Potable Water

The Centers for Disease Control and Prevention's Vessel Sanitation Program is proud to bring to you the following session: Potable Water. While this presentation is primarily intended for cruise vessels under the jurisdiction of the Vessel Sanitation Program, it may also be used by anyone who is interested in this topic. This session should not be used as a replacement for existing interactive training, but should be used as an adjunct to a comprehensive training program.

Learning objectives. Our learning objectives in this session will be to list pathogens that can cause waterborne illness, list the common deficiencies in drinking water systems that can cause waterborne illnesses, list the free halogen residuals required for production and distribution, list the information required during documentation of maintenance, cleaning, and disinfection of potable water tanks, list the requirements for manual monitoring should the far point analyzer recorder fail.

Potable water illnesses. England. In Soho, England, in 1854, there was a large cholera outbreak resulting in over 10,000 people dead. This outbreak occurred at a well on Broad Street in this community. Dr. John Snow lived there at the time, and noticed that the incidents of the disease amongst the population occurred from the people drinking from this particular well. Although he couldn't get the town fathers to stop utilizing the well, he did get them to remove the pump handle, which decreased the incidents of cholera in that area.

Pennsylvania. In 1885, in Plymouth, Pennsylvania, there was a large typhoid outbreak resulting in 1,000 people becoming ill. The town was low on water during this wintertime, and they would run pipes into the river to pump water up to fill the reservoirs. Unbeknownst to the people of the community of Plymouth, in a small community called Wilkes-Barre just north upstream of Plymouth, the people dumped their raw sewage into the river. The town fathers were literally pumping raw sewage up into the water system in Plymouth.

As we can see from this slide, the rates for typhoid fever were very high prior to 1908. In 1908, chlorination of public drinking water systems was begun in the United States. After that, as we can see from the slide, the rates of typhoid fever dropped dramatically.

Missouri. Cabool, Missouri. In 1989 there was a large outbreak of gastrointestinal illness caused by E. coli 0157:H7. There were 243 cases, 32 hospitalizations, and four deaths.
This outbreak was the result of E. coli contamination of the wells in the town of Cabool. This city was not chlorinating their water at the time.

Wisconsin. In 1996 there was a large cryptosporidium outbreak in Milwaukee, Wisconsin, population 800,000. 370,000 people became ill, with 4,400 people hospitalized and approximately 40 deaths. This outbreak occurred due to a surface water system that the city pulled from. During heavy rains, the surface water treatment system became overwhelmed, and cryptosporidiumosis broke through and contaminated the entire water system throughout the city.

Alabama. In 1992 there was a large outbreak of Vibrio cholera associated with seafood in Mobile, Alabama. This outbreak was traced back to tankers dumping ballast water from water they had originated from South America.

Waterborne illnesses. Routes of exposure include ingestion, respiration, and contact. Pathogens types of concern are bacteria, viruses, and protozoa.

Pathogens and water. Some of the pathogens we're concerned about in drinking water are shigella species, giardia, cryptosporidium, Vibrio cholera, Escherichia coli, and legionella.

Cryptosporidium parvum. Cryptosporidium parvum is a coccidian protozoan. The reservoir is humans, cattle, and other domestic animals. Water treatment optimization includes sedimentation, coagulation, and filtration. Filtration is required at the 0.1 to one micron level. Boiling water for one minute will eliminate the oocyst.

Vibrio cholera is a bacterial illness. Humans are the reservoir, and disinfection with chlorine is very effective.

Eschericia coli, or E. coli. Two important strains are enterohemorrhagic and enteroinvasive. Several important pathogenic strains based on serology and virulence exist.

Eschericia coli, EHEC. This is E. coli 0157:H7. Cattle are the primary reservoir for this E. coli. Chlorination of water is an effective treatment.

Eschericia coli, not EHEC. The infectious dose is ten to the eighth to ten to the tenth organisms. Humans are the primary reservoir of this E. coli. Again, chlorination is an effective treatment for water.

Waterborne illness associated with drinking water by etiologic agent, United States, 1999-2000. As we can see from this slide, a little more than 50% of the outbreaks in the
United States during this time period were related to parasitic, bacterial, and viral organisms.

Waterborne illness associated with drinking water by deficiency, United States, 1999-2000. As we can see from this slide, more than 80% of the waterborne illnesses were associated with untreated groundwater, a treatment deficiency, a distribution system deficiency, or an untreated surface water source.

Potable water. We're going to discuss the importance of potable water, water sources, water storage, water distribution, and bacteriological testing or monitoring.

Potable water sources. Bunkered water or water loaded from shoreside, production water which includes evaporators and reverse osmosis units, or RO units.

Bunkered water. Bunkered water can come from many different sources. You may have groundwater, surface water, mixed groundwater and surface water sources, or desalinization plants. Bunkered water. The minimum requirement for bunkered water is it must meet world health organization drinking water quality standards. You must have a recent water quality report onboard the vessel. Bunkered water. The advantages of bunkered water are large quantities. The disadvantages are variable quality and cost.

Potable water filling. Bunker hoses. We're going to discuss storage, handling, connection procedures, and labeling.

Hose storage. Hoses should be used for no other purpose. They should be drained after use, they should be rolled up or placed on a hose reel, and they should be capped or coupled together to prevent contamination. Hose storage. A cabinet or locker should be provided for hose storage. The material the locker is constructed of should be durable. The locker or cabinet should be labeled, it should be easy to clean, it should be self-draining, and it should be elevated off the deck at least 45 centimeters or 18 inches.

