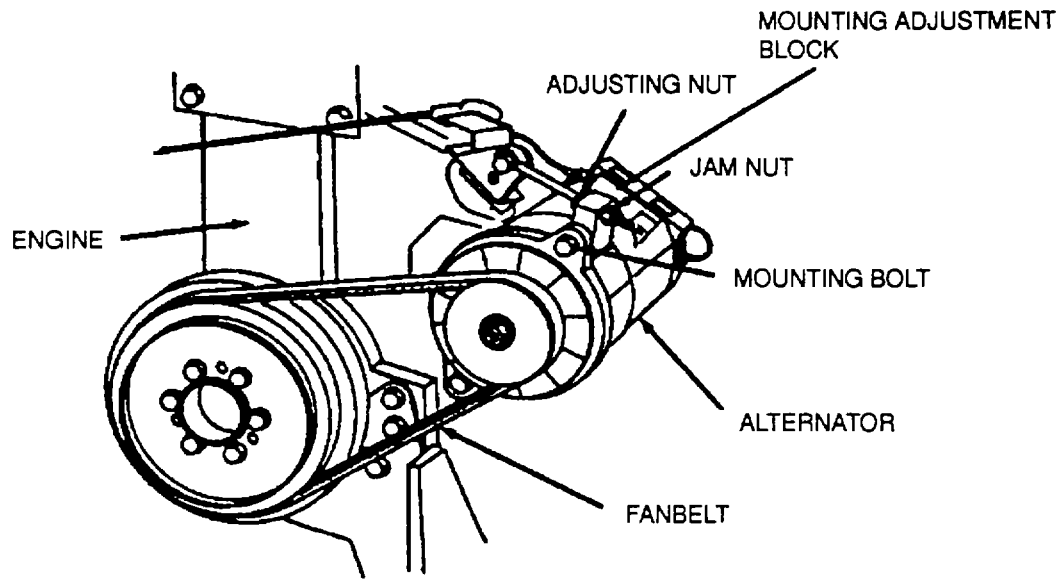


Figure 4-6. HP Pump Diesel Engine Alternator

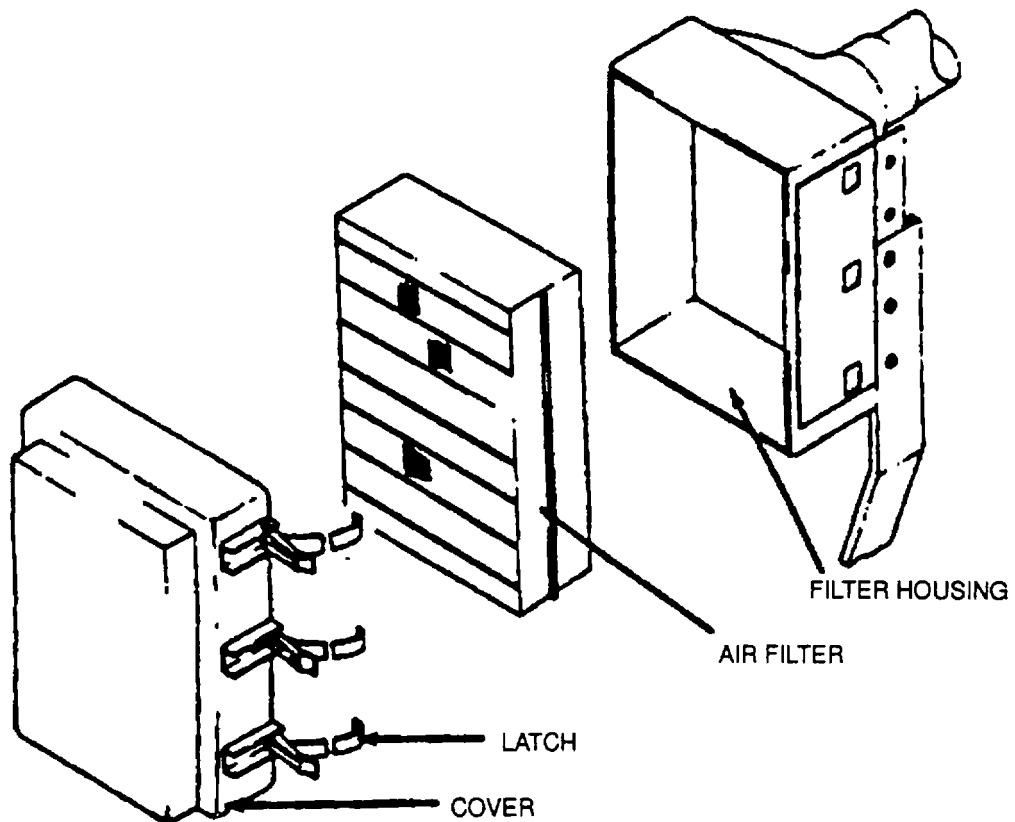


Figure 4-7. HP Pump Diesel Engine Air Filter

4-7.3.5 Diesel engine cooling system 500 hour service. All water is corrosive at engine operating temperatures. Cooling system conditioner liquid or coolant conditioner element treats either plain water or ethylene glycol anti-freeze solution to minimize corrosion. If cooling system uses conditioner liquid instead of a coolant conditioner element, perform the following service every 500 hours of operation.

WARNING

At operating temperatures, engine coolant is hot and under pressure. It also contains alkaline materials harmful to eyes and skin. To avoid personal injury, check coolant level only when engine is stopped and filler cap is cool enough to be touched with a bare hand. Should engine coolant come in contact with eyes or skin, immediately flush affected area with clean water and seek medical assistance if necessary.

CAUTION

Never use both the liquid cooling system conditioner and coolant conditioner element at the same time.

Do not use cooling system conditioner or coolant conditioner elements with Dowtherm 209 Full-Fill coolant.

- a. Loosen filler cap slowly to relieve pressure and remove cap.

NOTE.

To allow for the addition of conditioner, some coolant may have to be drained.

- b. Add cooling system conditioner to achieve a 3 percent concentration.
- c. Inspect filler cap gasket and replace if necessary.
- d. Install filler cap.

4-7.3.6 Diesel engine cooling system replenishment.

CAUTION

Never add coolant to an overheated engine. Allow engine to cool first.

- a. Mix anti-freeze to provide protection to the lowest expected ambient temperature.

NOTE.

When filling cooling system, allow for addition of conditioner.

- b. To avoid air pockets, add coolant slowly, at 5 U.S gallons (19 liters) per minute or less. Cooling system holds 9 U S gallons.

WARNING

Cooling system conditioner contains alkali. Avoid contact with skin and eyes.

CAUTION

Never use both the liquid cooling system conditioners and coolant conditioner elements at the same time.

Do not use cooling system conditioner or coolant conditioner elements with Dowtherm 209 Full-Fill coolant.

- c. Add cooling system conditioner to achieve a 3 percent concentration or insert the proper precharge element.
- d. Bring the coolant level to within 1/2 Inch (1 cm) of the bottom of the fill pipe.

NOTE

When refilling cooling system, coolant level must be rechecked when engine reaches operating temperature.

- e. Start engine with coolant cap off Add coolant, if necessary, when engine reaches operating temperature and coolant level stabilizes.
- f. Stop engine Replace cap seal if damaged Install cap.

4-7.3.7 Diesel engine coolant (anti-freeze) change Change diesel engine cooling system anti-freeze every 2000 hours of operation.

WARNING

At operating temperature, engine coolant is hot and under pressure. It also contains alkaline materials harmful to eyes and skin. To avoid personal injury, check coolant level only when engine is stopped and filler cap is cool enough to be touched with a bare hand. Should engine coolant come in contact with eyes or skin, immediately flush affected area with clean water and seek medical assistance if necessary.

- a. Loosen filler cap slowly to relieve pressure and remove cap.
- b. Remove engine block drain plugs and allow coolant to drain (Figure 4-8).
- c. Clean drain plugs and reinstall.
- d. Fill engine cooling system (paragraph 4-7.3.6).

4-7.3.8 Diesel engine cooling system cleaning. Most commercial cooling system cleaners may be used in the following procedures.

- a. Drain cooling system (paragraph 4-7.3.7).
- b. Install drain plugs Fill system with cleaning solution [2 lbs. Sodium Bisulfate (NaHSO₄) per 10 U S gallons (1 kilogram per 40 liters) of water].
- c. Start and run engine for 1/2 hour. Stop engine and drain cleaning solution.
- d. Flush system with fresh water until water is clean Do not run engine while flushing.
- e. Install drain plugs Fill system with neutralizing solution [1/2 lb Sodium Carbonate Crystals (Na₂CO₃) per 10 U S gallons (250 grams per 40 liters) of water].
- f. Start and run engine for 10 minutes Stop engine and drain neutralizing solution.
- g. Flush system with fresh water until water is clean Do not run engine while flushing.
- h. Install all drain plugs.
- i. Fill cooling system (paragraph 4-7.3.6).

4-7.3.9 HP pump pedestal bearing oil change. Change pedestal bearing oil every 6 months or 4000 hours of operation, whichever comes first This Interval must be reduced to 4 months or 2500 hours for pumping at temperatures above 2000 F.

- a. Place container under drain plug to catch used oil (Figure 4-9).
- b. Remove drain plug underneath pedestal and allow oil to drain.
- c. Replace plug.
- d. Remove oil breather and add 6 quarts of oil (OE/HDO-MIL-L-2104) Replace oil breather.
- e. Clean up any spills and record completion of maintenance action In maintenance logbook.

4-7.3.10 HP pump oil breather cleaning. Clean HP pump oil breather (Figure 4-10) as follows.

- a. Remove wingnut, lockwasher, and flatwasher from oil breather Remove oil breather top.
- b. Remove element from oil breather.
- c. Wipe all dirt from oil breather top and body.

WARNINGS.

- Solvent may cause toxic fumes. Work only In a well-ventilated area Avoid skin and eye contact Do not breath vapors.
 - Solvent Is flammable Do not bring open flame or sparks near solvent.
- d. Clean oil breather element with Drycleaning Solvent, Type 2 (A-A-711) Dry thoroughly.
 - e. Install oil breather element on body.
 - f. Install oil breather top, flatwasher, lockwasher, and wingnut.

4-7.3.11 HP pump V-belt adjustment. Adjust HP pump V-belts (Figure 4-11) as required.

- a. Remove 32 mounting bolts and lockwashers Remove front V-belt housing (two pieces).
- b. Place a straight edge on V-belt In a straight line with bearing bases.
- c. Place tension meter pointer on the line on the center of the front belt.

NOTE

Do not contact O-ring on tester stem.

- d. Press down on tester stem until register flange just contacts the next belt.
- e. Release pressure and note pressure scale reading under O-ring.
- f. Repeat steps b thru e for rear belt.
- g. Both readings should be 21-25 lbs (9 5-11 25 kg) and within 1 lb (0 45 kg) of each other.
- h. If belts are not adjusted correctly, proceed as follows:
 - (1) Loosen four bolts.
 - (2) Loosen two adjusting screw locknuts.
 - (3) Turn adjusting screws equally to adjust belt tensioner assembly.

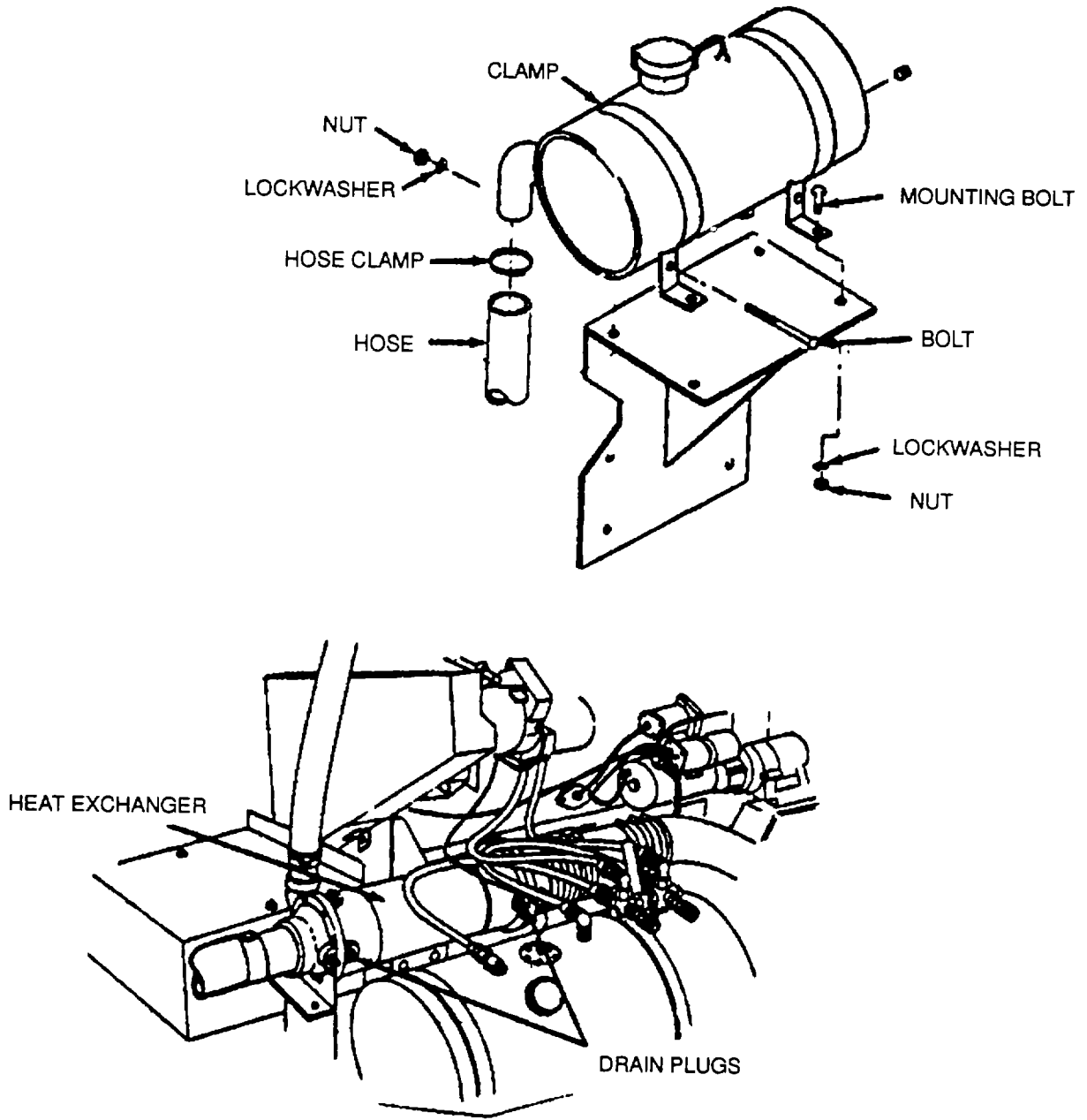


Figure 4-8. HP Pump Diesel Engine Cooling System.

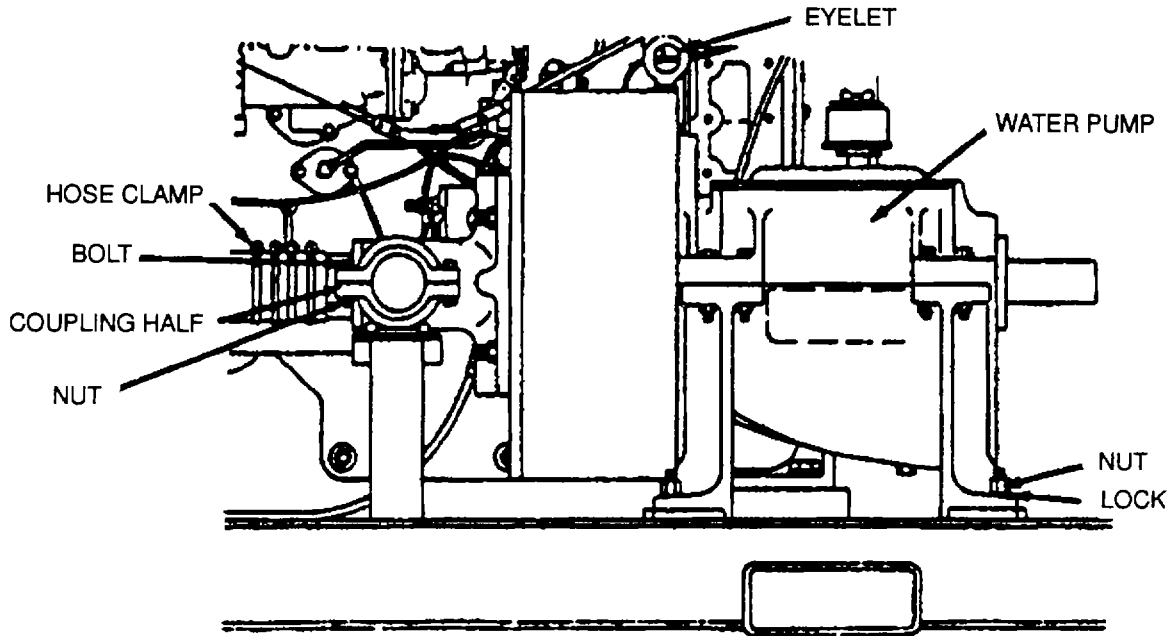


Figure 4-9. HP Pump Pedestal Bearing

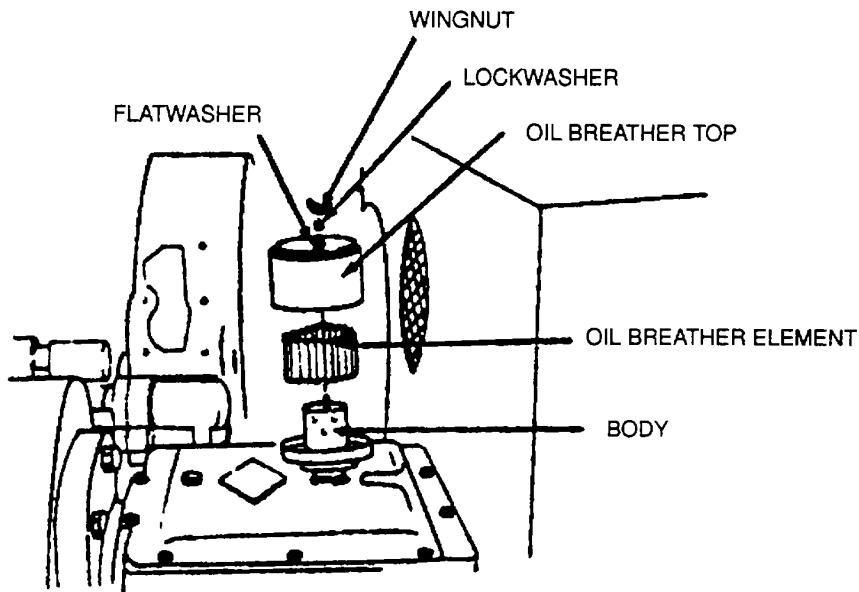


Figure 4-10. HP Pump Oil Breather

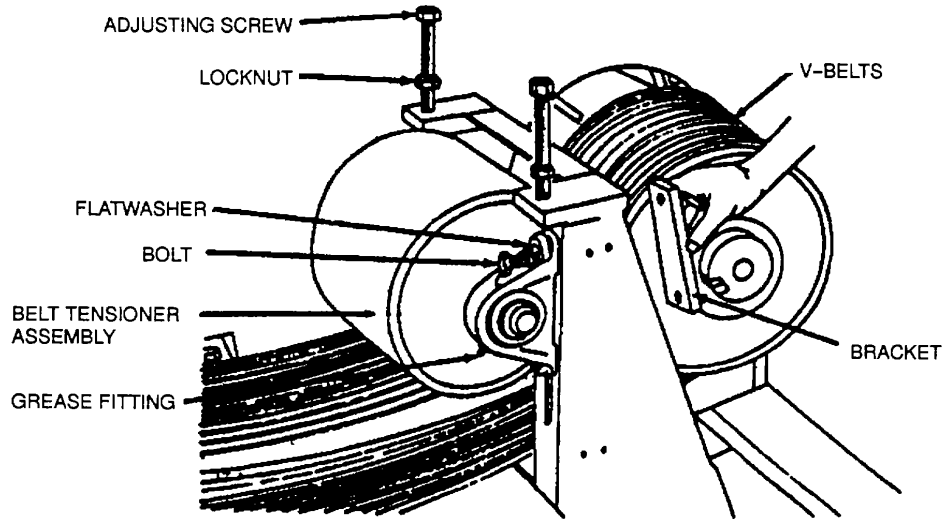


Figure 4-11. HP Pump V-belt.

