Bullard Industrial Technologies, Inc.

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THE DEAERATING FEEDWATER HEATER

The deaerating feedwater heater is one of the most important components of the steam generation cycle in a boiler plant. Besides heating the feedwater, it also liberates and removes the non-condensable gases (primarily Oxygen and Carbon Dioxide) present in the water. These gases would cause pitting and corrosion if allowed to enter the boiler with the feedwater. A good quality deaerator should be constructed to conform to the requirements of the “Deaerator Standard” from the Heat Exchange Institute (HEI). HEI is acknowledged worldwide as the leading standards development organization for heat exchange and vacuum apparatus.

By understanding how the deaerator works and knowing what to check regarding its operation, the owner can very easily monitor the deaerator’s efficiency and react accordingly when operating conditions go awry.

The feedwater heater is an ASME Code pressure vessel where condensate and soft make-up water enter the top of the shell and are distributed through spray nozzles traveling downward through a series of distribution trays. The combination of the action of the spray nozzles and the water cascading through the very small openings in the distribution trays breaks the water down into minute droplets. As low pressure steam introduced at the bottom of the vessel flows upward through the spray water the water and the steam come into direct contact with each other. This direct contact of water and steam serves two purposes:

1) The water absorbs heat from the steam, thus raising its temperature

2) The hot steam drives off corrosive gases (Oxygen and Carbon Dioxide) entrained in the water, removing them through an atmospheric vent at the top of the heater shell. The water leaving the open heater will attain the same temperature as the steam entering it, due to the direct contact of each. The low pressure steam is usually steam turbine exhaust or extraction steam with live steam through a pressure reducing valve available should there not be a sufficient supply of exhaust steam.

DEAERATION

The term “deaeration” as applied to feedwater heaters is defined as the ability to heat boiler feedwater to a sufficient temperature to remove all non-condensible gases from the water. Deaeration begins when the water reaches a temperature of 180 degrees F. Complete deaeration is not achieved until the water temperature reaches @225 degrees F. To assure maximum deaeration feedwater temperature must be maintained at a temperature above 225 degrees, F. This is accomplished by controlling the temperature of the low pressure steam supplied to the deaerator. The following table illustrates the temperatures of various temperatures of low pressure steam:

1 psig = 215.4 degrees F	6 psig = 230 degrees F	11 psig = 241.6 degrees F
2 psig = 218.5	7 psig = 232.4	12 psig = 243.7
3 psig = 221.5	8 psig = 234.8	13 psig = 245.8
4 psig = 224.5	9 psig = 237.1	14 psig = 247.9
5 psig = 227.4	10 psig = 239.4	15 psig = 249.8

Based on the data in the table above, a deaerator must be supplied with steam at a pressure of no less than 5 psig just to be border-line in achieving maximum deaeration of the feedwater.

Sufficient pressure must be maintained on the deaerator at all times to prevent the water in the heater from flashing into steam at pressures above 0 psig and temperatures above 212 degrees F. Pressure is maintained on the deaerating feedwater heater by restricting the escape of steam through the atmospheric vent to allow a build-up of pressure within the vessel. By maintaining this back pressure on the heater, the water temperature can be carried as high as 250 degrees F, depending upon the pressure maintained on the heater, thus securing complete deaeration of the water.

OPERATIONAL ANALYSIS OF THE DEAERATOR'S PERFORMANCE

Since a deaerator both heats the water and removes corrosive gases, these are the only two characteristics of the unit that need to be considered when evaluating its performance. Both can be easily accomplished. By comparing the temperature of the water in the feedwater storage section (See Fig. 1 Item "I") of the deaerator and referring to the above table of steam pressures and related temperatures a deaerator's heating efficiency can be easily and quickly determined. Due to the direct contact of the steam and water, the temperature (See. Fig. 1 Item "Q") of the water in the feedwater storage section of the heater must correspond exactly to the temperature indicated for the steam pressure supplied to the deaerator's de-gasifying or deaerator section (See Fig. 1 Item "A").

