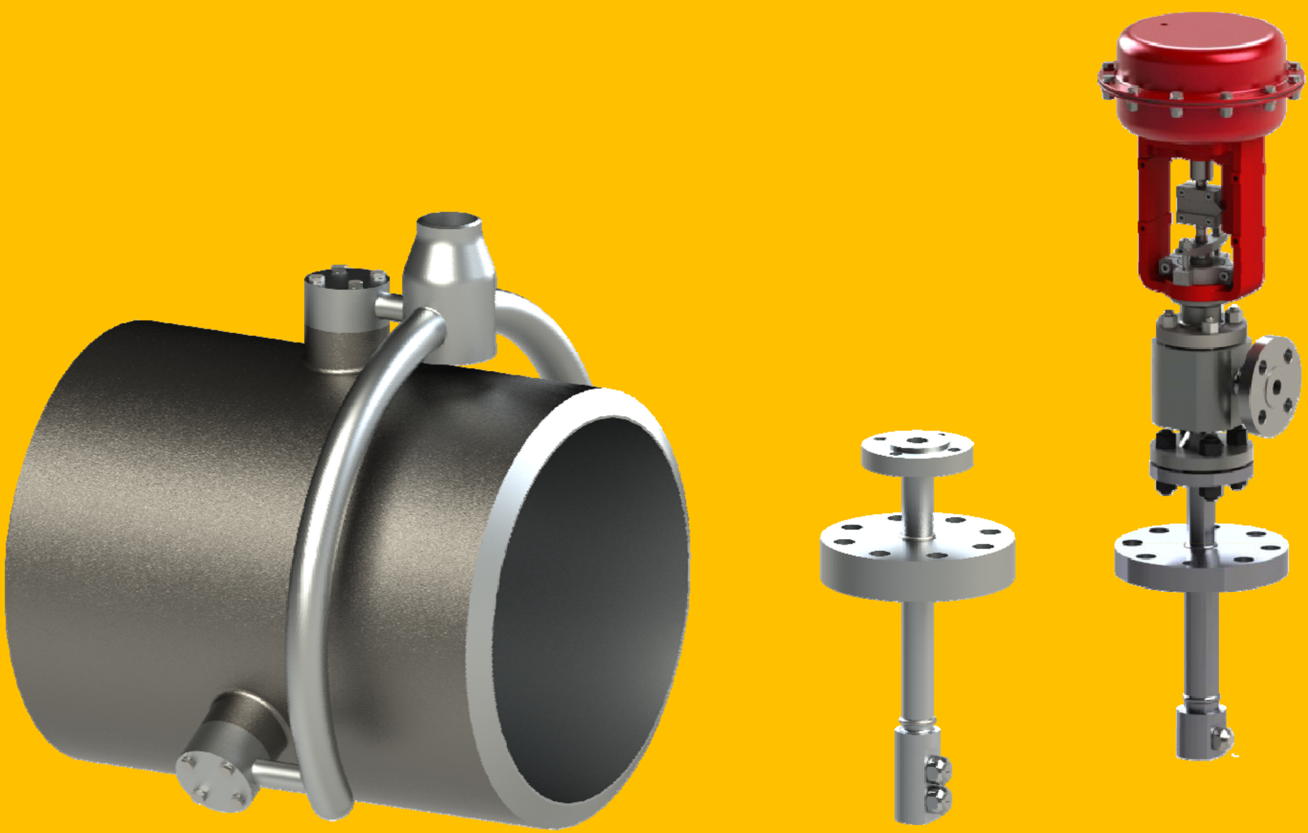
SNSD/DNSD/TNSD/CCSD-Series DESUPERHEATERS

Probe Type Steam Desuperheater

MNSD-Series DESUPERHEATER

Multiple Variable Area Spray Nozzle Steam Desupeheater



Introduction

BFS offers the industry's broadest line of desuperheaters ranging from relatively variable area nozzle types to state-of-the-art, highly efficient pressure reducing and desuperheating stations.
This catalogue begins with a general introduction to desuperheating as a described on pages 3. The simplest desuperheaters are discribed initially, moving on through the catalog in increasing order of efficiency, capability and performance.
The addition pages will help in the selection of a desuperheater that will suit most any particular application. The chart details performance requirements and installation requirements which ultimately leads to the sizing and selection of the proper desuperheater.

