BOILER FEEDPUMP RECIRCULATION

APPLICATION

High pressure feedwater pumps are subject to overheating and subsequently very rapid damage if used at low flow as compared to the rated capacity. The minimum flow required for pump protection is specified by the pump manufacturer. It is never less than 15 % and can sometimes be 40 % or more. When the flow required by the boiler is below this limit, the feedwater pump flow demand is artificially increased by discharging to the deaerator or sometimes to the condenser through a recirculation valve. (Fig. 1).

VALVE PROBLEMS

The recirculation valve is required to operate during start-up, shutdown or in case of turbine trip.

The control valve is required to operate either **on-off** within a selected range of values of flow to the boiler, or **on** in modulating service. In this case, the flow through the control valve is equal to the difference between the pump minimum flow and the actual flow to the boiler. Modulating service avoids the waste of energy since the recirculated flow is kept at the minimum acceptable value, but it is more severe in terms of valve service.

This control valve application is one of the most difficult in a power station. The precautions to be taken while selecting a recirculation valve are listed below:

a) Cavitation

Due to a very high inlet pressure and almost saturated water at the outlet, a multistage valve is required with a very high pressure recovery factor (F_L) to avoid cavitation. Changes of direction within the valve also contribute to increase the F_L value.

b) Pressure drop distribution

The F_L of a multistage valve with n stages is given by the following formula:

Boiler Feedpump Recirculation Piping Diagram

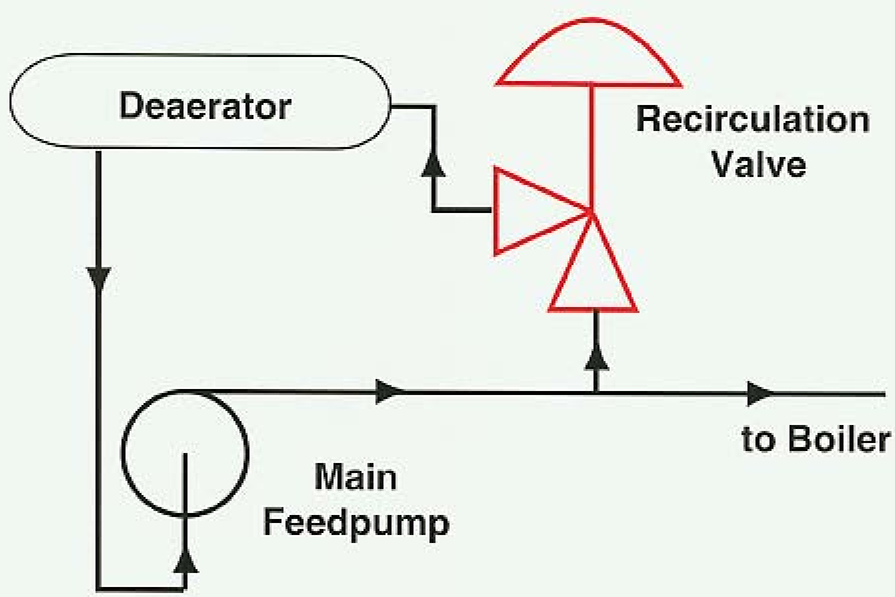


Figure 1

Boiler Feedpump Recirculation Pressure Gradient

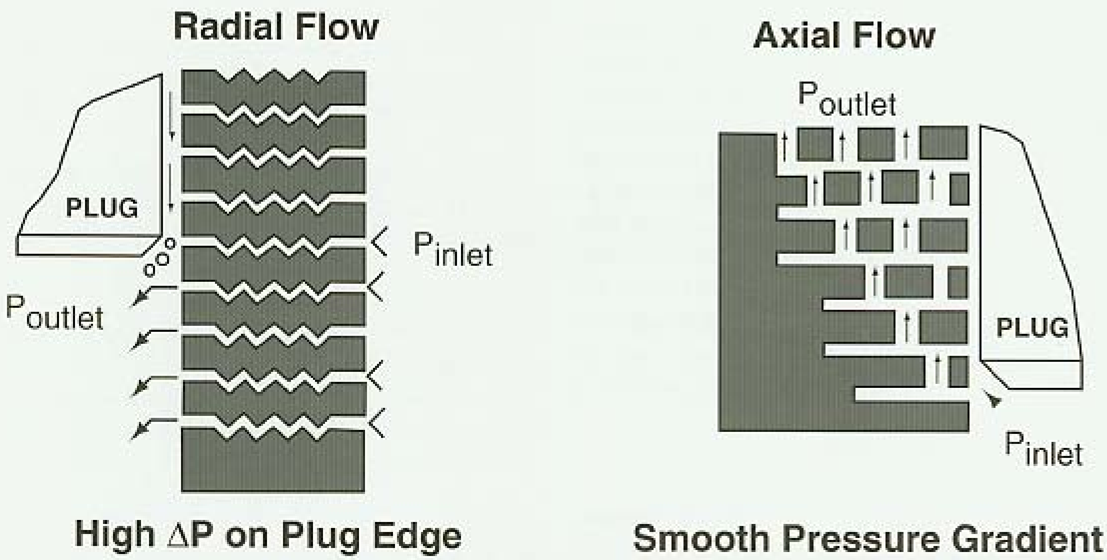


Figure 2

$$\frac{1}{F_L^2} - 1 = \left(\frac{1}{F_{Ln}^2 - 1}\right)\frac{\Delta P_n}{\Delta P}$$

F_{Ln} and ΔP_n being respectively the pressure recovery factor and pressure drop at last stage.

To increase F_L, $\Delta P_n / \Delta P$ has to be minimized. This can be accomplished by increasing the number of stages, but the consequence is a costlier design, and the need to oversize the valve to reach the required Cv value.

Another approach consists of using a trim with progressive resistance, i.e. more flow area / less pressure drop at downstream stages than at upstream stages. However, for a given number of stages and total pressure drop, the pressure drop at upstream stages should not exceed reasonable limits, say 55 to 70 bar depending on the service and materials, in order to avoid erosion. Finally the valve design should preferably provide for flexibility on the pressure gradient to optimize the F_L and keep an acceptable velocity / ΔP at the upstream stages.

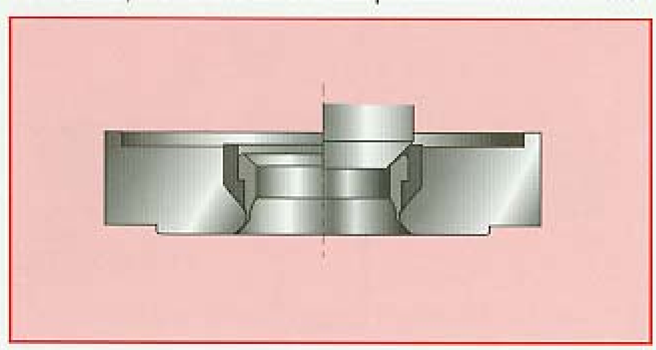
c) Axial / Radial design

Radial design valves, even multistage, are inherently critical since the plug edge is always submitted to the full differential pressure while opening parallel flow paths since throttling occurs at one stage only, i.e. at the first stage if the flow tends to open, and at the last stage if the flow tends to close. (Fig. 2)

In axial designs, all stages are throttling simultaneously, and the pressure gradient on the plug edge is not exceeding the pressure drop of first stage only.

d) Shut-off / Wire drawing

Most of the time, the recirculation valve is closed, under a very high differential pressure. Experience proved that it is not realistic to expect a durable tightness under such high differential pressures with metal to metal sealing. Even if carefully lapped at manufacturer's plant, impurities may cross the valve during start up and damage the seating surface. As soon as any leakage flow starts, the whole differential pressure is concentrated