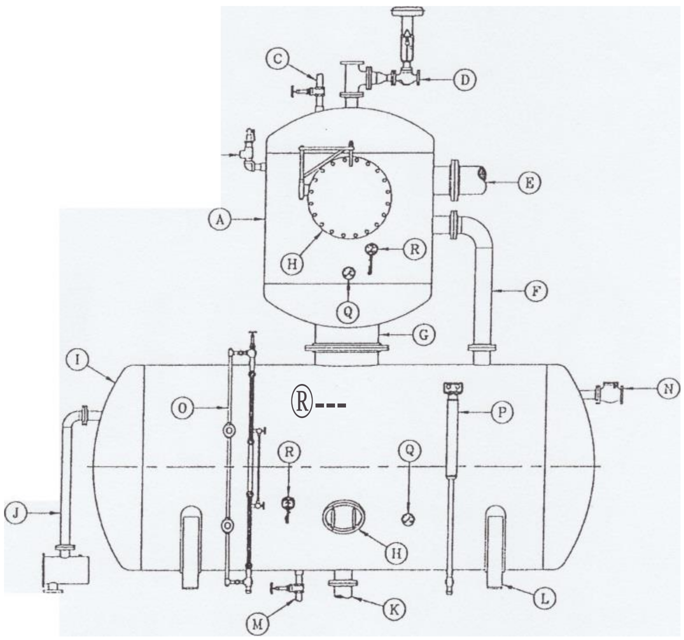
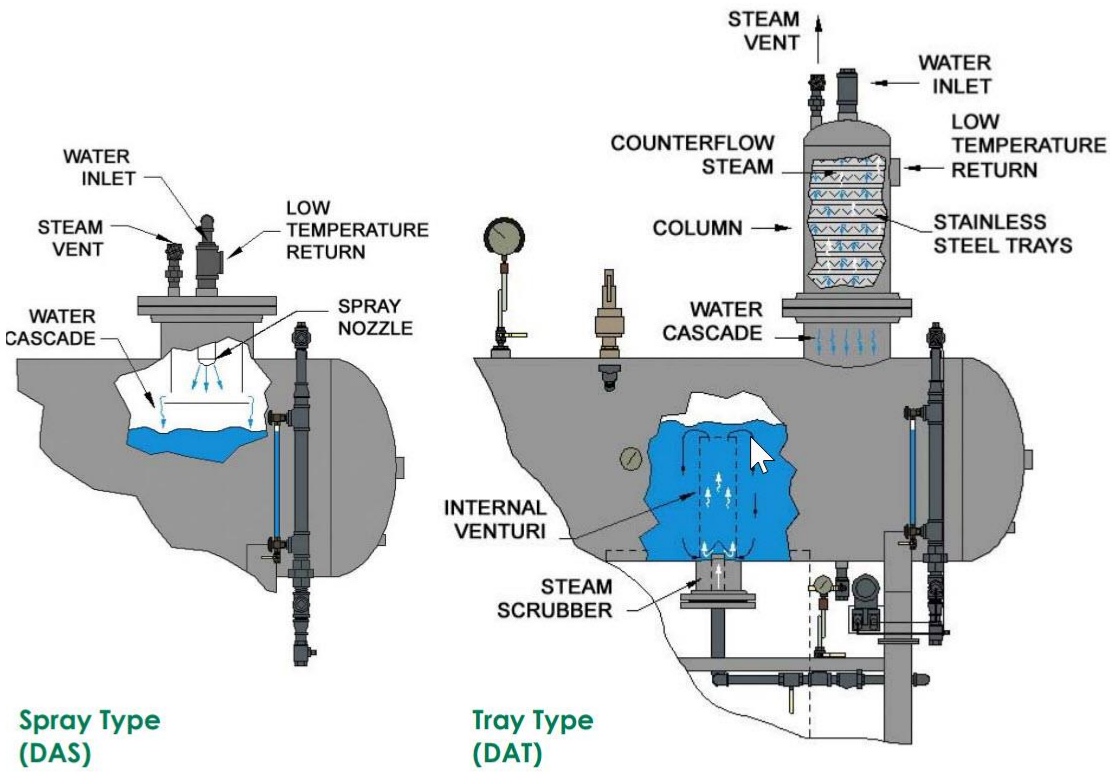


