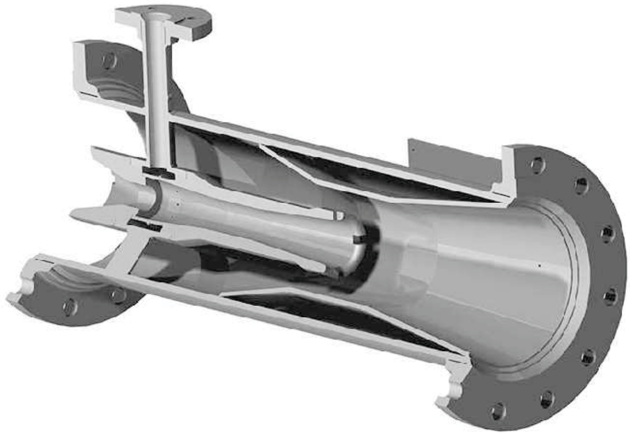
In typical process plants, process steam is usually superheated or heated to a temperature above saturation. The difference, between the saturation temperature and the actual temperature of the steam is called 'superheat'.

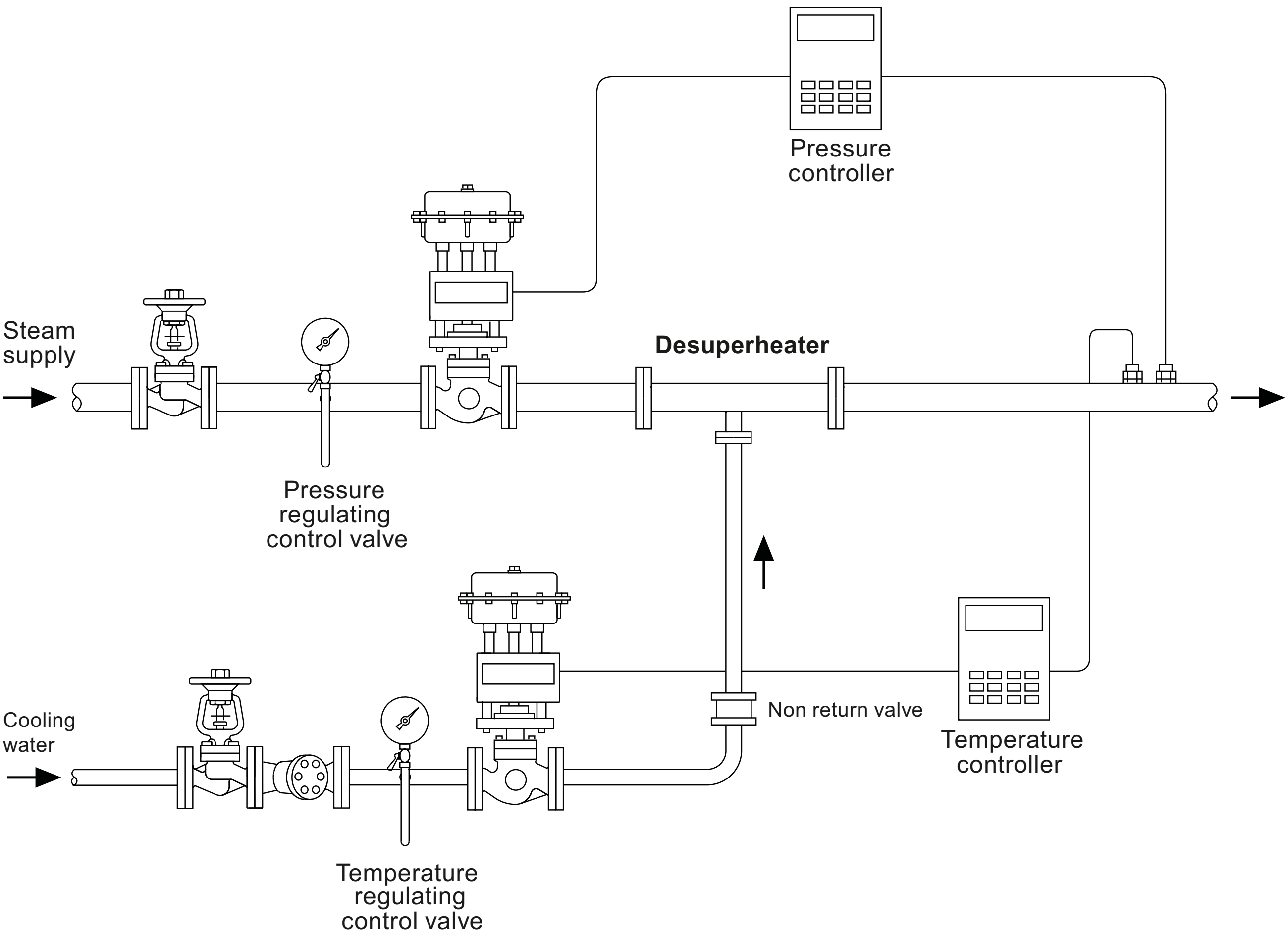
Desuperheated steam is more efficient in the transfer of thermal energy, consequently desuperheaters are used to bring the outlet degree of superheat closer to that of saturation.