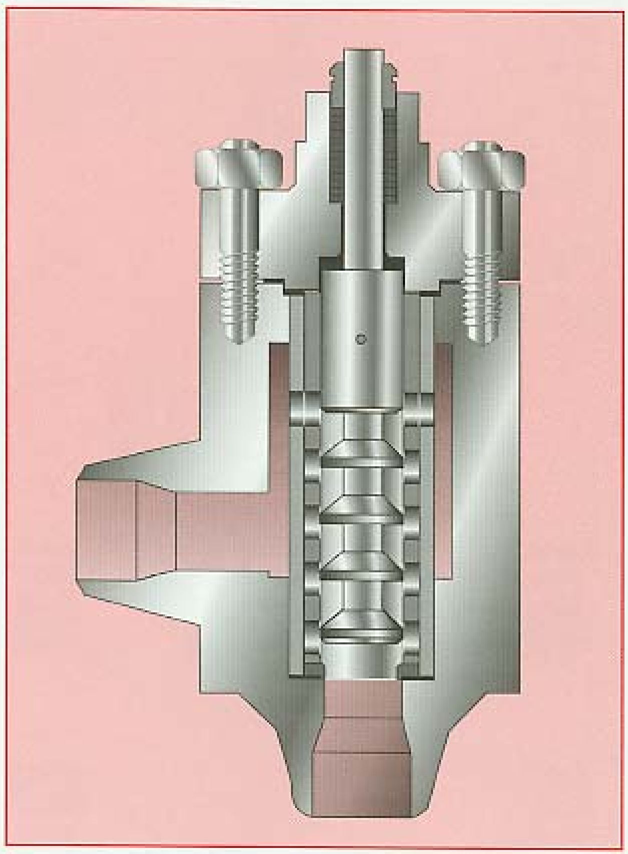
Soft-Seat Design
Figure 3

at the seat level since the resistance of orifices of successive stages is negligible as compared with the resistance of plug seat leak path.

The result is wire drawing which rapidly erodes the seating area, generating bigger and bigger leakage flow and cavitation damage on the trim and body. It is therefore essential to have a proven soft seat design, compatible with the rather high temperatures inherent with this application. (Fig. 3) The soft seat should not be subject to fluid impact or exposed to a high velocity flow path during throttling. A design requirement is that the elastomeric insert is protected with a dead stroke before the throttling part of the trim starts operating.

