DESIGN & MANUFACTURING
OF INSTRUMENTATION DEVICES
FOR FLUID MEASUREMENT AND CONTROL

FLOW • PRESSURE • TEMPERATURE • ACCESSORIES

Deltafluid

MEASURING UP TO YOUR EXPECTATIONS

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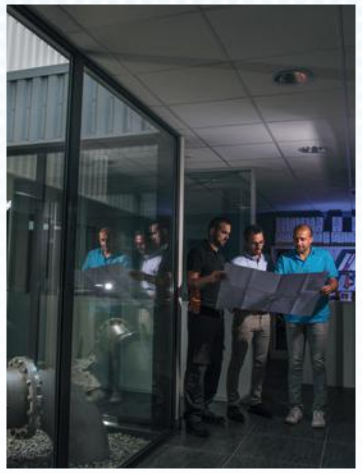
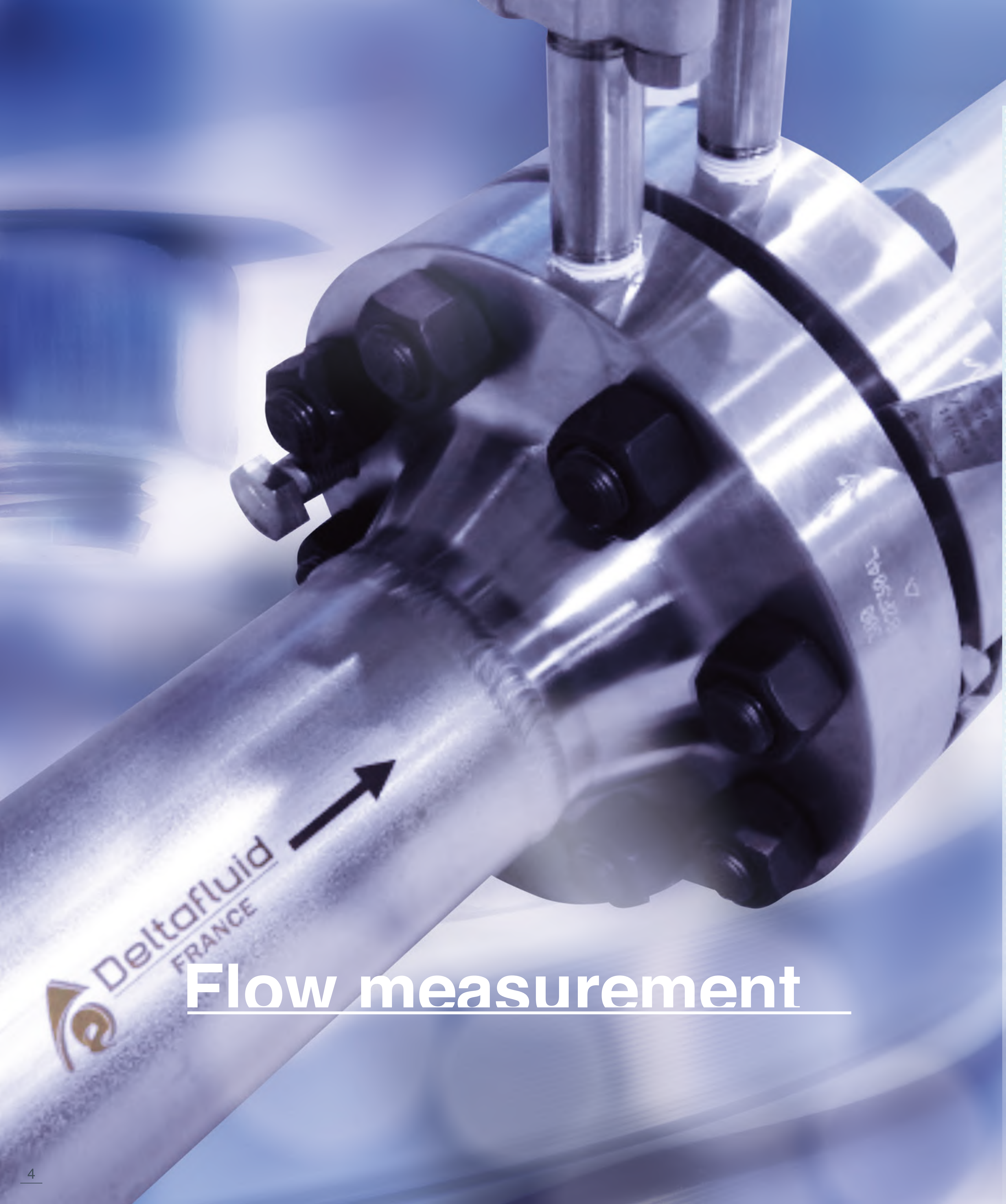
Summary





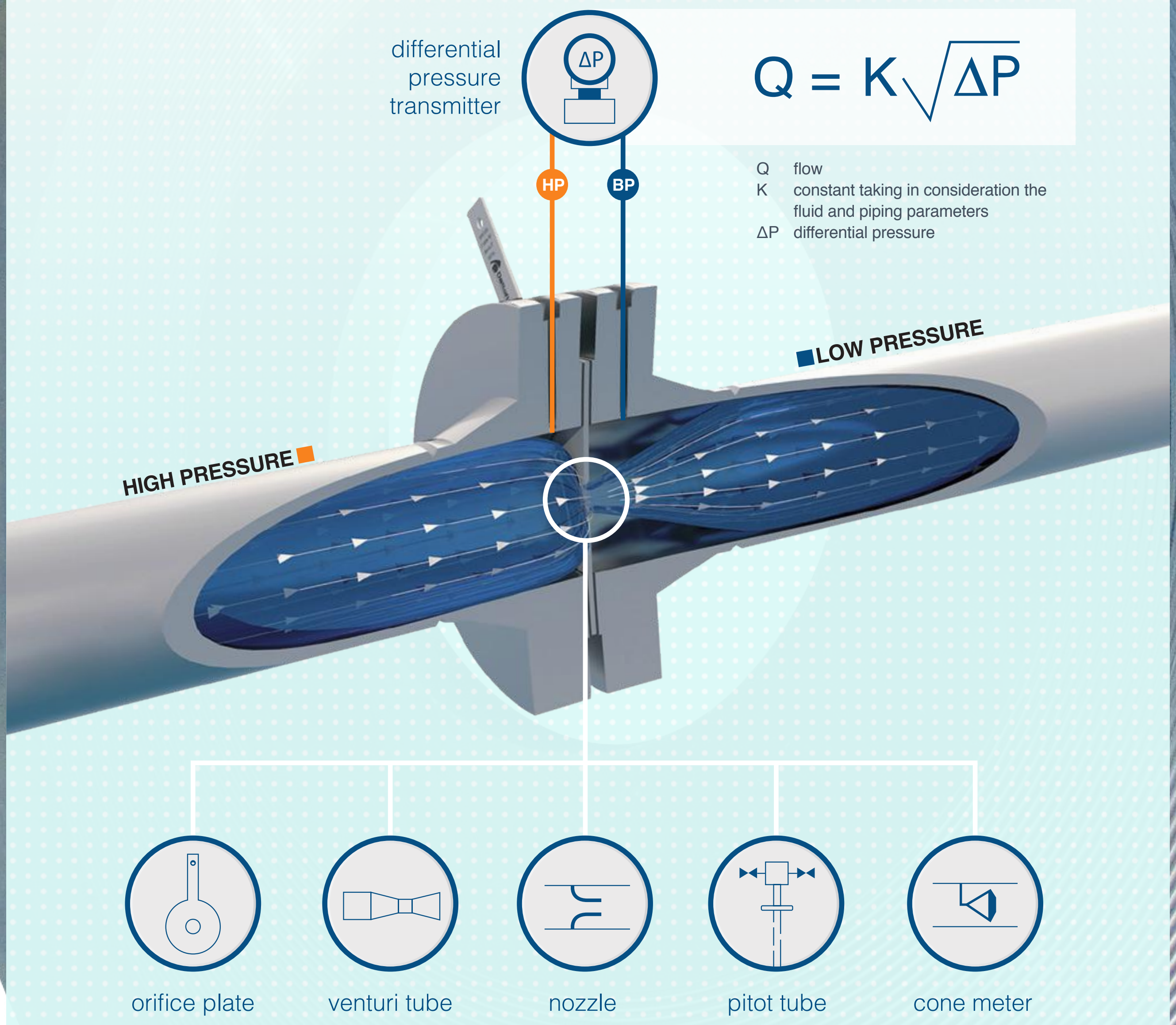
Flow measurement

DIFFERENTIAL PRESSURE FLOW MEASUREMENT

A MEASURE WITH **MANY BENEFITS**

applicable for all types of fluids and mixtures in **liquid, gas or steam** form

STANDARDIZED	COST-SAVING	ROBUST
UNNECESSARY CALIBRATION GUARANTEED PRECISION	QUICK AND EASY INSTALLATION MAINTENANCE FREE	NO MOVING PARTS LONG LIFE TIME



$$Q = K\sqrt{\Delta P}$$

Q	flow
K	constant taking in consideration the fluid and piping parameters
ΔP	differential pressure

A TURNKEY SOLUTION

Flow measuring elements supplied with accessories adapted to meet your needs

Instrumentation accessories

- differential pressure transmitter
- relative and absolute pressure transmitter
- manifold
- temperature sensor
- calculator
- housing

Flow measuring elements

- orifice plate
- venturi
- nozzle
- cone meter
- compact
- meter run
- pitot tube

Piping accessories

- flanges
- condensation pot
- thermowell
- flow straightener
- valve
- instrumentation holder

PRIMARY ELEMENT SELECTION GUIDE

Primary elements allow to cover a very wide range of applications.
The below table will help you select the most suitable solution for your installation.

REYNOLDS NUMBER Re_D

$$Re_D = \frac{V_1 D}{\nu_1} = \frac{4\,q_m}{\pi\,\mu_1\,D}$$

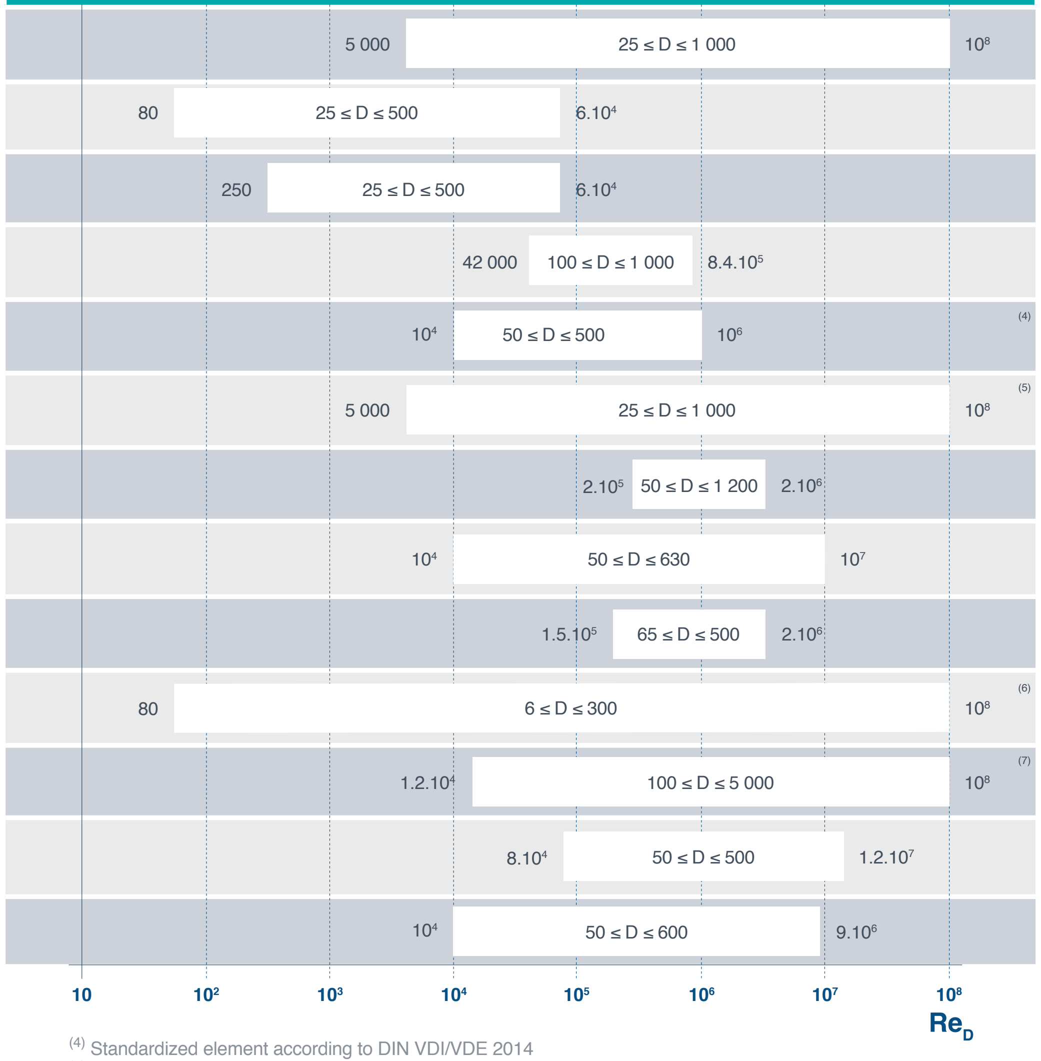
V_1 fluid velocity in m/s
D pipe internal diameter in m
ν_1 kinematic fluid viscosity in m²/s
q_m mass flow rate in kg/s
μ_1 dynamic fluid viscosity in Pa.s

The Reynolds number (Re_D) is a dimensionless parameter which expresses the relationship between the inertia and viscosity forces in a pipe. It qualifies the type of flow (laminar, transient or turbulent).

The below table provides the Reynolds number limitations and the recommended pipe diameter as per the standards. It is possible to extend these values by performing a calibration of the device concerned.

✓✓ recommended
✓ adapted

			GAS		LIQUID				STEAM	STANDARDIZED VALUES ACCORDING ISO 5167 & ISO/TR 15377: - Reynolds number Re_D - Internal diameter of the pipe D, in mm				MAIN ADVANTAGE	PAGE
			CLEAN	DIRTY	CLEAN	DIRTY	VISCOUS	AGRESSIVE							
ORIFICE PLATE	SHARP EDGE(1)		✓✓		✓✓			✓ (2)	✓✓ (2)	5 000	25 ≤ D ≤ 1 000	10^8		Economical and reliable	10
	CONICAL ENTRANCE(1)		✓				✓✓	✓ (2)	✓✓ (2)	80	25 ≤ D ≤ 500	6.10^4		Low flowrate and/or viscous fluid	11
	QUARTER CIRCLE(1)		✓	✓	✓	✓	✓✓	✓ (2)	✓✓ (2)	250	25 ≤ D ≤ 500	6.10^4		Viscous fluid	12
	ECCENTRIC(1)			✓✓		✓✓		✓ (2)	✓ (2)	42 000	100 ≤ D ≤ 1 000	$8.4.10^5$		Dirty, charged or two-phase fluid	13
	SEGMENTAL(1)			✓✓		✓✓		✓ (2)	✓ (2)	10^4	50 ≤ D ≤ 500	10^6	(4)	Dirty, charged or two-phase fluid	14
	CONDITIONING(1)	SHORT STRAIGHT LENGTH	✓✓		✓✓			✓ (2)	✓✓ (2)	5 000	25 ≤ D ≤ 1 000	10^8	(5)	Short straight length (2D/2D)	15
VENTURI TUBE		SHORT STRAIGHT LENGTH	✓✓	✓	✓✓	✓		✓	✓	2.10^5	50 ≤ D ≤ 1 200	2.10^6		Short straight length and low permanent pressure drop	16 à 18
NOZZLE			✓✓	✓	✓✓	✓	✓	✓✓ (2)	✓✓ (2)	10^4	50 ≤ D ≤ 630	10^7		Large flowrate	19 - 20
VENTURI-NOZZLE			✓✓	✓	✓✓	✓	✓	✓✓	✓✓	$1.5.10^5$	65 ≤ D ≤ 500	2.10^6		Large flowrate and low permanent pressure drop	21
METER RUN(3)			✓✓		✓✓	✓	✓	✓	✓✓	80	6 ≤ D ≤ 300	10^8	(6)	High accuracy	22 à 24
PITOT TUBE			✓✓		✓✓		✓			$1.2.10^4$	100 ≤ D ≤ 5 000	10^8	(7)	Wide pipe and very low pressure drop	26
CONE METER		SHORT STRAIGHT LENGTH	✓✓	✓	✓✓	✓		✓	✓	8.10^4	50 ≤ D ≤ 500	$1.2.10^7$		Short straight length	27
WEDGE METER				✓✓		✓✓	✓✓	✓✓	✓	10^4	50 ≤ D ≤ 600	9.10^6		Fluid charged with impurities	28



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(1) All of these primary elements can be integrated in a compact flowmeter version - see page 25.
(2) For a very corrosive / abrasive fluid, provide a resistant material and / or a coating protection on the edge of the restriction : stellite coating, ceramic projection.
(3) The meter run is a complete solution including the primary element, gaskets, flanges, pressure taps, upstream and downstream straight lengths… see page 23.
Special meter run :
- Integrated orifice for diameters up to 40 mm - see page 22.
- High precision measurement tube with differential pressure transmitter and temperature sensor if needed for the most accurate measure of the market - see page 24.

(4) Standardized element according to DIN VDI/VDE 2014
(5) Non standardized element, recommended Re_D and D ranges
(6) From 6 to 40 mm, standardized element according to ASME MFC-14M
(7) Standardized element according to ASME MFC-12M

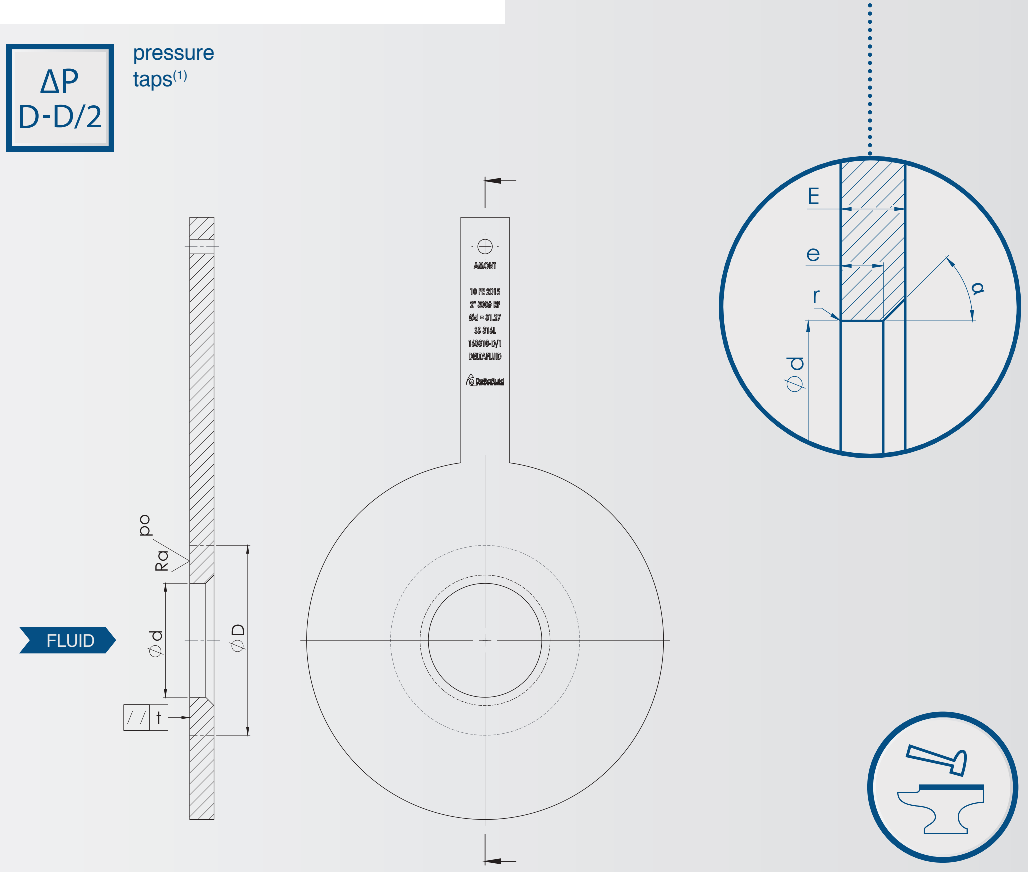
SHARP EDGE
ORIFICE PLATE

Cost-saving and reliable solution

GENERAL DATA

- Standards: ISO 5167-1&2, ASME MFC-3M, ISO/TR 15377
- Flange mounting[1]:
    - o ISO PN 2.5 to PN 420
    - o ASME 150# to 2500#
    - o Others: upon request
- Material:
    - o Standard: stainless steel 304L / 316L
    - o Others[1]: according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 25 to 1 000 mm
- Accuracy: 0.5 % of the max flow rate
- Repeatability of measurement: 0.1 %

ΔP 0/0 | ΔP 25/25 | ΔP D-D/2 pressure taps[1]



Optional: stellite coating[1]

TECHNICAL CHARACTERISTICS

		ISO/TR 15377	ISO 5167-1&2	ASME MFC-3M
Re_D	Reynolds number in the pipe	$5\,000 \leq Re_D \leq 10^8$		
D[2]	Inside pipe diameter	25 mm ≤ D < 50 mm	50 mm ≤ D ≤ 1 000 mm	
d	Orifice diameter	d ≥ 12.5 mm		
ß	d/D	0.5 ≤ ß ≤ 0.7	0.1 ≤ ß ≤ 0.75	
Ra	Upstream face roughness	$Ra < 10^{-4}.d$		
r	Sharp edge radius	r < 0.000 4.d		
e	Orifice thickness	0.005.D ≤ e ≤ 0.02.D		
E	Plate thickness	e ≤ E ≤ 0.05.D		
α	Angle of the downstream bevel	α = 45° ± 15°		
t	Flatness tolerance	t < 0.005.(D - d)/2		

[1] For more details, see «Technical information» section on page 54.

