York - Shipley Global
Division of AESYS Technologies, LLC

WHY DEAERATE?

WHY INSTALL A DEAERATOR?

Deaeration of boiler feedwater is almost universally practiced. There are very strong reasons for doing so. Water fed to boilers consists of raw make-up water and condensate returns, most commonly a mixture of the two. Both contain oxygen and carbon dioxide in solution in varying amounts. These gases, particularly at the elevated temperatures encountered in modern boilers, greatly accelerate the rate of corrosion of the steel surfaces within the boiler, as well as piping and other plant apparatus in contact with the condensing steam.

While oxygen and carbon dioxide could be removed by the addition of scavenging chemicals to the feedwater alone, this practice is extremely costly in all but the smallest plants. Generally speaking, plants generating in excess of 10,000 lb/hr. of steam can justify the installation of a deaerator. If the percentage of make-up to the system is above 50% and/or the $C0_2$ content or alkalinity of the feedwater is high ($C0_2$ + HCO_3 exceeding 100 ppm.) the use of a deaerator will result in worthwhile savings even below 10,000 lb/hr. boiler capacity.

Although deaerators are capable of reducing oxygen and carbon dioxide to very low levels, they should not be considered as a substitute for proper internal boiler feedwater treatment. They are not an alternative to proper softening and dealkalization of the make-up feedwater. They will, however, greatly reduce the amount of "scavenging chemicals" which must be fed to maintain proper residuals with the boiler.

DEAERATOR VS. DEAERATING HEATER

The rating and performance standards from the latest edition of "Standard and Specifications of Deaerators" published by the Heat Exchange Institute defines a "deaerator" as a unit capable of removing from the water all dissolved oxygen in excess of .005 cc/liter (7 parts per billion) at all loads up to and including the rated capacity. The generally accepted definition of a "Deaerating Heater" is a unit which can reduce the oxygen content down to 03 cc/liter (44 parts per billion).

A DEAERATOR IS SIX TIMES AS EFFECTIVE AS A "DEAERATING HEATER".

.005 cc/liter equals 7 parts per billion.
.03 cc/liter equals 44 parts per billion.

The selection of a "Deaerator" over a "Deaerating Heater" can be confusing due to the various lines of distinction that can be drawn between the economy of a "Deaerating Heater" versus the efficiency of a Deaerator. A "Deaerating Heater" is approximately 10 to 25% less expensive than a Deaerator; however, a Deaerator is SIX (6) times more effective than a "Deaerating Heater".

Some individuals feel that a "Deaerating Heater" is sufficient for low pressure small boiler applications. Whenever possible, a Deaerator should be used rather than a "Deaerating Heater" to gain the full effectiveness of deaeration.

A DEAERATOR WILL ACCOMPLISH THE FOLLOWING:

A. Oxygen Removal is the primary reason for deaerating water and is the first thing most individuals think about when they begin to consider the application or need for a Deaerator. Oxygen in feedwater will cause the following problems and this is why oxygen must be removed.

1. Oxygen is extremely corrosive to boilers. We are all well aware of how corrosive oxygen in water is to an iron pail, or any other iron container at natural temperatures. When heat is added to water, dissolved oxygen becomes even more corrosive. The maximum safe figure for most boilers is approximately .005 cc/liter (7 parts per billion).

2. As steam condenses, any oxygen that is carried over with the steam will be highly corrosive to the condensate lines and the process equipment. Carbon Dioxide may also be present in the steam and condensate. Carbon Dioxide is corrosive when it condenses and combines with water, but when oxygen is also present, the condensate becomes approximately four times more corrosive than when only oxygen, or only carbon dioxide is present by itself. In order to protect the process equipment and condensate lines the oxygen must be removed.

3. Where there is condensate being returned to the boiler, the condensate should be deaerated for removal of all oxygen that may have been drawn into the system or into the condensate receiver. If condensate is not deaerated a recycling of oxygen and carbon dioxide may occur in the system.

B. Carbon Dioxide Removal

Most raw waters contain free carbon dioxide which is very corrosive when combined with water to form carbonic acid. Carbon dioxide in its free state requires all of the mechanical requirements of good deaeration for removal. In steam, carbon dioxide is not corrosive, but when the steam condenses, the carbon dioxide combines with water and forms very corrosive carbonic acid, which will dissolve return lines and process equipment rapidly. Of course, carbon dioxide alone is not as dangerous as it is when there is a small amount of oxygen present in the system, but it should be removed when possible. When combined with dissolved oxygen, carbon dioxide is considerably more corrosive.

