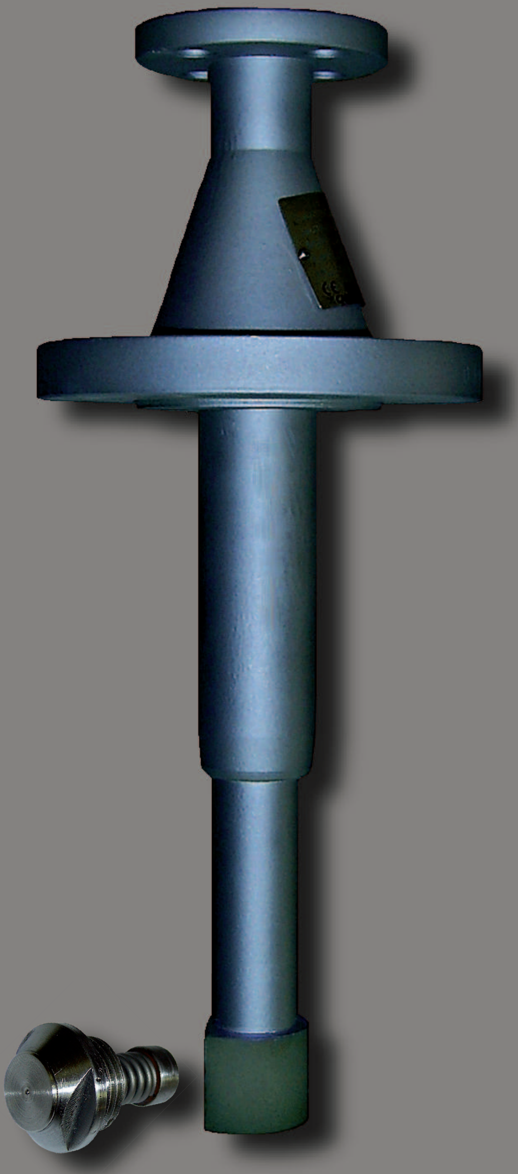
DM VARI*spring*

Variable area spring assisted desuperheater



DF VARI*fix*

Fixed area desuperheater

Suitable for:

- Steam
- Process gas

Markets:

- Oil & gas
- Power
- General industry

ISO 9001 - Cert N 0298
ISO 14001 - Cert N 0358A

DM VARI*spring*

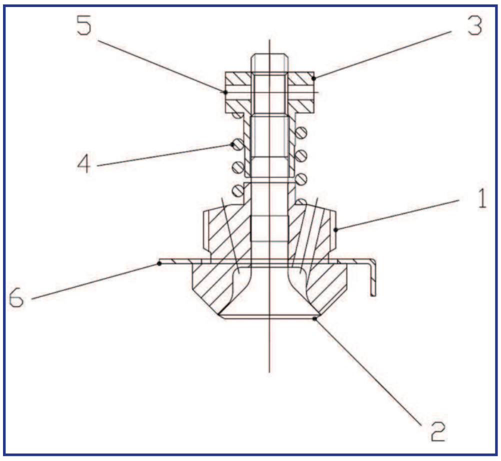


Fig. 1 - DM Nozzle

Introduction

Variable area Varispring DM nozzles minimize the limitation of fixed area types deriving from the fluid velocity reduction when flowrate decreases (see insert for other information).
This is obtained by automatically reducing the passage area when flowrate decreases so to maintain a fluid velocity consistent with the need of a good atomization.

With reference to Figure 1 here below the description of this nozzle :
The spring (4) is loaded by the nut (3) and keeps the plug (2) in the closed position.
Nut is locked by the pin (5) to avoid any loosening.

When water pressure inside the nozzle tends to rise, the Δp between steam and water increases till the water action on the plug exceeds the spring load and the plug starts to open.
The water starts to blow out from the nozzle flowing through the special drilling of the nozzle body (1) which whirls the flow before it gets in contact with the plug conical surface.
The plug atomizes the water through a 90 degrees about-shaped conical pattern.
Spring load can be set to obtain the desired start opening pressure.

ITEM	NAME	MATERIAL
1	Nozzle body	AISI 422
2	Plug	17-4 PH H1100
3	Nut	AISI 316
4	Spring	INCONEL X750
5	Pin	AISI 304/316
6	Locking washer	AISI 316L

Why is this device called variable area nozzle?
Should the outlet section remain constant the spray velocity would decrease at low flow, in spring-assisted DM nozzles, the spring load being almost constant, the flow section is reduced and the Δp tends to be constant.

In other words, being
F_{spring} = thrust area · Δp ≈ constant and flowrate ÷ Cv · $\Delta p^{0,5}$

The static balance of the plug is maintained only if Cv is reduced when flowrate decreases. Therefore the plug automatically closes, the Δp doesn't fall down and the water velocity tends to be the same.
Unfortunately the real thrust area of the plug is not constant through its travel and the relationship between Fspring and Δp is not just linear.
The thrust area is greater near the closed position and Δp tends to decrease with a less efficient atomization at low flowrates. Therefore to find the relationship Cv vs Δp tests are necessary.

