Chief, Bureau of Medicine and Surgery
7700 Arlington Blvd., Falls Church, VA 22042

NAVMED P-5010-6 (Rev. 1-2022)

Manual of Naval Preventive Medicine

Chapter 6

WATER QUALITY AFLOAT

DISTRIBUTION STATEMENT "A"

This publication supersedes NAVMED P-5010-6 of 2005

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NAVMED P-5010-6

Chapter 6
Manual of Naval Preventive Medicine
Water Quality Afloat

26 Jan 2022

To: Holders of the Manual of Naval Preventive Medicine

1. Purpose. This manual sets forth medical surveillance guidance for potable water systems for United States Ships (USS) and United States Naval Ships (USNS).

2. Background. This revision reflects the latest potable water system health, sanitation and preventive medicine requirements, and incorporates recently updated afloat potable water system information and guidance from the U.S. Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention (CDC), Naval Sea Systems Command (NAVSEASYSCOM), the Navy Bureau of Medicine and Surgery (BUMED), and applicable government and industry standard organizations.

3. Action. Replace entire Chapter 6 with this version.

G. D. SHAFFER
Acting

Releasability and distribution:
This publication is cleared for public release and is available electronically only via the Navy Medicine Web site at, https://www.med.navy.mil/Directives

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CHAPTER 6
WATER QUALITY AFLOAT

TABLE OF CONTENTS

CHAPTER 6
WATER QUALITY AFLOAT

TABLE OF CONTENTS

CHAPTER 6
WATER QUALITY AFLOAT

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

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CHAPTER 6
WATER QUALITY AFLOAT

SECTION I. GENERAL INFORMATION

6-1. Purpose

1. The primary purpose of this chapter is to serve as a guide to Medical Department personnel assigned responsibilities for medical surveillance of potable water systems aboard ships and submarines of the United States Navy and ships of the Military Sealift Command (USS and USNS). The basic public health protection principles outlined in this chapter when followed should help prevent water-borne disease outbreaks. The use of trademark names in this publication does not imply endorsement by the Department of Navy (DON), but is intended only to assist in identifying specific products.

2. Personnel with responsibilities for bunkering (i.e., loading), production, treatment, storage, distribution, and testing of potable water should be familiar with current applicable naval instructions, technical manuals, and directives applicable to their roles.

3. The primary goal of medical surveillance of shipboard potable water systems is the health and safety of personnel who will consume or otherwise be exposed to the system's product. Medical surveillance of drinking water quality plays a critical role in preventing waterborne disease outbreaks, detecting water quality problems, and public health risks in order to protect the lives and health of water system consumers.

6-2. Potable Water Afloat Resources. A list of applicable references and information resources is provided in appendix A.

6-3. Terms, Definitions, Acronyms, and Abbreviations. The glossary provided in appendix B defines terms as they are used in this chapter. A list of acronyms and abbreviations used in this chapter is provided in appendix C.

6-4. Policy

1. The Safe Drinking Water Act (SDWA) was signed into law on 16 December 1974. The SDWA and subsequent amendments directed the U.S. Environmental Protection Agency (EPA) to develop federally enforceable National Primary Drinking Water Regulations (NPDWR) (https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations) for all public water systems (PWS). The NPDWR are published in Title 40 Code of Federal Regulations (CFR) parts 141 through 142.

2. Under the SDWA, the EPA has developed National Secondary Drinking Water Regulations (NSDWR) (https://www.epa.gov/dwregdev/drinking-water-regulations-and-contaminants#Secondary) for all PWSs. NSDWR refer to contaminants that may affect the aesthetic quality of drinking water. The NSDWR are published in 40 CFR 143. Unlike the NPDWR, the NSDWR are not federally enforceable, but may be incorporated into State law and enforced by respective states.

3. It is DON policy that all Navy public water systems be operated and maintained to comply with Federal and State laws and regulations, as well as Department of Defense (DoD) and DON policies. While they do not directly apply to Navy vessels, references (a) through (c) set forth policies for implementing SDWA and Federal Drinking Water Regulations at Navy shore installations located in the continental United States and U.S. Territories and Possessions. Environmental Final Governing Standards (FGS) have been established for installations outside the continental United States (OCONUS) that are operated or controlled by the U.S. Navy (or another DoD entity). Potable water obtained by Navy vessels berthed inside the continental United States (CONUS) and OCONUS U.S. Navy installations is required to meet or exceed these standards.

4. The NPDWR are adopted as the afloat water quality standards for maximum contaminant levels (MCLs) for organic chemicals; inorganic chemicals; disinfection byproducts; residual disinfectant levels; and radionuclides. However, neither routine nor periodic testing of ship water quality to these water quality standards is required for vessels. Rather, these standards are used to influence the material choices for design and maintenance of ship potable water systems. After completion of new construction and maintenance, these standards are used as performance standards to establish disinfection and residual disinfectant compliance of the potable water systems.

6-5. <u>Responsibilities</u>

1. <u>Commander, Naval Sea Systems Command (COMNAVSEASYSCOM)</u> has responsibility for the design and construction, as well as operation and maintenance procedures for shipboard potable water systems. This includes shipboard treatment systems and shipboard processes necessary to ensure potable water systems are delivered to the Fleet following construction and maintenance in compliance with the disinfection requirements of the NPDWR.

2. <u>Shore Installation Commanding Officer (CO)</u> has responsibility to ensure a safe supply of potable water is provided to berthed ships, which meets Navy water quality standards as set forth in references (c) through (e). Reference (f) provides drinking water quality standards, determination of fit for human consumption (FFHC), hauled drinking water, laboratories, records management and reporting requirements, sanitary survey execution, certification of chemicals used in drinking water treatment, certification of drinking water systems modification or construction, and operators training and certification requirements for Navy Overseas Drinking Water (ODW) Programs.

3. <u>Commander, Naval Supply Systems Command (NAVSUPSYSCOM)</u>, per reference (g), is responsible (via the NAVSUPSYSCOM Global Logistics System lead contracting executive and regional Fleet Logistics Centers) for the solicitation, award, and monitoring of services for all husbanding contracts used by the U.S. Navy. Husbanding contracts provide logistic support services, including the purchase of potable water for ship port visits throughout the world where there are no U.S. Navy facilities. Support is provided by husbanding service providers for Navy vessels entering non-U.S. Navy facilities.

4. Chief, Bureau of Medicine and Surgery (BUMED) is responsible for establishing and promulgating afloat and shore installation water quality standards. Reference (d) sets forth potable water quality standards for shore installations in the United States and its Territories, and on foreign soil. Additionally, BUMED sets forth via this chapter the potable water system medical surveillance procedures and responsibilities for ship medical department personnel.

5. Commander, Navy and Marine Corps Public Health Center (NAVMCPUBHLTHCEN) provides subject matter experts to deliver public health advice and consultation for water quality concerns, formal public health risk assessments, and risk communication support for afloat commands as requested or required. Additionally, NAVMCPUBHLTHCEN maintains and updates Navy Medicine policy and guidance related to drinking water quality, as needed.

6. Type Commanders have the responsibility for issuing the necessary implementing directives to ensure adequate water sanitation standards are provided and enforced in each ship within their chain of command.

7. The Captain, Master, (hereafter referred to as CO) or other applicable responsible party of each ship, per reference (h) has responsibility for providing adequate quantities of safe potable water for the crew. This includes promulgating a water sanitation bill to ensure procedures for receipt, transfer, treatment, storage, distribution, and surveillance are provided and followed.

8. The Ship Engineering Officer, per references (h) and (i) is responsible to the CO for the production, treatment, operation, and maintenance of the ship's potable water system. The engineering officer is responsible to ensure all ship-to-shore connections are made only by authorized and trained personnel. The engineering department conducts chloride and hydrogen ion (pH) testing of the ship's potable water. The engineering department ensures a minimum halogen residual is maintained at a potable water tank with the minimum contact time before placing a potable water tank on-line to the ship's potable water distribution system.

9. The Medical Officer or Medical Department Representative (MDR), per references (h) and (i), is responsible for conducting a medical surveillance program of the ship's potable water system to include, collection of samples and testing for total coliform and *E. coli* bacteria, and halogen residual (disinfectant) measurements from the distribution system as prescribed in this chapter. The MDR must advise the CO of any public health concerns observed for the potable water system during medical surveillance oversight.

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CHAPTER 6
WATER QUALITY AFLOAT

SECTION II. FUNDAMENTALS OF SHIP POTABLE WATER

6-6. Fundamentals of Ship Potable Water

1. This section provides a brief overview of ship potable water, potable water receipt from shore sources, and production by shipboard potable water systems. The U.S. Navy defines potable water as water that has been treated and confirmed via testing to meet established water quality standards and declared FFHC.

a. FFHC is the term used by the U.S. Navy to indicate the water is safe for drinking, cooking, bathing, showering, dishwashing, and maintaining oral hygiene. Thus, potable water is FFHC.

b. Potable water to be used in the preparation of food and drinks must ONLY be obtained from cold water faucets. It is never acceptable to use potable water from hot water faucets for food or drink preparation. Water from hot water faucets is not subject to monitoring or surveillance.

2. Potable water for ships must be obtained only from approved water sources and water suppliers that provide potable water of a quality that meets or exceeds the NPDWR (40 CFR 141 and 142) and NSDWR (40 CFR 143) if applicable, specifically for microbial, chemical, physical, and radiological requirements. Great care must be taken in all operations and procedures associated with ship potable water and potable water systems to avoid the introduction of contaminants. Contamination may occur during production, handling, storage, or distribution of ship potable water.

3. Per article 1.9 of reference (j), ships are designed to have desalination production and fresh water storage capacity capable of providing 40 gallons per person, which include ship's company and all embarked personnel, per day. This capacity does not include non-habitability requirements.

4. Although ship potable water production and treatment is an engineering department responsibility, medical department personnel should understand the systems and processes involved to enable them to provide public health surveillance and make appropriate recommendations.

5. Deficiencies in any of the physical, chemical, or biological parameters of potable water quality (see article 6-7 of this chapter) could present health risks to personnel who consume or are otherwise exposed to the ship's potable water. In the event of a water quality issue, a public health risk assessment using an operational risk management approach should guide the MDR in advising the CO of the vessel on force health protection courses of action. This risk decision includes a consideration of the crew health risk relevant to the probability and severity risk code associated with a water quality contamination event. The MDR is encouraged to contact the cognizant Navy Environmental and Preventive Medicine Unit (NAVENPVNTMEDU) or NAVMCPUBHLTHCEN for public health consultation and advice.

6. Operational engineering oversight of shipboard water plants during water production, and the inspection and approval of ashore water sources are precautions necessary to protect the ship's potable water storage and distribution system from contamination to assure a safe water supply. Many points of possible contamination exist within the ship and may contribute to a waterborne illness or disease outbreak. Therefore, regardless of the source of the water, there must be vigilant surveillance by all crew members to assure adequate protection of the potable water supply from subsequent contamination.

7. Potable water is used aboard ships for services that support decontamination and marine sanitation device (MSD) flushing. Cross-connections between potable water and non-potable water services presents an acute health risk and are not permitted without approved backflow prevention devices.

8. The use of seawater in food services spaces, including sculleries, is prohibited and seawater outlets in these spaces must be removed. The dangers of cross-connections and using polluted overboard water cannot be overemphasized. Cross-connections between the potable water and seawater or other systems in food service spaces are not permitted.

6-7. Water Quality Standards

1. Physical Water Quality. Drinking water should be clear, colorless, and odorless. It should contain no sediment or other suspended matter. Pure water has no taste or odor. Tap water that has been treated has a mild scent and slight taste of the disinfectant used in the potable water system. It may also have other discernable tastes and odors from minerals, sulfur, and treatment compounds that do not affect water quality.

2. Salinity (chloride content)

a. The chloride content of water from a desalination plant should be at or below 0.065 equivalent per million (EPM), 0.25 grains of sea-salt per gallon or less than 2.3 parts per million (ppm) (milligram per liter (mg/L)). Salinity testing is conducted by the engineering department on ship-produced water.

b. If the chloride level of potable water exceeds those of water produced by the desalination plant, or initial levels in potable water obtained from shore sources, contamination of potable water by seawater should be suspected. Appropriate action, including investigation, repair, cleaning, and disinfecting must be initiated immediately.

3. Temperature and pH

a. The optimal pH range for a drinking water distribution system is 6.5 to 8.5.

b. Variations in the temperature and pH of water may affect treatment or disinfection procedures. Halogen disinfectants are more effective at lower pH and warmer temperatures. Water with pH levels > 8.5 will adversely affect the disinfectant properties of chlorine and bromine.

c. Testing for pH is routinely performed by engineering department personnel on feed-water. The test may also be used for potable water and is outlined in Naval Ships Technical Manual (NSTM), chapter 220, volume 2, Boiler Feed Water Test Treatment.

d. Testing for pH may also be accomplished using the N,N-diethyl-p-phenylenediamine (DPD) Chlorine-Bromine pH combination test kit.

4. Microbiological Water Quality. The microbiological water quality standard is zero colonies (or absence of) both total coliform and *E. coli* bacteria.

5. Halogen Residual (Chlorine, Bromine)

a. Surface ships (and submarines as applicable) must maintain a 0.2 ppm (mg/L) free available chlorine (FAC) or total bromine residual (TBR) in the potable water distribution system following initial treatment. Ships with large distribution systems such as aircraft carriers must maintain at least a detectable level of disinfectant at the most distal points of their distribution systems.

b. Chloramines in lieu of chlorine are used by many municipal water systems because of concerns related to disinfection byproduct water quality compliance. When chloramine is used for shore water source disinfection, the appropriate chlorine test is TC. Ensure TC is from 0.5-2.0 ppm (mg/L).

c. The maximum allowable chlorine, or TC residual at the point of ingestion is 4.0 ppm (mg/L). Water with high chlorine residual (>2.0 ppm [mg/L]) may be unpalatable for some consumers.

d. The maximum allowable bromine residual at the point of ingestion is 1.0 ppm (mg/L) per 40 CFR 180.519.

6-8. Approved Sources of Ship Potable Water. Potable water may be produced on board, received from approved shore sources (shore to ship or barge to ship), or provided from other U.S. Navy vessels (ship to ship).

1. Shore Installations (Shore to Ship, or Barge to Ship)

a. U.S. Environmental Protection Agency (EPA) (State and Territory) approved public water systems delivering water that meets the standards discussed in articles 6-6.2 and 6-7 of this chapter.

(1) All U.S. military installations are required to comply with the SDWA, the NPDWR, and as applicable, the NSDWR to ensure safe, sanitary water that is FFHC is delivered to all water system consumers. By complying applicable Service specific directives, U.S. military installations may be considered approved sources for bunkering shipboard potable water. For additional information about U.S. Navy drinking water programs and requirements for shore installations, refer to references (c) through (f).

(2) When ships are in port at a shore installation in the United States or its Territories, potable water is provided by the installation through its water system. Potable water may be delivered to ships either directly by hoses connected to the potable water riser on the pier or via a potable water barge or boat as illustrated in Figure 6-8.1.