[2] Orifice plates with diameters D from 6 mm are described in the ASME MFC-14M standard - see page 22.

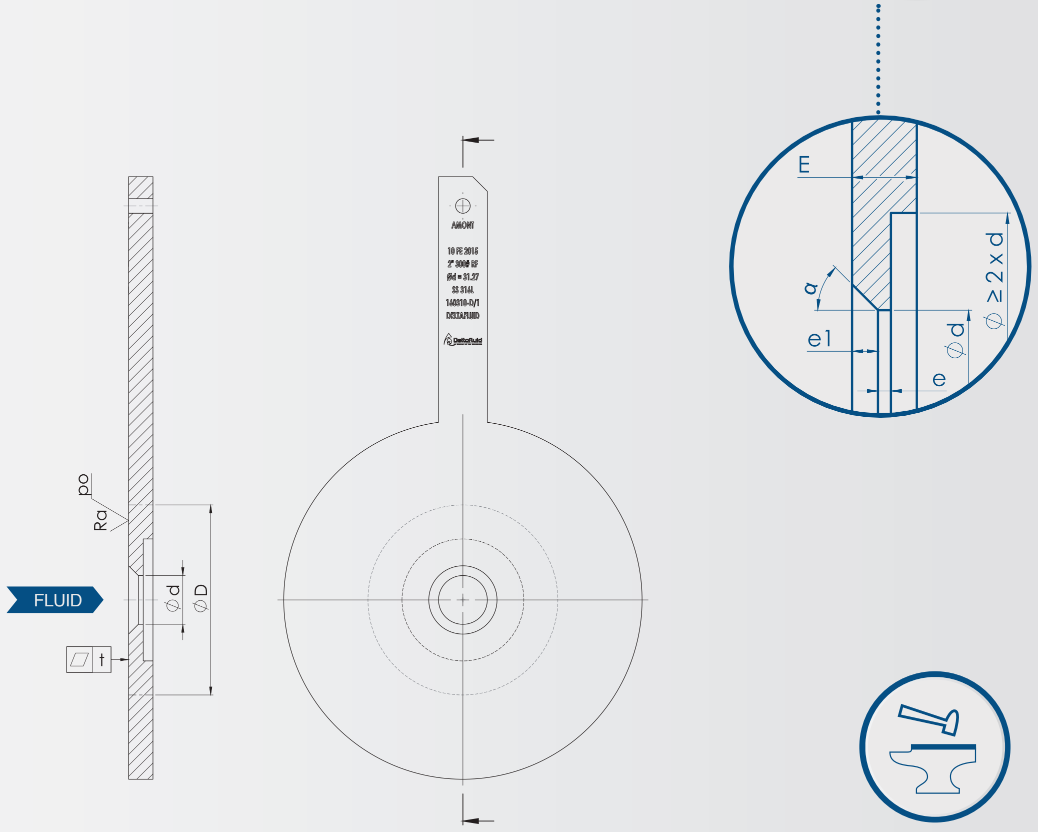
ORIFICE PLATE
WITH CONICAL ENTRANCE

Recommended for small flow rates and/or viscous fluids

GENERAL DATA

- Standard: ISO/TR 15377
- Flange mounting[1]:
    - o ISO PN 2.5 to PN 420
    - o ASME 150# to 2500#
    - o Others: upon request
- Material:
    - o Standard: stainless steel 304L / 316L
    - o Others[1]: according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 25 to 1 000 mm
- Accuracy: 2 % of max the flow rate
- Repeatability of measurement: 0.1 %

ΔP 0/0 pressure tap[1]



Optional: stellite coating[1]

TECHNICAL CHARACTERISTICS

		ISO/TR 15377
Re_D	Reynolds number in the pipe	$80 \leq Re_D \leq 6.10^4$
D	Inside pipe diameter	25 mm ≤ D ≤ 500 mm
d	Orifice diameter	d > 6 mm
ß	d/D	0.1 ≤ ß ≤ 0.316
Ra	Upstream face roughness	$Ra \leq 10^{-4}.d$
e_1	Thickness of the conical entrance	$e_1 = 0.084.d \pm 0.003.d$
e	Cylindrical part thickness	e = 0.021.d ± 0.003.d
E	Plate thickness	E ≤ 0.1.D
α	Angle of the upstream bevel	α = 45° ± 1°
t	Flatness tolerance	$t < 0.005.(D - d - 2.e_1)/2$

[1] For more details, see «Technical information» section on page 54.

QUARTER CIRCLE
ORIFICE PLATE

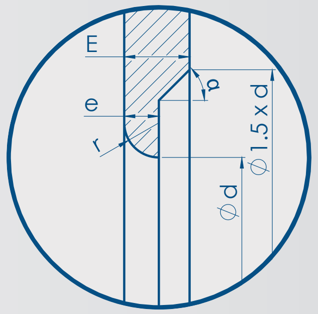
Recommended for viscous fluids

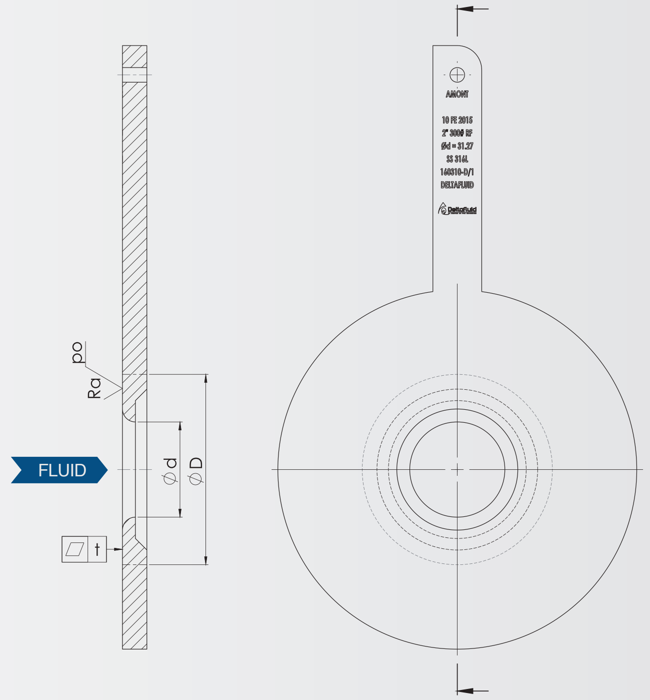
GENERAL DATA

- Standard: ISO/TR 15377
- Flange mounting[(1)]:
  - o ISO PN 2.5 to PN 420
  - o ASME 150# to 2500#
  - o Others: upon request
- Material:
  - o Standard: stainless steel 304L / 316L
  - o Others[(1)]: according to your application
- Fluid: liquid, gas, steam
- Pipes from ɸ 25 to 500 mm
- Accuracy: 2 % of the max flow rate
- Repeatability of measurement: 0.1 %

ΔP 0/0 | ΔP 25/25 pressure taps[(1)]

D ≥ 40 mm





Optional: stellite coating[(1)]

TECHNICAL CHARACTERISTICS

		ISO/TR 15377
Re_D	Reynolds number in the pipe	$250 \leq Re_D \leq 6.10^4$
D	Inside pipe diameter	25 mm ≤ D ≤ 500 mm
d	Orifice diameter	d ≥ 15 mm
ß	d/D	0.245 ≤ ß ≤ 0.6
Ra	Upstream face roughness	$Ra \leq 10^{-4}.d$
r	Quarter circle radius	0.100.d ≤ r ≤ 0.207.d
e	Quarter circle orifice thickness	2.5 mm ≤ e ≤ 0.1.D
E	Plate thickness	E ≥ r
α	Angle of the downstream bevel if needed	α = 45°
t	Flatness tolerance	Contact us

[(1)] For more details, see «Technical information» section on page 54.

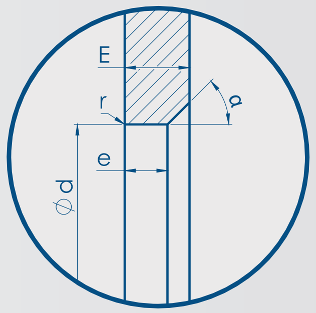
ECCENTRIC
ORIFICE PLATE

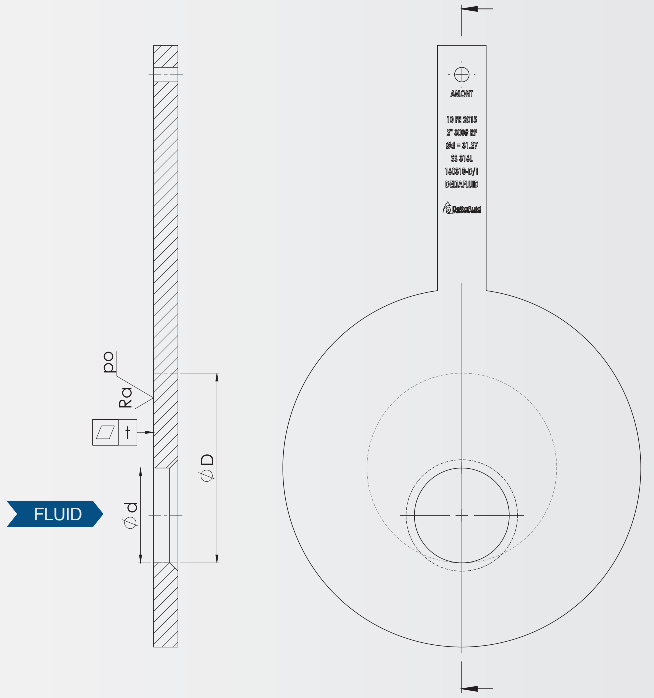
Recommended for dirty fluids with small particles or two-phase fluids

GENERAL DATA

- Standard: ISO/TR 15377
- Flange mounting[(1)]:
  - o ISO PN 2.5 to PN 420
  - o ASME 150# to 2500#
  - o Others: upon request
- Material:
  - o Standard: stainless steel 304L / 316L
  - o Others[(1)] : according to your application
- Fluid: liquid, gas, steam
- Pipes from ɸ 100 to 1 000 mm
- Accuracy: 1 % of the max flow rate
- Repeatability of measurement: 0.1 %

ΔP 0/0 pressure tap[(1)]





Optional: stellite coating[(1)]

TECHNICAL CHARACTERISTICS

		ISO/TR 15377
Re_D	Reynolds number in the pipe	$42\,000 \leq Re_D \leq 8.4.10^5$
D	Inside pipe diameter	100 mm ≤ D ≤ 1 000 mm
d	Orifice diameter	d ≥ 50 mm
ß	d/D	0.46 ≤ ß ≤ 0.84
Ra	Upstream face roughness	$Ra \leq 10^{-4}.d$
r	Radius of the upstream sharp edge	r < 0.000 4.d
e	Cylindrical orifice thickness	0.005.D ≤ e ≤ 0.02.D
E	Plate thickness	e ≤ E ≤ 0.05.D
α	Angle of the downstream bevel if needed	α = 45° ± 15°
t	Flatness tolerance	t < 0.005.(D - d)/2

[(1)] For more details, see «Technical information» section on page 54.

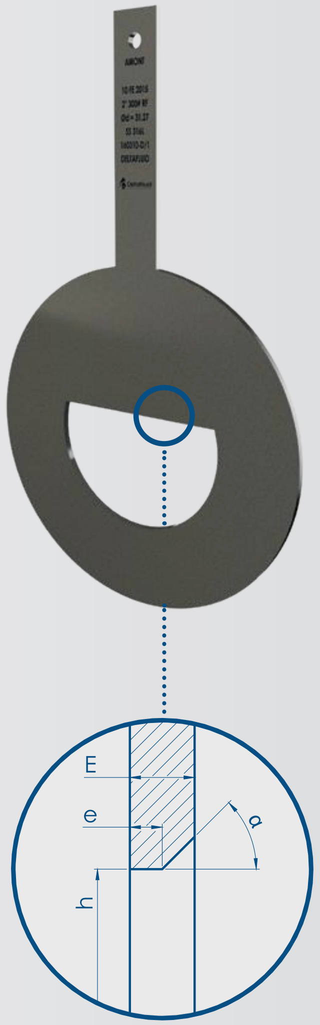
SEGMENTAL
ORIFICE PLATE

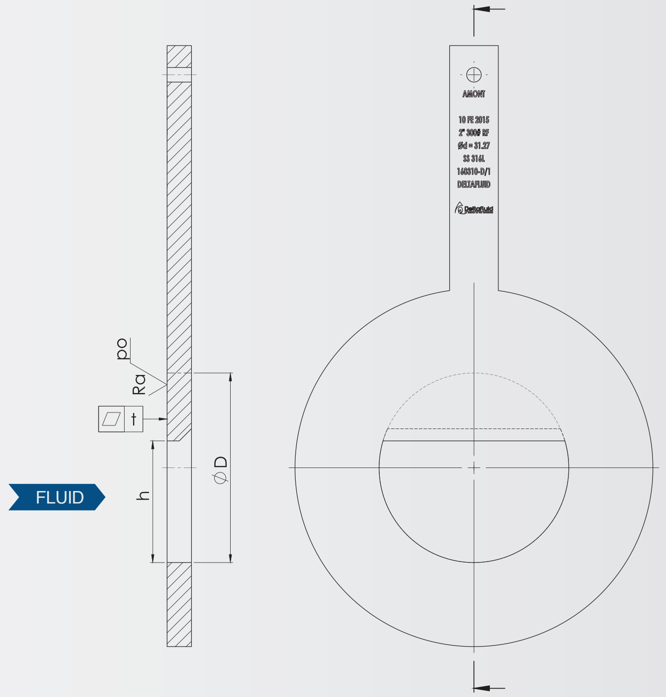
Recommended for dirty fluids with small particles or two-phase fluids

GENERAL DATA

- Standard: DIN VDI/VDE 2041
- Flange mounting(1):
    - o ISO PN 2.5 to PN 420
    - o ASME 150# to 2500#
    - o Others: upon request
- Material:
    - o Standard: stainless steel 304L / 316L
    - o Others(1): according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 100 to 350 mm
- Accuracy: 1.2 % of the max flow rate
- Repeatability of measurement: 0.1 %

ΔP 0/0 | ΔP 25/25 | pressure taps(1)





Optional: stellite coating(1)

TECHNICAL CHARACTERISTICS

		DIN VDI/VDE 2041
Re_D	Reynolds number in the pipe	$10^4 \leq Re_D \leq 10^6$
D	Inside pipe diameter	50 mm ≤ D ≤ 500 mm
h	Orifice height	h ≥ 12.5 mm
ß	h/D	0.316 ≤ ß ≤ 0.707
Ra	Upstream face roughness	$Ra \leq 10^{-4}.h$
e	Orifice thickness	0.005.D ≤ e ≤ 0.02.D
E	Plate thickness	e ≤ E ≤ 0.05.D
α	Angle of the downstream bevel if needed	α = 45° ± 15°
t	Flatness tolerance	t < 0.005.(D - h)/2

(1) For more details, see «Technical information» section on page 54.

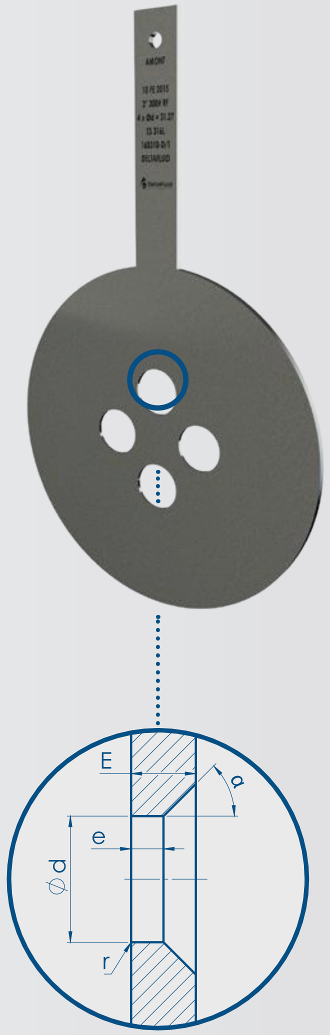
CONDITIONING
ORIFICE PLATE

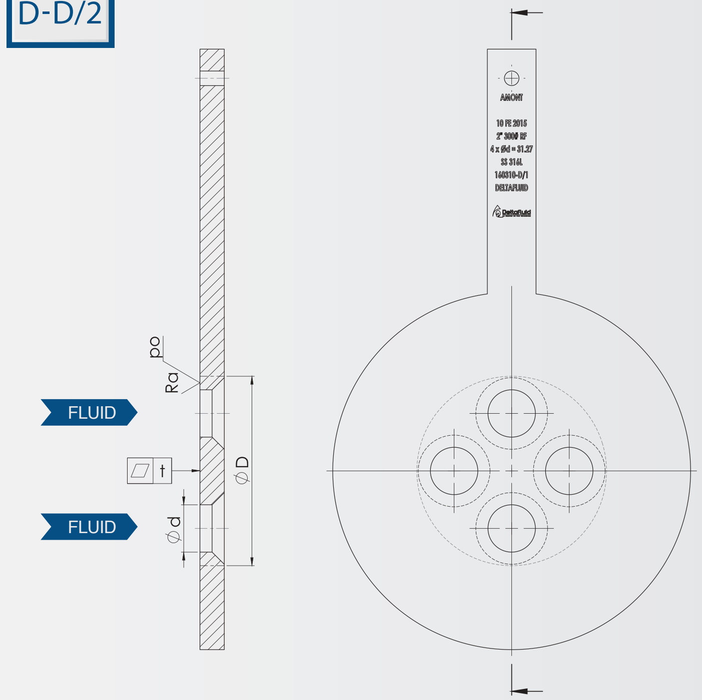
Cost-saving solution thanks to reduced upstream and downstream straight lengths

GENERAL DATA

- Design based on ISO 5167-1&2 or ASME MFC-3M standards
- Flange mounting(1):
    - o ISO PN 2.5 to PN 420
    - o ASME 150# to 2500#
    - o Others: upon request
- Material:
    - o Standard: stainless steel 304L / 316L
    - o Others(1): according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 25 to 1 000 mm
- Accuracy: 0.5 % of the max flow rate
- Repeatability of measurement: 0.1 %

ΔP 0/0 | ΔP 25/25 | ΔP D-D/2 | pressure taps(1)





TECHNICAL CHARACTERISTICS

Optional: stellite coating(1)

Re_D	Reynolds number in the pipe	$5\,000 \leq Re_D \leq 10^8$
D	Inside pipe diameter	25 mm ≤ D ≤ 1 000 mm
d	Orifice diameter	d ≥ 6 mm
ß	d/D	0.2 ≤ ß ≤ 0.65
Ra	Upstream face roughness	$Ra \leq 10^{-4}.d$
r	Shard edge radius	r < 0.000 4.d
e	Sharp edge orifice thickness	0.005.D ≤ e ≤ 0.02.D
E	Plate thickness	e ≤ E ≤ 0.05.D
α	Angle of the downstream bevel if needed	α = 45° ± 15°
t	Flatness tolerance	t < 0.005.(D - d)/2

(1) For more details, see «Technical information» section on page 54.

