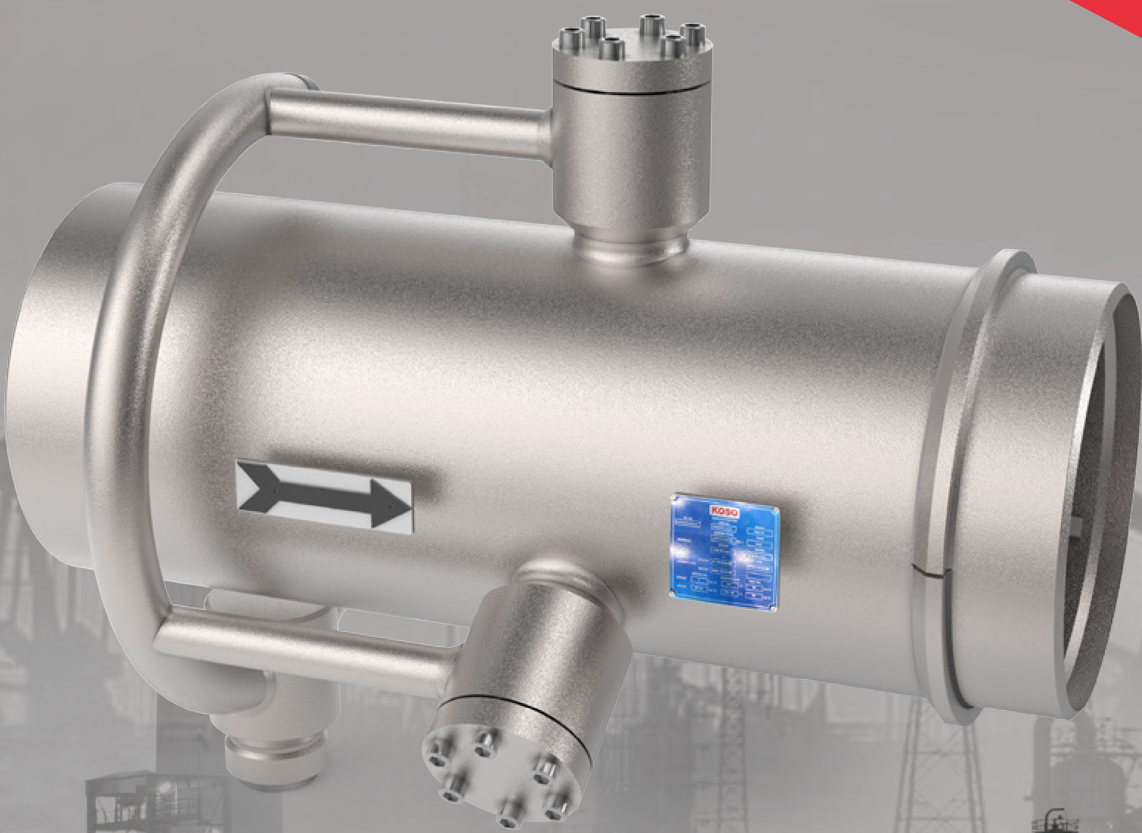
D-SERIES

KOSO

DESUPERHEATERS



Standard Specifications

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Overview

KOSO provides a variety of desuperheating solutions and has expertise in selecting the right solution based on expert analysis and experience. This document offers an overview of KOSO's standard desuperheaters along with options for customization to meet specific application needs.

Desuperheating

Desuperheating is the process of cooling superheated steam by directly injecting water to meet required conditions for downstream processes. This is essential in various industries including power stations, refineries, pulp and paper and desalination plants, where maintaining specific steam temperature and it is crucial for efficient operation.

