ARI ARMATUREN
ARI ARMATUREN STEAMLINE LLP

Deaerator & Feedtank Systems

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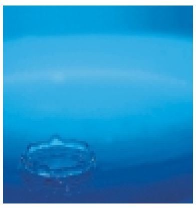

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THE STORY BEHIND 'DEAERATION'

Air is always present during equipment start-up and in the boiler feed-water. The most common source of corrosion in boiler systems is dissolved gas: oxygen, carbon dioxide and ammonia. Of these, oxygen is the most aggressive. The importance of eliminating oxygen as a source of pitting and iron deposition cannot be over-emphasized. Even small concentrations of this gas can cause serious corrosion problems.

Makeup water introduces appreciable amounts of oxygen into the system. O_2 can also enter feed water via the condensate return system. Possible return line sources are direct air-leakage on the suction side of pumps, systems under vacuum, the breathing action of closed condensate receiving tanks, open condensate tanks and leakage of non-deaerated water used for condensate pump seal and/or quench water. With all of these sources, good housekeeping is an essential part of the preventive program.

BEWARE OF OXYGEN and CARBON DIOXIDE

The feedwater used in generating steam will, of course, contain oxygen. It can also contain bicarbonate and carbonate alkalinities which, when broken down due to high temperatures, will produce C02. These two gases, O2 and CO2, alone or combined, when disolved in condensate are very corrosive.

One of the most serious aspects of oxygen corrosion is that it occurs as pitting. This type of corrosion can produce failures even though only a relatively small amount of metal has been lost and the overall corrosion rate is relatively low. The degree of oxygen attack depends on the concentration of dissolved oxygen, the pH and the temperature of the water. The presence of dissolved oxygen in feedwater causes rapid localized corrosion in boiler tubes.

Carbon dioxide will dissolve in condensate, resulting in low pH levels and the production of corrosive carbonic acid. Low pH levels in feedwater causes severe acid attack throughout the boiler system. When combined, the oxygen accelerates the corrosive effects of the acid.

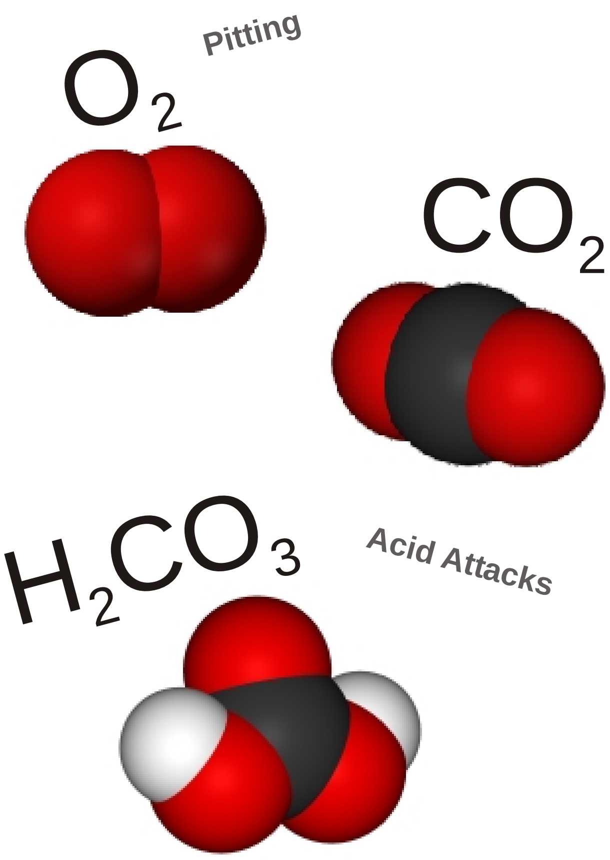
The influence of temperature on the corrosivity of dissolved oxygen is particularly important in closed heaters and economizers where the water temperature increases rapidly. Elevated temperature in itself does not cause corrosion. Small concentrations of oxygen at elevated temperatures do cause severe problems. This temperature rise provides the driving force that accelerates the reaction so that even small quantities of dissolved oxygen can cause serious corrosion.