(3) U.S. Navy approved overseas public water systems. This includes public water systems on overseas installations that the U.S. Navy (or other DoD entity) controls or operates per reference (b) and host nation FGS. Reference (b) is the base document that applies the U.S. standards, including the SDWA, to overseas installations. The FGS reconcile the requirements of applicable international agreements and host nation environmental standards with reference (b). The FGS often reflect the more protective requirement unless a specific international agreement with the host nation mandates a different standard applicable to installations. Not every overseas DoD port automatically meets U.S. drinking water standards unless the shore installation is part of the Navy ODW Program. Examples of port locations not in the Navy ODW program are as follows:

(a) Gaeta Fleet Landing, Italy

(b) Augusta Bay (North Atlantic Treaty Organization (NATO) Pier)), Italy

(c) Marathi Pier (NATO Pier), Crete

(d) Jebel Ali, United Arab Emirates (UAE)

b. Potable water purchased in overseas, non-U.S. Navy port facilities via husbanding contracts, including hauled water must meet the standards discussed in articles 6-6.2 and 6-7 of this chapter and the requirements of the husbanding contract.

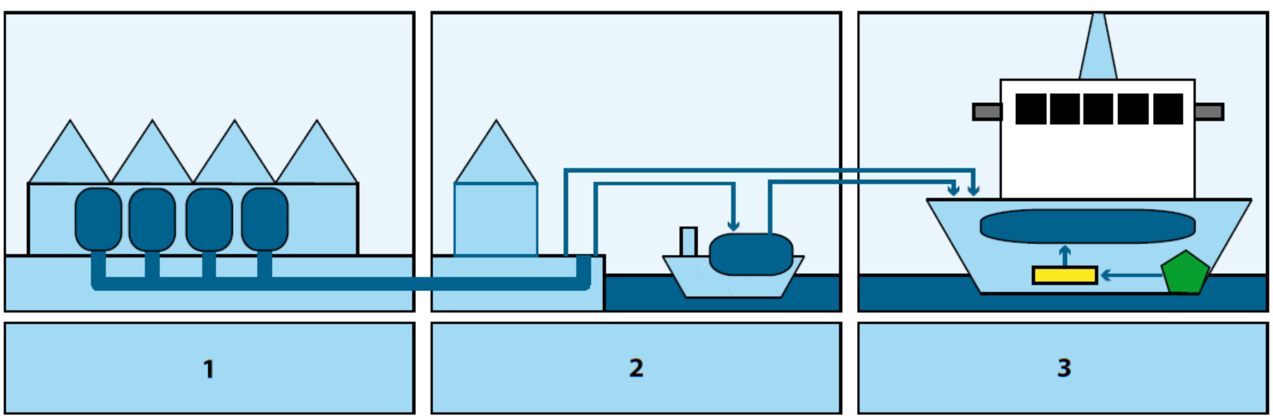

Figure 6-8.1. Illustration of Ship Potable Water Supply Chain, showing 1) shore source, 2) transfer and delivery system and 3) ship water production system. (World Health Organization, 2011)

c. Although shore installations in the U.S. and its Territories are considered approved sources for potable water, the ship's medical department and engineering department personnel should not permit bunkering of potable water from the shore installation to the ship without prior verification that the water from the shore installation contains the required disinfectant residual discussed in article 6-7 of this chapter. If the water does not contain adequate disinfectant residual, steps must be taken to protect the ship's potable water storage and distribution system from contamination (also described in section IV of this chapter) before loading potable water from that source.

d. Per references (i) and (k), as well as the Guide to Ship Sanitation (World Health Organization, 2011), ships must avoid using their onboard water production plants to make water while in port or in harbors. Seawater in ports and harbors should be considered polluted. Source water in harbors or ship navigation lanes is likely to be contaminated by fuel, oil slicks, or other pollutant sources. Biological contaminants are also likely to be present in these waters. If it is necessary, under emergency circumstances, to operate the distilling plant or reverse osmosis (RO) unit while in polluted waters, the procedures provided in article 533-2.4.5 of reference (i) must be strictly followed.

2. <u>Onboard Water Production</u>

a. Water production plants aboard naval ships are designed to make the ship as self-sufficient as possible. Generally, ship water treatment plants are capable of producing potable water which meets water quality standards, provided the treatment and operation procedures set forth in references (i) and (l) (volumes 1 through 3) are followed. Shipboard water production technology is covered in section III of this chapter.

b. Most U.S. Navy combatant ships and submarines are equipped with RO water production plants. Those that do not have RO plants utilize either flash-type steam desalination or electric thermo-compression water production plants. Ships of the Military Sealift Command are equipped with flash-type desalination plants or RO plants, with planned conversion to RO plants during overhaul.

c. Water produced aboard ships must be disinfected prior to being introduced into the potable water storage and distribution system. Presence of a measurable disinfectant residual contributes to ensuring the water is microbiologically safe for the intended use. Disinfection is discussed in section IV of this chapter.

d. Direct chemical additives to potable water systems afloat should be tested and certified by the product manufacturer per National Sanitation Foundation International Standards NSF/ANSI Standard 60: *Drinking Water Treatment Chemicals – Health Effects*. Likewise, indirect chemical additives which are relevant to potable water system components should be tested and certified by the product manufacturer per NSF/ANSI Standard 61: *Drinking Water System Components – Health Effects*. Manufacturers should meet other applicable NSF and ANSI potable water public health standards as indicated for point of use applications. To obtain more information about NSF and ANSI standards for drinking water system components and water treatment chemicals, visit the NSF Web site at https://www.nsf.org/testing/water/onsite-wastewater-systems/wastewater-protocols. Figure 6-8.2 shows examples of NSF and ANSI certification marks.

Figure 6-8.2. Examples of NSF/ANSI Certification Marks.
(NSF® is a registered trademark of NSF International, Ann Arbor, Michigan.)

3. Bottled Water. Commercial bottled water supply must be acquired from DoD approved sources as included in the *Worldwide Directory of Sanitarily Approved Food Establishments for Armed Forces Procurement* (U.S. Army MEDCOM Circular 40-1).

6-9. Sources of Doubtful Quality or Unapproved Sources

1. All water supplied by public or private systems, where the water quality cannot be verified to meet or exceed the standards discussed in article 6-6.2 of this chapter, should be considered of doubtful quality. This may include water purchased in overseas, non-U.S. Navy port facilities.

2. When doubt exists as to the quality of the water, ship personnel (medical and engineering) must investigate the source and examine the water as thoroughly as possible with the means available. They should then advise the CO of the necessary procedures, safeguards, and disinfection. In instances where the ship must receive water of doubtful quality, disinfection will be accomplished per article 6-21 of this chapter.

6-10. Receipt and Transfer of Potable Water

1. When receiving or transferring potable water via approved sources, proper procedures must be followed to prevent contamination.

a. The required disinfectant residual level of the water to be transferred depends on the type of disinfectant utilized in the source water system. For example, some shore water systems may utilize hypochlorite disinfectant, while others may employ chloramines (combined chlorine and ammonia). Water being received from another ship may be disinfected using either hypochlorite or bromine. Prior to receiving water, ensure that it contains the appropriate disinfectant residual level.

(1) For hypochlorite disinfectant, ensure the FAC is at least 0.2 ppm (mg/L).

(2) When chloramine is used for shore water source disinfection, the appropriate chlorine test is TC. Ensure TC is from 0.5-2.0 ppm (mg/L).

(3) If receiving from a ship using bromine to disinfect its water, the TBR should be at least 0.2 ppm (mg/L).

b. If the transferring water source does not have the minimum required halogen residual (FAC or TBR), the first course of action should be to request that the shore installation Naval Facilities Engineering Command (NAVFAC) public works department (PWD) or transferring ship take action to boost the halogen residual in its water supply. The ship may need to boost the halogen level to achieve 0.2 ppm (mg/L) residual in the distribution system. Higher residual levels may be required at the potable water tank in order to maintain a 0.2 ppm (mg/L) residual at a service tap due to halogen demand.

c. When a shore installation uses chloramine, which is widely used by CONUS municipal water systems for disinfection, ship personnel (medical or engineering) should test the pier water source to confirm at least 0.5 ppm (mg/L) TC residual is present at the pier riser. If the TC residual level is < 0.5 ppm (mg/L) then ship personnel should notify port services who in turn should forward a report to the installation NAVFAC PWD. Boosting halogen residual aboard ship when water supply is from an approved U.S. shore water source containing chloramine is not recommended. Adding chlorine or bromine to water containing chloramine disinfectant can cause a loss of residual (FAC or TBR) and taste and odor problems. Instead, recommended shore PWD take action to boost the TC residual for the shore water supply.

d. When potable water from the transferring source contains at least the minimum required halogen residual, no further treatment is required, and the water may be consumed immediately.

e. Measurement of the halogen residual must be conducted with an approved water test kit for the specific disinfectant being used and must follow the manufacturer’s directions using the proper supplies and test procedures. Manufacturer’s testing instructions and materials for testing for FAC or TC are generally different methods which require different consumable materials.

2. Potable water connections between shore and ships must be made by authorized and trained personnel. The individual making the potable water hose connections must ensure hoses are not connected to a non-potable water system. Engineering will notify the MDR prior to making potable water hose connections. The MDR will determine if the correct disinfectant residual (FAC or TC) is present in the source water and if it is not, he or she will notify the engineering department representative. An entry in the potable water log or approved electronic medical database will be made.

3. Potable water hoses must not be submerged in harbor waters.

6-11. <u>Connection and Transfer Procedures</u>. Table 6-11.1 provides guidelines for connection procedures covering shore-to-ship and ship-to-ship transfer of potable water. Modification of these procedures may be necessary or required due to ship configuration or operating conditions. The table is to be read top-down, not left-right.

Table 6-11.1. Potable Water Transfer Procedures for Shore-to-Ship and Ship-to-Ship*

Shore-to-Ship	**Ship-to-Ship**
Remove shore cap and flush pier side potable water outlet for 15-30 seconds. Immerse outlet and rinse fitting in solution containing 100-ppm FAC for at least 2 minutes. Flush water to waste for 15-30 seconds.	Both ships disinfect their respective potable water riser connections. The leading potable water hose must have the hose cap in place during the high-line procedure.
Deliver a clean disinfected potable water hose to the outlet just before the connection is made (potable water hoses should be provided by the shore facility). Remove hose caps or uncouple hose ends and disinfect if not previously disinfected. Connect hose to pier side outlet and flush.	When the receiving ship secures the potable water hose, the cap is removed and the hose coupling is disinfected.
Disinfect shipboard riser connections with 100-ppm FAC solution. Connect hose to the potable water shipboard riser and deliver potable water. Other FDA listed food contact surface disinfectants such as iodine may be used if approved by the MDR.	The supplying ship connects its end and flushes the hose.
When the transfer is completed, secure the shore water source; remove the ship connection, then the shore connection. Thoroughly flush the potable water outlet and recap.	When the transfer is completed, the receiving ship removes the potable water hose and replaces the caps on the receiving connection and the potable water hose.
Drain the potable water hose thoroughly and properly store in the potable water hose storage locker.	The supplying ship then retrieves, couples or caps, and properly stores the potable water hose.

* Table should be read in columns; top to bottom, not left to right.

CHAPTER 6
WATER QUALITY AFLOAT

SECTION III. PRODUCTION, STORAGE, AND DISTRIBUTION

6-12. Potable Water Production

1. Current Navy ships and submarines are equipped with the capability of producing large quantities of very high-quality fresh water on a continual basis to satisfy a variety of requirements and demands. Technological advances in desalination methods, water treatment and disinfection, and materials used in water system components will continue to evolve and improve the systems, processes, and quality of water produced on Navy ships. Paragraph 2 of this section is a brief description of shipboard water production capabilities in use as of the date of this writing. Shipboard medical personnel responsible for medical surveillance of potable water are encouraged to engage with engineering department personnel, and applicable technical manuals and ship specific procedures, for more information about ship potable water production and distribution systems.

2. Types of Shipboard Water Production Plants

a. Ship potable water systems are designed and constructed per the general guidance of reference (i), MIL-STD-777, MIL-STD-438, and ship specific builder specifications.

b. Desalination plants. There are three general types of desalination plants installed on naval vessels. The majority of the water produced by these desalination plants is used for habitability purposes. Fresh water produced by these plants is also used for various propulsion plant purposes, aircraft wash-down, and firefighting. At new construction, desalination plants are sized with respect to gallons-per-day of water production to meet reference (j) habitability requirements, all non-habitability needs, and contractual personnel and machinery growth margins.

(1) Steam desalination plants are operated by steam supplied directly or indirectly from a power plant or auxiliary boiler. They are subdivided into two groups, submerged type and flash type. These subdivisions differ mainly in the pressure in the heating elements and evaporator shell.

(a) Waste heat distilling plants are submerged tube-type and use heat derived from diesel engine jacket water.

(b) Vapor-compression-type distilling plants require primarily only electrical energy for operations; however, additional heat exchangers that use waste heat (exhaust gas or cooling water) may be installed.

(2) In the flash-type distilling plant, the temperature of the water is never raised above 175°F (79°C) and is only raised to this temperature within the last pass of tubes of the saltwater heater. Flash-type evaporation takes place at temperatures as low as 104°F (40°C).

(a) The term “flash-evaporation” means that water is converted to steam as it enters an evaporating chamber without further addition of heat.

(b) Flashing at low temperature is possible only when a vacuum is maintained on the chamber, since the boiling point of water decreases as the pressure in the chamber is reduced.

(c) According to the International Organization for Standardization (ISO) standards, water that has been produced below 176°F (80°C) needs to be disinfected before it can be defined as potable water.

(d) If the feed water entering the evaporating chamber contains volatile organic compound, these compounds may be carried over to the product side of distillation units and concentrated.

(3) RO. Single and multiple pass RO plants are the most common water production technology on Navy ships and submarines. RO plants consist of a pre-filtration section that can include a coarse strainer, a mixed media (i.e., sand) filter, a centrifugal separator and cartridge filters meant to remove suspended particles from the feed water (seawater) stream. Multiple pass RO plants (also known as high-purity RO plants on surface ships) have inlet cartridge filters to remove suspended particles from the feed water stream. A brief discussion of RO treatment:

(a) Through a high-pressure pump, the pre-filtered water is boosted up in pressure to as much as 1,000 pounds per square inch then introduced into the RO pressure vessels that contain circularly wrapped polyamide thin film RO membranes. A portion of the filtered water, typically 20-25 percent, permeates through the membrane to become fresh water. The remaining brine, which does not pass through the RO membrane, is discharged from the RO unit as waste.

(b) Although the RO membrane is theoretically capable of removing all viruses and bacteria from the feed water under optimal operating conditions, membrane fouling may occur and can compromise the integrity of the membranes. RO is not solely relied upon for accomplishing pathogen removal in single-pass RO plants. Disinfection of this water is accomplished through the addition of chlorine, bromine, or a mixed oxidant solution downstream of the RO plant discharge.

(c) In multiple-pass RO plants, the requirement for disinfection is not necessary because it is assumed that the redundancy of three membranes, connected in series accomplishes adequate removal of pathogenic organisms. Per references (i), and volume 3 of reference (l), RO treated water from a single-pass RO unit ranges in purity from 350 to 500 ppm (mg/L) total dissolved solids (TDS), while distilled water purity is on the order of 1 to 2 ppm (mg/L) TDS. Multiple pass RO units can produce water with less than 1 ppm (mg/L) TDS.

6-13. Potable Water Storage

1. Storage of ship potable water is another crucial stage in the system. Potable water storage tanks must be protected from the introduction of contaminants, including contaminated water at all times.

