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Brominated Resins

for Specialized Water Disinfection Applications

If you live in a city such as New York, San Francisco or Chicago that is on a large body of water, would you be able to tell if your drinking water was disinfected using chlorine, chloramines or a completely different halogen—bromine? All three have been effectively used as disinfectants in thousands of drinking water applications, but your answer would depend on whether you're on land or in the ocean. Even though bromine is used to disinfect drinking water systems, it lacks visibility in many water treatment circles because The U.S. Environmental Protection Agency (EPA) has limited the use of bromine as a disinfection agent to marine drinking water applications. In fact, disinfection systems using bromine are as common on board U.S. warships, commercial vessels and offshore oil drilling platforms as chlorine and chloramines are in municipal water treatment facilities. You may not be aware of bromine because currently it is not used in municipal drinking water applications.

While water is drawn from many sources in offshore and marine environments, a reliable supply of high-quality safe water is critical for the well-being, productivity and morale of the crew stationed onboard. Often the water is produced by the ship's desalinization system, which could be reverse osmosis or a distillation system. Other common water sources are shore water, barged water, another ship or a mixture of sources.

At present, two halogen compounds—chlorine and bromine—are the only EPA-approved methods for disinfecting shipboard potable water. While chlorine is the preferred disinfectant for land-based water treatment facilities, applying it in offshore applications poses some significant disadvantages. Chlorine in a gas, liquid or solid form is very dangerous on ships or offshore oil platforms. Chlorine is very reactive and corrosive, which makes it an extremely hazardous chemical to handle. Use of chlorine gas is impractical on ships due to handling problems and the confined spaces where it would be stored.

Powdered calcium hypochlorite has been used as a source of chlorine because it provides 70 percent available chlorine. However, it is a very strong oxidizing agent and has been responsible for causing several shipboard fires.[1] Fires on a ship or offshore oil platform are especially dangerous because the only place to escape a fire that can't be extinguished is overboard. There are other disadvantages to powdered calcium hypochlorite.

Figure 1. Recirculating Bromine Feeder

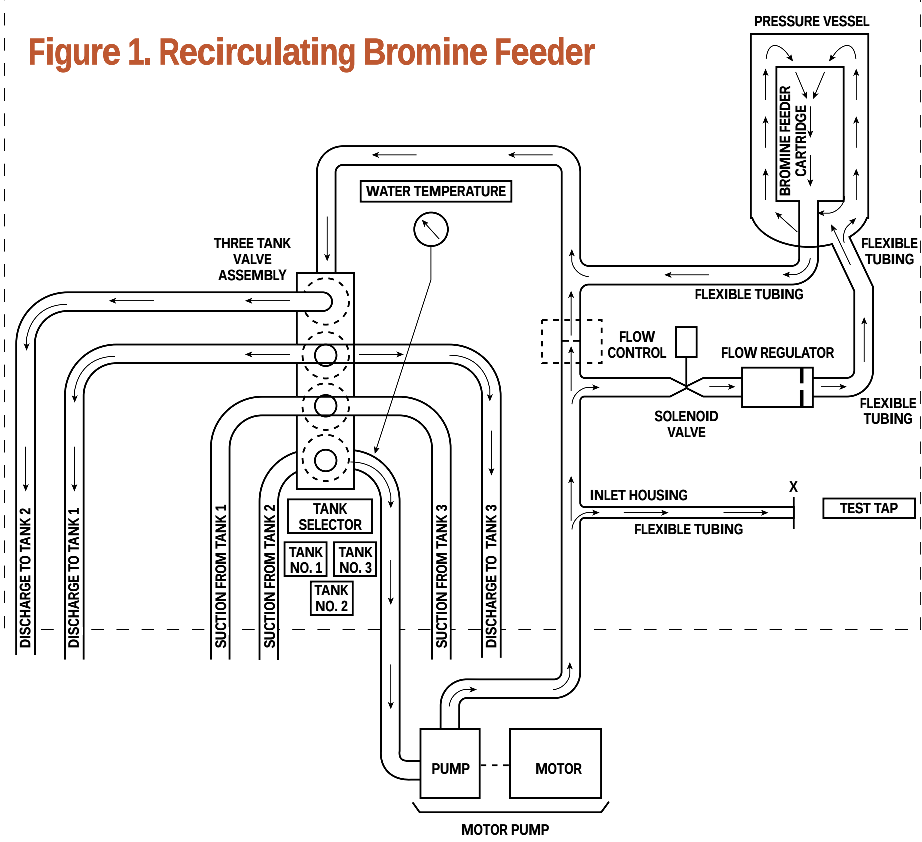

Table 1. Bactericidal Activity of Bromine Compared to Chlorine When Introduced to Ammonia

	Time (seconds)	
NH_3 (ppm)	*Chlorine (0.5 ppm)*	*Bromine*
0.0	15	15
0.1	> 180	30–60
1.0	> 1200	30–60
10.0	> 3600	30
100.0	∞	30

The brominated ion exchange resin provides a safer alternative than the previously used elemental bromine (liquid) for offshore water treatment applications.