There is an additional problem with carbon dioxide that exists in every boiler application. All raw waters contain bicarbonates and carbonates. When these elements break down, carbon dioxide is released. The bicarbonates are broken down as the temperature increases. The deaerator will break down some of the bicarbonates and when this is done, the bicarbonates produce carbonates and free carbon dioxide. Carbon dioxide that is released through the process of deaeration will be removed from the system.

All of the carbon dioxide cannot be removed since it is united chemically with the carbonates (and bicarbonates) in the water. When a boiler is treated with phosphates, all of the carbonates combine with phosphates (provided enough are present) and this chemical reaction releases the carbon dioxide tied up in the carbonates. This carbon dioxide is produced in the boiler and then carries over with the steam. A deaerator cannot remove this portion of the carbon dioxide from the water since it is chemically united in the carbonates.

When condensate return systems are involved, it is most important that all of the condensate be deaerated to remove all of the free carbon dioxide created in the boiler and carried through the system. If the condensate is not deaerated, then the carbon dioxide will recycle in the system, increasing the carbonic acid concentrations of the condensate to very corrosive and dangerous levels. Venting the condensate will not in itself remove the carbon dioxide without all the requirements of good deaeration because it is combined with the water as carbonic acid.

C. Raise the Temperature of the Feedwater.

A deaerator raises the feedwater temperature and while removing the free oxygen and carbon dioxide, as well as breaking down bicarbonates to carbonates and free carbon dioxide which is readily removed, a deaerator also benefits the system in other ways because of the increase in the feed-water temperature. The addition of hot feedwater greatly reduces the chances of thermal shock caused by expansion and contraction of heating surfaces.

This is greatly aggravated in boilers which have on and off control because of the large volume of feedwater addition over normal steaming rate. For example, a boiler may be rated at 500 horsepower with a feedwater requirement of 35 gallons per minute at high load. The pump is sized from 1-l/3 to 2 times the boiler requirement. At low fire, water is added at the rate of up to 70 gallons per minute, whereas the boiler may only require 10 gallons per minute or less. Thermal contraction is caused by cooling of the heating surfaces. Also, the large volume of cold water will collapse steam bubbles, causing unstable water level and fluctuating firing rates. The fluctuating firing rate aggravates the water level and vice versa, causing an uncontrolled water level and inefficient operation. The more stability you can build into the boiler's operation, the more economical the whole operation will be.

Because of the problems created by on-off control, many engineers are now specifying boilers with modulating feedwater and firing controls for the economy of the operation.

Achieving an economical operation without using heated water is like a driver trying to average 50 miles per hour by fluctuating between 40 miles per hour and 60 miles per hour. Efficiency is reduced considerably. Even water that is 140°F. is cold in relation to a boiler operating at 100 PSIG at 338° F.

D. Improve Heat Transfer

Air or non-condensable gases in steam cause losses as high as four times in thermal efficiency. Air or non-condensable gases in steam cause a thermal blanket which reduces the heat transfer across the tube wall. It is a well recognized fact that steam that is high in non-condensable gases retards heat transfer because it acts as an insulating blanket. The gases (primarily oxygen and carbon dioxide) that cause this decrease in heat transfer are removed when proper deaeration is employed.

E. Utilize Low Pressure Exhaust and Flash Steam

By employing this steam to heat the boiler feedwater, two significant advantages are gained: (1) The heat in the steam is reclaimed, directly reducing fuel costs for steam generation and (2) The condensed steam reduces the quantity of make-up water required, thus resulting in a savings in water and external treatment costs. In this connection continuous blow-down equipment is often employed in conjunction with a deaerator. Depending on the boiler pressure and the quantity of blowdown, this may involve flash tanks to deliver flash steam from the blowdown to the deaerator and/or heat exchangers to transfer blow-down heat directly to the heater make-up water.

F. Common Collection Point

A deaerator provides a very convenient collection point for both high and low temperature condensate returns. In the case of the former, considerable heat is returned directly to the feedwater in many plants. The deaerator also provides a supply of water for the boiler feed pumps which allows the plant to function smoothly during changes in load or other upsets, thus protecting the boilers from loss of essential feedwater.

G. Economizing of Overall Operation

1. Return line corrosion and process equipment corrosion is prevented by the reduction and removal of oxygen and carbon dioxide.

2. Oxygen pitting in the boiler is eliminated when a .005 cc/liter (7 parts per billion) type deaerator is employed.

3. Thermal shock, boiler maintenance, and utility costs are reduced substantially.

4. There will be a substantial reduction in the chemical treatment costs when a deaerator is employed. Oxygen scavengers such as sodium sulfite and hydrazine, and filming and neutralizing amine usage will be reduced.