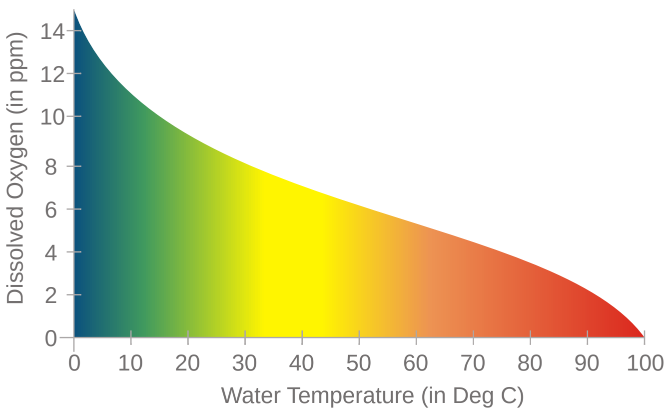
Deaerating the feedwater removes almost all of these gases. In general, as the feedwater enters the deaerator low pressure steam, typically 0.35 kg/cm2 g, is used to break up the water into a spray continuing across the spray carrying off the gases.

All modern boilers have some form of deaeration arrangement. The removal of this oxygen can be done by three ways – chemical, mechanical and thermal. In chemical removal of oxygen, an oxygen scavenger like Sodium Sulphite is dosed to the feedtank, which absorbs the oxygen. However, this is detrimental because the addition of any chemical to the boiler water increases its TDS, again causing problems. In mechanical de-aeration, water is stirred or sprayed, causing removal of oxygen from the feed water.

Thermal de-aeration uses the property of water shown in the graph on the right.

As seen, the amount of dissolved oxygen in water is proportional to its temperature. So if we can heat the make-up water before it enters the feedtank, it will liberate the oxygen, thus preventing corrosion of the tank. Further, if the system used to preheat the make-up is made of Stainless Steel, corrosion will be negligible.





Graphical representation - Thermal de-aeration

WHAT IS DEAERATION?

It is essential to remove the dissolved gases – "deaerate" – before it can be released in the boiler or the feedtank, to prevent corrosion of the tank, the boiler and the steam system. While dissolved gases and low pH levels in the feedwater can be controlled or removed by the addition of chemicals, it is more economical and thermally efficient to remove these gases mechanically. This mechanical process is known as de-aeration and will increase the life of a steam system dramatically.

HOW IS DE-AERATION DONE?

Deaeration is based on two scientific principles. The first principle can be described by Henry's Law. Henry's Law asserts that gas solubility in a solution decreases as the gas partial pressure above the solution decreases. The second scientific principle that governs deaeration is the relationship between gas solubility and temperature.

Easily explained, gas solubility in a solution decreases as the temperature of the solution rises and approaches saturation temperature. A Deaerator utilizes both of these natural processes to remove dissolved oxygen, carbon dioxide, and other non-condensable gases from boiler feedwater. The feedwater is sprayed in thin films into a steam atmosphere allowing it to become quickly heated to saturation. Spraying feedwater in thin films increases the surface area of the liquid in contact with the steam, which, in turn, provides more rapid oxygen removal and lower gas concentrations. This process reduces the solubility of all dissolved gases and removes it from the feedwater. The liberated gases are then automatically vented from the Deaerator, without allowing steam to escape to the atmosphere.

With these principles in mind, Steamline employs a two-stage system of heating and deaerating feedwater. This system reduces dissolved oxygen concentration to less than 0.005 cc/liter (7 ppb), and completely eliminates the dissolved gas concentration.

HEATING FEEDWATER

Cold make-up water and returned Condensate usually mix in the feedtank. Conventionally, both make-up water and condensate are fed to the feedtank above the water surface.

We heat feedwater because of three reasons.

- Cold feed will result in thermal shock to the boiler. When we feed at optimum temperatures the life of boiler is also prolonged.

- When feedwater is at the highest temperature for injection to the boiler, the boiler efficiency increases drastically. Return of condensate further boosts efficiency.