- (4) Check adjustments (steps b thru g).
 - (5) Tighten adjusting screw locknuts.
 - (6) Tighten four bolts.
- i. Check adjustment after 2 hours of operation. Adjust as necessary Check again after 2 more hours of operation.
 - j. Install front V-belt housing (two pieces) Install 32 mounting bolts and lockwashers.

4-7.3.12 HP pump mechanical seal replacement. The mechanical seal in the pump (Figure 4-12) requires no maintenance or adjustment. When seal has become worn or damaged and leaks excessively, It must be replaced Maximum allowable leakage for the mechanical seal is 1 gallon per hour.

CAUTIONS

- The mechanical seal is a precision product. Treat it with care Do not scratch face of carbon ring or let it drop Take particular care not to scratch the lapped face that comes in contact with the carbon ring.
 - Seals should never be immersed in solvent as this could damage the internal pacing.
- a. Slip carbon seal cartridge through an O-ring positioned in a groove In the end bell manifold. Some oil on the O-ring will facilitate assembly,.
 - b. Check pump lubricant level and add oil as necessary.

4-7.3.13 HP pump belt tensioner bearings lubrication.

- a. Clean grease from belt tensioner bearings grease fittings (Figure 4-13) with a clean, lint-free cloth.
- b. Using a hand pump grease gun, pump grease (MIL-G-10924) into bearings until grease appears.
- c. Wipe off excess grease.

4-7.3.14 Power takeoff oil replenishment.

- a. With engine running at low idle, remove oil fill cap with dipstick attached.
- b. Add oil (OE/HDO-MIL-L-2104) if necessary until oil level is between LOW and FULL marks on dipstick. Replace fill cap.

4-7.3.15 Power takeoff oil change.

- a. Remove oil fill cap.

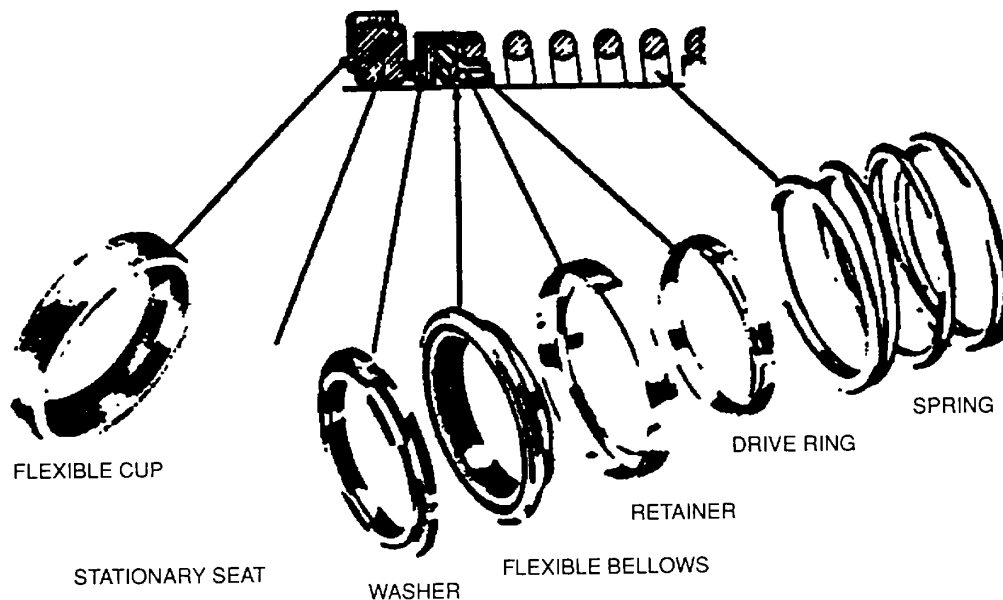


Figure 4-12. HP Pump Mechanical Seal.

- b. Place drain pan under gear box.
- c. Remove drain plug and drain oil.
- d. Replace drain plug.
- e. Remove filler plug and add oil (OE/HDO-MIL-L-2104) until oil level is between LOW and FULL marks on dipstick. Replace filler plug.
- f. Immediately clean up any spills.
- g. Record completion of this action in, maintenance logbook.

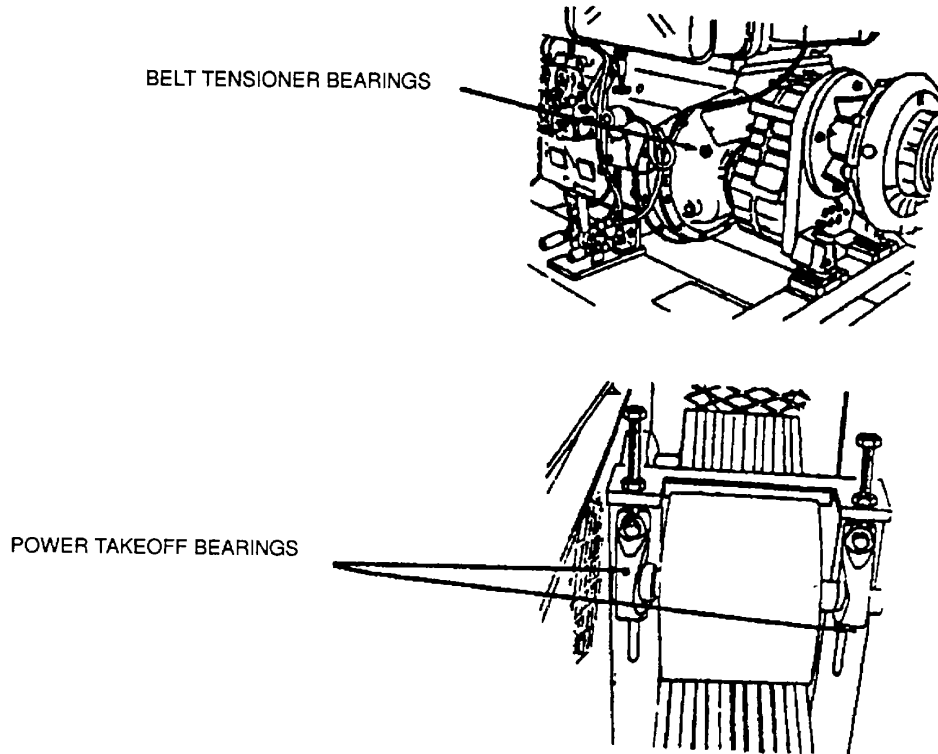


Figure 4-13. HP Pump Grease Fittings

4-7.3.16 Power takeoff bearings lubrication.

- a. Clean grease from belt tensioner bearings grease fittings (Figure 4-13) with a clean, lint-free cloth.
- b. Using a hand pump grease gun, pump handle three times to force grease (MIL-G-10924) into bearings.
- c. Wipe off excess grease.

4-7.4 RO block. The RO block membranes need cleaning when the pressure difference between HP pump discharge pressure gauge P4 (Figure 3-2) and brine discharge pressure gauge P5 (Figure 3-1) exceeds 25 psi. The process, depending on the water temperature, takes from 2 to 4 hours. These procedures are for normal cleaning operations using seawater pump 1 for cleaning ROWPU 1 RO block and seawater pump 2 for cleaning ROWPU 2 RO block.

4-7.4.1 Preliminary procedures. If the HP pump diesel engine is operating, perform the following.

- a. Close valve RO15 to prevent product water from flowing to drinking water tanks. Open valves RO20 and R021 to allow product water to flow directly overboard.

CAUTION

Do not immediately stop engine. Operating engine for 5 minutes at low idle allows hot areas to cool and turbidcharger to slow down while still maintaining oil pressure on the turbine shaft.

- b. Gradually reduce HP pump diesel engine throttle setting to idle (Figure 3-2). Leave engine idling.
- c. Open throttling valve RO7.
- d. Stop coagulant pump and Inhibitor pump at control station by setting ON/OFF switches (Figure 3-1) to OFF.
- e. After HP pump diesel engine has been running at Idle for about 5 minutes, stop engine by pushing in on shutdown lever (Figure 3-2).
- f. Stop seawater pump by turning pump OFF/ON/START switch on control station (Figure 3-1) to OFF.

4-7.4.2 RO block membrane cleaning procedures.

- a. Install full drum of membrane cleaning agent (Hydrakleen-20) according to paragraph 4-7.4.3
- b. Perform step (1) below to clean ROWPU 1 Perform step (2) below to clean ROWPU 2.

(1) For ROWPU 1 cleaning using seawater pump 1, position seawater (SW) valves as indicated:.

		o = open				x = closed.						
SW valve no.	1	5	7	9	11	13	16	19	20	22	24	29
Valve position	o	x	x	o	o	x	o	x	o	x	x	x

(2) For ROWPU 2 cleaning using seawater pump 2, position SW valves as indicated ;

		o = open				x = closed.						
SW valve no	2	6	8	10	12	13	17	18	19	21	23	25.
Valve position	o	x	x	o	o	x	o	x	x	o	x	x

- c. Position RO valves as Indicated.

o = open
A = position A

x = closed.
C = position C.

RO valve no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Valve position	C	C	C	A	x	x	o	x	x	o	x	x	x	x	x	o	x	o	o	o

- d. Open vent on top of RO block to allow air to escape.
- e. Start seawater pump 1 for ROWPU 1 or pump 2 for ROWPU 2 by setting OFF/ON/START switch on control station (Figure 3-1) to ON.
- f. Close RO block vent after a steady stream of water flows from vent (Figures NO TAG and NO TAG).
- g. Close seawater valve SW9 for ROWPU 1 or SW10 for ROWPU 2 to allow water/Hydrakleen solution to recirculate.
- h. Open valves RO13 and RO14 to allow Hydrakleen to drain out and return to drum.
- i. After water circulates for 15 minutes, stop seawater pump.
- j. Close valves RO13 and RO14.
- k. Disconnect used drum of Hydrakleen-20, and attach a new drum according to paragraph 4-7.4.3
- l. Open valves RO13 and RO14 m Start seawater pump.

- n. Read seawater temperature at temperature gauge T1 Determine how long seawater pump should operate by using table below.

<u>Temperature.</u> <u>at T1 (F)</u>	<u>Operating time.</u>
60 or less	2 hours 40 minutes.
65	2 hours 20 minutes.
70	2 hours.
75	1 hour 40 minutes.
80	1 hour 30 minutes.
85	1 hour 20 minutes.
90 or more	1 hour 10 minutes.

- o. After allotted time, stop seawater pump.
- p. Close valves RO13 and R014.
- q. Open valve RO12 and close RO19.
- r. Open seawater valve SW9 for ROWPU 1 or SW10 for ROWPU 2.
- s. Start seawater pump to flush RO block.
- t. After flushing with seawater for 30 minutes, take a water sample at valve RO17 Using a water testing kJt, check sample for pH according to TM 5-6630-215-12 If pH is not acceptable, flush RO block membranes for 30 minutes more and test again. Continue flushing until water is acceptable (pH 7).
- u. Stop seawater pump.
- v. Prepare ROWPU for normal operation (paragraph 3-4).

4-7.4.3 Membrane cleaning agent drum replacement.

WARNING

Wear safety goggles or faceshield and rubber gloves while replacing cleaning agent drum. Immediately wash off agent that contacts skin. If agent touches eyes, Immediately flush eyes at eye wash station. Wash spills with water. Dry mop to prevent slipping.

- a. Close valve R013 on hose connected to large threaded drum bunghole.
- b. Disconnect hose containing valve RO13
- c. Close valve RO14 on hose connected to small threaded drum bunghole.
- d. Disconnect hose containing valve RO14.
- e. Tip drum from vertical position and remove used drum using drum lifter and bridge crane with 2-ton hoist.

WARNING

Ensure that correct drum is removed and replaced.

- f. Obtain new drum using drum lifter and bridge crane with 2-ton hoist.

- g. Position drum on stand so large bung hole is on bottom and small bung hole is on top when drum is tipped into place.
- h. Connect hose containing valve RO14 to small threaded drum bung hole.
- i. Connect hose containing valve RO13 to large threaded drum bung hole.

4-7.4.4 RO block throttling valve lubrication.

- a. Clean grease from RO block throttling valve R07 using a clean, lint-free cloth.
- b. Using a hand pump grease gun, pump grease (MIL-G-10924) into bearings until grease appears.
- c. Wipe off excess grease.

4-8. Component repair or replacement.

4-8.1 Pretreatment skid.

4-8.1.1 Chemical metering pump replacement. Remove and replace chemical metering pumps as follows.

WARNING.

Avoid exposure to coagulant (Hydrapol-50) and inhibitor (Hydrapol-100). Until pump has been cleaned, wear safety goggles or faceshield and rubber gloves. If chemicals are swallowed, do not induce vomiting. Drinkwater and seek medical attention. If chemicals get in eyes, flush with water and seek medical attention. If chemicals contact skin, wash with soap and water.

- a. Remove chemical metering pump as follows.
 - (1) Turn pump off by setting pump ON/OFF switch on control station (Figure 3-1) to OFF.
 - (2) Redtag switch with "WARNING - DO NOT ACTIVATE REPAIRS BEING MADE".
 - (3) Unplug two clamping nuts and remove suction discharge tubes from valves on rear of pump.
 - (4) Remove all clamps from pump cable.
 - (5) Tag and disconnect wires in electrical enclosures.
 - (6) Wash pump with water to remove any chemicals.
 - (7) Remove nuts, mounting screws, and flatwashers from pedestal. Remove pump.
- b. Install chemical metering pump as follows:
 - (1) Install pump on pedestal using two flatwashers, mounting screws, and nuts.
 - (2) Connect wires in electrical enclosure Remove tags.
 - (3) Install dampers on pump cable.
 - (4) Install suction and discharge tubes on valves on rear of pump Tighten clamping nuts.
 - (5) Remove red tag from pump ON/OFF switch.
- c. After reinstallation, prime pump according to paragraph 4-7.1. 5.

4-8.1.2 Chemical metering pump diaphragm replacement. When chemical seeps from around head disc (Figure 4-2), replace pump diaphragm as follows:

- a. Place pump stroke length knob (Figure 3-5) at 100 percent.
- b. Remove four screws and flatwashers holding dosing head to pump. Remove dosing head.
- c. Place pump stroke length knob at zero percent. Remove pump diaphragm by turning counterclockwise. The head disc will also fall free.
- d. Install replacement diaphragm by holding head disc in position (drain slot on inside) and turning diaphragm clockwise onto plunger shaft end. Grasp penmeter of diaphragm and hand tighten.
- e. Place pump stroke length knob at 100 percent. Rotate head disc until marker hole is up and drain slot is down. Align four screw holes with motor housing holes.
- f. Install dosing head with arrow oriented up. Secure dosing head with four screws and flatwashers. Tighten screws evenly.

4-8.1.3 Chemical metering pump fuse replacement. Replace chemical metering pump fuse (P/N 60-30-110) as follows (Figure 3-5):

- a. Open (OFF) switchboard circuit breaker P6 or P7 as appropriate. Redtag circuit breaker with the following: "WARNING - DO NOT ACTIVATE. REPAIRS BEING MADE".
- b. Press In and turn fuse cover to left to remove. Remove cover and fuse. Remove fuse from cover.
- c. Install replacement fuse in cover. Install fuse and cover. Press in and turn to right.
- d. Close (ON) switchboard circuit breaker P6 or P7 and remove red warning tag.

4-8.1.4 Chemical metering pump tubing and cap replacement.

WARNING

Avoid exposure to coagulant (Hydrapol-50) and Inhibitor (Hydrapol-100). Wear safety goggles or faceshield and rubber gloves when working around chemicals. If chemical is swallowed, do not induce vomiting. Drink water and seek medical attention. If chemical gets in eyes, flush with water and seek medical attention. If chemical contacts skin, wash with soap and water.

- a. Cut new tubing the same length as bad tubing being replaced.
- b. Install new tubing.

4-8.1.5 Flow Indicator (F1) replacement.

NOTE

Do not operate the ROWPU while performing the following procedures.

- a. Loosen two screws securing guard and remove guard.
- b. Loosen sealing nut with special wrench (P/N 51884-1) and unscrew flow indicator.
- c. Install replacement flow indicator and tighten sealing nut.
- d. Ensure flow indicator operates satisfactorily and does not leak when ROWPU operates.
- e. Record completion of maintenance in maintenance logbook.

4-8.1.6 Temperature gauge (T1) and pressure gauge (P1 thru P5) replacement.

NOTE

Do not operate the ROWPU while performing the following procedures.

- a. Remove existing gauge.
- b. Apply pipe thread sealant to threads of replacement gauge and Install gauge.
- c. Ensure replaced gauge operates satisfactorily and does not leak when ROWPU operates.
- d. Record completion of maintenance in maintenance logbook.

4-8.1.7 Control station Indicator light bulb replacement. Replace indicator light bulb (P/N 60-18-131) as follows:.

- a. Open (OFF) switchboard circuit breaker P6 or P7 as appropriate Redtag circuit breaker with the following. "WARNING - DO NOT ACTIVATE REPAIR BEING MADE".
- b. Unscrew lens to expose light bulb.
- c. Unscrew burned out bulb and Install replacement bulb.
- d. Reinstall lens.
- e. Close (ON) switchboard circuit breaker P6 or P7 and remove red warning tag.

4-8.1.8 Control station fuse replacement.

- a. Open (OFF) switchboard circuit breaker P6 or P7 as appropriate Redtag circuit breaker with the following. "WARNING - DO NOT ACTIVATE REPAIRS BEING MADE".
- b. Open control station cover and remove 1 OA fuse from spring clip holder.
- c. Install new fuse and close control station cover.
- d. Close (ON) switchboard circuit breaker P6 or P7 and remove red warning tag.

4-8.2 Media filters.

4-8.2.1 Media replacement. When proper flow and filtration can no longer be attained by backwashing and flushing (paragraph 4-7.2), then media replacement in the media tanks is required.

- a. Preliminary procedures.
 - (1) Stop ROWPU selected for media replacement (paragraph 4-7.2.1).
 - (2) Stop seawater pump by turning pump OFF/ON/START switch on ROWPU control station (Figure 3-1) to OFF.
 - (3) Drain selected media tank (or tanks) by disconnecting piping at lowest point and allowing water to drain.

CAUTION.

Do not drop access cover into media tank after opening. Protect cover lining of tank.

- (4) Attach a line to access cover on top of media tank Open cover and carefully remove from tank.

- b. Removing media.

CAUTION.

Remove shoes before entering media tank to prevent damage to lining. Always carefully place feet to prevent damage. Do not step on filter under drain assembly or internal components.

- (5) Remove media by using plastic buckets and passing them up through access hole. Dispose of media overboard or as directed by shift leader.
- (6) When media has been removed, flush filter body interior with water.
- (7) Visually inspect inside of filter body for cleanliness. Remove foreign materials as necessary and wipe liner clean.

- c. Media loading.

WARNING.

To prevent respiratory damage, avoid breathing dust from filter media. Use an approved dust mask well-fitted to the face when loading media.