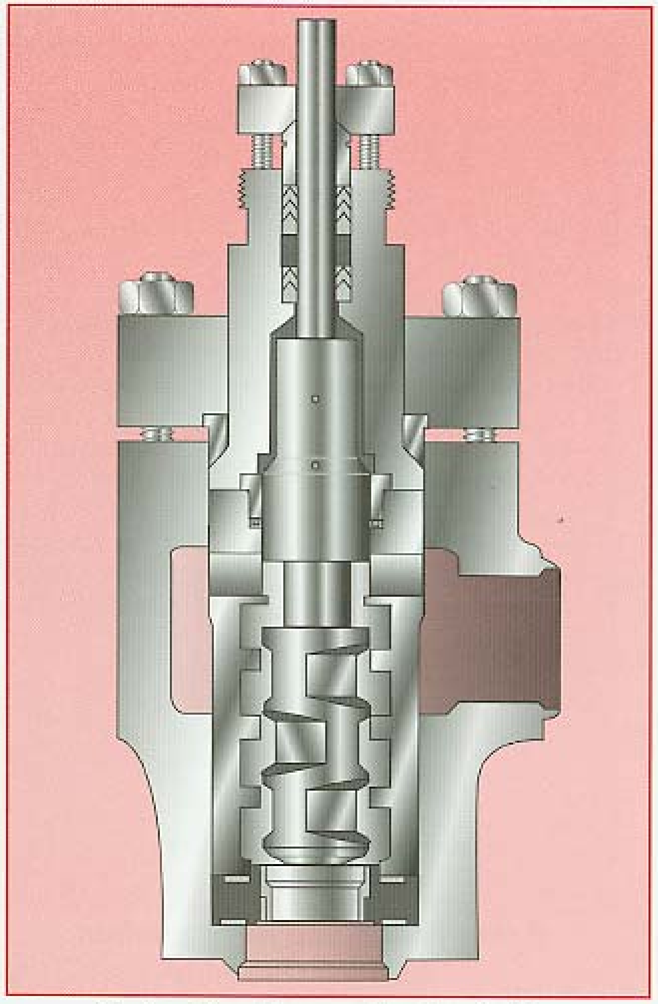
e) Clogging

Care must be taken that the valve orifices are not clogged by weld slags or other entrained solid particles.



Boiler Feedpump Recirculation 78000 / 78000 PRT Design

Figure 4



Boiler Feedpump Recirculation 78200 *LINCOLNLOG™* Design

Figure 5

f) Vibrations

If the valve is not properly guided, the very high amount of energy dissipated in the valve is a source of vibration, resulting in a deterioration of the shut-off capability, with the consequences described above.

g) Failure position

For the safety of the pump, it is necessary that the valve is open on air failure and mounted with flow to open so that it does not fail closed under any circumstance, for example in case the plug is disconnected from the stem.

TYPICAL SERVICE CONDITIONS

Although generic problems are similar, a wide range of flowing conditions can be found from small boilers with

ΔP = 70 to 100 bar and T = 110 to 130°C to drum boilers of power stations with ΔP = 200 to 250 bar and T = 180 to 250°C and supercritical boilers with ΔP = 250 to 300 bar and T = 200 to 280°C

All the above applications are successfully covered by Masoneilan 78000 / 78000 PRT (Fig. 4), 78200 *LINCOLNLOG* (Fig. 5) and 79000 VRT valves (Fig. 6), except 600 lbs rating small pumps which can more economically be equipped with 78000 multistage trim fitted into 21000 series body (Fig. 7).

Nuclear power plants usually have ΔP = 70 to 140 bar and T = 100 to 140°C. They require large size valves, most often 41017 VRT type (Fig. 8).