There are five basic steps:

- Injection of the correct amount of spraywater
- Spray atomization (primary and secondary)
- Spray penetration and pre-evaporation mixing
- Evaporation and mixing
- Right sizing and selection of desuperheater

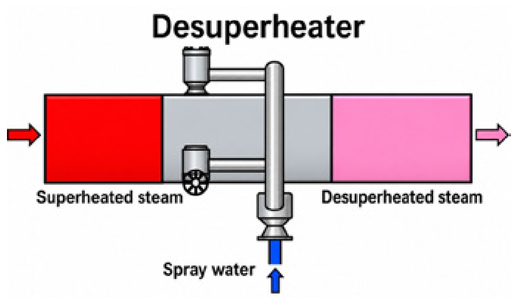

Figure 1: Simple Schematic of a desuperheating process

Spray Water Injection

The proper injection of spraywater flow is essential for the effective operation of desuperheating systems. Careful selection of the spraywater flow control element, such as an external control valve, is crucial for maintaining consistent flow across all required ranges. For high pressure drops, a multi-stage pressure drop ensures long-term reliability. The needed cooling water quantity is calculated using heat and mass balance principles.

$$Q_W = Q_S \times \frac{h_1 - h_1}{h_2 - h_w}$$

Where,
Q_W = Water quantity required in kg/hr
Q_S = Steam flow in kg/hr
h_1 = Enthalpy of inlet steam in kJ/kg
h_2 = Enthalpy of outlet steam in kJ/kg
h_w = Enthalpy of spray water in kJ/kg

Atomization

Atomization of injected spraywater into droplets enhances heat transfer with surrounding steam by increasing surface area. Smaller droplets are preferred for easier evaporation. The key factor in atomization is the Weber number, which is defined as:

$$w_e = \frac{\rho U^2 d}{\sigma}$$

Where,
ρ = Density of steam in kg/m3
U = Relative velocity of Steam in m/s
d = Droplet diameter in m
σ = Surface tension of water in N/m

Droplets remain stable when the Weber number is between 12-16, while higher values lead to continued breakup until a stable size is reached. Primary atomization is influenced by spray nozzle design, particularly those utilizing pressure drop. Secondary atomization (Figure 2) occurs when the energy from surrounding flowing steam breaks up the droplets.

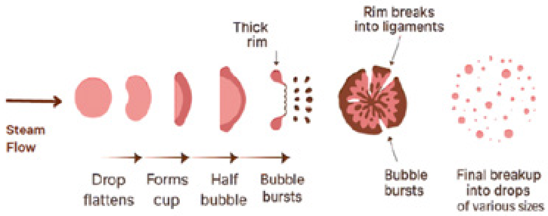

Figure 2: Secondary breakup of water droplet by interaction with steam

Small droplets are beneficial in desuperheating because they evaporate faster and also stay suspended easily in the steam flow. Good atomization is a very critical step in desuperheating. KOSO uses both primary and secondary atomization principles to achieve small droplet sizes below 250 μm diameter as a general rule.

Spray Penetration

Spraywater penetration into steam relies on the initial jet size, momentum ratio between steam and spraywater and their respective distances. After the initial momentum dissipates, the droplets mix with steam and are carried downstream.

$$h = f\left\{\left(\frac{q_L}{q_G}\right), d_j, X\right\}$$

Where,

h = spray penetration

q_L = momentum of spraywater jet

q_G= momentum of steam

d_j= jet diameter (or, spray sheet thickness)

X = distance from spraywater injection

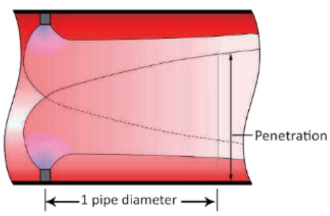

Figure 3 : Schematic of penetration of spray water in a cross flow of steam

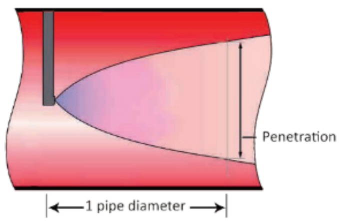

Figure 4 : Schematic of penetration of spray water in an inline flow of steam

Evaporation and Mixing

Evaporation of suspended droplets occurs as heat transfers from the superheated steam. Evaporation time is influenced by factors like droplet size, desired steam superheat, spraywater amount and local heat transfer coefficient. Uniform steam temperature is reached after all spraywater evaporates through turbulent mixing in the steam pipe. However, design considerations are crucial for effective operation, including reliable spraywater flow control, multi-stage pressure letdown design, appropriate spray nozzle selection for proper atomization and penetration and optimal pressure drop distribution between the valve and nozzles.