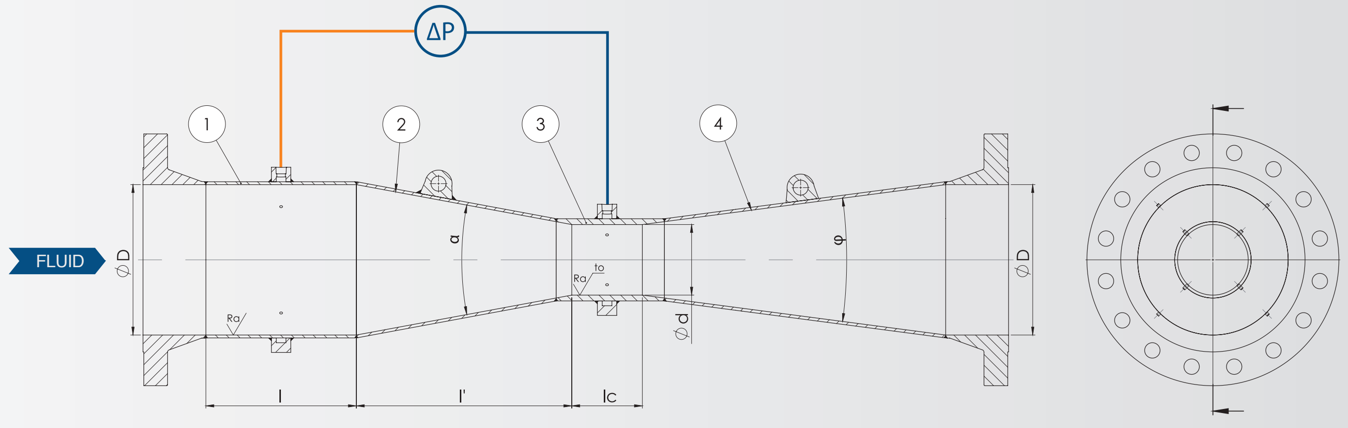
ROLLED WELDED VENTURI TUBE

Suitable for large diameters and/or low permanent pressure drop

GENERAL DATA

- Standards: ISO 5167-1&4 or ASME MFC-3M
- Weld-end (BW) or flanged connection⁽¹⁾
- Material:
  - o Standard: carbon steel, stainless steel
  - o Others⁽¹⁾: according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 100 to 1 200 mm
- Accuracy: 1.5 % of the max flow rate
- Repeatability of measurement: 0.1 %

MARK	DESIGNATION
1	Entrance cylinder
2	Convergent
3	Throat
4	Divergent



Upstream and throat pressure taps: annular chambers or four tappings with a «triple-T» arrangement

TECHNICAL CHARACTERISTICS

		ISO 5167-1&4	ASME MFC-3M
Re_D	Reynolds number in the pipe	$2.10^5 \leq Re_D \leq 2.10^6$	$2.10^5 \leq Re_D \leq 6.10^6$
D	Inside pipe diameter	200 mm ≤ D ≤ 1 200 mm⁽²⁾	100 mm ≤ D ≤ 1 200 mm⁽²⁾
ß	d/D	0.40 ≤ ß ≤ 0.70	0.30 ≤ ß ≤ 0.75
Ra	Throat roughness	$Ra \leq 10^{-4}.d$	
	Entrance cylinder and convergent roughness	$Ra \leq 5.10^{-4}.D$	
l	Entrance cylinder minimal length	l = D	
l’	Entrance convergent length	l’ = 2.7.(D - d)	
α	Entrance convergent angle	α = 21° ± 1°	
lc	Throat length	lc = d ± 0.03.d	
φ	Exit divergent angle	7° ≤ φ ≤ 15°	

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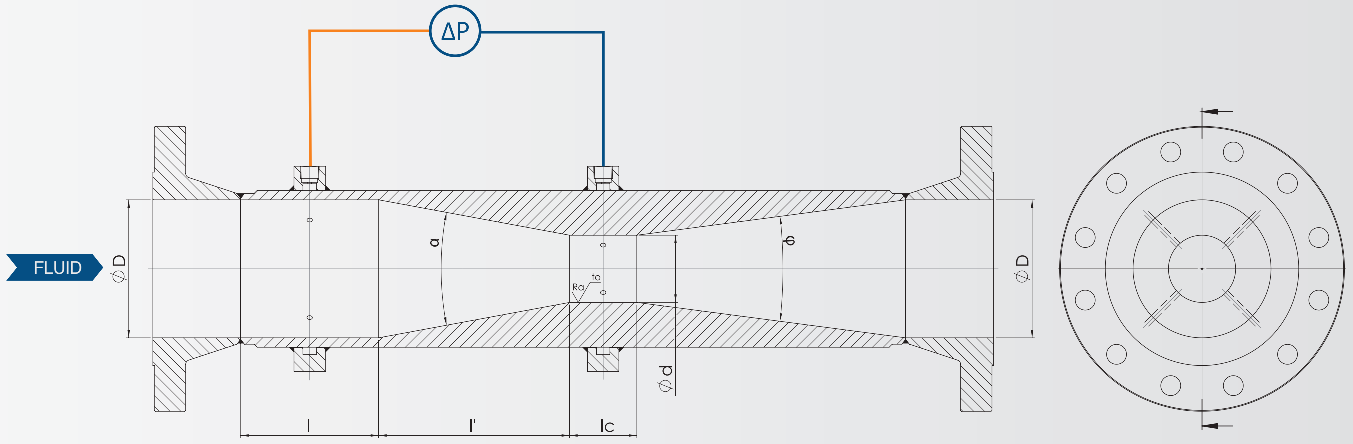
(1) For more details, see «Technical information» section on page 54.
(2) Diameter > 1 200 mm available on request.

MACHINED VENTURI TUBE

Suitable for small diameters and/or low permanent pressure drop

GENERAL DATA

- Standards: ISO 5167-1&4 or ASME MFC-3M
- Weld-end (BW) or flanged connection⁽¹⁾
- Material:
  - o Standard: carbon steel, stainless steel
  - o Others⁽¹⁾: according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 50 to 250 mm
- Accuracy: 1 % of the max flow rate
- Repeatability of measurement: 0.1 %



Upstream and throat pressure taps: annular chambers or four tappings with a «triple-T» arrangement

TECHNICAL CHARACTERISTICS

		ISO 5167-1&4	ASME MFC-3M
Re_D	Reynolds number in the pipe	$2.10^5 \leq Re_D \leq 10^6$	$2.10^5 \leq Re_D \leq 6.10^6$
D	Inside pipe diameter	50 mm ≤ D ≤ 250 mm	
ß	d/D	0.40 ≤ ß ≤ 0.75	0.30 ≤ ß ≤ 0.75
Ra	Throat roughness	$Ra \leq 10^{-4}.d$	
	Entrance cylinder and convergent roughness	$Ra \leq 10^{-4}.d$	
l	Entrance cylinder minimal length	l = D	
l’	Entrance convergent length	l’ = 2.7.(D - d)	
α	Entrance convergent angle	α = 21° ± 1°	
lc	Throat length	lc = d ± 0.03.d	
φ	Exit divergent angle	7° ≤ φ ≤ 15°	

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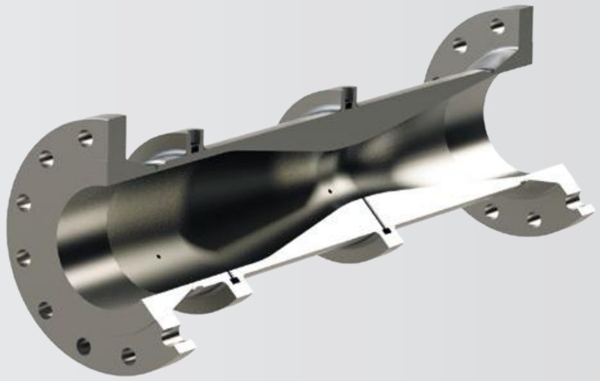
(1) For more details, see «Technical information» section on page 54.

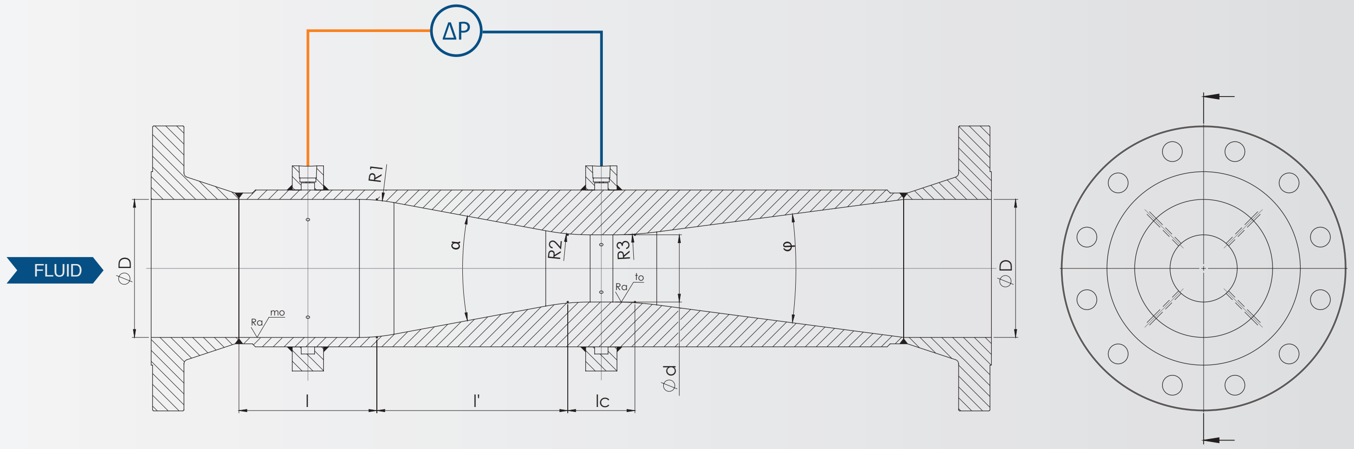
AS CAST
VENTURI TUBE

For a better accuracy

GENERAL DATA

- Standards: ISO 5167-1&4 or ASME MFC-3M
- Weld-end (BW) or flanged connection[1]
- Material:
  - o Standard: carbon steel, stainless steel
  - o Others[1]: according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 100 to 1 200 mm
- Accuracy: 0.7 % of the max flow rate
- Repeatability of measurement: 0.1 %





Upstream and throat pressure taps: annular chambers or four tappings with a «triple-T» arrangement

TECHNICAL CHARACTERISTICS

		ISO 5167-1&4	ASME MFC-3M
Re_D	Reynolds number in the pipe	$2.10^5 \leq Re_D \leq 2.10^6$	$2.10^5 \leq Re_D \leq 6.10^6$
D	Inside pipe diameter	100 mm ≤ D ≤ 800 mm	100 mm ≤ D ≤ 1 200 mm
ß	d/D	0.30 ≤ ß ≤ 0.75	
Ra	Throat roughness	$Ra \leq 10^{-4}.d$	
	Entrance cylinder and convergent roughness	$Ra \leq 10^{-4}.D$	
l	Entrance cylinder minimal length	l = D ou[2] (0.25.D + 250 mm)	
l'	Entrance convergent length	l' = 2.7.(D - d)	
α	Entrance convergent angle	α = 21° ± 1°	
lc	Throat length	lc = d ± 0.03.d (minimum value = d/3)	
R_1	Radius of curvature 1 between the entrance cylinder and the convergent section	$R_1 = 1.375.D \pm 0.275.D$	
R_2	Radius of curvature 2 between the convergent section and the throat	$R_2 = 3.625.d \pm 0.125.d$	
R_3	Radius of curvature 3 between the throat and the divergent section	$5.d < R_3 < 15.d$	
φ	Exit divergent angle	7° ≤ φ ≤ 15°	

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[1] For more details, see «Technical information» section on page 54.

[2] Consider the smaller value.

ISA 1932
NOZZLE

Suitable for large flow rates with high speeds

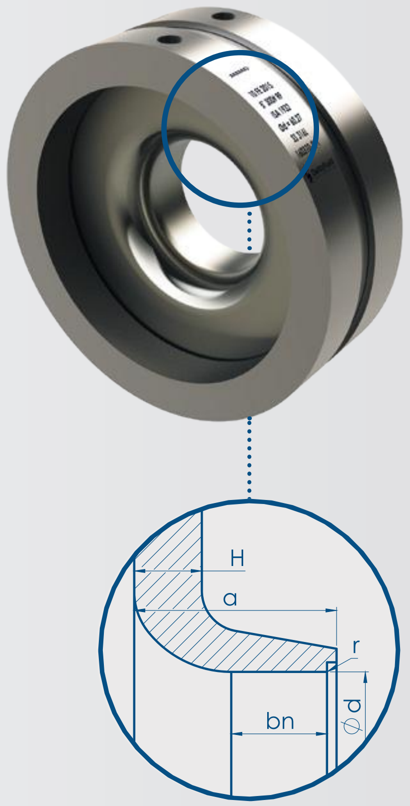
GENERAL DATA

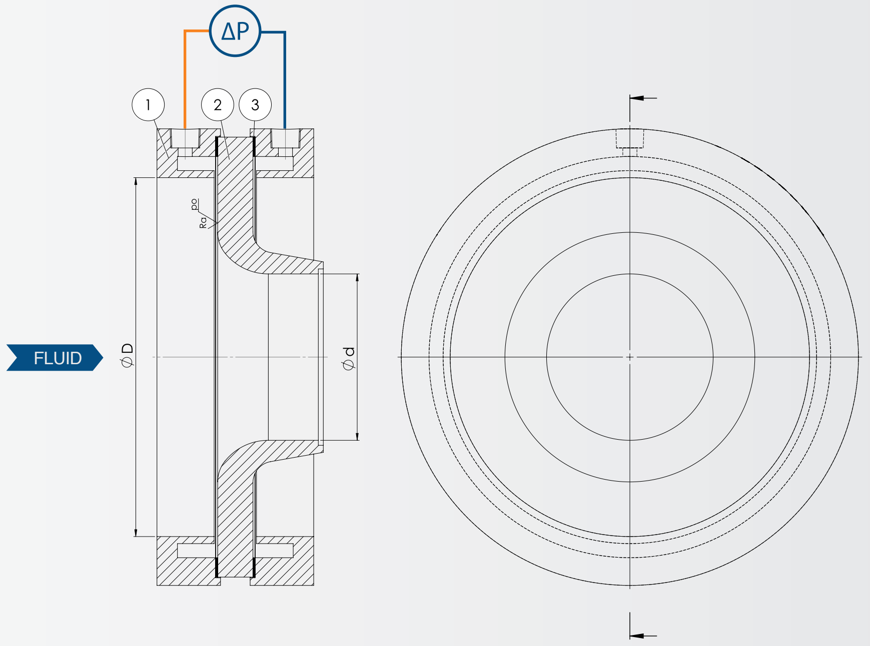
- Standards: ISO 5167-1&3 or ASME MFC-3M
- Flange mounting[1] :
  - o ISO PN 2.5 to 420
  - o ASME 150# to 2500#
  - o Others: upon request
- or weld-end connection (BW)
- Material :
  - o Standard: carbon steel, stainless steel
  - o Others[1]: according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 50 to 500 mm
- Accuracy: 0.8 % of the max flow rate
- Repeatability of measurement: 0.1 %

ΔP
0/0

pressure tap[1]

MARK	DESIGNATION
1	Annular chamber
2	ISA 1932 nozzle
3	Gasket





Optional: stellite coating[1]

TECHNICAL CHARACTERISTICS

		ISO 5167-1&3 & ASME MFC-3M
Re_D	Reynolds number in the pipe	$2.10^4 \leq Re_D \leq 10^7$
D	Inside pipe diameter	50 mm ≤ D ≤ 500 mm
ß	d/D	0.3 ≤ ß ≤ 0.8
Ra	Roughness of the upstream face and throat	$Ra \leq 10^{-4}.d$
b_n	Cylindrical throat length	$b_n = 0.3.d$
a	Nozzle total length	Upon request
r	Downstream sharp edge radius	r < 0.000 4.d
H	Thickness	H ≤ 0.1.D

---

[1] For more details, see «Technical information» section on page 54.

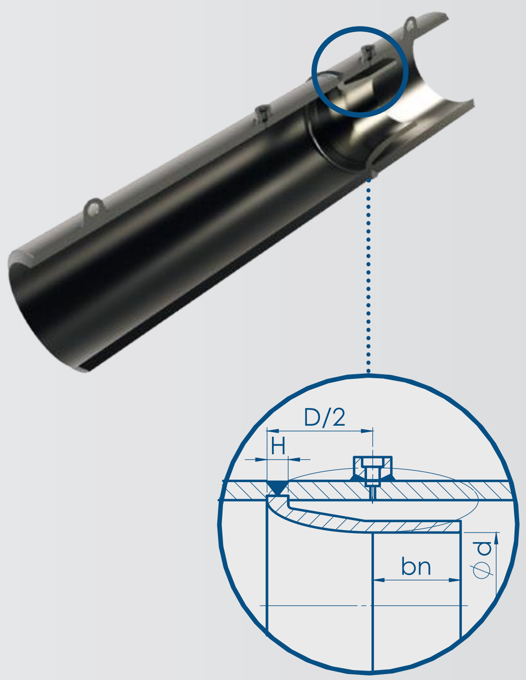
LONG RADIUS NOZZLE

Suitable for big steam flow rates

GENERAL DATA

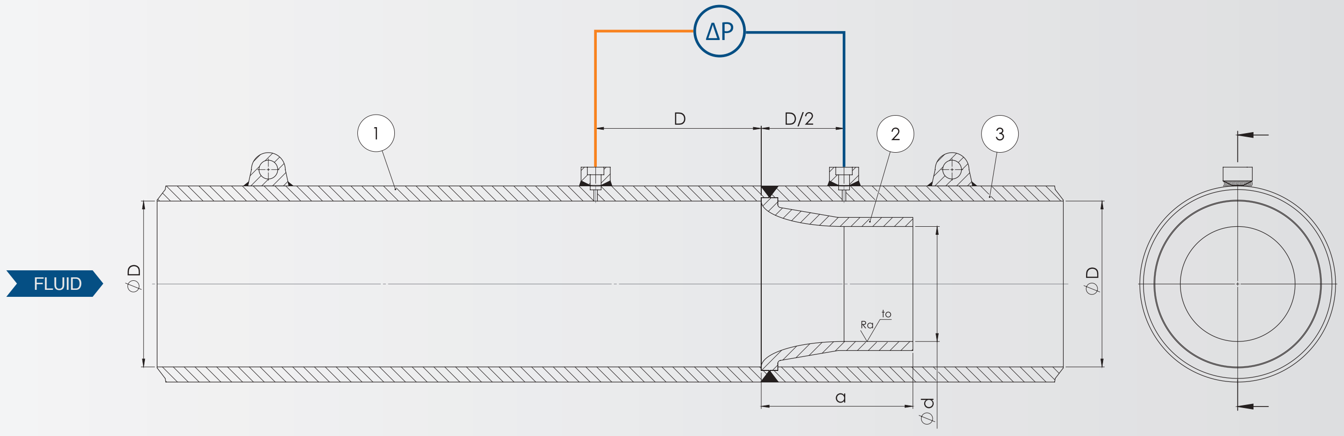
- Standards: ISO 5167-1&3 or ASME MFC-3M
- Flange mounting(1) :
  - o ISO PN 2.5 to 420
  - o ASME 150# to 2500#
  - o Others: upon request

  or weld-end connection (BW)
- Material:
  - o Standard: carbon steel, stainless steel
  - o Others(1): according to your application
- Fluid: liquid, gas, steam
- Pipes from φ 50 to 500 mm
- Accuracy: 2 % of the max flow rate
- Repeatability of measurement: 0.1 %



ΔP D-D/2 pressure tap(1)

Mark	DESIGNATION
1	Upstream pipe
2	Long radius nozzle
3	Downstream pipe



Optional: stellite coating(1)

TECHNICAL CHARACTERISTICS

		ISO 5167-1&3 & ASME MFC-3M	
		High-ratio nozzle	Low-ratio nozzle
Re_D	Reynolds number in the pipe	$10^4 \leq Re_D \leq 10^7$	
D	Inside pipe diameter	50 mm ≤ D ≤ 630 mm	
ß	d/D	0.25 ≤ ß ≤ 0.8	0.2 ≤ ß ≤ 0.5
Ra	Roughness of upstream face and throat	$Ra \leq 10^{-4}.d$	
b_n	Cylindrical throat length	$b_n = 0.6.d$	
a	Nozzle total length	a = D/2 + 0.6.d	a = d + 0.6.d
H	Thickness	3 mm ≤ H ≤ 0.15.D	

---

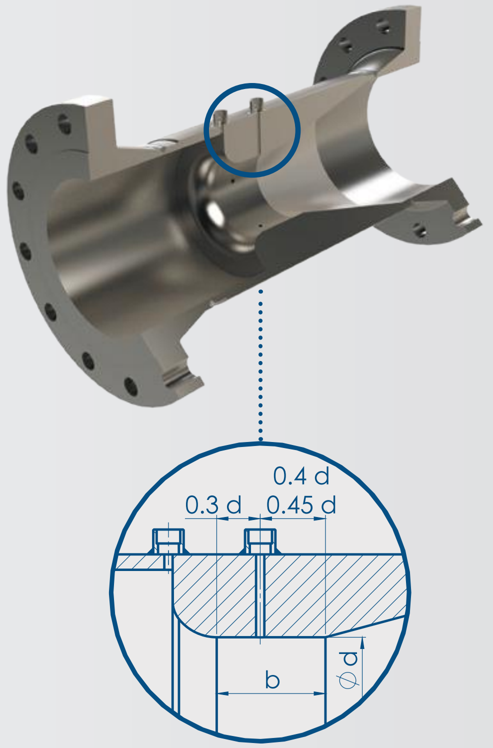
(1) For more details, see «Technical information» section on page 54.