In Fig.2 the test results of Carraro DM nozzles

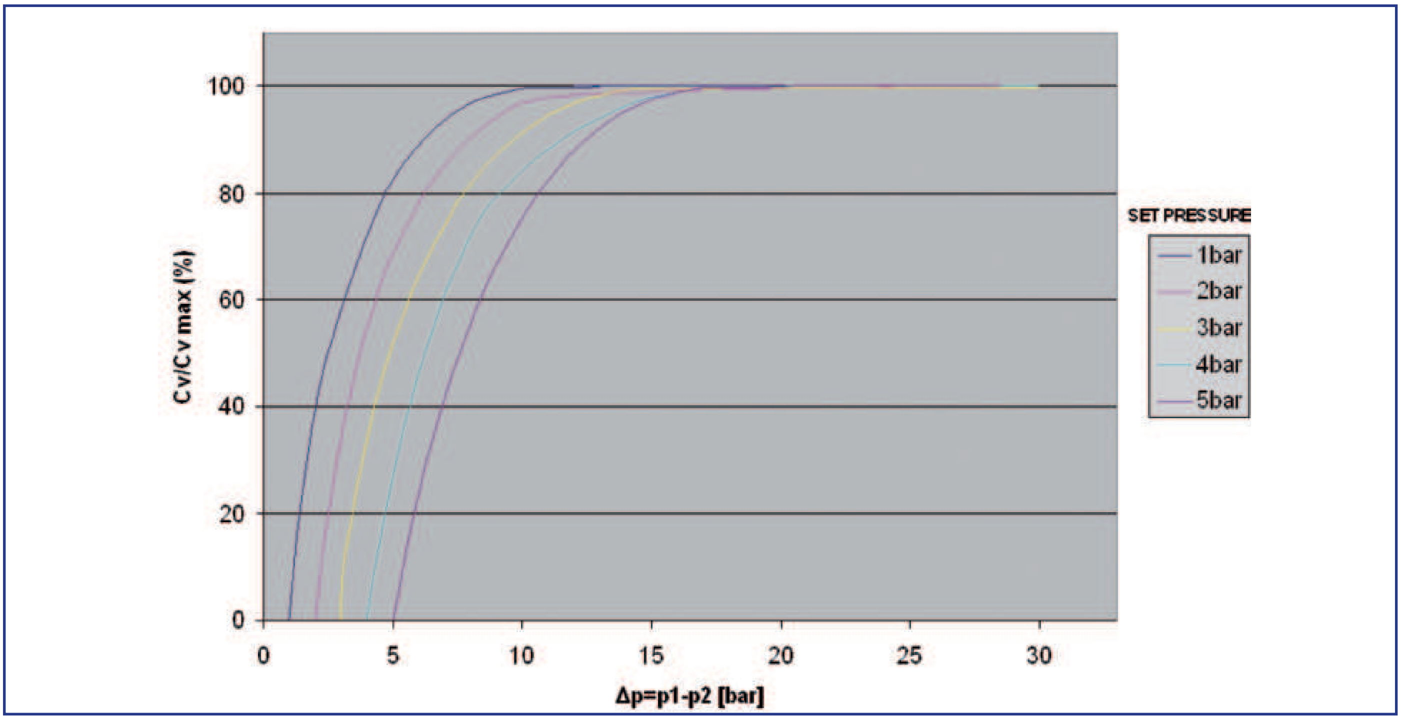


Fig. 2 - Cv of DM nozzles vs the Δp for every set pressure

VARIABLE AREA vs FIXED AREA NOZZLES

To approach variable area equipments a comparison with the fixed area devices is necessary with particular regards to the rangeability characteristic.

Fixed area plain nozzles have a constant flow rate changes. The ratio Cvmax/Cvmin is = 1 and consequently their rangeability is:

$$Ry = 1.\sqrt{\frac{\Delta p_{max}}{\Delta p_{min}}}$$

If the minimum fluid velocity through a fixed area nozzle to produce satisfactory water atomization is 35 m/s (4 ÷ 7 m/s upstream and 40 m/s in vena contracta) the corresponding Δp is 6 bar and the rangeability is therefore:

$$\sqrt{\Delta p_{max} / 6}$$

Assuming these nozzles can operate under a Δp_{max} = 25 ÷ 40 bar depending on water temperature the corresponding max value of Ry will be within:

$$Ry = \sqrt{25 \div 40 / 6} = 2 \div 2{,}5$$

To improve the performance of fixed area nozzles the **vortex type** is available. Such design increases the atomization degree of water with the same mean velocity and Δp. So the min Δp is dramatically reduced to about 1 bar and the corresponding Ry, even though Cvmax/Cvmin is = 1 again , is increased to:

$$Ry = \sqrt{25 \div 40 / 1} = 5 \div 6$$

Main characteristics

Sizes: DM4, DM8, DM12, DM25, DM40, DM 65
Flow capacity: see Cv table
Flow characteristic: Cv/Δp characteristic curves are plotted in the diagram of Fig. 2 for various values of set pressure.
Settings:standard setting = 3 bar
Other settings (from 1 to 5 bar) may be used for special applications.
The set pressure must be selected to take into account :
- the need of a back pressure on the control valve to limit cavitation
- a minimum seat load to limit leakage in closed position
- the control range of desuperheater

The std set pressure of 3 bar is a compromise through various needs.

Max Δp: 25 bar
Rangeability: from 15 to 30 depending on nozzle size and its set pressure

$$Ry = \frac{Cv_{max}}{Cv_{min}} \cdot \sqrt{\frac{\Delta p_{max}}{\Delta p_{min}}}$$

The ratio Cvmax/Cvmin varies from 8 for sizes DM4 and DM8 to 9 ÷ 10 for greater sizes.
The min Δp corresponding to min Cv can be drawn out by the Fig.2 on the curve of selected set pressure.

Example:
nozzle DM8, set pressure 3bar, at Cv_{max}/Cv_{min}= 12,5%, Δp_{min}= 4 bar if Δp_{max}= 25 the max Ry of DM8 is :

$$Ry = 8 \cdot \sqrt{\frac{25}{4}} = \mathbf{20}$$

With a set pressure 1 bar the corresponding value of Ry is about 30

Mounting: DM nozzles are used in two different constructions:
- probe type, flanged construction with optional injection chamber
- wall-welded-in, single or multiple construction with an injection chamber

Cv and flow capability of DM nozzles

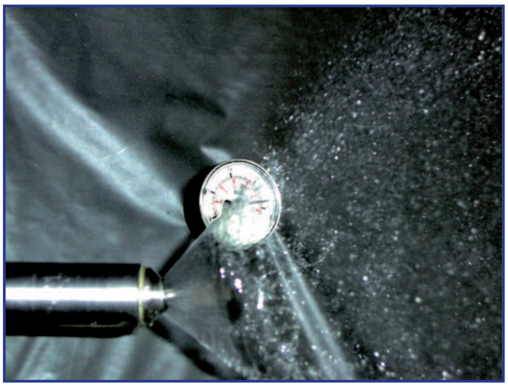
Nozzle	Seat diameter	Cv max	Travel	Max flowrate m3/h (1)
DM4	14 mm	1	0,7	4,3
DM8	21 mm	2	1	8,6
DM12	28 mm	3	1,2	12,9
DM25	39 mm	6	1,5	25,9
DM40	48 mm	10	2	43
DM65	55 mm	15	2,5	64,5

Note(1) - Δp = 25 bar – density 1000 kg/m3

The below table summarizes the rangeability and other characteristics of DM variable area nozzles compared with those of fixed area devices.