Desuperheater Sizing and Selection

The requirements for desuperheating applications can vary significantly, ranging from non-severe to extremely severe conditions. It is the severe service applications that demand the most careful attention during the selection and sizing process. The severity of a desuperheating application is determined by several factors:

- Required temperature reduction (ΔT_{steam})
- Water to steam ratio (W_{spray}/W_{steam})
- Closeness of final steam temperature to saturation ($T_{steam\text{-}final} - T_{saturation}$)
- Range of steam flow rates ($W_{steam\text{-}max} : W_{steam\text{-}min}$)
- Range of spray water rates ($W_{steam\text{-}max} : W_{steam\text{-}min}$)
- Available spray water ΔP
- Installation-related considerations

Some examples of applications with severe desuperheating requirements include turbine bypass, main steam and reheat steam attemperation, auxiliary steam systems and process steam for export.

Calculations for atomization, spray penetration and evaporation necessitate realistic physical modeling of these processes. The KOSO software utilized in selecting the optimal desuperheater allow for a detailed analysis that accurately determines the required distance to the first elbow and the downstream temperature feedback sensor.

Key principles grounded in physics and field experience that should be adhered to when sizing and selecting desuperheater technologies include :

- Droplet size must be less than 250 microns for all operating conditions.
- Spray penetration should range between 15% and 85% of the pipe diameter to prevent cold water from impacting hot metal boundaries.

D-Series Overview

The D-Series family of desuperheaters caters to various steam plant applications. It offers three common water-injection spray nozzle technologies: fixed-area, variable-area, and steam-assist. Additionally, the D-Series includes integrated spraywater flow control, removing the need for a separate control valve.

D SERIES		
Variable Area Nozzle	DMR	Multinozzle ring with Spring-loaded nozzle
	DPS	Probe-type with spring-loaded nozzle
Fixed Area Nozzles	DV1	Venturi
	DVL	Venturi low- loss
	DPF	Probe type
DSH with Valve	D42	Multiple nozzle desuperheaters (Integral de-superheating with spray control valve)

The choice of a desuperheater for an application depends on specific process requirements, but key principles remain constant: small droplet sizes, preventing spraywater from hitting hot pressure boundaries, proper control logic and effective piping layout. These systems can be integrated with control valves for steam-conditioning or Pressure-Reducing Desuperheating Systems (PRDS).

Product Specifications

Design Standard & Material Standard	• ASME Section I, Section VIII Div.1, ASME B31.1 & ASME B31.3 • Flange design - ASME B16.5 • Material comply to ASME, EN and Custom standards
Industry Served	• Power • Oil & Gas (Specific) • LNG (Specific) • Refinery
Quality Standard Compliance	• Integrated management system with : - ISO 9001 - API Spec Q1 • PED/CE as per 2014/68/EU & ATEX 2014/34/EU
Certification	• IBR • PED/CE Marking • CRN • ASME S-Stamp

Variable Area Nozzle

DMR Multi-Nozzle Ring

Description

- Spring-loaded variable area spray nozzles
- Radial Injection into the steam pipe
- DAS (Steam Assist Nozzle) is possible along with DMR

Key Applications

- HP turbine bypass to cold reheat
- Turbine bypass to condenser
- PRDS
- Process steam desuperheating
- Auxiliary steam systems
- Interstage and terminal attemperation

Standard Features	
Pressure boundary material	A335 P11 / A182 F11
	A335 P22 / A182 F22
	A335 P91 / A182 F91
	A335 P92 / A182 F92
Steam pipe	6” to 48” (bell expander for connection to larger pipes downstream)
Water pipe	1” to 8”
Connections	Steam pipe: BW / Flanged Water pipe: BW / Flanged
Ratings	ASME B31.1 ASME VIII Div 1, Job rated
Rangeability	Water: 20: 1 typical Steam: 15: 1 (higher rangeability available upon request)
Achievable temperature	Up to 10° C of saturation for control with temperature feedback (wet final steam condition requires feed-forward control)
Spray water control	Separate external control valve