Contents

Model Numbering System

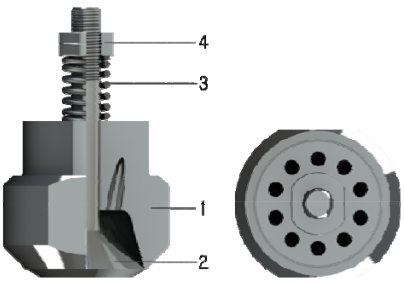
SNSD Single Variable Area Nozzle Steam Desuperheater (Prove type)
DNSD Double Variable Area Nozzle Steam Desuperheater (Prove type)
TNSD Triple Variable Area Nozzle Steam Desuperheater (Prove type)
CCSD Cooling Water Control Valve Combined Steam Desuperheater (prove type)
MNSD Multi Variable Area Nozzle Steam Desuperheater

1	2	3	4	5
Body series	**Size/Inch**	**Schedule**	**Nozzle Number**	**Nozzle Q'ty**
SNSD-Series	Actual size	Actual schedule	**20**-VN20	Actual Quantity
DNSD-Series			**28**-VN28	
TNSD-Series			**40**-VN40	
CCSD-Series				
MNSD-Series				

1. Water Injection Variable Nozzle

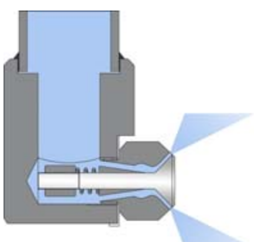
Spring loaded Nozzle Desuperheating HP & LP desuperheating features. Integral spring-loaded water injection nozzle that optimize water injection over a wide range of flow rates at low pressures. With a range-ability of up to 50:1, the spring loaded water injection nozzle varies the water flow as required to achieve the fine water droplet size needed for automization. The Spring loaded water injection nozzle design provides the smallest water droplet size possible without steam assist.

For Precise and economical control of steam temperature., the bFS desuperheater automatically introduces cooling water into steam flow in response to a pneumatic or electric signal. The bFS desuperheater represents a major advance in the design of this type of equipment. It has an unusually high turn-down-ratio double that of unit previously available. This permits its use in systems with wide fluctuations in steam flow unit



Nozzle Head Cross Section

1. Nozzle Body *2. Nozzle Plug*
3. Nozzle Spring *4. Spring Adjust Nut.*



Spray of Variable Nozzle of SNSD

Small enough to mount through a 3" flange in the steam line, it includes features previously found only in larger, more space consuming desuperheater units. Water pressure 3-4Bar to 62Bar above steam pressure is the spring loaded water injection nozzles. The fine sprays evaporate rapidly in the steam, thereby minimizing the tendency for spray water to accumulate in the line.

The following recommendations apply to inter-stage and final-stage Attemperators for HP and Reheat. Where the differential temperature between inlet steam and injected water exceeds 250deg.C (450deg.F)

1-1. Spring loaded variable area nozzles required.
1-2. The minimum clearance of the spray boundary from the pipe wall shall be12% of the pipe diameter, measured at a distance of one pipe diameter downstream of the spray injection point.
1-3. Circumferentially, wall mounted nozzles are required.
1-4. Spray water valve and attenperator must be separate components when the delta T between injected water and inlet steam exceeds 250deg.C (450deg.F)
1-5. A liner is required.
1-6. Nozzles protrusion into steam shall be minimized
1-7. Attemperator should incorporate a thermal barrier.
1-8. The maximum water droplet size exiting from the attemperator shall be 125microns for all operating conditions. Supplier shall calculate the water droplet size for all operating conditions. The basis and results shall be shown by manual or computer calculations.
1-9. Spring loaded nozzles shall be capable of opening at least 0.08inch (2mm)
1-10. Moving parts (spray nozzles, water valve trim componets) shall be easily removable without the need to cut the steam pipe.
1-11. Water valve must remain closed when there is no steam pressure in pipe.
1-12. For the range of operating conditions flashing and/or cavitation shall be permitted.
1-13. The water control valve trim shall provide a sufficient number of discrete pressure drop stages to maintain the trim exit velocity less than 100ft/sec(30m/s)
1-14. Selection of Nozzle Size

To select a nozzle suitable for your system, start with the calculation of :

- The maximum cooling water flow in kg/min that is required, and convert this value to ㎥/hr.

- The lowest available pressure difference between the steam pressure in the line and the cooling water pressure.

then select from the capacity curve situated above the intersection of the above values.