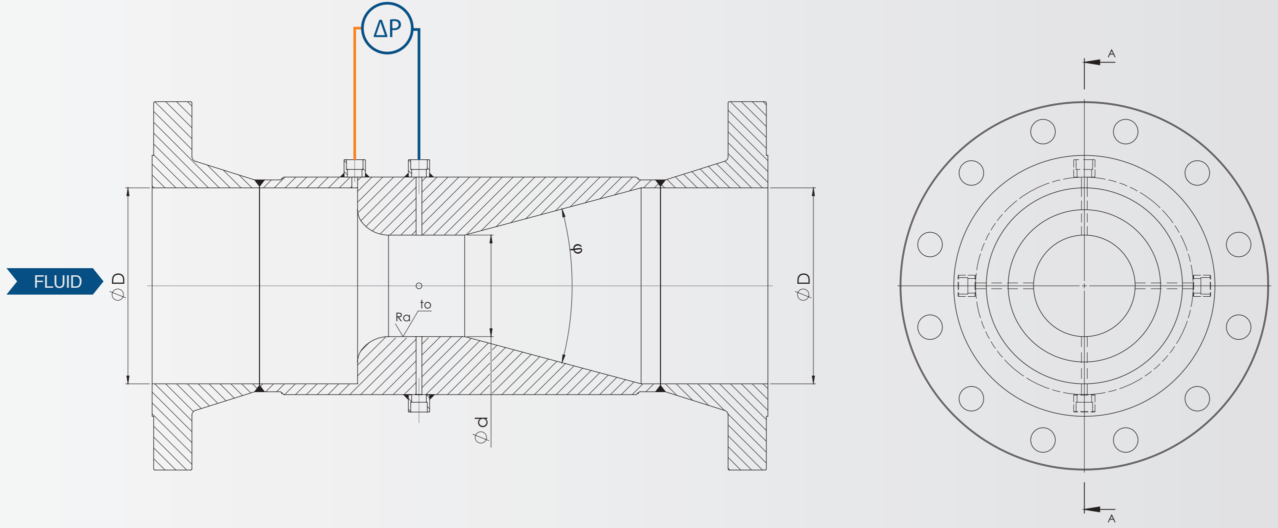
VENTURI-NOZZLE **MACHINED OR WELDED CONSTRUCTION**

Suitable for large flow rates with low permanent pressure drop

GENERAL DATA

- Standards: ISO 5167-1&3 or ASME MFC-3M
- Weld-end (BW) or flanged connection(1)
- Material:
  - o Standard: carbon steel, stainless steel
  - o Others(1): according to your application
- Fluid: liquid, gas, steam
- Pipes from φ 65 to 500 mm
- Accuracy: > 1.2 % of the max flow rate
- Repeatability of measurement: 0.1 %





Throat pressure taps: annular chambers or four tappings with a «triple-T» arrangement

TECHNICAL CHARACTERISTICS

		ISO 5167-1&3 & ASME MFC-3M
Re_D	Reynolds number in the pipe	$1.5.10^5 \leq Re_D \leq 2.10^6$
D	Inside pipe diameter	65 mm ≤ D ≤ 500 mm
d	Orifice diameter	d ≥ 50 mm
ß	d/D	0.316 ≤ ß ≤ 0.775
Ra	Roughness of upstream face and internal surfaces	$Ra \leq 10^{-4}.d$
b	Cylindrical throat length	b = 0.7.d to 0.75.d
φ	Exit divergent angle	φ ≤ 30°

---

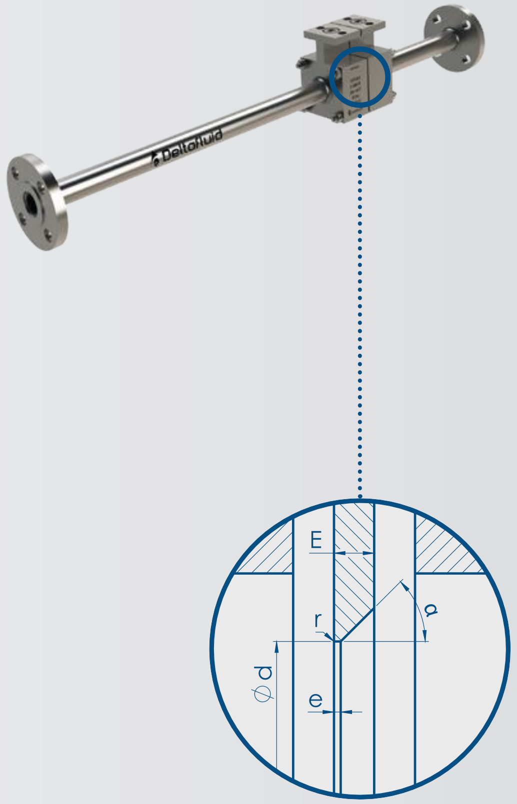
(1) For more details, see «Technical information» section on page 54.

INTEGRATED ORIFICE

Complete measuring element with special flanges
Suitable for diameters of pipes ≤ 40 mm

GENERAL DATA

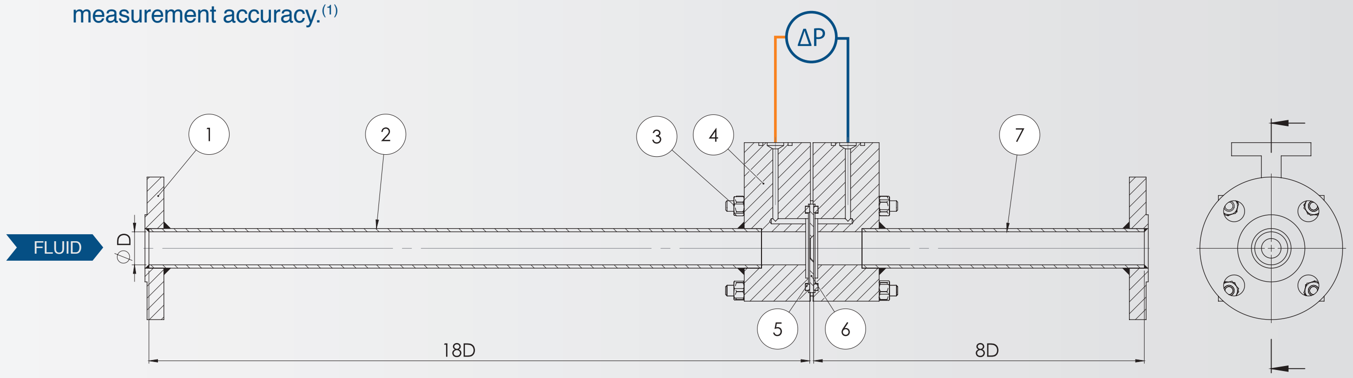
- Standard: ASME MFC-14M
- Mounting of the sharp edge orifice plate between special flanges (direct mounting of the manifold and of the differential pressure transmitter)
- Weld-end (BW) or flanged connection[1]
- Material:
  - o Standard: carbon steel, stainless steel
  - o Others[1]: according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 6 to 40 mm
- Accuracy: 0.5 % of the max flow rate
- Repeatability of measurement: 0.1 %



ΔP 0/0 pressure tap[1]

MARK	DESIGNATION
1	Flange
2	Upstream pipe
3	Bolts
4	Annular chamber
5	Gasket
6	Sharp edge orifice plate
7	Upstream pipe

The construction is carried out in compliance with the standards (primary element, roughness of upstream and downstream pipes, centering of the primary element, pipe circularity, upstream and downstream straight lengths…) in order to achieve optimum measurement accuracy.[1]



TECHNICAL CHARACTERISTICS		ASME MFC-14M
Re_D	Reynolds number in the pipe	$Re_D > 1\ 000$
D	Inside pipe diameter	6 mm ≤ D ≤ 40 mm
ß	d/D	0.1 ≤ ß ≤ 0.8
Sharp edge orifice plate		
Rɑ	Roughness of the upstream face	Rɑ < 1.27 µm
r	Sharp edge radius	r < 0.000 4.d or[2] 0.025 µm
e	Orifice thickness	e < 0.02.D or[2] 0.125.d
E	Plate thickness	E < 3.2 mm
ɑ	Angle of the downstream bevel of the plate	ɑ = 45° ± 15°
t	Flatness tolerance	t < 0.01.(D - d)/2

(1) For more details, see «Technical information» section on page 54.

(2) Consider the smaller value.

METER RUN

Complete and flexible measuring element to facilitate on-site installation

GENERAL DATA

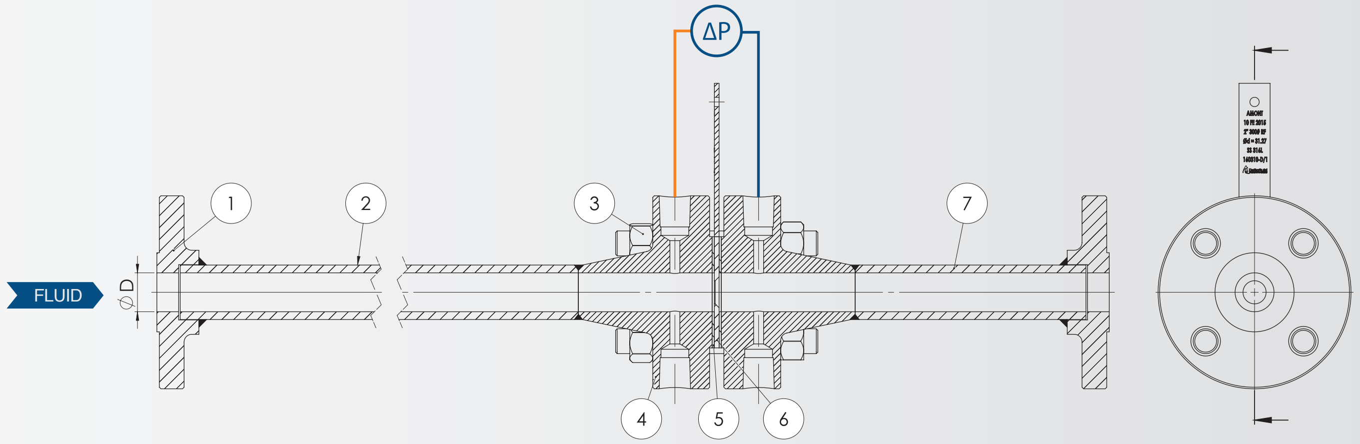
- Standards: ISO 5167-1&2, ASME MFC-3M or ISO/TR 15377
- Mounting of the primary element between flanges[1] :
  - o ISO PN 2.5 to 420
  - o ASME 150# to 2500#
  - o Others: upon request
- Weld-end (BW) or flanged connection[1]
- Material:
  - o Standard: carbon steel, stainless steel
  - o Others[1]: according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 25 to 300 mm (for easy assembling)
- Accuracy: according to the primary element considered
- Repeatability of measurement: 0.1 %

ΔP 0/0 ΔP 25/25 pressure taps[1]

MARK	DESIGNATION
1	Flange
2	Upstream pipe
3	Bolts
4	Orifice flange*
5	Gasket
6	Orifice plate**
7	Upstream pipe

* mounting also possible between annular chamber
** all types of orifice plates (as well as nozzles) can be mounted in a meter run

The assembly is carried out in our workshop in compliance with standards (roughness of upstream and downstream pipes, centering of the primary element, pipe circularity, ustream and downstream straight lengths…) in order to reach optimum measurement accuracy.



TECHNICAL CHARACTERISTICS - according to the primary element considered

Orifice plates	See corresponding technical datasheet	p 10 to 15
Nozzles		p 19 to 20
Upstream and downstream straight lengths, pipe roughness and circularity, centering of the measuring element (1)		p 72 to 78

ACCESSORIES

Manifold	See corresponding technical datasheet	p 51
Differential pressure transmitter		p 52

(1) For more details, see «Technical information» section on page 54.

HIGH PRECISION MEASURING TUBE

Complete metering tube for an easy on-site installation and for a highly accurate flow measurement

GENERAL DATA

- Standards: ISO 5167-1&2, ASME MFC-3M or ISO/TR 15377
- Mounting of the primary element between flanges(1) :
    - o ISO PN 2.5 to 420
    - o ASME 150# to 2500#
    - o Others: upon request
- Weld-end (BW) or flanged connection(1)
- Material:
    - o Standard: stainless steel 304L / 316L
    - o Others(1): according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 25 to 300 mm (for easy assembling)
- Overall measurement accuracy ≤ 1 %
- Repeatability of measurement: 0.1 %

ΔP 0/0

ΔP 25/25

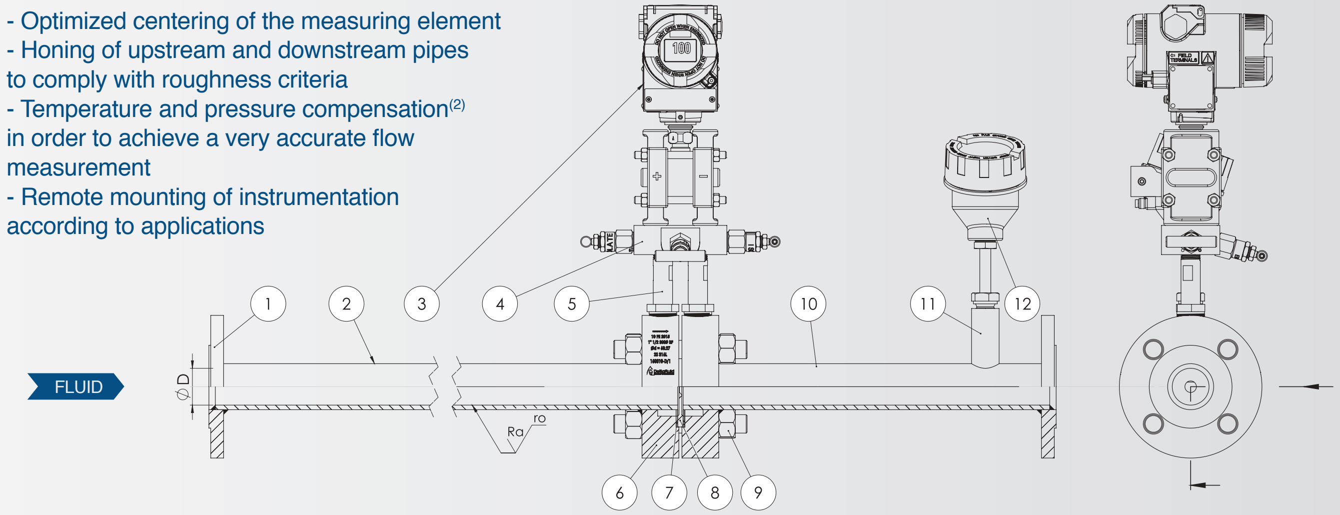
pressure taps(1)

MARK	DESIGNATION	MARK	DESIGNATION
1	Flat flange	7	Gasket
2	Upstream pipe	8	Orifice plate**
3	Differential pressure transmitter	9	Bolts
4	Manifold	10	Downstream pipe
5	Connecting tube	11	Nipple
6	Annular chamber*	12	Temperature sensor

* flange mounting also possible

** all types of orifice plates (as well as nozzles) can be mounted in a metering tube

- Optimized centering of the measuring element
- Honing of upstream and downstream pipes to comply with roughness criteria
- Temperature and pressure compensation(2) in order to achieve a very accurate flow measurement
- Remote mounting of instrumentation according to applications



TECHNICAL CHARACTERISTICS - according to the primary element considered

Orifice plates	See corresponding technical datasheet	p 10 to 15
Nozzles		p 19 to 20
Upstream and downstream straight lengths, pipe roughness and circularity, centering of the measuring element(1)		p 72 to 78

ACCESSORIES

Temperature sensor	Sensor mounted on the downstream pipe	p 41
Multivariable differential pressure transmitter(2)	This transmitter enables the correction of density of gases as a function of temperature and pressure	p 52

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[1] For more details, see «Technical information» section on page 54.

[2] The density of gases and steam is variable depending on their temperature and pressure. Compensation is essential for an accurate measurement.

COMPACT FLOWMETER

Simple, cost-saving and leakage free solution

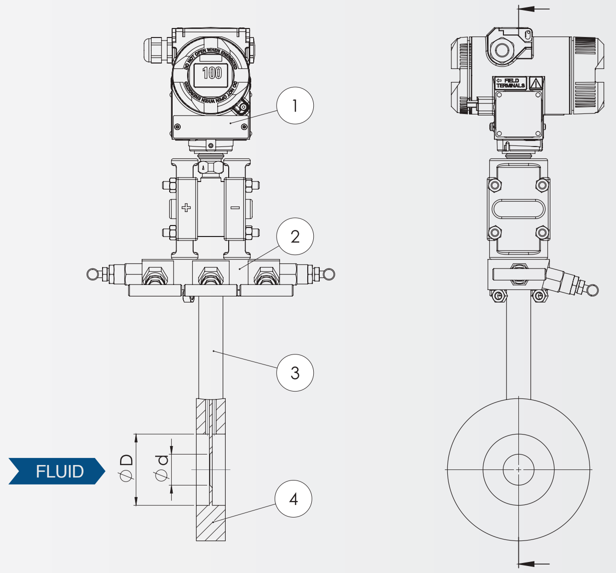
GENERAL DATA

- Standards: ISO 5167-1&2, ISO/TR 15377 or ASME MFC-3M
- Flange mounting(1) :
    - o ISO PN 2.5 to 420
    - o ASME 150# to 2500#
    - o Others: upon request
- Material:
    - o Standard: stainless steel 304L / 316L
    - o Others(1): according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 25 to 600 mm – beyond, contact us
- Accuracy: 0.5 % of the max flow rate
- Repeatability of measurement: 0.1 %

ΔP 0/0

pressure tap(1)

Mark	DESIGNATION
1	Differential pressure flowmeter
2	Manifold
3	Connecting pipe
4	Orifice carrier (monoblock)



- Direct mounting of the differential pressure transmitter, no connecting tubes
- Reduced installation and commissioning costs
- No risk of leakage : factory-tested device, no maintenance

The compact flowmeter includes:
- the suitable orifice,
- the compact pressure taps,
- the integrated 3-ou 5-way manifold or bracket,
- optional pre-set differential pressure transmitter.

TECHNICAL CHARACTERISTICS - according to the primary element considered

Orifice plates (sharp edge, conical entrance, quarter circle, eccentric, segmental, conditioning)	See corresponding technical datasheet	p 10 to 15

ACCESSORIES

Temperature sensor	Sensor mounted on the downstream pipe	p 41
Multivariable differential pressure transmitter(2)	This transmitter enables the correction of density of gases as a function of temperature and pressure	p 52

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[1] For more details, see «Technical information» section on page 54.

[2] The density of gases and steam is variable depending on their temperature and pressure. Compensation is essential for an accurate measurement.

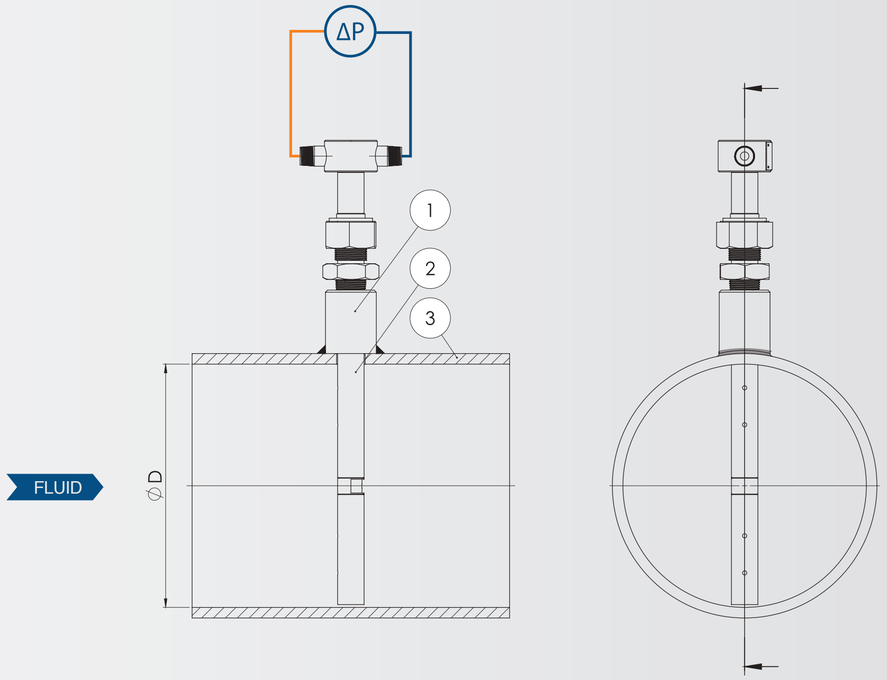
PITOT TUBE

Suitable for flow measurement in large pipes, for installations with low pressure

GENERAL DATA

- Standard: ASME MFC-12M
- Measurement averaged over the entire length of the tube
- Mounting on the pipe:
    - o compression fitting
    - o flange: ISO PN 2.5 to PN 420 or ASME 150# to 2500#
    - o retractable
- Material:
    - o Standard: stainless steel 304L / 316L
    - o Others[(1)]: according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 100 to 5 000 mm
- Accuracy: contact us
- Repeatability of measurement: 0.1 %

MARK	DESIGNATION
1	Boss
2	Pitot tube
3	Pipe



TECHNICAL CHARACTERISTICS

		ASME MFC-12M
Re_D	Reynolds number in the pipe	$Re_D > 1.2.10^4$
D	Inside pipe diameter	100 mm ≤ D ≤ 5 000 mm
L1	Upstream straight length	L1 ≥ 7.D
L2	Downstream straight length	L2 ≥ 3.D
P	Maximum allowable pressure	P ≤ 600 bar
T	Maximum allowable temperature	T ≤ 1 300 °C
µ	Maximum fluid viscosity	0.2 Pa.s

In case of extreme conditions, a calculation to check the mechanical resistance will be carried out according to ASME PTC 19.3.

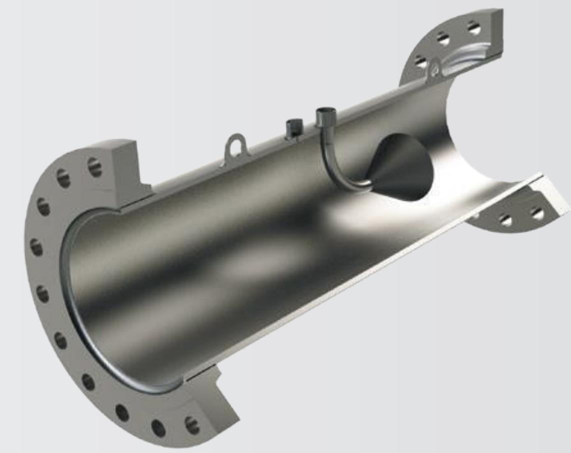
[(1)] For more details, see «Technical information» section on page 54.