Figure 5: DMR installed with a turbine bypass valve

Figure 6: Multi-nozzle ring-type desuperheater

Body & Trim Sectional View

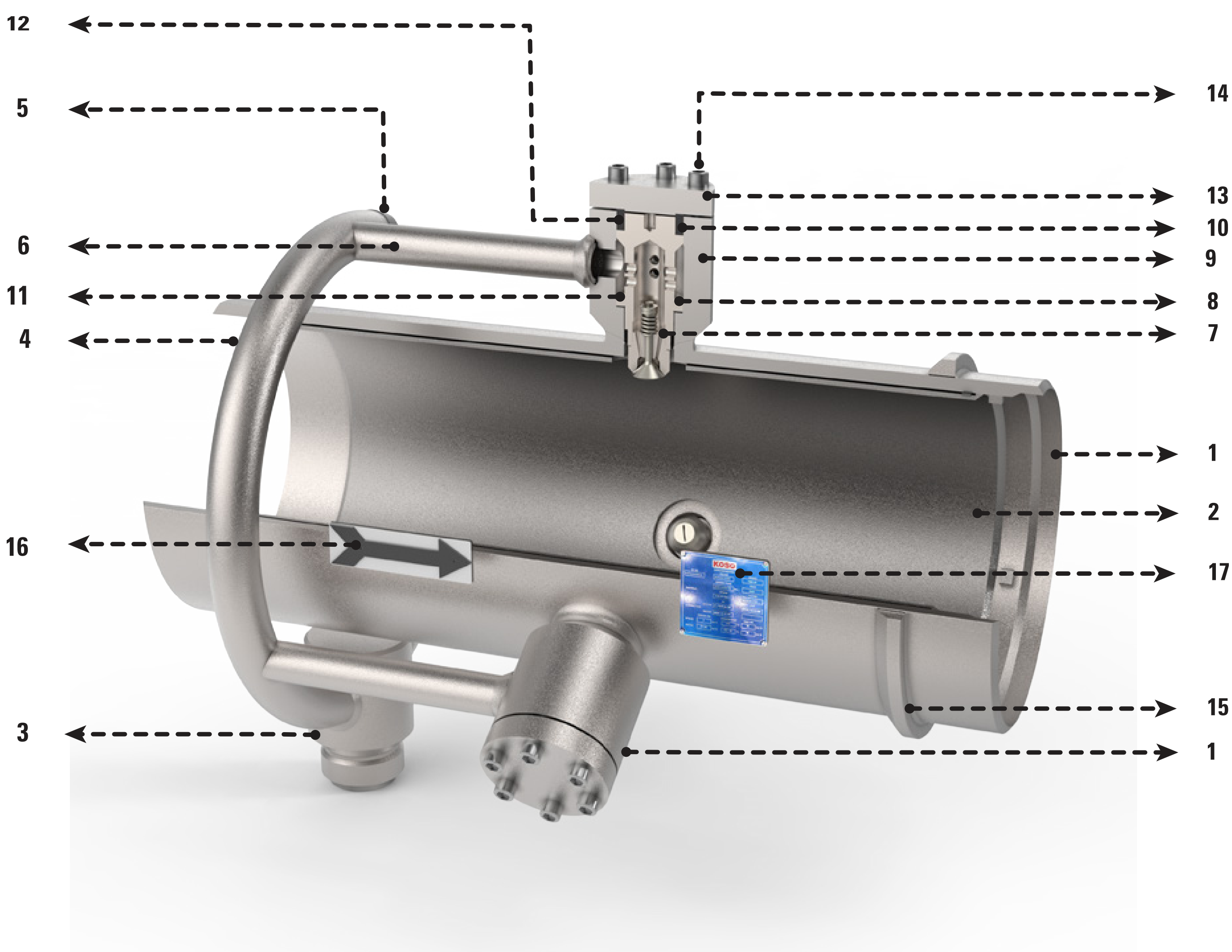

Figure 7: DMR Multi-Nozzle Ring Cross Sectional View

SR.NO.	LABEL
1	STEAM PIPE
2	LINER PIPE
3	WATER STUD
4	RING PIPE
5	END CAP
6	FEEDER PIPE
7	NOZZLE ASSEMBLY
8	NOZZLE HOLDER
9	NOZZLE HOUSING BOX