- All water sources have a certain amount of dissolved gases mixed in them at ambient temperature. Cold water absorbs free oxygen and other gases. As the condensate heats the make-up water, the temperature of the make-up water rises. At high temperatures undesirable gases have minimum solubility and are liberated when heated.

WHAT IS THE JOB OF A DEAERATOR?

Deaerators remove oxygen, carbon dioxide and other noncondensable gases from feed water. Oxygen and carbon dioxide are very harmful to boiler systems. Deaerators are designed to remove dissolved gases from boiler feedwater. They are effective and oxygen can be reduced to trace levels, about 0.005 ppm.

Along with temperature control systems, an effective deaeration system can heat the incoming cold makeup water and mix it with available return condensate.

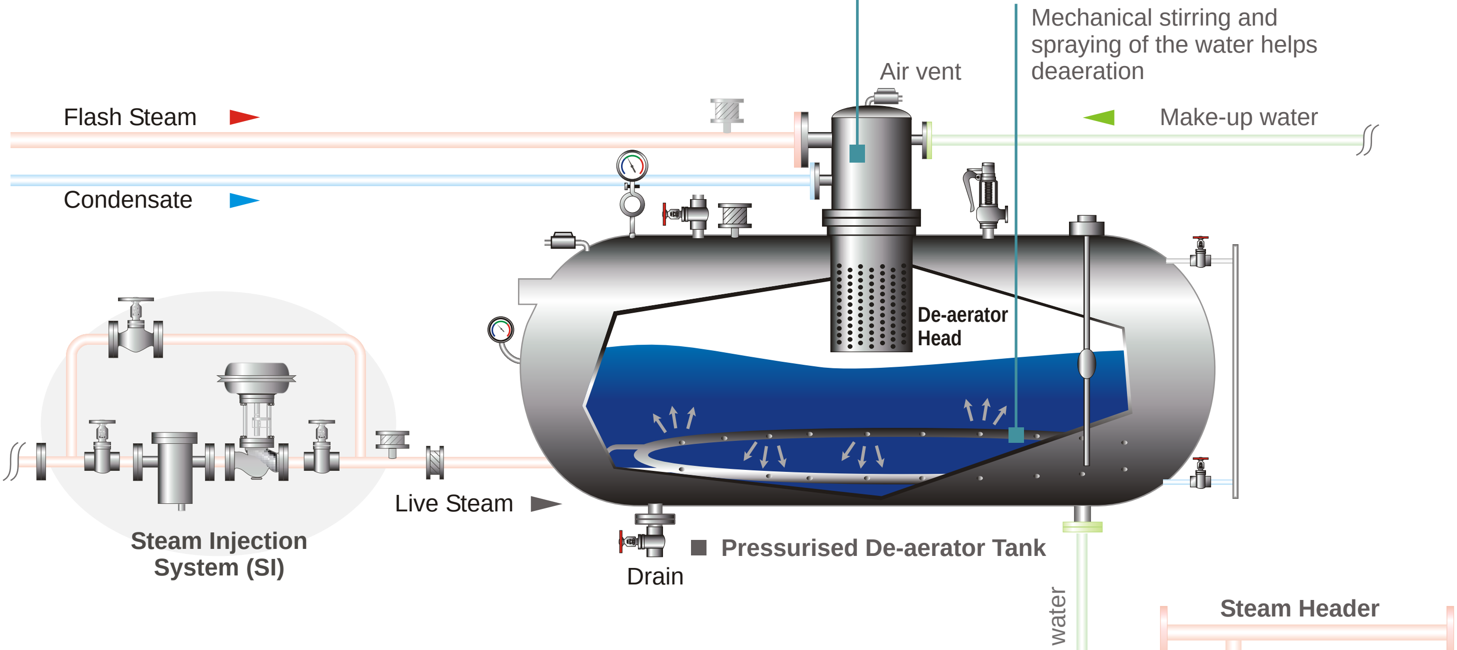
Pic. Pressurized ARI Steamline Deaerator at Fresenius Kabi, Ranjangaon