CONE METER

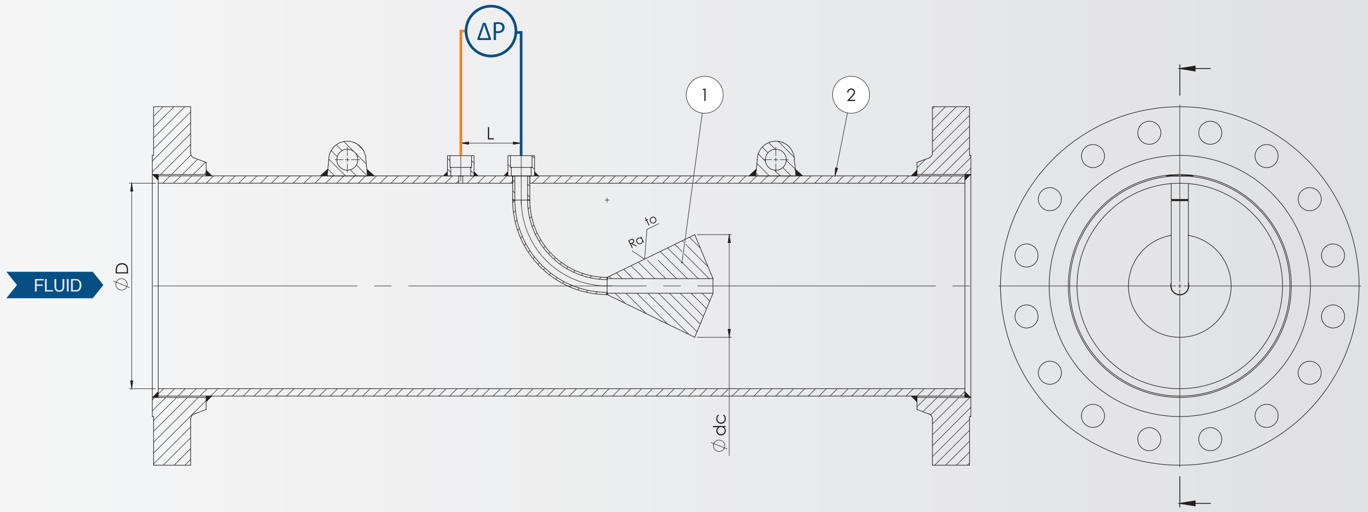
Suitable for short straight lengths and low flow rates

GENERAL DATA

- Standard: ISO 5167-1&5
- Weld-end (BW) or flanged connection[(1)]
- Material:
    - o Standard: carbon steel, stainless steel
    - o Others[(1)]: according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 50 to 500 mm
- Accuracy: 5 % of the max flow rate
- Repeatability of measurement: 0.1 %



MARK	DESIGNATION
1	Cone
2	Tube



TECHNICAL CHARACTERISTICS

		ISO 5167-1&5
Re_D	Reynolds number in the pipe	$8.10^4 \leq Re_D \leq 1.2.10^7$
D	Inside pipe diameter	50 mm ≤ D ≤ 500 mm
ß*	dc, diameter of the cone at the point where its circumference is maximum	0.45 ≤ ß ≤ 0.75[(2)]
Ra	Cone surface roughness	$Ra < 5.10^{-4}.d_c$
R_1	Bending radius of the cone at its maximum circumference	$R_1 < 0.000\ 5.d_c$ ou < 0.2 mm
L	Distance between upstream and downstream pressure tap	50 mm ≤ L ≤ 2.D

$$^*\beta = \sqrt{1 - \frac{d_c^2}{D^2}}$$

[(1)] For more details, see «Technical information» section on page 54.

[(2)] For β > 0.75, the cone meter needs to be calibrated.

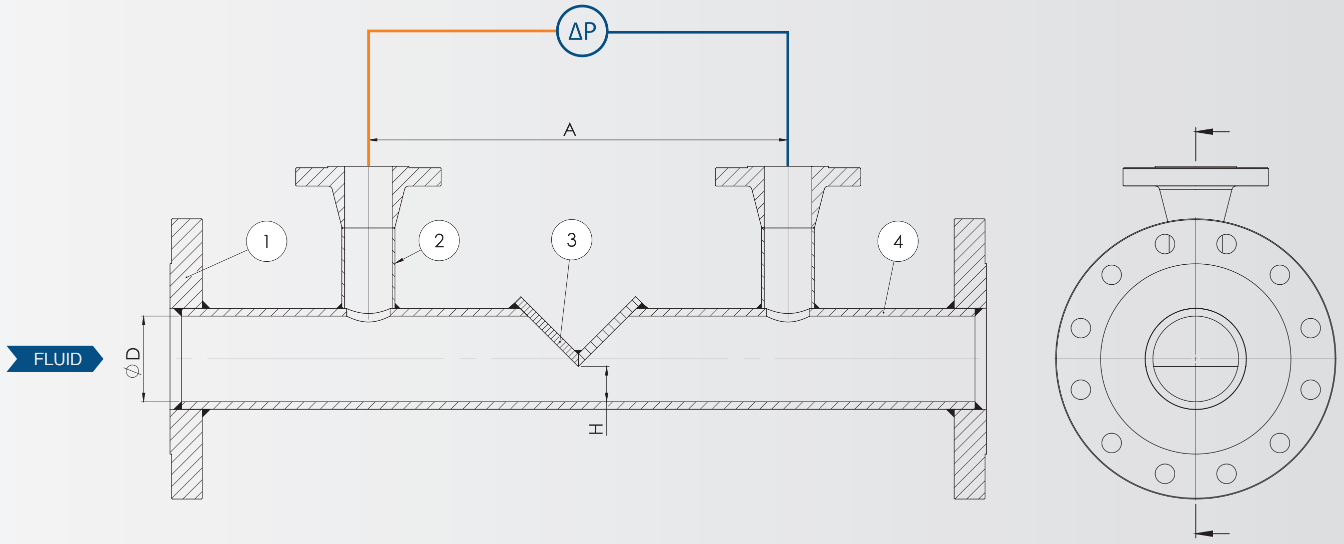
WEDGE METER

Suitable for low flow rates and dirty fluids with small particles

GENERAL DATA

- Standards: ISO 5167-1&6, R.W. MILLER
- Weld-end (BW) or flanged connection[(1)]
- Material:
  - o Standard: stainless steel 304L / 316L
  - o Others[(1)]: according to your application
- Fluid: liquid, gas, steam
- Pipes from ϕ 12.5 to 600 mm
- Bi-directional measurement possible
- Accuracy: 2 % of the max flow rate
- Repeatability of measurement: 0.1 %

MARK	DESIGNATION
1	Flange
2	Pressure tap
3	Wedge
4	Tube



TECHNICAL CHARACTERISTICS		ISO 5167-1&6	R.W. MILLER
Re_D	Reynolds number in the pipe	$10^4 \leq Re_D \leq 9.10^6$	$Re_D > 500$
D	Inside pipe diameter	50 mm ≤ D ≤ 600 mm	12.5 mm ≤ D ≤ 600 mm
H	Orifice height	-	H > 12.5 mm
H/D	Height ratio	0.2 ≤ H/D ≤ 0.6	0.2 ≤ H/D ≤ 0.5
ß coin	ß equivalent	0.377 ≤ ß ≤ 0.791	0.3 ≤ ß ≤ 0.71

[(1)] For more details, see «Technical information» section on page 54.

SONIC NOZZLE FOR CALIBRATION APPLICATIONS

Used to measure the reference flow in calibration applications

GENERAL DATA

- Standards: ISO 9300, ASME PTC 19.5
- Flange mounting[(1)]
- Material:
  - o Standard: stainless steel 304L / 316L
  - o Others[(1)]: according to your application
- Fluid: gas
- Value of β < 0.25 (β = d/D)
- Accuracy: 0.3 % of max flow rate
- Repeatability of measurement: 0.1 %

Sonic condition through the nozzle means that the flow reaches the velocity of sound when passing through the throat. Under these conditions, the flow rate depends mainly on the upstream pressure and the fluid temperature. This allows to deliver a steady and perfectly known flow rate, independent of the downstream pressure conditions from the nozzle.

VENTURI TUBE AND ORIFICE PLATE FOR WET GAS APPLICATIONS

Suitable for measuring a multiphase flow with 95% gas minimum

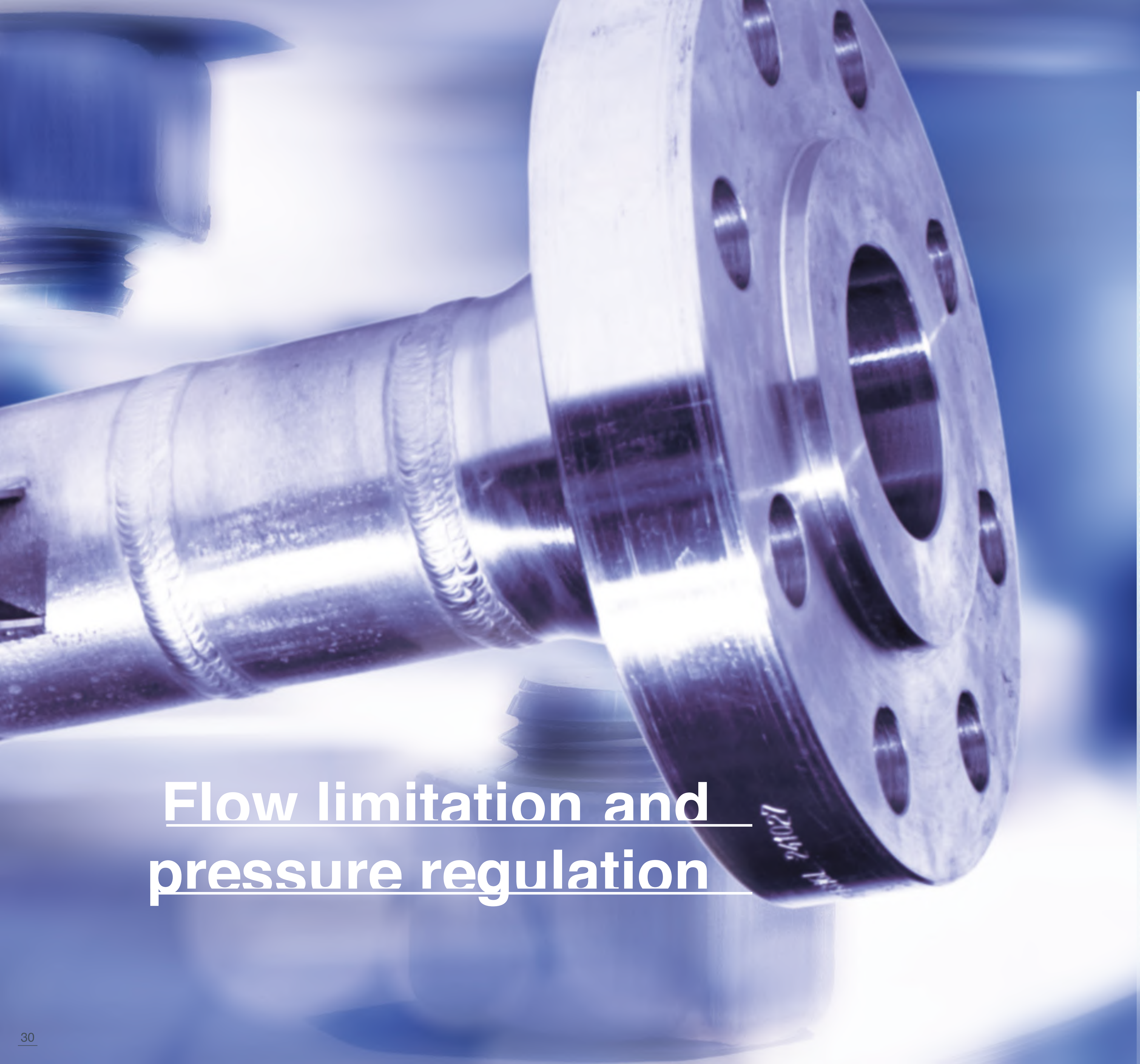
GENERAL DATA

- Standard: ISO/TR 11583
- Horizontal mounting
- Material:
  - o Standard: stainless steel 304L / 316L
  - o Others[(1)]: upon request
- Venturi tube accuracy: 2.5 to 6 % of max flow rate
- Orifice plate accuracy: 2 to 7 % of max flow rate
- Repeatability of measurement: 0.1 %
- Other information: see technical datasheets, venturi tube on page 16 to 18 and orifice plates on pages 10 to 15

In addition to the pressure taps of the ISO 5167 standard, a 3rd pressure tap is required for wet gas applications.
It is located 6D downstream:
- o of the orifice plate (with drain),
- o or from the end of the divergent for the venturi tube.

Reduced straight lengths according to ISO 5167 are not recommended. It is required to comply with standard straight lengths summarized in «Technical information» section on pages 72 to 76. Similarly, using flow conditioners is not recommended.

[(1)] For more details, see «Technical information» section on page 54.



Flow limitation and pressure regulation

RESTRICTION
ORIFICE

TO **LIMIT** A FLOW
OR **REDUCE** A PRESSURE

Calibrated device placed in a pipe. It is calculated according to your technical specifications in order to achieve the desired pressure or flow rate while preserving the plate and piping integrity. This type of device is a very good alternative to non-piloted control valves.

COST-SAVING	ROBUST	MAINTENANCE FREE

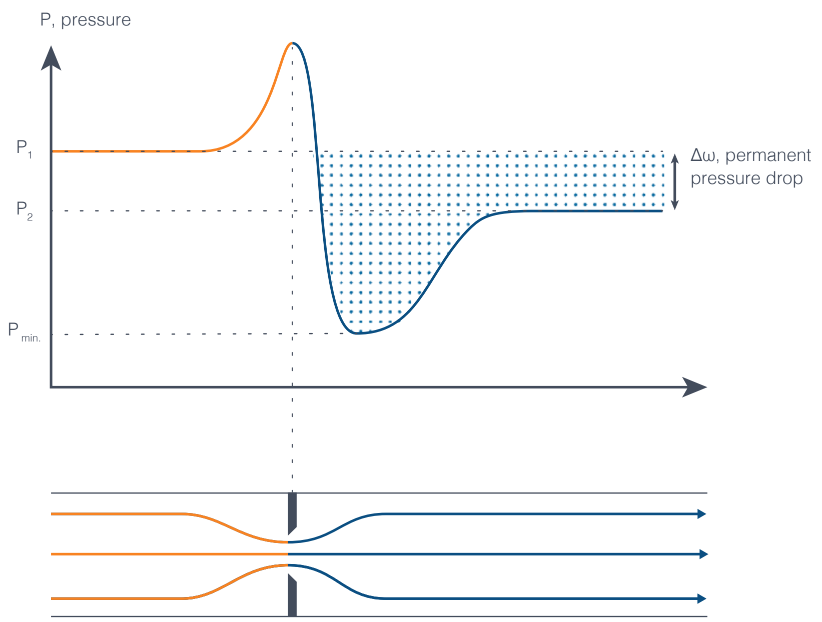
To meet all your applications:
corrosive fluids: sea water, chlorine, liquid sulfur...

even the most extreme:
high temperature, high pressure fluids

thanks to manufacturing with suitable materials and design:
cupro-nickel, bronze, hastelloy®, duplex, titanium, PTFE coating...

Such as for the flow measurement, **the fluid pressure decreases when passing through a restriction** (see page 6). It reaches its minimum value shortly after the orifice (Pmin) then increases again to a stable value (P_2). The permanent pressure loss Δω (P_1 - P_2) generated by turbulence enables reducing the pressure in a pipe and / or to limit a flow rate.

Permanent pressure drop Δω



Our expertise covers all aspects of the study and takes into account the essential operating conditions as well as specific parameters such as noise level, cavitation and critical flow (sonic conditions).
A fine understanding of all of these phenomena is needed to avoid premature erosion of the pipe and orifice plate, excessive noise and vibration levels.

Permissible pressure difference of a restriction orifice (SS 316L at 20°C)

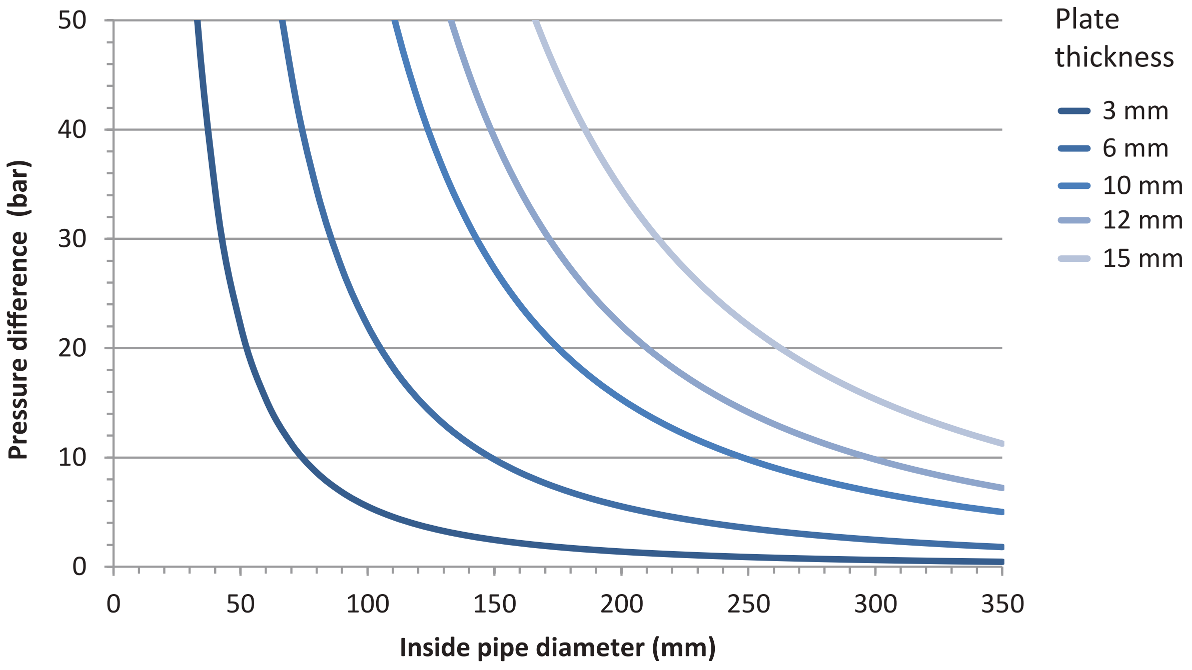


Plate thickness calculation is based on the differential pressure created and the inside pipe diameter to prevent plate deformation during operation.
The above graph indicates the minimum thickness requirements for a SS 316L plate at 20 °C according to B31.3 standard.
For a rough calculation, the formula to calculate plate thickness is this one aside.

$$Ep = ID\sqrt{\frac{3P}{16SE}} + c$$

Ep	plate tickness (mm)
ID	inside pipe diameter (mm)
P	pressure (MPa)
S	maximum allowable stress (MPa) - see table below
E	quality factor (equals to 1 for material types listed below)
c	corrosion thickness (mm)

S, MAXIMUM ALLOWABLE STRESS (MPa)

TEMPERATURES (°C) / MATERIALS	40	65	100	150	200	250	300	350	400	500	600
STAINLESS STEEL (A240 316L)	115	115	115	115	109	103	98.1	94.3	90.9	84.2	67.9
CARBON STEEL (A516 GR.70)	161	161	159	154	150	144	136	128	101	-	-
ALLOY STEEL (A385 GR.11)	138	138	138	138	136	131	127	123	119	73.7	17.6

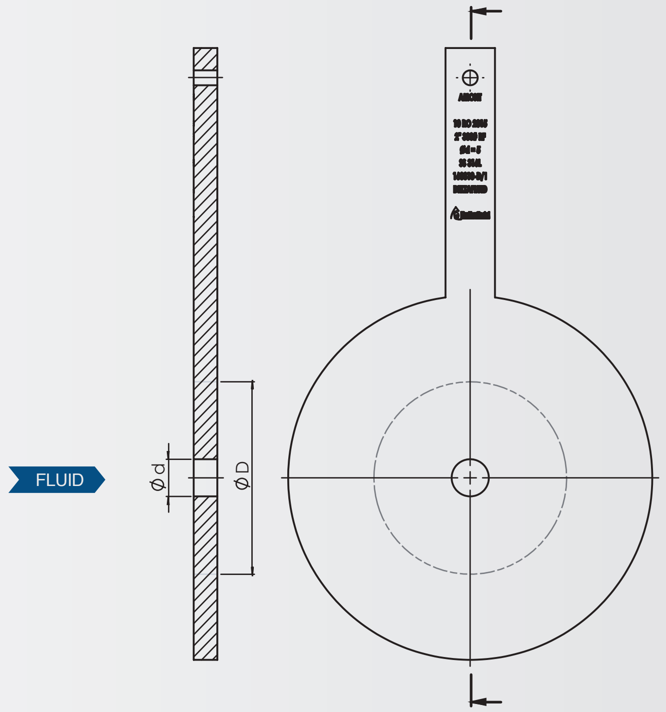
[1] Warning, this formula does not take into account the gasket factor.

SIMPLE ORIFICE
RESTRICTION ORIFICE

Cost-saving solution

GENERAL DATA

- Design based on ISO 5167, ASME MFC-3M or R.W. Miller standards
- Flange mounting[1]:
  - o ISO PN 2.5 to PN 420
  - o ASME 150# to 2500#
  - o Others: upon request
- Material:
  - o Standard: stainless steel 304L / 316L
  - o Others[1]: according to your application
- Fluid: liquid, gas, steam
- For all pipe sizes



Optional: stellite coating[1]

TECHNICAL DESCRIPTION

Orifice diameter	Sized according to the fluid, to the desired pressure drop and flow rate when passing through the restriction.
Plate thickness	Calculation based on the pressure drop created by the plate and the piping inside diameter to prevent plate deformation during operation.
Noise	Noise level control estimated at 1 m. In the event of a high noise level, refer to the multi-hole plate - see page 35.
Cavitation[2]	The level of cavitation is checked for each plate. In the presence of cavitation, a multistage alternative can be proposed depending on the operating conditions of the restriction.
Critical flow or Choked flow[2]	If the fluid reaches its maximum speed when passing through the restriction, its flow rate can no longer increase. A multi-stage solution can be proposed depending on the operating conditions of the restriction - see page 37.