Desuperheaters reduce the temperature of superheated process steam by introducing finely atomized cooling water droplets into the steam flow. As the droplets evaporate, sensible heat from the superheated steam is converted into latent heat of vaporization.

A typical desuperheater installation is shown below:



Spraytech Systems Combined pressure reducing / desuperheating station for venturi and spray type desuperheaters

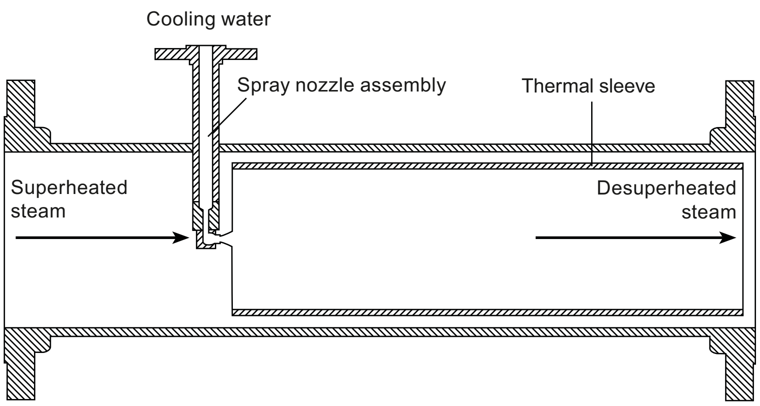


Types of desuperheater

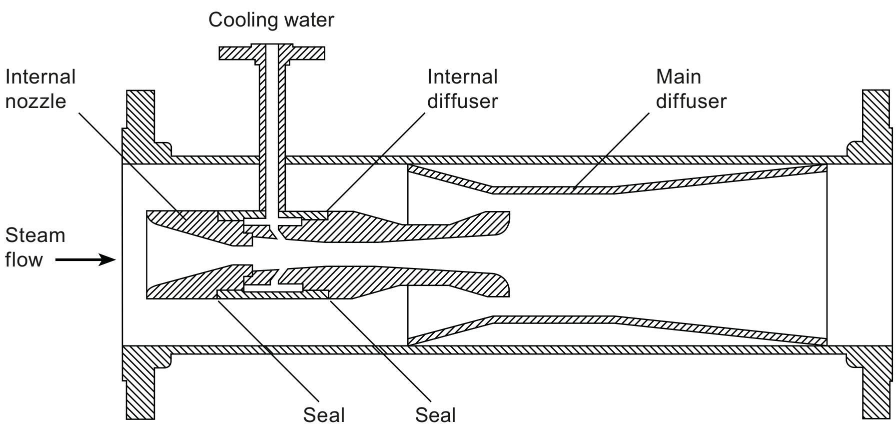
From the foregoing paragraphs, it is easy to understand why there has to be a period of good contactbetween the droplets of cooling water the superheated steam. If good contact is lost, the water can no longer absorb heat effectively from the steam, evaporation stops and the desuperheating process comes to a halt.