The differential pressure steam/water should not be lower than 2.5bar to ensure good quality atomization of the water, but not exceed 30bar to prevent erosion of the nozzle. A good average differential pressure is 10bar

Nozzle Model

Model	VN20	VN28	VN40	Unit
ΔP	2.5～30	3.0～12	1.0～14	bar
Cv	2.3	4.2	6.8	Max

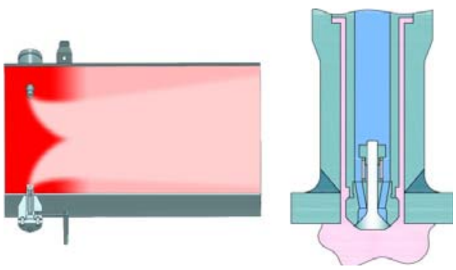
1-15. Design & Operation

The BFS Variable area nozzle steam desuperheater consists of a tube-shaped with a flange for fixing of the desuperheater on the header. The water inlet, too, is flanged and at 90 ° to the desuperheater to facilitate service access.

The injection nozzle is screwed onto the body and secured by a lock washer

The cooling water enters the desuperheater through the flange and a series of orifices in the body that are oriented in a way to induce the water leaving the spray orifice (2) into rapid rotation. The angle of the nozzle's seat is slightly different from the one of the injectors body so as to obtain a maximum velocity of the water leaving the nozzle. These two design particulars - fast rotation and high velocity of the water at leaving the nozzle- guarantee very fast evaporation of the cooling water in the steam.

In order to maintain constant pressure inside the injection nozzle, the latter is preloaded by a series of disc springs calibrated in function of the water/steam ΔP. Thanks to design characteristic, any load variation in the external water control valve is immediately compensated by a change of the orifice section of the nozzle, assuring optimum water atomisation at all times.



Thermal Sock Barrier

2. Order Specification

In order to give you a complete quotation and correct delivery time we like to have the following data.

Main Steam

- Steam flow : kg/hr. (Q1)
- Pressure : barA (P1)
- Inlet Temperature : ℃ (T1)
- Outlet Temperature : ℃ (T2)
- Pipe diameter : inch.

Available cooling water

- Temperature : ℃ (T3)
- Pressure : barA (P3)

Additional

- Required turn-down ratio
- Installation parameter
- Availability of spray water / steam
- Accessory requirements.

Calculations

Calculate the required flow of cooling water needed to control the steam temperature at the outlet by the heat balance method.

$$Q_W = \frac{W_S(H_1 - H_2)}{(H_2 - H_W)}$$

Sizing

Required data for the desuperheater sizing

Where

Qw : Required flow of cooling water (Kg/h)

Ws : Inlet steam flow (Kg/h)

H1 : Enthalpy of superheated steam at inlet(Kj/Kg)

H2 : Enthalpy of steam mixture at outlet (Kj/Kg)

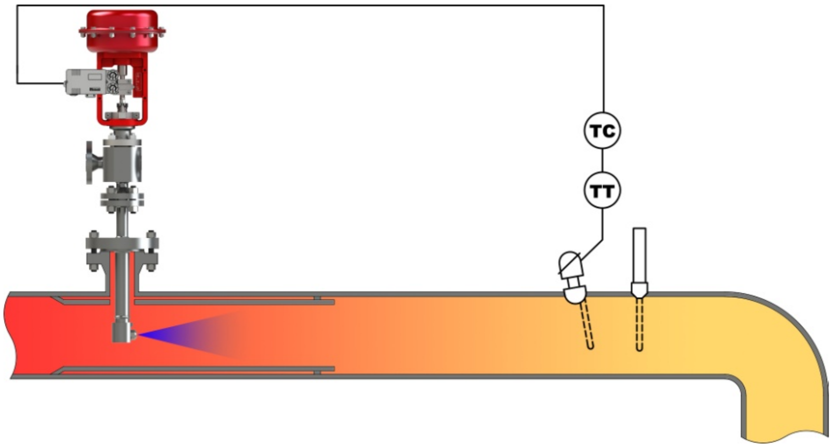
Hw: Enthalpy of cooling water at outlet (Kj/Kg)

Performance

The performance of a desuperheater is depending on themodynamic and fluid mechanical properties such as.

- Steam Velocity
- Steam Pressure
- Steam temperature before and after desuperheating.
- Water pressure and available ΔP.
- Water temperature and viscocity
- Water droplet size and distribution.
- Difference between actual steam temperature and saturation temperature.

Those variables, however, do not refer to the size of the steam piping and the type of injection nozzles and their pray pattern.