CAUTION.

To prevent clogging, make sure no foreign matter gets into media.

- (1) Inspect the filter under drain for broken or plugged parts.

NOTE.

When loading media, open bags outside the filters. Transfer media to a clean plastic bucket or other soft container before loading in filter body.

- (2) In the order listed below, carefully load the following media through the access hole.
 - (a) Gravel, P/N 52036-1 (4 bags).
 - (b) Coarse garnet, P/N 52037-1 (6 bags).
 - (c) Fine garnet, P/N 52038-1 (4 bags).
 - (d) Silica sand, P/N 52039-1 (12 bags).
 - (e) Anthracite, P/N 52040-1 (17 bags).
- (3) Inspect access cover gasket. Replace if required.

CAUTION.

To prevent leakage, take care not to damage gasket when installing access cover.

- (4) Attach a line to access cover to avoid dropping it into tank and install access cover.

- d. Record completion of maintenance action in maintenance logbook.

4-8.2.2 Air eliminator (air vent) replacement. Unscrew existing air vent on top of media tank (Figure 4-14) and install new vent (P/N 51896-1):.

4-8.3 HP pump assembly.

4-8.3.1 Diesel engine replacement. Remove and replace HP pump diesel engine as follows.

- a. Removal. .
 - (1) Prepare engine for removal as follows.
 - (a) Remove battery cables and batteries.
 - (b) Remove power cable assembly.
 - (c) Drain coolant (paragraph 4-7.3.7).
 - (d) Remove engine start switch, throttle control, and KILL START lever.
 - (e) Remove muffler pipe.
 - (f) Remove power takeoff.
 - (g) Remove fuel lines.
 - (2) Loosen two hose clamps from lower water pump hose Remove hose from water pump.
 - (3) Remove wire from fuel level sending unit Cut wire ties and move wire aside.

WARNING.

Injury to personnel or damage to equipment can result if lifting instructions are not carefully followed. Use designated lifting points and adhere to Instructions on equipment decals and Instruction plates when moving heavy equipment.

- (4) Using overhead hoist, support weight of engine.
- (5) Remove 12 engine support mounting bolts and lockwashers.

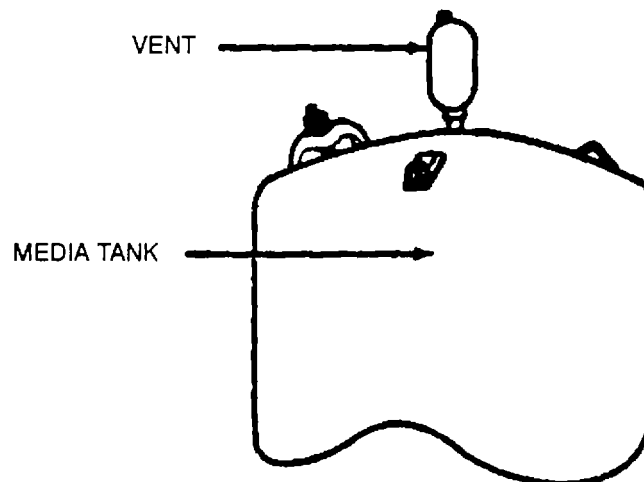


Figure 4-14. Media Tank Air Vent.

- (6) Raise engine.
- (7) Remove 16 engine mounting bolts and lockwashers holding supports to engine Remove engine.
- b. Reinstall engine as follows:
 - (1) Install supports on engine Install 16 engine mounting bolts and lockwasher.
 - (2) Install engine on slat assembly Install 12 engine support mounting bolts and lockwashers.
 - (3) Remove lifting device from engine.
 - (4) Install wire to fuel level sending unit.
 - (5) Install lower hose on water pump Install two hose clamps on hose.
 - (6) Install fuel lines.
 - (7) Install power takeoff.
 - (8) Install muffler pipe.
 - (9) Install throttle control, KILL START lever, and engine start switch.
 - (10) Fill cooling system (paragraph 4-7.3.6).
 - (11) Install power cable assembly.
 - (12) Install batteries and battery cables.

4-8.3.2 Diesel engine alternator testing. Use a multimeter to test a questionable alternator as follows:

- a. Remove battery cover.
- b. Set multimeter on 50-volt scale (use 100-volt scale if meter does not have 50-volt scale).
- c. Connect positive (+) lead to alternator cable that connects to positive battery terminal.
- d. Connect negative (-) lead to alternator cable that connects to negative battery terminal.
- e. Start engine (paragraph 3-4).
- f. Multimeter reading should be 24 to 28 volts If not, replace alternator (paragraph 4-8.3.3).
- g. Disconnect multimeter negative (-) and positive (+) wires from battery.
- h. Install battery cover.

4-8.3.3 Diesel engine alternator replacement.

WARNING.

To prevent electric shock, ensure battery is disconnected before performing this procedure.

- a. Removal.
 - (1) Disconnect battery.
 - (2) Remove alternator cover.
 - (3) Remove jam nut and loosen alternator adjusting nut (Figure 4-6).
 - (4) Loosen mounting nut.

- (5) Remove bolt and flatwasher from mounting adjustment block.
- (6) Push alternator toward engine Remove fanbelt from vibration damper and alternator pulleys.
- (7) Tag and disconnect two wires from alternator.
- (8) Remove two nuts, four flatwashers, two lockwashers, and two mounting bolts Remove alternator.

b. Installation.

- (1) Install alternator Install two mounting bolts, four flatwashers, two lockwashers, and two nuts. Hand tighten nuts.
- (2) Install bolt and flatwasher on mounting adjustment block.
- (3) Install adjusting arm and jam nut Do not tighten.
- (4) Install fanbelt on vibration damper and alternator pulleys.
- (5) Connect two wires to alternator and remove tags.
- (6) Adjust fanbelt (paragraph 4-7.3.3).
- (7) Connect battery.
- (8) Test alternator (paragraph 4-8.3.2).

4-8.3.4 Diesel engine emergency shutdown cable replacement. Replace emergency shutdown cable (P/N 2914317-1) as follows:

- a. Unhook cable from spring attached to HP pump V-belt housing.
- b. Free cable by removing damp attaching cable to engine.
- c. Disconnect cable at pump V-belt housing by removing nut securing cable.
- d. Remove cable by pulling through pulleys.
- e. Secure replacement cable to pump V-belt housing with nut.
- f. Route cable through pulleys on both sides of engine.
- g. Connect cable to spring attached to pump V-belt housing.
- h. Adjust cable tension and secure cable to engine with clamp.
- i. Record completion of maintenance action in maintenance logbook.

4-8.3.5 Diesel engine muffler replacement. Remove and reinstall diesel engine mufflers (located on the deckhouse top) as follows.

a. Removal.

- (1) Gain access to cage surrounding mufflers.
- (2) Remove eight nuts, lockwashers, flatwashers, and mounting bolts securing muffler (Figure 4-15).
- (3) Remove muffler from support.
- (4) Remove and discard gasket.

b. Installation.

- (1) Install muffler n support.
- (2) Install gasket.
- (3) Install eight flatwashers, mounting bolts, lockwashers, and nuts to secure muffler.

4-8.3.6 Diesel engine fuel filter replacement.

- a. Remove filter (Figure 4-5).

CAUTION.

To ensure a proper seal, ensure all old gasket material is removed.

- b. Clean gasket sealing surface of the filter base.
- c. Put light coat of oil (MIL-L-2104) on filter seal.
- d. Install filter. Tighten by hand until gasket contacts base, then tighten 1/2 to 3/4 turn more.
- e. Bleed fuel system (paragraph 4-8.3.7).

4-8.3.7 Diesel engine fuel system bleeding. Following fuel system maintenance or if engine misfires or smokes, bleed air from the system as follows:

- a. Ensure fuel line valve is open and the engine shutoff control is OFF.
- b. Unlock the fuel priming pump (Figure 4-16).
- c. Operate the priming pump until resistance is felt.
- d. Lock the fuel priming pump.
- e. If engine continues to smoke or misfire, further bleeding is necessary. With engine running, loosen the fuel line nuts, one at a time, several times in succession and allow the fuel to run until free of air bubbles. Tighten fuel line nuts.

4-8.3.8 Diesel engine starter replacement. Remove and replace starter (P/N 2914359-1) as follows (Figure 4-17).

- a. Removal.

WARNING.

To prevent electric shock, make sure battery is disconnected before performing maintenance.

- (1) Disconnect engine battery.
- (2) Tag and disconnect wires and cables.
- (3) Support weight of starter.
- (4) Remove three bolts and flatwashers. Remove starter.
- b. Installation.
 - (1) Ensure starter gasket is in good condition. Replace if necessary.
 - (2) Position starter on flywheel housing and install three flatwashers and bolts. Torque bolts evenly (Table 4-3).
 - (3) Connect wires and cables. Remove tags.
 - (4) Connect engine battery.
 - (5) Record completion of maintenance action in maintenance logbook.

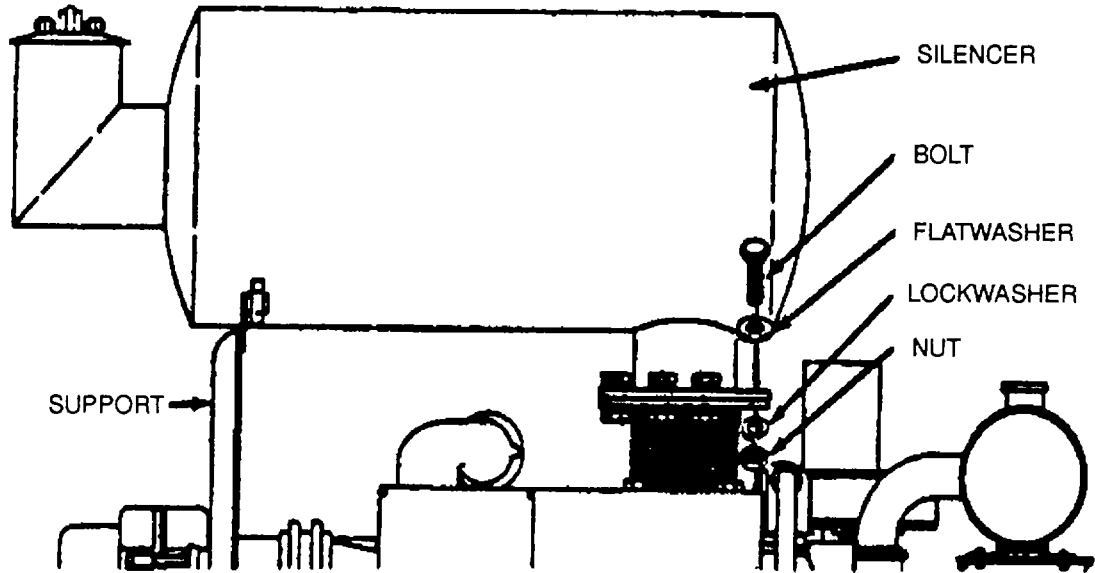


Figure 4-15. HP Pump Diesel Engine Fuel System Bleeding

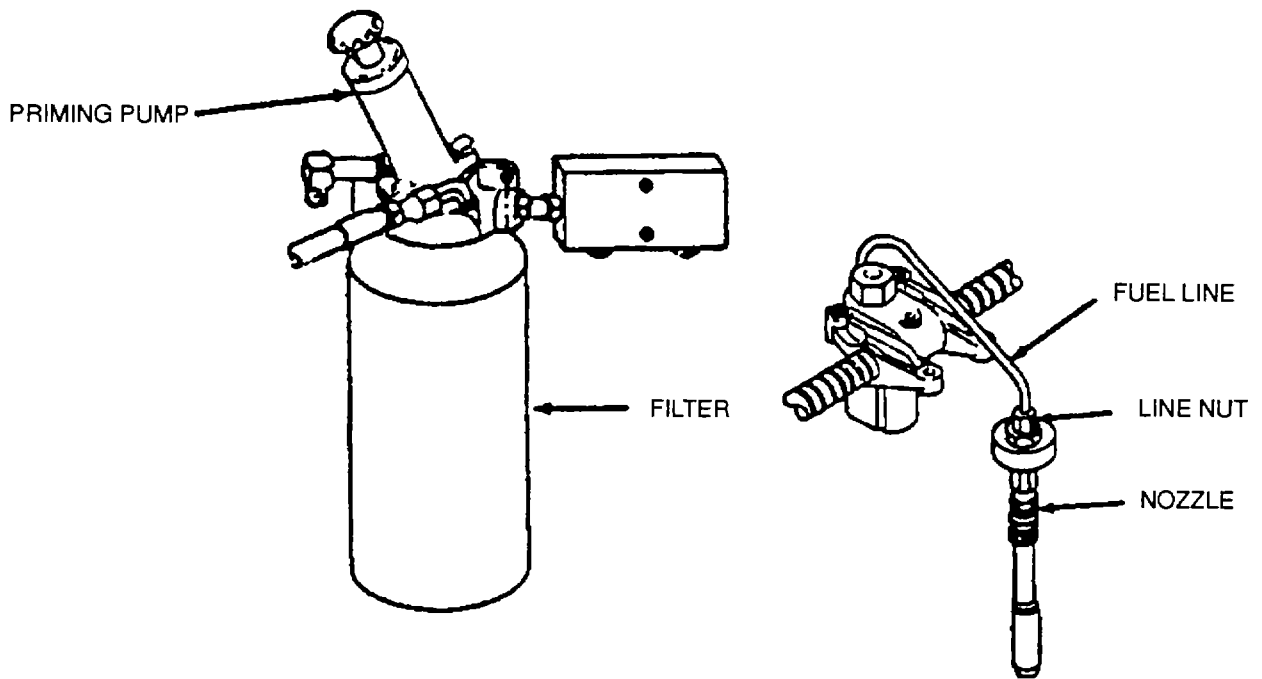


Figure 4-16. HP Pump Diesel Engine Fuel System Bleeding

4-8.3.9 Diesel engine throttle cable replacement. Remove and replace engine throttle cable (P/N 2914426-1) as follows:

- a. Remove cotter key connecting cable to engine throttle.
- b. Remove cable clamp securing cable to engine.
- c. Disconnect cable at speed control.
- d. Remove old cable.
- e. Connect replacement cable to speed control.
- f. Connect cable to engine throttle and secure with cotter key.
- g. Install cable clamp.
- h. Start engine and check throttle cable movement. Adjust as necessary.
- i. Record completion of maintenance action in maintenance logbook.

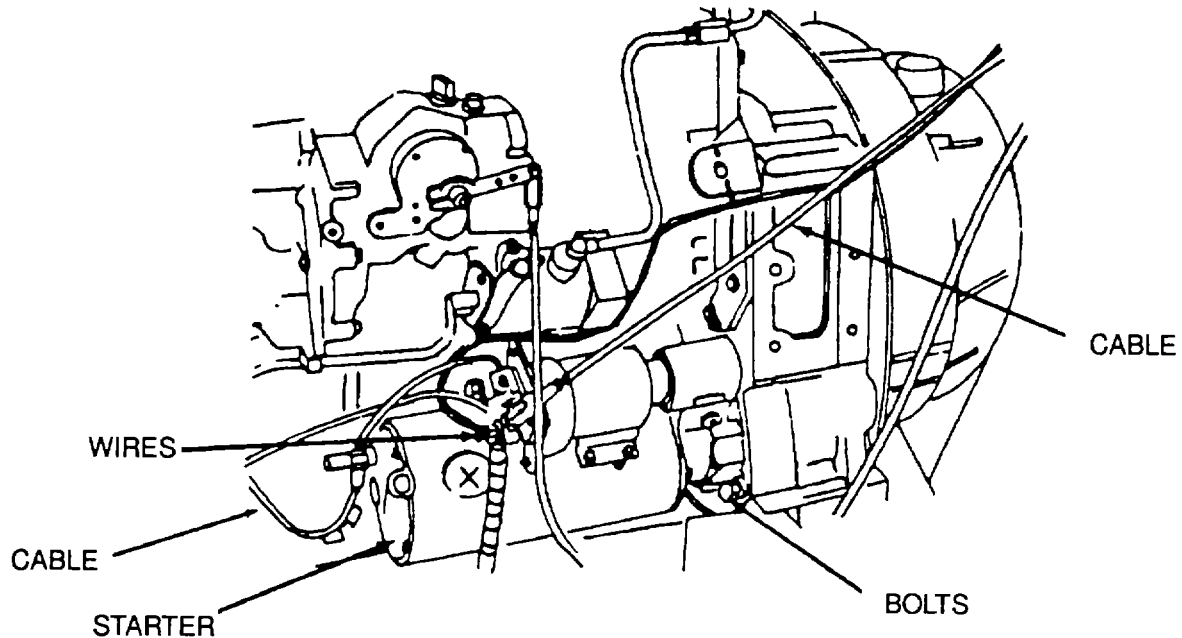


Figure 4-17. HP Pump Diesel Engine Electric Starter.

4-8.3.10 HP pump replacement. Remove, stow, and replace HP pump (P/N 2914352-1) as follows.

- a. Removal.
 - (1) Stop ROWPU system.
 - (2) Close valve RO11.
 - (3) Disconnect suction piping from pump Cover pipe opening.
 - (4) Disconnect discharge piping from pump Cover pipe opening.

- (5) Drain pump by removing drain plug. Replace plug.
- (6) Remove V-belts (paragraph 4-8.3.11).
- (7) Remove three bolts from sheave (Figure 4-18).
- (8) Install three bolts in threaded holes of sheave. Tighten bolts evenly to remove pulley from bushing.
- (9) Remove three bolts from threaded holes of sheave.
- (10) Mark location of bushing on back of pump shaft.
- (11) Tap wedge in slot of bushing and remove bushing.
- (12) Remove four pump mounting nuts and lockwashers.

WARNING.

Injury to personnel or damage to equipment can result if lifting instructions are not carefully followed. Use designated lifting points and adhere to instructions on equipment decals and instruction plates when moving heavy equipment.

- (13) Using ROWPU trolley crane with 2-ton hoist, lift pump from mount.

b Stowage.

- (1) Remove access plate in deck over void 4 starboard.
- (2) Remove four bolts holding replacement pump in place in void 4 starboard.

WARNING.

Injury to personnel or damage to equipment can result if lifting instructions are not carefully followed. Use designated lifting points and adhere to instructions on equipment decals and instruction plates when moving heavy equipment.

- (3) Use void 4 hoist to position replacement pump under opening in deck.

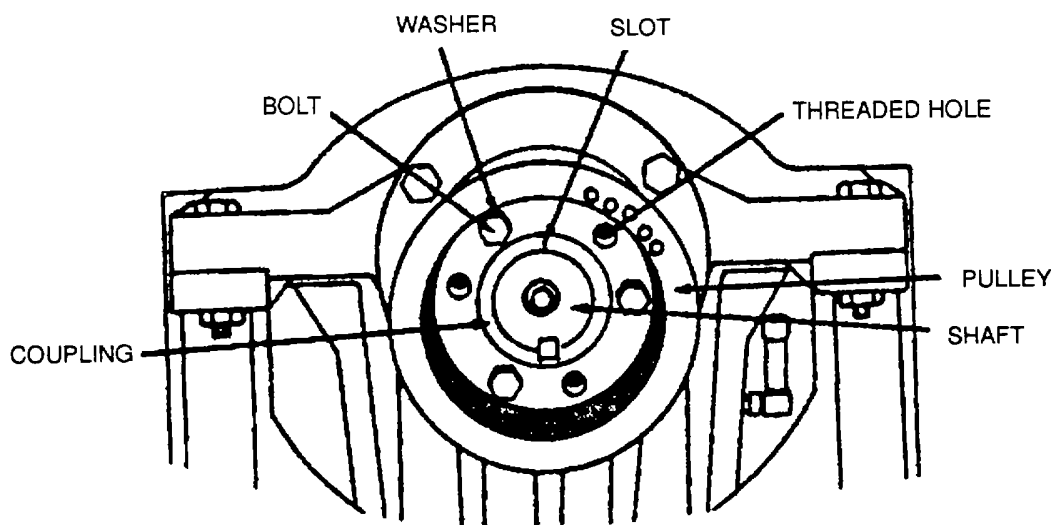


Figure 4-18. HP Pump V-belt Pulley.

