Deaerators in Industrial Steam Systems

Deaerators are mechanical devices that remove dissolved gases from boiler feedwater. Deaeration protects the steam system from the effects of corrosive gases. It accomplishes this by reducing the concentration of dissolved oxygen and carbon dioxide to a level where corrosion is minimized. A dissolved oxygen level of 5 parts per billion (ppb) or lower is needed to prevent corrosion in most high-pressure (>200 pounds per square inch) boilers. While oxygen concentrations of up to 43 ppb may be tolerated in low-pressure boilers, equipment life is extended at little or no cost by limiting the oxygen concentration to 5 ppb. Dissolved carbon dioxide is essentially completely removed by the deaerator.

How They Work

The design of an effective deaeration system depends upon the amount of gases to be removed and the final oxygen gas concentration desired. This in turn depends upon the ratio of boiler feedwater makeup to returned condensate and the operating pressure of the deaerator.

Deaerators use steam to heat the water to the full saturation temperature corresponding to the steam pressure in the deaerator and to scrub out and carry away dissolved gases. Steam flow may be parallel, cross, or counter to the water flow. The deaerator consists of a deaeration section, a storage tank, and a vent. In the deaeration section, steam bubbles through the water, both heating and agitating it. Steam is cooled by incoming water and condensed at the vent condenser. Non-condensable gases and some steam are released through the vent.

Steam provided to the deaerator provides physical stripping action and heats the mixture of returned condensate and boiler feedwater makeup to saturation temperature. Most of the steam will condense, but a small fraction (usually 5% to 14%) must be vented to accommodate the stripping requirements. Normal design practice is to calculate the steam required for heating and then make sure that the flow is sufficient for stripping as well. If the condensate return rate is high (>80%) and the condensate pressure is high in comparison to the deaerator pressure, then very little steam is needed for heating and provisions may be made for condensing the surplus flash steam.

Deaerator Steam Consumption

The deaerator steam consumption is equal to the steam required to heat incoming water to its saturation temperature, plus the amount vented with the noncondensable gases, less any flashed steam from hot condensate or steam losses through failed traps. The heat balance calculation is made with the incoming water at its lowest expected temperature. The vent rate is a function of deaerator type, size (rated feedwater capacity), and the amount of makeup water. The operating vent rate is at its maximum with the introduction of cold, oxygen-rich makeup water.

Suggested Actions

- Deaerator steam requirements should be reexamined following the retrofit of steam distribution system, condensate return, or heat recovery energy conservation measures.
- Install continuous dissolved oxygen monitoring devices to aid in identifying operating practices that result in poor oxygen removal.

Resources

U.S. Department of Energy—DOE's software, the *Steam System Assessment Tool* and *Steam System Scoping Tool,* can help you evaluate and identify steam system improvements. In addition, refer to *Improving Steam System Performance: A Sourcebook for Industry* for more information on steam system efficiency opportunities.

Visit the BestPractices Web site at www.eere.energy.gov/industry/bestpractices to access these and many other industrial efficiency resources and information on training.

Additional Benefits

Deaerators provide the water storage capacity and the net positive suction head necessary at the boiler feed pump inlet. Returned condensate is mixed with makeup water within the deaerator. Operating temperatures range from 215° to more than 350°F, which reduces the thermal shock on downstream preheating equipment and the boiler.

Insulation

The deaerator section and storage tank and all piping conveying hot water or steam should be adequately insulated to prevent the condensation of steam and loss of heat.

Function Clarification

The deaerator is designed to remove oxygen that is dissolved in the entering water, not entrained air. Sources of "free air" include loose piping connections on the suction side of pumps and improper pump packing.

Pressure Fluctuations

Sudden increases in free or "flash" steam can cause a spike in deaerator vessel pressure, resulting in re-oxygenation of the feedwater. A dedicated pressure-regulating valve should be provided to maintain the deaerator at a constant pressure.

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DOE/GO-102006-2263
January 2006
Steam Tip Sheet #18

Revised from DOE/GO-102000-1118 • December 2000