When the steam velocity is too low, 'water droplet fall-out' occurs and a pool of water is formed which runs along the bottom of pipe. At this point good contact between cooling water and the steam is lost and effective desuperheating will not occur. By following the guidelines presented in this document or using the Spraytech systems online sizing software, problems due to droplet fall-out can be avoided.

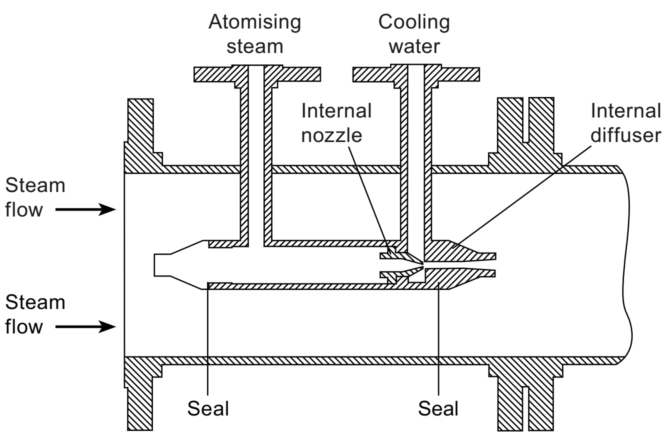
There are three basic types of Spraytech Systems desuperheater (shown below) which all use a different method to atomise the cooling water droplets. Each one has its own merits and the desuperheater selection chart shown on the following page determines which type should be selected.



Complete spray type desuperheater



Venturi type desuperheater



Steam atomising desuperheater

Finer droplets, therefore smaller absorbtion length and / or better turndown and approach to saturation

Desuperheater selection

There are various types of desuperheater available so evaluation of the process duty is crucial tensure selection of the right equipment. Turndown capability, pressure drop and outlet superheat play lead roles in desuperheater design and selection:

Turndown: (Maximum steam flowrate ÷ Minimum steam flowrate)
Turndown represents the variability of the steam flowrate. For many processes, turndown is very small or fixed. Generally, the higher the turndown, the more complicated the Desuperheater design.

Outlet superheat:
Although desuperheaters are capable of desuperheating to the saturation temperature of the steam, typically, desuperheaters are designed to produce steam temperatures at 3^{0} C to 5^{0}C above saturation. This is because it becomes increasingly difficult to control the process (and there is very little advantage) at lower temperatures.

Steam pressure drop (for venturi type desuperheaters):
For most pressure systems, a 0.4 to 0.7 bar g drop is considered reasonable. It should be noted that as the required turndown increases, so does the pressure drop. This is because there is a minimum acceptable pressure drop at the minimum flowrate case that ensures sufficient velocity to atomise the water droplets. Therefore, as the maximum steam flowrate increases, so does the velocity and hence the maximum pressure drop.