5. A savings in heat can be recovered from high pressure flash steam on trapped systems when taken to the deaerator.

PRINCIPLES OF GOOD DEAERATION

The function of the Atomizing Deaerator is to remove dissolved oxygen and other gases from boiler feedwater thus preventing corrosion in piping, economizers, boilers, and delivers the deaerated water at saturated steam temperature. Deaeration is achieved through surface exposure and scouring action by steam agitation as the water descends in thin films. The released gases are vented to the atmosphere.

The basic factors in all deaerating processes are time, liquid exposure surface and gas concentration in both the water being deaerated and the vapors by which the deaeration is being accomplished.

To remove non-condensable gases from solution in water - deaeration - the temperature is raised to the boiling point. Solubility of the gas depends upon the temperature of the water and the partial pressure of the gas in contact with it.

When the temperature of the water is actually at boiling point for the pressure, the solubility of the gases is zero.

Merely rendering the gases insoluble by heating to the boiling point does not of itself eliminate molecules and bubbles of gases in the mass of the water. In order to escape from the mass of water, gas molecules must diffuse through the surface films surrounding the particles of water. Spraying atomization and the vigorous contact of water and steam and the maintenance of a pure steam atmosphere by venting causes rapid diffusion and elimination of the gas.

HOW TO ACHIEVE GOOD DEAERATION

The Atomizing Deaerator comprises the following essential parts:

1. Spray Distribution, which heats the water by spraying it into the steam atmosphere of the heating compartment. There are one or more Spray Distributors, depending on the capacity of the unit.

2. Vent Condenser, which concentrates the vapors in the primary heating stage and ejects the non-condensable gases. The Vent Condenser is a Direct Contact Vent Condenser.

3. Storage Compartment, which receives the deaerated water and holds a reserve supply ready for feeding to the boiler.
4. Accessories, for regulating the inlet and overflow water, protection of the unit, and means to check the operation.

Atomizing Deaerator section and storage tank are mounted horizontally within a single shell.

In the Atomizing type deaerator, water is first sprayed through steam, and heated to within a few degrees of steam temperature. In this primary heating stage, 90% to 95% of the oxygen originally in solution is removed from the water being heated. The water is then passed to the atomizing section where a high velocity jet of incoming steam forcibly breaks up, or atomizes, the water into minute particles. The atomized water presents a tremendous amount of surface exposure to the violent scrubbing action of the high velocity steam and accomplishes the complete removal of dissolved gases. The deaerated water passes from the atomizing section to the storage tank, and the steam flows counter-currently from the deaerating section to the pre-heating section.

The steam jet atomizing valve is spring loaded and adjustable. It maintains a substantially constant pressure differential on the steam supply, regardless of the load at which the deaerator is operated and regardless of the temperature at which water is received by the deaerator.

Under variable load conditions with substantially constant water inlet temperature, the spring-loaded, steam jet atomizing valve maintains continuous high velocity and uniform energy application to the deaerating process.

The spring loading on the atomizing valve is adjusted to the exact requirements of the particular installation operation conditions.

All steam used to heat the incoming water and substantially all the steam used in both the heating and deaerating processes pass through the deaerating stage and provide a volume of scrubbing vapors 100 to 150 times the volume of the water being deaerated.

ARE CHEMICALS OR OXYGEN SCAVENGERS REQUIRED WITH A DEAERATOR?

Unless a deaerator is employed, chemical treatment must be used. Oxygen scavengers are used to remove oxygen, and return line treatments are used to protect against oxygen and carbon dioxide carried over with the steam. Oxygen scavengers must also be used to remove the last traces of oxygen when an .03 type deaerator is employed. This becomes very expensive and great care must be taken that a residual of oxygen scavengers is always in the system to cover the various loads of fluctuations and changes in the feedwater make up. These residuals are wasted through boiler blowdown.

Chemical treatment alone is very expensive, since enough treatment must be added to reduce the oxygen to zero. If good deaeration is not employed, chemical treatment can still be costly.

Are oxygen scavengers required even with .005 cc/liter deaerators? Engineers and competent personnel in charge of boiler operations most frequently use oxygen scavengers in boilers regardless of the type of deaerator employed. Powerhouse and sea going vessels, which use almost distilled water, still employ the use of oxygen scavengers for a final "polishing" to remove oxygen to 0.00000 cc/liter. The use of oxygen scavengers, particularly in industrial plants is useful in indicating any problems in the system. A valve leakage or any other inoperative function of the deaerator will be immediately evident by an increase in the amount of oxygen scavengers required