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CHAPTER 533

POTABLE WATER SYSTEMS

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TABLE OF CONTENTS

CHAPTER 533
POTABLE WATER SYSTEMS

SECTION 1. GENERAL

Paragraph		Page
533−1.1	INTRODUCTION	1−1
533−1.1.1	SCOPE	1−1
533−1.1.2	POTABLE WATER SYSTEMS	1−1
533−1.1.3	DISINFECTING POTABLE WATER	1−1
533−1.1.3.1	Disinfecting Surface Ship Potable Water	1−1
533−1.1.3.2	Disinfecting Submarine and Service Craft Potable Water	1−1
533−1.1.4	REFERENCES	1−1
533−1.2	RESPONSIBILITIES	1−1
533−1.2.1	SHORE STATION COMMANDING OFFICER	1−1
533−1.2.2	SHIP OFFICERS	1−1
533−1.2.2.1	Engineer Officer	1−1
533−1.2.2.2	Medical Officer	1−2

SECTION 2. DESCRIPTION, OPERATION, AND SAFETY PRECAUTIONS

533−2.1	FILLING SYSTEM	2−1
533−2.1.1	GENERAL	2−1
533−2.1.2	FILL CONNECTIONS	2−1
533−2.1.3	HOSES	2−1
533−2.1.4	RELIEF VALVES	2−1
533−2.2	STORAGE SYSTEM	2−1
533−2.2.1	STORAGE TANKS	2−1
533−2.2.2	DELIVERY TO THE DISTRIBUTION SYSTEM	2−1
533−2.2.3	POTABLE WATER PIPING MAINTENANCE	2−1
533−2.2.4	REPAIRS	2−6
533−2.3	DISTRIBUTION SYSTEM	2−6
533−2.3.1	IDENTIFICATION	2−6
533−2.3.2	MAINTENANCE	2−6
533−2.3.3	CROSS−CONNECTIONS	2−6
533−2.3.3.1	Air Gaps	2−6
533−2.3.3.2	Approved Devices	2−6
533−2.3.4	TEMPORARY HOSE CONNECTIONS	2−6
533−2.3.5	APPROVED HOSE CONNECTIONS	2−6
533−2.3.5.1	Sink Hose Vacuum Breaker	2−6
533−2.3.5.2	Laboratory and Shop Sink Hose Vacuum Breakers	2−6
533−2.3.5.3	Permanent Direct Connections	2−7
533−2.3.5.4	Nonpotable Water Systems	2−7
533−2.3.6	SOUNDING TANKS	2−7
533−2.3.7	WATERHEATERS	2−7
533−2.4	DESALINATORS	2−7
533−2.4.1	GENERAL	2−7
533−2.4.2	POLLUTED WATER	2−7

TABLE OF CONTENTS (Continued)

Paragraph		Page
533−2.4.3	OPERATION IN SEAWATER	2−8
533−2.4.4	OPERATION IN FRESH OR BRACKISH WATER	2−8
533−2.4.5	OPERATION IN POLLUTED WATER	2−8
533−2.4.6	DISINFECTION OF DISTILLED WATER ON SURFACE SHIPS	2−8

SECTION 3. DISINFECTION AND CLEANING

533−3.1	INTRODUCTION	3−1
533−3.1.1	GENERAL	3−1
533−3.1.2	POTABLE WATER DISINFECTION	3−1
533−3.1.2.1	Halogen Residual	3−1
533−3.1.2.2	Halogen Treatment	3−1
533−3.1.2.3	Effect of pH on Disinfection	3−1
533−3.1.2.4	Doubtful Potable Water Quality	3−1
533−3.1.2.5	Approved Sources	3−1
533−3.2	EMERGENCY POTABLE WATER	3−1
533−3.2.1	GENERAL	3−1
533−3.2.2	EMERGENCY POTABLE WATER TREATMENT	3−2
533−3.2.3	ADDITIONAL EMERGENCY POTABLE WATER SOURCE	3−2
533−3.3	REQUIRED HALOGEN RESIDUALS FOR SUBMARINES AND SERVICE CRAFT	3−2
533−3.4	SPECIAL HALOGEN HANDLING AND STORAGE REQUIREMENTS	3−2
533−3.4.1	GENERAL	3−2
533−3.4.2	CALCIUM HYPOCHLORITE	3−2
533−3.4.3	BROMINE CARTRIDGES	3−3
533−3.4.4	BROMINE CARTRIDGE STORAGE	3−3
533−3.4.5	BROMINE CARTRIDGE READY SERVICE LOCKERS	3−3
533−3.4.6	BROMINATOR HOSE STATION	3−3
533−3.4.7	BROMINATOR WARNING PLATE	3−3
533−3.5	METHODS OF DISINFECTING POTABLE WATER	3−3
533−3.5.1	TREATMENT METHODS	3−3
533−3.5.1.1	Brominator Disinfection Method	3−3
533−3.5.1.2	Brominators, Miscellaneous	3−6
533−3.5.2	CHLORINE DISINFECTION METHOD	3−9
533−3.5.2.1	Chlorinator Method	3−9
533−3.5.2.2	Chlorine Batch Method	3−9
533−3.5.2.3	Disinfection of Hose and Hose Components	3−12

SECTION 4. POTABLE WATER SYSTEM MONITORING

533−4.1	HALOGEN RESIDUAL TEST	4−1
533−4.2	RESIDUAL DECLINE	4−1
533−4.3	HALOGEN RESIDUAL TESTING REQUIREMENTS	4−1
533−4.3.1	GENERAL	4−1
533−4.3.2	MEDICAL DEPARTMENT	4−1
533−4.3.3	ENGINEERING DEPARTMENT	4−1
533−4.3.4	SAMPLE TAKING	4−1
533−4.3.5	RESIDUAL TEST METHOD	4−1
533−4.4	HALOGEN RESIDUAL TEST EQUIPMENT	4−2
533−4.4.1	GENERAL	4−2

TABLE OF CONTENTS (Continued)

Paragraph		Page
533−4.4.2	DETERMINING HALOGEN RESIDUAL OF WATER RECEIVED FROM SHORE	4−2
533−4.4.3	RESIDUAL CHLORINE	4−2

LIST OF ILLUSTRATIONS

Figures **Page**

Figures		Page
533−2−1	Pumping System Installation for Large Surface Ships.	2−2
533−2−2	Pumping System Installation for Small Surface Ships.	2−3
533−2−3	Vacuum Priming Installation for Surface Ships.	2−4
533−2−4	Potable Water System Arrangement for Submarines.	2−5
533−3−1	Warning Plate for Bromine Cartridge Stowage Lockers	3−3
533−3−2	Warning Plate for Brominator	3−4
533−3−3	Distilling Plant Brominator, Dual Feed	3−5
533−3−4	Recirculation Brominator System	3−7
533−3−5	Distilling Plant Chlorinator Installation	3−10
533−3−6	Combined Distilling Plant and Shore Filling Chlorinator Installation	3−11

LIST OF TABLES

Tables		Page
533−1−1	REFERENCES	1−2
533−3−1	LIST OF REQUIRED HALOGEN RESIDUALS	3−2
533−3−2	RATE OF BROMINE RELEASE BY WATER TEMPERATURE FOR AUTOMATIC PROPORTIONING BROMINATORS	3−8
533−3−3	QUANTITY (TEASPOONS) OF HALOGEN REQUIRED FOR CHEMICAL DISINFECTION	3−12
533−3−4	CHLORINE DOSAGE CALCULATOR	3−12

CHAPTER 533. POTABLE WATER SYSTEMS

SECTION 1. GENERAL

533−1.1 INTRODUCTION

533−1.1.1 SCOPE. This chapter provides information to shipboard personnel operating potable water systems. This system is often called the freshwater system. This identification is not correct, because fresh water is not potable unless it is safe for human consumption. This chapter will cover the measures and precautions that shall be taken to maintain the quality of water in the potable water system. Only by ensuring acceptable potable water quality can the health of the crew be protected. For shipboard service, knowledge of system requirements and operation is essential. Reference shall be made to the applicable Ship Information Books (SIB) and technical manuals for detailed information on the potable water system and its components.

533−1.1.2 POTABLE WATER SYSTEMS. The potable water system varies greatly from ship−to−ship with respect to size, arrangement, and operation of components. In the following list, items a through d are common to all ships; items e and f are common to most ships:

a. An arrangement that will allow shore water to be taken onboard for storage, distribution, or both

b. Storage capabilities

c. A method of delivering water from storage tanks to distribution system

d. A method of distributing water to various outlets on the ship

e. The capability of distilling seawater to make fresh water

f. The capability of treating fresh water to make it potable.

533−1.1.3 DISINFECTING POTABLE WATER. Because water may be contaminated by disease−causing micro−organisms during production, handling, storage, or distribution, it must be disinfected prior to consumption. Treatment with a halogen, normally chlorine or bromine, is the only approved method for disinfecting potable water. Submarines and service craft are not equipped to use the halogen treatment method, but are provided with emergency methods to treat fresh water.

533−1.1.3.1 Disinfecting Surface Ship Potable Water. Potable water is defined as water that is suitable for human consumption. Potable water is produced aboard ships and is received from shore facilities. This water must be disinfected before consumption to inactivate disease carrying microorganisms called pathogens. Contamination may occur during production, handling, storage, or distribution. Current Navy disinfection practice requires the introduction of a disinfecting halogen (i.e., chlorine, bromine). The use of a halogen is preferred to other common disinfection techniques because residual (trace, excess) halogen levels can be easily detected and maintained.

533−1.1.3.2 Disinfecting Submarine and Service Craft Potable Water. Submarines and service craft are not equipped to use the halogen treatment systems, but are provided with emergency methods to treat fresh water.

533−1.1.4 REFERENCES. References given in this chapter are listed in Table 533−1−1.

533−1.2 RESPONSIBILITIES

533−1.2.1 SHORE STATION COMMANDING OFFICER. The shore station Commanding Officer is responsible for the delivery of potable water from shore station to ship. The Commanding Officer shall ensure that trained shore personnel make all water connections, that the potable water contains a trace of chlorine, and that all shore connection components are correctly used, supplied, maintained, and marked.

533−1.2.2 SHIP OFFICERS. The ship's Engineer and Medical Officers are responsible for the receipt, distribution, and quality testing of potable water.

533−1.2.2.1 Engineer Officer. The ship's Engineer Officer is responsible to the ship's Commanding Officer for the supply and treatment of potable water and for the system components that receive, store, distribute, produce, and treat potable water. The Engineer Officer shall ensure that all ship−to−shore connections are made only by trained shore personnel, when available, or in their absence, ship personnel who are properly supervised by authorized shore personnel; and that all connections required for ship−to−ship potable water transfer are made by personnel trained in handling potable water. In addition, the Engineer Officer is responsible for the chloride and hydrogen ion (pH) testing of the ship's potable water.

533−1.2.2.2 Medical Officer. The ship's Medical Officer or medical department representative is responsible to the ship's Commanding Officer for the quality testing (except for chloride and pH testing) and monitoring of potable water handling, treatment, and storage.

a. The Medical Officer shall evaluate the adequacy of treatment and disinfection of the shore potable water prior to its receipt, and shall ensure that the required halogen residual is present in the potable water and that no potable water hose is connected to a nonpotable water system.

b. Medical Department personnel shall be guided by NAVMED Instruction 6240.1, **Standard for Potable Water**; NAVMED P−5010−5, **Manual of Preventive Medicine−Water Supply Ashore**; and NAVMED P−5010−6, **Manual of Preventive Medicine−Water Supply Afloat.**

Table 533−1−1. REFERENCES

Title	Publication Number
Inspections, Tests, Records and Reports	NSTM Chapter 090
Boiler Water/Feedwater	NSTM Chapter 220
Piping Systems	NSTM Chapter 505
Distilling Plants Low Pressure	NSTM Chapter 9580
Submerged Tube Steam Plants Preservation of Ships In Service — Surface Preparation and Painting	NSTM Chapter 631 (Vol 2)
Stowage, Handling, and Disposal of Hazardous General Use Consumables	NSTM Chapter 670
Manual of Naval Preventive Medicine — Water Supply Ashore	NAVMED P−5010−5
Manual of Naval Preventive Medicine — Water Supply Afloat	NAVMED P−5010−6
Standards for Potable Water	NAVMED INST 6240.1

SECTION 2. DESCRIPTION, OPERATION, AND SAFETY PRECAUTIONS

533−2.1 FILLING SYSTEM

533−2.1.1 GENERAL. Shore−to−shore and ship−to−ship potable water filling functions shall be performed by trained personnel using hoses, hose valve connections, relief valves, piping, and valves arranged so as to permit potable water to be directed either to the distribution potable water tanks for storage and (if required) treatment. Hoses and fittings shall be handled so that they will not be immersed in nonpotable water at any time, having due regard for tidal fluctuations while filling is in progress. The components of the filling system are described in paragraphs 533−2.1.2 through 533−2.1.4.