Concept of Desuperheater Installation

3. Desuperheating System

The performance of a desuperheater is depending on thermodynamic and fluid mechanical properties, such as:

- Steam Velocity
- Steam Pressure
- Steam temperature before, and after desuperheating.
- Water pressure and available ΔP.
- Water temperature and viscosity.
- Water droplet size and distribution.
- Difference between actual steam temperature and saturation temperature.

Those variables, however, do not refer to the size of the steam piping and the type of injection nozzles and their pray pattern.

3-1. Desuperheater Installation

A desuperheater requires straight pipe-runs both upstream and downstream to provide good performance.

The reason for having straight pipe-run upstream is that a pipe bend creates a flow pattern that is non-uniform. Espcially two or more pipe bends in 3 dimensions (x, y, z) just before the desuperheater is known to cause very unstable flow.

3-2. Straight Pipe-run Upstream Recommendations.

BFS recommends upstream straight pipe to be.

Φ <200mm (8")	1m or longer
Φ 200(8") to 400mm(16")	min 5 x Φ
Φ > 400mm(16")	min 3 x Φ

If a flow divider is installed upstream, the distance to the desuperheater should be minimum twice the normal straight upstream recommendations.

3-3. Distance to First Bend

After a desuperheater, it takes some time before most of the water drops evaporate. To avoid problems with free water hitting the pipe wall and causing erosion and free water following the pipe wall, it is necessary to have minimum distance before the first bend. To minimize that problem, we recommend that the distance before the first pipe bend should be at a minimum 0.1s x maximum steam velocity..

3-4. Distance to the Temperature Sensor

The recommended distance before the temperature sensor is 0.2 s x maximum steam velocity for 15% ratio spray water/steam flow or less and 0.3 s x maximum steam velocity for more than 15% ratio spray water/steam flow.

The valves are based on 10℃ above saturation and a cooling water temperature of 90℃.

Lower ΔP gives longer distance and higher ΔP gives a shorter distance. Lower cooling water temperature can significantly increase the required minimum distance to the temperature sensor.

3-5. Minimum Distance to Temperature Sensor

In desuperheater applications with low velocity, the required distance can be longer than usual and minimum distance to temperature sensor should therefore never be shorter than 12m.

3-6. Distance to Flow Dividers

The outlet from a desuperheater must never be divided by a T-piece, Y-piece or any other configuration before the outlet temperature can be properly controlled.

3-7. Low Velocity in the Steam Line at Minimum Load
It is much better to install a liner instead of decreasing the line size and then enlarge the pipe again.

3-8. A liner has several advantages:
- The decrease in diameter creates vortexis which will improve the turbulence and therefore the mixing between steam and water.
- The velocity will increase and improve the automizing off the water drops which will increase the effectiveness of the desuperheater.
- The abrupt enlargement will with the liner increase the turbulence and therefore the mixing between steam and water.

4. Desuperheater Series

4-1. MNSD-Series
Multi-variable-Nozzle Steam Desuperheater

The bFS steam desuperheater MNSD used in desuperheater applications where large spray water flows are required for cooling of the steam.

The MNSD is part of the steam line with a number of water atomizing nozzles, Variable Nozzles. The nozzles are connected to a common spray water pipe connection.

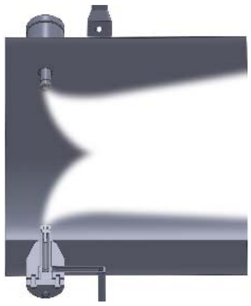
The spray water flow is controlled by a separate spray water control valve. A liner can be installed in the MNSD to improve the system turn down or protect the steam line.

The MNSD can easily be adapted for any special requirement, such as incorporation of separate emergency cooling arrangement or split range operation

4-1-1. Typical MNSD-Series

1. Size / 8" (200A) to 60"(1500A).
2. Turn down ratio / Selected water control valve
3. Pressure Class / ANSI 150# to 4500#
4. Minimum straight pipe run upstream of the MNSD : Pipe Diameter x 6 or at least 4m for pipe diameters larger than, or equal to 28" (700mm).
5. Min. straight pipe run downstream the MNSD 7m. to 12m.
6. Size / 8" (200A) to 60"(1500A)
7. Turn down ratio / Selected water control valve
8. Pressure Class / ANSI 150# to 4500#
9. Minimum straight pipe run upstream of the MNSD : Pipe Diameter x 6 or at least 4m for pipe diameters larger than, or equal to 28" (700mm).
10. Min. straight pipe run downstream the MNSD 7m. to 12m..

