A-T ARMATUREN-TECHNIK GMBH

Turbine Bypass Systems

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Content

1. Turbine Bypass Systems

A-T ARMATUREN-TECHNIKs typical Turbine Bypass system indudes the Turbine Bypass Valve (Steam Condftioning Valve) Type DZE as well as a Spraywater Control Valve Type ESV. Its main job comprises to route steam from the main steam line to the cold reheat line or from the hot reheat line to the condenser respectively in the following cases occurring:

a) During start up of Boiler (cold-, hot-, superheated start up):
The Steam Condilioning Valve keeps the permissible pressure and temperature aiteration velocity inside the boiler keeps up the steam pressure as well as reduces it to a minimum during a cold start up.

b) During start up of turbine:
The Steam Condilioning Valve regulates the steam transfer to the turbine. By opening of the Turbine Inlet Valves, the orifice cross section of the main valve will be closed.

c) During normal operation:
The Steam Conditioning Valve dissipates the excess steam in case of abrupt dedine in output and also absorbs pressure peaks.

d) During breakdown:
The Steam Condilioning Valve ensures that the steam pressure inside the boiler as well as inside the main steam line does not exceed the maximum permissible value. Therefore the valve is able to dissipate the complete amount of steam generated by the boiler to the reheat line or to the condenser respectively.