533−2.1.2 FILL CONNECTIONS. Potable water fill connections are 2−1/2−inch hose valves for large ships and 1−1/2 inches for smaller ships. Fill lines for potable water shall not be cross− connected with any nonpotable waterline or system. If not in use, filling connections shall be closed with screwcaps attached with keeper chains. connections shall be at least 18 inches above the deck with the receiving connection turned down to protect it from contamination. Filling connections shall be conspicuously designated by a warning plate bearing the inscription **POTABLE WATER ONLY** in 1−inch letters.

533−2.1.3 HOSES. Hoses shall be labeled **POTABLE WATER ONLY** at 10-foot intervals. Potable water hoses shall be used to transfer potable water only. Hoses shall be kept in good condition at all times, examined routinely, and removed from service if cracks develop in the lining. Cracks in lining are usually caused by normal deterioration and stress. They shall be stored with the ends coupled or closed with screw−type caps, in padlocked, vermin− proof lockers or cabinets. Lockers shall be identified and labeled Potable Water Hose. Lockers shall be located out of the weather, if practical, and at least 18 inches off the deck. Printed instructions outlining step−by−step procedures for disinfection of potable water hoses shall be posted in a conspicuous location in the hose storage area. Potable water hoses shall be used to transfer potable water only, and for no other purpose. Disinfection of hoses and valves is described in paragraph 533−3.5.2.3.

533−2.1.4 RELIEF VALVES. Relief valves are provided on the filling piping to limit and protect the plumbing systems fixture valves from overpressure, and on potable water tanks or the filling manifold, to protect the tanks from overpressure if filling from shore. Relief valve settings should be checked in accordance with the Planned Maintenance System (PMS) and Ship Information Book (SIB).

533−2.2 STORAGE SYSTEM

533−2.2.1 STORAGE TANKS. Although potable water tanks are constructed and situated to prevent content contamination, they may be innerbottom or skin tanks or they may have a common bulkhead with ballast tanks, fuel tanks, or other storage spaces. Special attention shall be given to monitoring and maintaining the quality of the potable water in these tanks because of their susceptibility to contamination. Potable water tanks shall be inspected in accordance with **NSTM Chapter 090, Inspections, Tests, Records, and Reports**, and shall be coated in accordance with **NSTM Chapter 631 (Vol 2), Preservation of Ships In Service — Surface Preparation and Painting**. Tank disinfection is described in paragraph 533−3.1.2.

533−2.2.2 DELIVERY TO THE DISTRIBUTION SYSTEM. Surface ships use either constantly running pumps or a pressure set to move potable water from storage tanks to distribution system. If potable water tanks are low in the ship, in relation to pump elevation, the pump is equipped with a vacuum priming system. A pumping system installation for a large surface ship is shown in Figure 533−2−1. An installation for a small surface ship is shown in Figure 533−2−2; note the use of pressure sets. A vacuum priming installation is shown in Figure 533−2−3. Compressed air is usually employed on submarines to charge the potable water tanks and to deliver the water to the distribution system. A potable water system arrangement for submarines is shown in Figure 533−2−4.

533−2.2.3 POTABLE WATER PIPING MAINTENANCE. Special consideration shall be given to piping installed in the bilge area, particularly piping on the suction side of potable water pumps. Because this piping is subject to immersion in bilge water, any leakage will result in contamination. This piping shall be hydrostatically tested in accordance with the PMS, and kept in good, sound, working order. All potable water piping that is normally pressurized shall also be kept in good working order because the piping may occasionally lose pressure, or be under no pressure which could allow contaminated water to enter the pipes.

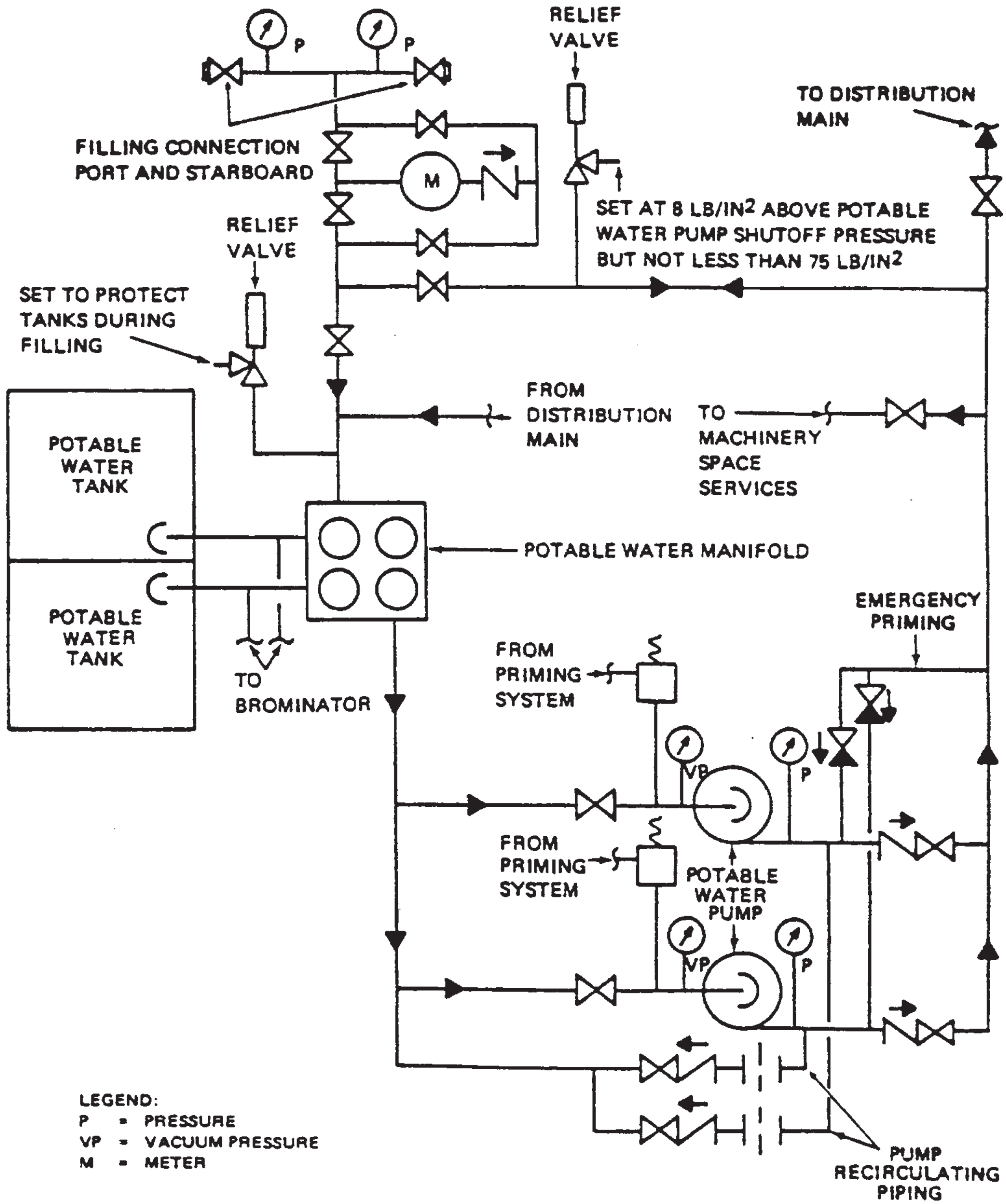

Figure 533−2−1. Pumping System Installation for Large Surface Ships.

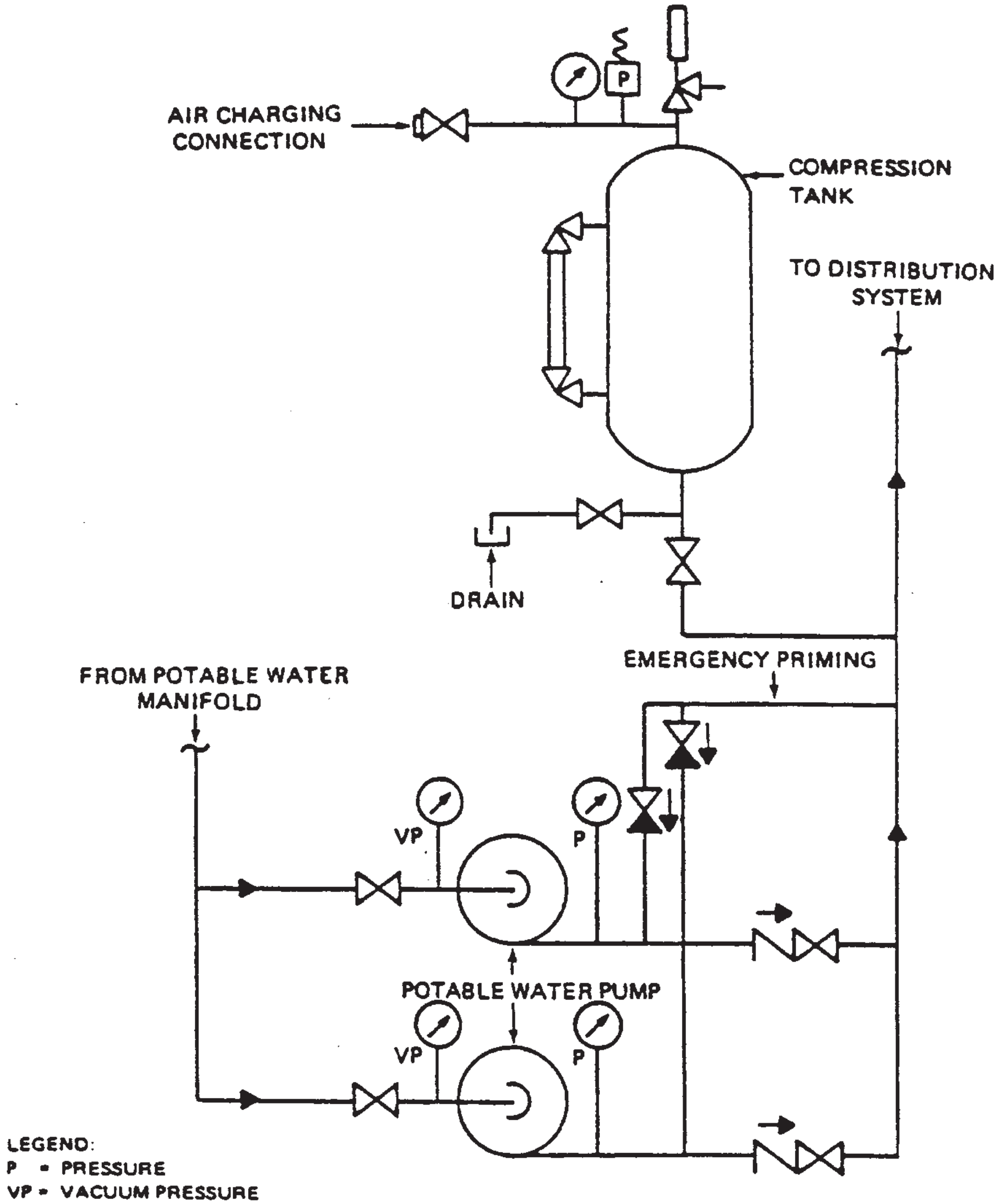

Figure 533−2−2. Pumping System Installation for Small Surface Ships.

