KOSO

TURBINE BYPASS & PRDS SYSTEMS

Standard Specifications

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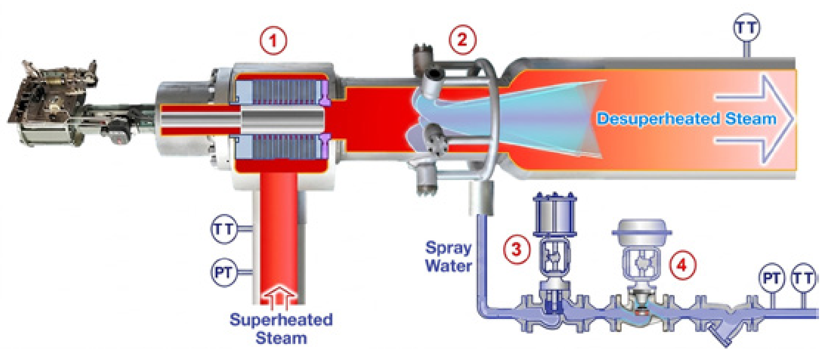
Overview

Turbine bypass systems increase the flexibility in operation of steam power plants. They assist in faster start-ups and shutdowns without incurring significant damage to critical and expensive components in the steam circuit due to thermal transients. In some boiler designs, turbine bypass systems are also used for safety function.



1. Steam Pressure Reducing Valve (PRV)
2. Desuperheating Spray Section (DSH)
3. Spray Water Temperature Control Valve (TCV)
4. Spray Water Temperature Isolation/ Shutoff Valve (SOV)
5. Dump Tube (not shown)
6. Pre-warming Valve (not shown)

Figure 1: Major hardware components of turbine bypass systems

Performance of the turbine bypass system has a strong influence on plant heat rate and capacity, effective forced outage rate (EFOR) and long-term health of critical components such as boiler tubes, headers and steam turbines. Therefore, correct sizing and selection of all components in turbine bypass systems is essential for smooth operation of a steam plant. Turbine bypass systems are generally sized for a specific percent bypass, which depends on the end-users' intent and desire for functionality. Common practices for bypass capacity are 30%-35%, 60%-70% and 100% of the design flow. Each of these reflects differing intent of how the plant is operated and/or the functionality desired in operation.

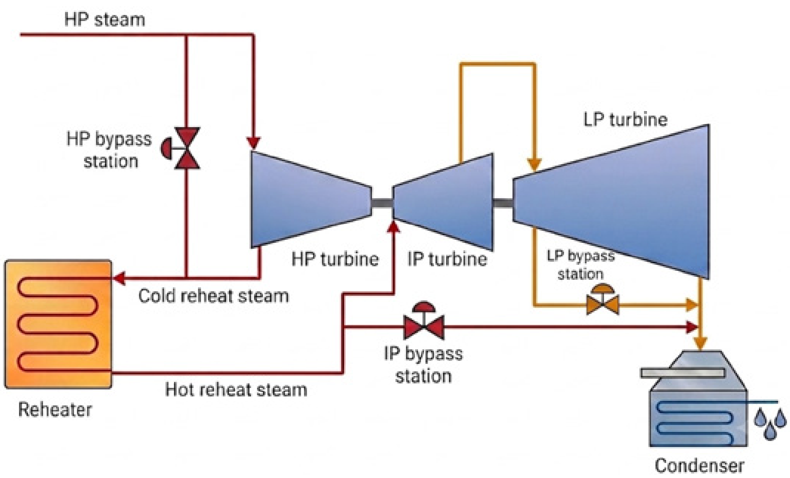


Figure 2: Various Turbine Bypass systems

KOSO bypass systems are configured with pneumatic actuators. Electro-hydraulic actuation is available upon request. Electric actuators are generally not used for this application unless slower response is permitted by the steam system design.

Key Applications & Benefits

- HP bypass to Cold Reheat, HP bypass to condenser
- HRH/IP bypass to condenser, LP bypass to condenser
- Steam bypass to process / district heating

High reliability	High reliability is necessary to achieve stable plant availability.
Low vibration and noise	Low vibration and noise for personnel and equipment safety.
Fine control	Fine control for smoothness of start-ups and shutdowns as well as for long-term life of critical high-pressure high temperature components.
Tight Shutoff	Tight shutoff is necessary to avoid penalty in heat rate and/or reduction in plant output; Class V is standard and MSS SP-61 shut-off is available upon request.
Performance	Highly reliable desuperheating performance for long-term protection of the downstream equipment.