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It must be used in the dissolved form and any calcium hypochlorite particles that remain undissolved will interfere with the operation of the feeder releasing it into the water supply.

Before 1957 bromine wasn't a good alternative for offshore applications. As with chlorine, elemental bromine (a liquid) is too hazardous to use in offshore applications. Elemental bromine is extremely corrosive and becomes even more so when combined with even trace amounts of water, which makes the liquid form of bromine incompatible with most materials. However, in 1957 The Dow Chemical Corp. addressed the negatives of using bromine by creating a brominated ion exchange resin, which opened up the use of bromine in offshore water treatment applications.[2] Today, polybromide resin is used in many offshore water treatment systems. It is a strong base anion exchange resin impregnated with elemental bromine to the level of 30 percent by weight. Polybromide resin is a dry solid that is safer to handle than calcium hypochlorite because it is nontoxic and will not start fires if combined with petroleum distillates such as paint or fuel. Polybromide resin is available in sealed cartridges for use in brominating systems, making it easy to contain, handle and monitor as the bromine needed for disinfection is released into the water supply at a predictable rate. The fact that bromine can be added to water that previously has been chlorinated makes polybromide resin a practical solution to accommodate the multiple sources of water in offshore applications.

One of the benefits of the dry brominated resin is that it can be stored under the proper conditions, for up to two years. When it is needed, the cartridge is loaded into a proportioning or recirculating feeder, and a controlled amount of bromine is released into the water. Once the cartridge is spent, it can be safely disposed of in the regular trash without the concern of causing a fire or releasing a dangerous gas.

Table 2. Bromine Feed Adjustments for Temperature Variations

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

Bromine Advantages Over Chlorine

Although the general properties of bromine are similar to chlorine, there are distinct differences between the two halogens. Among its advantages, polybromide resin is safer to use, it is affected only negligibly by ammonia, it has a long shelf life and it Is an effective disinfectant over a wider pH range than chlorine.

Bromine and Ammonia

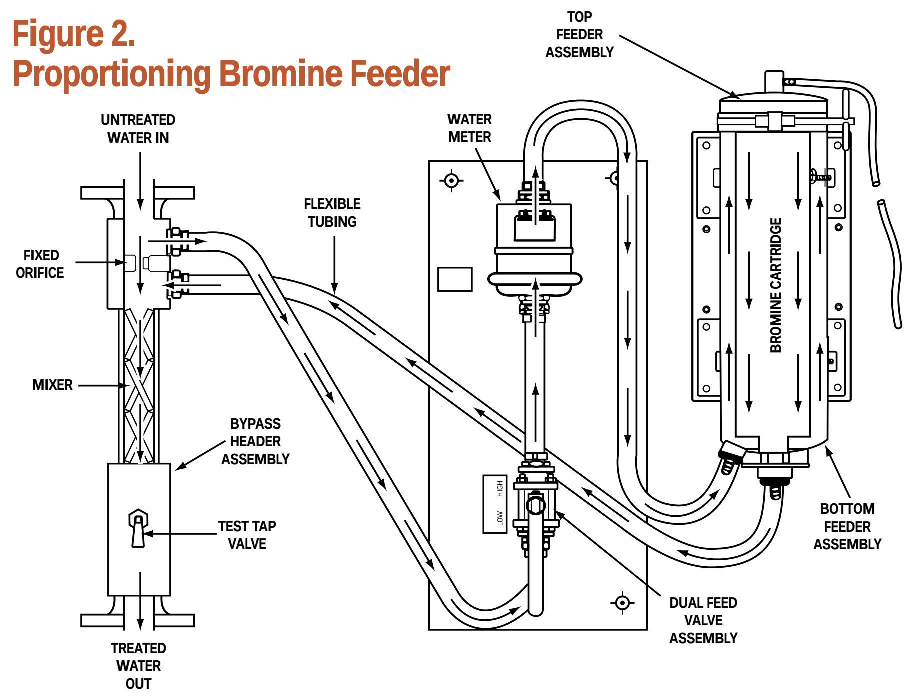
The most common source of ammonia in a marine application would be from water that was received from a municipal supply that contained chloramines or naturally occurring ammonia. When the ammonia is recombined with chlorine or bromine in an offshore holding tank, it is important to know the effect of this ammonia on the halogen that is used to disinfect the water. A study by Johanneson has demonstrated that the bactericidal activity of bromine is not significantly affected by the presence of ammonia.[3] However, the bactericidal properties of chlorine are appreciably affected by the presence of even trace amounts of ammonia, requiring much longer times for 99 percent inactivation of *E. coli* organisms. (See Table 1.)

Polybromide resin is an effective disinfectant over a wider pH range than chlorine. Chlorine is 50 percent active at a pH of 7.6, whereas bromine is 50 percent active at a pH of 8.7. Bromine also is less affected than chlorine by the presence of organics that contribute to halogen demand.