2. Scope of delivery for typical power plants

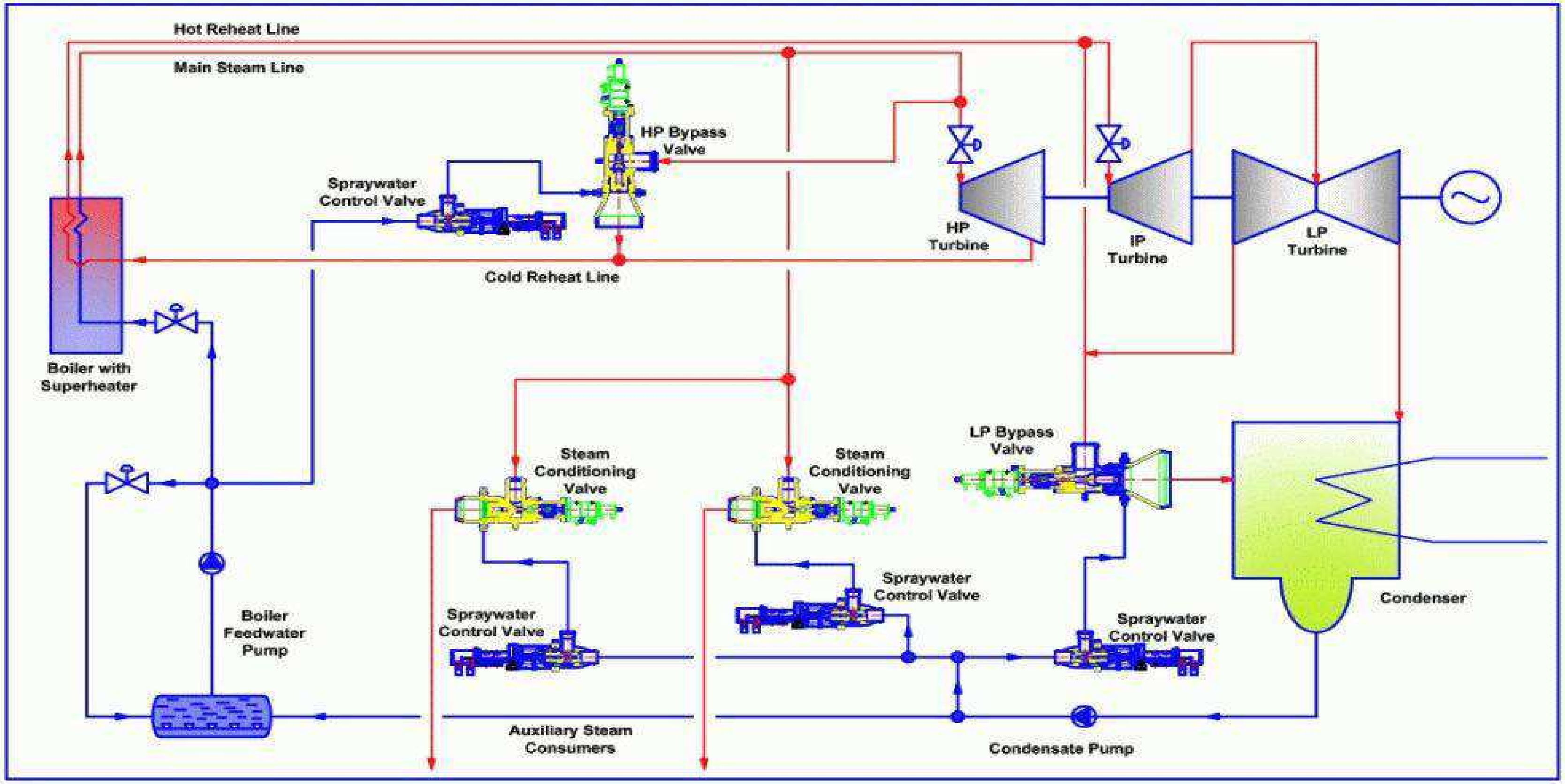


Figure 1: Illustration of bypass systems

3. Typical Shapes

Steam Conditioning Valves Type DZE

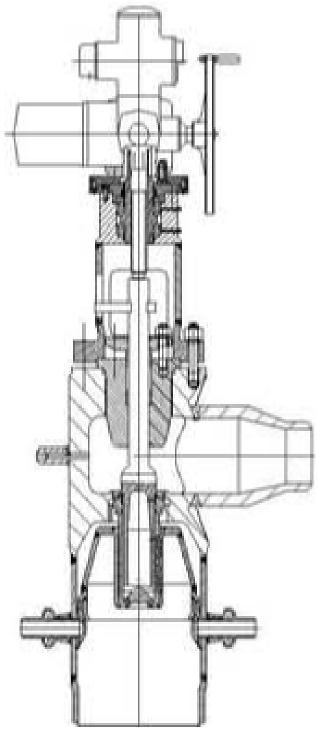


Figure 2: DZE with angle-type casing shape

Spray Water Control Valves Type ESV

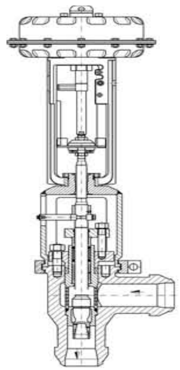


Figure 3: Spraywater valve with angle-type casing shape

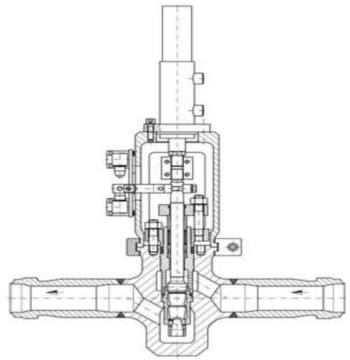


Figure 4: Spraywater valve with straight-type casing shape

4.1 Steam Conditioning Valve type DZE - Overview

- Are custom designed
- Require little space
- Reduce the initial cost
- Have a low noise level
- Are approved by important approval organizations:
  - European Community: CE-marking acc. to Pressure Equipment Directive (PED) 97/23/EC
  - Germany: TÜV approval acc. to PED, AD 2000-Merkblatt A2 and AD — Merkblatt HPO as well as TRD 201