(4) Use ROWPU trolley crane with 2-ton hoist to lower removed pump into void 4 starboard and to lift replacement pump from void.

(5) Stow removed pump in void 4 starboard and secure until pump is to be repaired.

(6) Reinstall access plate in deck.

c Installation.

WARNING

Injury to personnel or damage to equipment can result if lifting instructions are not carefully followed. Use designated lifting points and adhere to instructions on equipment decals and instruction plates when moving heavy equipment.

(1) Using ROWPU trolley crane with 2-ton hoist, lift pump into position and secure with four mounting nuts and lockwashers.

(2) Connect suction and discharge piping.

(3) Install bushing, aligning it with mark on back of water pump shaft.

(4) Insert three bolts through unthreaded holes in sheave.

(5) Install sheave on bushing.

NOTE.

Sheaves must be in perfect alignment. Straight edge must touch each side of both sheaves.

(6) Using a straight edge, align water pump sheave with drive sheave.

(7) Tighten bolts. Recheck alignment.

(8) Install V-belts (paragraph 4-8.3.11).

(9) Add oil.

d. Record completion of maintenance action in maintenance logbook.

4-8.3.11 HP pump V-belt replacement Remove and replace HP pump V-belts as follows.

a. Housing removal Remove 32 mounting bolts and lockwashers Remove front V-belt housing (two pieces).

b. V-belt removal.

(1) Loosen two locknuts and two adjusting screws (Figure 4-12).

(2) Remove four bolts, flatwashers, two brackets, and belt tensioner assembly.

CAUTION.

Do not use any tool to force belts on or off belt sheaves.

(3) Remove V-belts from pulleys.

(4) Inspect sheaves for wear or damage. Wipe off oil or grease Remove rust and burrs.

c V-belt installation.

(1) Check sheave alignment by placing straight edge across face of driven and driver sheaves Make sure there is less than 0.025 inch gap between straight edge and face of sheaves.

CAUTION

Do not use any tool to force belts on or off belt sheaves

NOTE

Always use a new set of matched V-belts when replacing. Belts must be properly installed to ensure maximum belt life and reduce wear on bearings.

- (2) Install V-belts on pulleys by hand without forcing belts.
 - (3) Install belt tensioner assembly, two brackets, and four flatwashers and bolts.
 - (4) Tighten two adjusting screws Tighten two locknuts.
 - (5) Pump grease into grease fittings.
 - (6) adjust V-belts (paragraph 4-7.3.11).
- d. Housing installation Install front V-belt housing (two pieces) Install 32 mounting screws and lockwashers.
 - e Record completion of maintenance action In maintenance logbook.

4-8.4 RO block.**4-8.4.1 RO block membrane element removal and replacement.**

- a Remove RO block pressure tube end caps (Figure 4-20) according to paragraph 4-8.7.
- b Remove membrane elements from pressure tubes as follows.

NOTE

The following procedure requires two people.

- (1) Position one person at feedwater end of tube with removal tool P/N 52100-1 (Figure 4-20). Position other person at product end of tube to support membrane element's weight as it emerges from tube Insert removal tool and slowly push elements through tube.
 - (2) Repeat step 1 for other 15 tubes.
- c. Install replacement membrane elements as follows.
 - (1) Rinse out inside of tubes with a garden hose.
 - (2) Remove brine seal from RO membrane element and Inspect Replace seal If damaged Lightly coat seal. with silicone lubricant Install seal on element and verify It is properly seated.

NOTE

Ensure lip of brine seal faces product water end of pressure tube

- (3) Place lead end of element In feedwater end of pressure tube Check to see that brine seal is in place.
- (4) Slide element about three-quarters of the way into tube.
- (5) Remove two O-rings from Interconnector Lightly coat O-rings with silicone lubricant Install O-rings on interconnector by expanding O-rings slightly. Do not roll them into position.
- (6) Insert interconnector with O-rings on core tube of element.
- (7) Remove brine seal from next element and Inspect Replace seal if damaged. Lightly coat seal with silicone lubricant Install seal on element and verify It is properly seated.

CAUTION

DO NOT allow weight of element to rest on interconnector. Damage to interconnector may result.

NOTE

The following procedure requires two people.

- (8) Have one person support weight of next element while the other person installs it on the interconnector. Slide element about three-quarters of the way into tube. Repeat steps c (5) through c (8) until all five RO membrane elements are loaded in pressure tube.
- (9) Lightly coat inboard connector O-rings with silicone lubricant. Insert O-rings in grooves in connector.
- (10) Insert an inboard end connector with O-rings on core tube of element at each end of pressure tube.
- (11) Install one outboard end connector in brine discharge end of pressure tube. Push RO membrane element train against spacer.
- (12) Repeat step c for other 15 pressure tubes.

- d Install RO block end caps according to paragraph 4-8.7.

4-8.5 RO block sampling valve repair/replacement. Remove, repair, and reinstall sampling valve (Figure 3-3) as follows:

- a Removal.

- (1) Disconnect discharge tube from end cap and move it aside.
- (2) Disconnect product tube.
- (3) Remove sample valve assembly from pressure tube.
- (4) Remove sample valve and two reducers from T-pipe.
- (5) Remove male connector and reducer from T-pipe.

- a. Repair. Inspect parts for damage. Replace as required.

- b. Installation.

- (1) Install reducer and male connector in T-pipe.
- (2) Install two reducers and sample valve in T-pipe.
- (3) Install sample valve assembly in pressure tube.
- (4) Connect product tube and discharge tube.

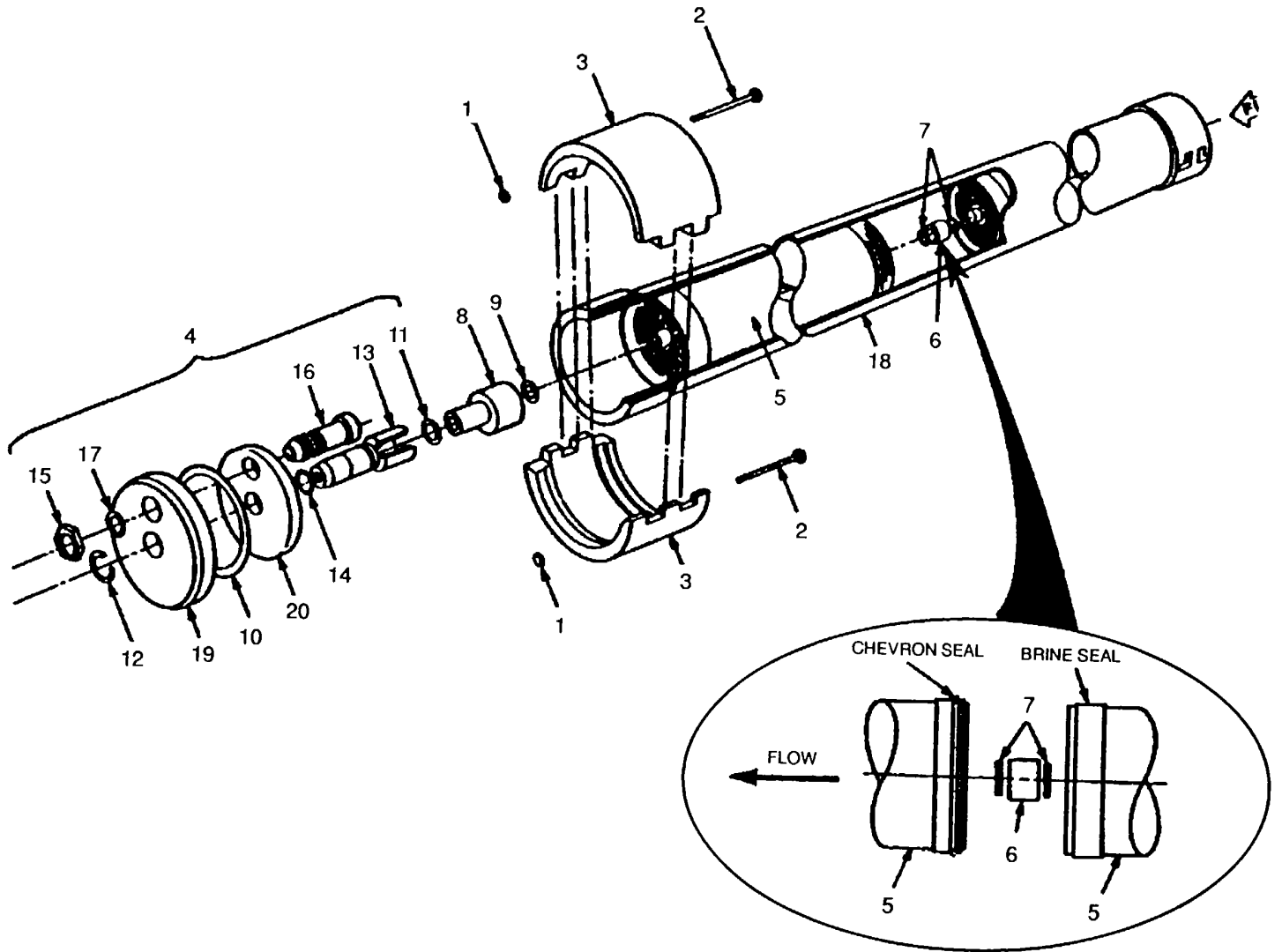


Figure 4-19. RO Block Pressure Tube Assembly (sheet 1 of 2)

KEY TO FIGURE 4-19.

<u>Item.</u> <u>Number</u>	<u>Description</u>	<u>Part Number.</u>
1	Clamp nut	52074-5
2	Clamp bolt	52074-4
3	End clamp assembly	52074
4	End cap assembly	---
5	RO membrane element (GFE)	NSN 4610-01-105-2075
6	Interconnector	26753
7	Interconnector O-ring	10-12-102
8	Inboard end connector	52073
9	Inboard end connector O-ring	70-12-102
10	End cap O-ring	70-12110
11	Outboard end connector O-ring	70-12-111
12	Retaining ring, 1-5/8 inches	70-12-112
13	Outboard end connector	52072
14	O-ring	70-12-113
15	Bulkhead nut	70-12-114
16	Feed connector	52021
17	Feed connector O-ring	70-12-115
18	Pressure tube	52078
19	End cap hub	52076
20	End cap diaphragm	52075

Figure 4-19. RO Block Pressure Tube Assembly (sheet 2 of 2).

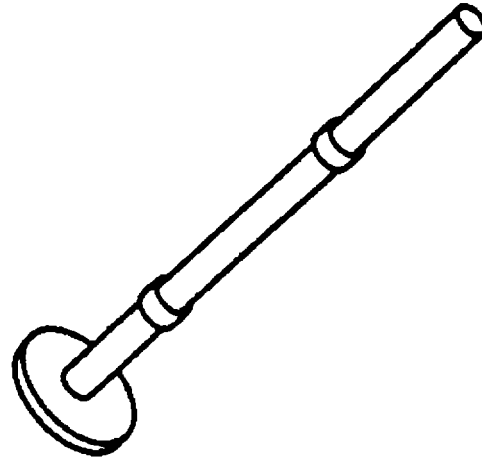


Figure 4-20. RO Block Membrane Element Removal Tool

4-8.6 RO block product tube assembly repair/replacement. Remove, repair, and reinstall product tube assembly (Figure 4-21) as follows.

a Removal.

- (1) Unscrew line nut on each end of tube assembly.
- (2) Remove tube.

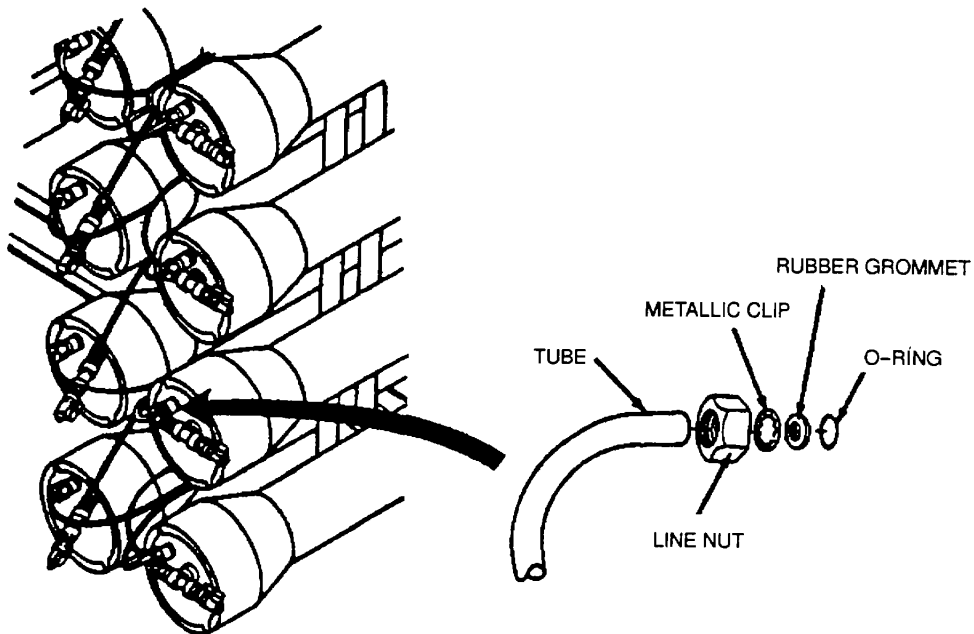


Figure 4-21. RO Block Product Tubes

- b. Disassembly.
 - (1) Remove O-ring, rubber grommet, metallic clip, and line nut.
 - (2) Remove O-ring, rubber grommet, metallic clip, and line nut from other end Discard metallic clips.
- c Assembly.

NOTE.

If tube is to be replaced, measure length of old tube and cut new tube to same length.

- (1) Install two line nuts with threads facing ends of tube.
 - (2) Install two metallic clips.
 - (3) Install two rubber grommets with beveled side facing metallic clip.
 - (4) Install two O-rings.
- d Installation.
 - (1) Install tube.
 - (2) Tighten line nuts.

4-8.7 RO block pressure tube seals replacement. Pressure tube and caps must be removed to replace pressure tube seals Proceed as follows:

- a Removal.
 - (1) Tag all rigid and flexible tubes at the product water end of the RO block assembly Loosen rigid tube nut.
 - (2) Loosen rigid tube nut at high pressure manifold DO NOT remove Swing tube away from end cap assembly.
 - (3) Loosen flexible tube nut. Remove flexible tube from end cap.
 - (4) Remove two bolts, two nuts, and two end damp halves.
 - (5) Gently work end cap assembly back and forth to remove from pressure tube Use care to avoid damaging seals. Set aside In a clean place Go to other (feedwater) end of pressure tube.
 - (6) Tag all rigid tubes at feedwater end of the pressure tubes Loosen rigid tube nut.
 - (7) Loosen rigid tube nut at manifold. DO NOT remove Remove rigid tube from end cap assembly Swing tube away from end cap assembly.
 - (8) Remove two bolts, two nuts, and two end damp halves.
 - (9) Gently work end cap assembly back and forth to remove from pressure tube Use care to avoid damaging seals Set aside in a clean place.
- b Replacement. Inspect pressure tube seals on end cap assembly Replace if damaged.
- c Reinstallation.
 - (1) At brine (concentrate) discharge end of pressure tube, wash end cap assembly with a cloth and clean water.
 - (2) Lightly coat outside of end cap assembly O-ring with silicone lubricant Align end cap assembly with inboard end connector.
 - (3) Rotate end cap assembly to align with rigid tube Gently push end cap assembly onto inboard end connector in pressure tube Use care to seat O-ring seal properly and avoid pinching seal.
 - (4) Swing rigid tube back over end cap assembly Install tube on end cap assembly and tighten rigid tube nut.

- (5) Tighten rigid tube nut at manifold.
- (6) Install end damp halves. Install two bolts and two nuts. Go to other (product water) end of pressure tube.
- (7) At product water end of pressure tube, wash end cap assembly with a cloth and clean water.
- (8) Lightly coat outside of end cap assembly O-ring with silicone lubricant Align end cap assembly with inboard end connector.
- (9) Rotate end cap assembly to align with rigid tube. Gently push end cap assembly onto inboard end connector in pressure tube. Use care to seat O-ring seal properly and avoid pinching seal.
- (10) Swing rigid tube back over end cap assembly. Install tube on end cap assembly Tighten rigid tube nut and remove tag.
- (11) Tighten rigid tube nut at high pressure manifold.
- (12) Install flexible tube on end clamp assembly. Tighten flexible tube nut and remove tag.
- (13) Install end damp halves Install two bolts and two nuts.
- (14) Repeat step c for other 15 pressure tubes.

4-8.8 Valve repair/replacement. Repair or replace worn or damaged valves in accordance with TM 53-503

CHAPTER 5 STORAGE

NOTE

Additional operation, maintenance and parts information may be found in the following technical manuals which cover the 150, 000 Gallon Per (GPD) Day Reverse Osmosis Water Purification Unit (ROWPU):

TM 10-4610-229-10, Operator's Manual for 150,000 GPD ROWPU

TM 10-4610-229-24, Unit, Direct and General Support Maintenance Manual for 150,000 GPD ROWPU

TM 10-4610-229-24P, Repair Parts and Special Tools List for 150,000 GPD ROWPU

5-1 Short-term storage. If barge is to be taken out of service for more than 7 days but less than 30 days, follow shutdown procedures in paragraph 3-6.1. Operate ROWPU system every 7 days for at least 30 minutes. Coordinate this operation with short-term operating/storage procedures for other major systems onboard. For the ROWPU's, follow procedures in paragraph 3-4. Discharge product water directly overboard.

5-2 Administrative storage. If barge is to be taken out of service for more than 30 days but less than 6 months, barge remains a unit responsibility and shall be maintained by unit personnel.

5-2.1 Administrative storage procedures. If barge is placed in administrative storage, ROWPU system is processed for storage as specified below and inspected during storage according to paragraph 5-2.2.

NOTE

Coordinate ROWPU system storage with storage procedures for drinking water system (TM 55-1930-209-14&P-5), chlorination system (P-4), and seawater system (P-2).

- a. Shut down ROWPU's 1 and 2 according to paragraph 3-6.1.

WARNING

Be sure diesel engine has cooled down before attempting to dean HP pump.

- b. Clean HP pump assembly as follows:

WARNING

Solvent may cause toxic fumes. Work only in a well-ventilated area. Avoid skin and eye contact. Do not breath vapor. Solvent is flammable. Do not bring open flame or sparks near solvent.

CAUTION

Exercise care to prevent dry cleaning solvent from coming in contact with electrical components.

- (1) Clean painted metal surfaces with a clean, lint-free cloth moistened with cleaning solvent (P-D-680, Type II). Scrub off hard deposits with a bristle brush that has been dipped in solvent. Dry surfaces with a clean, lint-free cloth.
- (2) Clean linkages and control rods with cleaning solvent (P-D-680, Type II), and dry with a clean, lint-free cloth.
- (3) Clean instrument faces using a clean, lint-free cloth.
- (4) Inspect HP pump assembly for damaged components. Repair and/or replace damaged components.

WARNING

Corrosion prevention compound (MIL-C-16173) is flammable and slightly toxic. Avoid skin and eye contact. Do not breath vapor. Skin and eye protection and breathing apparatus are required.