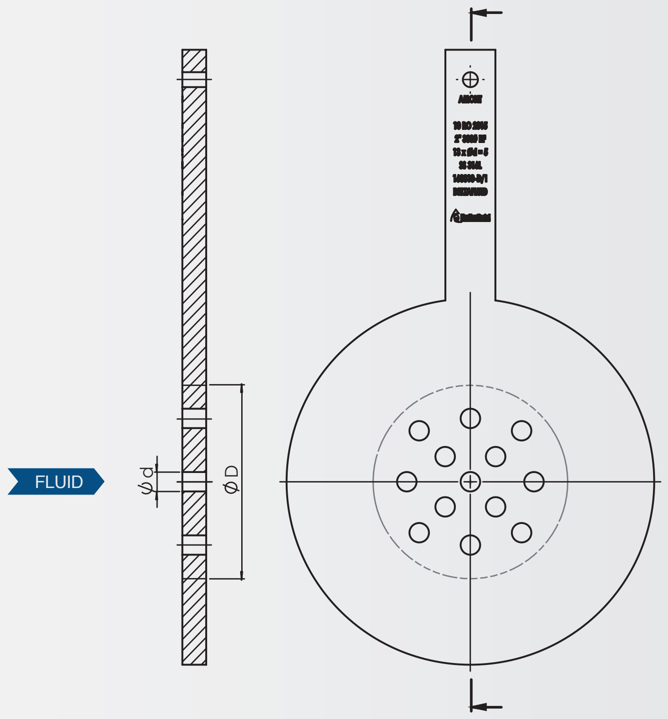
[1] For more details, see «Technical information» section on page 54.
[2] For more details, see page 36.

MULTI-ORIFICE
RESTRICTION ORIFICE

Suitable to reduce noise when passing through the orifice

GENERAL DATA

- Design based on ISO 5167, ASME MFC-3M or R.W. Miller standards
- Design according to Idel'cik for holes with rounded or bevelled edges possible on request
- Flange mounting[1]:
  - o ISO PN 2.5 to PN 420
  - o ASME 150# to 2500#
  - o Others: upon request
- Material:
  - o Standard: stainless steel 304L / 316L
  - o Others[1]: according to your application
- Fluid: liquid, gas, steam
- For all pipe sizes



Optional: stellite coating[1]

TECHNICAL DESCRIPTION

Orifices	Sized according to the fluid, pressure drop and flow rate passing through the restriction.
Plate thickness	Calculation based on the pressure drop created by the plate and the piping inside diameter to prevent plate deformation during operation.
Noise	The number of orifices is determined according to the noise level not to be exceeded. The maximum noise level depends on the operating conditions: limited to 85 dB(A) by the regulatory framework for average daily exposure in continuous operation. Intermittent or emergency operation - higher values acceptable (see corresponding regulations). If the noise level is still too high, it is possible to switch to a multi-stage restriction orifice.
Cavitation[2]	The level of cavitation is checked for each plate and the orifices are calculated in order to avoid cavitation.
Critical flow ou Choked flow[2]	Orifices are calculated at critical flow limit to generate a maximum pressure drop.

[1] For more details, see «Technical information» section on page 54.
[2] For more details, see page 36.

DESIGN OPTIMIZATION OF **RESTRICTION ORIFICES**

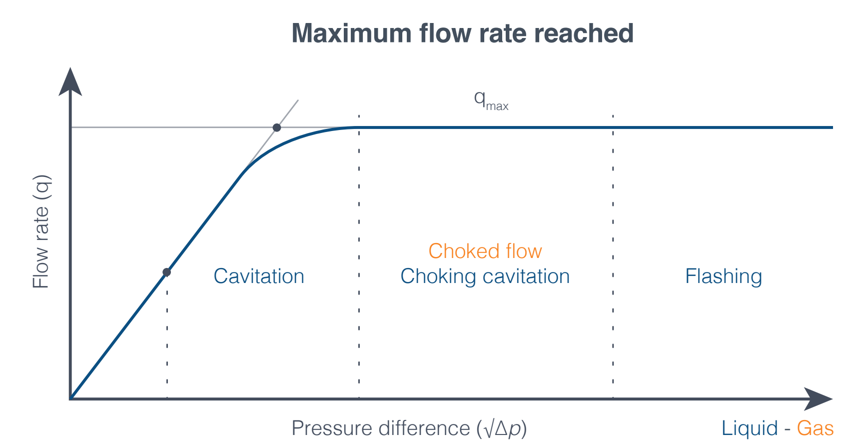
CAVITATION - CRITICAL FLOW - NOISE

CAVITATION

Liquid cavitation occurs when low local pressure (lower than the vaporization pressure) is sufficient to allow the fluid to change phase from liquid to vapor (gas bubbles appearing). This phenomena can happen when the pressure is droping as the fluid is passing through the orifice. If downstream pressure is recovering above the phase change pressure, the implosion of these gas bubbles can generate significant noise levels and damage metallic components due to the energy dissipation.
If the pressure remains below the vaporization pressure downstream of the restriction, the fluid remains in gaseous form. This is the phenomenon of flashing.

CRITICAL FLOW

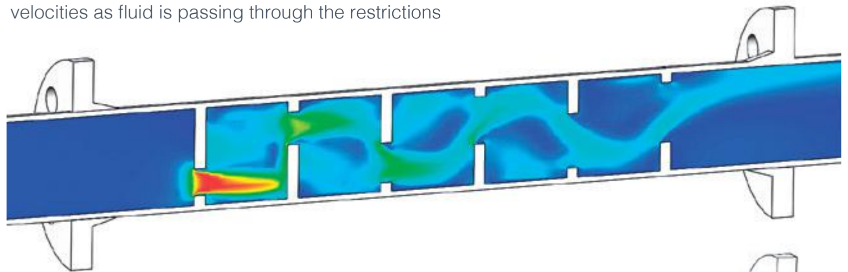
When approaching the restriction, the fluid velocity is increasing until it reaches its maximum speed as it flows through the restriction. If the sonic speed is reached (choked flow) or if the cavitation is too important (choking cavitation), the flow passing through this orifice does not increase even if the downstream pressure continues to drop.



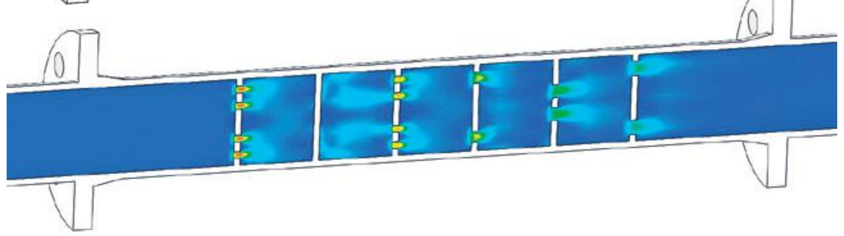
To avoid the two phenomena mentioned above or **to reduce the noise level of the device**, a multi-stage restriction orifice can be proposed.

To optimize the design and validate analytical calculations of complex applications, our engineering office is able to perform fluid flow simulations (CFD).

Example: design validation of a restriction orifice after comparing velocities as fluid is passing through the restrictions



Fluid velocity with simple orifice plates



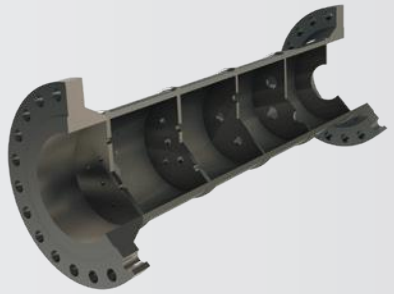
Fluid velocity with multi-orifice plates

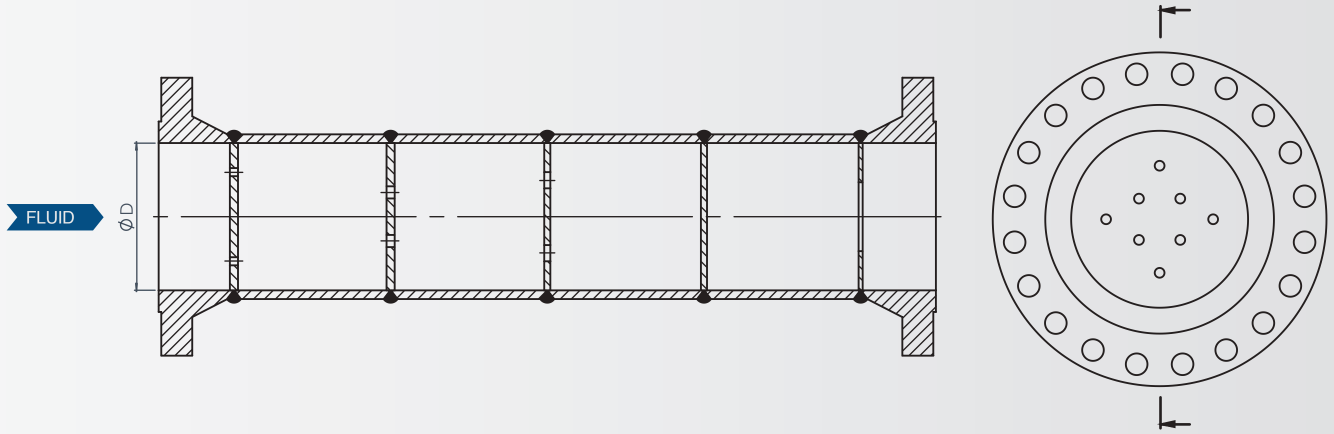
MULTI-STAGE RESTRICTION ORIFICE

Multiple plates in series when the desired pressure drop cannot be achieved with a single plate

GENERAL DATA

- Design based on ISO 5167, ASME MFC-3M or R.W. Miller standards
- Weld-end (BW) or flanged connection(1)
- Material:
  - o Standard: stainless steel 304L / 316LL
  - o Others(1): according to your application
- Fluid: liquid, gas, steam
- For all pipe sizes



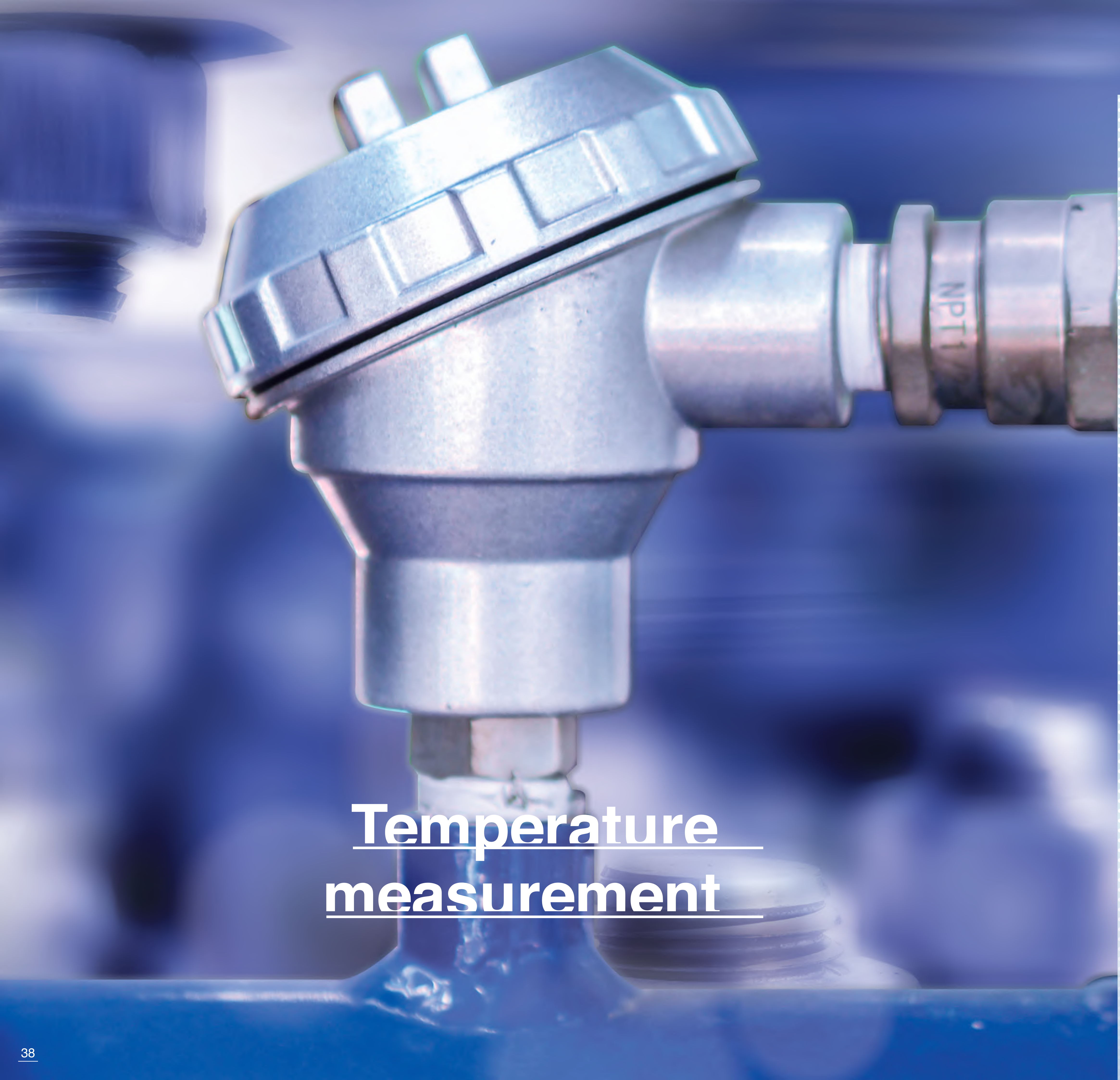


Optional: stellite coating(1)

TECHNICAL DESCRIPTION

Plate mounting	Plates mounted in series – spacing between plates from 1D to 5D optimized for each device (D, inside pipe diameter)
Number of plates	Calculation of the number of stages optimized according to the specifications of the application, each plate enabling to reduce the pressure to the maximum while avoiding the phenomena of cavitation(2) and critical flow(2)
Noise	Control of the noise level of the complete device estimated at 1 m. Multi-hole plates reduce the noise level per stage. External enclosure solutions can be added if the noise level remains too high (contact us)
Thermodynamics	Thermodynamic properties of the fluid are taken into account for the calculation of each stage: phase change, temperature, composition and density of the mixture, viscosity, compressibility factor
3D simulation	Possibility of a numerical simulation to complete the analytical calculations – see images on page 36

(1) For more details, see «Technical information» section on page 54.
(2) For more details, see page 36.



Temperature measurement

LIQUID OR GAS
EXPANSION THERMOMETER

A robust and reliable measurement

OPERATING PRINCIPLE

The measuring element is composed of a tube connected to a reservoir located in the probe. The assembly is filled with liquid or gas and sealed. Temperature variation causes a variation in the fluid volume which drives the pointer on a display.

GENERAL DATA[1]

- Standard: EN 13190
- Capillar remote measurement or direct measurement
- Measuring element: rigid bulb
- With or without thermowell

BIMETAL THERMOMETER

A simple and functional measure

OPERATING PRINCIPLE

The helically shaped measuring element is composed of two alloys with different thermal coefficients. Temperature variation causes a deformation of the spiral which drives the pointer on a dial.

GENERAL DATA[1]

- Standard: EN 13190
- Measuring element: bimetallic element
- With or without thermowell

TECHNICAL CHARACTERISTICS[1]

	Expansion thermometer	Bimetal thermometer
Measuring scale	From -200 °C to +700 °C	From -70 °C to +600 °C
Dial diameter	100 mm - 150 mm	100 mm - 150 mm
Case	Stainless steel	Stainless steel
Stem	Stainless steel	Stainless steel
Stem diameter	Up to 12 mm	Up to 12 mm
Stem useful length	Up to 300 mm	Up to 1000 mm
Capillary length	Up to 10 m	-
Connection designs	Screw-in	Screw-in
Protection rating	Up to IP66	Up to IP66
Accuracy	Class 1 or 2 according to EN 13190	Class 1 or 2 according to EN 13190

[1] Only standard data are exposed on this page. Other designs are available on request.

RTD TEMPERATURE
PROBE

A measurement of great precision and great long-term stability

OPERATING PRINCIPLE

The measuring element is composed of coiled platinum wires, which resistance varies according to the temperature. The resistance / temperature correspondence is documented in standard IEC 60751.

GENERAL DATA[1]

- Pt 100 or Pt 1000 probe (composed of a platinum resistance whose initial value is respectively 100 Ω or 1000 Ω at 0 °C)
- Standard: IEC 751

THERMOCOUPLE
PROBE

Suitable for a wide range of temperature application (high temperatures)

OPERATING PRINCIPLE

A thermocouple is composed of two wires made of different metals or metal alloys welded at one point (hot weld = measuring junction). This junction is placed in the medium whose temperature is to be measured. The other end of the conductors are joined at a point called reference junction, which is compensated to simulate the 0 °C reference. The temperature difference between the two junctions creates an electromotive force that varies only with the temperature of the measuring junction and can therefore be used to measure its temperature.

GENERAL DATA[1]

- Thermocouple type T, J, E, K, N, R, S or B
- Standard: IEC 584

TECHNICAL CHARACTERISTICS[1]

	RTD temperature probe	Thermocouple
Measuring scale	From -200 °C to +600 °C	From -200 °C to +1600 °C
Protective tube	Stainless steel	Stainless steel (or other depending on the thermocouple type and temperature application)
Stem diameter	Up to 8 mm	Up to 8 mm
Stem useful length	Up to 1000 mm	Up to 1000 mm
Connection	Standard single element 3 or 4 wires or double element on request	Standard single element 2 wires or duplex on request
Protection rating	Up to IP68	Up to IP68
Electrical approval[2]	ATEX explosion-proof or intrinsically safe on request	ATEX explosion-proof or intrinsically safe on request
Accuracy	Class A according to IEC 751/ NF EN 60751	Class 1 according to IEC 584 / NF EN 60584

[1] Only standard data are exposed on this page. Other designs are available on request.

[2] For more details, see information on ATEX on page 81.

CHOICE
OF PROBE

TEMPERATURE RANGES

RTD TEMPERATURE PROBE		TEMPERATURE RANGE
Pt 100 Ω / Pt 1000 Ω		-200 °C to +600 °C
THERMOCOUPLE PROBE	TYPE	TEMPERATURE RANGE
Cu - CuNi	T	-200 °C to +350 °C
Fe - CuNi	J	-40 °C to +750 °C
NiCr - CuNi	E	-200 °C to +900 °C
NiCr - NiAl	K	-200 °C to +1200 °C
NiCrSi - NiSi	N	-200 °C to +1200 °C
PtRh13% - Pt	R	0 °C to +1600 °C
PtRh10% - Pt	S	0 °C to +1600 °C
PtRh6% - PtRh30%	B	+100 °C to +1600 °C

OPERATING TEMPERATURE LIMITS

Heads, cables and stems have operating temperature limits depending on the materials used. These temperatures are given as an indication. The environment can modify these characteristics.

HEAD	
MATERIAL	Limit T[1]
PVC	100 °C
Polypropylene	160 °C
Epoxy coated aluminium	400 °C
Stainless steel	1000 °C

CABLE	
MATERIAL	Limit T[1]
PVC	100 °C
Teflon / silicone	180 °C
Teflon	250 °C
Glass silk	450 °C

STEM	
MATERIAL	Limit T[2]
SS316	1000°C
Inconel 600	1200 °C

[1] Temperature considered without electronics (transmitter) in the head. Temperature transmitter should not exceed 85 °C.

[2] Maximum temperature; the characteristics of the wires in the stem, their mounting (presence of protection, insulation) and the characteristics of the environment should also be considered.

RESPONSE TIME

The response time indicates **the time it takes for the probe to react to a change in temperature**; it quantifies the speed of the probe. We consider the response time as the time required (in seconds) to go from the initial temperature to 63 % of the final temperature. Here we show the response times of the most common thermocouple probes with hot weld isolated.