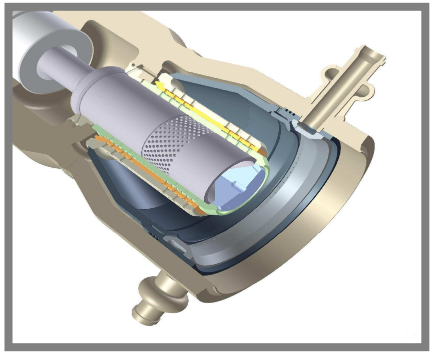


Figure 5: Isometric view of a steam conditioning valve

4.2 Steam Conditioning Valve type DZE

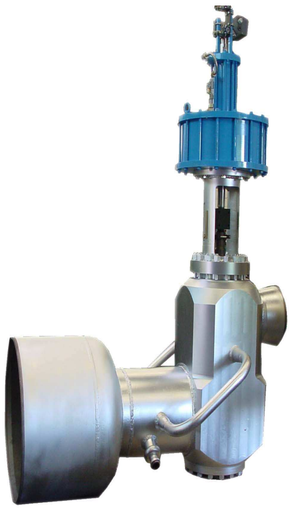
Application

The steam conditioning valve Type DZE represents the essential part of any turbine bypass system whose primary job is steam conditioning. Its design is suitable for any available steam condition at the highest operating values to the lowest initial ones. Therefore the steam conditioning valve is attractive for power stations, steam distribution mains in the chemical industry, paper mills and sugar factories etc. .

Design & Operation

The steam conditioning valve combines two functions in one: high-pressure throttling integrated with desuperheating.
Its design is based on a combination of high-speed water injection into a high-velocity steam flow. The injection occurs outside the body — the motive steam atomizes the spraywater immediately after the injection. The spray pattem is within the outlet to provide an even temperature distribution at all flow conditions.

The throttling is effected by a mutti-stage expansion which guarantees low sound emission and vibration.



Valve of angle type
pneumatic operated

4.3 Sound emission and reduction measures

During the pressure reduction in a valve, a pari: of the energy of the process medium is converted into sound energy and radiates both from the valve itself, but also primarily from the pipe system. Guidelines as well as health and safety at work legislation are pushing towards quiet valve solutions; sound level requirements of 70 to 75 dB(A) are not unusual.

The increasing demand for lower sound emissions from process plants often come up against not only economic boundaries but also technical limitations. Low-noise valves require not only more complex inner parts, but often also a longer body. This is reflected in significantly higher costs. Extreme levels of sound emission are always also an expression of mechanical stress. Whenever considering sound emission it must always be come in mind that the sound is in fact generated in the valve, the sound radiation actually emanates from the downstream pipe system.

With reference to sound generation, a differentiation must be made here between incompressible and compressible media.

For gases or vapours the main cause of sound emission is, for subcritical expansion, the partial conversion of energy into sound energy. Due to the significantiy higher flow velocities compared with liquids, the sound level increases sharply with rising pressure difference. Even for relatively small valves, it can already lie above permissible limits and cause impairments to health. If the pressure ratio across the control valve exceeds the XT value, shock waves are the main cause of sound emission in the expansion zone.

4.4 Primary Reduction Measures

In gaseous flows, a reduction of the level of sound generation is achieved by distributing the throttling area into many smaller individual flow passages (perforated cage). In this manner, the sound-generating source is divided into many individual sound sources. On account of the lower extent of the turbulent zone and the higher frequency range, these generate in total a lower noise level in the A-weighted sound spectrum relevant to human hearing.
The second effective measure is the distribution of the throttling process into a number of stages. In this manner, a lowering of the flow velocities, which are causally responsible for the sound generation, is achieved in the individual throttling stages.

The sum of the individual sound levels adds up to a significantly lower overall level in comparison with the single-stage throttling process. In particular, if cavitation and supertritical expansion are present, distribution of the throttling process is always to be considered as a primary measure. In spite of their "open" flow areas, perforated cages also have an encapsulating effect on the sound generated by the upstream stages and thus act furlher to reduce sound levels.

Figure 6: Perforated plug with peforated cage

4.5 Secondary Sound Reduction

Secondary sound reduction measures are concemed not with sound gemeration but rather sound radiation. For this purpose are mainly downstream sound dampers used.