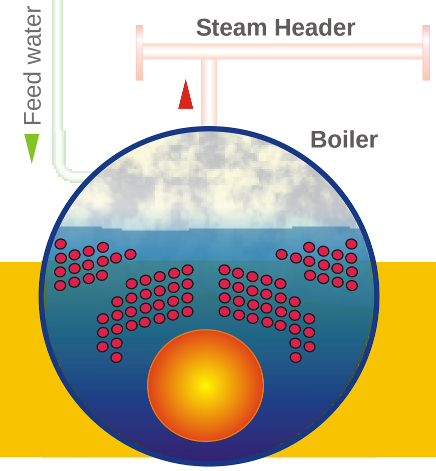
ARI STEAMLINE DEAERATORS – HOW DO THEY WORK?

On larger boiler plants, pressurised de-aerators like the one shown above are installed. Live steam is used to bring feed water temp above 100ºC to "drive off" the oxygen content. This action is normally enhanced by the steam "scrubbing" the feedwater. The make-up water enters the deaerator and is broken into a spray or mist, and scrubbed with steam to force out the dissolved gases. At the elevated temperature the solubility of oxygen is extremely low. Steam and other non-condensibles flow upwards into the vent condensing section where the steam is condensed. Freed oxygen and other gases are vented to the atmosphere through the vent outlet.

This type of deaerator usually consists of a heating and a deaerating section. The storage section of these units typically have a residual deaerated feedwater storage tank often designed to hold about 10 mins of rated capacity of boiler fedwater.

Deaerators are typically elevated in boiler rooms to help create head pressure on pumps located lower. This allows hotter water to be pumped without vapor locking should some steam get into the pump.





- We make completely packaged Feedwater Deaerators and guarantee low levels of dissolved oxygen.
- ARI Steamline Deaerators use a combination of mechanical and thermal de-aeration.
- The ARI Steamline Flash Condensing Deaerator Head has an all SS assembly and is fitted to the top of the FWT with inlets for condensate, make-up water and flash steam.
- For smaller plants, our Deaerator Head can be retrofitted to any existing feedtank.
- Flash or live steam heats the water to liberate oxygen via a Steam Injection System (SI).
- Purpose designed for complete deaeration of make up water.
- Three stage deaeration in a common vessel – no recycling pumps required
- Conforms to BS 5500 standard for pressure vessel design
- Assured quality of materials and fabrication to meet safety requirements
- Exceeds ASME recommendations for oxygen level – below 7 PPB (0.005 PPM)
- Completely eliminates titratable free carbon dioxide
- Stainless Steel Deaeration Assembly
- Stainless Steel Steam Injection Sparger
- Auto Vent Valve completely eliminates gases at start up
- The Deaerator has a residual deaerated feedwater storage tank which holds minimum 10 mins of rated capacity of boiler feedwater.
- One year warranty for complete system including controls

FEATURES OF
ARI STEAMLINE
DEAERATORS & FEEDTANK SYSTEMS

- Integral Level Control automatically introduces make up water to supplement condensate only when necessary to meet boiler demand
- Integral Temp. Control system doses steam only as required to maintain the correct temperature without steam wastage
- Optional on-line TDS monitoring for effective TDS level of feed water
- Completely Packaged units for cost effective installation
- Supplied with Data Dossier – Material Testing

As seen, larger plants have pressurised de-aerators installed. However, these are pressure vessels and are therefore expensive.

Accordingly, the Deaerator Head was developed – a compromise for retro-fitting to any feedtank, to drive off as much oxygen as possible at atmospheric pressure.

DEAERATOR HEADS

ARI Steamline Deaerator heads offer the perfect solution for completely condensing flash steam generated in condensate return systems at the feedtank. This all SS assembly is fitted to the top of the feedtank, and has inlets for condensate, make-up water and flash steam.

The ARI Steamline De-aerator Head uses a combination of thermal de-aeration and mechanical de-aeration. It has three restrictions to the flow – a nozzle in the make-up line, a baffle plate between the mixing head and the immersion tube, and a sparger in the immersion tube. Therefore it ensures that the oxygen in the make-up water is driven off by using the heat in the condensate which it is mixed with, and all the dissolved gases are released in the De-aerator Head before it enters the feed tank and the boiler. These are vented out by the automatic Air Vent on top of the De-aerator Head.