Fixed vs variable area nozzles characteristics:

Type of nozzle	Δp max	Δp min	Cvmax | Cvmin	Ry
Fixed area plain hole	30 bar	6 bar	1	2,2
Fixed area vortex type	30 bar	1,5 bar	1	4,5
Variable area DM type (set pressure 3 bar)	25 bar	3 ÷ 4 bar	8 ÷ 10	15 ÷ 30

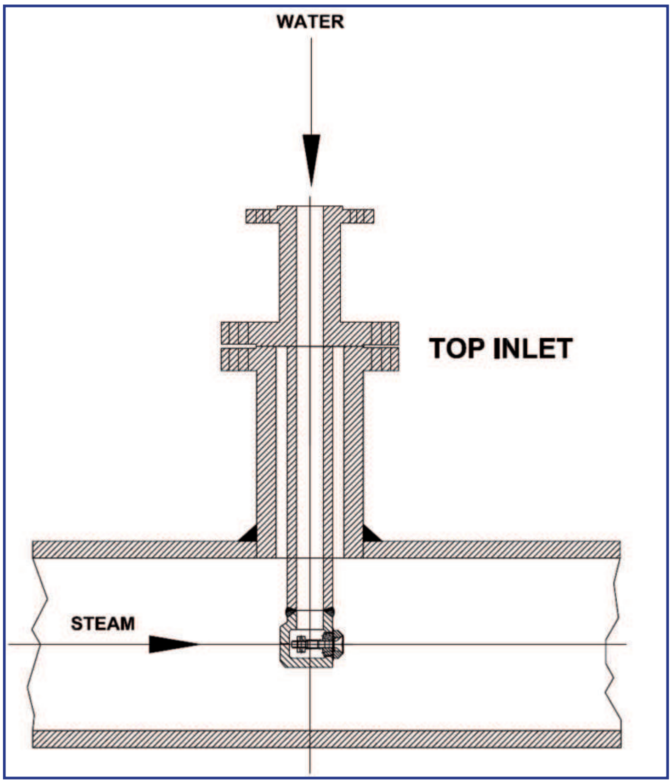


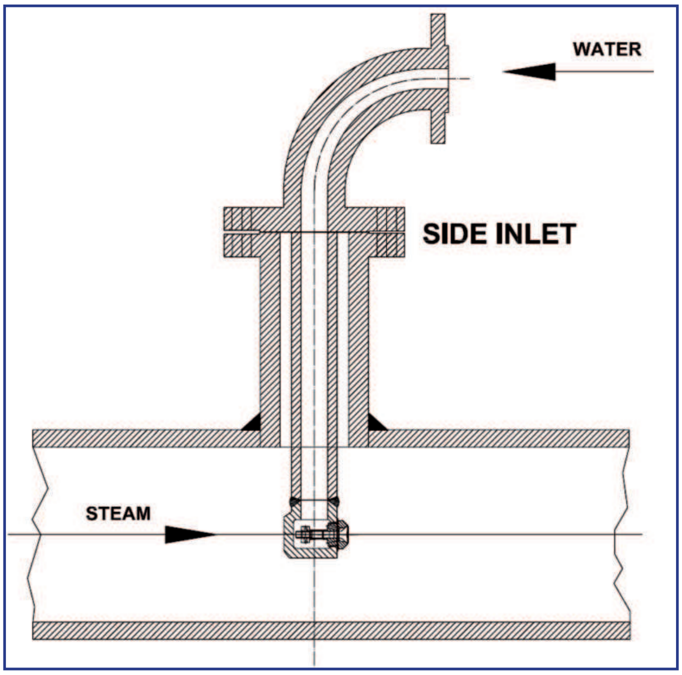
DM DESUPERHEATERS probe assembly

One or max two DM nozzles are fastened at the end on a tubular extension flanged to the pipe. Dimensions and ratings are listed in the next tables.
The injection is performed close to the pipe axis by adjusting the probe lenght. A reference pin located on the desuperheater flange ensures the correct orientation of the nozzle inside the piping. Probe assembly is normally performed with the same pipe material.
In the below table the standard combinations of water connections and pipe sizes are listed.

Nozzle type	DM4	DM8	DM12	DM25	DM40	DM65
water connection(1)	1"	1"	1"½	2"	2"½	3"
steam fitting connection(1)	2"	3"	4"	4"	6"	8"
minimum steam pipe size (C)	4"	6"	8"	8"	12"	14"

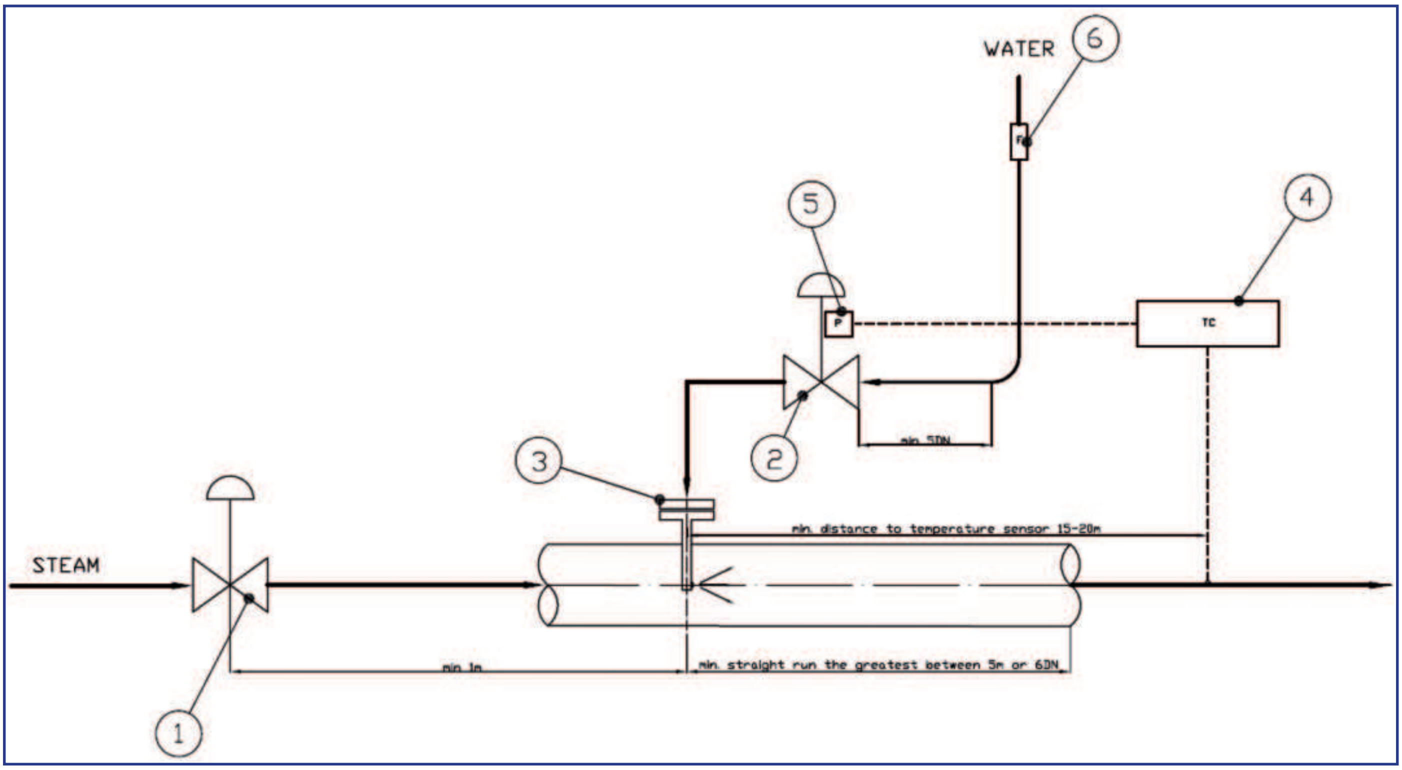
(1) Other size on request.