2. Potable water storage tanks on ships and submarines are sized to store enough water to meet peak water demand requirements while the ship is underway. The high demand for potable

water for drinking, cooking, personal hygiene, and other purposes ensures frequent turnover of the potable water tanks. This frequent turnover of the potable water tanks helps to prevent water quality problems caused by prolonged detention times, also referred to as hydraulic residence time. If the water stored in potable water tanks is subject to prolonged detention times, water quality may deteriorate. Typical problems with stored water include:

a. Loss of disinfectant residual.

b. Bacterial growth (biofilm).

c. Nitrification in water disinfected with chloramines.

d. Formation of disinfection by-products (DBP).

e. Accumulation of debris and sediment.

f. Degradation of tank coatings, materials and plumbing.

3. <u>Potable Water Tanks</u>

a. Potable water tanks are constructed and situated, to the greatest extent possible, in a manner intended to prevent contamination of their contents. However, shipboard space utilization design considerations place some potable water tanks along the inner bottom of the ship or in other locations, just inside the skin of the ship.

b. If tanks must be entered, personnel should be equipped with clean, single use coveralls, face mask, disposable gloves, and shoe covers. Any tools used in the tank need to be cleaned and disinfected prior to entering the tank. No person with an acute illness (e.g., diarrhea) should be allowed to enter potable water tanks.

c. If the epoxy coating used on potable water tank interior surfaces is not properly mixed or cured after application, it will cause chemical contamination of the water supply, resulting in taste and odor problems. Section VI of this chapter addresses taste and odor problems.

d. Potable water tanks should not be filled with ballast water unless absolutely necessary for the survival of the ship for damage control. If non-potable water is introduced into potable water tanks, all tanks, lines, fittings, and pumps must be disconnected from the potable water system, plugged or capped and not reconnected until properly cleaned, flushed, disinfected, and tested as applicable per article 6-24 of this chapter.

e. Cross-connections between potable water and all other non-potable water and fluid systems must be prevented at all times. If prevention cannot be achieved, approved backflow preventers must be utilized.

6-14. Filling Lines

1. Filling connections must be clearly labeled and color-coded per reference (m). They should be conspicuously designated by a warning plate bearing the inscription POTABLE WATER ONLY in 1-inch letters.

2. Fill lines for potable water must not be cross-connected with any non-potable water line or system.

3. When not in use, filling connections must be closed with screw-caps attached with keeper chains.

6-15. Potable Water Piping

1. Every component in the potable water system including potable water piping must be clearly identifiable and protected from the introduction of contamination at all times. Cross-connections without approved backflow prevention devices, between potable water lines and all other fluid systems are prohibited. Refer to section IX of this chapter for information on cross-connection prevention.

2. Potable water pumps should be air-tight and free from cross-connections. Non-potable water must never be used for priming pumps or maintaining packing gland seals. Pumps that have been dismantled for repair must be disinfected after reassembly prior to being returned to service.

3. Materials that will be in contact with water must be safe for use in potable water systems as indicated by NSF/ANSI 61 certification. Potable water pipes, fittings, joints, and fixtures containing lead materials should not be used anywhere in the potable water system, as these can leach into and contaminate the water.

4. Special attention must be given to potable water piping located in bilge areas, particularly the piping on the suction side of the potable water pumps where leakage could result in contamination. This piping should be hydrostatically tested per the preventive maintenance system and kept in good working order.

5. The use of point-of-use potable water treatment devices such as charcoal impregnated or other filter equipment is not recommended and is not typically part of the inherent system design.

6. The distribution system for any ship may contain problem areas that can accelerate water quality deterioration:

a. Dead-ends where the water remains stagnant for extended periods of time.

b. Tanks that are not turning over due to minimal demands (i.e., lengthy water detention times due to tank size relative to water demand).

c. Artificial dead-ends created by closed valves that should be open.

d. Tanks that are hydraulically locked out of the system (i.e., due to water pressure constraints, tanks that are not routinely emptied and filled).

7. The typical problems encountered within water distribution systems include:

a. Loss of disinfectant residual within the distribution system.

b. Bacterial growth (biofilm).

c. Growth of nitrifying bacteria in chloramine treated water.

d. Excessive levels of Trihalomethanes (THM) or other DBPs.

e. Leaching or contamination of chemicals and biological contaminants from corrosion, other structural integrity problems in piping, and other distribution system components.

f. Discolored water.

g. Taste and odor problems.

h. Excessive disinfectant residuals (i.e., greater than the Maximum Residual Disinfectant Level [MRDL]) from excessive disinfectant boosting or disinfectant dosage for piping and storage disinfection.

i. For ship systems receiving chloramine disinfected water, excess free ammonia in the water being delivered to the distribution system.

8. To avoid scald injuries, the temperature setting for the water heaters serving habitability space showers and lavatories must be set not to exceed 120° Fahrenheit or 48° Celsius at the tap. Water heaters serving wash basins and showers must not support work spaces that have higher temperature requirements such as the galley, scullery, and laundry.

6-16. <u>Repairs</u>

1. In the event of a break or compromise in the potable water system, or if a potable water tank is entered for any reason, all involved tanks, parts, and lines must be cleaned, flushed, and disinfected prior to being returned to service. Refer to article 6-24 of this chapter for more information about cleaning and disinfection of potable water tanks. The MDR must be notified of the break or entry and the disinfection procedure accomplished by the engineering department. Prior to use, test the system according to article 6-21 of this chapter.

2. For potable water piping repairs including flanged joints, only use sealants and lubricants certified to NSF/ANSI Standard 61. Confirmation concerning authorized sealants and lubricants may be obtained by consulting with NAVSEASYSCOM.

3. If repairs require the replacement of piping, fittings, or valves, the replacement parts must conform to the requirement of NSF/ANSI Standard 61.

6-17. Labeling and Color-Coding

1. All potable water system piping, hoses, valves, and other connections must be distinctly identified per reference (m).

2. Potable water sounding tubes must be clearly labeled with an identification plate. The sounding tube cap must be color-coded dark blue. On ships using steel tapes for sounding potable water tanks, the tape handle must be color coded dark blue, labeled, or otherwise identified "POTABLE WATER USE ONLY."

3. Valves for receiving or supplying potable water must be conspicuously designated by a warning plate bearing the inscription "POTABLE WATER ONLY" in ¼ inch high letters.

4. Potable water hoses must be labeled "POTABLE WATER ONLY" with 1-inch high letters approximately every 10 feet of hose, and the end couplings must be dark blue in color.

5. Potable water piping passing through any given space must be appropriately labeled to indicate the type of service and with an arrow indicating the direction of flow.

6-18. Care of Shipboard Potable Water Hoses and Equipment

1. Potable water hoses must not be used for any other purpose. They must be properly labeled, stored, and protected from sources of contamination at all times. Hoses must be examined frequently (i.e., before each use and per type commander requirements by MDR) and removed from use when cracks develop in the lining or leaks occur. For disinfection procedures for potable water hoses, refer to article 6-25 of this chapter.

2. As described in reference (i), potable water risers must be properly labeled and fitted with a cap and keeper chain. The potable water riser valve or valve handle must be properly color-coded per reference (m). Riser hose connections must be disinfected prior to connecting a potable water hose to them.

3. Potable water tank sounding tubes will be equipped with screw caps attached to keeper chains. Screw caps will be secured with a lock. On those ships with sounding rods, the rod should remain in the tube at all times. Potable water sounding tapes must be sanitized prior to each use and will only be used for potable water tank volume measurements.

6-19. Potable Water Hose Storage Lockers

1. Potable water hose storage lockers must be conspicuously identified and labeled "POTABLE WATER HOSE ONLY." The lockers must be vermin proof, self-draining, and mounted at least 18 inches above the deck. They should be constructed from smooth, non-toxic, corrosion resistant material.

2. When not in use, the potable water hoses must be coupled or capped and stored in the designated lockers. In addition to the potable water hoses, all fittings and tools used exclusively for potable water must also be stored in the designated potable water hose locker. The lockers must always be kept closed and locked when the hose is not being used.

3. Printed instructions outlining step-by-step procedures for disinfection of potable water hoses and risers must be posted in a conspicuous location in or near the hose storage locker.

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SECTION IV. DISINFECTION

6-20. Disinfection of Potable Water Supplies

1. Disinfection is the process of destroying microorganisms that might cause human disease in individuals who drink or otherwise come into contact with potable water. Disinfectants react with and kill or inactivate microorganisms and contaminants in the water supply. Besides the ability to kill pathogens and oxidize contaminants, a disinfectant must also maintain a concentration (residual) in the water for an extended period of time to account for additional pathogens or contaminants that might be introduced or otherwise present in the potable water supply.

2. Approved Shipboard Potable Water Disinfectants

a. Chlorine

(1) Chlorine in the form of granular calcium hypochlorite (65-70 percent available chlorine) or sodium hypochlorite in varying strengths as a liquid are the most common halogens utilized for disinfection of potable water supplies. All calcium hypochlorite or sodium hypochlorite products used for potable water disinfection must be NSF/ANSI 60 certified.

(2) Chlorine may be added to the potable water system via mechanical methods or manually if mechanical methods are not available.

(3) Some ship classes are now equipped with automated electrolytic hypochlorite generators that use an electrolytic cell to produce a mixed oxidant solution with 2 to 3 percent sodium hypochlorite from NSF/ANSI 60 certified solar salt that is injected into the ship's potable water system.

b. Bromine

(1) Bromine in the form of a bromine impregnated resin cartridge is another commonly used potable water disinfectant on some ship classes.

(2) Bromine can only be added to the potable water system via mechanical methods. If the ship's brominators are unable to generate quantities of bromine sufficient to produce the required residual concentration following a 30 minute contact time, calcium hypochlorite may be manually added to the system to boost the concentration to obtain the required residual.

3. Direct chemical additives to potable water systems afloat should be tested and certified by the product manufacturer per NSF/ANSI Standard 60: *Drinking Water Treatment Chemicals – Health Effects*. To obtain more information about NSF/ANSI standards for drinking water system components and water treatment chemicals, visit the NSF Web site at: http://www.nsf.org/services/by-industry/water-wastewater.

4. Calcium hypochlorite presents a serious potential personnel and fire hazard due to its corrosiveness and chemically active nature. It is classified as a hazardous material and requires special storage precautions and must be handled and stowed per reference (n). Calcium hypochlorite storage requirements for surface vessels and submarines are discussed in article 6-31 of this chapter.

5. Bromine is classified as slightly corrosive and requires proper handling and storage procedures. Bromine cartridges must be stored in a clean, dry, well ventilated storeroom. Bromine storage lockers require a hazardous warning plate as described in reference (i). Bromine cartridges have a shelf life of 2 years from the date of manufacture. Cartridges exceeding the shelf life may still be used, but chemical disinfection efficiency may be reduced.

6-21. Shipboard Potable Water Disinfection Requirements

1. Maintaining disinfectant residuals throughout the distribution system is used as a barrier against intrusion of bacterial and viral pathogens into distribution systems, and as a mechanism to reduce the formation of biofilms, and the growth and persistence of free-living pathogens. Disinfectant residuals should be detectable (preferably ≥ 0.2 ppm [mg/L]) but must be below the MRDL throughout the distribution system, including the location representing maximum residence time in the distribution system. The absence of a FAC or TBR in the ship's potable water may indicate contamination and should trigger engineering department follow up action.

2. Submarines have historically been exempt from routine disinfection requirements for potable water produced on board while underway. When maintained and operated properly, the submarine desalination equipment produces ample quantities of fresh potable water containing nearly no dissolved solid materials and free of biological contaminants. However, some submarines have been retrofitted with in-line brominators to disinfect water produced on board while underway.

3. Shipboard water is disinfected by the addition of sufficient quantities of chlorine or bromine to produce not less than a 0.2 ppm (mg/L) FAC or TBR concentration after 30 minutes of contact time measured at the potable water tank. The amount of chlorine or bromine required to produce a FAC or TBR of not less than 0.2 ppm (mg/L) after 30 minutes of contact can vary widely because of high disinfectant demand, water temperature, and other factors.

4. A disinfectant residual of 0.2 ppm (mg/L) FAC or TBR throughout the distribution system is the desired operational parameter and public health goal.

a. The MRDL for chlorine is 4.0 ppm (mg/L), however a residual chlorine concentration > 1.0 ppm (mg/L) at the tap is generally not necessary or recommended.

b. Per 40 CFR § 180.519, residual bromine levels must be controlled to not exceed 1.0 ppm (mg/L) in the final treated water.

5. Water without a disinfectant residual (FAC or TBR) that was obtained from an approved source, or water produced on board must be chlorinated or brominated to produce at least a 0.2 ppm (mg/L) residual (FAC or TBR) at the end of a 30-minute contact time in the potable water tanks.

6. Water received from an unapproved source, a source of doubtful quality, or an area where amebiasis or infectious hepatitis is endemic, must be chlorinated or brominated to provide at least a 2.0 ppm (mg/L) chlorine residual or a 1.0 ppm (mg/L) bromine residual at the potable water tanks at the end of a 30-minute contact time. In these instances, since a TBR of 2.0 ppm (mg/L) exceeds the allowable residual of 1.0 ppm (mg/L), the disinfectant level must be boosted by the "batch method" via a potable water sounding tube to obtain not less than 2.0 ppm (mg/L) FAC at the potable water tank after 30-minute contact time. After a 2.0 ppm (mg/L) FAC is maintained for 30 minutes in the potable water tank, the water is considered safe for distribution.

6-22. Mechanical Disinfectant Addition Methods

1. For ship classes that use chlorine to disinfect potable water, there are several different types of chlorinators installed. Chlorinators may be installed in the desalination plant, in the permeate line, and in the shore fill line. The chlorinator may also serve both the permeate line and the shore fill line.

a. The permeate line is generally provided with an electric, motor driven chlorinator. These chlorinators have controls, which energize the chlorinator in conjunction with the permeate pump motor and water-flow past the chlorinator.

b. The shore fill line is generally provided with a hydraulically actuated chlorinator or an electrical motor driven chlorinator. The hydraulically actuated unit injects hypochlorite solution into the water system in proportion to the flow of water through a meter.

c. The permeate line and fill line may be served by a fill line chlorinator unit if the desalination plant is large enough to permit sufficient flow through the unit. This type of installation is generally provided with a hydraulically actuated or an electric motor driven chlorinator.

2. For ship classes that use bromine to disinfect potable water, there are two types of brominators installed. One type is used on the discharge line and the other is used to recirculate water in the potable water tanks during treatment.

a. The in-line (proportioning) brominator is used when the desalination unit is online and making water. Multiple vendors manufacture these devices. Dependent on design, the unit is either provided with a set of orifices that gauges a predetermine proportion of flow through a bromine cartridge or via a throttle valve design which controls flow. In-line brominator units contain an orifice preset to deliver 0.7 ppm (mg/L) bromine to the water during normal operating procedures and an orifice to deliver 2.0 ppm (mg/L) bromine to the water when an increase in total bromine is required. The throttle valve design also allows for adjustment of bromine feed. Dissolved bromine via the bromine cartridge(s) enters bypassed water stream feed to a potable water tank. One in-line brominator is required for each water plant.

b. The recirculation brominator unit is designed to boost bromine residual for water in a potable water tank. Treatment is accomplished by the recirculation of potable water from a potable water tank through the brominator and back to the same tank. This treatment offers diversity in recirculation and bromination of water received from external water sources, as well as providing capability to boost bromine levels from ship produced water, when necessary.

c. As the water in a selected tank is recirculated, a portion of the recirculated water is automatically proportioned to flow through the bromine cartridge. A timing device to achieve the required bromine feed into the selected tank limits flow through the cartridge. After a pre-calculated period of time, the timing device terminates the bromine feed into the water. Recirculation of water continues for an additional pre-calculated time period to complete an even dispersion of bromine disinfectant throughout the potable water tank.

d. These time period calculations are based on individual tank volume and temperature of the water. This recirculation unit is also preset to deliver 0.7 ppm (mg/L) bromine to the water being recirculated. A sampling tap is present to test the bromine residual after recirculation; if the desired level of bromine has not been achieved through the initial recirculation process, the timer may be reset and the water recirculated until the desired level of TBR is achieved; however, efforts to achieve bromine levels at the 2.0 or higher ppm (mg/L) level may not be practical due to the length of time required.

e. It may be more convenient to use batch chlorination procedures to rapidly raise the levels of chlorine in the water supply, particularly in the event of contamination or necessity to achieve higher chlorine levels.

