

# Water, Ship's Blood

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How a drop of water in the ocean propels a ship to other continents.

## Overview

When I do a tour, I need a theme for the tour. In this case, I trace the water through the ship. Start with a view of the bay > Forward Aux Machinery Room > Fire Room #2 > Forward Engine Room. As a time filler, I also stop at the Forward Emergency Diesel Room.

## Water

*(Take guests to view the bay)*

The ship sets on top of nearly unlimited water. Problem is that the water is not pure. It is about 95% water, about 2.5% sodium chloride, magnesium chloride and calcium chloride. The remaining 2.5% of the ocean contains dissolved gases such as oxygen, nitrogen, carbon dioxide, and other organic materials. The organic is plant and animal life. All of these impurities are not good for humans, or equipment. Not even the water you drink is pure enough for usage in an engine room. We need to clean it up. How does that happen?

## States of Water

Water has three states of matter. Solid, liquid and gas. We typically call those three states of matter, ice, water and steam. What does it take to convert water to ice? Drop the temperature of the water below 32°. To convert it back to water, raise the temperature to above 32°. How do we change water to steam? Raise the temperature over 212°. Sorry, that is not enough of an answer. Would it surprise you that I can make water boil at room temperature and prevent it from boiling at over 500°? Drop the pressure to .2psi and it will boil at 60°, raise the pressure 700psi and it will stay liquid at over 500°.

