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OVERVIEW OF

STEAM DESUPERHEATING




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Steam desuperheating

Steam is used in the energy sector as a carrier of mechanical energy (turbines) or as a heat transfer fluid (heat exchangers). To reach the highest possible efficiency in these processes specific parameters of steam are needed. For turbines superheated steam is necessary, while for exchangers saturated steam is the better choice. To obtain saturated steam it is necessary to cool superheated steam by injecting water. This seemingly simple process is in fact rather complicated because multiphase flow typically occurs and the process requires a particular set of steps according to specific parameters.

Steam cooling systems

Two basic systems of spraying injection water are currently used. They use either mechanical atomizing of the cooling water (using the kinetic energy of the water itself) or atomizing the cooling water with the help of the kinetic energy of the steam.

For mechanical atomizing, nozzles with either fixed or variable geometry are used. For atomizing, using the kinetic energy of the steam, a Laval nozzle is most often used, where either an auxiliary external steam source is brought in or the kinetic energy of the cooled steam accelerated in the tapered neck of a desuperheater is utilized.

Each of these systems has its application range depending on the required parameters of the steam conditioning.

Influence of some parameters on cooling efficiency

Velocity: with higher steam velocity better atomizing of the injected water is achieved, which increases the heat transfer surface between the water and the steam. The heat transfer is also elevated by a higher velocity gradient. The disadvantage of the higher steam velocity is the need for a longer straight part of the steam pipeline and longer distance between the temperature sensor and the injection point.

Injected water temperature: higher temperature water has a lower surface tension, which facilitates the atomizing of the water and also shortens the time necessary for heating to boiling point. However, the temperature of the water should be at least 5°C below the saturation limit because of the danger of flashing in the injection valve and/or nozzle.

Temperature of the steam after cooling: the advantage of a higher final steam temperature is a higher temperature difference between that of the steam and the boiling point of the injected water.

Pressure drop across the nozzle: a larger pressure drop causes finer atomization of the water and increases the heat transfer surface. The disadvantage is the higher risk of nozzle damage.

Diameter of the steam pipeline: small dimensions of the pipeline at the injection point brings the danger of water droplets falling onto the pipeline wall and thus causing a decrease in cooling efficiency. The impacts of the droplets on the wall also reduce the lifetime of the pipeline, therefore a thick-walled pipeline or an inner protecting shield is recommended.