Engineering practice for efficient desuperheating

For efficient desuperheating the arrangement of installation are shown in figure.



LEGENDA

1) Pressure reducing valve
2) Water control valve
3) Carraro desuperheater
4) Temperature controller
5) Positioner
6) Filter (recommended)

VARI*spring* dimensions

NOZZLE	L		A	B	C min	G min(1)
	up to ANSI 900	ANSI 1500				
DM4	147	147	1”	2”	4”	49
DM8	186	186	1”	3”	6”	73,5
DM12	205	205	1-1/2”	4”	8”	97
DM25	205	205	2”	4”	8”	97
DM40	237	267	2-1/2”	6”	12”	146
DM65	250	300	3”	8”	14”	192

(1) The dimensions are consistent with sch.80 thicknesses. For different design (rating & dimensions) contact Carraro technical department.

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<tr><th rowspan="3">DN steam</th><th colspan="2">DM4</th><th colspan="2">DM8</th><th colspan="2">DM12</th><th colspan="2">DM25</th><th colspan="2">DM40</th><th>DM65</th></tr>
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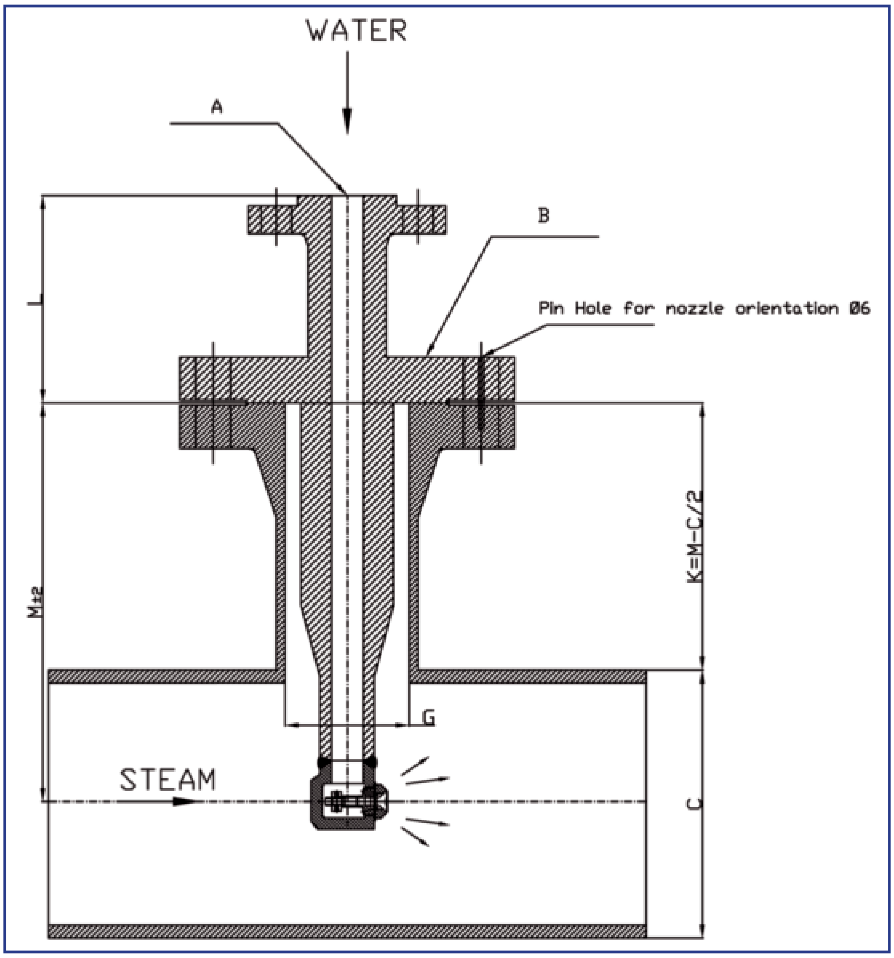


NOTE
K is the same for 28” to 40” pipe diameter.

MDM VARI*bull*

DM wall-mounted springloaded desuperheaters

In this rugged and compact design the DM nozzle is threaded inside a drilled cage fitted in a shaped fitting which is directly welded to the main steam pipe or to a separate chamber. A flanged plate at the end of this fitting allows the easy maintenance of internal parts. The single design of this device is normally assembled downstream a valve on an integral extension of the body, which acts as an injection chamber.

The multiple design MDM is equipped with several DM wall-mounted nozzles connected among themselves and welded to an injection chamber BW inserted into the steam pipe. According to the operating conditions the injection chamber may be provided with an inside protection jacket (liner).
The nozzles of MDM design may have different size and settings, for top performances of desuperheating at various flowrates, and to improve turndown as well. However, such an arrangement should be adopted with caution, since it may complicate the supply of spare parts. The connection among the DM injectors is performed by a complex piping leading to a single water inlet. When more than two nozzles are used the arrangement of piping accounts for uniform distribution of pressure losses to keep the same pressure upstream the nozzles.
The use of long arms of water distributor system, parallel to the pipe, assures the uniform efficiency of nozzles but also moderates the thermal stresses due to different water and steam temperatures.
Also, where eight or more nozzles are linked, the connecting piping is properly designed to avoid dangerous thermal stresses by a “symmetrical thermal design".

Characteristic data

Water connection: single DM type: ½” to 2“ - MDM type: 1” to 4”.
Chamber or pipe size: from 8” through 40” - greater sizes on request.
Connection: ANSI, UNI, DIN flanges for water connection .
BW for the injection chamber.
Rating: water side: ANSI 150÷1500 (PN16÷250).
steam side: ANSI 150÷1500 (PN16÷250).
Flow rate: may be calculated by using the Cv's listed apart as a function of nozzles number.
Δp max & min: the same of basic DM nozzles.
Turndown: see values of DM nozzles. Turndown improvement is possible through a combination of different nozzle sizes and settings or by increasing the number of nozzles.
Max water/steam ratio: see table values vs number of nozzles and/or sections.
Construction: fabricated by welding of forged or laminated parts.
Materials: Desuperheaters: Carbon or Cr-Mo steels according to operating temp.
Injection chamber: same material as the pipe.
Internal liner: Cr-Mo steels.