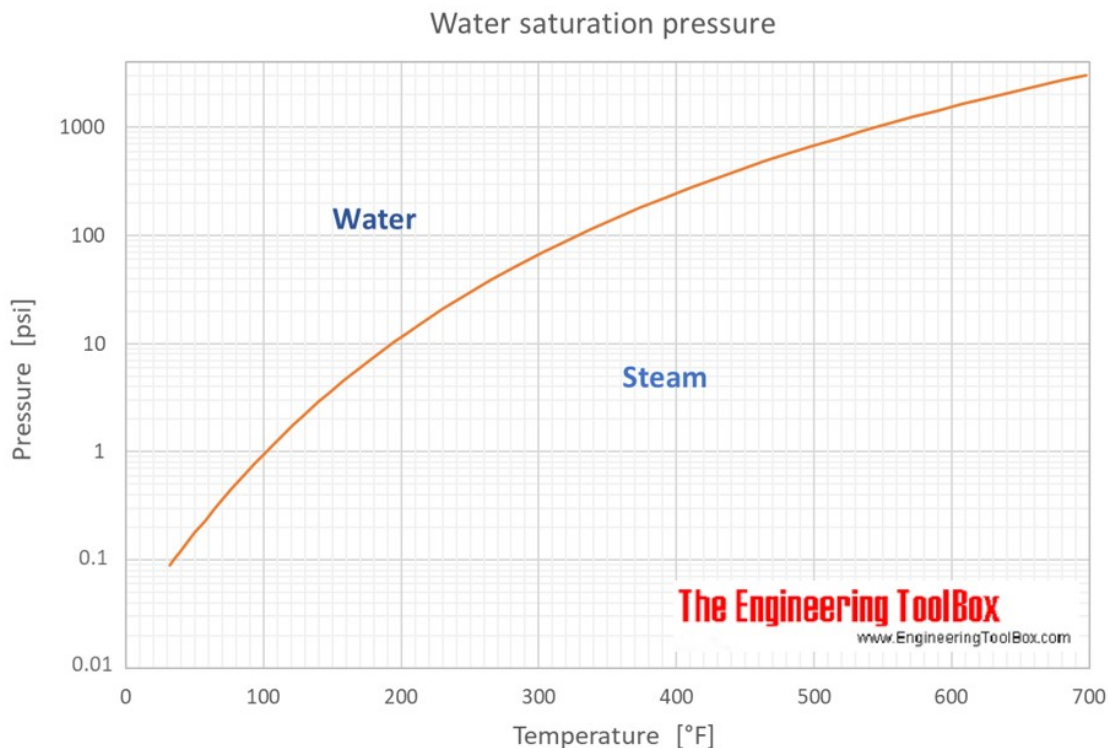


Figure 1 Steam, Temperature vs Pressure PSIA

## Pressure

The air around us is about 15psi, also known as 1 atmosphere. If we put the water in a tank and draw a vacuum, we can lower the pressure to near zero. Often, we do not measure pressure less than an atmosphere in psi. Often, we use inches. How can you measure pressure in units of length? It is based on how far you can lift mercury with a vacuum. If you can lift mercury 10 inches, it is called 10 inches of vacuum which we shorten to just saying 10 inches. Why don't we use how far you can lift water with a vacuum? It is because we can lift water about 30 feet. That requires a very long tank.

## Evaporators

### *Auxiliary Machinery Room*

The US Navy seems to use the terms Evaporator, Distiller and Desalination interchangeable. Distillation is the process boiling something, collecting the gas, and condensing it back into the liquid that you want. This ship used a three-stage distiller. The machine is labeled as evaporator. Technically evaporation is a natural process but distillation is forced by man. Next, we need to decide if we are going to heat up the water to a higher temperature than the ocean or lower the pressure below the atmosphere or perhaps something in between. Consider why we might want to do one versus the other. If we don't raise the temperature over 120°, microbes can live through the distillation process. If we raise the temperature over 140°, we get a lot of scale deposits in the machine. That puts us in a range of about 2 to 3 pounds of pressure or 24 to 26 inches of vacuum. We start with about 140-° water that we used steam to heat up and lower the pressure to 24 inches. The gas or steam is collected and cooled by warming the incoming sea water. The left-over we call brine and it is passed along to the next two stages where we get a bit more water from it. After that the brine is pumped overboard. Essex class carriers had three distillation plants with 5 evaporators that distilled about 110,000 gallons of water per day.

## Water Usage

The water is then pumped into tanks where it is stored until it is needed for hotel loads like washing clothes, making and cooking food, bathing, washing planes and the engine room.

## Deaerating Feed Tank

### *Boiler Room*

There is a tank in the engine room that feeds water to the boilers De-aerating Feed Tank. When the water level gets low in the tank, water is pumped from the storage tanks to the DFT. We will talk more about the DFT when we get to the engine room.

## Booster Pump

### *Fire Room*

The booster pumps raise the pressure of the water from about 15 psi in the DFT to about 300 psi.