MNSD-series
Multi-Nozzle Steam Desuperheater



Cooling water Spray

4-2. SNSD/DNSD/TNSD-Series,
Variable-Area-Nozzle Steam Desuperheater

The bFS steam desuperheater SNSD consists of a tube shaped body with flange for bolting of the desuperheater to the insertion stud that is welded to the steam pipe. The water inlet is also flanged, at 90deg. angle to the desuperheater, to equipment service access.

The cooling water enters the inner nozzle chamber in the desuperheater through the flange. In the inner nozzle chamber the water is induced to fast rotation around the control plug by the special arrangement of the admission holes. The angle of the nozzle seat is slightly different from the nozzle holder so that the water velocity will accelerate the whole time and reach its maximum as it leaves the nozzle.

In order to maintain a constant pressure inside the injection nozzle, the latter is preloaded by a spring calibrated in function of the water/steam differential pressure.

Used for desuperheating of steam in small and medium sized pipes and is specially useful when the cooling water temperature is close to saturation.

4-2-1. Typical SNSD-Series

- Single Variable Area Nozzle Steam Desuperheater
- Size / 4" to 8"(150A).other size/option.
- Turn Down Ratio / 50:1
- Pressure Class / ANSI 150# to 4500#
- We recommend you to protect the desupe-heater from unnecessary wear and clogging by installing a filter between the SNSD and the water valve.
- Option : Under 3"desuperheater (Orifice type)

SNSD-series
Single Nozzle Steam Desuperheater

4-2-2. Typical SNSD-Series

- Size / 4" to 8"(150A).other size/option.
- Turn Down Ratio / 50:1
- Pressure Class / ANSI 150# to 400#
- We recommend you to protect the desupe-heater from unnecessary wear and clogging by installing a filter between the SNSD and the water valve.
- Option : Under 3"desuperheater (Orifice type)

DNSD-series
Double Nozzle Steam Desuperheater

4-2-3. Typical DNSD/TNSD-Series

- Construction
  ; DNSD - Double Variable Nozzle Desuperheater
  ; TNSD - Triple Variable Nozzle Desuperheater
- Trim Form : Variable Area Nozzle
- Ragneability : 50 vs 1
- Application Pipe Size : 12" to 24" (Option <24")
- Pressure Rating : ANSI Class 150 to 4500
- Typical Application :
  ; Direct installation in the steam line will save consider-able space.

TNSD-series
Triple Nozzle Steam Desuperheater

4-3. CCSD-series

Cooling Water Control Valve Combined Steam Desuperheater (Nozzle/SNSD,DNSD,TNSD)

The CCSD cooling water spray control valve combines a desuperheater for a complete desuperheating system in one piece of equipment.

The variable nozzle spray type desuperheater is designed to reduce steam temperature by the introduction of a coolant directly into the hot fluid to achieve contact desuperheating. The coolant is atomized as it passes under pressure through a series of spray nozzles which assists it in evaporating into the vapor and results in an increased quantity of vapor at the specified final temperature.

The CCSD desuperheaters are available in pressure classes 600 lb.900lb, 1500lb. and 2500 lb. per ANSI B16.5. The head is designed using the rules of ANSI B16.34 and is supplied for mounting to a suitable branch on the main vapor header.

CCSD-series (SNSD/DNSD/TNSD)
Cooling-water Control Valve Combined Desuperheater

Typical CCSD-Series

- Construction : Desuperheater Combined Cooling-water Control Valve.
- TCV Trim Form : MH1S, MH2S, MH3S, X[iks]-trim.
- Nozzle Type : Variable Area Nozzle
- Rangeability : 50 vs 1
- Application Pipe Size : 6" to 26"
- Pressure Rating : ANSI Class 300 to 4500
- Typical Application :

; Direct installation in the steam line will save considerable space / Attemperator Desuperheater.

5. Additional Terminology

To get a well performing temperature loop it is also very important to consider.

- Response time for temperature sensor.
- Time response and sampling time controller / DCS
- Time response and sampling time for actuator.
- Pipe size, large pipes frequently have non-uniform temperature distribution and should have three temperature sensors perpendicular to the pipe with 120 degrees between each other.
- Velocity at minimum load. If the minimum velocity is below ≈- 12 m/sec. depending on pipe size, steam-assisted desuperheater should be used, or a liner to increase velocity.
- Protective pockets quick response type should always be used..

If the desuperheater is installed downstream a pressure reduction valve, the factory must always be contacted since many valves create such non-uniform flow patte-rn pattern that the desuperheater function will be very poor. The piping must be considered separately for each application and no general guidelines can be given.