A multiple MDM 24” with four DM25 nozzles

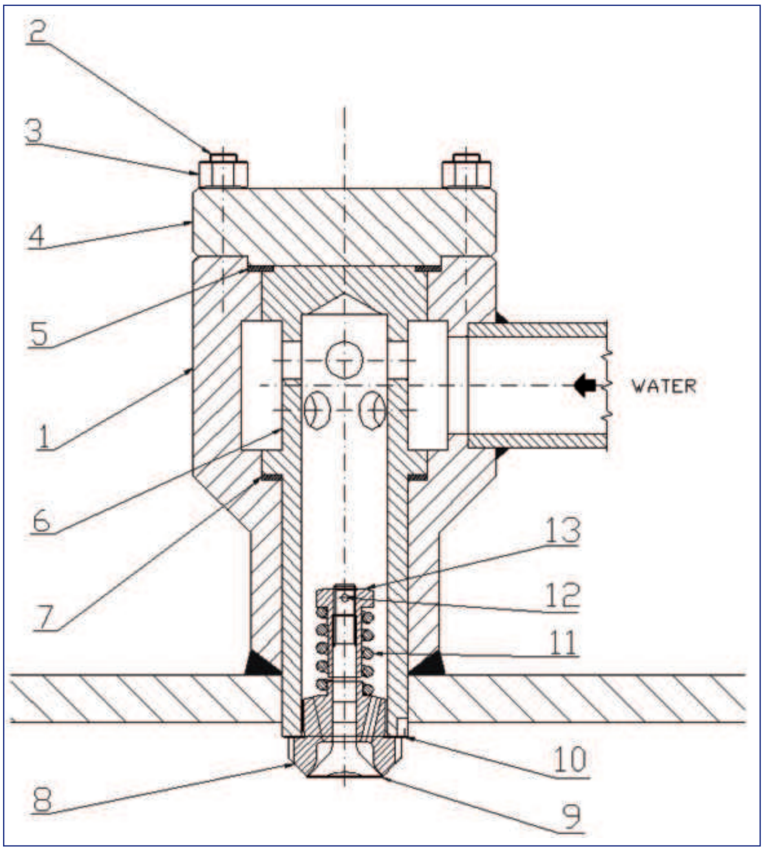
Cv of DM wall-mounted designs

Number of nozzles	1	2	4	8	12
DM4	0,9	1,7	3,4	6,8	10
DM8	1,8	3,5	7	14	20
DM12	2,8	5,4	11	22	33
DM25	5,7	10	20	41	60
DM40	9.7	17	35	70	105
DM65	14	26	52	104	150

Note:
the applications of marked cells are used only when:
- pipe is not large enough
- extra-turndown values are requested
- high water/steam ratio

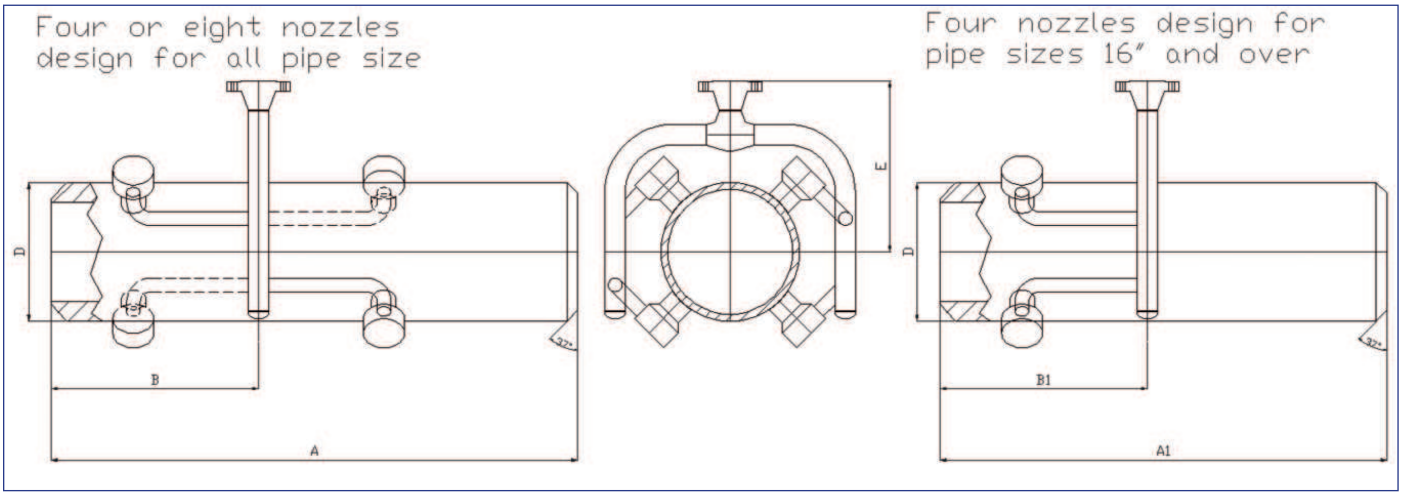
Max water-to-steam ratio

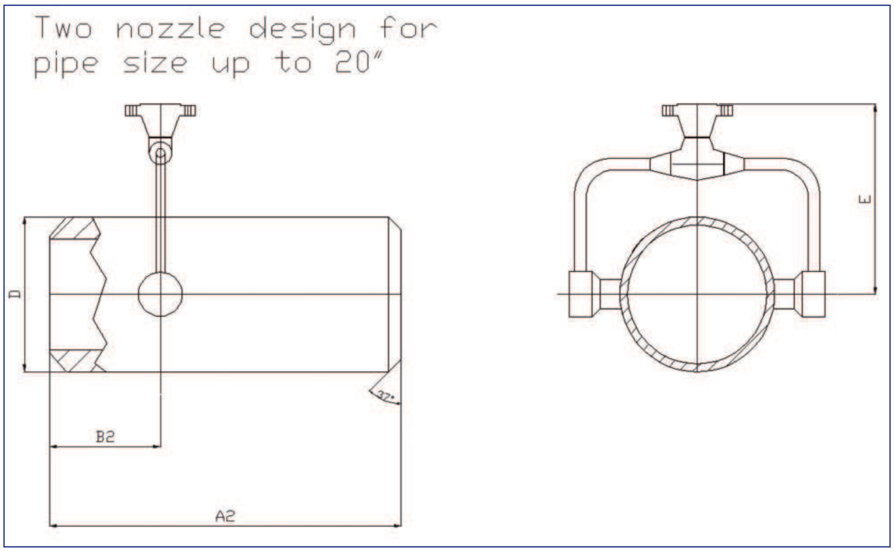
Number of nozzles	1	2	4	6	8	12
One section	22%	25%	27%	28%	//	//
Two sections	//	//	30%	32%	33%	35%