## Fire Room

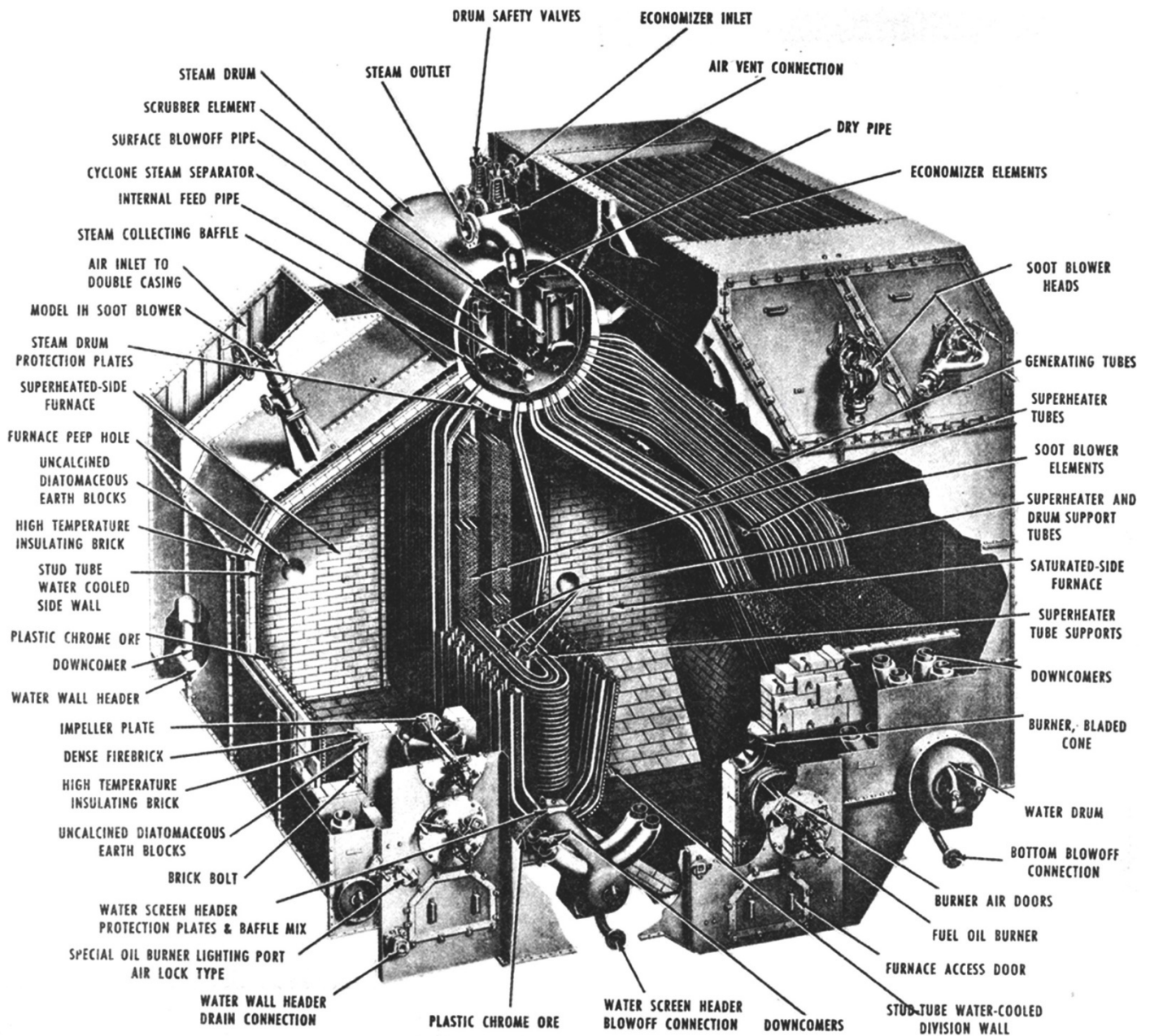


Figure 2 Babcock and Wilcox Boiler

## Boilers Upper Level

### Economizers

When the engines need water, it is pumped into the de-aerating feed tank in the engine room where it is about 270° and about 15 psi. We will see that tank later when we get to the engine room. Main Feed Booster pumps bring the water from the engine room to the boiler room raising the pressure to about 300 psi. Main Feed pumps then raise the pressure to about 650 psi where it enters the boiler via the economizer. The Economizer is a preheater for the water. This cools the exhaust gas and warms the water to about 300°. The water then flows through the downcomers to the water drum

Inside the smoke stack is a light and a periscope that is used on the lower level.

### Saturated Boiler

The water then enters the water drum in the lower part of the saturated boiler where it flows into the steam generating tubes. As the steam is produced, it rises into the steam drum. This is where moisture is removed by screens and cyclone

steam separators. Auxiliary steam is siphoned off for hotel loads like shower heaters, laundry, cooking, auxiliary pumps and evaporators.

### Super Heater

The saturated steam is then funneled into tubes for super heating in the super heater raising the steam temperature from about 600° to 850°. That steam is piped into the engine room for use in the main engines.

### Heating the Water

Bunker C oil is nearly solid at room temperature. It must be heated to 250° before it can be pumped. It enters fireroom upper level through strainers and then flowing into the fuel oil heater. Auxiliary steam heats the oil up to 400° so it can be burned.