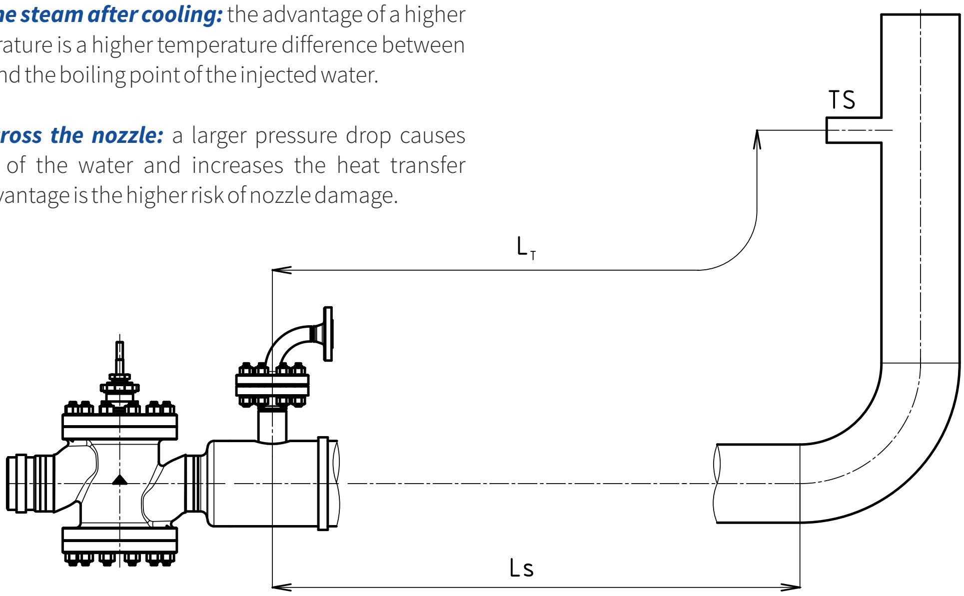
Temperature measurement

Regarding the above mentioned, the outlet pipeline must be correctly designed and the temperature sensor properly placed. The temperature sensor should be located after a bend in the pipeline at a minimum distance of 10m beyond the injection point. The actual distance must be set according to the particular parameters of the steam conditioning. At an outlet steam temperature of more than 30°C above the saturation point, it is possible to use the simplified equation based on the output steam velocity.