Handling. Hoses should be handled in a sanitary manner. They should not be placed in the harbor or in standing water, and do not drag the hose ends on the deck. Connection procedures recommended. Sanitize the connections utilizing 100 milligrams per liter of chlorine. Flush the shoreside connection to waste. Connect the hose or hoses to the shore side. Flush the hose to waste, then connect to the vessel. Potable water hose labeling. Each connection into the hose should be labeled "potable water only."

Production water. The advantages of production water are consistent quality, unlimited supply, and low cost. Disadvantages of production water include you may operate at sea only, and you may have quantities limited by your production capacity.
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Reverse osmosis. Reverse osmosis works by pressurizing the high saline water and pushing the liquid through a membrane, resulting in a potable water product.

Producing water in port. This is allowed only if the system cannot produce potable water. It must be completely separate from the potable water system.

Treatment of bunkered production water. Production water must be halogenated to two parts per million. Halogen level must be tested and recorded every four hours. Bunkered water must be halogenated to two parts per million. Halogen level must be tested and recorded every hour.

Potable water storage. Storage facilities. Tanks must be labeled "potable water." Tank coatings must be approved and documentation must be available on the vessel for the tank coatings and the manufacturer's procedures for applying and curing those coatings. Tanks must have a sample point which is turned down, and there must be a sanitary water depth determination method. Events and overflows must be protected.

Potable water tank maintenance. Tanks must be inspected every two years or every dry dock, whichever is less. Detailed records must be maintained on the vessel recording the type of maintenance performed, the cleaning procedures, and disinfection, including the residual, the contact time, and the flushing or dechlorination to less than five parts per million.

Water distribution system, water disinfection. Water disinfection methods. Methods include boiling, ultraviolet light, ozone, or halogenation.

Water disinfection, ultraviolet light. Advantages of ultraviolet light include no taste or odor and no byproducts. The disadvantage is there are no measurable residuals to protect the water system after the initial ultraviolet light treatment.

Water disinfection, ozone. Advantages include no taste or odor, and no byproducts. Again, the disadvantage is no measurable residual to protect the water system after the initial treatment. Water disinfection, halogenation of chlorine and bromine. Advantages of disinfecting with chlorine or bromine include available residual, easy to test for, and an inexpensive test. Disadvantages include taste and odor and byproduct formation.

Water treatment. In the following slides we'll discuss the addition of chlorine to treat the water. As we can see in this water droplet, we have added chlorine to treat pathogens. As the chlorine sits in contact, it starts combining with pathogens and removing them. Some pathogens are slightly more resistant, and take a longer contact time. But as the time passes, the chlorine effectively removes all of the pathogens. Free available chlorine. After the chlorine has been in contact with the water for some time, all the pathogens
have been destroyed, and we have a residual left called free available chlorine which is available to protect the water system should it become contaminated later on.

Chlorine mechanics. How does chlorine kill microorganisms? This slide shows how chlorine is effective against different types of microorganisms. To the left, on the vertical side, represents chlorine effectiveness from lowest to highest, bacteria being most easily destroyed by chlorine. In bacteria, the chlorine penetrates the cell wall and kills the organism. With viruses, which are not a living organism, the chlorine attaches to the virus and inactivates it. Giardia. Chlorine also inactivates this organism. Cryptosporidium is resistant to chlorine in levels seen in drinking water systems. Used alone, chlorine would have no effect on cryptosporidium.

Chlorination mechanics. Chlorine treatment standards, C times T, T being the time water is in contact with the chlorine and C representing the concentration of the free chlorine in milligrams per liter measured after a given amount of time. Chlorination mechanics. The fraction of microbes killed increases linearly with the disinfection concentration or the disinfection contact time. Therefore concentration can be traded for time, as in the example below. Five parts per million times 100 minutes is the same as 20 parts per million for 25 minutes. Bottom line, disinfectant plus microbe equals dead microbe.

Halogen level requirements. Halogen level must be measured at the far point in the distribution system, and the level must be maintained between 0.2 and five milligrams per liter or parts per million.

Treatment system. We're going to discuss halogen injection and monitoring. Halogen injection system. The system must be automatic with a backup system, and it must be analyzer controlled. You may use manual halogen injection in emergencies only.

Monitoring system. The monitoring system includes the halogen analyzer and the chart recorder. Free halogen analyzer. The free halogen analyzer must be located at a far point, the equipment must be accurate to plus or minus 0.2 milligrams per liter or parts per million, the system must be calibrated or checked daily, and those calibrations recorded in a log or on the charts. The free halogen analyzer must have a low halogen level alarm. This alarm must be audible and located in a continuously occupied location.

Chart recorder. The chart recorder range must be 0.0 to five milligrams per liter or parts per million. The chart must be dated, reviewed, and initialed, and changed every 24 hours. This is an example of a chart from a chart recorder.

Manual monitoring. If the automatic system fails, you're allowed to do manual monitoring. However, readings must be recorded every four hours. Manual monitoring can only be done for ten consecutive days maximum before the equipment must be
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repaired. The manual monitorings must be recorded. They can be recorded on the charts or in a separate log.

Microbiological testing. Requirements. Analyze for E. coli (fecal coliforms). Four samples must be taken a month from the distribution system. These samples should be taken at different points of the distribution system and rotated monthly, and a follow-up on positive tests must be done. Analysis. The microbiological analysis must meet standard methods for the examination of water and wastewater. Colilert and colisure tests done on the vessels meet this requirement. Additional methods include membrane filter technique and fermentation tube.

Record keeping. Records must be kept on board the vessel for at least 12 months.

This concludes our session on potable water. Resources and references. For further information, please visit the following Web sites: The Centers for Disease Control and Prevention at www.cdc.gov or www.cdc.gov/nceh/vsp. Or visit the Environmental Protection Agency Web site at www.epa.gov.