3. A growing number of ships (and classes) are being equipped with the automated electrolytic hypochlorite generators, which do not require the storage and handling of toxic chemicals. Each system is comprised of a fresh water system, a brine system, and an oxidant injection system. The system operates automatically.

a. Fresh water from the ship's fresh water system is brought into the hypochlorite generator unit and stored in the brine tank, where salt (sodium chloride) is added to make a brine solution. This solution is added to a larger flow of fresh water to make a 3 to 4 percent brine solution, which is then passed through the electrolytic cell, where an electrical current is passed through it.

b. The positively charged sodium ions and the negatively charged chloride ions are separated electrolytically in the cell. These ions then react with the water itself to produce a mixed oxidant solution containing 2 to 3 percent sodium hypochlorite. The resulting disinfectant solution is stored in the mixed oxidant tank until use. This electrolytic process also produces hydrogen gas, which must be properly vented to avoid an explosion.

c. As required, a metered flow of disinfectant solution is released into a flow of ship's fresh water to disinfect it.

6-23. Manual Disinfectant Addition Methods

1. Batch Chlorination may be used if mechanical methods are not available. However, this is considered the least desirable method of disinfecting potable water supplies, because it may result in over-chlorination due to the inability to properly mix the water and hypochlorite solution.

a. The proper dosage of chemical must be determined for the volume of water to be disinfected. Article 6-27 of this chapter provides guidance for determining the chlorine dosage.

b. When 65-70 percent strength calcium hypochlorite is used, the calculated amount of calcium hypochlorite is dissolved in a non-glass container of warm water (80°F to 100°F) and the suspended matter allowed to settle out. Only the clear fluid (supernatant) is introduced into the sounding tube when the tank is ¼ full. Add one gallon of potable water to flush the sounding tube afterwards. The remaining sediment should be discarded as waste. The chlorine solution must only be introduced into the potable water tanks via sounding tubes or air vents, but NEVER by removal of the manhole cover.

c. Under no circumstances should manual chlorination be attempted by adding the solution to the brominator cartridge container.

d. Sufficient mixing of the chlorine and water will be obtained by the stirring action of the incoming water as the tank is being filled. The motion of the ship will make a small contribution to mixing. Additional mixing may be accomplished by recirculation. If the chlorine solution must be introduced into a full tank, recirculation through a pump is the only way to achieve adequate mixing.

6-24. Disinfection of Potable Water Tanks and Systems

1. Potable water tanks and all affected parts of the potable water distribution system must be cleaned, disinfected, and flushed with potable water:

a. Before being placed in service;

b. Before returning to operation after repair, replacement; or

c. After being subjected to any contamination, including entry into a potable water tank.

2. There are two methods for disinfecting tanks:

a. Mechanical cleaning (including all measures necessary to clean tanks of foreign materials, rust, and other substances present within the tanks) with chemical disinfection.

b. Chemical disinfection.

3. Mechanical cleaning and chemical disinfection will be accomplished when the condition of a tank has deteriorated to the point where the chlorine demand has increased significantly, and bacteriological test results indicate the tank water quality is unacceptable. After any tank has been mechanically cleaned, it will be chemically disinfected per Table 6-24.1. Mechanical cleaning and chemical disinfection must be accomplished under the following conditions:

a. Tanks of new ships or tanks which have been repaired.

b. Where sludge or rust accumulation seriously impairs the quality of water.

c. Tanks that have been loaded with non-potable, ballast water.

4. Chemical disinfection is required when the following conditions exist:

a. Tanks in which there is continued bacteriological evidence of contamination after normal disinfecting procedures.

b. Pipelines, valves, pumps, etc., that have been dismantled, repaired, or replaced.

c. Tanks which have been entered.

5. Potable water tanks must be inspected, cleaned, and disinfected during dry dock and wet dock periods, or every 2 years, whichever is less.

6. Highly chlorinated water discharges must comply with Federal, State, local, or host nation environmental regulations. Water containing chlorine levels greater than 4.0 ppm (mg/L) is considered highly chlorinated but in many cases, chlorine levels of 0.2 to 4.0 ppm (mg/L) also require special precautions. Special provisions or permits may be required prior to discharge of highly chlorinated water. Local authorities (i.e., port services, NAVFAC Public Works) must be contacted prior to disposal of highly chlorinated water. American Water Works Association (AWWA) Standard ANSI/AWWA C652-02, Appendix B provides guidance for neutralizing highly chlorinated water.

Table 6-24.1. Methods for Disinfection of Potable Water Tanks* (Reference: ANSI/AWWA** Standard C652-02)		
METHOD 1	METHOD 2	METHOD 3
Fill tank to over flow level	Spray/apply directly 200 ppm FAC to all tank surfaces	Fill 5% of tank volume with 50 ppm FAC solution
Add chlorine to achieve 10 ppm FAC throughout the tank	Flush inlet/outlet pipes with 10 ppm FAC	Hold solution for 6 hours
Hold this solution for 24 hours	Disinfected surfaces must remain in contact with chlorine solution for a minimum of 30 minutes	Add potable water to chlorine solution to fill tank; hold this water for 24 hours
Drain tank	Refill tank with potable water with required halogen residual level	Drain tank
Refill tank with potable water with required halogen residual level		Refill tank with potable water with required halogen residual level
Perform bacteriological testing of potable water		
Upon satisfactory bacteriological testing and aesthetic quality water may be delivered to the system		

*Note: This table should be read from top to bottom, not left to right.
** American Water Works Association (AWWA)

6-25. Disinfection of Potable Water Hoses, Tapes, and Rods

1. Potable water hoses are disinfected by filling them with potable water containing a 100 ppm (mg/L) FAC. The solution must be in contact with the entire hose interior for at least 2 minutes. The hose must then be flushed with potable water for a minimum of 30 seconds prior to use.

2. The standard 2 ½ inch potable water hose has a volume of 0.25 gallons per foot of hose. This figure may be used in determining the volume of the hose for disinfecting purposes.

3. Prior to connecting the potable water hose to either the ship riser or the shore connection, the interior of the fittings must be disinfected by contact with a solution of 100 ppm (mg/L) FAC for not less than 2 minutes. The shore water source connection should be flushed to waste for at least 30 seconds prior to connecting the potable water hose to it.

4. Disinfection of sounding tapes and rods may be accomplished by wiping the rod or tape with a 100 ppm (mg/L) FAC solution of other suitable disinfectant that is safe for use with potable water (e.g., food contact surface disinfectant).

6-26. Emergency Disinfection of Water for Drinking and Cooking Purposes

1. If an approved water source is not available, it may be necessary to treat water from an unapproved source for drinking and cooking purposes in an emergency. The water to be treated should be clear and free of turbidity and obvious indications of chemical contamination. Before human consumption, this water must be chlorinated initially to at least 5.0 ppm (mg/L) FAC for a minimum 30-minute contact time. At the point of consumption, the water should have a final residual of at least 2.0 ppm (mg/L) FAC.

2. Water from an unapproved source may also be made safe for consumption by maintaining a rolling boil for at least 2 minutes.

3. If the water is excessively contaminated or turbid, bottled, canned, or other emergency drinking water sources should be considered.

6-27. Chlorine Dosage Calculations

1. Tables 6-27.1, 6-27.2, and 6-27.3 provide chlorine dosage information.

2. When 65-70 percent strength calcium hypochlorite is used, generally 1 ounce added to 5,000 gallons of water is the approximate dose required to achieve a 1.0 ppm (mg/L) chlorine concentration. This “rule of thumb” may be utilized to calculate chlorine dosages for batch chlorination. However, it is only a suggested starting point. The actual required dosage will depend on the temperature, pH, and chlorine demand of the water being treated.

3. In the tables provided, first find the table that represents the form and strength of hypochlorite being used (i.e., 5 percent liquid sodium hypochlorite, 65-70 percent granular calcium hypochlorite). Then select the row that represents the quantity (in gallons) of water to be treated. Then find the chlorine dosage for that quantity of water under the column that represents the desired chlorine concentration to be achieved in the water being treated.

Table 6-27.1. Chlorine Dosage Calculator for 5% Liquid Sodium Hypochlorite (Unscented)

Tsp = teaspoon Tbsp = tablespoon 3 Tsp = 1 Tbsp 2 Tbsp = 1 Oz Qt = quart Gal = Gallon

QUANTITY (GAL.)	PPM 1	PPM 5	PPM 25	PPM 50	PPM 100	PPM 200
50,000	1 Gal.	5 Gal.	25 Gal.	50 Gal.	100 Gal.	200 Gal.
25,000	2 Qt.	10 Qt.	50 Qt.	25 Gal.	50 Gal.	100 Gal.
10,000	26 Oz.	1 Gal.	5 Gal.	10 Gal.	20 Gal.	40 Gal.
5,000	13 Oz.	2 Qt.	10 Qt.	5 Gal.	10 Gal.	20 Gal.
2,000	6 Oz.	26 Oz.	1 Gal.	2 Gal.	4 Gal.	8 Gal.
1,000	3 Oz.	13 Oz.	2 Qt.	1 Gal.	2 Gal.	4 Gal.
500	2 Oz.	7 Oz.	1 Qt.	2 Qt.	1 Gal.	2 Gal.
200	1 Tbsp.	3 Oz.	13 Oz.	26 Oz.	52 Oz.	103 Oz.
100	2 Tsp.	2 Oz.	7 Oz.	13 Oz.	26 Oz.	52 Oz.
50	1 Tsp.	1 Oz.	4 Oz.	7 Oz.	13 Oz.	26 Oz.
25		1 Tbsp.	2 Oz.	4 Oz.	7 Oz.	13 Oz.
10			1 Oz.	3 Tsp.	3 Oz.	6 Oz.
5			1 Tsp.	5 Tsp.	2 Oz.	3 Oz.

Table 6-27.2. Chlorine Dosage Calculator for 10% Liquid Sodium Hypochlorite (Unscented)

QUANTITY (GAL.)	PPM 1	PPM 5	PPM 25	PPM 50	PPM 100	PPM 200
50,000	2 Qt.	10 Qt.	50 Qt.	25 Gal.	50 Gal.	100 Gal.
25,000	1 Qt.	5 Qt.	25 Qt.	50 Qt.	25 Gal.	50 Gal.
10,000	13 Oz.	2 Qt.	10 Qt.	5 Gal.	10 Gal.	20 Gal.
5,000	7 Oz.	1 Qt.	5 Qt.	10 Qt.	5 Gal.	10 Gal.
2,000	3 Oz.	13 Oz.	2 Qt.	1 Gal.	2 Gal.	4 Gal.
1,000	1.5 Oz.	7 Oz.	1 Qt.	2 Qt.	1 Gal.	2 Gal.
500	1 Oz.	4 Oz.	1 pt.	1 Qt.	2 Qt.	1 Gal.
200	2 Tsp.	2 Oz.	7 Oz.	13 Oz.	26 Oz.	55 Oz.
100	1 Tsp.	1 Oz.	4 Oz.	7 Oz.	13 Oz.	26 Oz.
50		0.5 Oz.	2 Oz.	4 Oz.	7 Oz.	13 Oz.
25		2 Tsp.	1 Oz.	2 Oz.	4 Oz.	7 Oz.
10		1 Tsp.			2 Oz.	3 Oz.
5					1 Oz.	2 Oz.

Table 6-27.3. Chlorine Dosage Calculator for 65-70% Powder Calcium Hypochlorite

Weight: 16 Oz. = 1 lb.

QUANTITY (GAL.)	PPM 1	PPM 5	PPM 25	PPM 50	PPM 100	PPM 200
50,000	10 Oz.	3 lb.	15 lb.	30 lb.	59 lb. 9 Oz.	119 lb. 4 Oz.
25,000	5 Oz.	24 Oz.	7.5 lb.	15 lb.	29 lb.12 Oz.	59.5 lb.
10,000	2 Oz.	10 Oz.	3 lb.	6 lb.	12 lb.	23 lb. 13Oz.
5,000	1 Oz.	5 Oz.	1.5 lb.	3 lb.	6 lb.	11 lb. 15 Oz.
2,000		2 Oz.	10 Oz.	19 Oz.	2 lb. 7 Oz.	4 lb.13 Oz.
1,000		1 Oz.	5 Oz.	10 Oz.	20 Oz.	2 lb. 7 Oz.
500			3 Oz.	5 Oz.	10 Oz.	19 Oz.
200			1 Oz.	2 Oz.	4 Oz.	8 Oz.
100				1 Oz.	2 Oz.	4 Oz.
50					1 Oz.	2 Oz.
25						1 Oz.

CHAPTER 6
WATER QUALITY AFLOAT

SECTION V. POTABLE WATER MEDICAL SURVEILLANCE

6-28. General

1. The objective of medical surveillance of drinking water quality is to ensure current shipboard drinking water quality processes adequately protect the health of all water system consumers, and provide early identification of water quality issues that could result in acute illness or a disease outbreak.

2. References (o) through (q) provide specific type commander (i.e., surface, submarine, and air) potable water medical surveillance program requirements and responsibilities for surface vessels and submarines of the U.S. Navy.

6-29. Potable Water Medical Surveillance for Surface and COMNAVAIRFOR Vessels

1. Disinfectant Residual Testing

a. Per references (o) and (q), and article 6-7 of this chapter, prior to receiving potable water from any off-hull source (i.e., shore water supply, another ship, or a potable water barge), the water must be tested to ensure the appropriate disinfectant residual (i.e., FAC, TBR, or TC) is present.

b. Daily disinfectant residual testing is required while the ship is underway or deployed. While the ship is in a CONUS or OCONUS U.S. Navy port using an approved shore water supply, residual testing will be conducted weekly. While berthed in overseas (non-U.S. owned or operated) ports, daily disinfectant residual testing is required. Sample locations must be varied and representative of the entire potable water distribution system (i.e., forward, amidships, aft, below deck, and in the superstructure). The number of samples required is specified in Table 6-29.1.

c. Disinfectant residual testing will be performed 30 minutes after chlorinating potable water tanks to verify that the required minimum of 0.2 ppm (mg/L) FAC or TBR residual is present.

d. Disinfectant residual testing will be accomplished using the color comparator kit listed in the applicable authorized medical allowance list (AMAL).

2. Bacteriological Examination

a. Per references (o) and (q), bacteriological examination of potable water must be performed at least weekly while in port and at sea. Samples will be collected from locations that are representative of the entire potable water distribution system, in addition to samples from one quarter of the potable water tanks. The number of samples to be collected from the distribution system is based on the size of the crew as indicated in Table 6-29.1. Samples collected from ice machines and dispensers are not to be considered as samples representative of the potable water distribution system. As described in reference (r), bacteriological examination of ice will be conducted at least weekly as part of food service sanitation inspections.

b. Colilert®, Colisure®, or Colitag® are approved presence and absence test methods that may be used for medical surveillance testing afloat. Sample collection and testing should be conducted per the manufacturer's instructions.

c. When the results of bacteriological examination of potable water reveals the presence of total coliform bacteria, the engineering department must be notified and repeat samples must be collected and tested. At least one repeat sample must be from the same tap as the original positive sample. Two other repeat samples must be collected from taps in the spaces adjacent to or near the location of the original positive sample. One sample must be taken upstream and the other downstream. If the original positive sample is at the end of the distribution system, two samples will be collected upstream. If total coliforms are absent in these samples, the water is safe to use. Presence of *E.coli* bacteria renders the water supply unsafe for ingestion until the contamination is corrected and verified via repeat negative water samples.