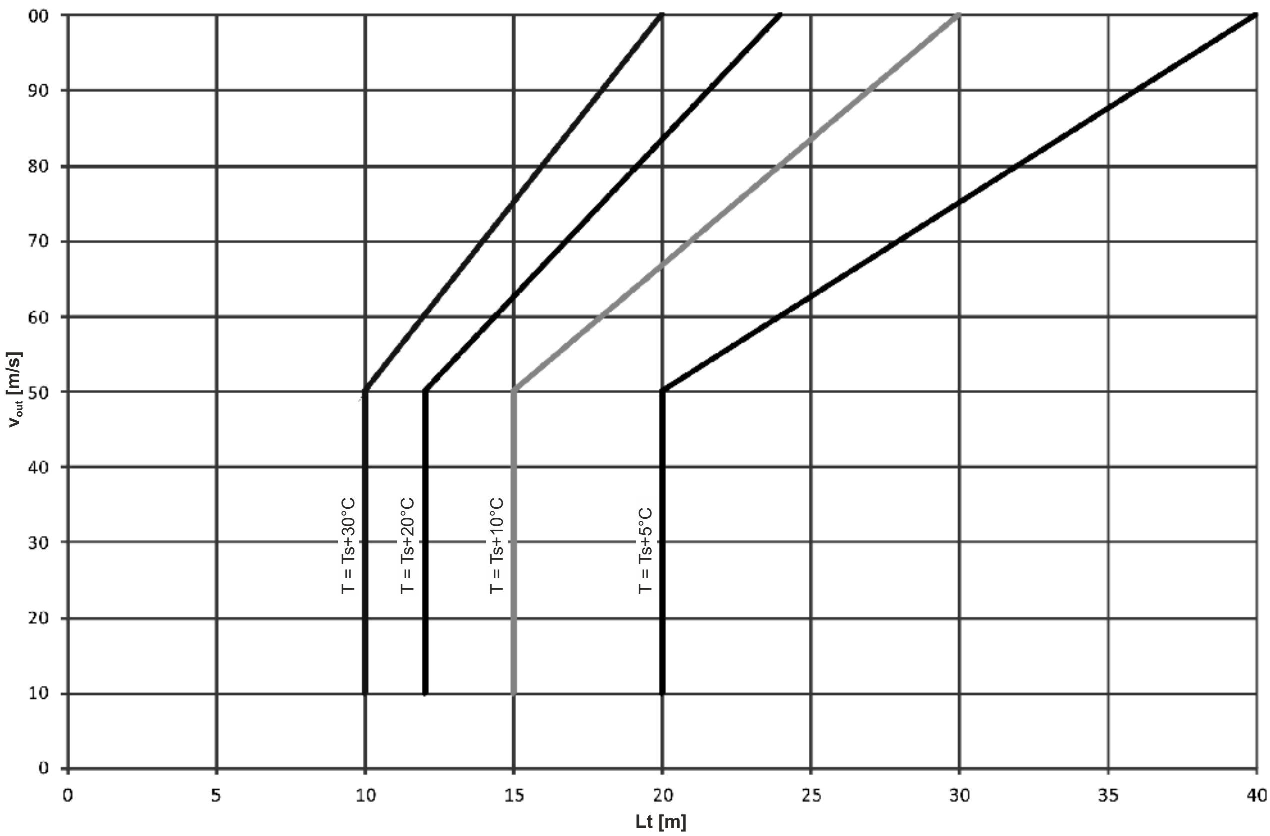
$$L_T = v_{OUT} \times t$$

$$Ls = \frac{L_T}{2}$$

L_T [m]	minimum required distance of temperature sensor beyond injection point
L_S [m]	minimum required length of the straight part of the pipeline
v_{OUT} [m/s]	outlet steam velocity
t [s]	vaporization time (at T ≥ Ts + 30°C, t = 0,2 s)
T [°C]	outlet steam temperature
Ts [°C]	saturation temperature



Distance between the temperature sensor and the injection point at a steam temperature approaching the saturation limit



Steam cooling near the saturation point is very complicated because the steam and water multiphase flow appears here and a lot of injected water does not vaporize. Droplets of water negatively affect the accuracy of temperature measurement which may cause flooding or conversely overheating of the steam pipeline. In the case of cooling down near the saturation temperature, it is necessary to control the injected flow of water on the basis of balance calculation with big enough over-injection of water around 30%. This solution is often applied at By-pass stations, where the outlet leads to a steam condenser.

Steam conditioning equipment produced by LDM

Type	Injected quantity		Steam pipeline size		Minimum required steam velocity [m/s]	Pressure drop across nozzle	
	Min [kg/h]	Max [kg/h]	Min	Max		Min [bar]	Max [bar]
VH	500 *)	9500 *)	DN150	-	8	2	15
VHF	5 *)	1680 *)	DN80	-	8	1	70
VHP	0	5500	DN150	-	3	0	15
CHPR	500 *)	9500 *)	DN200	DN600	6	2	15
CHPF	5 *)	1680 *)	DN40	DN200	8	1	70
CHPE	0	dle DN	DN40	DN200	10	0	15

*) quantity / nozzle

VH

Injection head, equipped with one to three nozzles with variable geometry that work on the mechanical principle of atomizing. During injection the flow area changes according to the quantity of the injected cooling water. The applied design increases the flow range by maintaining the quality of the atomization process required despite minimal injected quantity.

VH parameters

1 to 3 nozzles

QWATER: 0,5 – 9,5 t/hr per nozzle
min size of steam pipeline: DN 150
min steam velocity in pipeline: 8 m/s
pressure drop across nozzle: 2 to 15 bar