SR.NO.	LABEL
10	PACKING
11	GASKET
12	NOZZLE BOX SPACER RING
13	BLIND FLANGE
14	HEX HEAD CAP SCREW
15	STOPPER RING
16	ARROW PLATE
17	NAME PLATE

DPS Probe

Description

- Spring-loaded variable area spray nozzle
- Axial injection into the steam pipe
- Spray water throttling element is outside the steam pipe
- Available with, or without, steam pipe
- DAS (Steam Assist Nozzle) is possible along with DPS

Key Applications

- Main steam attemperator
- PRDS
- LP turbine bypass
- Process steam desuperheaters

Standard Features	
Pressure boundary material	A335 P11 / A182 F11
	A335 P22 / A182 F22
	A335 P91 / A182 F91
Steam pipe	6” to 24” (bell expander for connection to larger pipes downstream)
Water pipe	1” to 4”
Connections	Steam pipe: BW / Flanged Water pipe: BW / Flanged
Ratings	ASME 150 to 2500
Rangeability	20 : 1 typical (higher rangeability is available upon request)
Achievable temperature	Up to 10° C of saturation for control with temperature feedback (wet final steam condition requires feed-forward control)
Spray water control	Separate external control valve

Figure 8: Stand-alone probe type with variable area Spring-Loaded nozzle and flanged water inlet.

