Potable water on board ships

This is a guide on how the Norwegian drinking water regulation requirements can be implemented on a Norwegian flagged ship of 50 tonnes and above.

Regulations

The primary regulations for having proper control of drinking water onboard ship are:

- Regulations on equipment and catering service on vessels of 15 September 1992 No. 707.
- The Norwegian drinking water regulation of 4 December 2001 No. 1372.
- ILO Convention 178

Water supply

The Norwegian drinking water regulations (4 December 2001 No. 1372) applies to all drinking water regardless of its origin, and regardless of whether it delivers through the distribution network, from a tank lorry, a tanker, in bottles or other packaging. Furthermore, the regulation applies to all drinking water on land, on the continental shelf and on ships whether it is based on seawater or freshwater.

The drinking water regulation uses several terms that may be unfamiliar to the maritime sector. Transferred to the conditions on a ship the following should be basic understandings:
Water supply system: water intake, facilities for water production, water treatment plants, tanks, main tap point. Water supply system includes the water itself and operating procedures.
Internal distribution network: Water pipes and conduits in the ship, heaters, tanks, taps.
Waterworks owner: The owner of the ship.
Hygienic barriers: Water taken out on the ocean as well as technical measures to remove, neutralize or kill bacteria, viruses, parasites, etc.., and / or diluting, decompose or removing chemical or physical agents to a level where the substances no longer represent any health risk.
Operational analysis of drinking water: Internal analysis of the drinking water as part of internal control and adjustment of the operation of the drinking water facility, including the analysis taken in connection with the bunkering of potable water.
Simple and expanded routine: Routine analysis of water samples sent to an accredited laboratory on land, and used to document that the operation of drinking water facility has been satisfactory, and possibly as a basis for assessing changes in operations.

A long established principle in risk management of drinking water supply is to adopt an approach based on multiple barriers. In the Norwegian drinking water regulation the term "at least two hygienic barriers" is applied. No single treatment process may be expected to remove all the different types of pathogens or chemical substances found in water. Several barriers will provide extra security in case a processing step does not work optimally. The numbers and types of treatment processes required are dependent on the quality of the water that is used as raw water (the water source).
In some cases, a good clean water source itself could be regarded as an indicator of a barrier. Disinfection will in such cases often be regarded as barrier number two.

When taking in ocean seawater, assuming that the intake is on the lo-side of the ship and unaffected by any discharge from the ship, it is reasonable to assume that the water is of good quality. Algal blooms may be a problem in some areas.
Intake of seawater in coastal areas or ports must be avoided even if the water is treated on board.
When refilling from a land-based water company in Norway you should expect to have a good product in accordance with the drinking water regulation.
When refilling in other countries than Norway you should check the safety of drinking water with the relevant authority in the country.

The Norwegian drinking water regulation requirements for approval of water supply systems for ships with at least 50 people on board have practically not been enforced by the Food Safety Authority. Instead it has been addressed through the seaworthiness statement that the Norwegian Maritime Directorate, or different classification companies provide.

Water treatment

Ships produce in many cases drinking water from seawater using evaporation or reverse osmosis. In other cases they refill (bunkering) fresh water from land.
Depending on whether it is production on board or purchased from a water supply system on land, it will be necessary with different levels of internal control.
When producing water on board, there must be continuous control of the production line and periodic control of the internal distribution network. As a minimum, the water shall be disinfected.
When purchasing fresh water from land it is generally required only periodic control of the internal distribution network.
Operating and control procedures shall be based on a completed risk assessment.

Disinfection of water is often done either by chlorine or by UV. In both cases, the processes must be such that one has control of the disinfection to ensure that it will be optimal. When use of chlorine there should be detected a chlorine residual of at least 0.1 mg / l after 30 minutes. The amount of chlorine that needs to be added will often be between 0.3 to 0.5 mg / l. If water has a high colour value there will be need for a greater amount of chlorine. Disinfectant efficacy is achieved when the pH is less than 8. Chlorination must therefore be done before alkalizing.