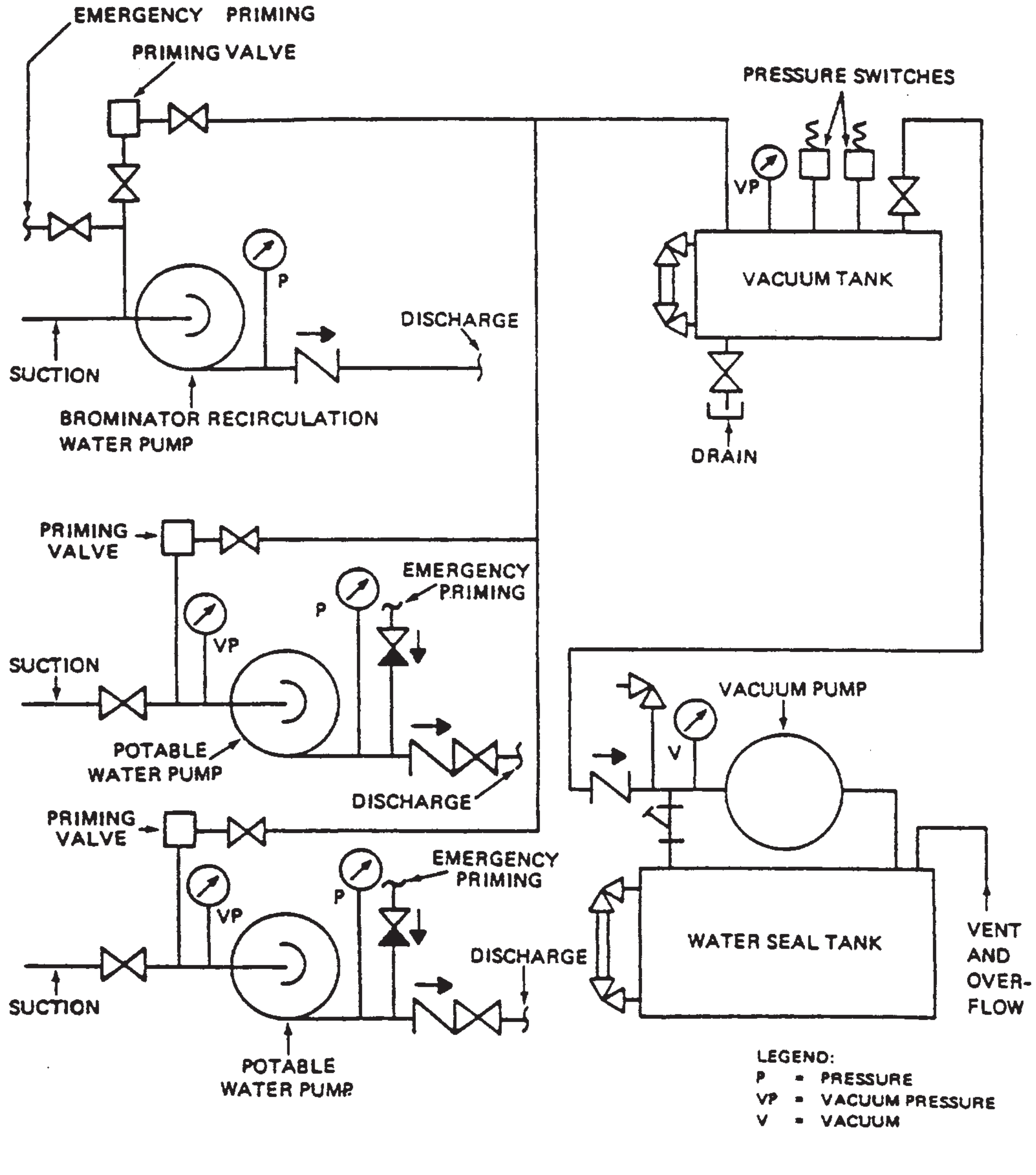

Figure 533−2−3. Vacuum Priming Installation for Surface Ships.

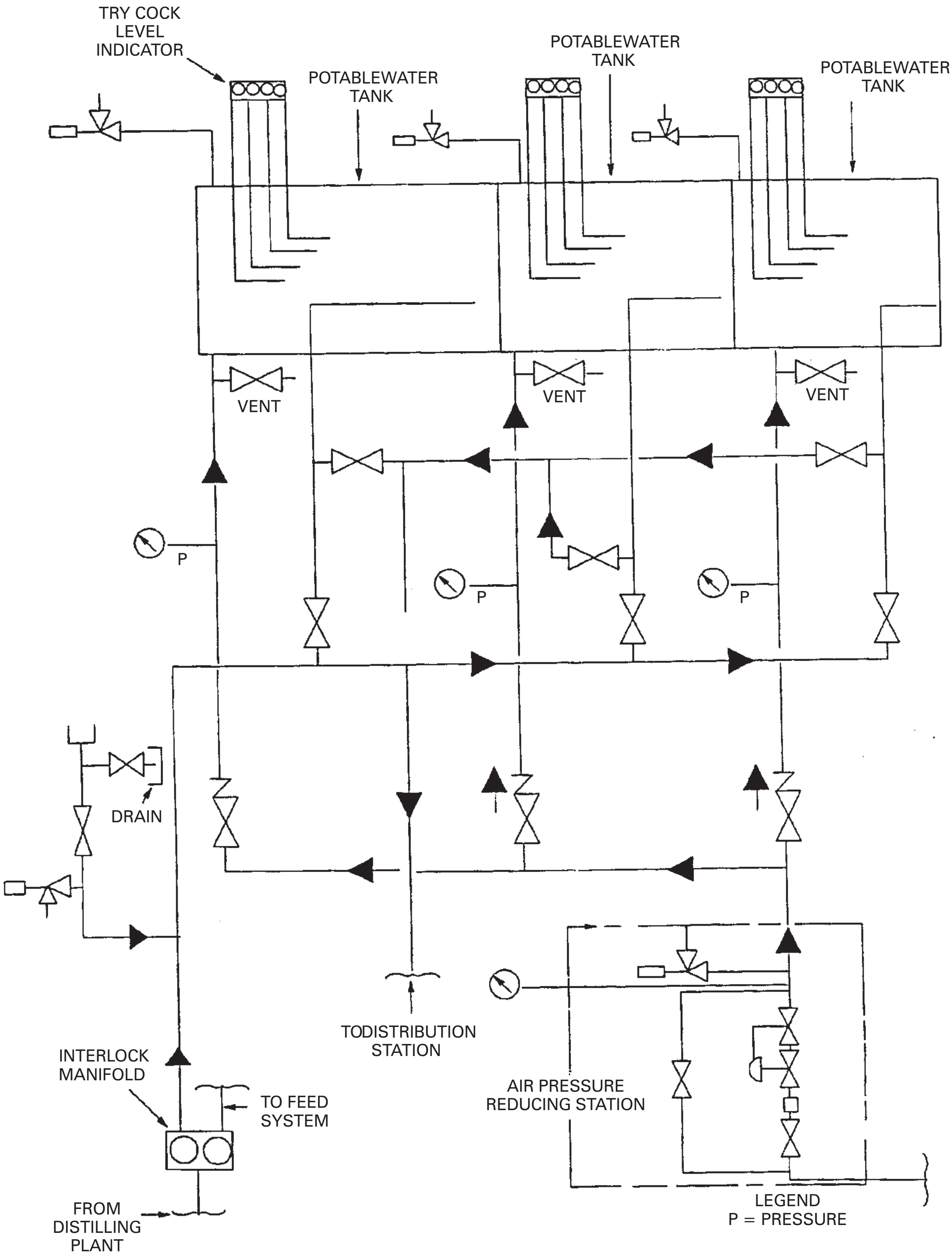

Figure 533−2−4. Potable Water System Arrangement for Submarines.

WARNING

Lead−containing materials, such as putty and white lead, are hazardous to personnel and shall not be used for piping repairs nor for buttering−up flanged or threaded joints.

533−2.2.4 REPAIRS. Piping repairs and buttering−up of flanged and threaded joints shall be done with a silicone compound. Silicone [Dow Corning's SILASTIC 738RTV, 3−ounce tube National Stock Number (NSN) 8040−00−118−2695] shall be used.

533−2.3 DISTRIBUTION SYSTEM

CAUTION

If operating a pumping system using a constantly pump, make certain that the pump recirculation valve open and directed toward the suction side of the operating pump or to the tank from which the pump is taking suction. This will prevent the pump from overheating if water is not being drawn off the system and the accidental pumping of water from one tank to another through the recirculation piping.

533−2.3.1 IDENTIFICATION. Potable water is distributed to the plumbing fixtures, hot potable water system, and other systems that require potable water by means of piping from the potable water tanks and pumps, or from the shore−filling connections while in port. All piping, hoses, valves, and other connections shall be distinctly identified in accordance with **NSTM Chapter 505, Piping Systems**. The components of the distribution system are described in paragraph 533−2.3.2 through 533−2.3.7.

533−2.3.2 MAINTENANCE. The piping, piping components, and plumbing fixtures shall be kept in sound, leakproof condition to conserve water and prevent contamination. All ship faucets shall be kept leak−free to conserve water (or water rationing may result) and to maintain pressure (or personnel may be delayed in using wash facilities).

533−2.3.3 CROSS−CONNECTIONS. Cross−connections between potable and seawater systems, or connections to other systems that could contaminate the potable water system are not permitted. Valves and blind flanges are not an acceptable means of separating potable water from the other systems. Potable water shall not be delivered to other systems, tanks, or facilities that could contain water of an inferior quality, unless an air gap or approved device that will prevent backflow and siphonage is provided.

533−2.3.3.1 Air Gaps. The installation and maintenance of an air gap is the best method of insuring that the potable water system does not become contaminated. An adequate air gap is defined as a distance of two supply pipe diameters between the supply pipe and the maximum (overflow) level in the receiver. The placement of faucets above the rims of sinks, steam kettles, potato peelers, and other open receivers provides an adequate air gap. Adequate air gaps are designed into most dishwashers and laundry machines. However, before a new machine is installed, the adequacy of the air gap shall be confirmed.

533−2.3.3.2 Approved Devices. All devices that are used in place of an air gap shall be approved by the Foundation for Cross− Connection Control and Hydraulic Research or the American Society of Sanitary Engineers.

533−2.3.4 TEMPORARY HOSE CONNECTIONS. All potable water hoses are to be disconnected, except when in actual use, to prevent any possible backflow. A warning label plate shall be installed in a conspicuous location at each potable water hose connection inscribed Disconnect Hose When Not In Use in 1−inch high red letters. In addition, potable water hose connections made to tanks or systems that may subject the potable water system to positive pressure (no matter how small) when the potable water branch cutout valves are closed, shall be manned at all times when connected and in use. Upon completion of the use, the hose shall be disconnected.

533−2.3.5 APPROVED HOSE CONNECTIONS. Do not connect hoses to potable water systems except with approved hose connections. Approved hose connections are those equipped with a cutout valve, a vacuum−breaker backflow preventer, and a hose connection; installed in that order from the potable water system. These components shall be installed so that they cannot be submerged in any liquid.

533−2.3.5.1 Sink Hose Vacuum Breaker. All sink and space faucets with hose threads shall be equipped with a hose connection vacuum breaker, NSN 4820−00−164−3377.

533−2.3.5.2 Laboratory and Shop Sink Hose Vacuum Breakers. Laboratory and shop sink faucets with smaller hose connections shall be equipped with approved hose vacuum breakers or a vacuum breaker, NSN 4510−01−052−2809 for 3/8−inch Navy Primary Standards (NPS) or NSN 4820−01−019−8967 for 1/2−inch NPS, installed at least 6 inches above the overflow level of the sink.

533−2.3.5.3 Permanent Direct Connections. Permanent direct connections to dishwashing machines that are not equipped with an air gap, and to garbage disposal units, urinals, water closets, grease interceptor hoods, or X−ray and photographic equipment shall be made by way of an approved atmospheric or continuous pressure vacuum breaker, or continuous pressure backflow preventor with internal relief at atmosphere, NSN 4820−00−422−9494 for 1/2− inch NPS, installed at least 6 inches above the overflow the unit services. No back pressure of any kind is allowed on the downstream side of these devices. Permanent direct connections to any nonpotable water tank or piping that can subject the potable water piping to any positive back pressure, no matter how small, can only be made with approved reduced pressure backflow preventors. This restriction applies to expansion tanks for freshwater cooling systems. All freshwater cooling systems are considered contaminated. Some systems (for example, the diesel engine jacket water−cooling system) contain poisonous rust inhibitors. Placement of the potable water connection above normal or high water levels in an expansion tank will not produce an adequate air gap.