In addition, sometimes Flash Steam is generated from high pressure Condensate. This flash steam will escape to the atmosphere and the heat will be lost. A third inlet is sometimes provided in a De-aerator Head to mix flash steam with make-up water, thus condensing the flash steam and saving its heat. This type of unit is called the Flash Condensing De-aerator Head.

PAYBACK CALCULATION

Now it is seen that the quantity of flash steam generated is very small, since the condensate pressure was not 6 barg as originally assumed but only 0.5 barg. However, even water as 0.5 barg will flash to the extent of about 2 –3 % of the condensate by mass. Once the flash vessel has been removed, this flash steam will appear at the receiver of the pump, as well as the condensate inlet to the tank. This may seem negligible, but as the condensate is pumped to the feed tank under pressure (from the pump), the flash steam will be released more vigorously at the entry to the tank.
Even the loss of 1% flash steam can be quantified as under:

Qty of condensate = 3000 kg/hr
So flash steam = 0.01 X 3000 = 30 kg/hr
Cost of the heat in this steam = (350 X 24 X 30 X 540 X 10) / (10200 X 0.88 X 0.9)
= Rs. 1,68,450 per year

Further, if a thermo-mechanical deaerator head is not used, the oxygen in the feedwater will need to be controlled by dosing an oxygen scavenger, which could cost up to Rs. 50,000 per year.

ARI Steamline De-aerators are fitted with all SS Deaerator Head – one or more depending on the capacity. This uses a combination of thermal de-aeration and mechanical de-aeration.

■ **Deaerator Head**

Pic. An ARI Steamline flash condensing Deaerator Head has an all SS assembly and is fitted to the top of the feedtank with inlets for condensate, make-up water and flash steam

Deaerator & Feedtank Systems

Reference list

Sr. No.	Client	Year Of Supply	Deaerator Tank Details
1	Fresenius Kabi India Pvt. Ltd.	2003 - 04	Capacity : 6KL Op. Pressure: 0.2 to 2 Kg/cm2g
2	Thermax Ltd.,C & H Division, Chinchwad, Pune	2002	Capacity : 8KL Op. Pressure: 0.5 Kg/cm2g
		2004	Capacity : 10KL Op. Pressure: 0.5 – 1 Kg/cm2g
		2006	Capacity : 5KL Op. Pressure: 0.5 Kg/cm2g
3	Dynamix Dairy Industries Ltd, Baramati	2003 - 04	Capacity : 30KL Op. Pressure: 0.5 to 3 Kg/cm2g
4	Intervet India Pvt Ltd, Pune	2004	Capacity : 5KL Design. Pressure: 3.5 Kg/cm2g
5	IIT Mumbai, Mumbai	2008	Capacity : 8KL Op. Pressure: 0.2 Kg/cm2g
6	Precision Controls, Pune	2009	Capacity : 5KL Op. Pressure: 0.2 Kg/cm2g
		2010	Capacity : 7KL Op. Pressure: 0.4 Kg/cm2g
7	Sajjan India Ltd, Ankleshwar	2010	Capacity : 20KL Op. Pressure: 0.3 Kg/cm2g
8	A2Z Infrastructure (P) Ltd, Gurgaon	2010	Capacity : 25KL Op. Pressure: 5.3 Kg/cm2g
9	Orchid Chemicals & Pharmaceuticals Ltd, Thiruporur, Tamilnadu	2010	Capacity : 25KL Op. Pressure: 0.45 Kg/cm2g

Note: We have also supplied many Deaerator heads for retrofitting to an existing feedtank to various industries and OEMs alike.

ARI Armaturen Steamline LLP TM • Survey No. 32/3/14, Kondhwa Budruk, Pune 411048 India
Phone: + 91 20 2693 2213 • Fax: + 91 20 2963 2214 • Email: sales@ari-steamline.com • Web: www.ari-steamline.com
ARI-Armaturen Albert Richter GmbH & Co. KG • Mergelheide 56-60 D-33758 Schloß Holte-Stukenbrock, Germany