Fig. 1

A. Degasifying section
B. Safety relief valve
C. Atmospheric vent
D. Inlet
E. Steam inlet
F. Equalizer
G. Downcomer
H. Access manway
I. Feedwater storage section
J. Overflow
K. Outlet
L. Support saddle
M. Drain
N. Vacuum breaker
O. Level gauge/alarm column
P. Level controller
Q. Thermometer
R. Pressure gauge

There are two basic deaerator designs: tray and spray. In the tray type of deaerator inlet water is sprayed into a steam atmosphere and falls onto a bank of trays through which the steam passes, causing direct contact of the steam and water. Steam flow may be co-current, cross-current or counter-current to the water flow. In the spray deaerator the water is sprayed into a steam atmosphere and falls onto a spray deck or catchment from which it flows into the scrubber/atmosphere where it is mixed with the incoming steam.



If the temperature indicated is different (usually lower) than the corresponding pressure showing in the table:

1. There could be a problem with one or more of the spray valves in the tray type or with the spray head assembly in the spray type. Most likely a weak or broken spring. Just 1 malfunctioning spray valve can result in a loss of several degrees of water temperature.
2. One or more of the distribution trays could be plugged or damaged thereby preventing proper mixing of the water and steam in the tray type.
3. The thermometer or temperature transmitter could be defective or out of calibration.

The deaerator removes corrosive gases by venting them to atmosphere. The deaeration process liberates the majority of the Oxygen from the water but not all of it. A deaerator built to the Heat Exchange Institute (HEI) Deaerator Standard will provide water with a dissolved Oxygen content of between 6 and 10 ppb (parts per billion). This level of dissolved Oxygen while only a trace amount is insufficient to prevent corrosion of the waterside heating surfaces of the boiler. Therefore an Oxygen scavenging chemical must be fed to absorb the balance of the dissolved Oxygen to reduce it to a level of zero ppb.

The Oxygen scavenging chemical additive will reduce the dissolved Oxygen content of the water to zero thus eliminating any possible oxygen pitting of the waterside heating surfaces of the boiler. Sodium sulfite is used as an oxygen scavenger for low to medium pressure steam systems. Sodium sulfite does add slightly to the dissolved solids in the boiler water but is not a problem as the lower pressure systems carry a higher boiler water conductivity. Hydrazine and Diethylhydroxlamine (DEHA) are used for medium to high pressure steam systems as they do not add to the dissolved solids in the boiler water.

Dissolved oxygen testing of the feedwater supplied by the deaerator can be accomplished by either using the colorimetric (color compactor) indigo carmine method or by installing a continuous Oxygen monitoring system over a period of several hours. Without Oxygen scavenger feed, the dissolved oxygen should not be higher than 10 ppb and with scavenger feed the dissolved Oxygen should be zero.

If either of these parameters cannot be met, the steam supply, feedwater temperature, spray valves, distribution trays and the atmospheric vent should all be checked to determine the cause.

Feedwater temperature VS steam supply temperature can be checked on a regular basis by the operator as part of regular equipment checks. This is an easy operating parameter to verify. Dissolved Oxygen content of the feedwater should be checked when the deaerator is at maximum loading conditions. A continuous Oxygen monitoring system can be installed but these are expensive systems and require frequent attention and maintenance. Colorimetric test kits can be provided by any of several water treatment vendors and portable Oxygen monitors can be rented as well for periodic checks of the dissolved Oxygen content of the feedwater.