533−2.3.5.4 Nonpotable Water Systems. Potable water systems downstream of reduced pressure backflow preventers are considered contaminated. All outlets downstream of these backflow preventers must be labeled with a warning placard indicating that the water is contaminated. Large photographic shops on aircraft carriers and tenders may have nonpotable water systems.

533−2.3.6 SOUNDING TANKS. All potable water tank sounding tubes shall be provided with valves or caps and with padlocks. The valve or cap shall be locked closed when not in use. The sounding tube shall have a label plate.

WARNING

The temperature of hot water supplied for the personal use of the crew shall not exceed 54.4°C (130°F) to prevent hot water burns.

533−2.3.7 WATERHEATERS. Potable water heaters shall be set and periodically checked and reset, if necessary, to maintain temperatures no greater than 54.4°C (130°F) at the nearest connected plumbing fixture delivering water for personal use. Heaters shall be set to deliver water at no less than 71.1°C (160°F) to galley grease interceptor hoods and pot sanitizing sinks, and no less than 82.2°C (180°F) for service to galley dishwashers and laundry machines that are not provided with their own integral booster heaters. Under no circumstances, however, shall heaters be permitted to allow water above 54.4°C (130°F) to be delivered to any shower or lavatory. Serious hot water burns can occur if this requirement is not strictly adhered to and the water heaters are not routinely checked. Hot water burn accidents occur more readily onboard ship than on shore due to changes in supply steam conditions, periodic interruptions in water supply, and because the motion of the ship may cause them to open wider. These personnel would not be burned during these circumstances if the water heaters are set properly. If at nay point in the system hot water is not delivered at a temperature of at least 48.9°C (120°F), and the heater is set properly, then a design deficiency may exist. Check the condition of the insulation around the supply piping and heater, then perform the prescribed PMS procedures. If everything appears to be in order, then report the discrepancy through normal channels to any U.S. Navy design activity. Include the name plate data of the heater, the heater outlet temperature and the temperature observed at the fixture, and the number and types of fixtures connected to that heater.

533−2.4 DESALINATORS

533−2.4.1 GENERAL. Distillers produce fresh water from seawater for use in boiler make-up, electronic cooling and potable water. Reverse Osmosis (RO) desalinators produce fresh water for potable water and, combined with a second RO stage or a demineralizer, produce higher grade water for boiler make-up and electronic cooling. The product water from a distiller is called “distillate,” whereas the RO product water is referred to as “permeate.”It helps to call the distillate or permeate “product water” before it enters the brominator for treatment, and “potable water” after the brominator.

533−2.4.1.1 Distillate purity is less than 2.3 parts per million (ppm) chloride ions, which equals 4.6 ppm Total Dissolved Solids (TDS). (4.6 ppm TDS = 9.2 micromhos/cm.) The permeate from a single stage RO unit ranges in purity from between 350 to 500 ppm TDS. The upper limit for potable water is 500 ppm TDS. For additional information refer to **NSTM Chapter 531, Desalination Reverse Osmosis Desalination Plants**, Volume 1, 2 & 3.

533−2.4.2 POLLUTED WATER. Unless determined otherwise, water in harbors, rivers, inlets, bays, landlocked waters, and the open sea within 12 miles of the entrance to these waterways, shall be considered to be polluted. Other areas may be declared to be polluted by Navy medical specialists. The desalting of polluted harbor water or seawater for human consumption shall be avoided except in emergencies. If distillation within the restricted areas is necessary, the procedures in paragraph 533−2.4.5 shall be followed.

533−2.4.3 OPERATION IN SEAWATER. Desalinators are designed to operate on full strength seawater in the open sea. Each desalinator has a salinity panel that monitors the product water and an automatic dump valve. Any increase in salinity or TDS from the normal level will activate an alarm and automatically dump the product water. A salinity or TDS increase while operating in full strength seawater indicates contamination of the product water by leakage or carryover. This product water may be disease-carrying if the original seawater feed is contaminated.

533−2.4.4 OPERATION IN FRESH OR BRACKISH WATER. The salinity of fresh or brackish water is generally much lower than that of seawater. When the desalination unit is operated in these waters, the microbiological and chemical purity of the product water cannot be assured as described in paragraph 533−2.4.3, because the meter is extremely sensitive to salt and these waters have much less salt. Small amounts of inlet water carryover or leakage would not be indicated by excessive salinity readings at the salinity panel. Under such conditions, instructions listed in paragraph 533−2.4.5 shall be followed.

533−2.4.5 OPERATION IN POLLUTED WATER. If it is necessary, under an emergency situation, to operate the distilling plant or the RO unit while in polluted waters, the following instructions must be scrupulously followed to minimize the risk of endangering the health of the ship's crew:

a. Distilling plants shall be operated at or below rated capacity with comparatively low water levels maintained in each submerged tube unit shell to minimize possibility of priming or carryover.

b. The transfer of evaporator−distilled water to the ship's potable water tank is prohibited if the chloride content exceeds 2.3 ppm. If the method of operation produces momentary flows of water containing more than 2.3 ppm of chloride, the temperature of the first−effect shell shall be maintained at not less than 73.9°C (165°F) (19 inches of mercury vacuum).

c. If fresh, brackish, or contaminated water is being distilled, this temperature of the first−effect shell shall be maintained at not less than 73.9°C (165°F) at all times. The temperature is necessary because the density of the feedwater may be so low that a low salt−content of the distillate will not accurately indicate freedom from priming and carryover. Under these conditions, a chloride content of less than 2.3 ppm is no indication that the distillate is free from contamination.

d. If submerged tube soloshell or vertical basket−type distilling units are operated with brackish feedwater, the temperature requirement of step 3 guards against contamination of the distillate resulting from carryover, but not from tube leakage in the distillate cooler or the distiller condenser. If flash−type distilling units are operated with brackish feedwater, contamination from carryover is automatically avoided because the feedwater in the feedwater heater is maintained at a temperature between 73.9°C and 76.7°C (165 oF and 170°F). Heat recovery− type distilling units do not heat the seawater feed to 73.9°C (165°F); however, most heat recovery−type units are equipped with a sterilizer that heats the distillate to between 98.9°F and 101.7°C (210°F and 215°F). Leaking tubes in any of the stage condensers, as well as in the distillate cooler, create a possible contamination source. The ship's medical department representative shall be made aware of this possibility.

e. The transfer of product water from an RO unit to the ship's potable water tanks is prohibited if the conductivity exceeds 1000 micromhos/cm (500 ppm total dissolved solids).

533−2.4.6 DISINFECTION OF DISTILLED WATER ON SURFACE SHIPS. Regardless of the method of distilling plant operation, the resulting distillate water shall be disinfected by the addition of a halogen compound (in accordance with Section 3) before the water is considered safe for human consumption.

SECTION 3. DISINFECTION AND CLEANING

533−3.1 INTRODUCTION

533−3.1.1 GENERAL. This section describes the disinfection practices for U.S. Navy Surface Ships.

533−3.1.2 POTABLE WATER DISINFECTION. Potable water is disinfected by addition of a halogen compound. Halogens used for potable water disinfection include chlorine and bromine compounds. A measurable residual trace of Free Available Chlorine (FAC) or Total Bromine Residual (TBR) shall be maintained in all parts of the potable water system. Trace readings (detectable color changes on the colorimeter) ensure that the potable water is free from microbial contamination. FAC or TBR is that excess of chlorine or bromine remaining in the water after 30 minutes of contact with the water. Required halogen residual levels are given in Table 533−3−1.

533−3.1.2.1 Halogen Residual. The halogen compound is added to produce an initial concentration of 1.0 parts per million (ppm) chlorine or 0.7 ppm bromine. This is necessary to obtain a minimum of 0.2 ppm FAC or TBR after a 30-minute contact period in potable water tanks. The amount of chlorine or bromine required to produce a 30−minute FAC or TBR residual of 0.2 ppm can vary widely because of the halogen demand. Halogen demand is defined as chlorine or bromine depleted (i.e., used up) in reacting with substances present in the water. In other words, the amount of halogen required to react with and to be absorbed by these substances is called the halogen demand. All water, including distilled water, has some halogen demand. Additional bromine or chlorine may be used on water already treated to achieve correct halogen residual level.

533−3.1.2.2 Halogen Treatment. The FAC content and the hydrogen ion concentration (pH) of shore potable water should be determined before the water is taken onboard ship. If the residual is 0.2 ppm or more, and the pH is 8.5 or less, no additional disinfection may be required. Additional halogen will be required because of a halogen demand (low residual). If the amounts of chlorine-demanding substances (such as ammonia) in the water are not known, a dose of no fewer than 1.0 ppm chlorine or 0.7 ppm bromine shall be used initially. If this dosage does not produce at least a 0.2 ppm BAC or TBR residual after a 30-minute contact period, additional disinfection is required.

533−3.1.2.3 Effect of pH on Disinfection. If the pH is 8.5 or less, no additional disinfection may be required. Additional halogen will be required if the pH is in excess of 8.5 within the ship's potable water storage or distribution system. High pH levels will adversely affect the disinfectant properties of chlorine and bromine. Whenever the pH is above 8.5 and chlorine is to be used as the disinfectant, the water shall be treated to provide at least a 0.6 ppm FAC residual at the end of a 30−minute contact period. Whenever the pH is above 9.5 and bromine is to be used as the disinfectant, the water shall be treated to provide at east a 0.6 ppm TBR residual at the end of a 30−minute contact period.

533−3.1.2.4 Doubtful Potable Water Quality. Water received from an unapproved source, a source of doubtful quality, or an area where amebiasis or infectious hepatitis is endemic shall be treated to provide at least a 2.0 ppm FAC or TBR residual at the end of a 30−minute contact period in the potable water tanks. All water supplied by public or private systems outside the United States should be considered of doubtful quality. When shore water quality is in doubt, the Medical Officer, medical department representative, or other responsible officer shall investigate the water source, make as complete an examination as possible, and advise the Commanding Officer relative to safeguards. Data on extracontinental sources may be available from local U.S. military representatives and from the area Environmental and Preventive Medicine Unit.

533−3.1.2.5 Approved Sources. All water received from approved sources or manufactured onboard shall be treated to provide at least 0.2 ppm FAC or TBR at the end of a 30−minute contact period. Approved sources are those approved by the U.S. Public Health Service, U.S. Navy Medical Representatives, or U.S. Government Representatives.

533−3.2 EMERGENCY POTABLE WATER

533−3.2.1 GENERAL. If no potable water is available, non-potable lake or river water may have to be obtained for drinking and cooking. The water to be treated in such an emergency should be clear and free of turbidity. Turbidity refers to having sediment stirred up and may make the water appear muddy or cloudy.

Table 533−3−1. LIST OF REQUIRED HALOGEN RESIDUALS

Treatment Requirement	Chlorination Dosage and Time Requirements	Bromination Dosage and Time Requirements
Minimum residual required for all potable water onboard or taken aboard	0.2 ppm after 30 minutes in tanks	0.2 ppm after 30 minutes in tanks
Water in potable water distribution system	*Trace readings throughout	*Trace readings through
Water from area where amebiasis or hepatitis is endemic or unapproved source is used	2.0 ppm after 30 minutes in tanks	2.0 ppm after 30 minutes in tanks
Disinfecting tanks and system	100 ppm initially; 50 ppm after 4 hours	Not applicable
Disinfecting hoses, couplings, and water connections prior to connection to potable water system	100 ppm for 2 minutes	Not applicable
Scrubbing interior of contaminated tanks when potable water is scarce	100 ppm	Not applicable
Emergency water supply for drinking and cooking	5.0 ppm after 30 minutes	Not applicable

* Trace readings are detectable color changes on the colorimeter.