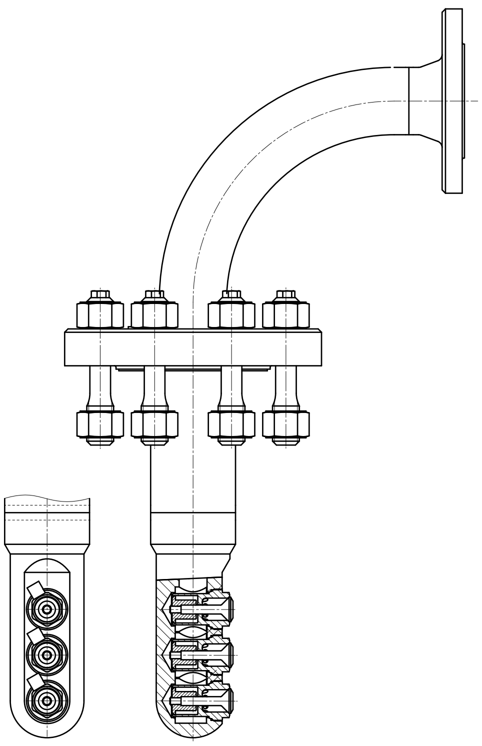
VHF

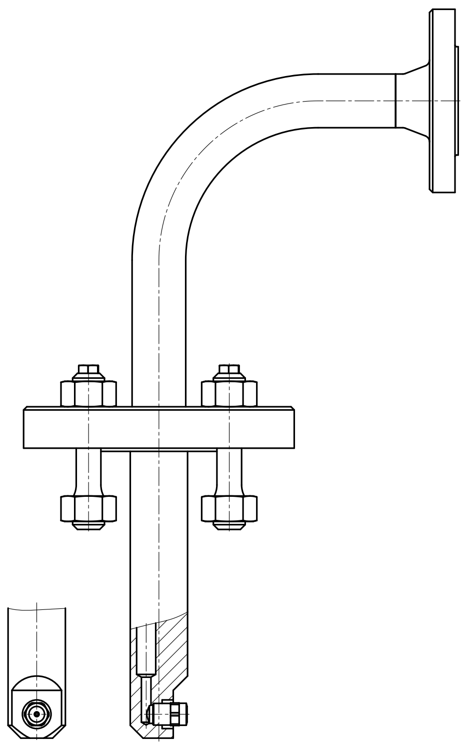
Injection head, equipped with one to three nozzles with fixed geometry, that works on the mechanical principle of atomizing. Two types of nozzles are used. Type H serves for injecting a higher water quantity where a full cone of bigger droplets of injected water is created. Type M utilizes a high pressure drop across the nozzle for very fine spraying of the injected water. This design is not recommended for control ranges higher than 1:4.

VHF parameters

1 to 3 nozzles

QWATER: 5 – 1680 kg/hr /nozzle
min size of steam pipeline: DN 80
min steam velocity in pipeline: 8 m/s
pressure drop across nozzle: 1 to 70 bar





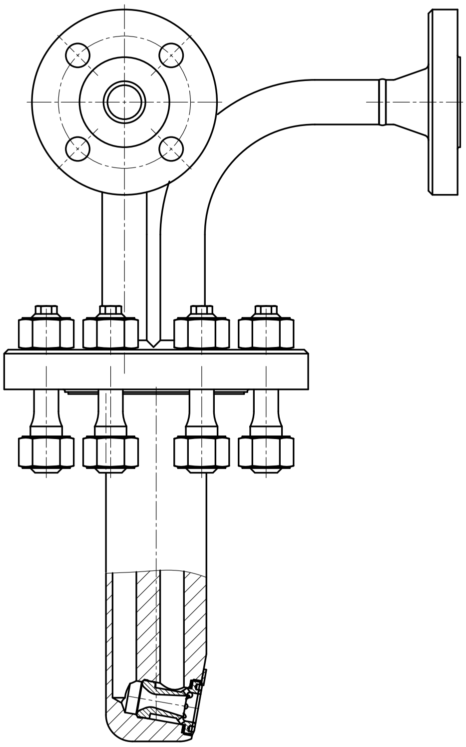
VHP

Injection head drive-steam type, utilizes the kinetic energy of the steam for atomizing the injected water. A stream of auxiliary steam is accelerated in a Laval nozzle, where the cooling water is brought in. This design is recommended for applications with a low quantity of injected water restricted only by the control range of the injection valve used. The necessary condition is a suitable source of atomizing steam.

VHP parameters

1 nozzle

Qwater: 0 – 5,5 t/hr / nozzle
min size of steam pipeline: DN 150
min steam velocity in pipeline: 3 m/s
pressure drop across nozzle: 0 to 15 bar