- (5) Repair all damaged surfaces. Coat unprotected metal surfaces with a preservative conforming to MIL-C-16173, Grade 3.
- (6) Change diesel engine oil and filter according to paragraph 4-7.3.1.
- (7) Add diesel engine cooling system conditioner or change coolant conditioner elements according to paragraph 4-7.3.6. Change diesel engine coolant according to paragraph 4-7.3.7.
- (8) Clean or change diesel engine air filter according to paragraph 4-7.3.4.

WARNING

When disconnecting battery cables, negative cable must be disconnected first to prevent electric shock.

- (9) Disconnect battery cables and use a wire brush to remove corrosion from battery terminals, cables, and mounting. Clean battery filler cap vent holes. Secure battery cables to frame or battery box with tape (PPP-T-60). Make sure batteries are fully charged.
 - (10) Seal all openings with tape (PPP-T-60).
- c. Backwash and flush media filters according to paragraph 4-7.2.
 - d. Clean RO block membranes according to paragraph 4-7.4.
 - e. Replace cartridge filter elements according to paragraph 4-7.1.2.
 - f. Perform the following when authorized by the bargemaster:
 - (1) Prepare for storage and store ROWPU's 1 and 2 RO block membrane elements as follows:
 - (a) Remove RO block membrane elements from each pressure tube according to paragraph 4-8.4.1.
 - (b) Submerge each membrane element in a solution of formaldehyde for 5 minutes.
 - (c) Place each membrane element in a polyethylene plastic bag (sleeve) about 6 mils thick. Heat seal sleeve.

CAUTION

Membrane elements must be stored indoors in a temperature between 40 and 120°F.

- (d) Store membrane elements aboard barge in void 5.
 - (2) Drain pumps at lowest point.
 - (3) Open all valves and drain piping at lowest point.
 - (4) Disconnect and flush clean all tubing from coagulant, inhibitor, and cleaning agent drums. Cap drum openings. Make sure drums are secure. Tape tubing to drums.
- g. Inspect all components for damage or rust. Repair or replace as necessary.
 - h. Thoroughly clean all external surfaces to remove any corrosion or other foreign matter. Clean all surfaces, except electrical parts, with soapy water and a stiff brush and flush with clean water. Clean electrical control station by wiping with a cloth moistened with silicone spray lubricant or similar substance. Remove any corrosion by wire brushing or sanding. Touch up paint, as necessary, to prevent further corrosion (TB 43-0144). Match paint to surrounding areas. Do not paint labels or threads.

5-2.2 Administrative storage inspection. Inspect ROWPU system at least once every 30 days when barge is in storage. Check for corrosion, damage, and pilferage. Correct as necessary.

5-3 Long-term storage. If barge is to be taken out of service for 6 months or more, turn it in to depot for preparation and placement into long-term storage. If barge is in administrative storage and is to be taken out of service and placed in depot long-term storage (6 months or more), process ROWPU system for normal operations as specified below before releasing to depot.

- a. Perform before operation checks specified in Appendix B.
- b. Start and operate both ROWPU's according to procedures in paragraph 3-2 thru paragraph 3-5. Perform during operation checks specified in Appendix B.
- c. When both ROWPU's have operated successfully for at least 1 hour, stop operation (paragraph 3-6) and perform after operation checks as specified in Appendix B.
- d. Upon successful completion of inspection, release ROWPU system to depot for long-term storage

APPENDIX A

REFERENCES

A-1 Drawings

US Army Belvoir Research and Development Center (97403)

- 13226E1892 ROWPU/Barge Arrangement
- 13226E1893 List of Label Plates
- 13226E1900 ROWPU Installation
- 13226E1932 Electrical Power Schematic Diagram
- 13226E1935 Electrical Power System Layout
- 13226E1944 Equipment Shutdown System
- 13226E1945 ROWPU Modification

A-2 Demolition to Prevent Enemy Use

TM 750-244-3 Procedures for Destruction of Equipment to Prevent Enemy Use

A-3 Cleaning

Fed. Spec. P-D-680 Metal Cleaning Solvent for Army Use

A-4 Maintenance

- DA PAM 738-750 The Army Maintenance Management System (TAMMS)
 - TM 55-503 Marine Salvage and Hull Repair
 - TM 5-6630-215-12 Operator and Organizational Maintenance, Water Quality Analysis/Sets
 - TM 10-4610-229-10 Operator Manual, Reverse Osmosis Water Purification Unit, 150,000 Gallon Per day
 - TM 10-4610-229-24 Unit, Direct and General Support Maintenance Manual, Reverse Osmosis Water Purification Unit, 150,000 Gallon Per day
 - TM 10-4610-229-24P Repair Parts and Special Tools List, Reverse Osmosis Water Purification Unit, 150,000 Gallon Per day
 - TB 43-0144 Painting of Vessels
 - Fed. Spec. PPP-T-60 Waterproof of Packaging Tape
-

APPENDIX B

Preventive maintenance checks and services (PMCS) for ROWPU System

B-1 Introduction to PMCS

NOTE

TM 55-1930-209-14&P-19 contains PMCS for all systems on the ROWPU Barge. This appendix contains only PMCS for the ROWPU System

NOTE

Additional operation, maintenance and parts Information may be found in the following technical manuals which cover the 150,000 Reverse Osmosis Water Purification Unit: (ROWPU):

TM 10-4610-229-10, Operator's Manual for 150,000 ROWPU

TM 10-4610-229-24, Unit, Direct and General Support Maintenance Manual for 150,000 ROWPU

TM 10-4610-229-24P, Repair Parts and Special Tools List for 150,000 ROWPU

a. General.

- (1) Systematic (B) before, (D) during, (A) after, and scheduled periodic PMCS are essential to ensure that the Reverse Osmosis Water Purification Barge is in operational readiness at all times. The purpose of the PMCS program is to discover and correct deficiencies and malfunctions before they cause serious damage or failure of the barges and their support systems. An effective PMCS program requires that operators report all unusual conditions noticed before, during and after operation as well as while performing periodic PMCS. All deficiencies and malfunctions discovered during maintenance inspections must be recorded, together with the corrective action taken, on DA Form 2404 (Equipment Inspection and Maintenance Worksheet).
- (2) A schedule for preventive maintenance inspections and service should be established and adhered to. When operating under unusual conditions, such as extreme heat or cold, it may be necessary to perform PMCS more frequently.
- (3) The PMCS items have been arranged and numbered in a logical sequence to provide for greater efficiency and the least amount of downtime required for maintenance.

b. PMCS columnar entries.

- (1) Item Number Column. Checks and services are numbered in chronological order regardless of interval. This column is used as a source of item numbers for the "Item Number" column on DA Form 2404, Equipment Inspection and Maintenance Worksheet, in recording results of PMCS.
- (2) Interval Column. The interval columns tell you when to do a certain check or service: before, during, or after operation. Sometimes a dot may be placed in more than one interval column which would mean you should do the check or service at each of those intervals.
- (3) Item to Be Inspected Column. This column lists the common name of the item to be inspected such as "Air Filters."
- (4) Procedures Column. This column tells you how to do the required checks and services. Carefully follow these instructions.
- (5) Equipment is Not Ready/Available if Column. This column tells you when and why your equipment cannot be used.

NOTE

The terms "Ready/Available" and "Mission Capable" refer to the same status: equipment is on hand and is able to perform its combat missions. (See DA PAM 738-750).

- (6) Increased Inspections. Perform weekly as well as Before Operations PMCS if:
 - (e) You are the assigned operator and have not operated the item since the last weekly PMCS.
 - (f) You are operating the item for the first time.

(7) Leakage definitions. In checking for fluid leaks, the following leakage definitions apply to all ROWPU barges and barge equipment, product water, and seawater leakage by class type.

- (a) Class I-Seepage of fluid (as indicated by wetness or discoloration) not great enough to form drops.
- (b) Class II-Leakage of fluid great enough to form drops, but not enough to cause drops to drip from the item being checked/inspected.
- (c) Class III-Leakage of fluid great enough to form drops that fall from the item being checked/inspected.

CAUTION

Equipment operation is allowable with minor water leakages (Class I or II). However, the fluid level or operating pressure of the item being checked/inspected must be considered. When in doubt, notify the shift leader or bargemaster. When operating with Class I or Class II water leaks, continue to check fluid levels as required by PMCS and operating instructions.

(8) The following fuel and hazardous material leakage procedures apply for any fuel, chemical, or bilge system.

WARNING

Class I, II or III leaks or seepage occurring in a fuel, chemical, or bilge container, tank, line, piping, or valve can cause fire or health hazards.

- (a) If any leaks or seepage from a fuel, chemical, or bilge container, tank, or fluid line is detected, it must be immediately reported to the shift leader or bargemaster for corrective action.
 - (b) To prevent combustible or toxic fumes from collecting or contaminated material from spilling, exercise extreme caution after detecting leaks or seepage of flammable or hazardous material.
- c. Continuous operation. When equipment must be kept in continuous operation for extended periods of time, check and service only those items that can be checked and serviced without disturbing operations. Perform complete checks and services when the equipment can be shut down.
 - d. Maintenance log. Always record the time and date of PMCS, any deficiencies noted, and corrective action taken in the PMCS log book.

B-2 Major components. The ROWPU System consists of two identical units, ROWPU 1 and ROWPU 2. Each unit includes a pretreatment skid assembly consisting of a control station, two chemical metering pumps, four water pressure gauges and a cartridge filter. It also includes a steel framework to support these components as well as the necessary electrical cabling switches, indicators, plus interconnecting piping and valves. Seawater pumps, components of the seawater system, provide pressure for the ROWPU system.

B-3 ROWPU system description. The ROWPU system processes sea water or brackish water supplied by the seawater system to create drinking water. Chlorine is added to the processed water by the chlorination system. The resulting drinking water is then discharged into four drinking water storage tanks.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
1	•		•	•							Small Components	a. Wipe components clean, especially pressure gauges, flowmeters, indicators and control panels. b. Check for leaks, paying special attention to joints, valves, fittings and piping. Report uncorrectable leaks to shift leader or bargemaster.	Gauges inoperable. Pressure drops below normal level.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
2	•	•	•								Chemical Metering Pumps and Tubing	<p>c. Check for physical damage and broken welds. Notify shift leader or bargemaster of damage that will affect normal operation.</p> <p>d. Check control station indicator lights for cracked or broken lenses and burned out bulbs. Replace lenses as follows: 1) Open (OFF) switchboard circuit breaker P6 or P7 as appropriate. Red tag circuit breaker with the following: WARNING-DO NOT ACTIVATE. REPAIRS BEING MADE. 2) Unscrew lens to expose light bulb. 3) Unscrew burned out bulb and install replacement bulb. 4) Reinstall lens. 5) Close (ON) switchboard circuit breaker P6 or P7 and remove red warning tag.</p> <p>e. Check valves RO1 through RO7 for ease of operation. If any valve is inoperable, notify shift leader or bargemaster for repairs.</p> <p>f. Check gauges for cracked or broken lenses. If damaged, notify shift leader or bargemaster for repairs.</p> <p>g. Check for loose or missing securements and fasteners. Tighten or replace as necessary.</p> <p>h. Check flowmeter F1 and temperature gauge for cracks, leaks and operation.</p> <p>a. Check chemical metering hoses for proper connection to pumps and drums. Check tubing and connections for leaks and cracks.</p>	<p>Damaged or broken welds.</p> <p>Valve inoperable.</p> <p>Gauges cracked or broken.</p> <p>Securements and/or fasteners missing or loose.</p> <p>Meters inoperable.</p>
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Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

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	B	D	A	D	W	M	Q	S	A				
	•		•									b. Check fuse on metering pump. Replace if necessary. c. Make sure coagulant and inhibitor drums each contain at least 2 to 3 gal of liquid. If level is low, disconnect metering pump hoses and replace drums as follows: <p style="text-align: center;">WARNING</p> Avoid exposure to coagulant and inhibitor. Wear safety goggles or face shield and rubber gloves when working around chemicals. If chemical is swallowed, do not induce vomiting. Drink water and seek medical attention. If chemical gets in eyes, flush with water and seek medical attention. If chemical contacts skin, wash with soapy water. <p style="text-align: center;">NOTE</p> Pump section hose enters drum through the larger of two plastic lungs which are screwed into the drum. 1) Remove suction hose, with suction foot valve and weight attached, from empty drum. <p style="text-align: center;">NOTE</p> Drum breather (vent) hose enters drum through smaller plastic lung and hangs over side. 2) Remove breather hose. 3) Remove empty drums and replace with full drum. <p style="text-align: center;">CAUTION</p> Carefully read labels on drums to insure that proper drum is being connected.	Fuse blown. Drums empty.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

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	B	D	A	D	W	M	Q	S	A				
												<ul style="list-style-type: none"> 4) Use drum lifter and bridge crane with 2-ton hoist to obtain new drum. Position and secure drum in rack 5) Install section hose in drum through hole in large lung. Foot valve should be just above the drum bottom. 6) Connect other end of suction hose to chemical metering pump. 7) Insert breather hose into smaller lung in drum. Make sure hose does not siphon chemical onto the deck. <p>d. Check for chemical seepage around head disk. If seepage occurs replace pump diaphragm as follows:</p> <ul style="list-style-type: none"> 1) Place pump stroke length knob at 100 percent. 2) Remove four screws and flatwashers holding dosing head to pump. Remove dosing head. 3) Place pump stroke length knob at 0 percent. Remove pump diaphragm by turning counterclockwise. The head disc will also fall free. 4) Install replacement diaphragm by holding head disc in position (drain slot on inside) and turning diaphragm clockwise onto plunger shaft end. Grasp perimeter of diaphragm and hand tighten. 5) Place pump stroke length knob at 100 percent. Rotate head disc until marker hole is up and drain slot is down. Align four screw holes with motor housing holes. 6) Install dosing head with arrow oriented up. Secure dosing head with four screws and flatwashers. Tighten screws evenly. 	Class III leaks.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
												<p>e. Check tubing for cracks and leaks. If necessary, replace as follows:</p> <p style="text-align: center;">WARNING</p> <p>Avoid exposure to coagulant and inhibitor. Wear safety goggles or faceshield and rubber gloves when working around chemicals. If chemical is swallowed, do not induce vomiting. Drink water and seek medical attention. If chemical gets in eyes, flush with water and seek medical attention. If chemical contacts skin, wash with soap and water.</p> <ol style="list-style-type: none"> 1) Cut new tubing the same length as bad tubing being replaced. 2) Install new tubing. 3) Slip carbon seal cartridge thru an O-ring positioned in a groove in the end bell manifold. Some oil on the O-ring will facilitate assembly. 4) Check pump lubricant level and add oil as necessary. 	Class III leaks.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

B-Before
D-During
A-After

D-Daily
W-Weekly
M-Monthly

Q-Quarterly
S-Semiannually
A-Annually

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:									
	B	D	A	D	W	M	Q	S	A													
3	•											f. Prime chemical metering pump after replacing coagulant or inhibitor. <ul style="list-style-type: none"> • Set stroke and speed controls to 100. • Set control station ON/OFF switch to ON. • Connect hose to purge air purge valve to collect any air or liquid. • While pump is priming open air purge valve. • Close air purge valve when fluid is free of air. • When pump is primed, turn control station ON/OFF switch to OFF. • Set chemical metering pump control: <table border="1" style="margin-left: 40px;"> <thead> <tr> <th></th> <th>STROKE LENGTH</th> <th>STROKE FREQUENCY</th> </tr> </thead> <tbody> <tr> <td>Coagulant (P2)</td> <td>50</td> <td>35</td> </tr> <tr> <td>Inhibitor (P4)</td> <td>100</td> <td>46</td> </tr> </tbody> </table> 		STROKE LENGTH	STROKE FREQUENCY	Coagulant (P2)	50	35	Inhibitor (P4)	100	46	
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Coagulant (P2)	50	35																				
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•											g. Make sure membrane cleaning agent (Hydrakleen) drums are full. If not, replace drums in accordance with Item 4 below. <p>a. Check chemical agent drum. Replace if necessary as follows:</p> <p style="text-align: center;">WARNING</p> <p>Wear safety goggles or face shield and rubber gloves while replacing chemical agent drums. Immediately wash off agent that contacts skin. If agent touches eyes, immediately flush eyes at eye wash station. Wash spills with water. Dry mop to prevent slipping.</p> <ol style="list-style-type: none"> 1) Close valve R013 on hose connected to large threaded drum bung hole. 2) Disconnect hose containing valve R013. 											

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
4	•	•	•		•						Media Filters	3) Close valve RO14 on hose connected to small threaded drum bung hole. 4) Disconnect hose containing valve R014. 5) Tip drum from vertical position and remove using drum lifter and bridge crane with 2-ton hoist. NOTE Membrane cleaning agent drum is normally painted black. 6) Use drum lifter and bridge crane with 2-ton hoist to position drum to stand so large bung hole is on bottom and small bung hole is on top when drum is tipped into place. 7) Connect hose containing valve RO14 to small threaded drum bung hole. 8) Connect hose containing valve R013 to large threaded drum bung hole. a. Check each media filter unit for damage and leaks. Check vent valve for proper operation. Replace vent valve as required. Unscrew existing air vent on top of media tank and install new vent (P/N 51896-1). b. Backwash and flush media filters when pressure difference between seawater pump discharge pressure gauge P1 and media filter output gauge P2 exceeds 35 psi, when MEDIA FILTER LIGHT OK light goes out, or when water sample taken from cartridge filter assembly drain valve R08 is dirty. c. If HP pump diesel engine is operating: 1) Position valve RO15 from product water flow to overboard flow.	Pressure in P1 and P2 exceeds 35 psi.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