533−3.2.2 EMERGENCY POTABLE WATER TREATMENT. Before nonpotable water can be used for human consumption, sufficient chlorine must be added to maintain at least 5.0 ppm FAC for 30 minutes. Water not treated with a halogen can be made safe by bringing it to a rolling boil in a steam kettle, maintaining the rolling boil for 5 minutes, cooling it, and then bringing it back to a rolling boil and maintaining the boil for another 5 minutes.

533−3.2.3 ADDITIONAL EMERGENCY POTABLE WATER SOURCE. In addition to canned drinking water, potable water in battle dressing stations and in water heaters can be used during an emergency.

533−3.3 REQUIRED HALOGEN RESIDUALS FOR SUBMARINES AND SERVICE CRAFT

533−3.3.1 Because submarines and service craft are not provided with mechanical means for adding halogens to potable water, care shall be exercised when loading shore water. Particular attention shall be paid to the potable water hoses and hose connections, and to the condition of the potable water system piping and components. Shore water shall be obtained from approved sources as noted in paragraph 533−3.1.2.5 and must contain at least a 0.2 ppm FAC residual.

533−3.4 SPECIAL HALOGEN HANDLING AND STORAGE REQUIREMENTS

533−3.4.1 GENERAL. Halogens require special handling to ensure personnel safety.

CAUTION

> Calcium hypochlorite is classified as a dangerous material and requires special storage precautions. It shall be handled and stowed in accordance with **NSTM Chapter 670, Storage, Handling, and Disposal of Hazardous General Use Consumables**. Contact between calcium hydrochlorite and an oxidizable material, such as paint, oil, or cloth may result in spontaneous combustion.

533−3.4.2 CALCIUM HYPOCHLORITE. Chlorine is available for disinfecting potable water in the form of calcium hypochlorite, a granular solid. However, calcium hypochlorite presents a potential hazard because of its corrosive and chemically active nature. Calcium hypochlorite is a strong oxidizer that can react explosively when coming in contact with organic matter (i.e., paint, oil, oily cloth).

533−3.4.3 BROMINE CARTRIDGES. Elemental bromine is impregnated on ion exchange resin beads. The resin beads are contained in a cartridge assembly. Elemental bromine is also a potential hazard, highly corrosive, and reactive. However, bromine cartridges are less hazardous than calcium hypochlorite since the elemental bromine is contained in the cartridge assembly and should not come in direct contact with the operator.

533−3.4.4 BROMINE CARTRIDGE STORAGE. Storage lockers shall be provided in clean, dry storerooms in sufficient quantities to store a 6−month supply of bromine cartridges, as calculated from the information in paragraph 533−3.5.1.2.12.

533−3.4.5 BROMINE CARTRIDGE READY SERVICE LOCKERS. In addition, ready service lockers may be installed in the machinery spaces containing the bromination equipment. A warning plate shall be installed on each bromine cartridge stowage locker (Figure 533−3−1).

533−3.4.6 BROMINATOR HOSE STATION. A hose with a quick-opening valve should be installed in the vicinity of each brominator. This hose station is supplied with cold potable water. Potable water from this source can be used for washdown in the event of a bromine resin spill, and for personnel use in the event of skin or eye contact with the bromine resin. The hose connection shall consist of 3/4-inch International Pipe standard (IPS) piping with a locked-open globe valve, a pressure-reducing valve set at 25 pounds per square inch (lb/in^2), a ball valve, a vacuum-breaker backflow preventer, a hose coupling, and a 4−foot length of hose.

533−3.4.7 BROMINATOR WARNING PLATE. A warning plate shall be installed at each brominator (Figure 533−3−2).

533−3.5 METHODS OF DISINFECTING POTABLE WATER

533−3.5.1 TREATMENT METHODS. Two treatment methods are approved for use aboard U.S. Navy surface ships. One type is the Brominator Method. This mechanical treatment method is in use on most surface ships and is the only approved primary means of potable water disinfection. Operating instructions are contained in the individual brominator technical manual. Maintenance information is contained in the Planned Maintenance System (PMS). If the bromine mechanical treatment method is unavailable, chlorine solutions may be introduced directly into the potable water tanks by the chlorine batch method (paragraph 533−3.5.2.2).

533−3.5.1.1 Brominator Disinfection Method. Bromine treatment of potable water is provided by two types of bromination systems. One type, a proportioning brominator, is installed in the distillate discharge line. It provides the initial treatment of distillate before it proceeds to the potable water tanks. The second type, a recirculating brominator, recirculates water to and from a potable water tank. It provides supplemental treatment of potable water when the bromine residual degrades below the acceptable level.

533−3.5.1.1.1 Distillate Discharge Line Brominator. Brominators installed in the distillate discharge line brominator are called automatic proportioning brominators. One brominator is typically required for each distilling plant. This brominator comprises three major components, as shown in Figure 533−3−3. These are the bypass header assembly, the dual feed valve assembly, and feeder assembly. Automatic proportioning brominators are capable of feeding bro-

WARNING
CONTAINS BROMINE CARTRIDGES WHICH PRODUCE IRRITATING VAPORS. DO NOT PUNCTURE OR OPEN CARTRIDGES. OPEN SHIPPING CONTAINER IN WELL-VENTILATED SPACES AND AVOID BREATHING DUST OR LOOSE MATERIAL FROM CONTAINER.
DO NOT HANDLE LOOSE BROMINE RESIN UNLESS ABSOLUTELY NECESSARY; IF NECESSARY, WEAR RUBBER GLOVES AND GOGGLES TO AVOID SKIN REDNESS AND EYE IRRITATION. IF SUCH CONTACT OCCURS, THOROUGHLY FLUSH THE AFFECTED AREA WITH POTABLE WATER FOR 15 MINUTES AND SEEK MEDICAL ATTENTION. BROMINE RESIN MAY BE HARMFUL IF SWALLOWED.
DISPOSE OF CARTRIDGE IN ACCORDANCE WITH NSTM, S9086−T8−STM−000/CH−593 CHAPTER 593, POLLUTION CONTROL. DO NOT INCINERATE.

Figure 533−3−1. Warning Plate for Bromine Cartridge Stowage Lockers

WARNING

DO NOT PUNCTURE OR OPEN BROMINE CARTRIDGE. OPEN CARTRIDGE SHIPPING CONTAINER IN WELL-VENTILATED SPACES AND AVOID BREATHING DUST OR LOOSE MATERIAL FROM CONTAINER.

DO NOT HANDLE LOOSE BROMINE RESIN UNLESS ABSOLUTELY NECESSARY; IF NECESSARY, WEAR RUBBER GLOVES AND GOGGLES TO AVOID SKIN REDNESS AND EYE IRRITATION. IF SUCH CONTACT OCCURS, THOROUGHLY FLUSH THE AFFECTED AREA WITH POTABLE WATER FOR 15 MINUTES AND SEEK MEDICAL ATTENTION.

IF UNIT IS NOT TO BE USED FOR 14 DAYS OR MORE: DRAIN CARTRIDGE CANISTER AND REMOVE CARTRIDGE; DRAIN CARTRIDGE AND REPLACE CARTRIDGE OUTLET CAP; AND RETURN CARTRIDGE TO ORIGINAL SHIPPING CONTAINER. DRAINAGE IS SLIGHTLY CORROSIVE. IF DRAINAGE COMES IN CONTACT WITH SKIN, WASH WITH WATER.

DISPOSE OF CARTRIDGE IN ACCORDANCE WITH NSTM, S9086−T8−STM−000/CH−593 CHAPTER 593, POLLUTION CONTROL. DO NOT INCINERATE

Figure 533−3−2. Warning Plate for Brominator

mine at two feed rates (see Figure 533−3−3). Dual feed rate automatic proportioning brominators are set to provide a fixed rate of either approximately 0.7 ppm TBR at the low feed rate or 2.7 ppm TBR at the high feed rate. The high rate of feed is to be used if the ship is distilling water when operating in contaminated waters.

533−3.5.1.1.1.1 Bypass Header Assembly. The bypass header assembly contains a flow switch, a time totalizing meter, a cartridge change indicator light, a system operating indicating light, a fixed orifice, a test tap, and inlet and outlet flanges. The flow switch is wired to the system indicator light to turn off the light if the flow rate is inadequate. The time totalizer provides a visual indication of time remaining before the next scheduled cartridge change. When the total elapsed time reaches the end of the cartridge service life, the cartridge change indicator light turns on to indicate the need for a cartridge change. The fixed orifice limits the flow through the bypass header assembly and develops a pressure differential which causes a percentage of the water to be diverted through the dual feed valve assembly and the feeder assembly.

533−3.5.1.1.1.2 Dual Feed Valve Assembly. The dual feed valve assembly is a two-position ball-type valve with a reduced size, cross-drilled hole (orifice) in the ball. Adjusting feed rates is accomplished using this two-position ball valve which contains two different sized orifices. The smaller orifice produces the low feed rate, and the larger orifice produces the high feed rate.

533−3.5.1.1.1.3 Feeder Assembly. The feeder assembly is basically a pressure vessel (or canister) which houses the bromine cartridge. Inlet and outlet tubing connections are provided at the base of the canister. The top of the canister incorporates an air-bleeder valve. The top is secured in place by a V-band clamp, and is removable for servicing and replacing the bromine cartridge. Elemental bromine from the cartridge is introduced into the bypassed water stream.

533−3.5.1.1.1.3.1 Bromine Feeder Cartridge. The bromine feeder cartridge is disposable when exhausted. The cartridge contains a bromine resin which is permanently sealed in the cartridge to prevent its escape into the water system. The resin releases bromine into the water passing through the cartridge. This release rate is proportional to water flow rate, temperature and water quality. The cartridge is fabricated of non-brittle plastic. All cartridge components are resistant to attack by the bromine resin contained within. Bromine cartridges have a full service capability of 24 months from the date the cartridge is filled. This date is stamped on each cartridge. While cartridges older than 24 months can be used, the quantity of bromine that can be washed from the resin decreases. This results in a decreased cartridge capacity. Cartridges older than 24 months may be used if no others are available. When using older cartridges, the recirculating brominator must be used to increase the halogen residual in the potable water tanks. Bromine cartridges should be stocked and rotated to ensure cartridges are expended prior to expiration date.

533−3.5.1.1.2 Distillate Discharge Line Brominator MACHALT. Automatic proportioning brominators are capable of feeding bromine at two feed rates. Proportioning brominators have dual feed capability ei-