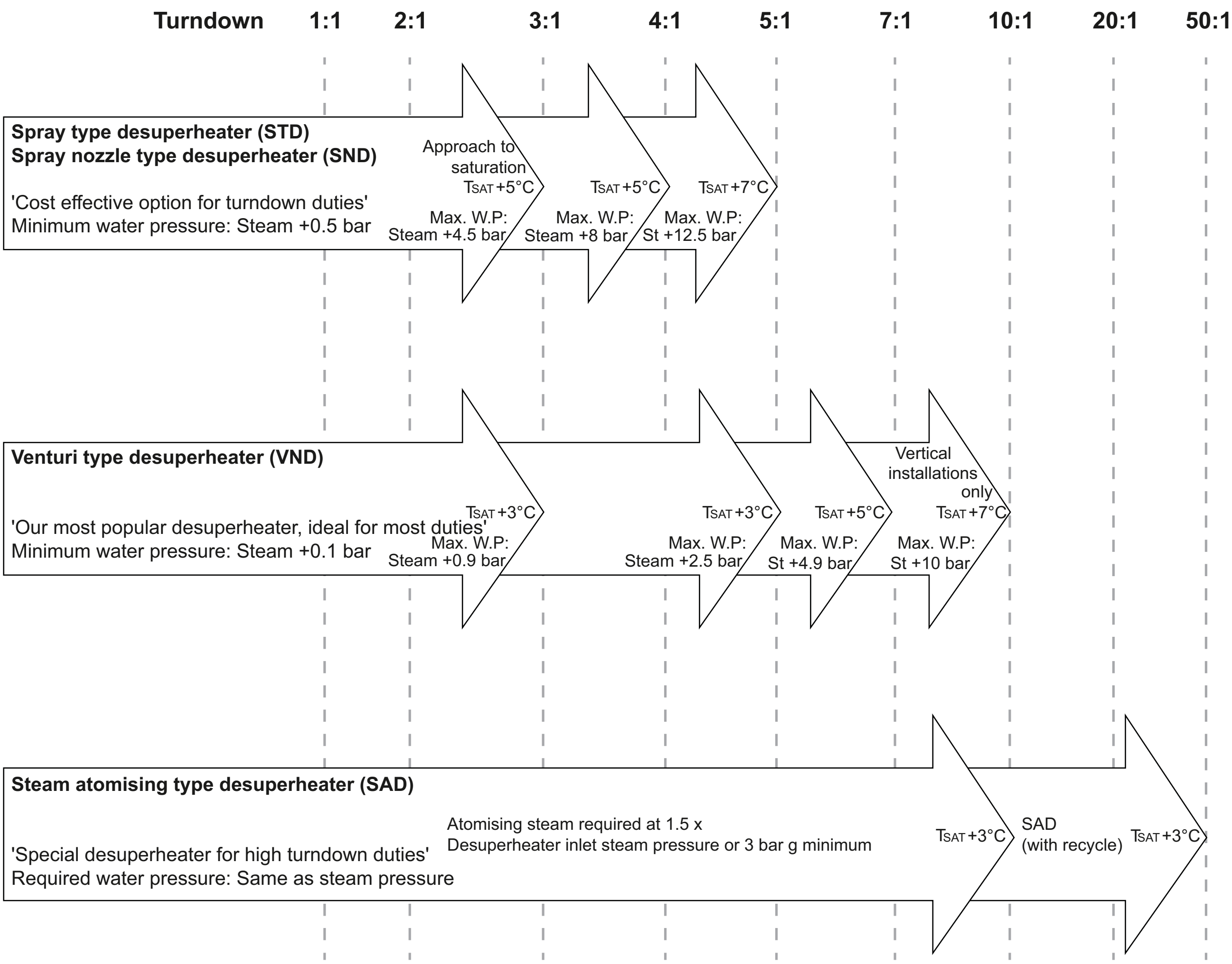
Water pressure drop (for spray type desuperheaters):
It should be noted that as the required turndown increases, the required cooling water pressure also increases.

Each type of Spraytech Systems desuperheater, employs a different method to create water droplets. The process by which the water droplets are created is usually referred to as 'atomisation'.

It must be remembered that the evaporation of the water droplets (and hence cooling of the steam) is a time dependent process and does not occur instantaneously. Consequently, most of the desuperheating does not occur in the desuperheater itself, but in the pipework immediately downstream. Thus, the design of the downstream pipework is a crucial factor in a successful desuperheater installation.

It is important that the water droplets remain suspended in the downstream pipework for as long as possible. To ensure this, it is necessary to maintain sufficient turbulence in the downstream piping by keeping the velocity relatively high – higher than is usually encountered in steam distribution systems (up to 60 m/s). This is the reason why desuperheaters and their associated pipework are often (not always) smaller than the distribution system in which they are being installed.

Desuperheater selection chart



Other considerations

Desuperheater orientation

Desuperheaters may be installed either horizontally or vertically (with the steam flowing upwards)In a vertical installation, increased turndown can be achieved; as the steam and water are countered by gravity, the water is less likely to fall out of suspension. Spraytech Systems strongly advises against installations in which the steam flow is vertically downwards, as the opposite would occur.