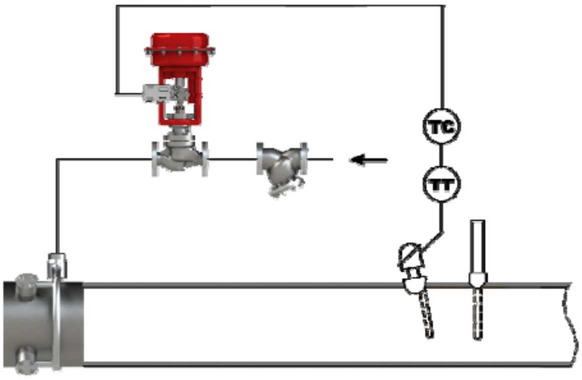
5-1. Installation of MNSD-series

Selector the location of installation carefully. This is especially important in cases where the steam velocity is low and the steam temperature is close to saturation. Straight pipe runs upstream and downstream are very important as well as the distance between the temperature sensor and the MNSD-series.

5-1-1. Use following rules thumb.

- Minimum straight pipe run upstream of the MNSD 6 x pipe diameter or at least 4m for pipe diameters larger than, or equal to 700mm(28")

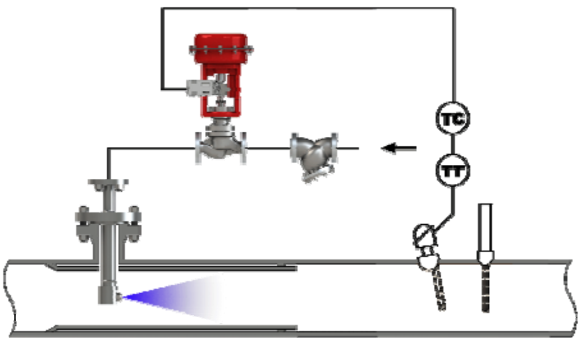
- Minimum straight pipe run downstream of the MNSD 6m.
- Minimum 12m if no protective sleeve for the thermo-well is used.
- Minimum 8m is a protective sleeve for the thermo-well is used.



Typical Installation of MNSD-series

5-2. Installation of SNSD/DNSD/TNSD-series

Select the installation point carefully. This is especially important in cases where the steam velocity is low and the steam temperature is close to saturation. It is equally important to install the temperature sensor where it. in a representative manner, can sense the temperature that shall be controlled.



Typical Installation of SNSD/DNSD/TNSD-series

5-3. Attemperator

Water is injected between the superheater sections in order to control the outlet temperature of the steam leaving the boiler. This desuperheater application is the most critical desuperheater application in a power plant.

The reasons are two:

- Very high rangeability is normally required because of start-up conditions and over-sizing due to design reasons.
- If the desuperheater is not functioning properly, the financial losses are much higher than the installation cost if the plant has to be stopped for a couple of hours.

5-3-1. Superheater Attemperator Spray Control Valve

To gain maximum efficiency from the steam and, at the same time, not damage the delicate blades of the turbine, the temperature of the steam must be carefully controlled. Between the primary and secondary superheater in the main steam system there is a desuperheater or attemperator in the steam line. The water spray from the attemperator lowers and regulates the temperature of the steam going in to the secondary superheater. This valve controlling the water spray flow is called the superheater attemperator spray valve. The water is taken from an auxiliary line off the feedwater pump. Its pressure is slightly higher than the steam line pressure, therefore, the pressure drop through the valve is low.

Typical service conditions are as follows

Drum Boiler	***Once Through Boiler***
P1 : 191 to 225bar	***P1 : 253 to 274barG***
ΔP : 7barD to 14barD	***ΔP : 7barD to 14barD***
Temp : 149℃to 204 ℃	***Temp : 149℃ to 204℃.***

5-3-2. Reheater Attemperator Spray Control Valve

The reheat attemperator spray control valve serves a function similar to the superheat attemperator spray control valve. In this case, the attemperator is located in the reheat line before the steam enters the low pressure turbine. The steam is at a much lower pressure in the reheat section so the water spray control valve experiences much higher pressure drop and is likely to cavitate. This is particularly demanding application because very low flows must be controlled in the presence of cavitation, Tight shut-off is also required.