Steam pressure reducing valve (PRV)

The steam pressure-reducing valve in turbine bypass systems is the primary mechanism of controlling the upstream pressure. It is available in different configurations:

- In-line globe body or angle body.
- Flow-to-open or flow-to-close.

This results in four combinations. The final choice should be made based on the plant piping layout and users' preferences. Any of the combinations, when correctly designed, can meet the critical functional requirements for turbine bypass service.

Angle body with flow to close configuration with pressurized seat generally results in tight shut off for extended period of time due to absence of any soft balance seals in the flow path.

Typical flow conditions at full flow for modern turbine bypass systems are:

- HP bypass inlet pressure of 180 bar(A) for subcritical Units and 260 bar(A) for supercritical units; temperature of 630°C for supercritical units.
- IP/HRH bypass inlet pressure of 50 bar(A) and temperature of 630°C.

For the bypass to the condenser, the outlet pressure is determined by the capacity of the dump tube under full-load conditions. The trim in the KOSO steam PRV is specially designed to maintain noise and vibration within acceptable limits. The diffuser dissipates the high-energy jet that would otherwise form at the seat ring region and enter the outlet piping. As the diffuser is integrated into the quick change trim, it can be easily inspected during routine maintenance, which is a major advantage over designs where similar baffles are welded into the body outlet region. For this application, screwed in seats or welded seats should be avoided.