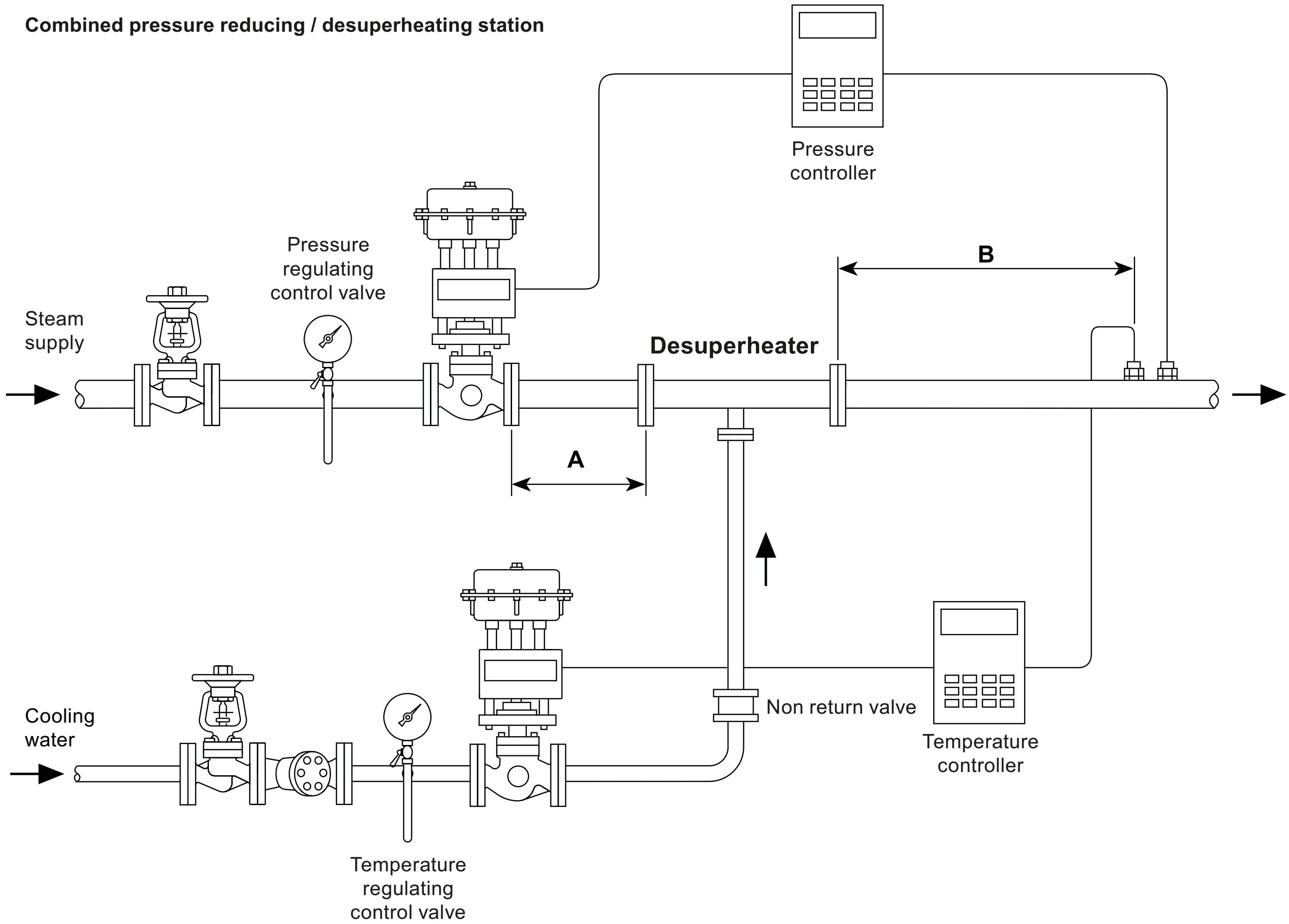
In the case of a horizontal installation the cooling water connection (and the atomising steam connection on a SAD (steam atomising desuperheater) should ideally point downwards, as this gives the best orientation for drainage of fluids in a shutdown situation. Other orientations are acceptable for satisfactory operation, but drainage is not as effective.