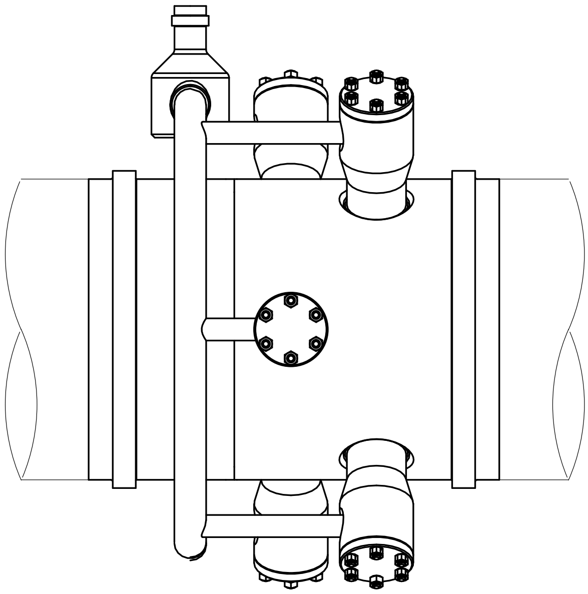
CHPR

Radial desuperheater, used for spraying the cooling water with the same nozzle design as the VH. The cooling water is injected perpendicular to the axis of the steam pipeline, which causes a higher velocity gradient between the steam and the injected water. CHPR is used mostly as a part of by-pass stations together with RS702 and RS902 valves, but it can also be a separate desuperheater.

CHPR parameters

2 to 6 nozzles

Qwater: 0,5 – 9,5 t/hr / nozzle
min size of steam pipeline: DN 200
min steam velocity in pipeline: 6 m/s
pressure drop across nozzle: 2 to 15 bar

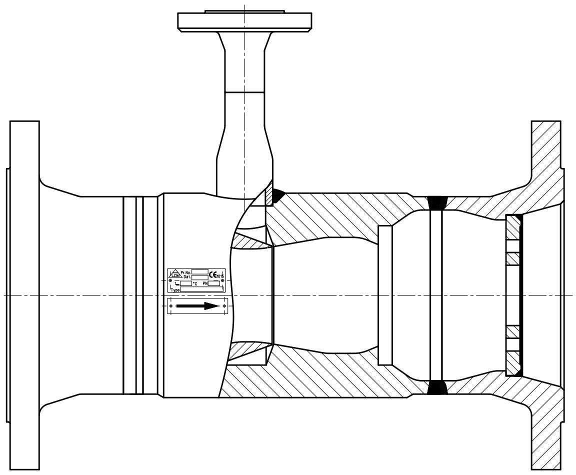


CHPE

The ejector steam desuperheater works on the same principle as a VHP, without the need for an auxiliary steam source. The cooling water is atomized with the help of the kinetic energy of the cooled steam, accelerated in the CHPE's tapered throat. To increase the cooling efficiency there is an orifice positioned in the cooler outlet, where secondary atomizing and evaporating of cooling water takes place. This design has a disadvantage in a higher pressure loss across the desuperheater.

CHPE parameters

Q_{WATER}: 0 – max. acc. to size DN
min size of steam pipeline: DN 40 - 200
min steam velocity in pipeline: 10 m/s
pressure drop across nozzle: 0 to 15 bar



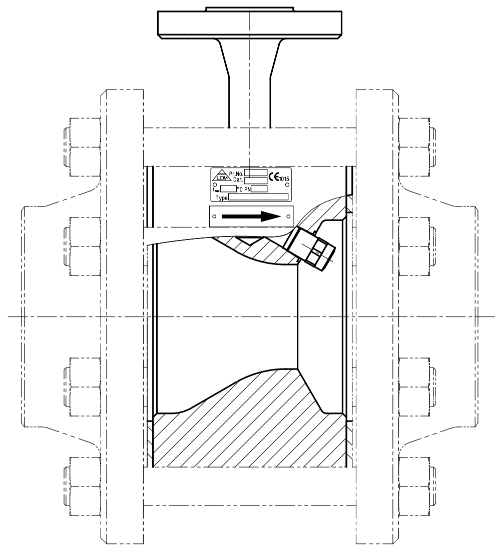
CHPF

The desuperheater is equipped with one or more nozzles (according to the desuperheater size and cooling capacity) with fixed geometry and works on the mechanical principle of atomizing. Two types of nozzles are used. Type H serves for injecting higher quantities of water; a full cone of bigger droplets of injected water is created. Type M utilizes a high pressure drop across the nozzle for very fine spraying of the injected water. This design is not recommended for control ranges higher than 1 : 4.