B-Before
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												<p align="center">CAUTION</p> <p>Do not abruptly stop engine except In an emergency. When shutting down engine, always reduce throttle and operate engine for 5 minutes at low idle to allow hot areas to cool and turbocharger to slow down while maintaining oil pressure on turbine shaft.</p> <p>2) Gradually reduce HP pump diesel engine throttle setting to IDLE. Leave engine idling and check oil and temperature gauges.</p> <p>3) Open throttling RO7.</p> <p>4) Stop coagulant pump and inhibitor pump at control station by setting ON/OFF switches to OFF.</p> <p>5) After HP pump diesel engine has idled for 5 minutes, stop engine by pushing in shutdown lever.</p> <p>6) Stop seawater pump by turning OFF/ON/START switch on control station to OFF.</p> <p>d. Backwash media filter 1: 1) Position RO valves as indicated below: O = Open X = Closed 1/2O = 1/2 open A = Position A B = Position B C = Position C</p> <table border="0"> <thead> <tr> <th>RO Valve No.</th> <th>Valve Position</th> </tr> </thead> <tbody> <tr><td>1</td><td>B</td></tr> <tr><td>2</td><td>A</td></tr> <tr><td>3</td><td>A</td></tr> <tr><td>4</td><td>C</td></tr> <tr><td>5</td><td>X</td></tr> <tr><td>6</td><td>1/2O</td></tr> <tr><td>7</td><td>X</td></tr> <tr><td>12</td><td>O</td></tr> <tr><td>18</td><td>O</td></tr> <tr><td>19</td><td>X</td></tr> </tbody> </table>	RO Valve No.	Valve Position	1	B	2	A	3	A	4	C	5	X	6	1/2O	7	X	12	O	18	O	19	X	
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												<p>2) Start seawater pump by turning pump OFF/ON/START switch on control station to START and then to ON.</p> <p>3) Adjust valve RO6 to obtain slow backwash flow rate of 162 gpm at seawater flow indicator F1 and a temperature reading of 800F at seawater temperature gauge T1. Exact flow rate depends on actual temperature reading. Cooler water requires less flow.</p> <p>TEMPERATURE (Backwash) FLOW RATE</p> <table border="1"> <thead> <tr> <th></th> <th>Slow backwash</th> <th>Fast backwash</th> </tr> <tr> <th>Temperature</th> <th>F1 flow</th> <th>F1 flow</th> </tr> <tr> <th><u>T1 (F)</u></th> <th><u>rate (agpm)</u></th> <th><u>rate (gpm)</u></th> </tr> </thead> <tbody> <tr><td>55</td><td>115</td><td>180</td></tr> <tr><td>60</td><td>125</td><td>200</td></tr> <tr><td>65</td><td>135</td><td>220</td></tr> <tr><td>70</td><td>144</td><td>240</td></tr> <tr><td>75</td><td>153</td><td>255</td></tr> <tr><td>80</td><td>162</td><td>270</td></tr> <tr><td>85</td><td>170</td><td>285</td></tr> <tr><td>90</td><td>177</td><td>300</td></tr> <tr><td>95</td><td>184</td><td>315</td></tr> <tr><td>100</td><td>191</td><td>325</td></tr> <tr><td>105</td><td>198</td><td>334</td></tr> <tr><td>110</td><td>204</td><td>342</td></tr> <tr><td>115</td><td>210</td><td>350</td></tr> <tr><td>120</td><td>216</td><td>355</td></tr> <tr><td>125</td><td>222</td><td>360</td></tr> </tbody> </table> <p>4) Observe condition of water at brine flow indicator. After 5 minutes or when water is clear, open valve RO6 to obtain fast backwash flow rate corresponding to water temperature at T1.</p>		Slow backwash	Fast backwash	Temperature	F1 flow	F1 flow	<u>T1 (F)</u>	<u>rate (agpm)</u>	<u>rate (gpm)</u>	55	115	180	60	125	200	65	135	220	70	144	240	75	153	255	80	162	270	85	170	285	90	177	300	95	184	315	100	191	325	105	198	334	110	204	342	115	210	350	120	216	355	125	222	360	
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	B	D	A	D	W	M	Q	S	A																																																
												<p>5) After 2 minutes of fast backwash, partially close valve RO6 to obtain slow backwash flow rate at FI.</p> <p>6) After 2 minutes of slow backwash, stop seawater pump by turning pump ON/OFF/START switch on control station to OFF.</p> <p>e. Backwash media filter 2:</p> <p>1) Position RO valves as indicated below:</p> <p>O = Open X = Closed 1/20 = 1/2 open A = Position A B = Position B C = Position C</p> <table border="0"> <thead> <tr> <th>RO Valve No.</th> <th>Valve Position</th> </tr> </thead> <tbody> <tr><td>1</td><td>A</td></tr> <tr><td>2</td><td>B</td></tr> <tr><td>3</td><td>A</td></tr> <tr><td>4</td><td>C</td></tr> <tr><td>5</td><td>X</td></tr> <tr><td>6</td><td>1/20</td></tr> <tr><td>7</td><td>X</td></tr> <tr><td>12</td><td>O</td></tr> <tr><td>18</td><td>O</td></tr> <tr><td>19</td><td>X</td></tr> </tbody> </table> <p>2) Follow procedures shown above.</p> <p>f. Backwash media filter 3:</p> <p>1) Position RO valves as indicated below:</p> <p>O = Open X = Closed 1/20 =: 1/2 open</p> <table border="0"> <thead> <tr> <th>RO Valve No.</th> <th>Valve Position</th> </tr> </thead> <tbody> <tr><td>1</td><td>A</td></tr> <tr><td>2</td><td>A</td></tr> <tr><td>3</td><td>B</td></tr> <tr><td>4</td><td>C</td></tr> <tr><td>5</td><td>X</td></tr> <tr><td>6</td><td>1/20</td></tr> <tr><td>7</td><td>X</td></tr> <tr><td>12</td><td>O</td></tr> <tr><td>18</td><td>O</td></tr> <tr><td>19</td><td>X</td></tr> </tbody> </table>	RO Valve No.	Valve Position	1	A	2	B	3	A	4	C	5	X	6	1/20	7	X	12	O	18	O	19	X	RO Valve No.	Valve Position	1	A	2	A	3	B	4	C	5	X	6	1/20	7	X	12	O	18	O	19	X	
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	B	D	A	D	W	M	Q	S	A																										
5	•	•									RO Block Pressure Tube Membrane	<p>2) Follow procedures above.</p> <p>g. Flush each media filter simultaneously:</p> <p>1) Position RO valves as indicated below:</p> <p>O = Open X = Closed 1120 = 1/2 open</p> <p>A = Position A</p> <p>B = Position B</p> <p>C = Position C</p> <table border="0"> <thead> <tr> <th>RO Valve No.</th> <th>Valve Position</th> </tr> </thead> <tbody> <tr><td>1</td><td>A</td></tr> <tr><td>2</td><td>A</td></tr> <tr><td>3</td><td>A</td></tr> <tr><td>4</td><td>C</td></tr> <tr><td>5</td><td>O</td></tr> <tr><td>6</td><td>O</td></tr> <tr><td>7</td><td>X</td></tr> <tr><td>12</td><td>O</td></tr> <tr><td>18</td><td>O</td></tr> <tr><td>19</td><td>X</td></tr> </tbody> </table> <p>2) Start seawater pump by turning pump ON/OFF/START switch on control station to START and then to ON.</p> <p>3) After 10 minutes of flushing, stop seawater pump by turning pump ON/OFF/START switch to OFF.</p> <p>NOTE</p> <p>Clean RO block tube membranes when the pressure difference between HP pump discharge pressure gauge P4 and brine discharge pressure gauge P5 exceeds 25 psi. Procedures are for normal cleaning operations using seawater pump 1 for cleaning ROWPU 1 RO Block and seawater pump 2 for cleaning ROWPU 2 RO Block.</p>	RO Valve No.	Valve Position	1	A	2	A	3	A	4	C	5	O	6	O	7	X	12	O	18	O	19	X	Pressure between P4 and P5 exceeds 25 psi.
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ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
	•	•	•			•						a. Check RO block for cracks and leaks. When replacement of pressure tube seals is necessary, notify shift leader or bargemaster. b. Spray end cap on RO block with silicone spray to protect against rust. c. Check system wiring for damage and loose connections. Tighten or replace as required. d. If the HP pump diesel engine is operating: 1) Position valve RO15 from product water flow to overboard flow. 2) Gradually reduce HP pump diesel engine throttle setting to IDLE. Leave engine idling. 3) Open throttle valve RO7. 4) Stop coagulant pump and inhibitor pump at control station by setting ON/OFF switches to OFF e. Clean RO block membrane: <p style="text-align: center;">WARNING</p> Wear safety goggles or face shield and rubber gloves while replacing chemical agent drums. Immediately wash off agent that contacts skin. If agent touches eyes, immediately flush eyes at eye wash station. Wash spills with water. Dry mop to prevent slipping. 1) Install full drum of membrane cleaning agent (Hydrakleen-20). 2) Close valve RO13 on hose connected to large threaded drum bung hole. 3) Disconnect hose containing valve RO13. 4) Close valve RO14 on hose connected to small threaded drum bung hole.	Class III leaks. Damaged wire.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:																												
	B	D	A	D	W	M	Q	S	A																																
												<p>5) Disconnect hose containing valve RO14.</p> <p>6) Tip drum from vertical position and remove using drum lifter and bridge crane with 2-ton hoist.</p> <p>7) Use drum lifter and bridge crane with 2-ton hoist to position drum to stand so large bunghole in on bottom and small bunghole is on top when drum is tipped into place.</p> <p>8) Connect hose containing valve R014 to small threaded drum bunghole.</p> <p>9) Connect hose containing valve R013 to large threaded drum bunghole.</p> <p>10) To clean ROWPU 1, use seawater pump 1. Position seawater (SW) valves:</p> <table border="0" style="margin-left: 40px;"> <tr> <td>O = Open</td> <td>X = Closed</td> </tr> <tr> <td>SW Valve No.</td> <td>Valve Position</td> </tr> <tr> <td>1</td> <td>0</td> </tr> <tr> <td>5</td> <td>X</td> </tr> <tr> <td>7</td> <td>X</td> </tr> <tr> <td>9</td> <td>0</td> </tr> <tr> <td>11</td> <td>0</td> </tr> <tr> <td>13</td> <td>X</td> </tr> <tr> <td>16</td> <td>0</td> </tr> <tr> <td>19</td> <td>X</td> </tr> <tr> <td>20</td> <td>0</td> </tr> <tr> <td>22</td> <td>X</td> </tr> <tr> <td>24</td> <td>X</td> </tr> <tr> <td>29</td> <td>X</td> </tr> </table>	O = Open	X = Closed	SW Valve No.	Valve Position	1	0	5	X	7	X	9	0	11	0	13	X	16	0	19	X	20	0	22	X	24	X	29	X	
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Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:																																																																												
	B	D	A	D	W	M	Q	S	A																																																																																
•												<p>11) To clean ROWPU 2, use seawater pump 2. Position seawater (SW) valves:</p> <table border="0"> <tr> <td>O = Open</td> <td>X = Closed</td> </tr> <tr> <td>SW Valve No.</td> <td>Valve Position</td> </tr> <tr> <td>2</td> <td>O</td> </tr> <tr> <td>6</td> <td>X</td> </tr> <tr> <td>8</td> <td>X</td> </tr> <tr> <td>10</td> <td>O</td> </tr> <tr> <td>12</td> <td>O</td> </tr> <tr> <td>13</td> <td>X</td> </tr> <tr> <td>17</td> <td>O</td> </tr> <tr> <td>18</td> <td>X</td> </tr> <tr> <td>19</td> <td>X</td> </tr> <tr> <td>21</td> <td>O</td> </tr> <tr> <td>23</td> <td>X</td> </tr> <tr> <td>25</td> <td>X</td> </tr> </table> <p>12) Position RO valves:</p> <table border="0"> <tr> <td>O = Open</td> <td>X = Closed</td> </tr> <tr> <td>A = Position A</td> <td></td> </tr> <tr> <td>C = Position C</td> <td></td> </tr> <tr> <td>RO Valve No.</td> <td>Valve Position</td> </tr> <tr> <td>1</td> <td>C</td> </tr> <tr> <td>2</td> <td>C</td> </tr> <tr> <td>3</td> <td>C</td> </tr> <tr> <td>4</td> <td>C</td> </tr> <tr> <td>5</td> <td>X</td> </tr> <tr> <td>6</td> <td>X</td> </tr> <tr> <td>7</td> <td>X</td> </tr> <tr> <td>8</td> <td>X</td> </tr> <tr> <td>9</td> <td>X</td> </tr> <tr> <td>10</td> <td>O</td> </tr> <tr> <td>11</td> <td>X</td> </tr> <tr> <td>12</td> <td>X</td> </tr> <tr> <td>13</td> <td>X</td> </tr> <tr> <td>14</td> <td>X</td> </tr> <tr> <td>15</td> <td>Overboard</td> </tr> <tr> <td>16</td> <td>O</td> </tr> <tr> <td>17</td> <td>X</td> </tr> <tr> <td>18</td> <td>O</td> </tr> <tr> <td>19</td> <td>O</td> </tr> <tr> <td>20</td> <td>O</td> </tr> </table>	O = Open	X = Closed	SW Valve No.	Valve Position	2	O	6	X	8	X	10	O	12	O	13	X	17	O	18	X	19	X	21	O	23	X	25	X	O = Open	X = Closed	A = Position A		C = Position C		RO Valve No.	Valve Position	1	C	2	C	3	C	4	C	5	X	6	X	7	X	8	X	9	X	10	O	11	X	12	X	13	X	14	X	15	Overboard	16	O	17	X	18	O	19	O	20	O	
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Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:																
	B	D	A	D	W	M	Q	S	A																				
•												<p>13) Open vent on top of RO block to allow air to escape.</p> <p>14) Start seawater pump 1 for ROWPU 1 or pump 2 for ROWPU 2 by setting OFF/ON/START switch on control station to ON.</p> <p>15) Close seawater valve SW9 for ROWPU 1 or SW10 for ROWPU 2 for ROWPU to allow water/Hydrakleen solution to recirculate.</p> <p>16) Open valves RO13 and RO14 to allow Hydrakleen to drain out and return to drum.</p> <p>17) After water circulates for 15 minutes, stop seawater pump.</p> <p>18) Close valves RO13 and RO14.</p> <p>19) Disconnect used drum of Hydrakleen-20 and attach a new drum as described in b.1 through b.9.</p> <p>20) Open valves RO13 and RO14.</p> <p>21) Start seawater pump.</p> <p>22) Read seawater temperature at temperature gauge T1 to determine how long seawater pump should operate. Use the following table.</p> <p style="text-align: center;">Seawater Pump Operating Time</p> <table border="0" style="width: 100%;"> <tr> <td style="text-align: center;">Temperature at T1 (F)</td> <td style="text-align: center;">Operating Time</td> </tr> <tr> <td style="text-align: center;">60 or less</td> <td style="text-align: center;">2 hrs. 40 min.</td> </tr> <tr> <td style="text-align: center;">65</td> <td style="text-align: center;">2 hrs. 20 min.</td> </tr> <tr> <td style="text-align: center;">70</td> <td style="text-align: center;">2 hrs.</td> </tr> <tr> <td style="text-align: center;">75</td> <td style="text-align: center;">1 hr. 40 min.</td> </tr> <tr> <td style="text-align: center;">80</td> <td style="text-align: center;">1 hr. 30 min.</td> </tr> <tr> <td style="text-align: center;">85</td> <td style="text-align: center;">1 hr. 30 min.</td> </tr> <tr> <td style="text-align: center;">90 or more</td> <td style="text-align: center;">1 hr. 10 min.</td> </tr> </table>	Temperature at T1 (F)	Operating Time	60 or less	2 hrs. 40 min.	65	2 hrs. 20 min.	70	2 hrs.	75	1 hr. 40 min.	80	1 hr. 30 min.	85	1 hr. 30 min.	90 or more	1 hr. 10 min.	
Temperature at T1 (F)	Operating Time																												
60 or less	2 hrs. 40 min.																												
65	2 hrs. 20 min.																												
70	2 hrs.																												
75	1 hr. 40 min.																												
80	1 hr. 30 min.																												
85	1 hr. 30 min.																												
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Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
6	•										Cartridge Filter Assembly	23) After allotted time, stop seawater pump. 24) Close valves RO13 and RO14. 25) Open valve RO12 and close valve RO19. 26) Open seawater valve SW9 for ROWPU 1 or SW10 for ROWPU 2. 27) Start seawater pump to flush RO Block. 28) Flush for 20 minutes and take a water sample at valve RO17. Use a water test kit to check pH. If pH not acceptable, flush RO block membrane for 30 minutes more and test again. Continue flushing until pH is acceptable (pH7). 29) Stop seawater pump. a. Charge cartridge filter assembly when pressure difference between media filter output pressure gauge P2 and cartridge filter assembly output pressure gauge P3 exceeds 12 psi or when CARTRIDGE FILTER OK light goes out. <p style="text-align: center;">NOTE</p> A minimum of 3 personnel and a bridge crane with a 2-ton hoist is required to change cartridge filter assembly (filter elements).	pH is 3.5 or below or element still dirty. CARTRIDGE FILTER OK light goes out or P3 gauge exceeds 12 psi.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
	•											<p>b. If the HP pump diesel engine is operating:</p> <ol style="list-style-type: none"> 1) Position valve RO15 from product water flow to overboard flow. 2) Gradually reduce HP pump diesel engine throttle setting to IDLE. Leave engine idling. 3) Open throttling valve R07. 4) Stop coagulant pump and inhibitor pump at control station by setting ON/OFF switch to OFF. 5) After HP pump diesel engine has idled for 5 minutes, stop engine by pushing in on shutdown lever. 6) Stop seawater pump by turning pump OFF/ON/START switch on control panel to OFF. <p>c. To remove cartridge case assembly (filter elements):</p> <ol style="list-style-type: none"> 1) Turn valve R04 to position C (OFF) to prevent seawater flow to cartridge filter assembly. 2) Drain cartridge filter assembly by opening valve RO8. 3) Disconnect camlock coupling on cartridge filter assembly output line. 4) Remove four hex nuts on top end assembly. <p style="text-align: center;">WARNING</p> <p>Do not manhandle heavy components. Use a bridge crane to lift heavy components.</p>	

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
	•											5) Use bridge crane and 2-ton hoist to remove top end assembly from filter housing and place it out of the immediate work area. 6) Attach a lifting rig to U-bolts of cartridge cage assembly. 7) Use bridge crane and 2-ton hoist to lift cartridge cage assembly while slowly rotating it to overcome O-ring resistance. As assembly clears housing, attach lines to the assembly to control movement. Lift assembly vertically and slowly to prevent damage. Move assembly away from filter housing, lower to deck and remove hoist. d. To install cartridge cage assembly: 1) Check that O-rings on cartridge cage assembly are in their grooves and lightly lubricated with silicone-based lubricant. Install new O-rings if damaged. 2) Attach lifting rig to cartridge cage assembly U-bolts. Use bridge crane with 2-ton hoist to lift assembly and guide it over filter housing. <p style="text-align: center;">CAUTION Be careful not to damage O-ring when installing cartridge assembly .</p> 3) Carefully lower assembly into the filter housing. Rotate assembly slightly, if necessary, to get O-rings into filter housing without damage. 4) Attach lifting rig to top end of assembly and lower onto filter housing. Insert tie rods into tie rod holes and align camlock connections.	
	•		•										