Body & Trim Sectional View

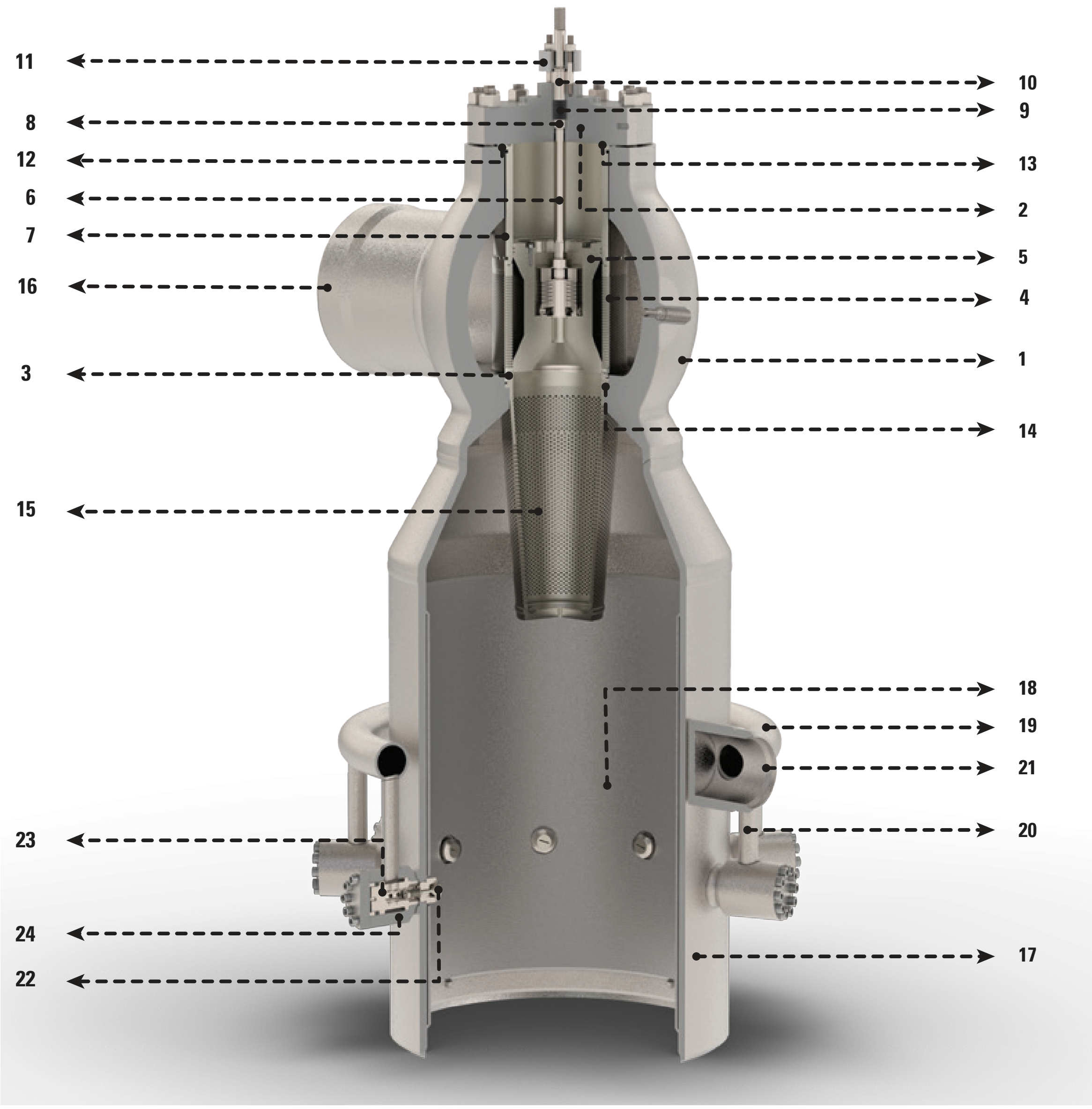


Figure 3: Cross-section of a steam pressure reducing valve with a 550A trim

SR.NO.	LABEL
1	BODY
2	BONNET
3	SEAT RING
4	CAGE
5	PLUG
6	STEM
7	BALANCE CYLINDER
8	PACKING SEAT

SR.NO.	LABEL
9	GLAND PACKING
10	GLAND RING
11	GLAND FLANGE
12	BODY - BONNET GASKET
13	SEAT GASKET
14	BALANCE SEAL
15	DIFFUSER ASSEMBLY
16	INLET SPOOL PIECE

SR.NO.	LABEL
17	STEAM PIPE
18	LINER PIPE
19	RING PIPE
20	FEEDER PIPE
21	WATER STUD
22	NOZZLE ASSEMBLY
23	NOZZLE HOLDER
24	NOZZLE HOUSING BOX

Commonly used material combinations

Component	Materials
Body	A182 F92, A182 F91 / A217 C12A, A182 F22 / A217 WC9
Bonnet	A182 F92, A182 F91 / A217 C12A, A182 F22 / A217 WC9
Inlet cage	A182 F22 / A182 F91
Plug	A182 F22 / A182 F91
Stem	Alloy 718
Seat	A182 F22 / A182 F91
Outlet cage	A182 F22 / A182 F91

*Alternative materials are available to meet specific design requirements.

Spray Water Temperature Control Valve (TCV)

The function of the spray water valve is to regulate the correct amount of spraywater flow into the desuperheater. These are generally small valves, typically 1 inch to 8 inch in size and are available in angle-body or in-line globe body configurations. Direction of flow-to-close is preferred because this is a liquid service.

Critical functional requirements for the spray water control valve are:

- High rangeabillty
- Quick response
- Good controllability
- Tight shutoff

Correct sizing of spray water valves is critical to proper operation of turbine bypass systems. Excessive over-capacity in spray water valves results in poor control at low flow rates. Equal percentage or modified equal percentage characteristics is recommended to achieve good controllability. High thrust for seating is recommended to achieve repeatable tight shutoff in servic.

Velocity control VECTOR™ trim : The HP bypass spray application requires a velocity control trim like the type shown in Figure 4. Fluid kinetic energy along the flow path, within acceptable limits, eliminates potential problems such as cavitation, vibration, noise, premature erosion etc. Alternative option is 550G-M trim.

Figure 4: Vector™ trim

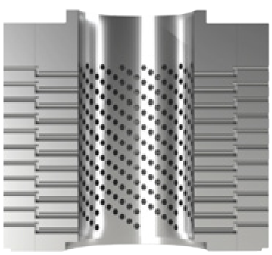


Figure 5: M trim

▶ Spray Water Isolation Valve/Shutoff Valve (SOV)

These are recommended as protection for the desuperheater. They are Intended to prevent cold spray water from dripping on to, or coming into direct contact, with hot metal in the desuperheater, in case that the spray water control valve develops a leak path.

▶ Desuperheater (DSH)

Desuperheating for turbine bypass applications is challenging because the amount of spray water is huge. Typical requirement for LP turbine bypass service is 30% - 35% of the incoming steam flow even for a 30% bypass system in a 600 MW station. This means a spray water flow rate of about 100 t/h or the equivalent of five fire-hydrants spraying in the pipe downstream of the LP bypass steam valve. Within the envelope of the pipe, the desuperheater design has to ensure that:

- The cold spray water does not impinge on the hot pipe wall. This is important for avoiding excessive thermal stresses and the resulting potential for cracking of pipes.
- All the spray water has to be evaporated within the short distance at downstream that is available.