Water Treatment Chemicals added to water shall be approved by the Norwegian Food Safety Authority.

When using UV there must be control of the intensity and the water flow to ensure that the UV dose is sufficient to inactivate (neutralise) potential micro-organisms. An UV dose of 30 mJ/cm2 would normally be expected to be sufficient. When seawater is taken in filtering of the water to remove colour, algae and other particles must often be performed in order for the UV system to function optimally. This means that the water transmission of UV rays in the range 254 nm must be good, preferably better than 70% per 5 cm. If the UV transmission is lower than 50% per 5 cm pre-treatment of water should be done to increase the UV transmission.

When bunkering from a land based supply analysis reports from the water company must be obtained. In addition, the water should be disinfected in connection with the bunkering or before

it is sent out on the internal distribution network, so that any microbial contaminants are taken care of as early as possible.

When production of potable water is done from seawater, it is essential that the drinking water is pH adjusted, e.g. by the addition of calcium to reduce corrosion in pipes and other components of the water supply system. Management of the production must follow the recommendations given by the equipment manufacturer.

Table A. The recommended water quality to minimize the water's corrosive properties

Parameter	**Unit**	**Concentration**
pH	pH-unit	8,0-9,0
Alkalitet (Carbonate)	mmol/l (mg/l HCO_3^-)	0,6-1,0 (36-60)
Calsium	milligram/l	15-25
Acidity (Free CO_2)	mmol/l milligram/l	As low as possible. As low as possible.

Water quality

The overall goal is that drinking water should be safe to use. The Norwegian drinking water regulation sets out 58 parameters that can affect your health. The regulation however covers any substance or organism. Chemical or biological components that are not listed in tables 1-3 in the drinking water regulation are covered if they can be present in quantities that could endanger human health.

Given the general requirement in § 12 first paragraph of the drinking water regulation, it is the responsibility of the owner of the water supply system to assess whether water quality can be affected by other components than those witch are set out in the regulation. The parameters which are set out in the regulation shall be documented. Whether they must be part of a regular monitoring of drinking water must be considered.

Water Sampling

The drinking water regulation requires that water shall be of drinking water quality where water is supplied to the user. In practice this will be at the water tap. This applies to any water tap in the ship. Since there are many taps in a ship a risk analysis has to be done to pick out the particular important taps or other points. If there are many points it may not be necessary to sample all of these every time, but rather add up to a rolling sampling regime.

Examples of important sampling points and / or control points can be:
- Seawater before the water treatment
- Filters used to filtering the intake water
- The water treatment processes
- Water from drinking water tanks
- Taps in the galley
- Points elsewhere on the pipelines, especially near the end of a pipeline.

For supply systems on shore the local Norwegian Food Safety Authorities have permission to limit the number of parameters to be examined based on a broad knowledge of the specific water company. For ships with seawater intake, this is both impractical and difficult, so here the ship owner / captain must make their own health assessments based on where in the world the ship is located. During inspection by Food Safety Authority or others, ship owner/captain must be able to prove why not a given parameter has been analyzed.

The drinking water regulation set out minimum requirement, primarily aiming vessels with 50 or more persons on board. Often more frequent sampling than the minimum must be taken in order to have adequate control of the water supply.
As mentioned, more samples must be taken when producing own water than when buying it.
The kind of sampling necessary in order to control the water production and water treatment will depend on the production method. The manufacturer's recommendations must be followed to the extent that these exist.
If bunkering freshwater from a supplier where there is uncertainty with regards to the water quality, sampling of the water should be done before bunkering.
Samples taken in connection with the production of water on board or while bunkering are defined as operating analysis.

When it comes to the finished drinking water produced on board, the Norwegian drinking water regulation requires according to “Simple and expanded routine test” in Table 4, at least quarterly sample from a (one) representative tapping point. That tapping point may be addressed as a main tapping point. If this main tapping point is some distance out on the internal distribution network, then it should be taken samples from a reference point near the water tank as well, in order to be able to document any changes between these points. This may imply that samples from 2 sites must be taken each quarter. These samples shall be analysed by a laboratory accredited for the relevant parameters. Ships with fewer than 50 people on board do not need to use an accredited laboratory.
In addition to these samples, you will have samples taken from the internal distribution network as part of the overall internal control. These, together with samples taken as process control of the drinking water production unit, can be analysed on board ship.

