DEAERATOR LEVEL CONTROL

APPLICATION

When water is vaporized in the boiler tubes, all air dissolved in the feedwater returns to a gaseous phase. This allows a continuous corrosion process to take place in the tubes. The subsequent jeopardy of the pressure vessel integrity would cause prohibitive maintenance costs.

It therefore is most important to eliminate dissolved air from the feedwater. This is done in the deaerator where maximum contact is provided between the feedwater droplets and steam from the turbine.

The solubility of oxygen in water is minimum at temperatures between 70°C and 150°C, thus the temperature of the deaerator should preferably be selected to be between these limits. The upper limit is generally preferred and often exceeded for process reasons (the feedwater pump suction pressure value is dictated by the deaerator pressure value). Since liquid and vapor phases are by essence in equilibrium, the deaerator pressure is often in the area of 5 to 10 bar. The steam supply is generally from the MP turbine exhaust while the water level control valve is located at condensate pump exhaust before the LP heaters (Fig. 1).

VALVE REQUIREMENTS

a) Valve capacity

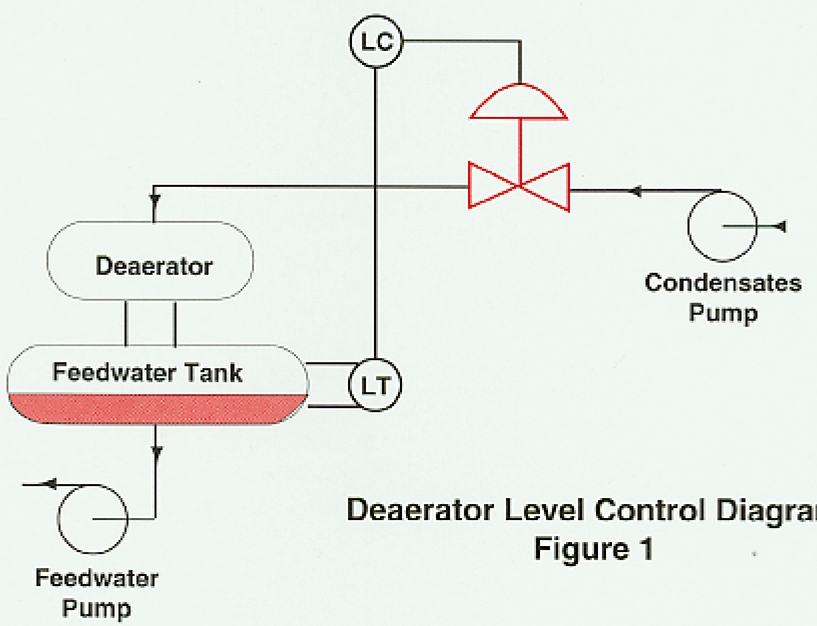
As with many other control valves in a power station, the deaerator level control valve is submitted to drastically different flowing conditions at various regimes.

At maximum load, the pressure drop in the valve is generally low since the condensate pump pressure is minimum and the pressure drop in the line is maximum. A high capacity valve is often preferred to minimize the size and the investment cost.

b) Cv ratio

At minimum load, the pressure drop in the downstream pipe is negligible while the pump pressure is maximum. Additionally P_2 may be much lower during start up conditions, when the deaerator pressure has not yet built-up, while the condensate pump is already supplying full pressure. The minimum flow being most often 5 % to 10 % of maximum flow, the Cv ratio requirement may be quite large:

$$\frac{Cv_{\max}}{Cv_{\min}} = \frac{Q_{\max}}{Q_{\min}} \bullet \sqrt{\frac{\Delta P \text{ at } Q_{\min}}{\Delta P \text{ at } Q_{\max}}}$$



Deaerator Level Control Diagram
Figure 1

Example:

In the practical case of a 400 MW combined cycle thermal power station:

At Q_{max} = 140 t/h, P_1 = 7.5 bar, P_2 = 6.5 bar
At Q_{min} = 10 t/h, P_1 = 15 bar, P_2 = 1 bar
Cv ratio = 52

Since the valve must not be fully open at maximum flow, the actual valve Cv ratio has to exceed the above calculated figure.

c) Cavitation

As developed in the above paragraph, it is clear that at minimum flow, ΔP is important (ΔP may not exceed 10 bar for simple cases but may approach 35 bar with a pump exhaust pressure of 40 bar and a deaerator pressure of 5 bar).

Minimum flow conditions therefore require special consideration and an adaptation of the trim type.

d) Shut-off

The deaerator level control valve is always throttling as long as the boiler is in operation, whatever the power regime is. Thus there is no shut-off requirement for this valve.

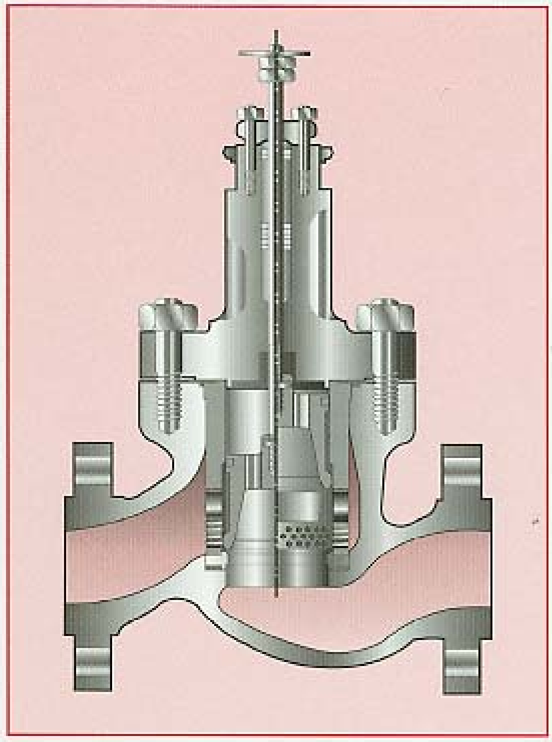
VALVE SELECTION

The user may be influenced by the low ΔP with large flow requirement corresponding to the maximum regime to select high capacity valves for obvious cost reasons.

For industrial boilers, with valve upstream pressure between 5 bar and 10 bar, Camflex valves are generally adequate.

For valve upstream pressure of the magnitude of 15 bar, it is often recommended to select 21000 series, generally with hard trim material such as 440C to cope with flowing conditions on the borderline of cavitation at low regime.

For large power plants, great care should be taken of the flowing conditions at various regimes. Users reports have been published describing repeated failures with high capacity valves. One of them, specially illustrative, reports successive failures of a sector ball valve, although equipped with a tube bundle supposed to control cavitation: A 12" valve had to throttle under 28 bar pressure drop at low loads. Despite several repairs and transformations, in close cooperation with the valve manufacturer, the valve was judged not repairable and had to be substituted with a cage globe valve.



Deaerator Level Control Valve
Figure 2

If the upstream valve pressure exceeds 15 to 20 bar, the plant designer should be asked to specify in detail several flowing regimes like maximum, normal, minimum and possibly some intermediate regime to fully appraise the situation. The valve type recommended is 41000 series with small anticavitation orifices at low lift, up to around 20 % of the rated Cv, to cope with cavitating conditions at low regimes, and mounted with flow tending to close. On the rest of the drilling, large openings are adequate to handle the large Cv requirement at low ΔP (Fig. 2). It may be required to lower the anticavitation drilling to 10 or 15 % of the Cv for less severe conditions and if an increase of the overall Cv is found necessary. This is to be reviewed case by case.

More investigation is recommended for plants subject to frequent start-up operations and/or load variations while less precautions may be taken for base load constant operation plants.