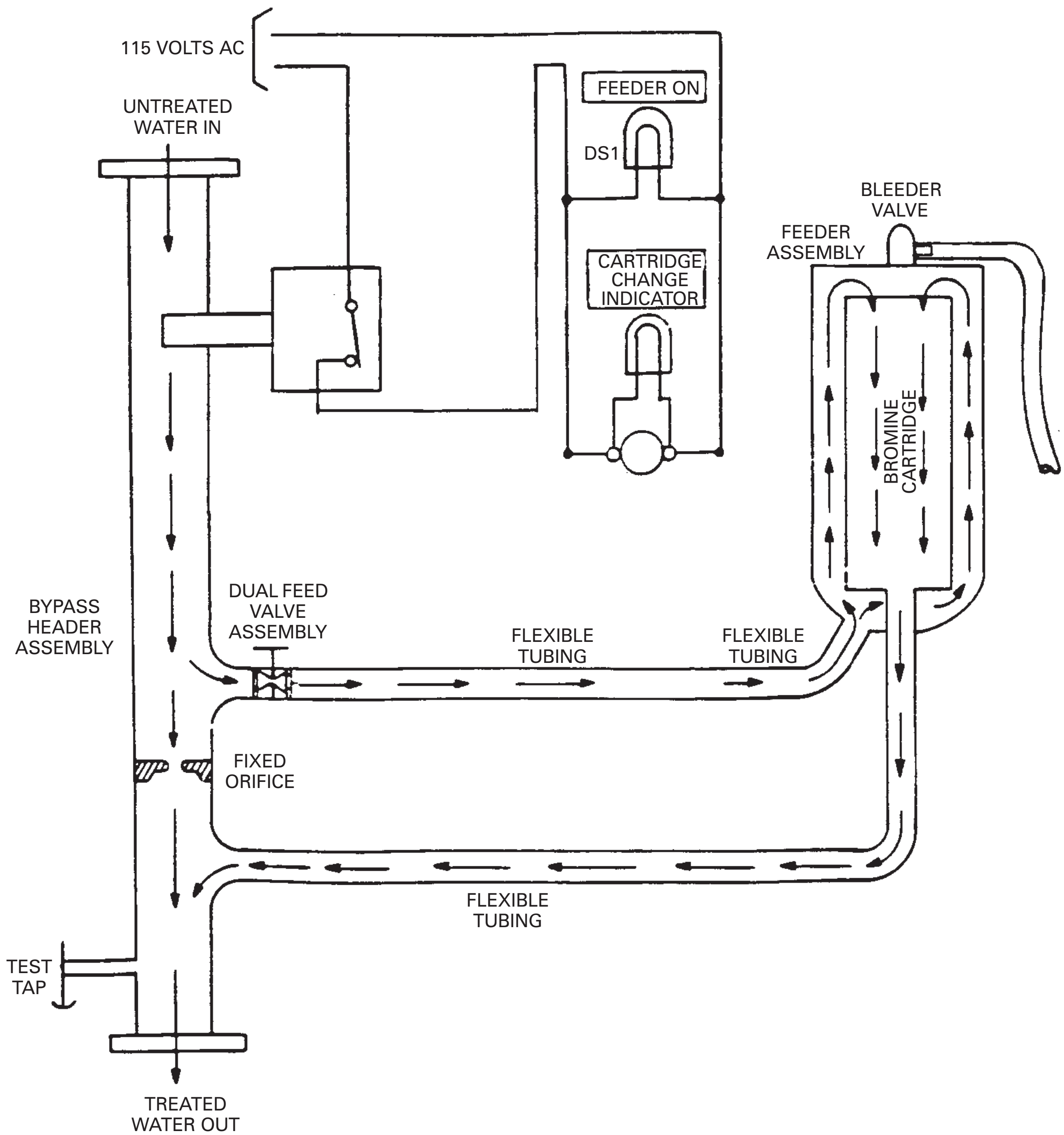

Figure 533−3−3. Distilling Plant Brominator, Dual Feed

ther through new installations or by the accomplishment of a Machinery Alteration (MACHALT) to convert all existing single feed proportioning units. The MACHALT eliminated a temperature sensor and replaces a solenoid valve with a ball valve. Brominator isolation valves must be in good material condition so that routine maintenance can be performed. The valves shall be routinely checked and repaired when necessary.

533−3.5.1.1.3 Brominators for Reverse Osmosis (R.O.) Desalinators. The water entering the R.O. Brominator comes directly from the R.O. Desalinator. The R.O. Brominator is designed to provide the required levels of halogen residuals for inlet water conditions that are unique to the product of the R.O. plant. Water produced by R.O. plants is typically lower in temperature and higher in total dissolved solids (TDS) connection than water produced by conventional evaporators. Low temperature reduces the rate at which bromine is fed from the bromine cartridge. High TDS concentration increases this rate of bromine feed. The R.O. brominator is similar to a conventional distilling plant brominator. The only significant differences are (1) the R.O. brominator is designed with two canister assemblies installed for parallel flow, and (2) a bypass flow valve is provided to allow continuous adjustment. The MHC 51 class R.O. desalinator does not require a modified brominator.

533−3.5.1.1.4 Recirculating Brominator. The recirculation brominator is designed to treat water in potable water storage tanks. Water is treated by the recirculation of potable water from a potable water storage tank through the recirculating brominator and back to the same tank. As the water in a selected tank is recirculated, a portion of the recirculated water is automatically proportioned to flow through the bromine cartridge. Flow through the cartridge is limited by a timing device to achieve the required bromine feed into the selected tank. After a precalculated time period, the timing device terminates the bromine feed. Water circulation continues for an additional calculated time period to disperse the bromine throughout the tank. Timing calculations are based on individual tank sizes and are listed on the operating instruction placards mounted on the brominators. A recirculation brominator system is shown in Figure 533−3−4.

533−3.5.1.1.4.1 Feed Time. Recirculation brominators are set when manufactured to feed a specific quantity of bromine to the water. The initial 0.7 ppm bromine feed is obtained by setting the brominator timer to the feed time indicated on the instruction plate mounted on the brominator. Feed time is based upon water quantity and temperature. To increase the initial residual, the feed time must be increased. For instance, if a residual of 1.0 ppm TBR is required, and the initial bromine residual test indicates 0 ppm TBR or FAC, the timer should be set to feed two times longer than the indicated feed time. This will provide sufficient bromine to obtain 1.4 ppm initially. However, after a 30-minute contact period, the TBR will be above 1 ppm if the water is not contaminated.

533−3.5.1.1.5 Securing Power. Secure power to the time totalizers before performing maintenance on the brominators. The solid state relay will be shorted out if the time totalizer cover is removed while the totalizer is energized.

533−3.5.1.2 Brominators, Miscellaneous.

533−3.5.1.2.1 Training. Training for operation and O-Level maintenance for the bromination system is available. Training courses which include instruction on bromination systems are available at the Class “A” school for BT’s, EN’s, and MM’s at the Great Lakes Naval Training Center, and for all fleet engineering personnel at the Fleet Training Center in San Diego and the Fleet Training Center in Norfolk, Virginia.

533−3.5.1.2.2 Damage. Brominators have been highly susceptible to damage over their life cycle. Damage can occur for many reasons, including inadequate design features. Care should be taken to prevent foreign objects striking the brominator; as a result of maintenance, for example. In addition, the brominator should be protected from direct contact with steam, water, oil, or chemicals. Temporary or permanent shields should be installed to protect the equipment from these types of potential hazard. Assistance in designing and installing shields can be obtained from Shore Intermediate Maintenance Activities (SIMA), NAVSEA Center, and Tenders.

533−3.5.1.2.3 Canister Assembly. Stainless steel canisters are manufactured with an inner coating to protect the canister from the corrosive bromine environment. The canister assembly will fail whenever the lining is breached. Care must be taken in handling the cover to avoid scraping the lining. Foreign objects striking the canister may also cause the lining to fail. Failure of the stainless steel canister is accelerated by concentrated bromine solutions that remain in idle canisters for extended periods of time. Cartridges should be removed from canisters whenever the brominator is not to be used for 14 or more days. Remove the cartridge carefully and drain the liquid. The cartridge may be retained for future use as long as there is a red color in the bromine resin. The partially spent

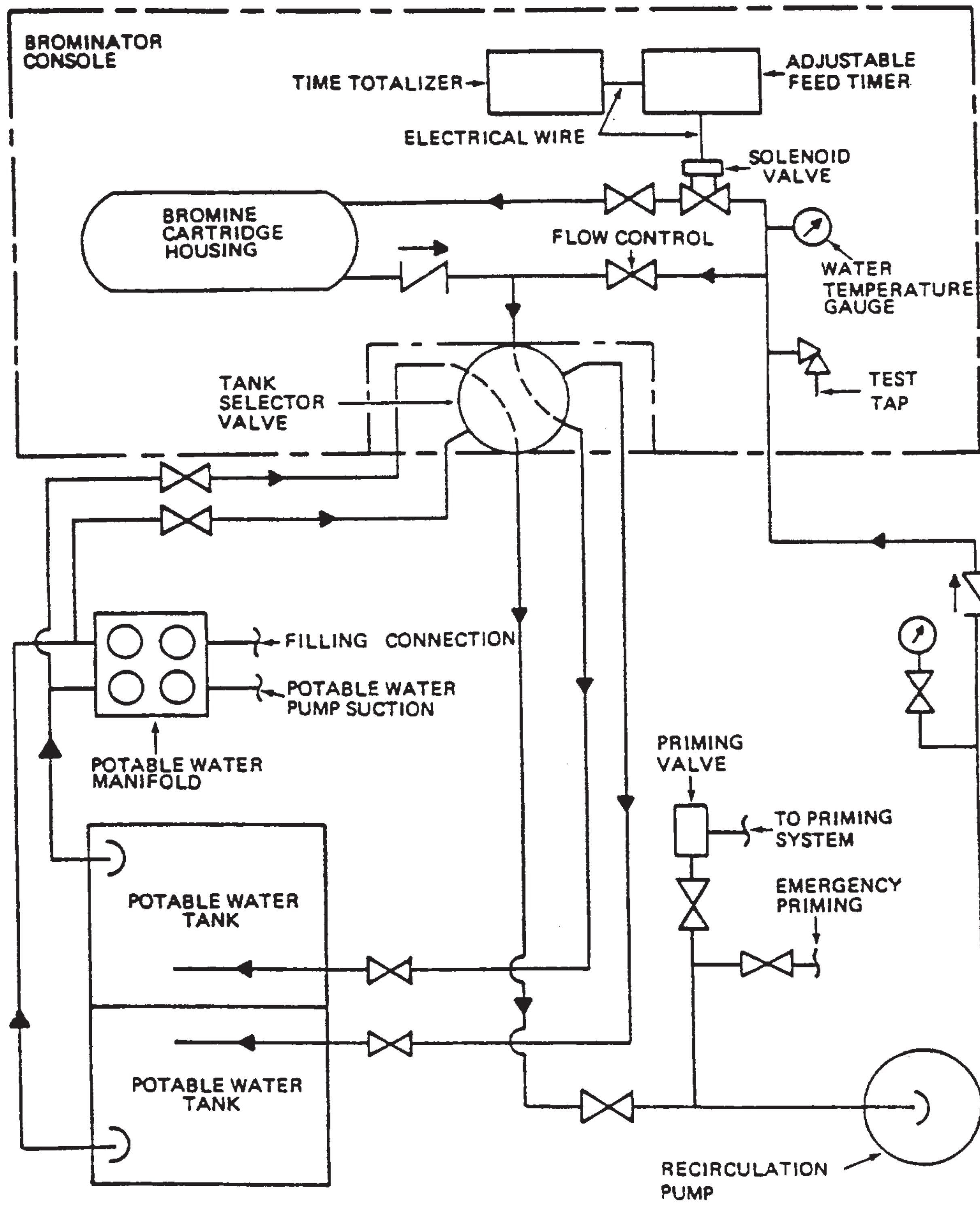

Figure 533−3−4. Recirculation Brominator System cartridge may be temporarily stored in its original shipping container.

533−3.5.1.2.4 Connected Tubing. Nylon-reinforced Polyvinyl Chloride (PVC) tubing is connected to the bromine canister. This tubing will discolor from transparent to amber for the hose upstream of the canister and dark brown for the hose downstream of the canister. This is normal and acceptable. The brownish discoloration is considered only a cosmetic change and is not an indication of impending failure. The hose should be replaced after 5 years of service or when the brominator is overhauled.

533−3.5.1.2.5 Bromine Cartridge Inspection. Each bromine cartridge should be visually inspected before insertion into the canister assembly. Bromine cartridges should not be used if they are visibly damaged or if any part of the cartridge is not intact. Bromine cartridges should not be used if beaded resin is visible in, or spills out of, the nipple when pointed down. Bromine impregnated resin will release hazardous vapors. This resin could cause injury if it comes in contact with skin. If the cartridge is found to be defective, place the cartridge in its original container. Dispose of the repackaged cartridge in accordance with procedures for hazardous waste disposal.

533−3.5.1.2.6 Alternate Disinfectants. Alternate disinfectants shall not be used as a replacement for the bromine cartridge in the bromination system canisters. Use of alternate disinfectants, such as calcium hypochlorite (clarified liquid or powder) will result in incorrect concentrations. Further, this will result in improper, uncontrollable feed rates. The use of calcium hypochlorite in a recirculating brominator will cause equipment damage. Unclarified liquid, which contains 30 percent insoluble calcium or powdered calcium hypochlorite, is abrasive and will score the teflon seats on the ball selector valves. Scored ball selector valve seats will cause recirculating pump priming problems.