For HP bypass to cold reheat systems, the situation is similar, even though the spray water is nearly about half of the LP bypass systems.

The performance goals described above require fine atomization and proper dispersion of the spray water. Large drops are not beneficial for the system. They tend to impinge on the side walls and/or fall out of the steam flow due to their high inertia. Even when they don't drop out of the steam flow, they require a long time to evaporate. Generation of small drops depends on the inherent nozzle injection characteristics (or primary atomization) as well as the energy of the steam flow into which the spray is injected.

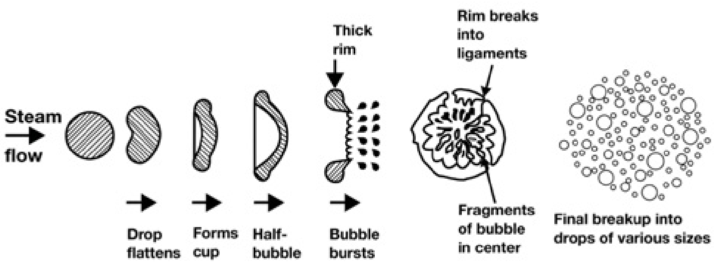
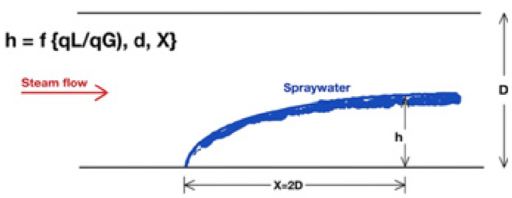


Figure 6: Break-up of a water droplet by interaction with steam when Weber number (We) is greater than 14. We = $\rho U^2 d/\sigma$ where ρ = steam density, U = relative velocity of steam, d= droplet diameter, σ = surface tension of water.



Where:
h = spray penetration,
qL = momentum of spraywater jet,
qG = momentum of steam
d = jet diameter

Figure 7: Schematic of penetration of spraywater in a cross-flow of steam

Dump Tube

Introduction

A Dump Tube is a specially engineered steam distribution and pressure dissipation device used in turbine bypass and steam dumping systems. It is designed to safely discharge high-pressure and high-temperature steam into the condenser during transient and emergency operating conditions. Dump tubes are installed downstream of bypass or steam conditioning valves and play a critical role in reducing steam pressure, controlling flow velocity, minimizing noise and ensuring uniform steam distribution within the condenser system. Proper dump tube design protects condenser internals and improves the reliability and safety of the entire power plant operation.

Applications

Dump tubes are commonly used during:

- Turbine trip conditions
- Plant start-up and shutdown
- Load rejection events
- Boiler bypass operation
- Emergency steam dumping
- Combined cycle power plant operations
- Thermal power stations
- Industrial steam systems

Figure 8: Dump Tube

Functions

- Pressure reduction
- Steam distribution
- Noise attenuation
- Condenser protection
- Controls steam velocity and turbulence before condensation occurs

Customization of Turbine Bypass Systems

Customization is more of a rule than an exception in the power industry. Customization may be driven by the system operation or by special performance requirements.

Common instances requiring such customizations are pre-defined piping layout, noise requirements, system operation etc. Special attention may be required for transitions between the steam valve and the desuperheater and from the desuperheater to the outlet pipe, to ensure that excessive noise will not be a problem. Similar materials of construction are preferred at the pipe joint to avoid welding of dissimilar materials in the field.

A collaborative effort between the plant designers and turbine bypass system providers is essential to solve the customization requirements. It results in cost-effective solutions that meet all the requirements and achieve optimum performance. Most importantly, it reduces the risk during the commissioning and for the long-term operation.