Typical service conditions are as follows

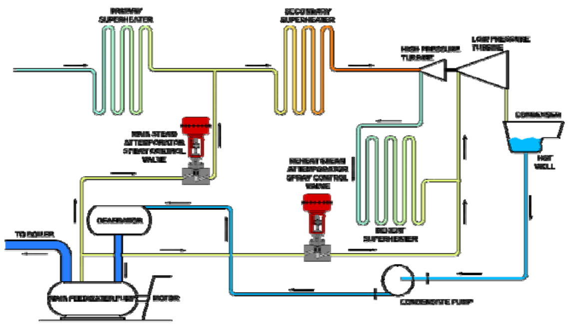
Drum Boiler	***Once Through Boiler***
P1 : 191 to 225barG	***P1 : 253 to 274barG***
ΔP : 162barD to 183barD	***ΔP : 162barG to 253barG***
Temp : 149℃ to 204℃	***Temp : 149℃ to 204℃***

5-3-3. Attemperators Application for HRSG's

Attemperator are utilized in **H**eat **R**ecovery **S**team **G**eneration (HRSG's) between the primary and secondary superheaters on the High Pressure(HP) and the Reheat (RH) lines in some designs, attemperators are also added after the final stage of superheating.

Attemperators installed in the HP interstage will typically see pressures up to 130 barg and temperatures 550℃ with steam flow rates in the region of 300,000kg/hr.

Attemperators installed on the RH interstage will typically see similar temperatures and flow rates, but pressure to only around 30 barg. The control temperature for these attemperators is adjusted so that the final superheater satisfies the start-up and steam turbine inlet requirement These attemperators are critical to the overall performance of the HRSG and provide the following functions:



Attemperator Control Diagram

★ Control final temperature from HRSG
- Prevent thermal damage stage piping and downstream equipment, such as the steam turbine.
- For start-up and allowing gradual heat rate to the steam turbine.

★ Control steam temperature to the second stage superheaters.
- Prevent overheating of superheater tubes.
- Prevent over stressing of superheater tubes.

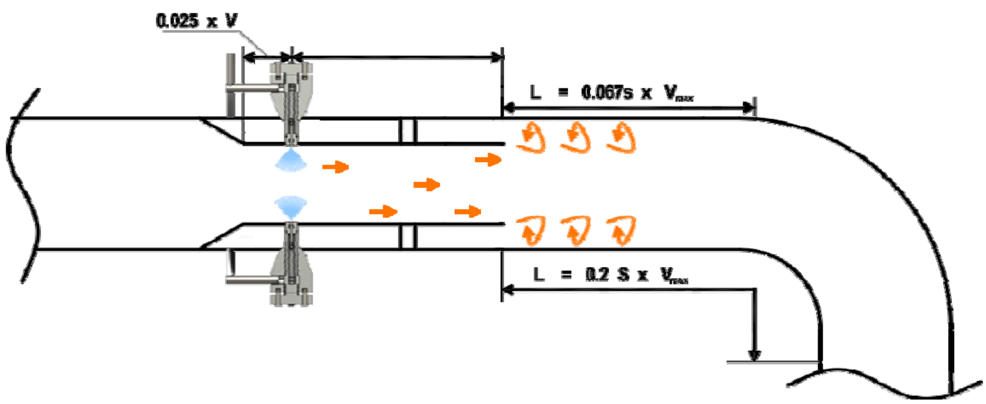
MNSD attemperator which satisfies all mechanical and thermo-dynamic & fluid dynamic considerations.
- Control valve element separate from attemperator
- Nozzle minimally protrude into the steam flow.
- Eliminates damaging vibration from von Karman vortex street.
- Incorporates a thermal liner for pipe wall protection and improved performance.
- Less than 125 micron droplet diameter assured.
- Each nozzle engineered to provide optimum spray pattern penetration and cross sectional coverage.

5-3-4. Liners

Typically, most attemperator suppliers will only provide a liner to protect the steam pipe wall from thermal shock. However, a properly engineered liner is capable of enhancing the attemperator performance. BFS utilizesliners to provide the following.
- Protects steam pipe from thermal shock.
- Increase velocity to improve secondary atomization.
- Generate vortices to further improve atomization and enhance mixing
- Assist with heat transfer and evaporation of water.

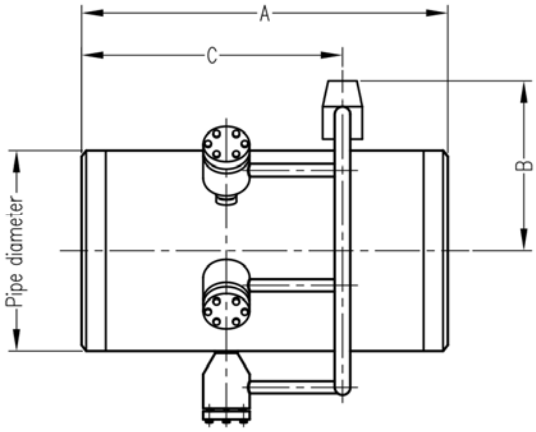
Improve cross sectional coverage
- Control penetration od spray pattern by flow profiling.