3. All potable water testing results will be recorded in the SNAP Automated Medical System/Theater Medical Information Program (SAMS/TMIP) environmental surveillance module or current approved electronic medical database. A report of potable water testing results will be routed to the CO via the engineering department head.

4. Inspection

a. The MDR will conduct inspections of the potable water system and report conditions to the CO, via the chief engineer. Per reference (o), inspections on surface vessels are conducted at least monthly. Per reference (q), inspections on COMNAVAIRFOR vessels are conducted at least quarterly. Potable water system inspections will include the following:

(1) Calcium Hypochlorite storage.

(2) Potable water hoses, storage lockers and connections.

(3) Cross-connection prevention and elimination.

Table 6-29.1. Routine Medical Surveillance Testing Procedure Summary

Ships Underway or Berthed at Overseas (Non-U.S. Operated) Port			
TESTING	PERSONNEL < 400 CREW	PERSONNEL 400-800 CREW	PERSONNEL > 800 CREW
Disinfectant Residual Ship Distribution System (FAC/TBR)	4 Tests Daily	8 Tests Daily	12 Tests Daily
Bacteriological* (Potable Water Tanks)	1/4 of Total Number of Potable Water Tanks Weekly		
Bacteriological* (Distribution System)	4 Tests Weekly	8 Tests Weekly	12 Tests Weekly
Emergency Potable Water Tanks (Battle Dressing Stations)	Each Emergency Potable Water Tank Monthly		
Ships Berthed at US or OCONUS (U.S. Territory) Port with approved public water supply			
TESTING	PERSONNEL < 400 CREW	PERSONNEL 400 – 800 CREW	PERSONNEL > 800 CREW
Disinfectant Residual Ship Distribution System (FAC/TBR)	4 Tests Weekly	8 Tests Weekly	12 Tests Weekly
Bacteriological * (Potable Water Tanks)	1/4 of Total Number of Potable Water Tanks Weekly (Engineering operation and maintenance to prevent stagnant water applicable)		
Bacteriological * (Distribution System)	4 Tests Weekly	8 Tests Weekly	12 Tests Weekly
Emergency Potable Water Tanks (Battle Dressing Stations)	Each Emergency Potable Water Tank Monthly.		

6-30. Potable Water Medical Surveillance for Submarines

1. Disinfectant Residual Testing

a. Per reference (p) and article 6-7 of this chapter, prior to receiving potable water from any off-hull source (i.e., shore water supply, another ship, or a potable water barge), the water must be tested to ensure the appropriate disinfectant residual (i.e., FAC, TBR, or TC) is present.

b. Daily disinfectant residual testing is not required while in a CONUS U.S. Navy port using an approved shore water supply. Medical surveillance testing for disinfectant residual will be performed weekly along with bacteriological testing. Sample locations must be varied and representative of the entire potable water distribution system (i.e., forward, amidships, aft, upper and lower decks, port, and starboard). When in overseas (non-U.S. owned or operated) ports using a shore water supply, one disinfectant residual test daily is required.

c. Disinfectant residual testing will be performed 30 minutes after chlorinating potable water tanks to verify the required 0.2 ppm (mg/L) FAC or TBR residual is present.

d. Submarines that are not equipped with in-line brominator units are exempt from disinfectant residual testing while at sea. Submarines that are equipped with in-line brominator units are required to conduct daily disinfectant residual testing while at sea when the brominator unit is being utilized to disinfect water produced by the ship's potable water plant. Sample locations must be varied and representative of the entire potable water distribution system (i.e., forward, amidships, aft, upper and lower decks, port, and starboard).

e. Disinfectant residual testing is accomplished using the color comparator kit listed in the applicable submarine AMAL.

2. Bacteriological Examination

a. Per reference (p), bacteriological examination of potable water must be performed at least weekly while in port and at sea on a minimum of three random samples that are representative of the entire potable water distribution system. A sample of ice from one ice machine or dispenser must also be examined on a weekly basis. As described in reference (r), bacteriological examination of ice will be conducted at least weekly as part of food service sanitation inspections. Weekly bacteriological testing must also include a positive and a negative control test.

b. Bacteriological examination of potable water samples and ice collected on the submarine may be performed on board or at a shore facility while in port.

c. Colilert®, Colisure®, or Colitag® are approved presence and absence test methods that may be used for medical surveillance testing afloat. Sample collection and testing should be conducted per the manufacturer's instructions.

d. When the results of bacteriological examination of potable water reveals the presence of total coliform bacteria, the engineering department must be notified and repeat samples must be collected and tested. At least one repeat sample must be from the same tap as the original positive sample. Two other repeat samples must be collected from taps in the spaces adjacent to or near the location of the original positive sample. One sample must be taken upstream and the other downstream. If the original positive sample is at the end of the distribution system, two samples will be collected upstream. If total coliforms are absent in these samples, the water is safe to use. Presence of *E.coli* bacteria renders the water supply unsafe for ingestion until the contamination is corrected and verified via repeat negative water samples.

3. All potable water testing results will be recorded in the SAMS/TMIP environmental surveillance module or current approved electronic medical database. A report of potable water testing results will be routed to the CO via the engineering department head.

4. Inspection

a. The MDR will conduct weekly inspections of the potable water system and report conditions to the CO, via the engineering department head. Potable water system inspections will include the following:

(1) Calcium Hypochlorite storage.

(2) Potable water hoses, storage lockers, and connections.

(3) Cross-connection prevention and elimination.

6-31. Calcium Hypochlorite Storage

1. Surface Vessels. Designated storage lockers are provided for safe storage of calcium hypochlorite per reference (n), article 670-5.5. Although the lockers are the responsibility of the engineering department, medical department personnel must be aware of their locations, proper storage requirements, and available quantities on hand.

a. The ready-use stock of 6-ounce calcium hypochlorite bottles issued to the engineering department must be stowed in a locked box mounted on a bulkhead, preferably in a cool, dry, well ventilated place where there is no danger of contact with oxidizable materials, such as the department office space. Under no circumstances is the box to be installed in a machinery space, flammable liquids storeroom, paint locker, berthing space, storerooms, or in the oil and water test laboratory areas. A metal box, such as a first aid locker is recommended for this purpose. Three ¼ inch vent holes must be drilled into the bottom of the box to allow release of any chlorine off gas vapors.

b. Storeroom stocks of calcium hypochlorite must be stowed in labeled, ventilated lockers or bins located in an area where the maximum temperature will not exceed 100°F (37.8°C) under normal operating conditions, and that is not subject to condensation or water accumulation. The area must not be adjacent to a magazine and the lockers or bins must be located at least 5 feet from any heat source or surface, which may exceed 140°F (60°C). They must not be located in an area used for stowage of paints, oils, grease, or other combustible organic materials. No more than forty-eight 6-ounce bottles may be stowed in any individual locker or bin. Issue will be made only to personnel designated by the MDR or engineering officer.

c. All lockers, bins, and enclosures containing calcium hypochlorite must be labeled with red letters on a white background, (HAZARDOUS MATERIAL, CALCIUM HYPOCHLORITE).

2. Submarines

a. In the event disinfection of submarine potable water is necessary, reference (p) authorizes submarines to maintain the minimal quantities of calcium hypochlorite (65-70 percent) on board:

(1) SSN Nine 6-ounce bottles

(2) SSBN/SSGN Twelve 6-ounce bottles

b. Individual bottles of calcium hypochlorite must be sealed in plastic bags and stored in a medical instrument box, plastic rigid, size 9 ½ x 9 x 7 inches. The case must be painted white and labeled: "HAZARDOUS MATERIAL, CALCIUM HYPOCHLORITE" in red letters. The case must be vented at the bottom and stored in an area away from engineering spaces. Refer to references (n) article 670-5.5 and (p) for more information about storage and handling of calcium hypochlorite.

6-32. Potable Water for Yard Craft

1. Yard craft includes barges, tugs, and other vessels capable of independent movement within the harbor, but not routine ocean-going travel. These vessels usually have no water producing capability; potable water is transferred from a shore facility. Most yard craft are equipped with a potable water storage tank and a limited distribution system. Disinfection of the water is not necessary when water is transferred from an approved potable water source. Most problems associated with contamination of water aboard yard craft are usually the result of improper transfer procedures or infrequent flushing of holding tanks. Yard craft should establish a frequent flushing planned maintenance action to prevent stagnant water in holding tank.

2. Although disinfection of yard craft potable water is not required under normal operating conditions, medical department personnel attached to the craft or the cognizant squadron or group staff, or shipyard are responsible for oversight of potable water quality and sanitation. Water testing requirements and periodicity are established and promulgated by the organization to which the craft is assigned and must be sufficient to safeguard against water quality problems.

6-33. Potable Water in Shipyards, New Construction, Overhaul

1. New Construction

a. As construction nears completion and all work involving potable water system tanks, pipes, valves, pumps, heaters, faucets, and all other system components has been completed, the shipbuilder must fill, pressurize, and flush the entire system with potable water to ensure all components function properly and there are no leaks in the system. The system must then be sanitized as described in article 6-24 of this chapter.

b. After the system has been sanitized and refilled with potable water containing the appropriate disinfectant residual following a 30-minute contact time, the shipbuilder, in collaboration with the BUMED liaison to the supervisor of shipbuilding, must collect samples from throughout the system to test for disinfectant residual and bacteriological contamination. Note: the sampling and testing procedures described in this article specifically apply to ships under construction and are not part of the ship's potable water medical surveillance program.

(1) At least one sample must be collected from every space that contains a potable water faucet or spigot (on all levels). Normally, only cold-water samples are collected and tested. Disinfectant residuals in samples collected downstream of water heaters will be lower than the residuals in cold water. Higher water temperatures increase the rate of chlorine consumption, resulting in diminished residuals.

(2) Samples must be collected from all faucets, fountains, and dispensers used for drinking, food preparation, cooking, personal hygiene, and medical purposes.

(3) Personnel collecting water samples must also observe the physical characteristics of the water and report any taste and odor problems to the BUMED liaison and shipbuilder's representative immediately.

c. All samples that reveal no residual disinfectant or the presence of coliform bacteria must be investigated by the shipbuilder and the BUMED liaison to determine the cause and courses of action to correct the problem, and prevent future contamination of the system. After the problem has been identified and corrected, the designated portions of the system must be flushed, disinfected, and re-tested.

d. When test results from all samples collected reveal proper disinfectant residuals and the absence of coliform bacteria, the shipbuilder will certify the ship's potable water is FFHC and turn the system over to the ship's CO and engineering department for all further operation and maintenance. The ship's medical department will begin its potable water medical surveillance program at that time as described in the appropriate type commander's shipboard medical department procedures manual and this chapter.

2. Ships Undergoing Overhaul

a. Similar to new construction, ships undergoing overhaul where the shipyard or maintenance facility takes the ship's potable water system out of service to make modifications or repairs to the system, must follow the procedures described in article 6-33.1 of this chapter to ensure the system is properly cleaned, flushed, sanitized, and tested prior to being certified as FFHC and returned to service.

b. If the potable water system is taken out of service, but the system is not breached for modifications or repairs, the ship's engineering department must ensure the system is thoroughly flushed, sanitized, and tested prior to being returned to service. The Medical Department will resume its potable water medical surveillance program at that time as described in the appropriate type commander's shipboard medical department procedures manual and this chapter.

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SECTION VI. EVALUATION OF TASTE AND ODOR PROBLEMS

6-34. Taste and Odor Problems in Ship Potable Water. The uniqueness of the shipboard environment, the complexity of its piping systems, and the multiple sources used to obtain potable water may individually or in combination be factors that cause taste and odor problems on ships. Tap water may contain minerals, sulfur, and water treatment chemicals that produce discernable tastes and odors that do not affect water quality. Taste and odor problems are usually only aesthetic, but are still a cause for concern aboard ship due to the negative effect they may have on crew morale and consumption of the water. Many individuals are extremely sensitive to even slight changes in the taste or smell of drinking water. Shipboard water treatment options are limited, which can make it difficult to correct taste and odor problems that develop. However, water produced by the ship's desalination plant is generally of very high quality. The lack of dissolved minerals in ship produced drinking water may cause the water to have no taste at all, compared to ordinary tap water. This may be interpreted as a taste problem.

6-35. Indicators of Taste and Odor Problems

1. The MDR is Responsible for Performing Medical Surveillance of the Potable Water System. Usually this function is accomplished through verification of the required minimum chlorine or bromine residuals from representative areas of the ship on a daily or weekly basis, and bacteriological testing of the potable water on a weekly schedule. This testing, as well as complaints from the crew, can be very helpful in identifying and locating the source of the taste and odor problems.

2. Crew Complaints. Initial complaints from the crew can provide important information, particularly if the complaints are associated with a specific space location and related to a specific time pattern. All of these factors can be compared to a particular potable water tank in use at the time, the disinfection processes for the tank, and the piping system associated with the tank. Each piece of information is important when investigating taste and odor complaints.

3. Bacteriological Testing. If there is organic growth (biofilm) in the potable water tanks or piping system, there may be taste and odor problems with the water. The standard bacteriological test utilized by ships and submarines for medical surveillance (Colilert®) detects the presence of total coliform and *E. coli*. Repeated positive results for total coliform may indicate that a biofilm problem exists. However, it is possible for a biofilm problem to exist without positive total coliform test results.

4. Disinfectant Residuals (FAC/TBR). Maintaining the required minimum disinfectant residual throughout the system is directly affected by the microbiological and chemical quality of the water. Loss of disinfectant residual may be an indicator of contamination or biofilm growth in the potable water tanks or piping system. Adding chlorine or bromine to water containing chloramine disinfectant can also cause a loss of residual and taste and odor problems.

6-36. Initial Evaluation of Taste and Odor Problems. These statements and questions represent an investigative approach to taste and odor complaints. The evaluation of these items may assist in identification of the source of the problem.

1. When was the problem identified or initial complaints received? This date and time may be related to a particular potable water tank that was on-line, a section of piping or repairs, and maintenance associated with the system.

2. What is the source of the water?

   a. Shore (direct pressure).

   b. Ship's tanks filled with shore water.

   c. Mixture of water remaining in ship's tanks and shore water.

   d. Barged water.

   e. Another ship.

   f. Produced by the ship's plant.

3. Does the water have a characteristic taste or odor? It is sometimes possible to determine the source of a water problem if it has a characteristic taste or odor.

4. Is the problem isolated to one section of the ship, or does it occur throughout the ship? If the problem is limited to a particular section of the ship, the investigation should be oriented to occurrences affecting the piping system or tank supplying that section of the ship. Cross-connections, repair or maintenance of the piping systems, sounding tubes, and a particular tank are possible sources of the problem.

5. Is the problem continuous or does it occur only while a particular tank is on-line? If the problem appears to be cyclic, compare the record of complaints and the particular tank(s), which are supplying water to different sections of the ship. Ongoing disinfectant residual testing may indicate increased halogen demand in the tank or particular sections of the piping system.