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
7	•		•								Cartridge Filter Element	<p>5) Install hex nuts on tie rods and torque evenly to 10 lb/ft. 6) Connect camlock coupling. 7) Close valve R08. 8) Return R04 to service position.</p> <p>Check cartridge filter element for cracks, leaks, and other damage. If necessary repair or replace as follows:</p> <p style="text-align: center;">NOTE</p> <p>To replace cartridge filter on filter element you will need: 12 new filter elements (P/N 52088) 1 set of socket wrenches and a torque wrench 12 upper seals (spare) (Hydraulics #52088) 12 lower seals (spare) (Hydraulics #52084) 3 O-rings (spare) (Parker 2-452C557-70) 1 Stiff bristle brush and clean, lint-free cloths. Clean workplace.</p> <p>a. Invert cartridge cage assembly and stand on three U-Bolts. b. Remove three 5/16 hex nuts, six washers, and three springs. Lift and lower spider from tie rods.</p> <p style="text-align: center;">CAUTION</p> <p>Do not remove upper and lower seals. If seals come loose, be sure to install upper seals on upper spider and lower seals on lower spider. Failure to Install seals correctly may result in water leakage.</p>	Cracks or leaks in cartridge filter element.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
	•	•										c. Remove used filter elements. Keep upper seals separate from lower seals. NOTE Examine used filter elements. If they contain large amounts of sand the frequency of replacement has increased, check media filters for internal damage.	
	•	•										d. Discard used filter elements. e. Clean internal parts and inside of filter housing with a stiff bristle brush and clean water and dry with clean, lint-free cloths.	
	•	•										f. Inspect upper and lower spiders. Check seals for damage and replace if nicked. Place new or reused upper seals in sockets on upper spider. Place lower seals on guide pins on lower spider.	Spiders are bent.
	•	•										g. Place three new filter elements in three center sockets on upper spider. Make sure upper seals remain properly seated.	
	•	•										h. Place lower spider on assembly so that tie rod holes on spider align with tie rods and center guide pins just engage filter core tubes.	
	•	•										i. Make sure seals remain in sockets and place nine outer filter elements in outer sockets on upper spider. Make sure upper and lower seals are properly seated for each filter.	
	•	•										j. Install six washers, three springs, and three hex nuts on spider tie rod ends. Hand tighten until nuts contact top washers. Tighten hex nuts evenly another seven turns each to compress but not to completely flatten spring.	Springs are missing.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
8											DIESEL ENGINE HIGH PRESSURE PUMP		
8A	•	•		•							All Components	a. Wipe off oil, grease and other foreign matter. Check for cracks, leaks, and loose or missing hardware. b. Check gauges for cracked or broken lenses. If damaged, notify shift leader or bargemaster for repairs.	Class III leaks.
8B	•	•		•							Crankcase	a. Check engine crankcase oil level. Add oil (OE/HDO-MIL-L-2104/MIL-L-46002), if necessary. Fill until level is between FULL and ADD marks on dipstick. b. Change HP pump diesel engine oil quarterly or every 250 meter hours, or as AOAP indicates. 1) Drain engine crankcase oil as follows: (a) Barge 1-Open crankcase drain valve BD12 to drain ROWPU 1 engine and BD13 to drain ROWPU 2 engine. (b) Barges 2 and 3-Connect one end of a utility hose to the quick-disconnect at crankcase drain. Connect other end to the quick-disconnect at crankcase drain oil disposal. Open valves BD12 and BD19 when draining ROWPU 2 engine. (c) Start bilge pump and run until crankcase is empty. Turn bilge pump off and close valve BD12 or BD13 and BD19. Disconnect utility hose, flush it clean, and return it to stowage or allow gravity to drain hose.	Oil level to low. Oil level to low.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
												2) Remove and replace filter as follows: (a) Wipe dirt from oil filter. (b) Remove and discard filter. (c) Clean the filter base and remove all old gasket material. (d) Lightly coat filter gasket with engine oil. (e) Install new filter. Hand tighten an additional 3/4 turn after gasket contacts the base. 3) Fill crankcase with 9 gal of oil. 4) Start and run engine to operating temperature. Check for leaks. c. Check pump lubricant level in sight glass. If necessary, unscrew HP pump oil breather and add oil (OE/HDO-MIL-L-2104) until level is between MAX and MIN marks on oil level gauge. <p style="text-align: center;">NOTE</p> The caterpillar model 3406T1 engine has been modified to accept installation of the Olidex filtered and controlled crankcase ventilation system. d. Empty and clean glass collecting bowl located at bottom of filtering system as follows: 2) Remove bowl by pulling down metal tab of cage holding the bowl. 3) Unsnap wire cage on each side of bowl bottom. 4) Remove bowl; wipe with clean cloth. Do not use abrasives.	Oil level to low.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
8C	•			•							Power Takeoff	5) Replace bowl in reverse order. e. Change engine crankcase filter system vapor filter element as follows: 1) Snap off two metal clips on top of filter body. 2) Lift off top and remove element. Discard and replace with new element. 3) Reinstall in reverse order. a. Check power takeoff oil lever. If necessary, add oil (OE/HDO-MIL-L-2104) until level is between LOW and FULL marks on dipstick. b. Grease belt tensioner bearings as follows: 1) Clean grease from belt tensioner bearings. Grease fittings. 2) Use hand pump grease gun to pump grease (MIL-G-10924) into bearings until grease appears. 3) Wipe off excess grease.	Oil level to low.
8D						•					Oil Breather	a. Check oil breather for dirt. Clean as follows: 1) Remove wingnut lockwasher, and flatwasher from oil breather and remove oil breather top. 2) Remove element from oil breather. 3) Wipe all dirt from oil breather top and body. WARNING Solvent may cause toxic fumes. Work only in a well-ventilated area. Avoid skin and eye contact. Do not breath vapors. Solvent is flammable. Do not bring open flame or sparks near solvent.	

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
8E					•						RO Block Throttling Valve R07	4) Clean oil breather element with dry-cleaning solvent, type 2 (A-A-7'11). Dry thoroughly. 5) Install oil breather element on body. 6) Install oil breather top, flatwasher, lockwasher, and wingnut. a. Grease RO block throttling valve R07 as follows: 1) Clean grease from RO block throttling valve R07 using a clean, lint-free cloth. 2) Use hand pump grease gun to pump grease (MIL-G-10924) into bearings until grease appears. 3) Wipe off excess grease.	
8F	•					•					Alternator	a. Check alternator belt for looseness, frays or cracks. Replace as necessary. If loose, adjust as follows: 1) Remove three nuts, bolts, lockwashers, and flatwashers. Remove alternator guard. 2) Place straight edges from vibration damper pulley to alternator pulley to adjust. b. Check alternator for loose mounting hardware and wire connections. Tighten or replace as necessary. c. Check for damaged alternator. If necessary, replace as follows: WARNING To prevent electric shock, ensure battery is disconnected before performing this procedure.	Alternator belt is loose, frayed or cracked. Alternator inoperable.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
						•						1) Removal (a) Disconnect battery. (b) Remove alternator cover. (c) Remove jam nut and loosen alternator adjusting nut. (d) Loosen mounting nut. (e) Remove bolt and flatwasher from mounting adjustment block. (f) Push alternator toward engine. Remove fan belt from vibration damper and alternator pulleys. (g) Tag and disconnect two wires from alternator. (h) Remove two nuts, four flatwashers, two lockwashers, and two mounting bolts. (i) Remove alternator. 2) Installation (a) Install alternator. Install two mounting bolts, four flatwashers, two lockwashers, and two nuts. Hand tighten. (b) Install bolt and flatwasher on mounting adjustment block. (c) Install adjusting arm and jam nut. Do not tighten. (d) Install fan belt on vibration damper and alternator pulleys. (e) Connect two wires to alternator and remove tags. (f) Adjust fan belt as instructed above.	

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:	
	B	D	A	D	W	M	Q	S	A					
8G											•	Cooling System	(g) Connect battery. (h) Test alternator as follows using a multimeter: (1) Remove battery cover. (2) Set multimeter on 50 V scale (use 100 V scale if meter does not have 50 V scale). (3) Connect positive (+) lead to alternator cable that connects to positive battery terminal. (4) Connect negative (-) lead to alternator cable that connects to negative battery terminal. (5) Start engine (TM 55-1930-209-14 & P-3). (6) Multimeter reading should be 24 to 28 V. If not, replace alternator as described in removal procedure above. <p style="text-align: center;">WARNING</p> At operating temperatures, engine coolant is hot under pressure. It also contains alkaline materials harmful to eyes and skin. To avoid personal injury check coolant level only when engine is stopped and radiator cap is cool enough to be touched with a bare hand. Should engine coolant come in contact with eyes or skin, immediately flush affected area with clean water and seek medical attention, if necessary. a. Check coolant level when engine is cool. Inspect filler cap gasket. Replace if damaged. Add coolant if necessary. Install filler cap.	Engine coolant level is low.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
8H	•			•					•		Fuel Tank	b. Check HP pump engine cooling system for leaks and signs of corrosion. coolant level and add coolant as required. Pressure test engine cooling system. a. Check fuel oil level in day tank Add fuel oil if necessary. b. Drain water from fuel filter. Replace filter as necessary at a minimum of 1000 hrs. as follows: <p style="text-align: center;">CAUTION</p> To ensure a proper seal, ensure all old gasket material is removed. <ol style="list-style-type: none"> 1) Clean gasket sealing surface of filter base. 2) Put light coat of oil (MIL-L-2104) on filter seal. 3) Install filter. Finger tighten until gasket contacts base, then tighten 1/2 to 3/4 turn more. 4) Bleed fuel system as follows: <ol style="list-style-type: none"> (a) Ensure fuel line valve is open and engine shut off control is OFF. (b) Unlock fuel priming pump. (c) Operate priming pump until resistance is felt. (d) Lock fuel priming pump. 	Class III leaks. Check Oil level is low.

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
81				•							Pump V Belts	<p>(e) Empty and clean glass collecting bowl on bottom of engine crankcase filter system as follows:</p> <ul style="list-style-type: none"> • Pull down on metal tab of cage surrounding bowl. • Unsnap wire cage on each side of bottom of bowl. • Remove bowl and wipe with clean cloth. Do not use abrasives. • Replace fuel filter in reverse order. <p style="text-align: center;">WARNING To prevent electric shock, ensure battery is disconnected before performing this procedure.</p> <p style="text-align: center;">NOTE Refer to TM 55-1930-209-14&P-3-2, para. 6.2.10 for complete instructions and illustrations on belt tensioning.</p> <p>a. Check tension on pump V-belts. If they appear to be slack, adjust tension.</p> <p>1) Adjust HP pump V-belt as follows:</p> <ul style="list-style-type: none"> • Remove 32 mounting bolts and lockwashers. Remove front V-belt housing (two pieces). • Place a straight edge on V-belt in a straight line with bearing bases. • Place tension meter pointer on the line on the center of the front belt. <p style="text-align: center;">NOTE Do not contact O-ring on tester stem.</p>	

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
												2) Press down on tester stem until register flange just contacts the next belt. 3) Release pressure and note pressure scale reading under O-ring. 4) Repeat steps (1) thru (2) for each belt. 5) Both readings should be 13-17 lb (9.5-11.25 kg) and outside belts should be within 1 lb (0.45 kg) of each other. 6) If belts are not adjusted correctly, proceed as follows: <ul style="list-style-type: none"> • Loosen four bolts. • Loosen two adjusting screw locknuts. • Turn adjusting screws equally to adjust belt tensioner assembly. • Check adjustments. • Tighten adjusting screw locknuts. • Tighten four bolts. 7) Check adjustment after 2 hours of operation. Adjust as necessary. Check again after 2 more hours of operation. Install front V-belt housing (two pieces). Install 32 mounting bolts and lockwashers.	V-belts cracked or frayed.
			•									b. Check for frayed or cracked HP pump V-belts. If necessary, replace as follows: <p style="text-align: center;">NOTE</p> When one V-belt requires changing, replace all 12 belts as a set. <ol style="list-style-type: none"> 1) Housing removal <ol style="list-style-type: none"> (a) Remove 32 mounting bolts and lockwashers. (b) Remove front V-belt housing 	

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

B-Before
D-During
A-After

D-Daily
W-Weekly
M-Monthly

Q-Quarterly
S-Semiannually
A-Annually

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
			•									2) V-belt removal (a) Loosen two locknuts and two adjusting screws. (b) Remove four bolts, flatwashers, two brackets, and belt tensioner assembly. CAUTION Do not use any tool to force belts on or off belt sheaves. (c) Remove V-belts from pulleys. Inspect sheaves for wear or damage. Wipe off oil or grease. Remove rust and burrs. 2) V-belt installation (a) Check sheave alignment by placing straight edge across face of driver and driver sheaves. Make sure there is less than 0.025 in gap between straight edge and face of sheaves. NOTE Always use a new set of matched V-belts when replacing, Belts must be properly Installed to ensure maximum belt life and reduce wear on bearings.	

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
			•									(b) Install V-belts on pulleys by hand without forcing belts. Install belt tensioner assembly, two brackets, and four flatwashers and bolts. (c) Tighten two adjusting screws. Tighten two locknuts. (d) Pump grease into grease fittings. (e) Adjust V-belts. 3) Housing installation (a) Install front V-belt housing (two pieces). Install 32 mounting screws and lockwashers. (b) Check battery fluid level. Add fluid if necessary. Make sure all electrical connections are clean and tight and batteries are clean and secure. (c) Check diesel engine and HP pump for leaks, general cleanliness, and placement and tightness of guards. (d) During engine startup, measure oil level while engine is running at low idle. Oil level must be between the ADD and FULL marks on the dipstick. (e) Add oil (OEIHDO-MIL-L-2104) if necessary.	

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

B-Before
D-During
A-After

D-Daily
W-Weekly
M-Monthly

Q-Quarterly
S-Semiannually
A-Annually

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
8J	•						•				Air Cleaner	<p>CAUTION Service air cleaner with engine stopped.</p> <p>m. Check HP pump drive engine air cleaner. If red service indicator piston is locked in raised position, service air cleaner. Inspect element after each cleaning. If exhaust smoke and/or loss of power continues after service, install new element as follows:</p> <ol style="list-style-type: none"> 1) Open six latches and remove air cleaner cover and element. 2) Cover air inlet opening to prevent foreign objects from entering engine. 3) Wipe filter housing and cover clean. 4) Before reinstalling filter, tap it gently on a hard surface to remove dirt and debris. 5) Remove covering from air inlet opening. <p>CAUTION Arrows on the side of the element indicate direction of air flow. Ensure element is installed correctly.</p> <ol style="list-style-type: none"> 6) Install either new or cleaned filter element. 7) Install air cleaner cover and secure latches. 8) Reset red service indicator by pushing in the reset button. 	

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:	
	B	D	A	D	W	M	Q	S	A					
8K											•	Turbo Charger	a. Check turbocharger mounting hardware for tightness. Tighten as required. b. Check for cracks and leaks. If damaged, notify shift leader or bargemaster so repairs can be made.	Loose or missing hardware.
8L											•	Throttle and Emergency Shutoff Cord	a. Check HP pump diesel engine throttle and emergency shutoff cord for proper operation. Repair as required. b. Check for loose mounting hardware. Tighten as required. Notify shift leader or bargemaster if replacement is required.	Emergency shutoff cord inoperable.
8M											•	Exhaust System	a. Check for leaks and cracks. Notify bargemaster or shift leader so repairs can be made. b. Check for loose or missing hardware. Tighten or replace as necessary, a. Remove and replace HP pump with spare HP pump stored in void 4 starboard. b. Turn in used HP pump to depot for disassembly, cleaning, inspection, and/or repair. c. Place a spare HP pump back in void 4 starboard.	Leaks or cracks exist. Loose or missing hardware.
8N											•	Pedestal Bearing	CAUTION The mechanical seal is a precision product. Treat It with care. Do not scratch face of carbon ring or let it drop. Take particular care not to scratch the lapped face that comes in contact with the carbon ring. Seals should never be immersed In solvent as this could damage the internal packing.	

Table B-1. Preventive Maintenance Checks and Services for ROWPU System (Continued)

ITEM NO.	INTERVAL										ITEM TO BE INSPECTED	PROCEDURES CHECK FOR AND HAVE REPAIRED OR ADJUSTED AS NECESSARY	EQUIPMENT IS NOT READY/ AVAILABLE IF:
	B	D	A	D	W	M	Q	S	A				
									•			<p>a. Check HP pump pedestal bearing oil. Change pedestal bearing oil every 6 months or 4000 hours of operation, whichever comes first. This interval must be reduced to 4 months or 2500 hours for pumping at temperatures above 2000F.</p> <ol style="list-style-type: none"> 1) Place container under drain plug to catch used oil (Figure 3-10). 2) Remove drain plug underneath pedestal and allow oil to drain. 3) Replace plug. 4) Remove oil breather and add 6 qt of oil (OE/HDO-MIL-L-2104). Replace oil breather. 5) Clean up any spills. <p>b. Replace pump mechanical seals if necessary. The mechanical seal in the pump requires no maintenance or adjustment. When seal has become worn or damaged and leaks excessively, it must be replaced. Maximum allowable leakage for the mechanical seal is 1 gal per hour.</p> <p>c. Refer to LO 10-4610-229-12 for complete lubrication instructions for 150,000 GPD ROWPU.</p>	<p>Oil level is low.</p> <p>Seal leaks exceed 1 gal per hour.</p>

APPENDIX C

MANUFACTURERS' SERVICE MANUALS/INSTRUCTIONS

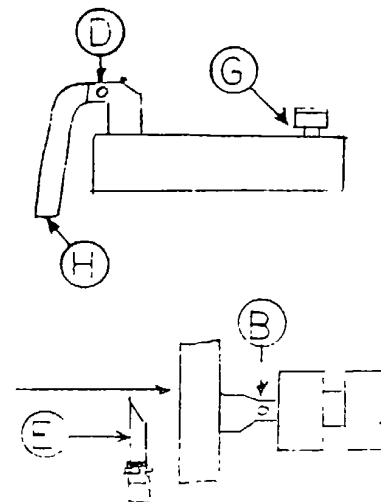
<u>Component</u>	<u>Document title</u>	<u>Manufacturer</u>
Crankcase Ventilation Water Purification Unit, Reverse Osmosis	Installation Instructions See NOTE below	Oildex Corp

NOTE

Operation, maintenance and parts Information may be found In the following technical manuals which cover the 150,000 Gallon Per Day (GPD) Reverse Osmosis Water Purification Unit (ROWPU):TM 10-4610-229-10, Operator's Manual for 150,000 GPD ROWPUTM 10-4610-229-24, Unit, Direct and General Support Maintenance Manual for 150,000 GPD ROWPUTM 10-4610-229-24P, Repair Parts and Special Tools List for 150,000 ROWPU

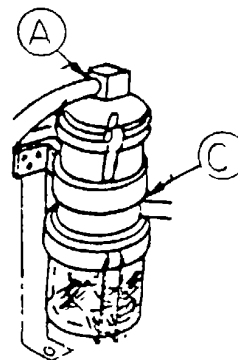
OILDEX® ORIGINATORS OF FILTERED AND CONTROLLED CRANK CASE VENTILATION
INSTALLATION INSTRUCTIONS - READ CAREFULLY

1. Remove valve cover and drill a 23/32" hole in valve cover at G. Tap with 1/2" pipe tap and install Oildex oil bath air filter. Remove cover and fill to oil level hole with engine oil. Replace cover. Reinstall valve cover on engine.
2. Remove road draft tube and drill a 37/64" hole in side of vent cap at D. Tap with 3/8" pipe tap and install Oildex hose fitting. Replace road draft tube and close end at H with solid cork furnished.
3. Install Oildex mounting bracket in any convenient location as close as possible to point D.
4. Place Oildex band bracket around Oildex unit and assemble to mounting bracket with Oildex side inlet hose fitting C pointing towards D.
5. Remove air cleaner and drill a 23/32" hole in turbocharger inlet housing at B. Tap with 1/2" pipe tap and screw Oildex venturi tube into hole. When tight be sure cut-off portion is pointing towards the turbo inlet per sketch E. Replace air filter.
6. Connect Oildex side inlet hose fitting C to D with Oildex hose.
7. Connect Oildex top outlet hose fitting A to B with Oildex hose.



NOTE: On some engines it may be necessary to fabricate and install an adaptor between the air cleaner and turbocharger inlet in order to install the venturi tubes, due to lack of clearance at point B.

When using an external oil level gauge or automatic oil level regulator they must be vented back to the crankcase or valve cover.