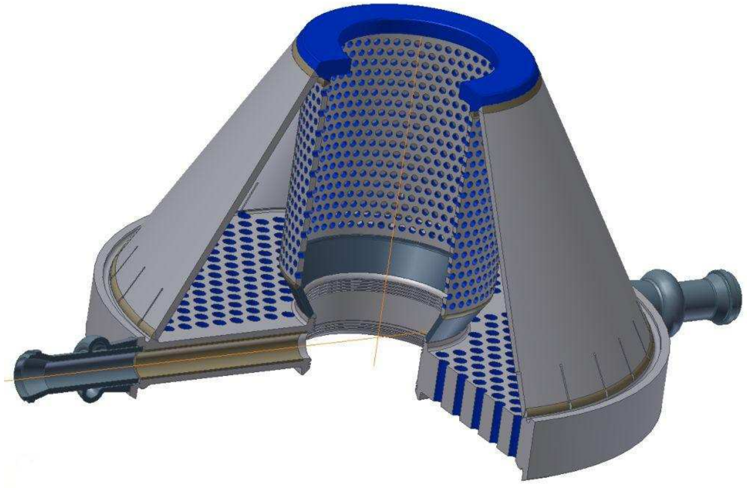
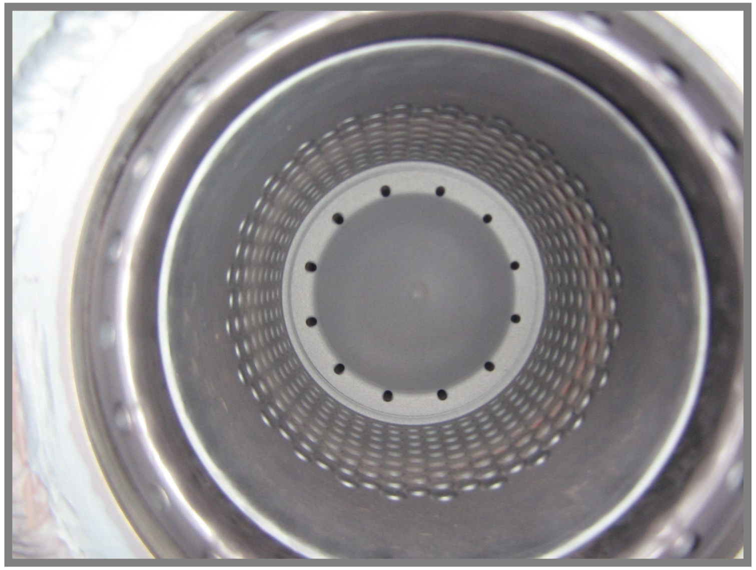


Figure 7: Isometric view of a silencer



Inspection of a A-T silencer after 18 years of operation

Since the sound radiation of the acoustic energy generated in a control valve occurs over a very long lenght of pipe, extending sometimes more than an hundred meters, the introduction of secondary sound reduction means is resource intensive and should therfore always be considered as an additional measure only.

5.1 Spraywater Control Valve type ESV - Overview

- Are custom designed
- Are low maintenance
- Have easy-to-service-seat / trim
- Have a short delivery period
- Are approved by important approval organizations:

  - European Community: CE-marking acc. to Pressure Equipment Directive (PED) 97/23/EC
  - Gerrnany: TÜV approval acc. to PED, AD 2000-Merkblatt A2 and AD — Merkblatt HPO as well as TRD 201, TRD 421

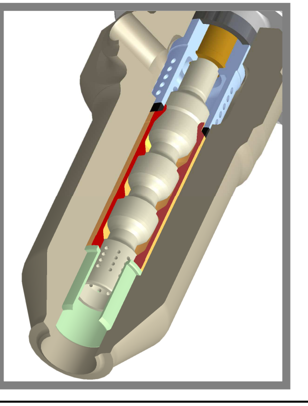


Figure 8: Isometric view of an angle-type spraywater control valve

5.2 Spraywater Control Valve type ESV

Application

Spraywater control valve Type ESV perceives itseif as final control element to provide service spraywater to the steam conditioning valve for steam temperature control. Its design is based on the operating values of the steam conditioning valve to ensure a consistent and reliable operation.

Design

Spraywater control valve Type ESV is designed for all severe service spraywater applications. Its basic design is characterized by:

- solid and die-forged body
- wear resistant seat and plug
- low-friction stem sealing
- static double sealing via seat and stern seal
- perforated cylinder

The design of the control elements can be single-stage as well as multi-stage, depending on the given operating values.