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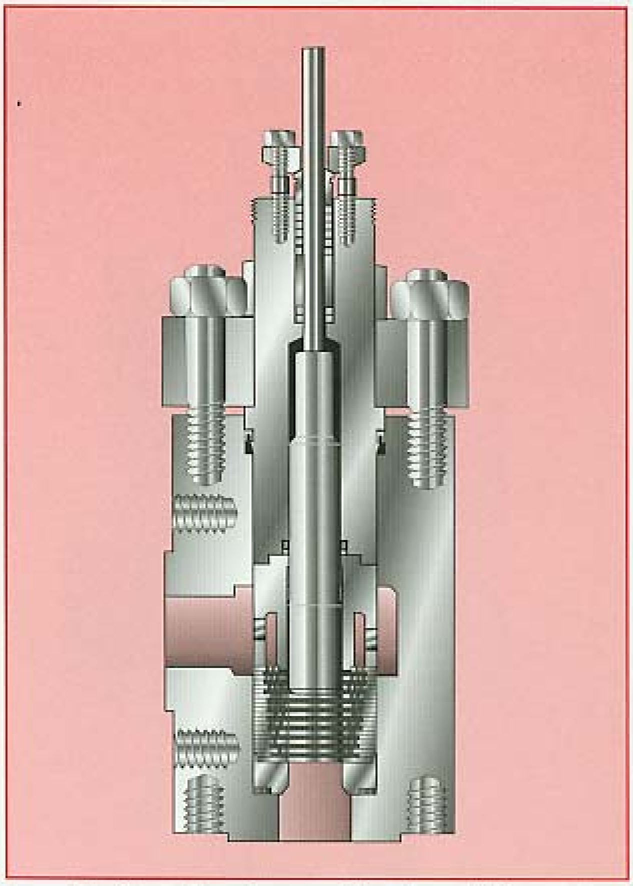
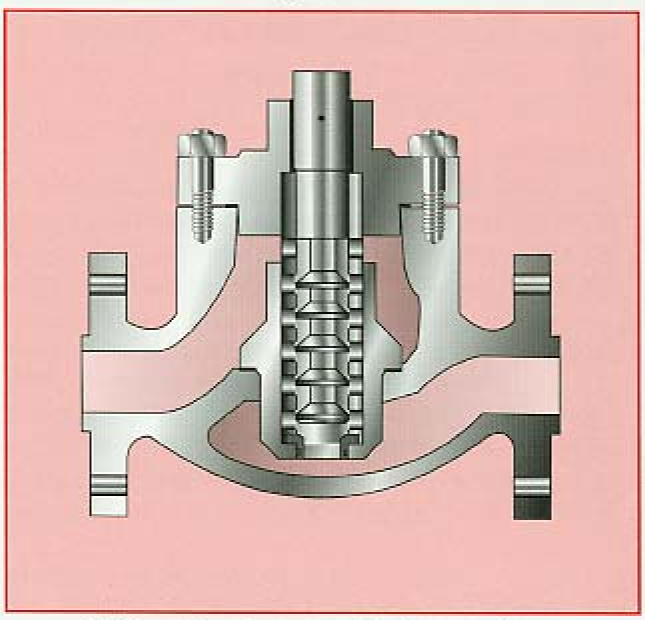
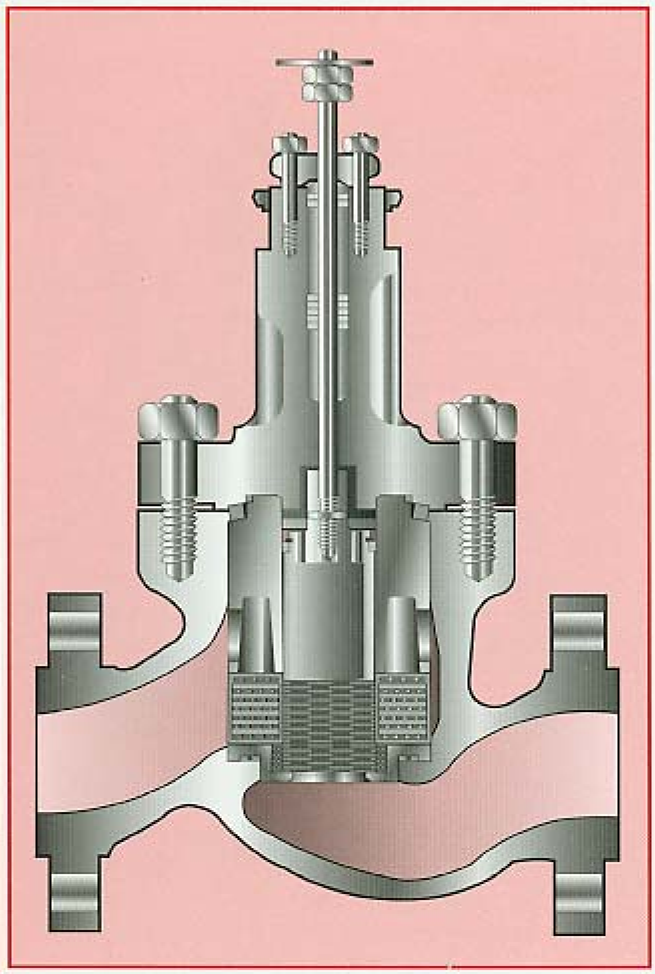


Boiler Feedpump Recirculation
79000 VRT® Design
Figure 6



Boiler Feedpump Recirculation
Multistage 21000 Design
Figure 7



Boiler Feedpump Recirculation
41017 VRT Design
Figure 8