### Boilers Lower Level

1. Light the boiler torch.
2. Place torch in burner lighting port #1.
3. Open bunker C fuel supply line to burner #1.
4. Other burners light from #1.
5. Repeat for super-heated side burners 6 through 11.
6. Check periscopes for exhaust color and adjust air flow for haze gray color.

## Engine Room

### Deaerating Feed Tank

Deaerating Feed Tank (DFT) has three purposes.

1. It is a surge tank. As the loads on the boiler and engines change, the amount of available water changes. The water level may rise or fall but averages about 3,000 gallons. The main feed booster pump cannot go dry. The men make sure that the water level stays inside the normal operating levels.
2. It removes dissolved gases from the feed water.
3. It preheats the feed water for the boilers.

Makeup feed from the water tanks and condensate from the condensers is sprayed into the top of the DFT. This water can be as cold as the surrounding ocean. The smaller the water drops are that easier it is for the dissolved gases to come out of solution. This water is sprayed into a steam blanket where it heats up to about 250°. It then gets hit with steam that spins the water through veins working to breakup the water into smaller particles. Any gases collect at the top of the DFT and are vented to atmosphere. The water then collects in the bottom of the tank to be pumped into the fireroom via the Main Feed Booster pump.

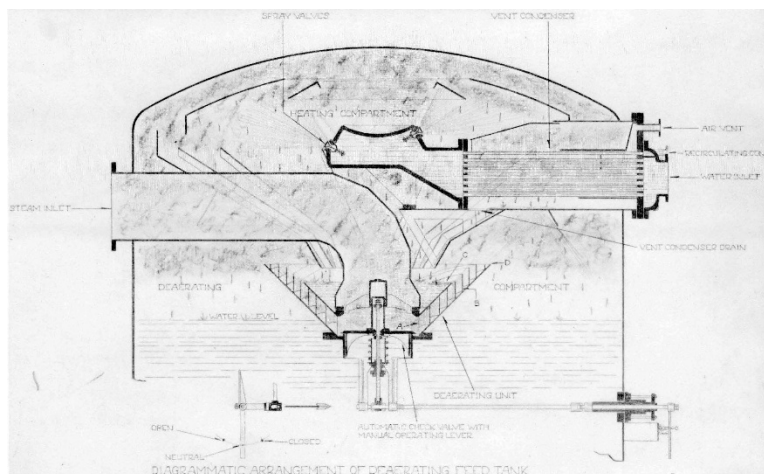


Figure 3 Deaerating Feed Tank Cutaway

## Main Steam

Main steam, 600psi at 850°, enters the engine room through Main Steam valve 11 (MS11) where it is distributed to the main engines and Ships Service Turbine Generator, SSTG.

## Temperature

Temperature is the measure of the average kinetic energy of the molecules of a substance. 600psi steam wants to be about 500°. With it being super-heated, it really wants to increase its volume. That expansion happens inside the high-pressure turbine where the kinetic steam energy is converted to kinetic mechanical energy via the turbine blades.

## Ahead Throttle

The ahead throttles are a poppet style valve. It would be very difficult to control steam flow and open a single large valve against 600psi, so the poppet valve is used. There are several smaller valves that lift in sequence making the easier to open and easier to control the amount of steam entering the High-Pressure turbine. The steam flows both forward and aft through turbine blades reducing the pressure to about 75psi and significantly dropping the temperature to about 300°.

This steam then enters the Low-Pressure turbine passing both forward and aft through the blades dropping the pressure to about 27" of vacuum and about 150°.

## Astern Throttle

The astern throttle is simpler due to not needing the speed or the delicate control. Similar to the ahead turbines, the astern turbine converts the kinetic energy of the steam molecules to mechanical kinetic energy in the turbine blades, but it does so in a single stage.

## Condenser

Both ahead and astern turbines dump their steam into the main condenser where the remaining heat is transferred to the sea water condensing the steam back into water. The condenser is maintained at 26" or more of vacuum. This condensate is then pumped into the DFT with the condensate pump where it completes the cycle.