In case of impurities in the service spraywater, the inner trim will be protected against coarse particles by the perforated cylinder. If the medium also contains fine particles, we prefer to precede a strainer.

Valve of angle type
pneumatic operated

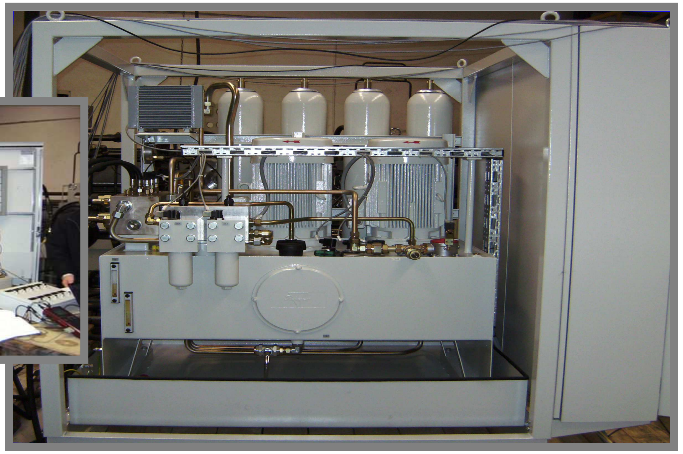
6. Hydraulic Power Unit HPU

<u>Continuous modulating position control of Steam Conditioning Valves</u>

Operating time approx. 20 seconds over the whole valve stroke during normal continuous modulating position control operation and 2 seconds over the whole valve stroke during quick operation. Fail open function within 2 seconds over the whole valve stroke in case of electric power supply failure, operated with 2 solenoid valves, with oil supply from the accumulators.

<u>Continuous modulating temperature control of spray water control valves</u>

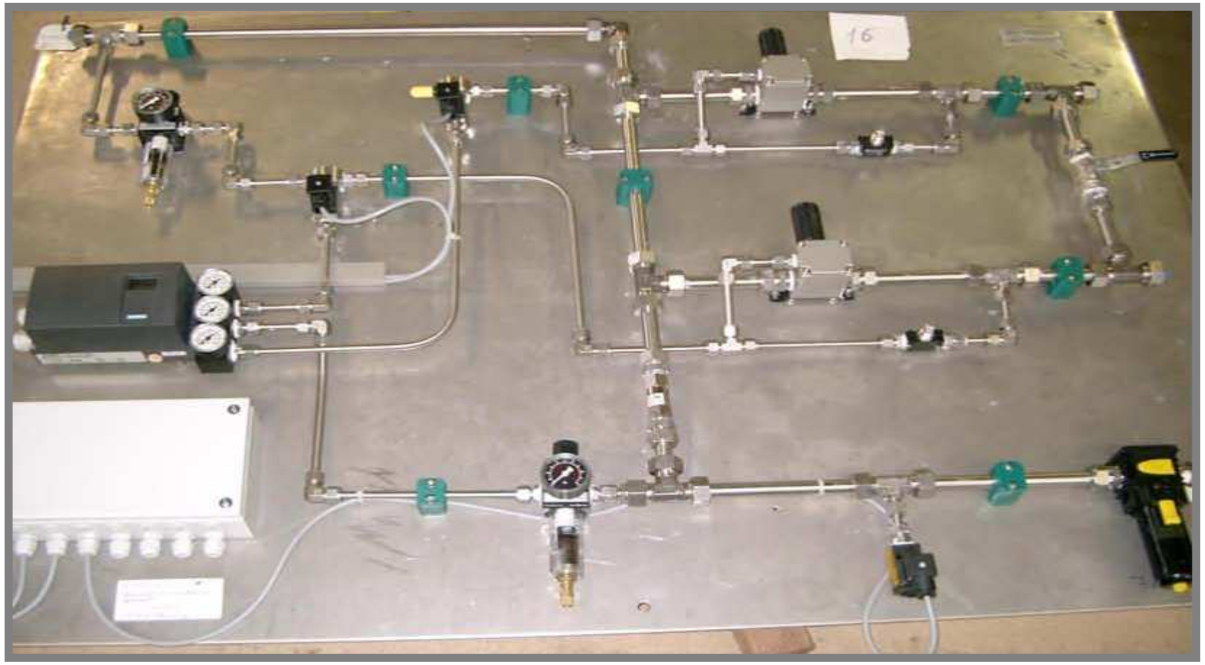
Operating time approx. 2 seconds over the whole valve strake during normal continuous modulating temperature control operation and
1 second over the whole valve stroke during quick operation. Fail open (or close) function within 1 second over the whole valve stroke in case of electric power supply failure, operated with 2 solenoid valves, with oil supply from the accumulators.