INSTALLATION NOTES:

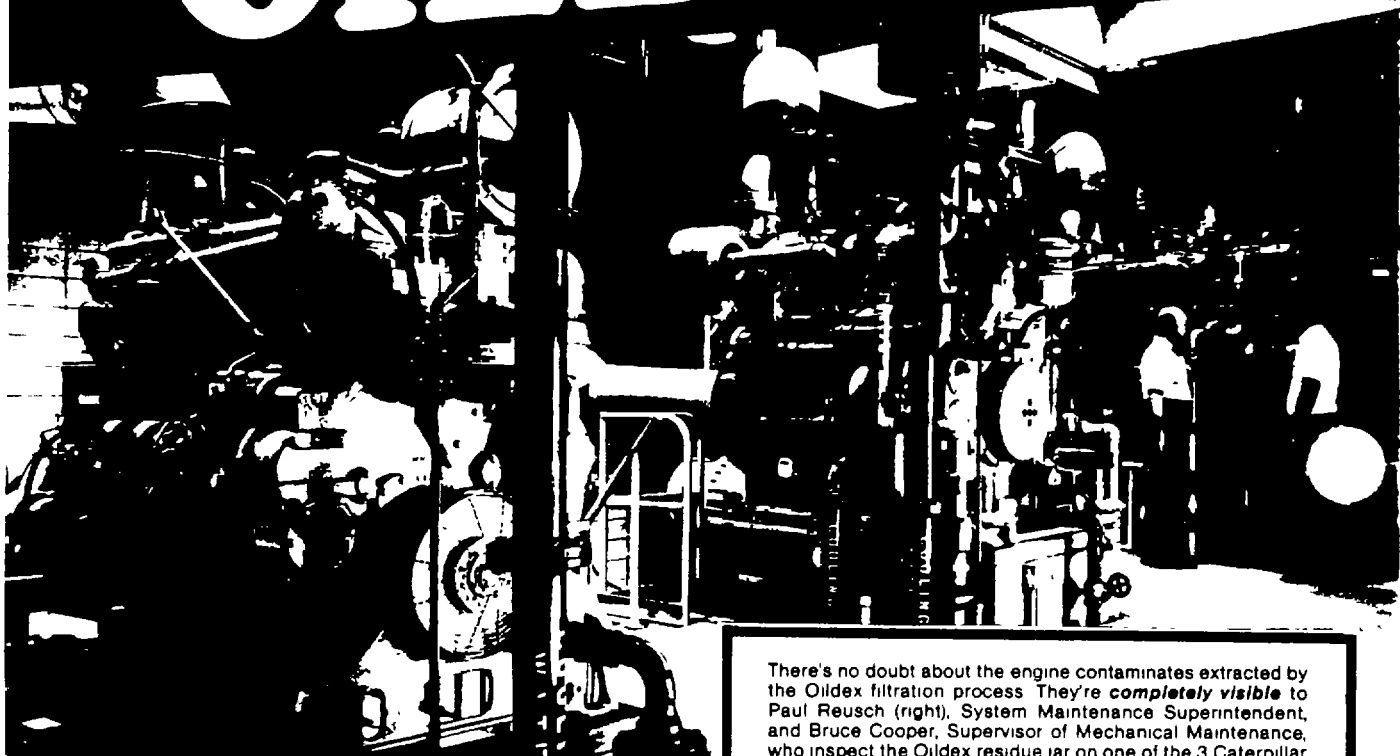
1. INSTALL OILDEX UNIT IN VERTICAL POSITION ALLOWING FOR HOOD CLEARANCE AND JAR AND ELEMENT INSPECTION AND REMOVAL.
2. MOUNT OILDEX UNIT AS CLOSE AS PRACTICAL TO INTAKE MANIFOLD USING A MINIMUM AMOUNT OF OILDEX HOSE WITHOUT SHARP BENDS.
3. START ENGINE AND RUN UNTIL NORMAL TEMPERATURE IS REACHED. ADJUST CARBURETOR IDLE AIR SCREW FOR SMOOTH IDLE. ALSO ADJUST CARBURETOR THROTTLE SCREW FOR DESIRED RPM.
4. MECHANICAL TAPPETS SHOULD BE CHECKED FOR PROPER CLEARANCE AFTER A FEW DAYS OF OPERATION WITH THE OILDEX SYSTEM.
5. CHECK FOR HOOD CLEARANCE WHEN INSTALLING OIL BATH AIR FILTER.

MATERIAL:	TOLERANCE UNLESS SPECIFIED		DATE
	DECIMAL:	DRN Y	
	FRACTIONAL:	CHECKED:	
	ANGULAR:	SCALE:	

OILDEX corporation Long Beach, California	
PART NAME- OILDEX® FILTERED AND CONTROLLED CRANKCASE VENTILATION SYSTEM for 3304 Caterpillar Turbocharged Diesel Engine and 3306	
DWG. NO.	XCAD-12T XCAD-13T

Wherever Engine Health is Absolutely Vital...

OILDEX!



THE SYSTEM THAT FILTERS OUT THE "ENGINE KILLERS"!

Bringing a continuous supply of water to the residents of arid Riverside County in Southern California is a vital need requiring pumping units driven by dependable natural gas engines. The Eastern Municipal Water District ensures an optimum degree of engine health with Oildex Filtered and Controlled Crankcase Ventilation Systems installed on every engine.

Oildex filters crankcase emissions, removing harmful acids, gums, fuel residue, carbon particles and abrasives, then, re-routes the cleansed oil vapor, gasses and steam vapor back to the induction system where they can serve a useful purpose -- providing top cylinder lubrication, dissolving carbon deposits and improving fuel economy.

The end result: extended life for the engine, plugs and oil filter elements, lower exhaust emissions, improved intake valve stem and guide lubrication, reduced crankcase pressure to help prevent leaky and blown oil seals, and all-around greater engine efficiency. The bottom line: A dependable water supply at minimum cost for the residents of Riverside County.

Oildex works on all internal combustion engines, new or used, and the savings achieved will pay for the system many times over. If you're not using Oildex, you're not getting the full potential from your engine investment. Available from your OEM or through authorized distributors. Complete information on request from Oildex Corp., P.O. Box 3755, Long Beach, CA 90803.

There's no doubt about the engine contaminants extracted by the Oildex filtration process. They're *completely visible* to Paul Reusch (right), System Maintenance Superintendent, and Bruce Cooper, Supervisor of Mechanical Maintenance, who inspect the Oildex residue jar on one of the 3 Caterpillar engines at the Mills Filtration Plant, which include a 500 h.p. G398, a 330 h.p. G379 and a 225 h.p. G342.



OILDEX®

For 48 years World Leader
in Filtered & Controlled Crankcase Ventilation

All crankcase ventilation devices help control air contamination!

Low-cost OILDEX systems improve engine health and performance at the same time!

Routing crankcase vapors into an engine's intake manifold helps reduce some sources of air pollution, but it can also contribute to air contamination when the diluents in the emission adversely affects engine performance. The Oildex system eliminates this problem to further improve air quality at the workplace. As the crankcase emissions pass through the Oildex System, acids, gums, fuel residue, carbon particles and abrasives are condensed and filtered out. Only the cleansed oil vapors, blow by gases and steam vapors are allowed to enter the induction system, through a volumetric control valve that precisely maintains the desirable amount of ventilation.

Thus the steam and light oil vapors clean and lubricate the intake valves, cylinders, equalize compression, extend plug life and generally

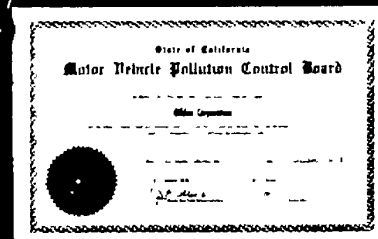
improve combustion all working to minimize exhaust emissions including CO

With the "engine killers" filtered out, engine maintenance costs are noticeably reduced, and the saving in oil, filters, plugs and fuel will quickly pay for the Oildex many times over.

Oildex works on new or old engines alike, and it's designed for use on forklift engines, industrial engines, tractors, trucks and automobiles with any type of fuels.

Right now, you can minimize the concentration of noxious elements in the air that workers breathe (and do your maintenance budget a big favor) when you protect your employees and equipment with Oildex—the originators of controlled and filtered crankcase ventilation. Available from your OEM or through authorized distributors.

FOR 40 YEARS
WORLD LEADER
IN FILTERED
& CONTROLLED
CRANKCASE
VENTILATION



The Oildex Control System is certified to meet stringent emission limits as designated in the California Administrative Code, for new and used motor vehicles.

OILDEX®

... the system that does something
for your engine ... NOT TO IT!

WRITE FOR FREE BROCHURE! For complete details on the OILDEX System of emission control and the name of your local distributor, write direct to: OILDEX Corp. P.O. Box 3755, Long Beach, California 90803

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As Advertised In **Modern Materials Handling**

Based on actual maintenance records,
**Flying Tiger Line extends engine
life on ground support equipment
by an estimated 40% with**

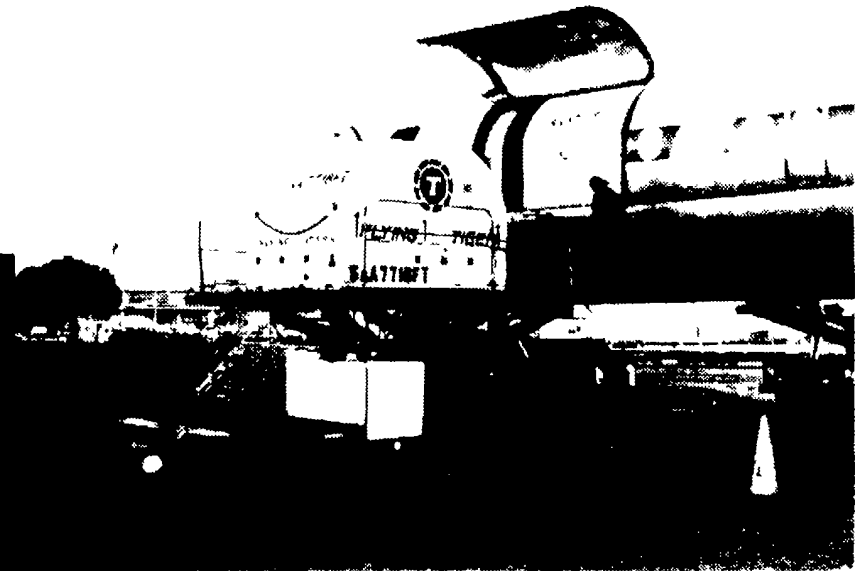
OILDEX®

... the crankcase ventilation system that
extracts the "engine killers" -- acids, gums,
fuel residue, carbon particles and abrasives!

"We don't allow malfunctions in ground equipment to hold up \$20 million aircraft," says William A. Margrave, Flying Tiger's general foreman of ground support equipment. "We've used the Oildex System for 19 years, achieving a 99.2% reliability factor on our ground equipment." Oildex is specified on every industrial engine purchased by Flying Tigers, including forklifts, motor generators, loaders and special transporters -- many of which have been in continuous around-the-clock service for as long as 7 years, still going strong.

With the "engine killers" filtered out, maintenance costs are reduced sharply, and the savings in oil, filters, plugs and fuel quickly pay for the Oildex many times over. Oildex works on new and old engines alike, regardless of fuel type. Get the facts on Oildex today. You can minimize the exhaust emissions, improve combustion and give engines a new lease on life when you install Oildex -- the originator of controlled and filtered crankcase ventilation. Available through your OEM or authorized distributor. For FREE brochure, write direct to OILDEX Corp., P.O. Box 3755, Long Beach, CA 90803.

**FOR 40 YEARS LEADER IN
FILTERED & CONTROLLED CRANKCASE VENTILATION**



Flying Tigers extend engine life by installing the Oildex System on forklifts, transporters and loaders as well as passenger vehicles everywhere they operate around the world.



**OILDEX® ORIGINATORS OF FILTERED AND CONTROLLED CRANK CASE VENTILATION
INSTALLATION INSTRUCTIONS - READ CAREFULLY**

1. Remove rear valve cover and using an H-24 hole saw cut one hole at D. With a soft hammer drive in Oildex vent tube with baffles. Install Oildex hose fitting in cap and install over end of vent tube. Replace valve cover.
2. Remove road draft tube assembly and cut a 1-1/8" hole at G. Weld the Oildex adapter over hole and replace road draft tube assembly. Install KN-5 air filter over adapter and secure in place with hose clamp.

Close road draft tube end at H with solid cork furnished.

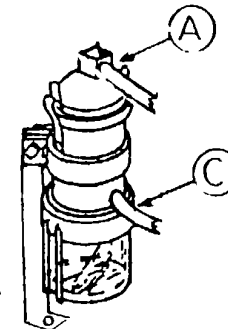
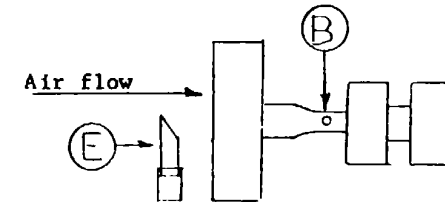
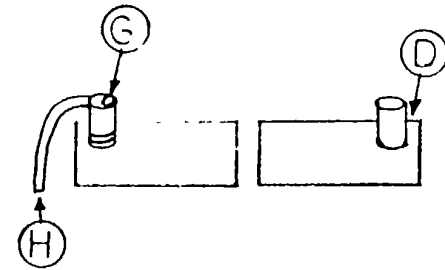
3. Install Oildex mounting bracket in any convenient location as near to D as practical. Place Oildex band bracket around Oildex unit and assemble to mounting bracket with Oildex side inlet hose fitting pointing towards D.
4. Remove air cleaner. Drill a 3/4" hole in tube between air cleaner and the turbocharger inlet at B. Install venturi tube in hole with cut-off side pointing towards the turbocharger inlet. Braze, weld or silver solder the tube into place. Replace air cleaner.

5. Connect Oildex side inlet hose fitting C to D with Oildex hose.
6. Connect Oildex top outlet hose fitting A to B with Oildex hose.

NOTE: On some engines it may be necessary to fabricate and install an adaptor between the air cleaner and turbocharger inlet in order to install the venturi tube, due to lack of clearance at point B.

NOTE: DRIVE BAFFLED VENT TUBES INTO VALVE COVER FROM UNDERNEATH SIDE, IN ITEM 1 ABOVE. WELD IN PLACE.

When using an external oil level gauge or automatic oil level regulator they must be vented back to the crankcase or valve cover.



INSTALLATION NOTES:

1. INSTALL OILDEX UNIT IN VERTICAL POSITION ALLOWING FOR HOOD CLEARANCE AND JAR AND ELEMENT INSPECTION AND REMOVAL.
2. MOUNT OILDEX UNIT AS CLOSE AS PRACTICAL TO INTAKE MANIFOLD USING A MINIMUM AMOUNT OF OILDEX HOSE WITHOUT SHARP BENDS.
3. START ENGINE AND RUN UNTIL NORMAL TEMPERATURE IS REACHED. ADJUST CARBURETOR IDLE AIR SCREW FOR SMOOTH IDLE. ALSO ADJUST CARBURETOR THROTTLE SCREW FOR DESIRED RPM.
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5. CHECK FOR HOOD CLEARANCE WHEN INSTALLING OIL BATH AIR FILTER.

MATL:

TOLERANCE UNLESS SPECIFIED		DATE
DECIMAL:	FRN:	Y
FRACTIONAL:	CHECKED:	

OILDEX corporation Long Beach, California	
PART NAME - OILDEX® FILTERED AND CONTROLLED CRANKCASE VENTILATION SYSTEM	
for 3406 Caterpillar Turbocharged Diesel Engine	
DWG. NO. XCAD-14T	

OILDEX® - How it Operates...

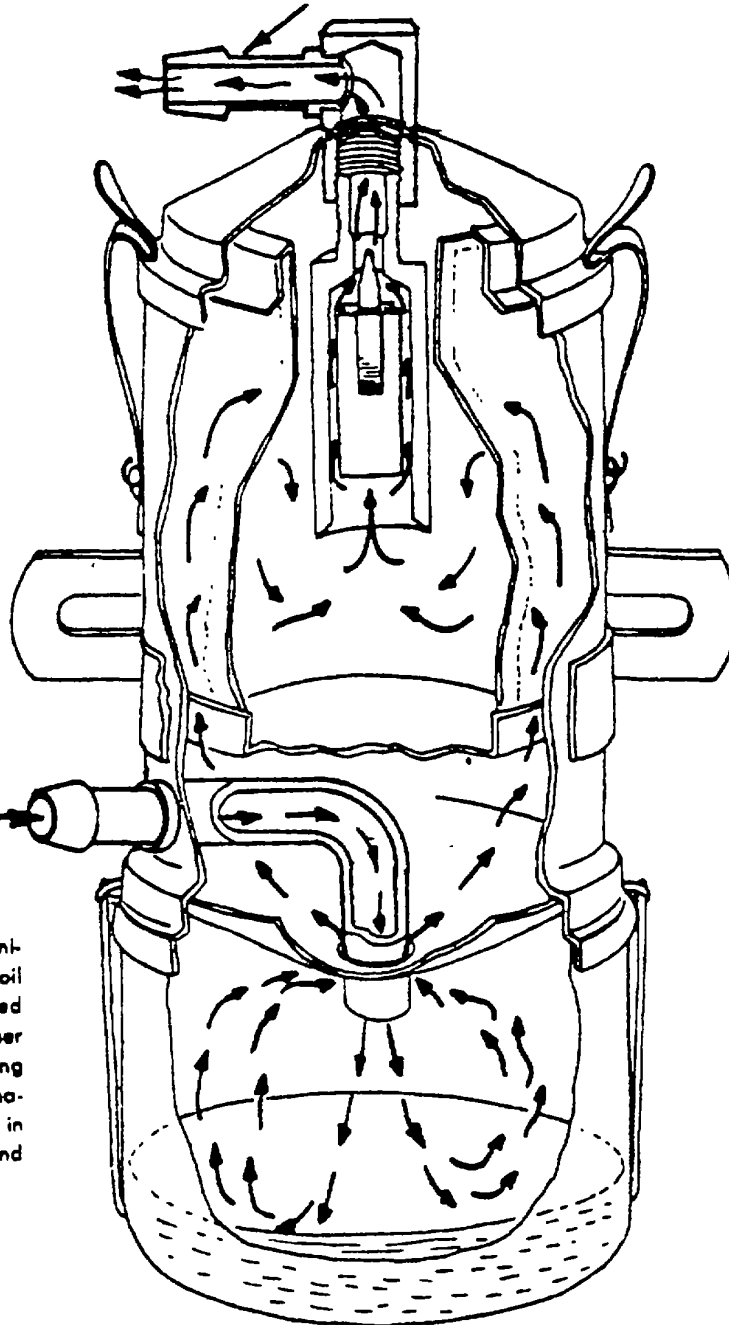
OUTLET TO MANIFOLD

● OILDEX GIVES CONTROLLED CRANKCASE VENTILATION AT ALL SPEEDS.

OILDEX is designed and engineered for the purpose of removing diluent vapors from the crankcase before they condense into damaging liquid impurities. OILDEX extracts, then filters these vapors and returns them through the OILDEX Volumetric control valve to the cylinders where they are utilized.

INLET FROM CRANKCASE

OILDEX retards the contamination of the crankcase oil by water, acid, unburned gasoline, varnish and other impurities — thus preventing the formation of carbonaceous materials; resulting in the relief of sticky valves and rings.



The "escalator," or up-and-down action of valve linear accurate, controlled crankcase ventilation, at both idle and high speed.

NOTE: Spring loaded valve not shown

Vapor Filtering Element removes carbonaceous materials, allowing the metering valve to operate freely. Keeps harmful varnish and other materials from clogging intake manifold and interrupting air ratio of carburetor to engine.

Baffle plate acts as a secondary retention to vapors from the crankcase, resulting in increased element life.

Retention chambers for unburned vapors and varnish which are drawn from crankcase while in vapor form.

Detects porous blocks or blown gaskets by extracting excessive water.

OILDEX/corporation

By Order of the Secretary of the Army:

GORDON R SULLIVAN
General, United States Army
Chief of Staff


Official:

MILTON H. HAMILTON
Administrative Assistant to the
Secretary of the Army
06960

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The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
 1 decimeter = 10 centimeters = 3.94 inches
 1 meter = 10 decimeters = 39.37 inches
 1 dekameter = 10 meters = 32.8 feet
 1 hectometer = 10 dekameters = 328.08 feet
 1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
 1 decigram = 10 centigrams = 1.54 grains
 1 gram = 10 decigram = .035 ounce
 1 decagram = 10 grams = .35 ounce
 acres
 1 hectogram = 10 decagrams = 3.52 ounces
 1 kilogram = 10 hectograms = 2.2 pounds
 1 quintal = 100 kilograms = 220.46 pounds
 1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliliters = .34 fl. ounce
 1 deciliter = 10 centiliters = 3.38 fl. ounces
 1 liter = 10 deciliters = 33.81 fl. ounces
 1 dekaliter = 10 liters = 2.64 gallons
 1 hectoliter = 10 dekaliters = 26.42 gallons
 1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
 1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
 1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
 1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
 1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47
 1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
 1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
 1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

<i>To change</i>	<i>To</i>	<i>Multiply by</i>	<i>To change</i>	<i>To</i>	<i>Multiply by</i>
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29,573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

Temperature (Exact)

°F	Fahrenheit	5/9 (after	Celsius	°C
	temperature	subtracting 32)	temperature	