6. Can disinfectant residuals (FAC/TBR) be maintained in the potable water tank? Engineering disinfectant testing at the potable water tanks may indicate increased disinfectant demand due to the presence of contaminants.

7. Has the ship experienced similar taste and odor problems in the past? Discussion with engineering personnel may provide information associated with a similar problem in the past.

8. Review the potable water log to identify fluctuations, which may be occurring in the potable water distribution system. This is easily accomplished by plotting a simple graph with disinfectant residual levels on the vertical axis and days on the horizontal axis. If this data can be plotted for the past 3 months, an accurate picture can be developed. Compare this data with the source of the water and tanks, which were on-line at the time. Perhaps a pattern will develop associated with a particular source of water or an individual tank.

9. Identify potable water tanks with common bulkheads to fuel, ballast, other tanks, or bilges. A potable water tank with a common bulkhead to bilges or other tanks containing fuel or ballast, and small leaks could be a persistent source of taste and odor problems. Identification of these tanks or associated non-potable liquids, which may contaminate the potable water system, must not be overlooked as the source of that problem.

10. Identify any non-potable piping, which has been permanently installed through potable water tanks. Any piping through potable water tanks should be enclosed in self-draining pipe tunnels to avoid contamination of the water system. In many instances, evaluation of this piping can only be accomplished upon entrance to the tanks, but MDR should be aware of the location and existence of this type of piping.

11. Review potable water disinfection procedures to ensure engineering personnel follow proper procedures. The engineering department is responsible for potable water treatment. The MDR must have a basic understanding of the system and review the procedures for disinfecting to ensure the proper amount of disinfectant is being added to achieve the prescribed disinfectant residuals in the distribution system.

12. Identify any repair or maintenance operations conducted on the potable water distribution system, which could have contributed to the taste and odor problem. There are numerous points in the potable water system, which can become a source of contamination through either cross-connections or as a result of repair or maintenance procedures. The operations should be reviewed and correlated to the location within the system, for possible sources of contamination.

13. Has medical surveillance of water quality been maintained for the potable water tanks while the ship is in port on direct shore service? Water remaining in potable water tanks may be ignored when the ship is tied up to the pier and utilizing shore water. Consequently, the water sits for long periods of time and may become stagnant and provide a source for taste and odor problems immediately upon resumption of tank usage.

14. Identify the type of paint coating, date, and location of application for each potable water tank. An improperly cured or applied potable water tank coating may be the source of a temporary or permanent taste and odor problem. Usually the evaluation of the tank coating is not a function which can easily be conducted by shipboard personnel. A temporary taste problem following application of new tank coatings is not unusual, but should resolve following usage of the tanks. In contrast, lack of ability to maintain halogen residuals in the tanks accompanied by persistent taste and odor problems may be directly related to an improperly applied or uncured tank coating.

6-37. Control Measures for Taste and Odor Problems

1. As previously indicated, mechanical processes for the control of taste and odor problems are quite limited aboard ship. Identification and elimination of the source of the taste and odor is an important quality of life issue and may be a significant health concern. If the ship is at sea and the system must be used, increasing the residual chlorine levels may aid in the control of taste and odor problems.

2. Increased chlorine residuals have been and are still being used as a control measure for taste and odor in municipal water supplies ashore. The elevated chlorine residuals often satisfy the disinfectant demand that may be present in the tanks or piping system. Therefore, ships that have not been able to identify a source of the taste or odor, should add sufficient chlorine to provide a dosage of 5.0 ppm (mg/L) in the potable water tanks, with the intent of providing 2.0 ppm (mg/L) free residual chlorine in the water distribution system. This procedure may satisfy the disinfectant demand in the tanks or system and resolve taste and odor problems of a temporary nature.

6-38. Request for Outside Assistance

1. If the evaluation procedures outlined in article 6-36 of this chapter have been carried out and no source can be identified for the taste and odor problem, contact NAVSEASYSCOM and the area NAVENPVNTMEDU or NAVMCPUBHLTHCEN via the type command medical officer for technical assistance. Medical and appropriate engineering personnel should be prepared to discuss the evaluation of specific items outlined in article 6-36 of this chapter.

2. NAVENPVNTMEDU personnel will provide consultative assistance for ship water quality taste and odor problems upon request. If NAVENPVNTMEDU personnel cannot provide onboard assistance due to geographical location, the preventive medicine authority from the nearest Navy Medicine Readiness and Training Command or Navy Medicine Readiness and Training Unit, in collaboration with the preventive medicine directorate at NAVMCPUBHLTH-CEN, may be requested to provide public health assistance.

3. Following a thorough review of the situation, NAVENPVNTMEDU personnel will provide appropriate recommendations for resolution of the taste and odor problem. If the problem cannot be resolved, or is suspected to involve tank coatings, a summary of investigative results will be provided to the ship with a recommendation to notify NAVSEASYSCOM, Washington, DC, via the chain of command. The NAVSEASYSCOM chain of command includes the applicable Naval Sea Systems Support Center or In-Service Engineering Agent. NAVENPVNTMEDU personnel will assist engineering personnel or NAVSEASYSCOM representatives in the evaluation and testing of tank coatings aboard the ship.

SECTION VII. EMERGENCY WATER SUPPLIES

6-39. Battle Dressing Stations

1. Some ships are equipped with built-in potable water storage tanks in battle dressing stations to provide an emergency potable water source. The tanks are designed for gravity flow and are valve isolated from the main potable water system. A piping diagram must be provided for each tank with appropriate instructions for filling and draining. Each battle dressing station emergency potable water tank must be tested monthly for presence or absence of coliform bacteria.

2. These emergency potable water storage tanks are part of the ship's planned maintenance system and must be carefully and consistently maintained.

6-40. Emergency Potable Water, 5-Gallon Containers

1. Some small ships store emergency potable water supplies in 5-gallon potable water approved containers due to the lack of an emergency tank in the battle dressing stations. These containers may be filled with water produced on board or from approved shore facilities. This storage is acceptable provided the containers have been properly cleaned and disinfected prior to filling.

2. Only approved 5-gallon potable water containers must be used for the storage of potable water. Under no circumstances will 5-gallon containers previously used for gasoline or other petroleum products be used as emergency potable water containers aboard ship.

3. Prior to disinfection and filling, the containers must be examined to ensure they have not been used for any purpose other than storage of potable water. Each container must be labeled "POTABLE WATER" on the exterior surface in at least one-inch high letters. The container must also be carefully inspected for the following conditions:

a. Evidence of rust or corrosion on the interior or exterior,

b. Evidence of open seams or breaks in the surface,

c. Interior coating of metal containers not uniform, cracked, pitted, or peeling away,

d. Any evidence of dirt, grit, organic matter, or other substance embedded in the interior surface of the container,

e. Carefully inspect the cap to ensure that it seats properly,

f. Inspect the gasket to ensure it is properly fitted and not deteriorated. If the gasket is deteriorated, it must be replaced prior to use,

g. Inspect the locking lever to ensure it works properly by engaging the seat or lock ring cam lugs,

h. Inspect the carrying handles to ensure they are properly attached and in good repair.

4. Manual washing is accomplished with warm water (110-125° F; 43-52° C), the recommended amount of approved food-service dishwashing detergent, and a suitable long-handled, slender brush. Thorough rinsing with potable water is necessary after cleaning.

5. All interior surfaces must be disinfected by exposure to an approved chemical disinfectant solution for at least 2 minutes. Approved chemical disinfectants for these containers are calcium and sodium hypochlorite. Refer to article 6-27 of this chapter for chlorine dosage calculation tables.

6. Potable water used to fill emergency containers must contain a trace FAC or TBR.

7. Each water container must be labeled with the date filled and the source of the potable water.

8. The 5-gallon containers must be stored in a clean dry place, away from direct sunlight in the immediate vicinity of anticipated use.

9. These containers must be emptied, flushed, and refilled with potable water containing a trace FAC or TBR at least quarterly.

10. Halogen residual and bacteriological testing are not required.

6-41. <u>Emergency Life Raft Drinking Water and Bottled Drinking Water</u>

1. Emergency drinking water is stored for use as a component of the abandon ship survival equipment in life rafts. Life rafts are maintained per reference (q). Plastic water bottles (500 ml) are replaced during the prescribed life raft inspection and maintenance cycle. A life raft also contains a manual reverse osmosis desalinator hand pump.

2. Commercial bottled water must be procured only from DoD approved sources. A list of approved sources can be found in the *Worldwide Directory of Sanitarily Approved Food Establishments for Armed Forces Procurement*.

3. Bottled water must be stored and maintained as described in reference (e), article 5-7.4c.

SECTION VIII. MAKING AND HANDLING OF ICE

6-42. Ice Making. Ice making aboard ships is accomplished by automatic ice cube machines and icemakers in most instances. In some smaller galleys, general messes, and small ships, ice is made in ice cube trays that are placed in the freezer. Ice that will be used for food, in drinks, for chilling food, and for medical purposes must be made from a potable water source. Regardless of its end use, all ice must be handled in a sanitary manner. Reference (s) also covers sanitary requirements for making and handling of ice.

6-43. Special Precautions for Handling of Ice

1. Due to its vulnerability to contamination, special precautions regarding the making, handling, and storage of ice are necessary.

a. All ice must be prepared using only approved potable water sources.

b. Ice machines must be plumbed properly to eliminate the possibility of cross-connections and back-siphonage. Ice machines must be installed per manufacturer specifications to ensure adequate air circulation around the machine to dissipate heat.

c. The ice machine drain from the ice storage compartment must be provided with an air gap between the ice storage compartment and the deck drain.

d. Ice must be removed from the storage compartment by the use of a clean ice scoop. The ice scoop must be stored inside the machine on a bracket above the maximum ice level or outside the ice storage compartment with the handle up in a free-draining metal bracket. The design of some ice machines precludes proper storage of the ice scoop inside the machine. Contact with the ice by bare hands is prohibited.

e. The ice scoop is considered to be food service equipment and must be washed, rinsed, and sanitized at least daily. For this reason, the permanent installation of ice scoops with chains or other permanent attachments is prohibited.

f. Ice machines should not be located in outdoor areas or close proximity to exterior doors subject to contamination from blowing dust or dirt; splash zones adjacent to warewashing activities, food prep sinks, or handwashing sinks; or in close proximity to other potential sources of contamination from spraying, dripping, or splashing.

6-44. Cleaning and Disinfection of Ice Machines

1. Ice machines are subject to contamination from improper control of condensation drain lines (for example, discharging directly into a sewage drain without maintaining an air gap), unsanitized ice scoops, unhygienic personnel handling ice, and other environmental sources. Over time, the interior of ice bins become unsanitary due to development of mineral, mold, and mildew buildup, which can harbor bacteria.

2. Periodic cleaning of ice machine bins is an essential function of the food establishment to prevent mineral, mold, and mildew buildup. Cleaning frequency will vary and should be scheduled before there are visible signs of buildup inside the bin or on the condensing unit. The food establishment should consult with the ice machine manufacturer for recommended cleaning procedures. The procedures for cleaning and sanitizing ice machines must be provided in a standard operating procedure by the food establishment for food service personnel.

3. Cleaning and sanitizing of ice machines must be restricted to personnel who have received food sanitation training as specified in reference (s), §2-501.11, subpart 2-503, and §2-504.30.

4. Ice machine water and air filters must be changed at a frequency recommended by the manufacturer or at least every 6 months.

5. Filter changes must be documented in a maintenance log or annotated on the filter using a permanent marker, indicating the date and name of the person who replaced the filter. Maintenance logs must be available onsite for inspection.

6-45. Bacteriological Quality of Ice

1. Samples of ice from at least one ice machine must be collected on a weekly basis as part of the food service sanitation inspection and examined for bacteriological contamination.

2. If samples of ice collected for biological analysis test positive for coliform organisms, the ice storage compartment must be emptied, cleaned, sanitized, and retested to confirm the absence of coliform organisms after cleaning.

3. Bacteriological testing of ice samples must be recorded in the SAMS/TMIP environmental surveillance module or current approved electronic medical database.

SECTION IX. CROSS-CONNECTIONS

6-46. Cross-Connections

1. In contrast to a shore potable water facility, plumbing aboard ship is a maze of piping systems fitted into compact spaces. The numerous separate piping systems carrying fuel, salt water, sewage, potable water, etc., offer multiple possibilities for cross-connections, particularly during repair, modification, or through negligence in operation. If present, cross-connections between potable water and piping systems containing other substances allow contamination of the potable water, which may result in water-borne illnesses in the exposed population.

2. The MDR, engineering department personnel, and crew at large must ensure constant surveillance of the potable water system to prevent cross-connections. Prevention of cross-connections must also encompass piping systems and connections originating outside the ship such as those found on piers and barges. Shipboard cross-connections and backflow prevention are discussed in reference (i). A list of approved backflow prevention assemblies may be obtained from the Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California, Los Angeles, CA 90089-2513 (https://fccchr.usc.edu/).

6-47. Cross-Connection Definitions

1. Cross-Connection. A cross-connection is any connection between two separate piping systems, one of which contains potable water, and the other water of unknown or questionable quality or some other substance. This condition may result in the flow of liquid from one system to the other, resulting in contamination.

2. Backflow and Back-Siphonage. Both terms indicate a reversal in the direction of flow in a potable water system and the entry of non-potable water or other substances into the potable water.

   a. Backflow. Non-potable water or other substances enter a potable water system through a cross-connection when the pressure of the non-potable system becomes greater than the pressure in the potable water system.

   b. Back-Siphonage. Non-potable water or other substances are drawn "by suction" into a potable water system through cross-connections or outlets as a result of negative pressure in the potable water system. The risk of back-siphonage is increased when the potable water system is secured during water hours, or for any other purpose.

3. Submerged Inlet. A potable water faucet or other outlet, including an attached hose located below the fill level of a sink, tub, container, tank, machine, etc.

4. Air Gap. An air gap is the actual vertical separation between a potable water supply outlet and the highest possible level of liquid in the sink, tub, container, tank, machine, etc., receiving the water. The actual distance of separation must be at least twice the diameter of the potable water supply pipe, but never less than 1-inch between the outlet and the highest possible liquid level in the receiving object.

5. Backflow Preventer. A device designed to prevent backflow and subsequent contamination of the potable water supply. These devices are installed at locations where there are limited alternatives to cross-connections, e.g., water closets, dish-washing machines, etc. There are numerous types of backflow or back-siphonage prevention devices, the most common being vacuum breakers. The degree of health hazard including whether or not the system is under continuous pressure will dictate the type of backflow prevention device needed. A valve located between a potable and non-potable system is not an acceptable method of cross-connection control.

6-48. Improper Piping Installation. In general, any type of water supply connection that permits the return of used or contaminated water into the potable water system is not permissible. Some examples of improper piping installations of potable water systems that have been observed or identified as the cause of disease outbreaks aboard ship are as follows:

1. Backflow

   a. Seawater and potable water lines connected to a common line or outlet.

   b. Direct potable water connections (without backflow prevention devices) to machines, equipment, and non-potable systems.

   c. Boiler feed-water and potable water lines connected to a common line.

   d. Drains for ice machines or food service equipment plumbed directly to the deck drainage or sewage system with no air gap.

2. Back-Siphonage

   a. Laundry trays, wash basins, service sinks, and deep sink with faucets below the fill level.

   b. Drinking fountains with orifice below the fill level or the vertical jet or orifice supply line surrounded by the waste drain line.

   c. Therapeutic tubs, sitz baths, or steam tables with inlets below the fill level.

   d. Improperly installed water operation waste ejectors, i.e., dental units, potato peelers, and garbage grinders.