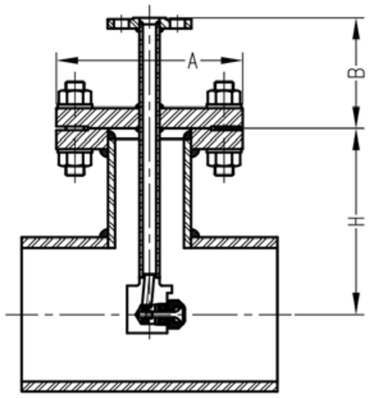
★ The minimum length of straight upstream of the liner should be 3 pipe diameter. Depending on the application conditions, the liner length downstream of the spray nozzle should be between 1 to 1.8m. For attemperator in HP and RH interstage lines, typically, the downstream distance from the end of the liner will be equivlent to ≈ 0.067s residence time. The downstream distance to the temperature sensor will be equivalent to ≈0.2s residence time from the end of the liner. Should the spray water-to-steam ratio be greater than 15%, the residence time should be increased to 0.3s. Precise estimates for these distance can be derived from detailed calculations for all the physical processes.



Liner Installation Details

6. Dimension Check





6-1. MNSD-series **unit : mm / inch**

No	Steam Pipe Size	A	B	C	Water Connection
1	200 / 8"	650 / 25.6	280 / 11	450 / 17.7	50 / 2
2	250 / 10"	700 / 27.6	310 / 12.2	450 / 17.7	50 / 2
3	300 / 12"	750 / 29.5	335 / 13.2	500 / 19.7	50 / 2
4	350 / 14"	800 / 31.5	350 / 13.8	500 / 19.7	65 / 2.5
5	400 / 16"	850 / 33.5	380 / 15	520 / 20.5	65 / 2.5
6	450 / 18"	900 / 35.4	405 / 15.9	520 / 20.5	80 / 3
7	500 / 20"	1000 / 39.4	430 / 16.9	550 / 21.7	80 / 3
8	550 / 22"	1000 / 39.4	455 / 17.9	550 / 20.7	80 / 3
9	600 / 24"	1000 / 39.4	480 / 18.9	600 / 23.6	100 / 4
10	650 / 26"	1000 / 39.4	505 / 19.9	600 / 23.6	100 / 4
11	700 / 28"	1100 / 43.3	530 / 20.9	620 / 24.4	100 / 4
12	800 / 32"	1100 / 43.3	580 / 22.8	620 / 24.4	100 / 4
13	900 / 36"	1200 / 47.2	630 / 24.8	750 / 29.5	150 / 6
14	1000 / 40"	1200 / 47.2	690 / 27.2	800 / 31.5	150 / 6
15	1100 / 44"	1200 / 47.2	740 / 29.1	800 / 31.5	150 / 6
16	1200 / 48"	1300 / 51.2	800 / 31.5	850 / 33.5	150 / 6
17	1300 / 52"	1300 / 51.2	850 / 33.5	850 / 33.5	150 / 6
18	1400 / 56"	1400 / 55.1	900 / 35.4	900 / 35.5	150 / 6
19	1500 / 60"	1400 / 55.1	950 / 35.4	920 / 36.2	150 / 6

The dimensions are typical. The length of the MNSD and the water connection are dependent on the number of nozzles required.

6-2. SNSD/DNSD/TNSD-series

No	Steam Pipe Size	A	B	C	Water Connection
1	200 / 8"	650 / 25.6	280 / 11	450 / 17.7	50 / 2
2	250 / 10"	700 / 27.6	310 / 12.2	450 / 17.7	50 / 2
3	300 / 12"	750 / 29.5	335 / 13.2	500 / 19.7	50 / 2

Dimension H is in accordance with the steam pipe size

6-3. CCSD-series

The dimension of CCSD is in accordance with pipe size and service condition

CCSD-series dimension and construction available, local sales representative or consult factory.

Best Flow Solution

BFS Incorporation

23block-3lot, Geumdan-Industrial-Complex

#17, 114beongil, Geumdan-ro, Seo-gu, Incheon-city, Korea

T/+82-32-329-9142 F/+82-32-329-9148

www.bfsvalve.com