Figure 9: Variable area spring-loaded nozzle

Body & Trim Sectional View

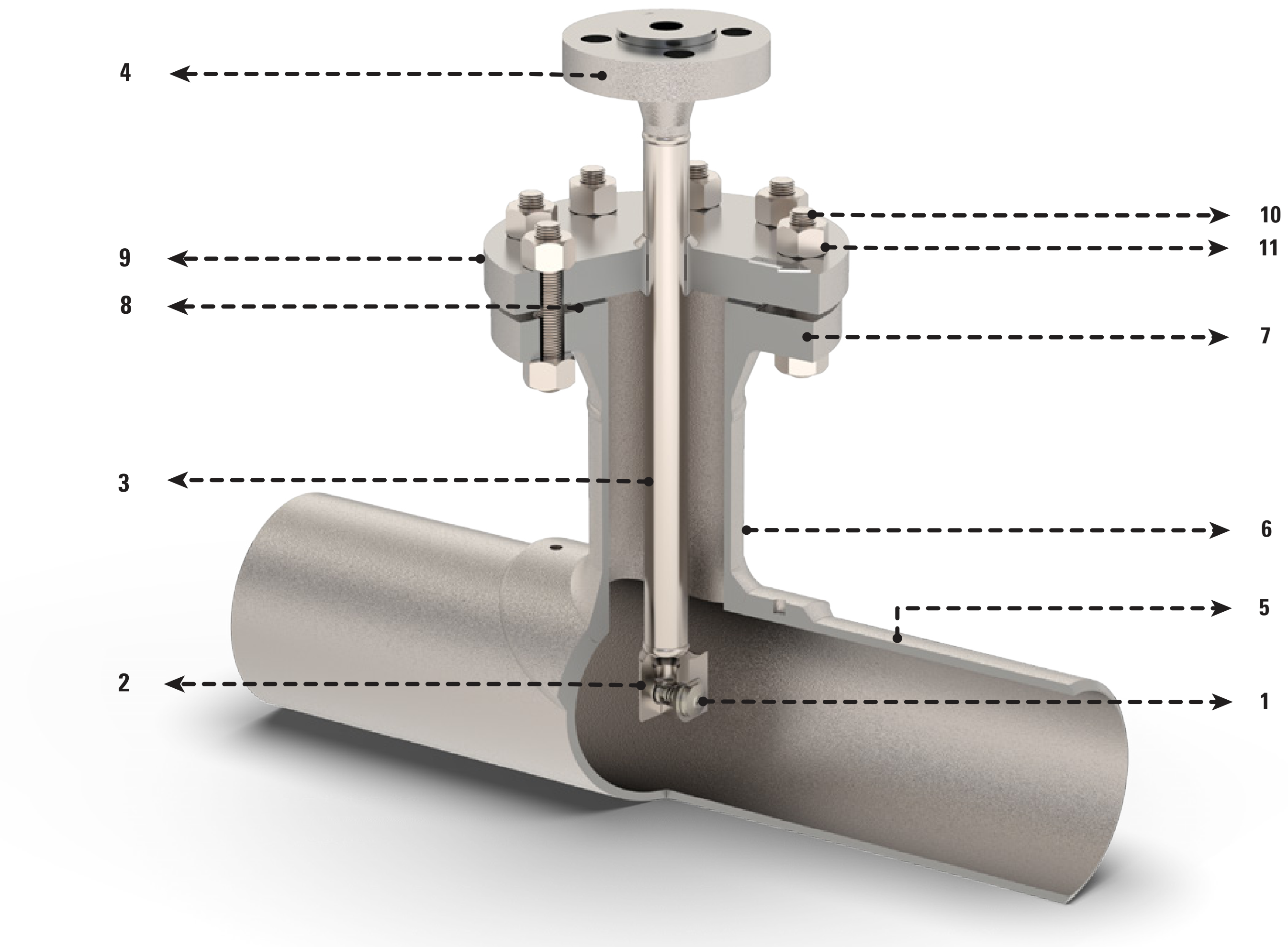

Figure 10: DPS Probe Cross Sectional View

SR.NO.	LABEL
1	NOZZLE
2	NOZZLE HOLDER
3	WATER PIPE
4	WN FLANGE
5	STEAM PIPE
6	STEAM STUB

SR.NO.	LABEL
7	STEAM STUB FLANGE
8	GASKET
9	STEAM COVER FLANGE
10	STUD BOLT
11	HEX. NUT

Fixed Area Nozzles
▶ DV1 Venturi

▶ Description

- Simple construction
- Fixed-area spray nozzle
- For small line size with an upstream steam pressure reducing valve (PRV)
- Relies on the energy of steam flow for atomization.

▶ Key Applications

- Process steam desuperheater
- Small PRDS

Standard Features	
Pressure boundary material	A182 F11
	A182 F22
	A182 F91
Steam pipe	2” to 6”
Body Size	2” to 6” (standard)
Water pipe	1” to 2”
Connections	Steam: Flanged / BW Water: Flanged
Ratings	ASME 150 to 1500 as standard ASME Section VIII Div I (other ratings on request)
Spray Water Pressure	Minimum 5 bar (73 psi) above steam pressure
Rangeability	10 : 1 (typical)
Achievable temperature	Up to 10° C of saturation for control with temperature feedback
Spray water control	Separate external control valve

Figure 11: Integral body flange type

Figure 12: Butt weld type

DVL Low-Loss Venturi

Description

- Simple construction
- High spray water pressure is not required
- For small line size with or without an upstream steam PRV
- Relies on the energy of steam flow for atomization
- High rangeability

Key Applications

- Process steam desuperheater
- Small PRDS
- Ideal for applications where pressure drop in steam line has to be kept minimum

Standard Features	
Pressure boundary material	A182 F11
	A182 F22
	A182 F91
Steam pipe	2” to 6”
Body Size	2” to 6” (standard)
Water pipe	1” to 2”
Connections	Steam: Flanged / BW Water: Flanged
Ratings	ASME 150 to 1500- as standard ASME Sec VIII Div I (other ratings on request)
Spray Water Pressure	At least equal to steam pressure*
Rangeability	10 : 1 (typical)
Achievable temperature	Up to 10° C of saturation for control with temperature feedback
Spray water control	Separate external control valve