3. Maintaining the appropriate pressure in the potable water piping system is a critical aspect of preventing backflow and back-siphonage.

6-49. Cross-Connection Surveillance

1. This equipment is normally hard-plumbed or has permanent flexible hose installed, and is to be provided potable water via an approved reduced pressure backflow prevention device installed above the overflow level: garbage grinders, chill water expansion tanks, and diesel-engine cooling jacket.

2. Throughout the ship, wherever a hose bib faucet permits connection of a hose to the potable water system, a hose connection vacuum breaker must be installed. Examples are deep sinks, galley, and weather deck wash down faucets.

3. The MDR and engineering personnel must be alert to prevent cross-connections. Modification or repairs to existing potable water systems aboard ship should alert the MDR to the potential for cross-connection problems. Frequent discussion with engineering personnel regarding the potable water system, and any repairs or proposed changes, is part of a cross-connections prevention strategy. If a cross-connection is suspected or identified, act quickly and effectively to determine if an unsatisfactory condition exists. This is best accomplished through discussion with the engineering officer, a review of the suspected site, and review of ship diagrams. If a cross-connection is identified, immediate action by the MDR and engineering personnel is required. Securing the affected part of the potable water system is appropriate until such time as the cross-connection is eliminated and the potable water system is disinfected, if necessary.

a. Use NSF® approved tracer dyes in potable water systems. Fluorescein sodium USP™ and Rhodamine WT™ are EPA-approved dyes and must be used per manufacturer's directions. The area NAVENPVNTMEDU can provide additional information concerning safe use of tracer dyes.

b. Standard sea marker dye is not approved for use in potable water systems.

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SECTION X. EMERGENCY BALLAST, HAULED WATER

6-50. Emergency Use of Potable Water Tanks for Ballast

1. In an extreme emergency, such as damage control procedures to save the ship, potable water tanks may be filled with non-potable seawater for ballast or other emergency purposes. If this becomes necessary, the affected potable water tank(s) and all associated pipes must be disconnected or otherwise isolated from the rest of the potable water system. Tanks and affected piping must not be reconnected to the potable water system until the tanks, piping, and all fittings have been properly cleaned, disinfected, tested, and approved by the MDR.

2. Water placed in these tanks must not be used for human consumption purposes until it has been adequately cleaned, disinfected, and bacteriological analysis confirms the water is safe for human consumption. If bacteriological tests are positive, the disinfection process must be repeated until the bacteriological analysis is negative prior to placing the tanks and piping back in service. Chemical analysis of the water may be necessary to ensure the water is safe and meets water quality standards.

6-51. Hauled Water (or Cargo Water)

1. The term cargo water as it is used in this section refers to potable water that is hauled in designated tanks on water ships, barges, or yard craft from a shore potable water connection to be transferred to the receiving ship. Ships that haul water must comply with the following:

a. Water must be taken from approved water sources as defined in article 6-8 of this chapter.

b. The water must be transferred in a manner that prevents contamination as described in article 6-10 of this chapter.

c. Vessels transporting potable water must maintain records of the following:

(1) Source of the potable water (indicate whether or not it is from an approved source),

(2) Daily disinfectant residual testing and type of disinfectant being used by shore source,

(3) Results of bacteriological testing (should be within the last 7 days),

(4) The information in article 6-51.1c(1) through 1c(3) of this chapter must be provided to the receiving ship prior to transfer of water.

d. Water vessels must deliver potable water to receiving ships with a disinfectant residual of at least 0.2 ppm (mg/L) FAC or TBR when the source is an approved water source. If the disinfectant residual is below 0.2 ppm (mg/L) FAC or TBR, sufficient chlorine or bromine must be added by the receiving ship to boost the disinfectant residual to 0.2 ppm (mg/L) FAC or TBR after a 30-minute contact time at the potable water tank.

e. Water obtained from an unapproved source must be treated (chlorinated or brominated) sufficiently to produce at least 2.0 ppm (mg/L) residual after a 30-minute contact time at the potable water tank per article 6-21.6 of this chapter.

2. <u>Vessels Receiving Water</u>

a. The MDR or engineering department personnel of the receiving ship must test the disinfectant residual of the water prior to transfer to ensure the minimum disinfectant residual of 0.2 ppm (mg/L) FAC or TBR is present.

b. If the water does not contain a disinfectant residual of at least 0.2 ppm (mg/L) FAC or TBR, it will be necessary for the engineering department to treat the water in the receiving tanks as described in article 6-21 of this chapter prior to placing the tank in service.

c. If the water is from an unapproved or questionable source, the MDR must conduct bacteriological testing of the water prior to and after adequate disinfection to 2.0 ppm (mg/L) FAC or TBR in the distribution system to ensure bacteriological quality.

d. The MDR must ensure appropriate entries are documented in the potable water log regarding the source, disinfectant residual, bacteriological testing, and recommendations made.

3. <u>Transfer of Water</u>

a. Water transferred from the ship that will be used for human consumption will contain a 2.0 ppm (mg/L) FAC or TBR residual and less than 4.0 ppm (mg/L) FAC or TBR. The water will be absent of total and fecal coliform bacteria and will have been tested within 1 week of transfer.

b. Properly trained shipboard personnel must monitor the procedures used for transfer of potable water from the ship. Hoses previously used for fuel or other liquids must not be used for transfer of potable water. Only hoses approved for contact with potable water must be used for transferring potable water.

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CHAPTER 6
WATER QUALITY AFLOAT

APPENDIX A
POTABLE WATER AFLOAT REFERENCES AND RESOURCES

References

(a) DoD Instruction 4715.06, Environmental Compliance in the United States of 4 May 2015.

(b) DoD Instruction 4715.05, Overseas Environmental Baseline Guidance Document of 1 Nov 2013

(c) OPNAV M-5090.1, Environmental Readiness Program Manual

(d) BUMEDINST 6240.10C, Department of the Navy Medical Drinking Water Program

(e) NAVMED P-5010-5, Water Quality for Shore Installations

(f) CNIC M-5090.1A, Navy Overseas Drinking Water Program Ashore Manual

(g) NAVSUPINST 4205.3F, Contracting Officer's Representative

(h) OPNAVINST 3120.32D, Standard Organization and Regulations of the U.S. Navy

(i) Naval Ships Technical Manual[1], Chapter 533, Portable Water Systems – request access at https://mercury.tdmis.navy.mil

(j) NAVSEA Technical Publication T9640-AC-DSP-010/HAB, Shipboard Habitability Design Criteria and Practices Manual (Surface Ships) for New Ship Designs and Modernization of 21 Dec 2016

(k) U.S. Public Health Service, CDC, Vessel Sanitation Program Operations Manual

(l) Naval Ships Technical Manual[1], Chapter 531, Desalination, Vol 1 – request access at https://mercury.tdmis.navy.mil

(m) Naval Ships Technical Manual[1], Chapter 505, Piping Systems – request access at https://mercury.tdmis.navy.mil

(n) Naval Ships Technical Manual[1], Chapter 670, Stowage, Handling, and Disposal of Hazardous General Use Consumables – request access at https://mercury.tdmis.navy.mil

[1] Naval Ships Technical Manuals are written for maintenance activities, not for underway decision making. These are included to provide guidance to water systems design and operation, access must be requested by NAVSEA to access these documents

(o) COMSURFLANT/COMSURFPACINST 6000.1A, Shipboard Medical Department Procedures Manual available at https://www.med.navy.mil/Portals/62/Documents/NMFA/NMCPHC/root/Program%20and%20Policy%20Support/Water%20Sanitation%20and%20Safety/SURFLANTPACINST_6000_1_6Mar2014.pdf

(p) COMSUBLANT/COMSUBPACINST 6000.2E, Standard Submarine Medical Procedures Manual available at https://www.med.navy.mil/Portals/62/Documents/NMFA/NMCPHC/root/Program%20and%20Policy%20Support/Water%20Sanitation%20and%20Safety/CSLCSPINST-6000.2E.pdf?ver=sG7MEppZ631AxjiW81VkcQ%3d%3d

(q) COMNAVAIRFORINST 6000.1B, Shipboard Medical Procedures Manual available at https://www.med.navy.mil/Portals/62/Documents/NMFA/NMCPHC/root/Program%20and%20Policy%20Support/Water%20Sanitation%20and%20Safety/COMNAVAIRFOR-6000-09Nov2020.pdf

(r) NAVMED P-5010-1, Tri-Service Food Code

(s) Naval Ships Technical Manual[1], Chapter 583, Boats and Small Craft
[1] Request access at https://mercury.tdmis.navy.mil

(t) Naval Ships Technical Manual[1], Chapter 631, Preservation of Ships in Service
[1] Request access at https://mercury.tdmis.navy.mil

National/International Industry Standards Organizations Publications

National Sanitation Foundation International, NSF/ANSI Standard 60, Drinking Water Treatment Chemicals-Health Effects

National Sanitation Foundation International, NSF/ANSI Standard 61, Drinking Water System Components-Health Effects

American Water Works Association Standard, ANSI/AWWA C652-02, Disinfection of Water Storage Facilities

American Water Works Association, Standard Methods for the Examination of Water and Waste Water

U.S. Code of Federal Regulations/U.S. Government

40 CFR Part 141, National Primary Drinking Water Regulations

40 CFR Part 142, National Primary Drinking Water Regulations Implementation

CHAPTER 6
WATER QUALITY AFLOAT

40 CFR Part 143, National Secondary Drinking Water Regulations

40 CFR 180.519, Bromide Ion and Residual Bromine; Tolerances for Residues

Public Law 93-523, The Safe Drinking Water Act 1974 and Amendments of 1977, 1979, 1980, 1986, 1996 and 2011.

U.S. EPA 570/9-89-007, Cross-Connection Control Manual

International Health Agencies Publications

World Health Organization, Guide to Ship Sanitation, 3rd Edition

CHAPTER 6
WATER QUALITY AFLOAT

APPENDIX B
TERMS AND DEFINITIONS

1. Acute Health Effect. An immediate (i.e., within hours or days) adverse health effect that may result from exposure to certain drinking water contaminants (e.g., pathogens).

2. Airgap. A physical separation sufficient to prevent backflow between the free-flowing discharge end of a potable water system outlet and any other system. An air gap is physically defined as a distance equal to twice the diameter of the outlet, but never less than 1 inch.

3. Backflow. The flow of non-potable water or other liquids, mixtures, or substances into the potable water supply system. Back-siphonage and back-pressure are the two types of backflow.

4. Backflow Prevention Device. A device or means designed to prevent backflow or back-siphonage. Most commonly categorized as air gap, reduced pressure principle device, double check valve assembly, pressure vacuum breaker, atmosphere vacuum breaker, residential dual check, double check with intermediate atmosphere vent, or barometric loop. An air gap is the preferred method for backflow prevention, but not always practical.

5. Back-Siphonage. Backflow resulting from negative pressure in the distribution pipes of a potable water system.

6. Biofilm. An accumulation of microorganisms' extracellular material and debris attached to the interior walls of distribution system pipes and tanks. Biofilm organisms do not usually pose a direct health risk. However, biofilm can be responsible for microbiological water quality violations such as growth of total coliform bacteria. Repeated positive total coliform tests may indicate a biofilm problem exists.

7. Check Valve. A self-closing device that is designed to allow the flow of fluids in one direction and to close if there is a reversal of flow.

8. Chloramine. An alternative means of disinfection often used to try to reduce disinfection byproducts formation. The equilibrium products of ammonia react with the equilibrium products of chlorine to form chloramines. Combined available chlorine (chloramine) has significantly less disinfecting power than chlorine.

9. Chronic Health Effect. The possible result of exposure over many years to a drinking water contaminant at levels above its MCL.

10. Coliform. A group of related bacteria whose presence in drinking water may indicate contamination by disease-causing micro-organisms or environmental contaminants.

11. Contaminant. Anything found in water (including microorganisms, minerals, chemicals, radionuclides, etc.) that may be harmful to human health.

12. CONUS. Indicates locations (military installations) within the continental United States.

13. Cross-Connection. Any actual or potential connection between the public water supply and a source of contamination or pollution.

14. Disinfectant. A chemical (commonly chlorine, chloramines or ozone) or physical process (e.g., ultraviolet light) that kills microorganisms such as bacteria, viruses, and protozoa.

15. Disinfection Byproduct (DBP). Chemicals that form when disinfectants (such as chlorine) react with plant matter and other naturally occurring materials in water. These byproducts may pose chronic health risks in drinking water.

16. Disinfection. A process that inactivates pathogenic organisms in water with chemical oxidants or equivalent agents.

17. Desalination. The total process utilized to remove mineral components from saline water (i.e., sea water), to include RO, flash-type steam, and electric thermo-compression.

18. *E. coli*. Is a subset of total coliform and fecal coliform bacteria. Commonly found in the intestines of animals and humans. *E. coli* is short for *Escherichia coli*. The presence of *E. coli* in water is an indication of recent sewage or animal waste contamination due to unsanitary practices during potable water production, storage, receipt or transfer, or a cross-connection somewhere in the system. Water with *E. coli* bacteria is acute health hazard and unsafe for crew consumption.

19. FAC (Free Available Chlorine). Chlorine available in the forms of hypochlorous acid and hypochlorite ions after chlorine demand has been satisfied.

20. FFHC (Fit For Human Consumption). This is the term used by the U.S. Navy to indicate the water is safe for drinking, cooking, bathing, showering, dishwashing, and maintaining oral hygiene.

21. Filtration. A process for removing particulate matter from water by passage through porous media.

22. Health Hazard. Any condition, including any device or water treatment practice that may create an adverse effect on a person's health and well-being.

23. Inorganic Chemicals. Mineral-based compounds such as metals, nitrates, and asbestos. These contaminants are naturally-occurring in some water, but can also enter the water stream through farming, chemical manufacturing, and other human activities.

24. MCL - Maximum Contaminant Level. The maximum permissible level of a contaminant in water that is delivered to any user of a public water system. MCLs are legally enforceable standards. For deployment settings, defer to the DoD Tri-Service Drinking Water Standards.

25. Medical Bacteriological Sampling and Surveillance. Bacteriological testing by the preventive medicine authority when warranted. It is not intended to meet Safe Drinking Water Act compliance monitoring requirements.

26. National Primary Drinking Water Regulations. Legally enforceable standards that apply to public water systems. These standards protect drinking water quality by limiting the levels of specific contaminants that are known or anticipated to occur in public water supplies and can adversely affect public health.

27. National Secondary Drinking Water Regulations. Non-enforceable Federal guidelines regarding cosmetic effects (such as tooth or skin discoloration) or aesthetic effects (such as taste, odor, or color) of drinking water.

28. Non-Potable Water. Water that has not been examined, properly treated, or approved by proper authorities as being safe for domestic consumption. All waters are considered non-potable until declared potable by the regulatory authority.

29. OCONUS. Refers to locations (military installations) outside the continental United States, but within a U.S. territory or possession.

30. Organic Chemicals. Carbon-based chemicals, such as solvents and pesticides that can enter a water source through runoff from croplands or discharge from factories.

31. Overseas. Refers to a location (military installation) that is not located in a U.S. territory or possession.

32. Pathogens. Disease-causing organisms, such as some bacteria, viruses, or protozoa.

33. Point of Use Treatment. Treatment device or technology intended to treat water at a single tap.

34. Potable Water. Water that has been treated and confirmed via testing to meet established water quality standards and declared FFHC. FFHC is the term used by the U.S. Navy to indicate the water is safe for drinking, cooking, bathing, showering, dishwashing, and maintaining oral hygiene.