In a vertical installation we recommend that, the cooling water pipework (and atomising steam pipework, if applicable) should be brought to the desuperheater from below the corresponding connections on the desuperheater. This will provide the best layout for drainage of fluids on shutdown.

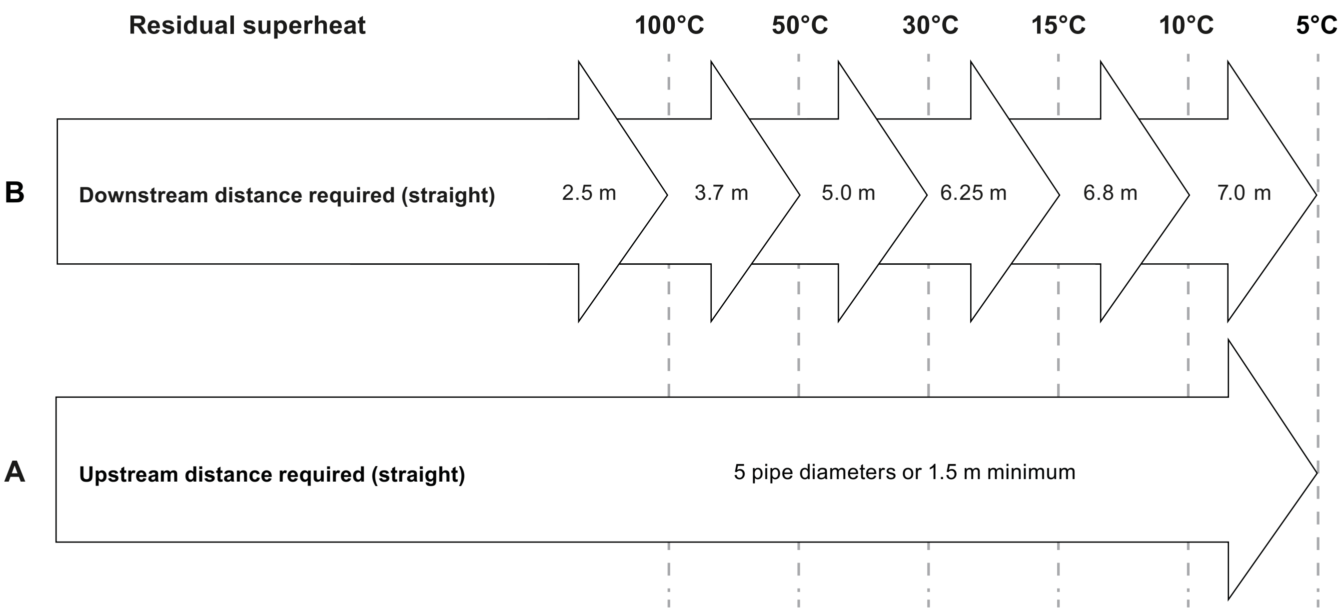
Distances

The diagram below indicates the recommended straight length distances between the desuperheater and upstream / downstream equipment. The distances are represented by length 'A' and 'B'.

Combined pressure reducing / desuperheating station



Recommended distances for location of pressure and temperature sensors and equipment:



'The greater the residual superheat, the faster the water droplets are absorbed'

Other considerations (continued)

Cooling water supply
Typical cooling water supply options are as follows:
- Boiler feedwater (BFW) (taken from the pressure side of the boiler feedpump).
- Demineralised water.
- De-ionised water.
- Condensate.

Town's water or process water may also be used, but depending on hardness, salts may be deposited on the inside of downstream pipework and the face of valve seats and plugs.

Cooling water quality
The quality of the injected water is important. The TDS (Total Dissolved Solids) of the injection water should be as low as possible since all these solids will come out of solution and be deposited on the faces of valves and could block up the small orifices in the desuperheater nozzles.