ITEM	NAME	MATERIAL
1	Valve body	A 105 - A182 F11/F22 /F91
2	Studs	ASTM A 193-B7
3	Nuts	ASTM A 194-4
4	Body cover	A 105 - A182 F11/F22 /F91
5	Gasket	AISI 316 + Grafite
6	Cage	ASTM A 182 F6NM
7	Gasket	AISI 316 + Grafite
8	Nozzle	AISI 422
9	Plug	17-4 PH H1100
10	Locking Washer	AISI 316L
11	Spring	INCONEL X750
12	Pin	AISI 316
13	Nut	AISI 316

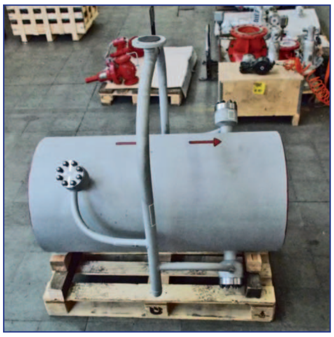
MDM VARI*bull* dimensions





D	A	B	A1	B1	A2	B2	E
8"	850	300	//	//	500	200	400
10"	900	300	//	//	500	200	400
12"	1000	400	//	//	500	200	500
14"	1050	400	//	//	600	200	500
16"	1150	450	700	450	600	200	500
18"	1250	450	700	450	600	200	600
20"	1350	500	800	500	700	200	600
22"	1450	500	800	500	//	//	600
24"	1550	550	800	550	//	//	700
26"	1650	550	900	550	//	//	700
28"	1750	600	900	600	//	//	700
32"	1850	600	1000	600	//	//	800
36"	1950	700	1000	700	//	//	800
40"	2100	700	1100	700	//	//	900

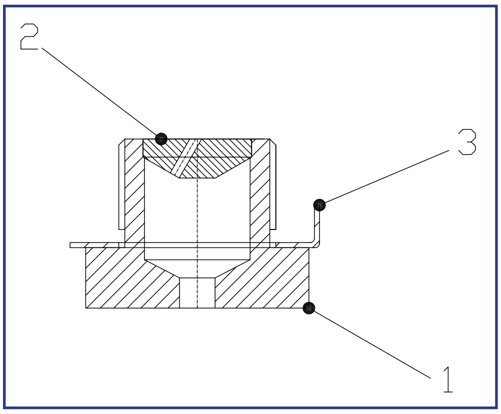
MDM VARI*bull*



DF VARI*fix*

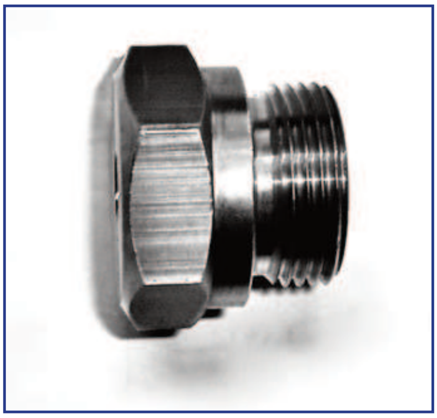
Introduction

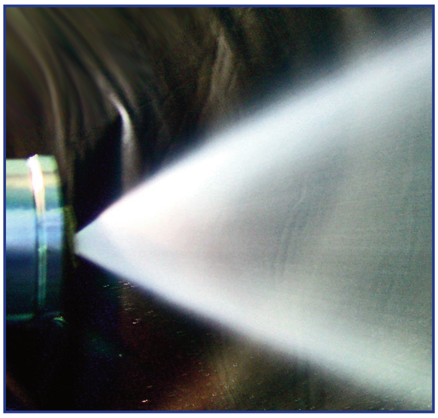
VARIfix DF nozzles are fixed area spraying devices, single or multiple, with an excellent atomizing characteristic due to a sophisticated internal vortex ring which assures very small water drops size at low differential pressures as well.
They are primarily intended for applications where load is nearly constant but moderate load fluctuations can be controlled due to the not negligible guaranteed rangeability. Maximum care is taken to keep narrow the angle of spray cone in order to minimize the impact of water against the internal pipe wall for probe type installation.



DF Nozzle

ITEM	NAME	MATERIAL
1	Nozzle body	AISI 422
2	Vortex ring	AISI 422
3	Locking washer	AISI 316L





To approach VARIfix vortex type nozzles a look to the plain area devices is necessary with particular regards to the rangeability characteristic. Fixed area plain nozzles have a constant flow rate changes.
The ratio Cvmax/Cvmin is = 1 and consequently their rangeability is:

$$Ry = 1 \cdot \sqrt{\frac{\Delta p_{max}}{\Delta p_{min}}}$$

If the minimum fluid velocity through a fixed area nozzle to produce satisfactory water atomization is 35 m/s the corresponding Δp is 6 bar and the rangeability is therefore:

$$\sqrt{\Delta p_{max} / 6}$$

Assuming these nozzles can operate under a Δpmax = 25÷40 bar, depending on temperature (Δpmax = 40 bar when steam temperature is < 400°C), the corresponding max value of Ry is:

$$Ry = \sqrt{25 \div 40 / 6} = 2 \div 2{,}5$$

Vortex type improves the performance of fixed area nozzles by increasing the atomization degree of water with the same mean velocity and Δp.
So the min Δp is strongly reduced to about 1 bar and the corresponding Ry, even though Cvmax/Cvmin is = 1 again, is increased to:

$$Ry = \sqrt{25 \div 40 / 1} = 5 \div 6$$

All the values of Ry vs available Δp are shown in the following table:

Δp - bar	5	10	15	25	30	40
RANGEABILITY	2,2 : 1	3 : 1	4 : 1	5 : 1	5,5 : 1	6 : 1

Main characteristcs

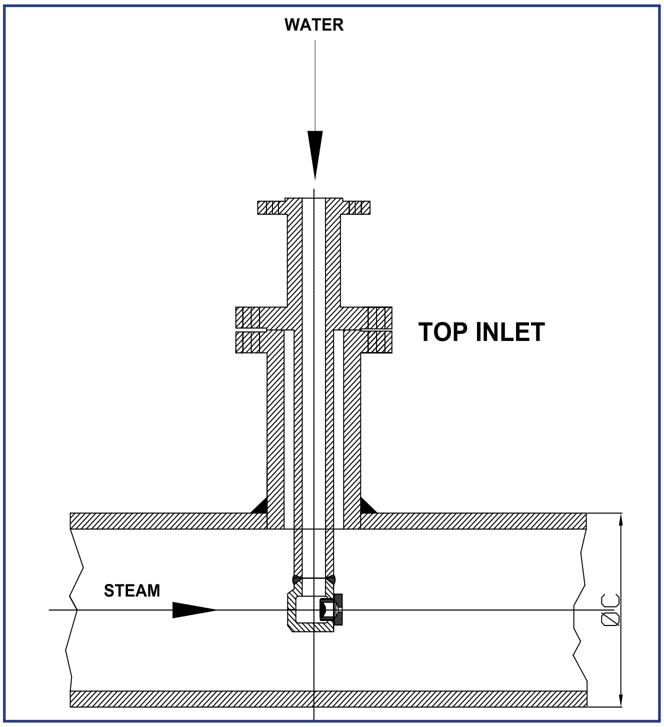
Sizes: 15 nozzles sizes are available from DF1 through DF15.
Materials: probe assembly F11/F22/F91, for nozzle materials see table pag. 1
Flow capacity: from 0,018 to 4,5 according to Cv table – when two nozzles are mounted more than 100 Cv's are available by the combination of different sizes.
Mounting: probe type with top water connection, also side connection is available on request.

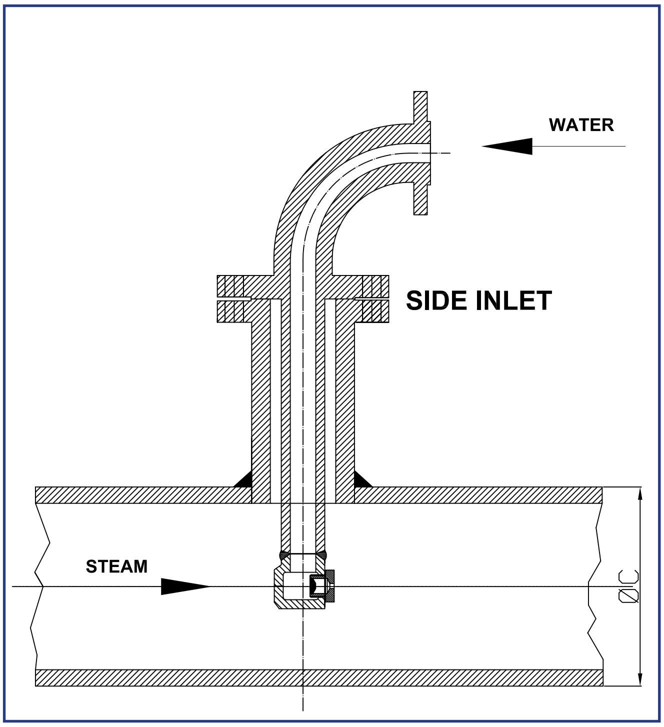
Nozzle	Cv max	Max flowrate m3/h (1)
DF1	0,018	0,085
DF2	0,03	0,142
DF3	0,06	0,284
DF4	0,12	0,569
DF5	0,22	1
DF6	0,36	1,7
DF7	0,5	2,4
DF8	1,1	5,2
DF9	1,5	7,1
DF10	2	9,5
DF11	2,5	11,8
DF12	3	14,2
DF13	3,5	16,6
DF14	4	19,0
DF15	4,5	21,3

Note(1): Δp = 30 bar – density 1000 kg/m3

VARI*fix* DESUPERHEATERS probe assembly

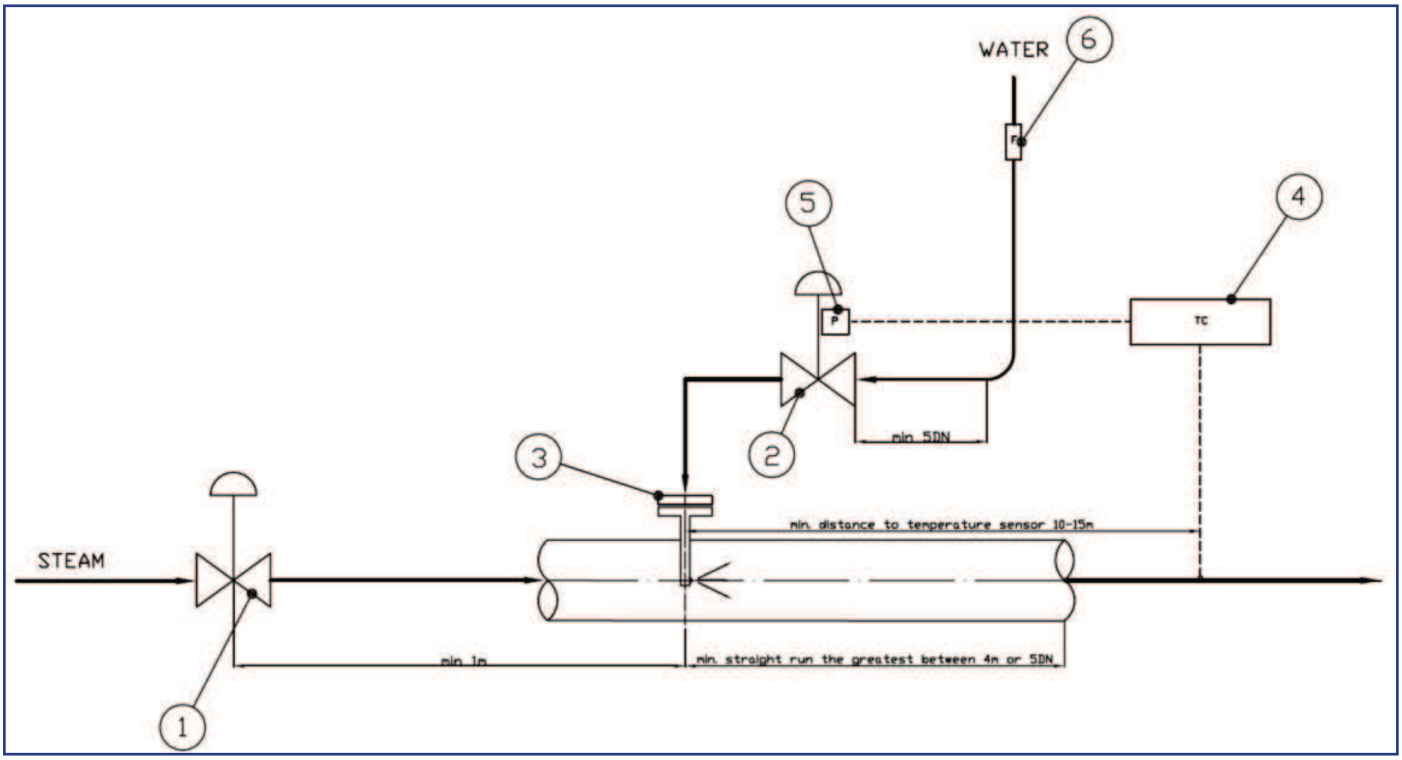
One or max two nozzles are fastened at the end on a tubular extension flanged to the pipe. The injection is performed close to the pipe axis by adjusting the probe length. A reference pin located on the desuperheater flange ensures the correct orientaton of the nozzle inside the piping. Probe assembly is normally performed with the same pipe material. In the tables the combinations of water and pipe connections are listed vs the nozzles dimensions. Steam connections can be oversized when two nozzles are mounted on the same probe.