CHPF parameters

1 to N nozzles

Q_{WATER}: 5 – 1680 kg/hr / nozzle
min size of steam pipeline: DN 40 - 200
min steam velocity in pipeline: 10 m/s
pressure drop across nozzle: 1 to 70 bar



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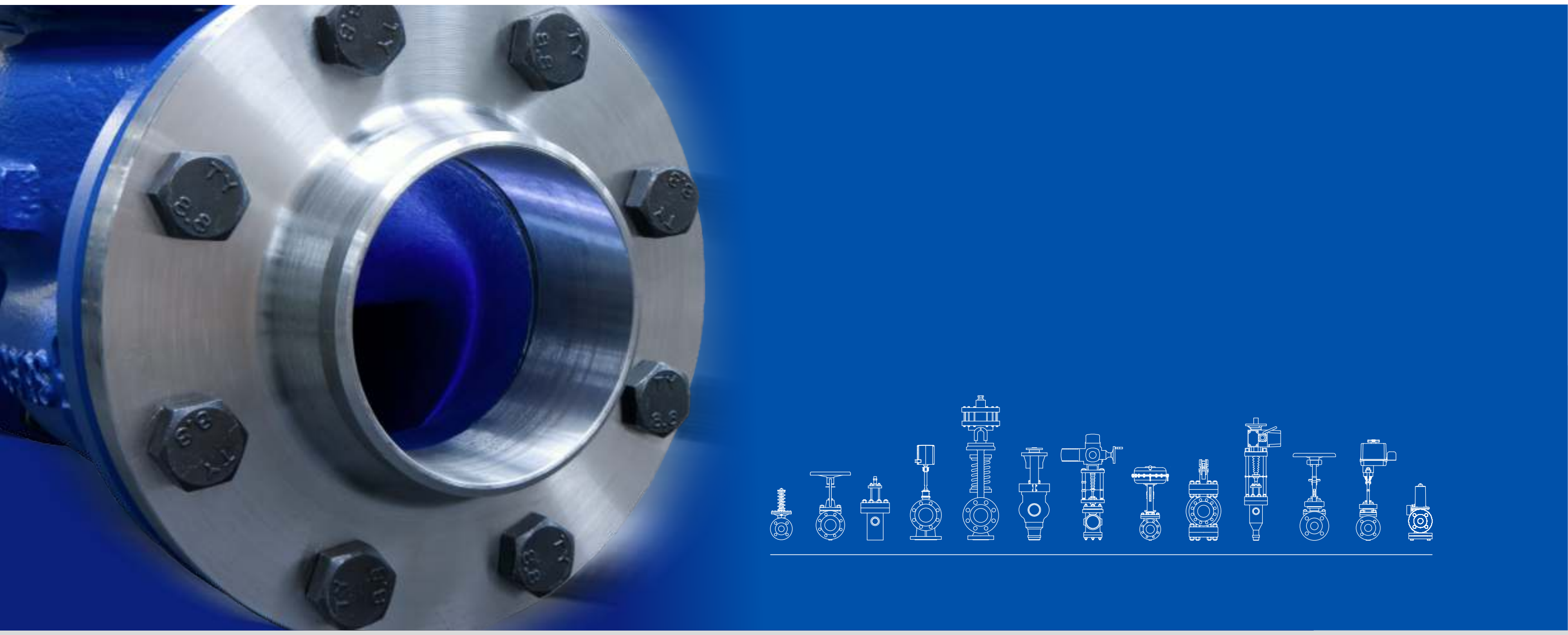

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