Cooling water temperature
Generally, the hotter the better. This is because hot droplets need to absorb less heat to reach their flash temperature than cold ones. Hence, hot droplets will evaporate more quickly, producing a more efficient desuperheating process. Using hot water also has the additional advantage that smaller amounts of water will fall onto the inside walls of the pipework.

Because of the benefits of using hot water, it is logical to insulate the water supply pipes to minimise heat loss.

Cooling water pressure and flowrate
In order to inject the cooling water, its pressure at the desuperheater nozzle must be equal to or greater than the operating steam pressure in the pipe. The requirement varies from one type of desuperheater to another, but typical minimum values are:
- Spray type desuperheater steam pressure + 0.5 bar
- Venturi type desuperheater steam pressure + 0.1 bar
- Steam atomising type desuperheater equal to steam pressure

For the spray and Venturi type desuperheaters, the highest water inlet pressure required will be at the highest cooling water flowrate.

It should be noted that the water flowrate is a function of the square of the pressure difference between cooling water and the steam. So if the water flowrate is to be increased by a factor of 4 for example, then the pressure difference must increase by a factor of 42 = 16. This is the reason why it is important not to over-specify the turndown as high cooling water pressures are quickly reached (especially with spray type desuperheaters).

If an independent or booster pump is used, a spill-back will be required to ensure that there is always flow through the pump.

Cooling water control valve
A pressure drop will be required over the water control valve. We have already said that ideally the water should be as hot as possible so care is needed to ensure that flashing conditions do not exist across the control valve.

Superheated steam pressure control
It is desirable that a constant steam supply pressure be maintained.

The temperature of the steam after the desuperheater controls the amount of water added. The higher the temperature, the more the control valve will open and the greater the amount of water that is added. Usually the target is to reduce the steam temperature to within a small margin of saturation temperature. In virtually all applications the upstream pressure will be controlled and constant, however, if the superheated steam supply pressure is increased, the saturation temperature will also increase. The set value on the Controller will not change, and an excessive amount of water will be added as the control system tries to achieve the set temperature. This would result in very wet saturated steam with its attendant problems.

Control
In this document we have frequently used the term 'turndown' to describe the performance of the different types of desuperheater. However, as far as an installation is concerned, it should remembered that the desuperheater is only one element of a desuperheating station. Obviously, if the controls that are fitted have lower turndown than the desuperheater, then the turndown of the desuperheater station will be reduced.

For example, in a particular pressure reducing / desuperheating station, the rangability of the cooling water valve may not be as high as the desuperheater. In this case it will be the rangability of the water control valve that limits the turndown of the desuperheating station.

Separator station
In applications where there must be no moisture present in the resulting steam (such as prior to a turbine for example) it is recommended that a separator is installed downstream of the desuperheater. This will protect downstream pipework and equipment from the effects of moisture in the event of a control system failure or abnormal operating conditions, for example at start-up.

The separator must be located after the temperature sensor thereby giving the water droplets as much time as possible to evaporate.

Strainer

Spraytech Systems recommend that a strainer is incorporated in the cooling water supply line to protect both the cooling water control valve and the small bores within the desuperheater from becoming blocked.

Isolation valves

To allow maintenance to be safely carried out, isolation valves are recommended upstream of:

- The superheated steam pressure control valve.
- The cooling water control valve.

Safety valve

In applications involving simultaneous pressure reduction, a safety relief valve may be needed to protect both the desuperheater and downstream equipment from the effects of:

- Excess pressure in the event of pressure control system failure.
- Excess temperature in the event of temperature control system failure.

It is essential that the desuperheater and downstream equipment are suitable for the maximum temperature of the superheated steam. This is to protect these items in the event of a failure of both the pressure and temperature control systems.

Recycle loop

For SAD steam atomising desuperheaters with a very high turndown a 'catchpot and recycle loop' are often installed as shown on the diagram below. The recycled condensate is hot which leads to faster absorption.

The desuperheater generates a small suction effect to draw the recycle water back to the desuperheater ensuring that the water doesn't 'by-pass' the desuperheater.

Spraytech Systems Combined pressure reducing / desuperheating station for steam atomising type desuperheaters