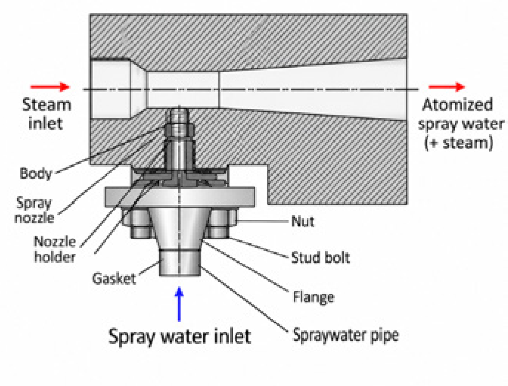

Figure 13: Low pressure loss venturi desuperheater

Figure 14: DVL desuperheater installed at the outlet of main steam

DPF Probe

Description

- Simple construction
- Fixed area spray injection
- Available with or without steam pipe

Key Applications

- Process steam desuperheater
- PRDS
- Non-sever process steam application

Standard Features	
Pressure boundary material	A335 P11 / A182 F11
	A335 P22 / A182 F22
	A335 P91 / A182 F91
Steam pipe	6” to 24” (bell expander for connection to larger pipes downstream)
Water pipe	1” to 4”
Connections	Steam pipe: Flanged Water pipe: Flanged
Ratings	ASME 150 to 15000 (Others on request)
Rangeability	4 : 1 typical
Achievable temperature	Up to 10° C of saturation
Spray water control	Separate external control valve

Figure 15: Probe with fixed-area nozzle

Figure 16: Nozzle

D42 Integral Desuperheating With Spray Control Valve

Description

The D42 series Integral desuperheating with spray control valves are designed to provide optimum performance and high rangeability. The independent spray nozzles, which are uncovered by throttling piston, provide a good water atomization even at minimum flow conditions.

Key Applications

- Low & medium pressure and temperature steam conditioning station
- Steam or process gas cooling
- Cryogenic applications

Standard Features	
Pressure boundary material	A335 P11 /A182 F11
	A335 P22 / A182 F22
	A335 P91 / A182 F91
Body size (Water x steam)	1.5”, 2” x 3”, 2”x 4” 4”
Connections	Size-1 Steam Connection: 3”, Water Connection: 1" & 1.5" Size-2 Steam Connection : 4", Water Connection : 1.5", 2" & 3"
Ratings	ASME 150 to 600; ASME 900 to 1500 (ASME 2500 if special requirement)
Rangeability	Spray-water Flow rangeability 40 : 1 (Typical) Higher rangeability is available on request
Spray water control	Integral

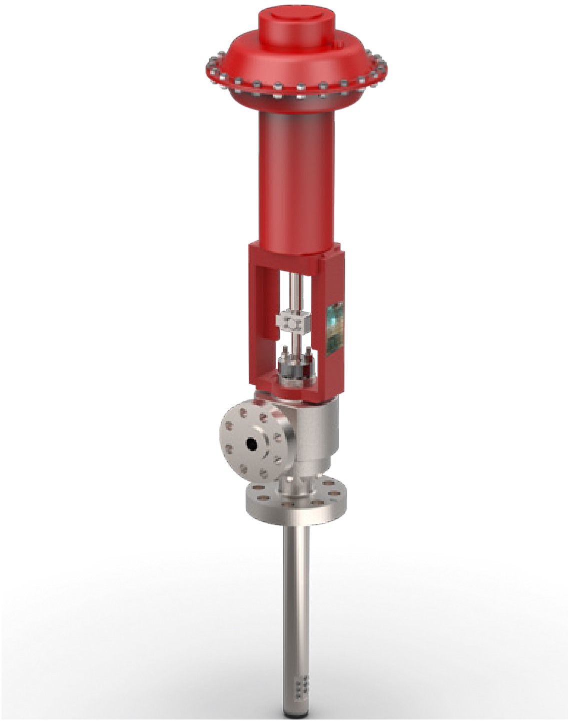

Figure 17A: D42 installed on a valve and actuator

Figure 17B: D42 body cross section

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NIHON KOSO CO.,Ltd.

1-16-7 Nihombashi, Chuo-ku, Tokyo, Japan | 103-0027 | +81-03-5202-4300
www.koso.co.jp

KOSO INDIA PRIVATE LIMITED

H-33 & 34, MIDC, Ambad, Nashik, Maharashtra, India | 422010 | +91-253-2408701
www.koso.co.in

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