Front- and
Side-view of a
Hydraulic Power
Unit

7. Pneumatics

Hydraulic actuators are known to have very good dynamics, stability, speed and high actuation forces. Their disadvantage is presumed by being expensive and resource-intensive to manufacture.



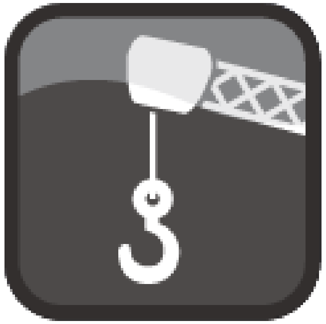
A-T pneumatic control panel

If certain circumstances require a cost-effective solution, pneumatic valve actuators can be used in potentially explosive areas without any problems. They have low actuating times, a constant sealing force, as well as safety positions that can easily be implemented.

8. Bringing into service

Installation

Steam Conditioning Valve	In general, the steam conditioning valve can be installed in any position. We recommend the installation with horizontal inlet and vertical outlet because no drainage points will be required. In case of any other installation position, drainage points will be required. All oil lines leading to the hydraulic cylinder must be laid free of tension and have to be equipped wilh air relief valves.
Spraywater Control Valve:	In general, the spraywater contol valve can be installed in any position. All oil lines leading to the hydraulic cylinder must be laid free of tension and have to be equiped wich air relief valves.
Electro-hydraulic System:	The hydraulic power unit has to run a performance test in the factory. The adjustment will be made within the entire system.



Adjustment

Steam Conditioning Valve:	The stroke is adjusted during assembly in the factory, but can also be readjusted at site.
Spraywater Control Valve:	The stroke is adjusted during assembly in the factory.
Electro-hydraulic System:	The hydraulic power unit has to run a performance test in the factory. The adjustment will be made within the entire system.

9.1 Calculation Steam Conditioning Valve

In accordance to TRD 421 the smallestflow cross-section of the steam conditioning valve can be calculated as follows:

$$A_0 = \frac{x \cdot qm}{\alpha_w \cdot p}$$

Where:

$A_0 \left[mm^2 \right]$ = Narrowst flow cross-section

$x \left[\frac{h \cdot mm^2 \cdot bar}{kg} \right]$ = Average pressure coefficient

The value can be derived from the regulations mentioned above. The cross section however can be calculated more exact via the following formula:

$$x = \frac{0.6211}{\psi} \cdot \sqrt{v \cdot p}$$

Where:

$v \left[\frac{m^3}{kg} \right]$ = Specific vapour pressure

$qm \left[\frac{kg}{h} \right]$ = Maximum quantity of vapour to be discharged

$p \left[bar \right]$ = Response pressure (absolute)