533−3.5.1.2.7 Residual Testing. The bromine feed rate of either 0.7 ppm or 2.7 ppm is a nominal rate. The actual rate will vary depending upon the temperature of the distillate flow (which varies), and the quality of water that flows through the bromine cartridge. None of these variables, except for bromine depletion in the cartridge will appreciably affect the nominal rate. However, it is extremely difficult to obtain a water sample which will indicate the nominal bromine residual. Water drawn from the sample valve provides an indication that the equipment is working, but should not be relied on to measure the actual bromine residual. In order to draw a sample from the sample valve on most ships, the cutout valve downstream of the brominator must be throttled temporarily to break the vacuum. The best place to test for residuals is in the potable water tanks by way of the recirculating brominator. For the low and high rates of bromine feed, 0.2 ppm and 2.0 ppm bromine residual, respectively, is required in the potable water tanks after the 30−minute contact time.

533−3.5.1.2.8 Temperature Effect on Bromine Feed Rates. Temperature affects the amount of bromine that is released from the bromine cartridge. A lower water temperature will result in less bromine released. The rate of decline in the amount of bromine being released to the water is given in Table 533−3−2. Distilling plant operation in cold waters will result in low distilled water output temperature and may result in the release of an insufficient quantity of bromine. To increase the bromine residual level to the proper amount, operation of the recirculating brominator is required. High distiilled water output temperature, above 37.8°C (100°F), results in the release of increased quantities of bromine. This will result in a more rapid depletion of the bromine in the cartridge and will require more frequent cartridge replacement.

Table 533−3−2. RATE OF BROMINE RELEASE BY WATER TEMPERATURE FOR AUTOMATIC PROPORTIONING BROMINATORS

Temperature	Low Feed	High Feed
37.8°C(100°F)	0.7	2.7
26.7°C(80°F)	0.5	1.9
15.6°C(60°F)	0.3	1.2
4.4°C(40°F)	0.2	0.8

533−3.5.1.2.9 Flow Rate Effect on Bromine Feed Rates. The rate of bromine feed will increase with an increase in flow rate. Conversely, the rate of bromine feed will decrease with a reduction in the flow rate.

533−3.5.1.2.10 Effects of Water Quality on Bromine Feed Rates. The amount of Total Dissolved Solids (TDS) will affect the bromine feed rate. Higher TDS, typical of Reverse Osmosis Desalinators, will increase the amount of bromine eluted from the cartridge. Conversely, a decrease in bromine feed rates occurs with a reduction in TDS.

533−3.5.1.2.11 Time Effect on Bromine Feed Rates. Bromine cartridge feed rates decrease over time. The initial release of bromine from a new cartridge is substantially higher than the required amount. This higher than normal feed rate should continue for the first several minutes of use. Thereafter, the feed rate will decrease relatively quickly. This rapid decline in feed rate should not be interpreted as a depleted cartridge. The operator should use the cartridge for the prescribed time interval, or in the event the timer is not functioning, until the absence of red color in the cartridge.

533−3.5.1.2.12 Bromine Cartridge Usage Rates. Usage rates for bromine cartridges are dependent upon the crew size, potable water usage rates, and location of ship operation (i.e., distilled water quality). The following can be used to estimate the daily number of cartridges required for various deployments:

a. No cartridges are required while in a continental U.S.A. port receiving shore water or in a foreign port receiving approved ready-for-use potable water.

b. The number of cartridges required daily while at sea or operating in uncontaminated waters equals the complement times 0.0005.

c. While at sea or in port, operating distilling plants in contaminated waters (Mediterranean Sea, close to shore in Asia, any port) or in port receiving water from shore that is contaminated or of doubtful quality, the number of cartridges required daily equals complement times 0.002.

533−3.5.2 CHLORINE DISINFECTION METHOD. Potable water in the tanks of all ships can be disinfected by the chlorine batch method. However, this treatment method is considered the least desirable because it usually results in overchlorination (caused by the difficulty in mixing the water and hypochlorite solution properly) and because it exposes the potable water to potential contamination. The proper dosages of chemicals are determined by the volume of water to be disinfected. Correct dosages for chlorine compounds are given in paragraph 533−3.5.2.1 This calculated amount is dissolved in a container of warm water, and any suspended matter is allowed to settle out. The resulting clear fluid is then introduced into a filled potable water tank through the sounding tube or tank vent. At the same time, at least 1 gallon of potable water must be poured into the sounding tube to ensure that the concentrated chlorinated water is flushed into the potable water tank. Extreme Care shall be exercised during this operation since the tank is open and exposed to contamination. Sufficient mixing will result from the stirring action of incoming water as the tank is filled. If the tank is full before adding chlorine, the water should be mixed using the potable water pumps and recirculating piping, if possible.

533−3.5.2.1 Chlorinator Method. Several types of chorinator installations are used for chlorine treatment. A chlorinator may be installed in either the distilling plant distillate line or in the shore fill line, or one chlorinator may serve both the distillate line and the fill line.

533−3.5.2.1.1 Distillate Chlorinator. The distillate line is generally provided with a chlorinator driven by an electric motor. This chlorinator will have controls that energize the chlorinator in conjunction with the distillate pump motor and waterflow past the chlorinator. A distillate line, motor-operated chlorinator installation is shown in Figure 533−3−5.

533−3.5.2.1.2 Shore Fill Chlorinator. The shore fill line is generally provide with a chlorinator that is hydraulically actuated or driven by an electric motor. Either unit injects hypochlorite solution into the water system in proportion to the volume of water flowing through a meter.

533−3.5.2.1.3 Distillate and Shore Fill Chlorinator. The distillate line and fill line may both be served by a fill line chlorinator unit if the distilling plant is large enough to permit sufficient flow through the unit. The chlorinator for this type of installation is generally hydraulically actuated or driven by an electric motor. A combination distillate line/fill line chlorinator installation is shown in Figure 533−3−6.

533−3.5.2.2 Chlorine Batch Method. The dosage rates for chlorination by the chlorine batch method are presented in Table 533−3−3 and Table 533−3−4. Water quality (that is, the organic and inorganic materials present) will affect the final chlorine residual. The amount of chlorine required to react with and to be absorbed by these materials is called the chlorine demand. Chlorine that has reacted with organic or inorganic matter (i.e., has been absorbed or neutralized) has little disinfectant value.

Therefore, enough chlorine shall be added (adequate dosage rate) to satisfy the chlorine demand and still provide FAC. FAC is the active disinfecting agent and is the chlorine reading desired if using the colorimetric test kit. As a rough calculation, a dosage rate of 1 ounce of granular calcium hypochlorite (70 percent) per 5,000 gallons of water yields 1.0 ppm chlorine. Because of chlorine demand, this dosage rate will probably produce an FAC residual of about 0.2 ppm after a 30−minute contact period.

533−3.5.2.2.1 Chlorine Batch Dosage. Select the desired ppm using the chlorine dosage calculator (Table 533−3−4). The required ppm of available chlorine is read from the top of Table 533−3−4. Determine the strength and the chemical (i.e., liquid so-