The fact that a ship in this context is defined as an internal distribution network implies that sampling requirements of this part is more driven by internal demand than by a fixed frequency in the drinking water regulation. However, it may be natural to use the principles related to pipeline control in the drinking water regulation as a basis for this sampling. According to this it should be taken samples at several places in the ship. Selection of points should be based on a risk assessment. If many sampling points a system of rolling selection of points may be established. Ship with a long internal distribution network or many passengers, may find it necessary to take more frequent samples than quarterly. Monthly samples from selected tap points can be a good start.

Table B. Quality requirements and recommended analysis program for the control of drinking water on board Norwegian ships.
See also the text under the table for further explanation.

Parameter	Minimum frequency at the main tap point	Parameter for process control	Network control	Notes
MIKROBIOLOGI				
E. coli	Quarterly		X	Shall not be detected.
Total count 22°C	Quarterly		X	Should be below 10 Qty / ml at the main tap point. Findings of more than 100 must be examined to find the cause, and so measures must be implemented.
Intestinal enterococci	Quarterly			Shall not be detected
Other microorganisms			Local assessment	Microorganisms that are not directly mentioned in the drinking water regulations may in any case be present in varying amounts. This is shown by plate count. The following organisms should not be detected: Listeria monocytogenes, Psudomonas aeruginosa, Legionella sp.
SENSORY				
Smell	Daily		X	No pronounced odor
Taste	Daily		X	No pronounced odor
PHYSICAL AND CHEMICAL				
Appearance	Daily		X	Clear and without discoloration
Color	Quarterly	X	X	Shall be less than 20 mg / l Pt, but should be expected to be less than 4 on board a ship.
Turbidity	Quarterly or On-line	X	X	Shall be less than 1 FNU (FTU, NTU)
UV-transmisjon		X On-line		High UV transmittance (%) is important. Need only be analyzed if the water is UV-irradiated. Measured before the UV system.
pH-unit	Quarterly or On-line	X	X	pH between 6.5 to 9.5. The water should not be corrosive. Shall be measured independently of the type of water treatment in use. Measured in relation to the chlorination step, the alkalizing step and on distribution network. It is usually sufficient with quarterly measurements

Parameter	Minimum frequency at the main tap point	Parameter for process control	Network control	Notes
				done manually from the network.
Conductivity	Quarterly or On-line	X		Normally the value will be less than 10 mS / m. The desalination values will be higher, but shall not exceed 250 mS / m. Alarm for production systems should be set at: - 6 mS / m for vaporator - 75 mS / m for reverse osmosis plants
Free chlorine	On-line	X	X	Should be between 0.1-0.5 mg / l free chlorine. Measured 30 min after the addition. Construction that disinfect with UV do not need to measure chlorine.
Total chlorine	Se merknad			Total chlorine amount should normally be less than 1 mg / l. Disinfection with UV do not need to measure chlorine.
Iron (Fe)	Quarterly			Limit is 0.2 mg / l
Copper (Cu)	Quarterly			Limit is 1 mg / l. The sample shall be taken so as to provide a representative value of a weekly average of the water used.
Bor (B)	Se notes	X		Limit is 1 mg / l. Should be considered measured as an operating parameter if reverse osmosis is used.
Bromat (BrO_3^-)	Se notes			Limit is 5 mg / l BrO3-. Need probably be measured only when seawater is treated with ozone. In that case it should be analyzed as an operating parameter.

Whether the specified minimum frequency of sampling is sufficient or not must be considered by the owner / captain for each ship.
The quarterly sample (simple and extended routine) should be taken from a tap point which is representative of the water used on board.
Parameters for process control must follow the recommendations of the supplier, usually with on-line measurements. In addition, samples may be taken quarterly.