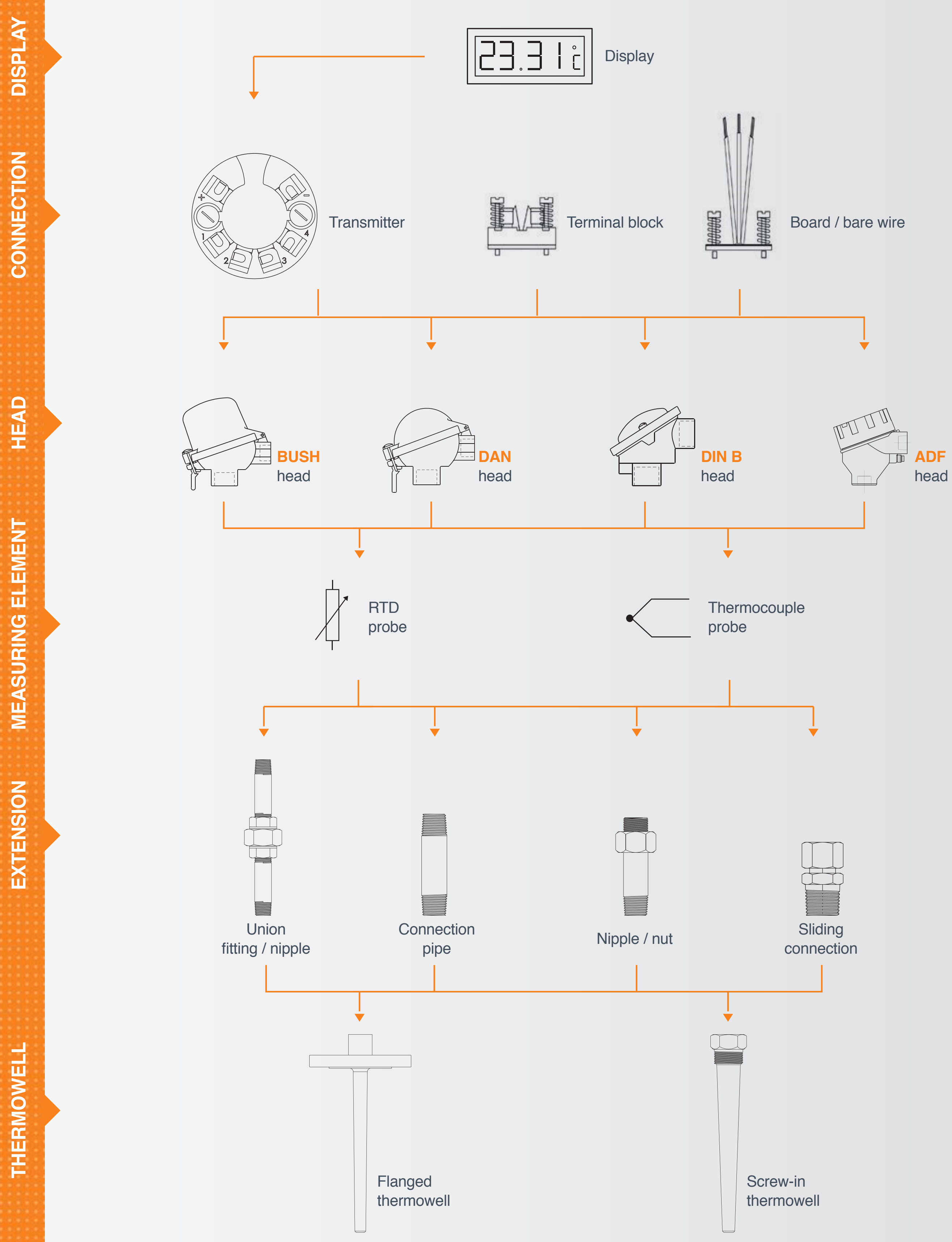
DIAMETER	0.5 mm	1 mm	1.5 mm	2 mm	3 mm	4.5 mm	6 mm	8 mm
RESPONSE TIME	0.3 s	0.4 s	0.6 s	0.9 s	1.5 s	2 s	4 s	7 s

RESISTANCE THERMOMETER / THERMOCOUPLE COMPARISON

PROBE	BENEFITS	DRAWBACKS
RTD probe	• Very good stability • High precision • Excellent repeatability of the measurement	• Longer response time • Limited in temperature • Self-heating
Thermocouple probe	• Fast response time • High and very high temperature operation	• Less stable • Lower repeatability of the measurement • Less sensible

CUSTOM
ASSEMBLY

BUILD YOUR SENSOR ACCORDING TO YOUR NEEDS



PYROMETRIC ROD

For high temperature applications

OPERATING PRINCIPLE

This set is composed of a measuring element, an insulating lining (often a ceramic sheath) and an outer mechanical protection sheath. A pyrometric rod is fitted with electrical connection devices and mechanical fixings. These sets are intended for high and very high temperature applications. The thermocouples are made in a cladded assembly with mineral insulation or in a beaded assembly with ceramic insulation. The protective sheaths can be metallic or ceramic.

GENERAL DATA

- See thermocouple datasheet page 41

MULTIPOINT SENSOR

For precise multi-temperature measurement

OPERATING PRINCIPLE

A multipoint column is formed by the assembly of several sensors of different lengths, designed to give precise and rapid temperature measurements at predetermined levels in vessels (tank, separator, column, reactor) or furnaces. They measure a temperature profile and detect hot spots. This system has the advantage of being compact and relatively easy to assemble.

GENERAL DATA

- See RTD and thermocouple probes datasheets page 41

TECHNICAL CHARACTERISTICS[1]

	Pyrometric rod	Multipoint sensor
Measuring scale	Thermocouple probe made in a cladded assembly with mineral insulation or in a beaded assembly with ceramic insulation	Thermocouple probe or RTD probe
Protective sheath	Metallic or ceramic	Special pipe if necessary
Useful length	Up to 2 m	Different lengths of sensors
Number of measuring points	1	Up to 40
Electrical connection[2]	Standard or ATEX compliant connection head	

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[1] Only standard data are exposed on this page. Other designs are available on request.

[2] For more details, see information on ATEX on page 81.

TRANSMITTER

To convert the measured physical value into a standardized output signal

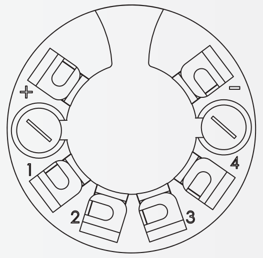
OPERATING PRINCIPLE

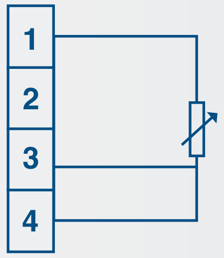
The electrical input connections (resistance probe or thermocouple) are made on the transmitter. It converts the temperature value and delivers a standardized output signal suitable for industrial control applications.

GENERAL DATA[1]

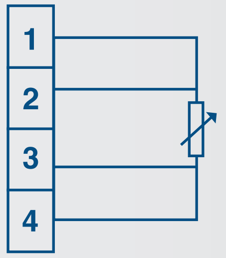
- Standards: IEC 61326 / NF EN 61326 (CEM)
- Mounting: probe head or DIN rail
- 4-20 mA or 0-10 V type standardized output signal
- Fixed input (resistance probe or thermocouple) or configurable universal input

EXAMPLE OF CONNECTION TO TRANSMITTER

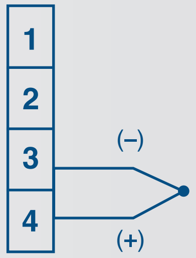




Pt 100 Ω – 1 x 3 wires



Pt 100 Ω – 1 x 4 wires



Simple thermocouple

TECHNICAL CHARACTERISTICS[1]

Programmable	via PC, HART communication
Sealing	Up to IP66
Measuring scale	-200 °C to +1600 °C depending on the probe
Supply voltage	8 – 30 Vcc
Electrical approval[2]	ATEX explosion-proof or intrinsically safe on request
Accuracy	Resistance probe ≤ 0.1 % of the measuring range or ≤ 0.5 °C whichever is greater Thermocouple: 0.5 °C to 5 °C depending on the temperature range
Galvanic isolation	1.5 kVac
Safety	SIL2[3]

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[1] Only standard data are exposed on this page. Other designs are available on request.

[2] For more details, see information on ATEX on page 81.

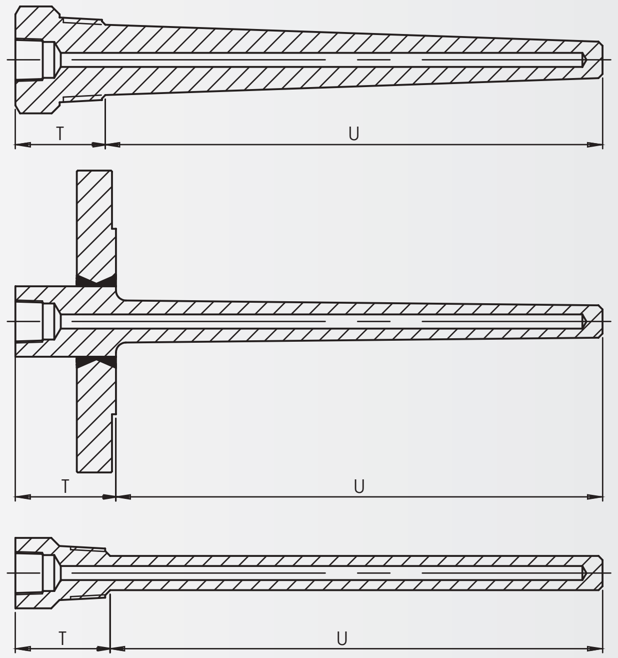
[3] SIL (Safety Integrity Level) certification reflects the operating safety level of measuring instruments according to IEC 61508 / NF EN 61508 standards. For more details, see «Technical information» section on page 81.

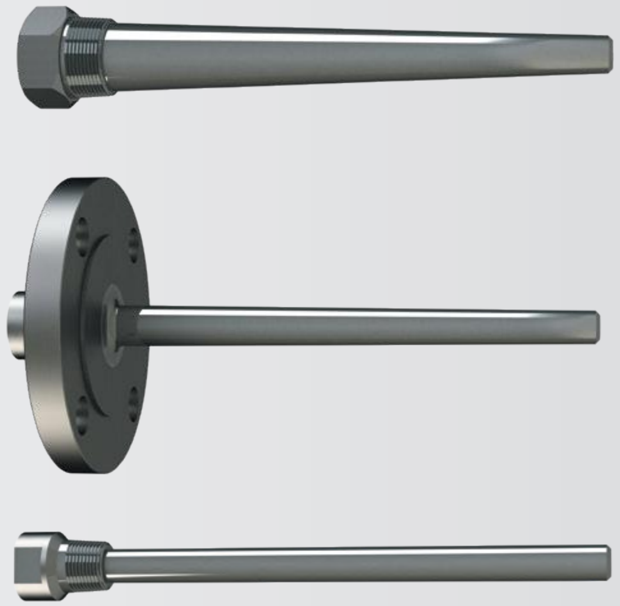
THERMOWELL
MACHINED FROM SOLID

For severe process conditions (high temperature, pressure or high flow)

GENERAL DATA[1]

- Material:
  - o Standard: SS 316L
  - o Others: according to your application
- All types of fluids in contact
- Coating possible for corrosive fluids
- Standard shape (straight or conical) or helical shape (reduction of vibratory stresses)





T, extension length
U, insertion length under thread

TECHNICAL CHARACTERISTICS[1]

Instrumentation connection	NPT thread or other on request
Process connection	Threaded, flanged (sealing weld, full penetration weld or machined from barstock), welded, clamp
Thermowell shape	Straight or conical, with or without restriction or helical
Immersion length	According to customer specifications
Inside and outside diameter	According to the application
Maximum process pressure and temperature	Depending on the execution of the thermowell (size, material, flange rating) and process conditions (flow rate, fluid velocity)
Stress calculation	According to ASME PTC 19.3 TW recommended for critical applications

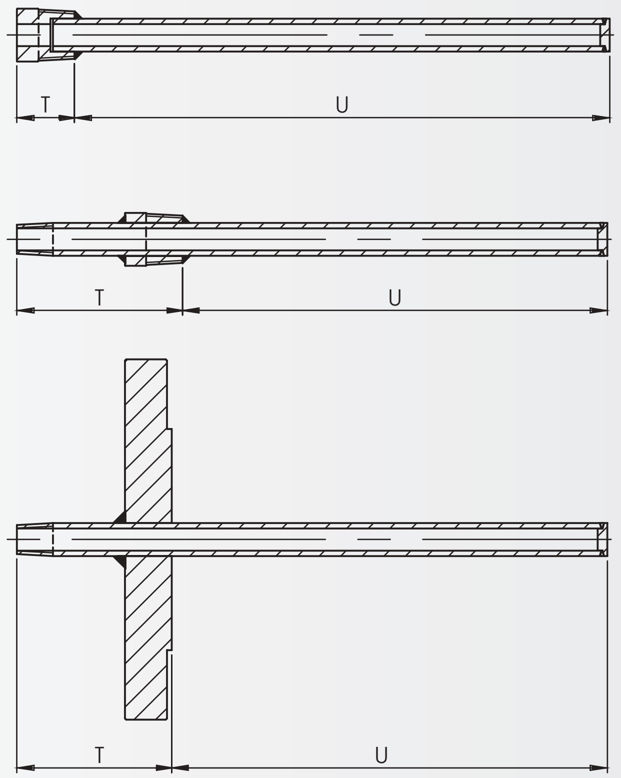
[1] Only standard data are exposed on this page. Other designs are available on request.

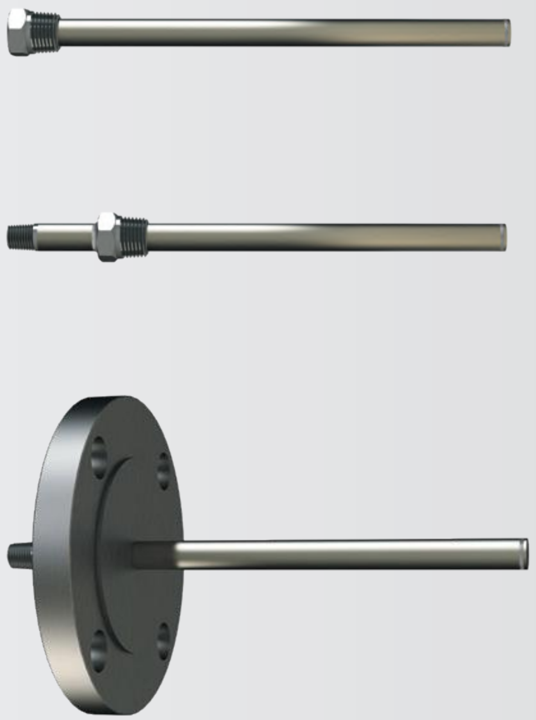
TUBULAR
THERMOWELL

For standard applications with no significant constraint

GENERAL DATA[1]

- Material:
  - o Standard: SS 304L / 316L
  - o Others: according to your application
- All types of fluids in contact
- Coating possible for corrosive fluids





T, extension length
U, insertion length under thread

TECHNICAL CHARACTERISTICS[1]

Instrumentation connection	NPT thread or other on request
Process connection	Threaded, flanged, welded, clamp
Immersion length	According to customer specifications
Inside and outside diameter	According to the application
Maximum process pressure and temperature	According to the thermowell design (size, material, flange rating) and process conditions (flow rate, fluid velocity)

[1] Only standard data are exposed on this page. Other designs are available on request.

Accessories

FLOW CONDITIONER

To stabilize a flow in a pipeline upstream of a measuring element

GENERAL DATA[1]

- Standards: ISO 5167, ASME MFC-3M
- Fluid: liquid, gas, steam
- Weld-end (BW) or flanged connection
- To reduce upstream straight lengths for flow measurement
- To be positioned downstream of any piping accessory, respecting the distances between the accessory and the conditioner and between the conditioner and the primary element specified in the standard
- Different types: tube bundle, AMCA or star flow straightener[2], Nova, Sprenkle or Zanker conditioner[3]


19-tube bundle straightener


SPRENKLE conditioner


NEL conditioner

FLANGES

To connect several pieces of piping; easy assembly and disassembly

GENERAL DATA[1]

- Standards: ASME B16.5, B16.36, B16.47, MSS SP-44, API6B
    - o Corresponding flanges: welding neck, orifice welding neck, slip on, socket welding, blind
    - o Operating pressure: ASME 150# to 2500# or API 200 PSI to 20 000 PSI
- Standards: NF EN 1092-1, NF EN 1759-1
    - o Corresponding flanges: welding flat flange (type 01), blind flange (type 05), welding neck flange (type 11)…
    - o Operating pressure: ISO PN 2.5 to 420
- All face designs: RF, RTJ, with groove/tongue face, other types of flange facings according to your application
- Diameter ND ¼'' to 24'' – up to 60'' on request
- Material:
    - o Standard: carbon steel, stainless steel, duplex
    - o Others: according to your application
- Thickness to be defined
- Schedule: 5 to XXS


SW flange


WN flange


Orifice WN flange

---

[1] Only standard data are exposed on this page. Other designs are available on request.
[2] A flow straightener is a device that considerably reduces disturbances.
[3] A conditioner is a device which reduces disturbances and which allows a satisfactory redistribution of the velocity profile over the whole section of the pipe.

CONDENSATION POT

For steam applications, protective element allowing the fluid to condense upstream of the pressure transmitter

GENERAL DATA[1]

- Material:
    - o Standard: carbon steel, stainless steel
    - o Others: according to your application
- Calculated according to B31.1 construction code
- Compliance with the pressure equipement directive PED 2014/68/UE on request
- To be positioned between the pressure taps (horizontal outlet recommended) and the pressure transmitter – see assembly instructions page 79


Condensation pot with piping elements


Weld-in condensate pot

MANIFOLD

Instrumentation accessories for setting and commissioning the measuring device

GENERAL DATA[1]

- Material:
    - o Standard: carbon steel, stainless steel
    - o Others: according to your application
- 2, 3 or 5-way
- To isolate the transmitter in case of intervention on the pipe
- To reset the zero of the transmitter or purge the pressure taps (5-way manifold)
- Transmitter interface according to EN 615188


2-way manifold


3-way manifold


3-way direct mount manifold


5-way direct mount manifold

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[1] Only standard data are exposed on this page. Other designs are available on request.

PRESSURE
TRANSMITTER

To convert the pressure measurement into an output signal

Differential pressure transmitter

OPERATING PRINCIPLE

A differential pressure sensor is a device that accurately measures a differential pressure (ΔP = upstream pressure - downstream pressure) and converts it into a 4-20 mA output signal.The flow is calculated with the following formula:

$$q_m = k\sqrt{2\,\Delta P\,\rho}$$

q_m	mass flow in kg/s
k	constant
ΔP	differential pressure in bar
ρ	density of the fluid in kg/m³

The density ρ of an incompressible fluid is constant at a given temperature (liquids can be considered as incompressible). The density ρ of a compressible fluid (gas) varies according to its pressure and its temperature. Thus, the choice of transmitter will be as follows:

LIQUID	GAS	
CONSTANT TEMPERATURE	CONSTANT TEMPERATURE AND PRESSURE	VARIABLE TEMPERATURE AND PRESSURE
DIFFERENTIAL PRESSURE TRANSMITTER		MULTIVARIABLE TRANSMITTER allows to correct* the pressure and temperature variations of the gas when coupled to a temperature sensor

*This correction can also be obtained with a differential pressure transmitter, a temperature sensor, a pressure transmitter and a calculator

The pressure transmitter can be placed in a closed insulating or temperature controlled housing. In a critical environment (temperature, humidity, etc.), the housing protects instrumentation accessories.

The housing is also available in a simple sun protection version to protect the accessories from direct sunlight.

Instrumentation case with differential pressure transmitters and calculator

Sun protection for transmitter

Special case of assembly with 2 transmitters: rangeability[1] increased from 1/6 to 1/36. Thus, the measurement uncertainty remains low over a range from 2 % to 100 % of the max flow rate.

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[1] For more details, see «Technical information» section on page 80.

FLOW INDICATOR

To visualize the flow passage in a pipe

GENERAL DATA[1]

- Weld-end (BW) or flanged connection
- Material:
  - o Standard: carbon steel, stainless steel
  - o Others: according to your application
- Fluid: liquid, gas, steam
- Diameter: according to the nominal diameter of the pipe

Flanged flow indicator

Weld-on fin flow indicator

SPECTACLE BLIND
(& SPADE OR SPACER)

To isolate a piping section or a specific equipment

GENERAL DATA[1]

- Standard: ASME B16.48
- Fluid: liquid, gas, steam
- Mounting between flanges:
  - o ISO PN 2.5 to 420
  - o ASME 150# to 2500#
- Diameter: according to the nominal diameter of the flange – see page 50
- Operating pressure : limited by the flange rating – see page 50
- All face designs: RF, RTJ, with groove/tongue face

RTJ female spectacle blind

Tongue face spectacle blind

RTJ male spacer

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[1] Only standard data are exposed on this page. Other designs are available on request.

Technical information

1. APPLICABLE CONSTRUCTION CODES AND STANDARDS

All our devices are designed and manufactured to meet current international standard requirements.

Fluid flow measurement standards by means of pressure differential devices	
ISO 5167	ISO 5167-1, general principles and requirements ISO 5167-2, orifice plates ISO 5167-3, nozzles and venturi nozzles ISO 5167-4, venturi tubes ISO 5167-5, cone meters ISO 5167-6, wedge meters
ISO/TR 15377	Specification of orifice plates, nozzles and venturi tubes beyond the scope of ISO 5167
ASME MFC-3M	Measurement of fluid flow using orifice plates, nozzles and venturi tubes
ASME MFC-12M	Measurement of fluid flow using multiport averaging pitot primary elements
ASME MFC-14M	Measurement of fluid flow using small bore precision orifice meters
ISO 9300	Measurement of gas flow by means of critical flow venturi nozzles (sonic nozzle)
ISO/TR 11583	Measurement of wet gas flow by means of pressure differential devices
ASME PTC 19.5	Performance test code for flow measurement
ASME PTC 6	Performance test code for steam turbine (PTC 6 nozzle)

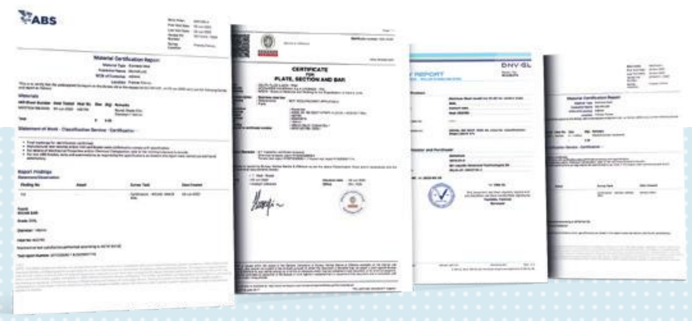
Depending on customer requirements, different construction codes may be applicable to design, manufacture, inspect and test our parts.