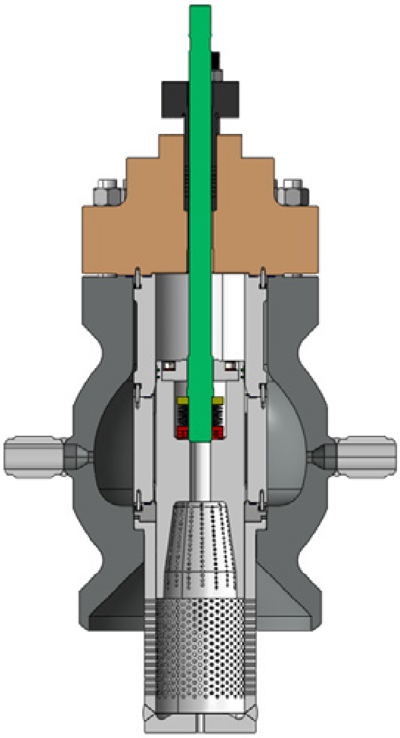


Figure 9: Skirted Plug Design for wet steam erosion occur during start-up

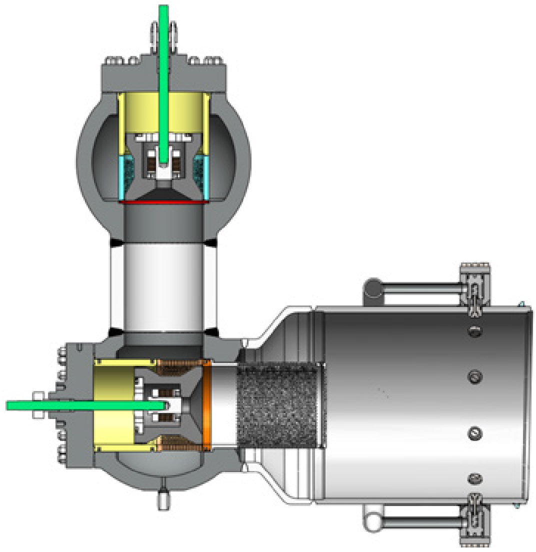


Figure 10: Pressurized seat design & Spherical Valve designs for LP/HRH bypass steam control valve to condenser

Actuation Solutions for Turbine Bypass Valves

Pneumatic actuators are widely used in modern turbine bypass systems due to their reliability, simplicity and ability to provide precise control with high thrust for tight shutoff performance. These actuators are typically supported by a dedicated local pneumatic control circuit that interfaces with the DCS, enabling accurate modulation along with fast open/close action and trip functionality. KOSO also offers Electro-Hydraulic (EH) actuators for applications where specified by the end user. The selection of the actuation system is often influenced by plant design philosophy and operating experience. Until the mid-1980s, turbine bypass valves were commonly employed conventional unbalanced trim designs, which required extremely high actuator thrust. As a result, EH actuators were considered the only practical solution for such applications. Although effective, EH systems were often associated with higher maintenance requirements, potential fire hazards, lower reliability and limited tolerance to harsh environments such as dust, humidity and elevated temperatures. In contrast, double-acting pneumatic actuators have long been recognized for their robust construction, operational reliability and ease of maintenance. Their associated control components are also well established and readily available throughout the industry.

The advancement of modern turbine bypass valve technology introduced balanced and pressurized seat trim designs, significantly reducing actuator thrust requirements and enabling the widespread adoption of pneumatic actuation systems.

The Pressurized Seat design (also referred to as Pilot Seat or Pilot Plug design) is a hybrid concept combining the advantages of both balanced and unbalanced plug configurations. In this arrangement, flow direction is always over the plug (Flow-To-Close configuration). Upstream pressure surrounds the outside diameter of the main plug and enters the upper bonnet cavity, where it applies a downward force on the plug to ensure tight shutoff — similar to an unbalanced plug design. To reduce opening thrust requirements, the main plug incorporates a central pilot opening fitted with a smaller pilot plug attached directly to the valve stem. Because the pilot plug has a much smaller effective area, the hydraulic loading force acting on it is significantly lower, requiring only minimal force to unseat the pilot plug.

Once the pilot plug lifts from the pilot seat, pressure across the main plug becomes equalized, eliminating the large differential pressure forces acting on the main plug, which helps main plug to lift with substantially lower thrust requirements. By reducing the required operating thrust, the Pressurized Seat design allows the use of smaller and more economical pneumatic actuators while maintaining excellent control performance and tight shutoff capability.

Today, with the combined advantages of improved reliability, lower maintenance, operational safety and cost efficiency, double-acting pneumatic actuators have become the preferred standard for many turbine bypass valve applications, while EH actuators continue to be used for specific high-force or customer-specific requirements.

Attribute	Pneumatic	Electro- hydraulic	Electric
Stroke time	< 2 seconds	< 1 seconds	< 2 seconds
Positioning accuracy	<2%	<0.5%	<2%
Step change response	<1% overshoot	No overshoot	No overshoot
Reliability	Very high	High	High
Maintenance requirement	Low	High	Moderate
Cost	Low	High	Moderate

Figure 11: Stop and Control Dual Stem Turbine Bypass Valve

Figure 12: HRH Stop Valve 28 inch ANSI 900CL

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