Engineering practice for efficient desuperheating

For efficient desuperheating the arrangement of installation are shown in figure.



LEGENDA

1) Pressure reducing valve
2) Water control valve
3) Carraro desuperheater
4) Temperature controller
5) Positioner
6) Filter (recommended)

VARI*fix* dimensions

NOZZLE	L	A	B	C min	G min[1]
DF1-5	147	1”	2”	4”	49
DF6-10	186	1”	3”	6”	73,5
DF11-15	205	1-1/2”	4”	8”	97

Note[1]: The dimensions are consistent with sch.80 thicknesses. For different design (rating & dimensions) contact Carraro technical department.

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<tr><th rowspan="3">DN steam</th><th colspan="2">DF1-5</th><th colspan="2">DF6-10</th><th colspan="2">DF11-15</th></tr>
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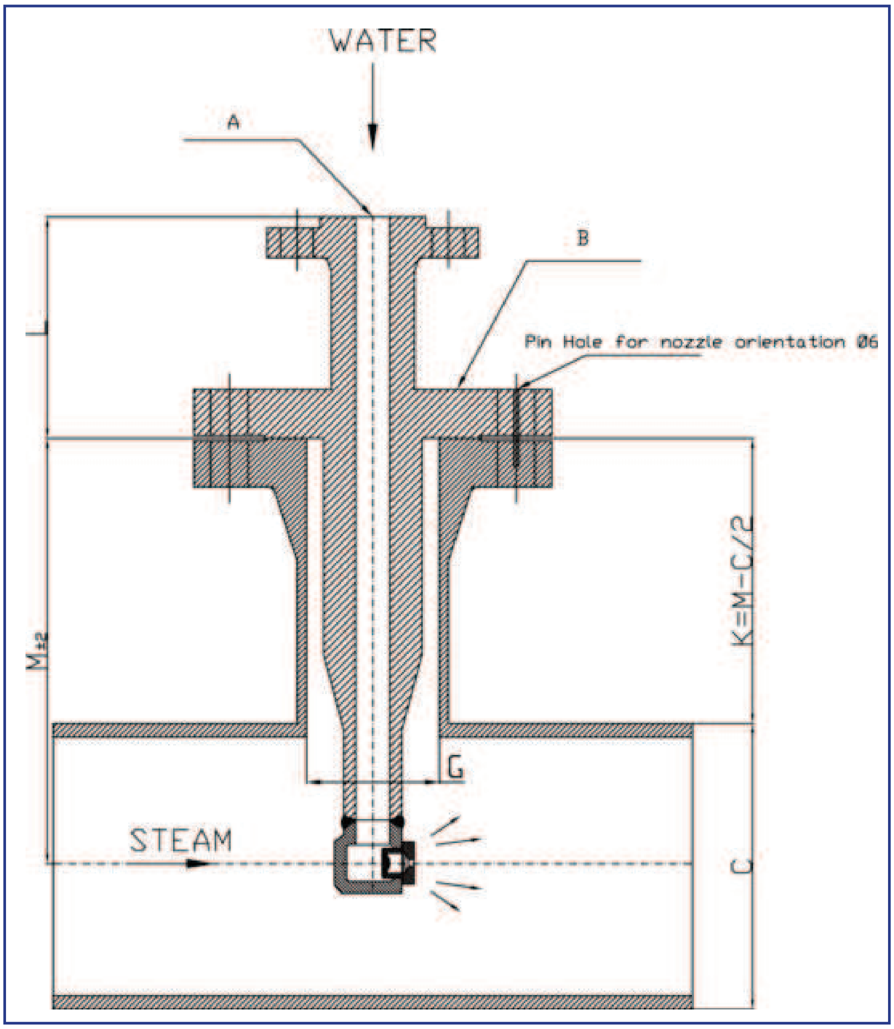

NOTE
K is the same for 28” to 40” pipe diameter

About Carraro

Carraro Srl is a private independent company, operative since 1924 in the field of industrial valves. The firm produces and commercializes worldwide a broad range of industrial pressure regulators, desuperheaters and safety valves for fluids such as steam, process gases and liquids.
The flexible organization of Carraro allows a great customization of the products and the production of “taylor made” constructions. Most of the Carraro’s product range can be realized also in “exotic” materials such as e.g. duplex, superduplex, monel, hastelloy, aluminum bronze and others. Supported by a global network of sales offices, representatives and distributors, Carraro offers a wide range of solutions for the Oil&Gas, the Power industry and all other diversified industrial applications.

Carraro: product range

UB Regulators: direct-operated pressure regulators with compact design
Maxomatic Series: multifunction pilot-operated regulators for liquids
MM-BPM series: direct-operated, spring pressure regulators
AT series: direct-operated temperature regulators
M51 series: direct-operated, weight and lever pressure regulators
CS series: safety valves for vapours, gas, liquids
CSV series: safety valves for steam and gases
VRE series: electrically operated control valves
MCP - ACP series: pneumatically operated control valves
AIRMATIC series: electropneumatic safety valves
DSH series: desuperheaters

Approvals and certifications

UNI EN ISO 9001: 2008	✔
UNI EN ISO 14001: 2004	✔
97 / 23 / CE (PED)	✔
94 / 09 / CE (ATEX)	✔
RINA	✔
GOST R+RTN	✔
CRN Canada	✔

Cooperations with notified bodies

LLOYD’s REGISTER	✔
ABS	✔
BV	✔
DNV	✔

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