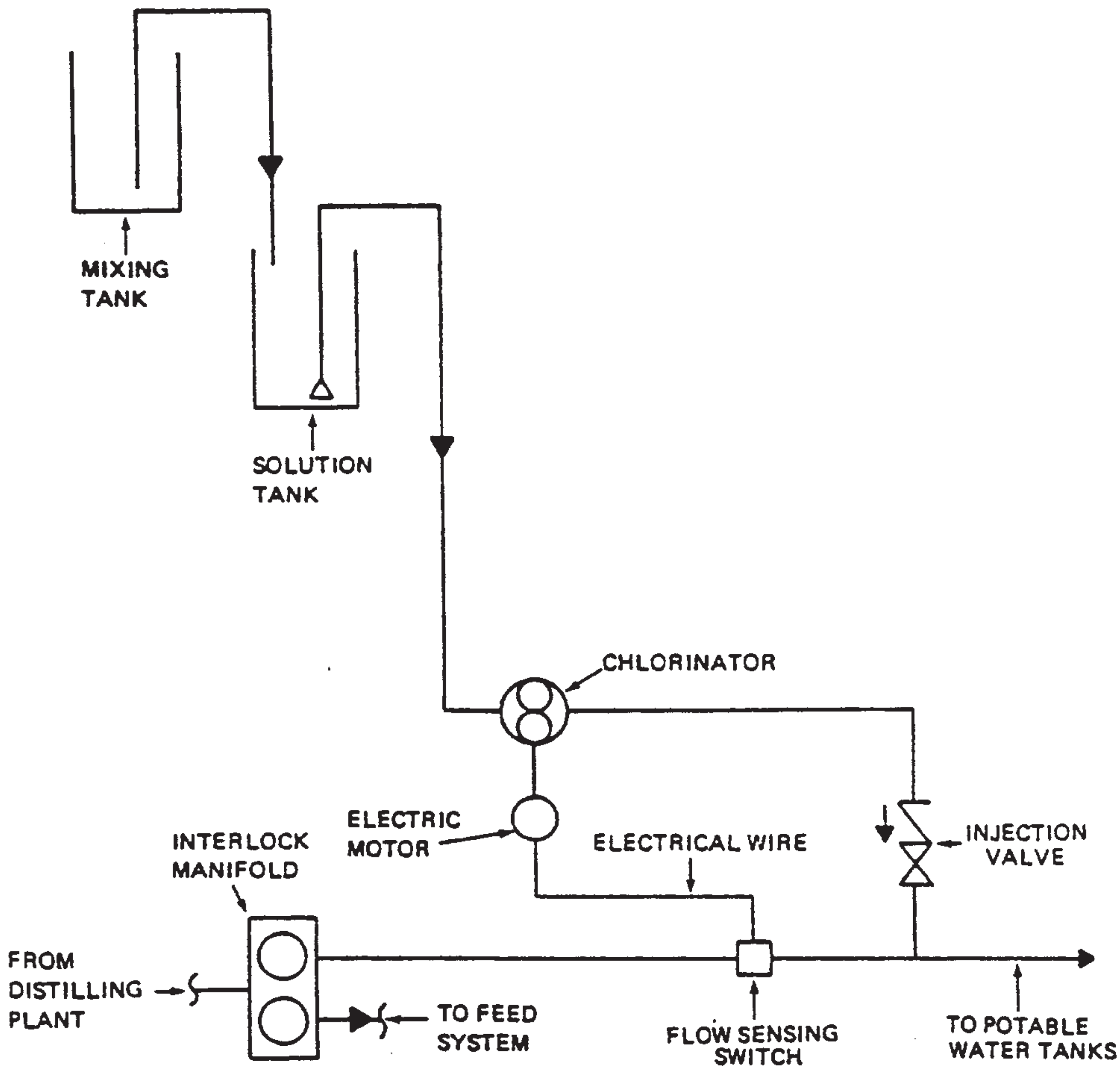

Figure 533−3−5. Distilling Plant Chlorinator Installation

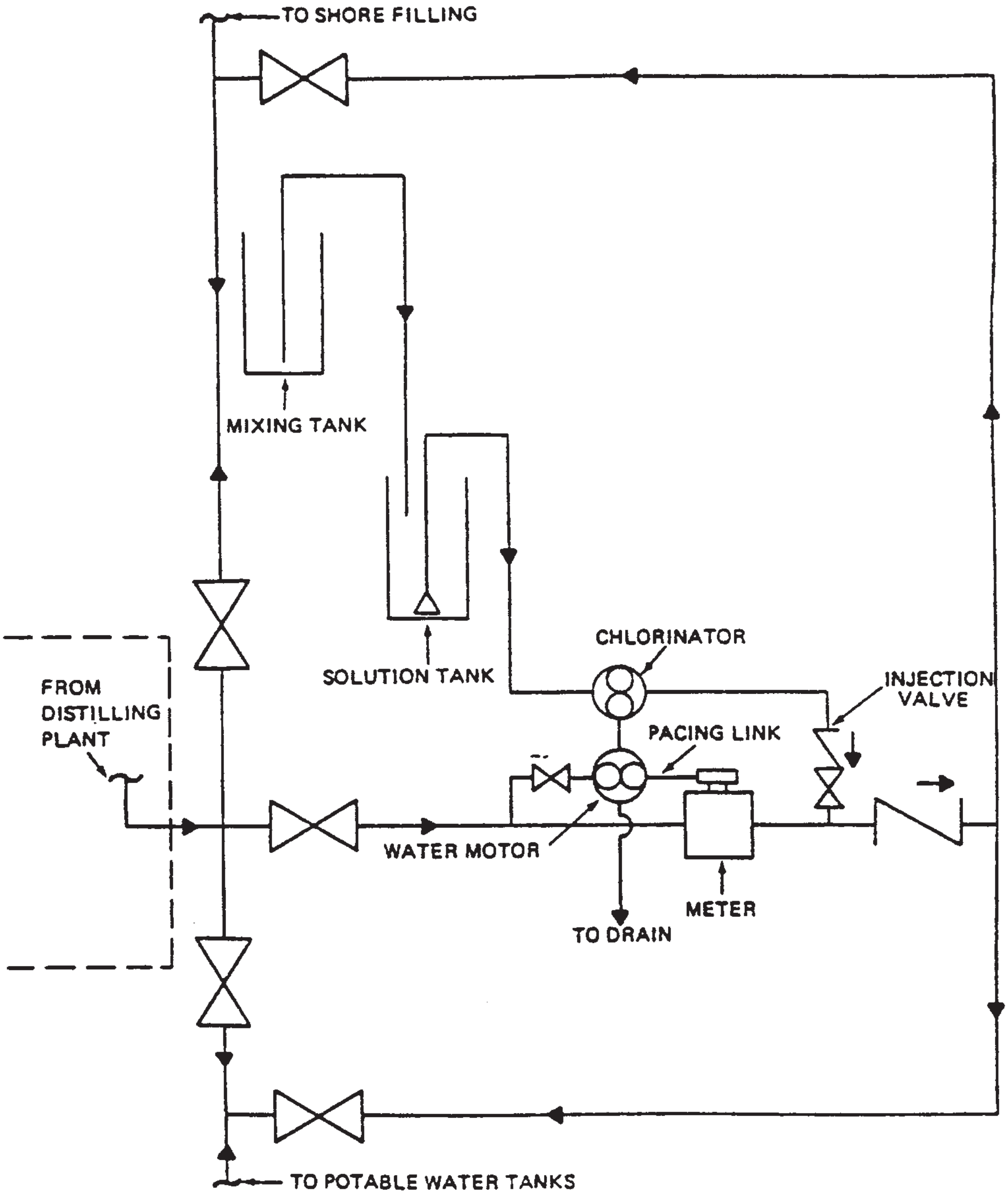

Figure 533−3−6. Combined Distilling Plant and Shore Filling Chlorinator Installation

dium chloride or calcium hypochlorite) to be used. Compute the number of gallons of water to be chlorinated. Read across the table to obtain quantity of chemical required. The 5−percent and 10−percent listings are for liquid sodium hypochlorite. These measurements are expressed as volume. The 70−percent listings are for granular calcium hypochlorite. These measurements are expressed as weight.

533−3.5.2.3 Disinfection of Hose and Hose Components. Potable water hose, hose fittings, and hose connections may be disinfected by the use of small quantities of calcium hypchorite or sodium hypochlorite (liquid beach). The dosage rate (in teaspoons) to be used with small quantities of water for disinfecting these components is given in Table 533−3−4.

Table 533−3−3. QUANTITY (TEASPOONS) OF HALOGEN REQUIRED FOR CHEMICAL DISINFECTION

Gallons (of Water	5	10	15	20	25
Calcium hypochlorite (technical 70% available chlorine) (100% ppm)	3/4	1−1/2	2	2−1/2	3
Sodium hypochlorite (liquid, 10% available chlorine) 100 ppm)	4	8	12	16	20

Note: Six teaspoons of liquid are equivalent to approximately 1 ounce. Three teaspoons equal 1 tablespoon. One ounce equals 29.57 cubic centimeters.

Table 533−3−4. CHLORINE DOSAGE CALCULATOR

Quantity Of Water To Be Treated	1			5			25			50			100			200			Parts Per Million Available Chlorine *
	5%	10%	70%	5%	10%	70%	5%	10%	70%	5%	10%	70%	5%	10%	70%	5%	10%	70%	
50,000	1 Gal	2 Qt	10 Oz	5 Gal	10 Qt	3 lb	25 Gal	50 Qt	15 lb	50 Gal	25 Gal	30 lb	100 Gal	50 Gal	59lb 9Oz	200 Gal	100 Gal	119lb 4Oz	
25,000	2 Qt	1 Qt	5 Oz	10 Qt	5 Qt	1lb 8Oz	50 Qt	25 Qt	7lb 8Oz	25 Gal	50 Qt	15 lb	50 Gal	25 Gal	29lb 12Oz	100 Gal	50 Gal	59lb 8Oz	
10,000	26 Oz	13 Oz	2 Oz	1 Gal	2 Qt	10 Oz	5 Gal	10 Qt	3 lb	10 Gal	5 Gal	6 lb	20 Gal	10 Gal	12 lb	40 Gal	20 Gal	23lb 13Oz	
5,000	13 Oz	7 Oz	1 Oz	2 Qt	1 Qt	5 Oz	10 Qt	5 Qt	1lb 8Oz	5 Gal	10 Qt	3 lb	10 Gal	5 Gal	6 lb	20 Gal	10 Gal	11lb 15Oz	
2,000	6 Oz	3 Oz		26 Oz	13 Oz	2 Oz	1 Gal	2 Qt	10 Oz	2 Gal	1 Gal	1lb 3Oz	4 Gal	2 Gal	2lg 7Oz	8 Gal	4 Gal	4lb 13Oz	
1,000	3 Oz	1.5 Oz		13 Oz	7 Oz	1 Oz	2 Qt	1 Qt	5 Oz	1 Gal	2 Qt	10 Oz	2 Gal	1 Gal	1kb 4Oz	4 Gal	2 Gal	2lb 7Oz	
500	2 Oz	1 Oz		7 Oz	4 Oz		1 Qt	1 Pt	3 Oz	2 Qt	1 Qt	5 Oz	1 Gal	2 Qt	10 Oz	2 Gal	1 Gal	1lb 3Oz	
200	1 Tbs	2 Tsp		3 Oz	2 Oz		13 Oz	7 Oz	1 Oz	26 Oz	13 Oz	2 Oz	1Qt 20Oz	26 Oz	4 Oz	3Qt 7Oz	1Qt 23Oz	8 Oz	
100	2 Tsp	1 Tsp		2 Oz	1 Oz		7 Oz	4 Oz		13 Oz	7 Oz	1 Oz	26 Oz	13 Oz	2 Oz	1Qt 20Oz	26 Oz	4 Oz	
50	1 Tsp			1 Oz	1/2 Oz		4 Oz	2 Oz		7 Oz	4 Oz		13 Oz	7 Oz	1 Oz	26 Oz	13 Oz	2 Oz	
25				1 Tbs	2 Tsp		2 Oz	1 Oz		4 Oz	2 Oz		7 Oz	4 Oz		13 Oz	7 Oz	1 Oz	
10					1 Tsp		1 Oz			3 Tsp			3 Oz	2 Oz		6 Oz	3 Oz		
5							1 Tsp			5 Tsp			2 Oz	1 Oz		3 Oz	2 Oz		

*Note: The 5% and 10% columns are liquid sodium hypochlorite and the quantities shown are by volume. The label on the bottle will indicate the percentage of chlorine available. Chlorine percentages other than 5% or 10% can be apportioned. The 70% column is granular calcium hypochlorite (HTH) and the quantities shown are by weight.

SECTION 4. POTABLE WATER SYSTEM MONITORING

533−4.1 HALOGEN RESIDUAL TEST

533−4.1.1 The chlorine and bromine tests are important because the biological safety of the water is dependent upon the residual concentrations of Free Available Chlorine (FAC) or Total Bromine Residual (TBR). A minimum trace of FAC or TBR must be maintained throughout the ship's potable water system. (Trace readings are detectable color changes on the colorimeter.) FAC or TBR is to be maintained regardless of the water source. An increased amount of initial residual may be required, depending on geographic location and on pH (paragraph 533−3.1.2).

533−4.2 RESIDUAL DECLINE

533−4.2.1 It is normal for halogen residuals to decline after the initial treatment. It is expected that under normal circumstances the initial treatment of distilling plant water will decline from 0.7 parts per million (ppm) to 0.2 ppm TBR for the low rate within the 30−minute contact time in the potable water tanks. Under normal circumstances the initial treatment of distilling plant water will decline from 2.7 (ppm) to 2.0 ppm TBR for the high rate within the 30−minute contact time in the potable water tanks. Thereafter the decline will continue and equal about 50 percent per 24−hour period. Additionally, the halogen residual will normally decline throughout the potable water system. Testing procedures at the user connections shall take into account the distance from the tank and the usage rate at that location.

533−4.3 HALOGEN RESIDUAL TESTING REQUIREMENTS

533−4.3.1 GENERAL. Testing for FAC or TBR residuals shall be routinely performed by the ship's medical and engineering departments.

533−4.3.2 MEDICAL DEPARTMENT. The medical department shall test for FAC or TBR residual as follows:

a. Prior to receipt of water onboard ship.

b. Potable water in a tank shall be tested at least once daily.

c. Water shall be sampled from points that are varied from time to time and that are representative of the ship's distribution system. For example, forward, midship, aft, and as far up in the superstructure as possible. If the required halogen residual is not detected, the applicable procedures shall be followed to increase the amount of chlorine or bromine in the system. The absence of FAC or TBR indicates system vulnerability to contamination. Further, this may indicate system contamination. However, it should be noted that trace levels may not be attainable in those parts of the distribution system that are located at considerable distance from treatment tanks, or in parts of the system that have low water usage rates. The occasional absence of trace readings in such areas does not, in the absence of positive bacteriological findings, indicate the need to increase the halogen dosage.

533−4.3.3 ENGINEERING DEPARTMENT. Testing for FAC or TBR residuals shall be routinely performed by the ship's engineering department to determine treatment effectiveness as follows:

a. Whenever cartridges are changed.

b. After a 30−minute contact period in the potable water tank.

c. Prior to putting the potable water tank into service.

533−4.3.4 SAMPLE TAKING. Water samples shall be taken from a potable water tank with care to ensure that a representative sample of water is taken, that the water sample is not contaminated by personnel taking the sample, and that the contents of the tank are not contaminated. Use of the sounding tube subjects the tank to possible contamination by the person sampling. Therefore, it is preferred that samples be taken by the use of petcocks on the tank, or test connection on the potable water pump or bromine recirculation system. When either the potable water pump or the bromine recirculation system test connection is used, the pump should be run for several minutes to clear the piping of nonrepresentative water. The test points and equipment shall be cleaned and the sampled water allowed to flush the test connection and test container. When a sounding tube is used, care shall be exercised to avoid introducing contaminants into the tanks.

533−4.3.5 RESIDUAL TEST METHOD. Chlorine or bromine residuals are determined by using either the diethyl p−phenylenediamine (DPD) or orthotolidine test methods. The DPD test method is preferred.

533−4.4 HALOGEN RESIDUAL TEST EQUIPMENT

533−4.4.1 GENERAL. Recommended halogen residual test equipment includes the DPD or bromine test equipment provided by the manufacturer at the time the brominator is installed or the DPD test kit (National Stock Number (NSN) 6630−01−067−3827). USE OF CHLORINE STANDARDS FOR BROMINE RESIDUAL DETERMINATION WILL PRODUCE ERRONEOUS READINGS. If a chlorine test kit is used to determine the bromine residual, the reading shall be multiplied by 2.25 to obtain the actual bromine (TBR) residual in ppm.

533−4.4.2 DETERMINING HALOGEN RESIDUAL OF WATER RECEIVED FROM SHORE. Ships equipped with bromine systems will receive chlorinated shore water. This water is then routed directly through the ship's distribution systems. If this water is tested for chlorine residuals using a bromine test kit, the chlorine comparator scale shall be used to determine the chlorine residual.

533−4.4.3 RESIDUAL CHLORINE. Two types of residual chlorine are measured by testing water: free available, and combined. The bactericidal action rate of chlorine is modified by the combination of chlorine with other compounds. The bactericidal action of FAC is approximately 30 times more effective than that of combined chlorine. In the test for chlorine, combined chlorine is distinguished from free chlorine by the time at which the color develops after the addition of DPD to the water sample. FAC reacts rapidly; therefore, an immediate recording of results furnishes the FAC residual.

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