α_w = Outlet factor according to the component test

ψ = Outlet factor in accordance to TRD421 Section 9.4

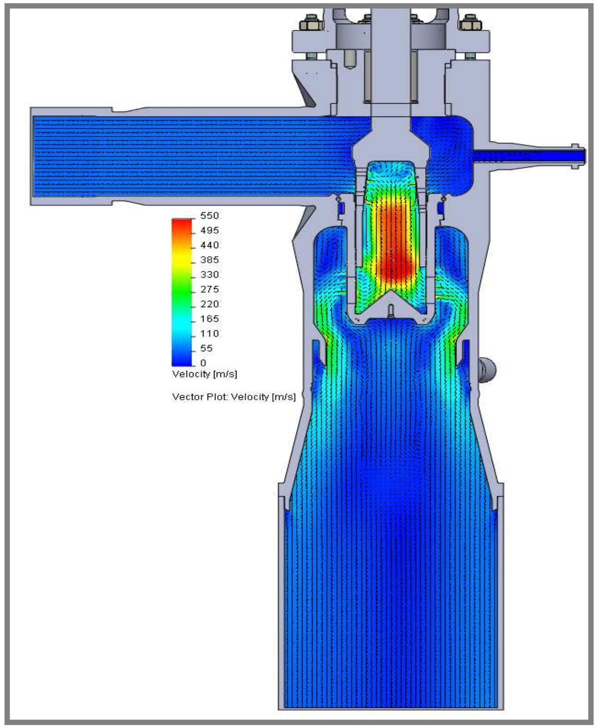


Figure 9: Distribution of fluid velocity inside a steam conditioning valve

9.2 Calculation Spraywater Control Valve

The necessary amount of spraywater which is needed to cool down the discharged steam flow of the steam conditioning valve can be calculated as follows:

$$Q_W = Q_{FD} \frac{h_1 - h_2}{h_2 - h_w}$$

Where:

$Q_w\left[\frac{t}{h}\right]$ = amount of spraywater

$Q_{FD}\left[\frac{t}{h}\right]$ = amount of live steam to be cooled

h_1 = specific heat content of live steam

h_2 = specific heat content of cooled steam

h_W = specific heat content of spraywater

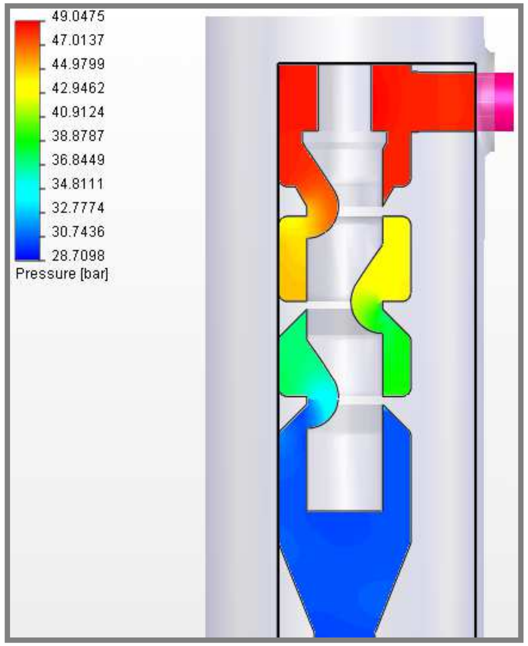


Figure 10: Distribution of fluid pressure inside a spraywater control valve

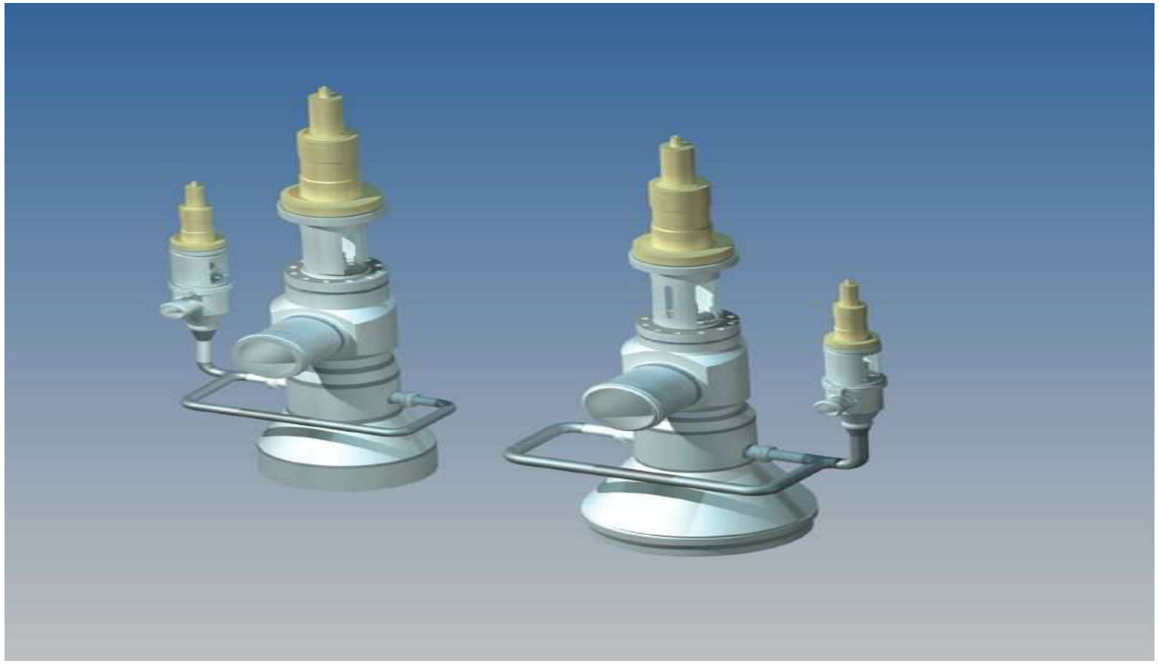
The detailed calculation of all components is carried out in accordance with valid technical regulations

10. Technical Data

	Steam Conditioning Valve	Spraywater Control Valve/Stop Valve
Nominal pressure	According to all pressure/temperature graduations occuring in modern powerstation constructions	According to all pressure/temperature graduations occuring in modern powerstation constructions
Nominal diarneter	According to the operating conditions occuring in modern power station constructions	According to the operating conditions at the steam conditioning valve
Connections	Welded ends	Welded ends
Materials	According to the prevalent operating conditions	Body: 1.5415/16Mo3, Inlet/Outlet acc. to the operating conditions occuring
Spraywater Connection	Flange	-
Trim	Noncorrosive steel, seat stellited	Noncorrosive steel, seat stellited
Stroke	Depending on size of seat	Depending on size of seat.
Characteristics	Modified linear	Equal percentage
Actuator	Unilaterally operating hydraulic cylinder with integral spring plate, air failure: spring open Control via electric actuator is possible	Hydraulic cylinder with integral spring plate, air failure: spring to open
Signal device:	Position feedback transmitter 0/4...20 mA with limit switches	Position feedback transmitter 0/4...20 mA with limit switches.

11. A-T Bypass Systems (excerpt)

YEAR	PROJECT	CUSTOMER
1990	**HP** Bypass	Dahlian, China
1991	**HP** Bypass	Jainghsu, China
1992	**HP** Bypass	Anpara, India & Ligang, China
1999	**HP** and **LP** Bypass	Novosibirsk, Russia
2000	**HP** and **LP** Bypass	Nishni-Nowgorod, Russia
2001	**HP** and **LP** Bypass	St Petersburg, Russia
2001	**HP** and **LP** Bypass	Wladivostok, Russia
2002	**HP** Bypass, HP Bypass w. safety function (SUV)	Baymina, Turkey
2002	**HP** Bypass (safety funct. SUV)	Phu My 3, Vietnam
2003	**HP** Bypass	Solvay Rheinberg Station 3/4, Germany
2004	**HP** Bypass	Bayer Uerdingen, Germany
2005	**HP** Bypass	Banwhol, Korea
2006	**HP** Bypass	Teluk Salut, Malaysia
2007	**HP, IP** and **LP** Bypass	Bypass Hwaseong, Korea
2008	**HP** Bypass (safety funct. SUV)	Az Zhour, Kuwait
2008	**HP** Bypass	Media Yanbu, Kingdom of Saudi-Arabia
2009	**HP** Bypass	Mondi Business Paper Sykyvkar, Russia
2009	**HP** and **LP** Bypass	Beijing ZNT, China
2010	**HP** and **LP** Bypass	Tanjung Awar-awar, Indonesia



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