Adjustments for Temperature Variations

Water temperature and total dissolved solids (TDS) do affect the amount of bromine that is released from the cartridge. The lower the water temperature, the less bromine released; therefore, an insufficient quantity of bromine may be released from the resin. To increase the bromine residual level to a proper amount, operation of a recirculating bromine feeder is required. The recirculating bromine feeder can treat up to four water storage tanks, depending on the type of feeder used, to maintain the proper residual. (See Figure 1.) The higher the temperature and/or TDS, the greater the amount of bromine released. (See Table 2.) If a test reveals an increase in source water temperature, an operator adjustment can be made to deliver a lower amount of bromine.

Figure 2. Proportioning Bromine Feeder

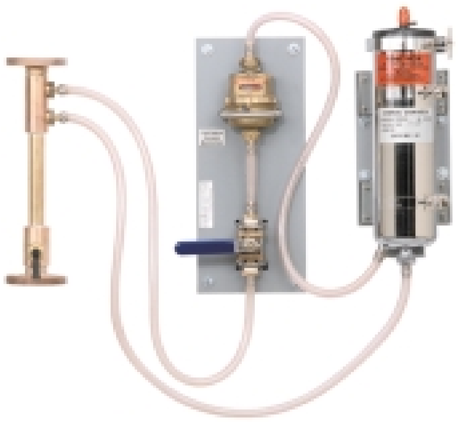


Types of Bromination Systems

Bromination of a potable water system requires two types of brominators. A proportioning

This is an example of a standard brominator system.

bromine feeder is used to treat potable water by adding a predetermined quantity of bromine to the desalinization system discharge line. The quantity of bromine added is contingent upon the seawater intake to the ship's water maker. If the seawater intake is considered noncontaminated, the low feed rate of 0.7 ppm bromine at 100ºF is acceptable. However, if the seawater intake is considered contaminated, the high feed rate of 2.7 ppm bromine at 100ºF is required. An operator can change the feed rate by adjusting the feed valve handle from either the parallel (high feed) to perpendicular (low feed) position or vice versa. (See Figure 2.) Monitoring the bromine residual will ensure the potable water is bacteriologically safe for cooking and drinking purposes.



Proportioning bromine feeders add a predetermined quantity of bromine to the desalinization system discharge line.

The other type of brominator is the recirculating bromine feeder system, which adds bromine to water after it is placed in a storage tank. This allows the convenience of multiple tank treatment at one location. This system recirculates the water in each individual tank and while recirculating, it adds bromine to the water, dispersing it evenly throughout the storage tank(s). The system utilizes a multiple position tank selector valve, which is designed to easily select the tank to be tested and/or treated. This system permits regular sampling of the treated water to insure that the desired disinfectant level in the tank can be reached. With the aid of a graph that displays water temperature versus tank volume, the feed time is determined (Bromine Feed Chart). This programmed time will increase by approximately 0.5 ppm the bromine content of potable halogen demand-free water.

Maintaining Halogen Residual for Safe Potable Water

Halogen-based disinfectants such as chlorine and bromine react with oxidizable substances in water. The initial utilization (usually within 30 minutes) of the disinfectant in a water supply is referred to as "halogen demand." The halogen demand in water will vary with respect to the amount of interference from the oxidizable substances that are present. This will reduce the initial supply of bromine added to the water. If the proper amount of halogen residual cannot be maintained in the tanks or potable water system, it is an indication that some substance has used or neutralized the disinfectant in the system. Further inspection of the water system should be done to determine the source of the contamination.

A measurable trace halogen residual should be maintained within the distribution system to ensure safe potable water. Water without a halogen residual should be brominated to provide 0.2 parts per million (ppm) halogen residual at the end of a 30-minute contact period. However, if the source water is of poor quality or unknown quality, it is best to maintain a residual of 2.0 ppm after a 30-minute contact time. Poor quality water often is the case when a ship is in port or within several hundred miles of a large city or port while making its own water. If water from a municipal supply cannot be trusted, it also would be considered poor quality.[4] This is because water in harbors or along the shore line as well as some municipal water around the world may contain harmful waterborne bacteria and viruses, which need to be destroyed to make the water safe to drink and use.

As you can see, making and purifying water in a marine application is quite different than in most land-based

Brominating cartridges provide a safe and easy-to-install solution.

systems. Much of what has been learned about purification of water in standard municipal applications is applied differently away from shore. Through the use of polybromide resins, water treatment can be conveniently and safely accomplished over a wide range of water chemistries and conditions without compromising the safety of the crew. The next time you go onboard a ship, ask how they make and purify their water. You are bound to discover something interesting and learn more about this field of water treatment. **WQP**

References

1. National Sanitation Foundation. "Survey and Evaluation of Currently Available Water Disinfection Technology Suitable for Passenger Cruise Vessel Use," *Water Disinfection Technology*, Contract No. 200-80-0535.

2. Dow is a registered trademark of The Dow Chemical Co.

3. Johanneson, J. K., *American Journal Public Health*, Vol. 50, pg 1731-1736, 1960.

4. Department of the Navy, "Water Supply Afloat," NAVMED P-5010-6.