35. Radionuclide. An unstable form of a chemical element that radioactively decays, resulting in the emission of nuclear radiation. Prolonged exposure to radionuclides increases the risk of cancer.

36. Reduced Pressure Principle Backflow Preventer. An assembly of differential valves and check valves including an automatically opened spillage port to the atmosphere designed to prevent backflow.

37. Reverse Osmosis. A pressure-driven treatment process using a specially prepared membrane that permits the flow of water through the membrane, but acts as a selective barrier to contaminants.

38. Total Available Chlorine. The sum of the chlorine forms present as free available chlorine and combined available chlorine.

39. Total Coliform. A group of closely related, mostly harmless bacteria that live in soil and water as well as the gut of animals. The extent to which total coliforms are present in the source water can indicate the general quality of that water, but may not necessarily be indicative of an acute or chronic health hazard. The presence or absence of total coliform bacteria is relevant to overall drinking water quality and absence of total coliform is the expected water quality parameter for potable water systems.

40. Turbidity. The cloudy appearance of water caused by the presence of tiny particles. High levels of turbidity may interfere with proper water treatment and monitoring.

41. Vacuum Breaker, Non-Pressure Type. A device or means to prevent backflow designed not to be subjected to static line pressure.

42. Vacuum Breaker, Pressure Type. A device or means to prevent backflow designed to operate under conditions of static line pressure.

43. Water Quality. The chemical, physical, radiological, and microbiological characteristics of water with respect to its suitability for a particular purpose.

CHAPTER 6
WATER QUALITY AFLOAT

APPENDIX C
LIST OF ACRONYMS

AMAL	Authorized Medical Allowance List
ANSI	American National Standards Institute
APHA	American Public Health Association
AWWA	American Water Works Association
BUMED	Bureau of Medicine and Surgery
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
CO	Commanding Officer
CONUS	Continental United States
DBP	Disinfection Byproduct
DoD	Department of Defense
DoDI	Department of Defense Instruction
DON	Department of the Navy
DPD	N,N-diethyl-p-phenylenediamine
EPA	U.S. Environmental Protection Agency
EPM	Equivalents per Million
FAC	Free Available Chlorine
FDA	Food and Drug Administration
FFHC	Fit for Human Consumption
FGS	Final Governing Standards
ISO	International Standards Organization
MCL	Maximum Contaminant Level
MDR	Medical Department Representative
MRDL	Maximum Residual Disinfectant Level
MSD	Marine Sanitation Device
Mg/L	Milligrams per Liter (same as parts per million for water)
NAVFAC	Naval Facilities Engineering Command
NAVMED	Navy Medicine
NAVSEASYSCOM	Naval Sea Systems Command
NAVSUPSYSCOM	Naval Supply Systems Command
NAVENPVNTMEDU	Navy Environmental and Preventive Medicine Unit
NAVMCPUBHLTHCEN	Navy and Marine Corps Public Health Center
NPDWR	National Primary Drinking Water Regulations
NSF®	National Sanitation Foundation International
NSDWR	National Secondary Drinking Water Regulations
NSTM	Naval Ships Technical Manual
OCONUS	Outside the Continental United States
pH	Hydrogen Ion Concentration
PPM	Parts per Million (same as mg/L for water)
PWD	Public Works Department
PWS	Public Water System

RO	Reverse Osmosis
SAMS/TMIP	SNAP Automated Medical System/Theater Medical Information Program
SDWA	Safe Drinking Water Act
TBR	Total Bromine Residual
TC	Total Chlorine
TDS	Total Dissolved Solids
THM	Trihalomethane
WHO	World Health Organization

CHAPTER 6
WATER QUALITY AFLOAT

APPENDIX D
SAMPLE SHIP WATER SANITATION BILL

Each ship must have a Water Sanitation Bill. The CO should promulgate the Water Sanitation Bill. The Water Sanitation Bill should be posted conspicuously in areas where potable water and associated materials are processed, treated, or stored.

Sample Ship Water Sanitation Bill

1. Responsibilities

a. The engineering department of the ship is responsible to the CO or master for implementing the requirements of the Naval Sea Systems Command. This responsibility includes the operation and maintenance of the shipboard water supply system, production of an adequate amount of water, and disinfection.

b. The Medical Department is responsible for conducting a comprehensive medical surveillance program of the potable water system including adequacy of disinfecting procedures, collection of samples for bacteriological analysis, and testing halogen (disinfectant) residuals from the distribution system. The Medical Department must notify the CO or master of any discrepancies observed in the potable water distribution system.

2. Sources of Potable Water

a. Processing of Seawater. Per NSTM chapter 533, ships must avoid using their onboard water production plants to make water while in port or in harbors. Seawater in ports and harbors should be considered polluted. Source water in harbors or ship navigation lanes is likely to be contaminated by fuel, oil slicks, or other pollutant sources. Biological contaminants are also likely to be present in these waters. If it is necessary, under emergency circumstances, to operate the distilling plant or RO unit while in polluted waters, the procedures provided in article 533-2.4.5 of NSTM chapter 533 must be strictly followed.

b. Shore Potable Water Sources. Potable water may be received from approved shore sources. Approved shore potable water sources:

(1) U.S. Environmental Protection Agency (EPA) (State and U.S. Territory) approved public water systems delivering water that meets the standards discussed in articles 6-6 and 6-7 of NAVMED P-5010, chapter 6.

(2) DoD approved overseas public water systems. This includes public water systems on OCONUS installations that the U.S. Navy (or other DoD entity) controls or operates per DoD Instruction 4715.05, Overseas Environmental Baseline Guidance Document (OEBGD) and host nation Final Governing Standards (FGS) of 1 Nov 2013.

(3) Potable water purchased in overseas, non-U.S. Navy port facilities via husbanding contracts that is verified to meet the standards discussed in articles 6-6 and 6-7 of NAVMED P-5010, chapter 6 and the requirements of the husbanding services contract.

c. Other Navy Vessels. Potable water may be received from other U.S. Navy ships.

3. Receipt and Transfer of Potable Water

a. The MDR will determine if the correct disinfectant residual (free available chlorine [FAC] or total chlorine(TC)) is present in the source water and if it is not, he or she will notify the engineering department representative.

b. Potable water connections between shore and ships must be made by authorized and trained personnel. The individual making the potable water hose connections must ensure hoses are not connected to a non-potable water system. Engineering will notify the MDR prior to making potable water hose connections.

(1) Remove shore cap and flush pier side potable water outlet for 15-30 seconds. Immerse outlet and rinse fitting in solution containing 100-ppm FAC for at least 2 minutes. Flush water to waste for 15-30 seconds.

(2) Deliver a clean disinfected potable water hose to the outlet just before the connection is made (potable water hoses should be provided by the shore facility). Remove hose caps or uncouple hose ends and disinfect if not previously disinfected. Connect hose to pier side outlet and flush.

(3) Disinfect shipboard riser connections with 100-ppm FAC solution. Connect hose to the potable water shipboard riser and deliver potable water. Other Food and Drug Administration (FDA) listed food contact surface disinfectants such as iodine may be used if approved by the MDR.

(4) When the transfer is completed, secure the shore water source; remove the ship connection, then the shore connection. Thoroughly flush the potable water outlet and recap.

(5) Drain the potable water hose thoroughly and properly store in the potable water hose storage locker.

c. For ship-to-ship transfer of potable water, follow these procedures:

(1) Both ships disinfect their respective potable water riser connections. The leading potable water hose must have the hose cap in place during the high-line procedure.

(2) When the receiving ship secures the potable water hose, the cap is removed and the hose coupling is disinfected.

(3) The supplying ship connects its end and flushes the hose.

(4) When the transfer is completed, the receiving ship removes the potable water hose and replaces the caps on the receiving connection and the potable water hose.

(5) The supplying ship then retrieves, couples or caps, and properly stores the potable water hose.

4. Potable Water Hoses

a. Potable water hoses must be labeled “POTABLE WATER ONLY” with 1-inch high letters approximately every 10 feet of hose, and the end couplings must be dark blue in color.

b. When not in use, the potable water hoses must be coupled or capped and stored in designated lockers. In addition to the potable water hoses, all fittings and tools used exclusively for potable water must also be stored in the designated potable water hose locker. The lockers must always be kept closed and locked when the hose is not being used.

c. Potable water hose storage lockers must be conspicuously identified and labeled “POTABLE WATER HOSE ONLY.” The lockers must be vermin proof, self-draining, and mounted at least 18 inches above the deck. They should be constructed from smooth, non-toxic, corrosion resistant material.

d. Potable water hoses must not be used for any other purpose. Hoses must be examined frequently and removed from use when cracks develop in the lining or leaks occur.

5. Potable Water Storage Tanks

a. Potable water tanks and all affected parts of the potable water distribution system must be cleaned, disinfected, and flushed with potable water:

(1) Before being placed in service;

(2) Before returning to operation after repair, replacement; or

(3) After being subjected to any contamination, including entry into a potable water tank.

b. In the event of a break or compromise in the potable water system, or if a potable water tank is entered for any reason, all involved tanks, parts, and lines must be cleaned, flushed, and disinfected prior to being returned to service. The MDR must be notified of the break or entry and the disinfection procedure accomplished by the engineering department.

c. Potable water tanks must be inspected, cleaned, and disinfected during dry dock and wet dock periods, or every 2 years, whichever is less.

d. Potable water tanks should not be filled with ballast water unless absolutely necessary for the survival of the ship for damage control. If non-potable water is introduced into potable water tanks, all tanks, lines, fittings, and pumps must be disconnected from the potable water system, plugged or capped, and not reconnected until properly cleaned, flushed, disinfected, and tested as applicable per article 6-24 of NAVMED P-5010, chapter 6.

6. Disinfection

a. Approved Shipboard Potable Water Disinfectants:

(1) Calcium Hypochlorite (technical 65-70 percent),

(2) Sodium Hypochlorite (unscented),

(3) Bromine Cartridges,

(4) Mixed Oxidant Electrolytic Disinfectant Generator.

b. Maintaining disinfectant residuals throughout the distribution is used as a barrier against intrusion of bacterial and viral pathogens into distribution systems, and as a mechanism to reduce the formation of biofilms, and the growth and persistence of free-living pathogens.

c. Disinfectant residuals should be detectable (preferably ≥ 0.2 mg/L) but must be below the Maximum Residual Disinfectant Limit (MRDL) throughout the distribution system, including the location representing maximum residence time in the distribution system. The absence of a FAC or TBR in the ship's potable water may indicate contamination and should trigger engineering department follow up action.

7. Disinfectant Residual Testing

a. The engineering department is responsible for ensuring the disinfectant residual at the potable water tank is at least 0.2 ppm (mg/L) prior to placing the tank on line with the potable water distribution system.

b. Disinfectant residual testing will be performed 30 minutes after chlorinating potable water tanks to verify the required 0.2 ppm (mg/L) residual is present.

c. Prior to receiving potable water from any off-hull source (i.e., shore water supply, another ship, or a potable water barge), the water must be tested to ensure the appropriate disinfectant residual (i.e., FAC, TBR or TC) is present.

(1) Water disinfected with chlorine must have at least 0.2 ppm (mg/L) FAC but less than 4.0 ppm (mg/L) FAC.

(2) Water disinfected with chloramine must have at least 0.5 ppm (mg/L) TC, but less than 2.0 ppm (mg/L) TC.

(3) Water disinfected with bromine must have at least 0.2 ppm (mg/L) TBR, but not greater than 1.0 ppm (mg/L).

d. Daily disinfectant residual testing by the Medical Department is required while the ship is underway or deployed. While the ship is in a CONUS or OCONUS U.S. Navy port using an approved shore water supply, residual testing will be conducted weekly. While berthed in overseas (non-U.S. owned or operated) ports, daily disinfectant residual testing is required.

e. Absence of disinfectant residual should be reported to the engineering department for investigation and appropriate corrective actions. The MDR should conduct bacteriological testing of the water in the location(s) where there is no disinfectant residual. Persistent absence of disinfectant residual must be reported to the CO with a copy to the engineering officer.

f. Results of disinfectant residual testing will be recorded in the SNAP Automated Medical System/Theater Medical Information System (SAMS/TMIP) environmental surveillance module or current approved electronic medical database.

8. Bacteriological Testing

a. The MDR will ensure water samples are collected and tested weekly for bacteriological contamination. Samples will be collected at representative points throughout the distribution system, as well as from potable water tanks. This includes potable water in storage tanks while the ship is in port and the system is receiving direct service from shore potable water pipes. Special or more frequent tests are required whenever chlorine demand increases; contamination is suspected, after cleaning and disinfection of potable water tanks, and upon completion of repairs to the system.

b. When the results of bacteriological examination of potable water reveals the presence of total coliform bacteria, the engineering department must be notified and repeat samples must be collected and tested. At least one repeat sample must be from the same tap as the original positive sample. Two other repeat samples must be collected from within five service connections of the original positive sample. One sample must be taken upstream and the other downstream. If the original positive sample is at the end of the distribution system, two samples will be collected upstream. If total coliforms are absent in these samples, the water is safe to use. Presence of *E. coli* bacteria renders the water supply unsafe for ingestion until the contamination is corrected and verified via a repeat negative water sample.

c. Results of bacteriological testing will be reported to the CO via the engineering officer and recorded in the SAMS/TMIP environmental surveillance module or current approved electronic medical database.

9. Temperature, pH and Salinity. These parameters are monitored at least daily by the engineering department. Variations in temperature, pH, and salinity may affect water treatment procedures.

10. Potable Water Distribution System

a. In general, any type of water supply connection that permits the return of used or contaminated water into the potable water system is not permissible. If present, cross-connections between potable water and piping systems containing other substances allow contamination of the potable water, which may result in water-borne illnesses in the exposed population.

b. The MDR, engineering department personnel, and crew at large must ensure constant surveillance of the potable water system to prevent cross-connections. Prevention of cross-connections must also encompass piping systems and connections originating outside the ship such as those found on piers and barges.

c. Like every other component in the potable water system, potable water piping must be clearly identifiable and protected from the introduction of contamination at all times. Cross-connections between potable water lines and all other fluid systems are prohibited.

11. Records

a. The engineering department should maintain adequate records to furnish documentary evidence of engineering responsibilities concerning production, treatment, and distribution of potable water.

b. The MDR will maintain a potable water log; the entries must be a 2-year chronological record of potable water surveillance. The SAMS/TMIP environmental surveillance module or current approved electronic medical database may be utilized in lieu of a hard-copy potable water log. Entries are made in chronological order and must contain the following:

(1) Each time a water sample is taken, record time and date, location of the ship, location of the sampling site, source of the ship's water, and whether or not from an approved source.

(2) Results of disinfectant residual test (state type of halogen) and reason taken, e.g., daily, in connection with bacteriological analysis, prior to receipt or in connection with disinfection of tanks or lines. Include any follow-up action taken when negative readings are obtained.

(3) Results of all bacteriological analysis including controls. State reason test performed such as weekly, special, or in connection with disinfection of tanks or lines. Record action taken in the case of positive samples, even if the tests were performed by another activity.

(4) Record any repairs or modification to the potable water system or tanks, any problems with taste or odor and their resolution, the findings of inspections and surveys, and any action taken.

12. The MDR must make frequent medical surveillance inspections of the potable water procedures and system to ensure the provisions of this bill are being carried out. Any discrepancies must be reported in writing to the CO as applicable with a copy to the engineering officer.