Construction codes	
CODETI div.1	Industrial piping
CODETI div.2	Transport pipelines
CODETI div.3	Penstocks
CODAP	Unfired pressure vessels
ASME B31.1	Pipelines in an industrial environment related to the energy sector (power piping)
ASME B31.3	Pipelines for all types of industrial processes (process piping)
ASME BPVC	Boiler & pressure vessel code and equipment for nuclear power plants (nuclear power piping)
EN 13480	Metallic industrial piping, pressure equipment
EN 13445	Unfired pressure equipment
RCC-M	Mechanical equipment for nuclear islands of pressurized water reactors
RCC-MRx	Mechanical equipment for high temperature structures and for experimental and fusion reactors

Because our devices are pressurised equipment, when installed in Europe, **they must comply to the European directive PED 2014/68/EU** related to the marketing of pressure equipment in Europe. The corresponding certificates are delivered with the technical documentation.

Additional decrees are completing or replacing this directive in case of specific applications:
- ESPN Decree of December 30, 2015 related to nuclear pressure equipment,
- «Multifluid» decree of December 15, 2016 related to the safety of gas, hydrocarbon or chemical transport pipelines,
- Decree of March 15, 2000 related to pressure equipment control operations.

2. MATERIALS



SPECIAL APPLICATION REQUIREMENTS

Depending on your application, we are able to source materials that can meet very specific requirements:
- **Material qualified** by bodies such as TÜV, Lloyd's Register, ABS, BV, DNV, CCS.
- **Material according to NORSOK or NACE standards** (NACE 0175 / ISO 15156 for materials in contact with hydrogen sulfide H_2S or NACE MR 103 / ISO 17945 for those used in a corrosive environment).
- **Material whose mechanical properties have been verified by tensile tests** (ambient or high temperature), impact tests (specific temperature) or a US control of the material.

TRACEABILITY: INSPECTION DOCUMENTS

Material inspection certification comply with NF EN 10204 standard.
There are several types of inspection documents:

Inspection documents		Document contents	Document approved by
Type 2.1	Certificate of conformity with the order	Declaration of conformity with the order	Manufacturer
Type 2.2	Test report	Declaration of conformity with the order including information related to non specific inspections	Manufacturer
Type 3.1	Material certificate 3.1	Declaration of conformity with the order including information related to specific inspections	The manufacturer's authorised inspection representative, independant from manufacturing.
Type 3.2	Material certificate 3.2		The manufacturer's authorised inspection representative, independant from manufacturing and an independent third party

SPECIFIC COATING

For particularly aggressive fluids that could alter our products, Deltafluid suggests applying a specific coating to the material in contact with the fluid. Thus, the product with this particular coating offers **better resistance to abrasive, corrosive and / or adherent fluids**. This is a **cost-saving solution**: the product is made with a standard material but the coating increases its lifetime.

FLUID	COATING	PRODUCT
Abrasive	Stellite	Resistant Increased life time Low maintenance
Corrosive	PTFE, Inconel®, Super duplex, Stellite	
Adherent	PTFE	

Examples :
- Stellite coating on the edge of an orifice plate
- Inconel® coating of the external surface of a thermowell in contact with a corrosive fluid
- PTFE coating (teflon) on the internal surface of a venturi tube

316L stainless steel is the most common material used in our applications. This is the reason why all of our equipment that may come in contact with the fluid is manufactured in SS 316L as a standard. However, we offer a **wide range of complementary materials*** adapted to your needs: carbon steel, stainless steel, duplex, super-duplex, hastelloy®, inconel®, soft iron, bronze, cupro-nickel, aluminum, titanium, ceramic, plastic, fiberglass…

*non-exhaustive list

We insure traceability of all our raw materials: we can provide inspection documents type 2.1, 2.2, 3.1 or 3.2 according to NF EN 10204 standard (see inspection documents on page 57).

		DENOMINATION					
TYPE	W.N°	AMERICAN			EUROPEAN	USUAL NAME	REMARKS
		ROUND	TUBE	SHEET METAL			
NON-ALLOY STEELS	1.0402	A 29 SAE 1020		A 830 SAE 1020	C22		Standard structural steel
	1.0501	A 29 SAE 1035		A 830 SAE 1035	C35		Standard structural steel
	1.0503	A 29 SAE 1045		A 830 SAE 1045	C45		Standard structural steel
	1.0535	A 29 SAE 1055		A 830 SAE 1055	C55		Standard structural steel
	1.0037	SAE 1009			S235		Standard structural steel
	1.0045	A 29 SAE 1518			S355		C-Mn structural steel
	1.0305	-	A/SA 106 gr.A	-	P235GH TC1		Steel for pressure vessels
	1.0345	-	-	-	P235GH		Steel for pressure vessels
	1.0405	-	A/SA 106 gr.B	-	P265GH TC1		Steel for pressure vessels
	1.0425	A/SA 105	-	-	P265GH		Steel for pressure vessels
	1.0488	-	-	A/SA 516 gr.60	P275NL1		Fine grain steel (higher resilience)
	1.0488	A/SA 350 LF2	-	-	P295GH		Steel for pressure vessels
	1.0481	-	A/SA 106 gr.C	-	P295GH		Steel for pressure vessels
	10566	-	-	A/SA 516 gr.70	P355NL1		Fine grain steel (higher resilience)
	1.0457	-	A/SA 333 gr.6	-	L245NB		Steel for low temperature pressure vessels
	1.0562	A 694 F52	API 5L X52		P355N		Steel for pressure vessels - fine grain (higher resilience)
	1.0582		API 5L X52		L360NB		Fine grain steel (higher resilience)
	1.8902	A 694 F50	API 5L X60		P420N		Steel for pressure vessels - fine grain (higher resilience)
	1.8972		API 5L X60		L415NB		Fine grain steel (higher resilience)
		ROUND	TUBE	SHEET METAL			
LOW ALLOY Mo AND Cr-Mo STEELS	1.5415	A/SA 182 F1	A/SA 335 P1	A/SA 204 Gr.B	16Mo3		Steel with high temperature characteristic
	1.7218	-	-	-	25CrMo4	AISI 4130 / 25 CD 4	Steel for mechanical construction suitable for hardening (good toughness) - Threaded rods
	1.7225	-	-	-	42CrMo4	AISI 4140 / B7	Steel for mechanical construction suitable for hardening (good toughness) - Threaded rods
	1.7335	A/SA 182 F11	A/SA 335 P11	A/SA 387 gr.11	13CrMo4-5		Steel with high temperature characteristic
	1.7335	A/SA 182 F12	A/SA 335 P12	A/SA 387 gr.12	13CrMo4-5		Steel with high temperature characteristic
	1.7380	A/SA 182 F22	A/SA 335 P22	A/SA 387 gr.22	10CrMo9-10		Steel with high temperature characteristic
	1.4903	A/SA 182 F91	A/SA 335 P91	A/SA 387 gr.91	X10CrMoVNb9-1		Steel with high temperature characteristic and high chromium content - Oil / gas market
	1.4901	A 182 F92	A 335 P92	-	X10CrWMoVNb9-2		Steel with high temperature characteristic and high chromium content - Oil / gas market
	1.7362	A/SA 182 F5	A/SA 335 P5	A/SA 387 gr.5	12CrMo19-5		Steel with high temperature characteristic
	1.7386	A/SA 182 F9	A/SA 335 P9	A/SA 387 gr.9	X11CrMo9-1		Steel with high temperature characteristic and high chromium content

		DENOMINATION					
TYPE	W.N°	AMERICAN			EUROPEAN	USUAL NAME	REMARKS
		ROUND	**TUBE**	**SHEET METAL**			
AUSTENITIC AND DUPLEX STAINLESS STEELS	1.4301	A/SA 182 F304	A/SA 335 P1	A/SA 240 304	X5CrNi18-10	304	Austenitic stainless steel with Ni ≥ 2.5 % but without molybdenum Excellent ductility (suitable for low temperature applications)
	1.4306	A/SA 182 F304L	A/SA 312 TP304L	A/SA 240 304L	X2CrNi19-11	304L	Austenitic stainless steel with Ni ≥ 2.5 % but without molybdenum Low carbon therefore less sensitive to corrosion than its 304 equivalent Excellent ductility (suitable for low temperature applications)
	1.4307	A/SA 182 F304L	A/SA 312 TP304L	A/SA 240 304L	X2CrNi18-9	304L	Austenitic stainless steel with Ni ≥ 2.5 % but without molybdenum Low carbon therefore less sensitive to corrosion than its 304 equivalent Excellent ductility (suitable for low temperature applications)
	1.4401	A/SA 182 F316	A/SA 312 TP316	A/SA 240 316	X5CrNiMo17-12-2	316	Austenitic stainless steel with Ni ≥ 2.5 % + molybdenum Excellent ductility (suitable for low temperature applications)
	1.4404	A/SA 182 F316L	A/SA 312 TP316L	A/SA 240 316L	X2CrNiMo17-12-2	316L	Austenitic stainless steel with Ni ≥ 2.5 % + molybdenum Low carbon therefore less sensitive to corrosion than its 316 equivalent Excellent ductility (suitable for low temperature applications)
	1.4541	A/SA 182 F321	A/SA 312 TP321	A/SA 240 321	X6CrNiTi18-10	321	Austenitic stainless steel with added titanium Excellent resistance to intergranular corrosion and oxidation up to 800 °C
	1.4571	A/SA 182 F316Ti	A/SA 312 TP316Ti	A/SA 240 316Ti	X6 CrNiMoTi17-12-2	316Ti	Austenitic stainless steel with added titanium Excellent resistance to intergranular corrosion and oxidation up to 870 °C
	1.4539	A/SA 182 F904L	A/SA 312 TP904L	A/SA 240 904L	X1NiCrMoCu25-20-5	904L / Uranus® B6	Austenitic stainless steel (high nickel, chromium and molybdenum content) Resistant to corrosion in contact with sulfuric and phosphoric acid
	1.4410	A/SA 182 F53	A/SA 790 S32750	A/SA 240 S32750	X2CrNiMoN25-7-4	Super duplex F53 / Uranus® 2507	Austeno-ferritic stainless steel More resistant but less ductile than conventional austenitic stainless steel Resistant to intergranular corrosion as well as corrosion in seawater
	1.4462	A/SA 182 F51	A/SA 790 S31803	A/SA 240 S31803	X2CrNiMoN22-5-3	Duplex F51 / Uranus® 2205	Austeno-ferritic stainless steel More resistant but less ductile than conventional austenitic stainless steel Resistant to intergranular corrosion as well as corrosion in seawater
	1.4462	A/SA 182 F60	A/SA 790 S32205	A/SA 240 S32205	X2CrNiMoN22-5-3	Duplex F60 / Uranus® 2205	Austeno-ferritic stainless steel More resistant but less ductile than conventional austenitic stainless steel Resistant to intergranular corrosion
		ROUND	**TUBE**	**SHEET METAL**			
HEAT-RESISTANT STAINLESS STEELS	1.4828	A/SA 479 309S	A/SA 312 TP309S	A/SA 240 309S	X15 CrNiSi20-12	309S	Austenitic stainless steel with Ni ≥ 2.5 % Good resistance to hot oxidation up to 1000 °C and good creep resistance up to 850 °C
	1.4845	A/SA 479 310S	A/SA 312 TP310S	A/SA 240 310S	X8CrNi25-21	310S	Austenitic stainless steel with Ni ≥ 2.5 % Insensitive to high temperature embrittlement under low cyclic conditions Frequent use for furnaces and boilers
		ROUND	**TUBE**	**SHEET METAL**			
NICKEL BASE ALLOYS (CORROSION AND HEAT RESISTANT)	2.4602	B 574 N06022	B 622 N06022	B 575 N06022	NiCr21Mo14W	Alloy C22	Similar to C 276 with more versatile corrosion resistance Frequent use in chemical treatment plant and paper converting (resistant to pitting, intergranular and stress corrosion) Resistant to wet chlorine gas, chlorine oxide and hypochlorite solutions
	2.4819	B/SB 574 N10276	B/SB 622 N10276	B/SB 575 N10276	NiMo16Cr15W	Alloy C276	Frequent use in chemical processing plants and pulp production (resistant to pitting, intergranular and stress corrosion) Resistant to wet chlorine gas, chlorine oxide and hypochlorite solutions
	2.4360	B/SB 164 N04400	B/SB 165 N04400	B/SB 127 N04400	NiCu30Fe	Alloy 400	Retains its mechanical properties up to 400/500 °C Insensitive to stress corrosion cracking induced by chloride ions (can work in contact with sea water) Authorized use in pressure vessels up to 425 °C
	2.4816	B/SB 166 N06600	B/SB 167 N06600	B/SB 168 N06600	NiCr15Fe	Alloy 600	Retains its mechanical properties at high temperature Used for the construction of industrial furnaces, and when high temperature gases contain elements of the halogen family Used in wet corrosion conditions
	2.4856	B/SB 446 N06625	B/SB 444 N06625	B/SB 443 N06625	NiCr22Mo9Nb	Alloy 625	Resistant to corrosion in contact with sulfuric and phosphoric acid Retains its mechanical properties at high temperature Frequent use in marine environment (resistant to pitting, intergranular and stress corrosion)
	1.4876	B/SB 408 N08800	B/SB 163 N08800	B/SB 409 N08800	X10NiCrAlTi32-20	Alloy 800	Resistant to hot oxidation and good creep resistance Used in the construction of industrial furnaces, carbonization plants, steam boilers and heat exchangers
	2.4858	B/SB 425 N08825	B/SB 163 N08825	B/SB 424 N08825	NiCR21Mo	Alloy 825	Resistant to corrosion in contact with sulfuric and phosphoric acid, and treatment of nuclear waste Authorized use in pressure vessels up to 425 °C

3. WELDING

For a steel welded assembly, **all documents requested for the welding record book** are supplied to the customer in accordance with the requirements of the applicable code:

DRAWING

WELDING MARKS AND DESCRIPTIONS

PQR	WPS	WPQ
PQR (PROCEDURE QUALIFICATION RECORD) ACCORDING TO ASME IX OR QMOS (QUALIFICATION DU MODE OPERATOIRE DE SOUDURE) ACCORDING TO NF EN ISO 15614-1	WPS (WELDING PROCEDURE SPECIFICATION) ACCORDING TO ASME IX OR DMOS (DESCRIPTIF DU MODE OPÉRATOIRE DE SOUDURE) ACCORDING TO NF EN ISO 15609-1	WPQ (WELDERS PERFORMANCE QUALIFICATION) ACCORDING TO ASME IX OR QS (QUALIFICATION SOUDEUR) ACCORDING TO EN ISO 9606-1
Grouping **all welding data used to weld a qualified assembly as well as the mechanical test results** corresponding to each welding process used.	Each assembly configuration and corresponding welding process are **precisely described and provide instructions** for performing welds.	The welder's qualification must correspond to the **variables given for each welding process used and each type of weld.**

European standards for arc welding

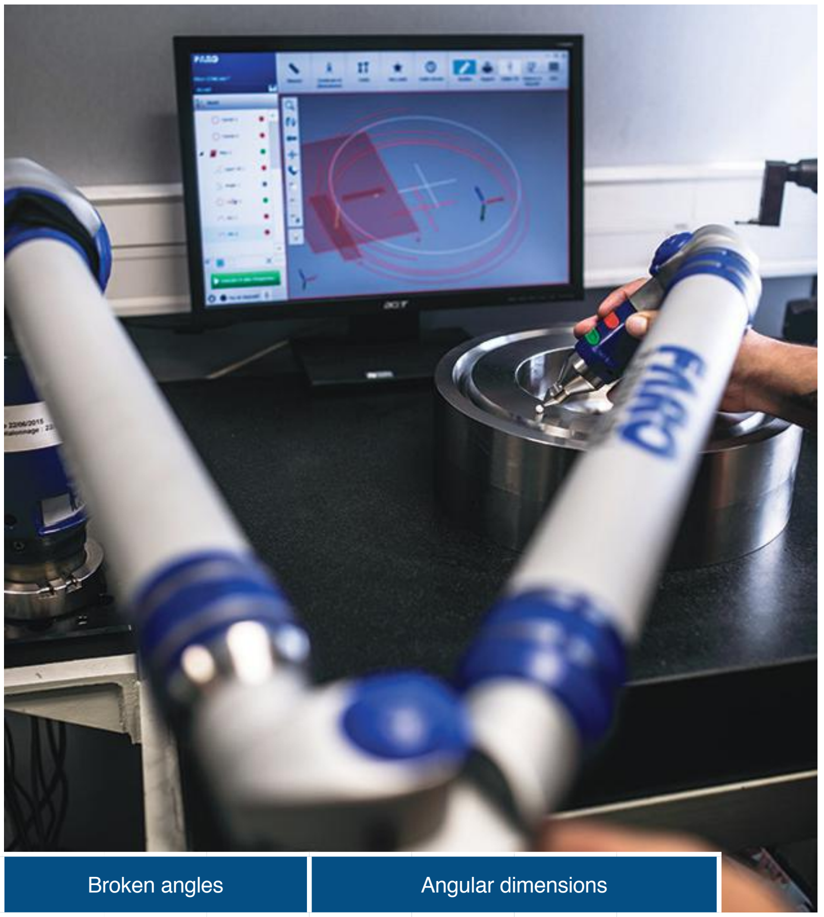
		QUALITY REQUIREMENTS	STANDARDS	ACCEPTANCE LEVEL
		Materials Groups	CEN ISO/TR 15608, 20172, 20173	
		QS (WPQ)	EN ISO 9606	
		DMOS (WPS)	EN ISO 15609	
		QMOS (PQR)	EN ISO 15614	
		NDT - staff qualification	EN ISO 9712	
INSPECTION & CONTROL	DURING WELDING	Preheating temp. measurement, temp. between passes	EN ISO 13916	
		Welding recommendations	EN 1011, ISO/TR 17671	
	AFTER WELDING	NDT - General rules	EN ISO 17635	
		Visual control	EN ISO 17637	EN ISO 5817
		X-ray	EN ISO 17636	EN ISO 10675
		Ultrasonic	EN ISO 17640, 10863, 22825	EN ISO 11666, 15626, 22825, 23279
		Magnetic particle	EN ISO 17638	EN ISO 23278
		Macro and microscopic	EN ISO 17639	EN ISO 5817
		Dye-penetrant	EN ISO 3452	EN ISO 23277
		Heat treatment associated with welding	EN ISO 17663	
DESTRUCTIVE TESTING		Impact bending	EN ISO 9016	
		Longitudinal tensile	EN ISO 5178	
		Transverse tensile	EN ISO 4136	
		Cross tensile	EN ISO 9018	
		Bending	EN ISO 5173	
		Texture	EN ISO 9017	
		Hardness	EN ISO 9015	
		Macro and mircoscopic	EN ISO 17639	
		Hot cracking	EN ISO 17641	
		Cold cracking	EN ISO 17642	
		Delta ferrite	EN ISO 17655	
		Process numbering	EN ISO 4063	
		Tolerances	EN ISO 13920	
		Welding positions	EN ISO 6947	

4. DIMENSIONAL CONTROL

At the end of the manufacturing processes, **all our parts are systematically visually and dimensionally inspected in accordance with the approved drawings**. Our control devices are periodically checked by a metrology laboratory.

In addition to the standard testing devices, we have the following items:
- MITUTOYO measuring column,
- MAHR roughness meter,
- FARO 3D measuring arm,
- MAHR Marsurf CD120 profilometer,
- ZEISS DuraMax measuring machine,
- MITUTOYO profile projector.

The dimensional and geometric aspects of our parts meet the corresponding tolerance standards.



General tolerances (machining) according to ISO 2768

LINEAR DIMENSIONS (mm)						Broken angles			Angular dimensions			
						Radius - Bevels			Dimension of the shortest side			
Accuracy class	**0.5 to 3 inclusive**	**3 to 6**	**6 to 30**	**30 to 120**	**120 to 400**	**0.5 to 3 inclusive**	**3 to 6**	**> 6**	**< 10**	**10 to 50 inclusive**	**50 to 120**	**120 to 400**
f (thin)	± 0.05	± 0.05	± 0.1	± 0.15	± 0.2	± 0.2	± 0.5	± 1	± 1°	± 30’	± 20’	± 10’
m (medium)	± 0.1	± 0.1	± 0.2	± 0.30	± 0.5	± 0.2	± 0.5	± 1				
c (wide)	± 0.2	± 0.3	± 0.5	± 0.80	± 1.2	± 0.4	± 1	± 2	± 1°30’	± 1°	± 30’	± 15’
v (very wide)	-	± 0.5	± 1	± 1.5	± 2.5	± 0.4	± 1	± 2	± 3°	± 2°	± 1°	± 30’

GEOMETRIC TOLERANCES (mm)											
Tolerances	— ▱					⊥			⌯			↗ ⌰ **Radial Axis**
Accuracy class	**< 10**	**10 to 30**	**30 to 100**	**100 to 300**	**300 to 1000**	**< 100**	**100 to 300**	**300 to 1000**	**< 100**	**100 to 300**	**300 to 1000**	**All dimensions**
H (thin)	0.02	0.06	0.1	0.2	0.3	0.2	0.3	0.4	0.5	0.5	0.5	0.1
K (medium)	0.05	0.1	0.2	0.4	0.6	0.4	0.6	0.8	0.6	0.6	0.8	0.2
L (wide)	0.1	0.2	0.4	0.8	1.2	0.6	1	1.5	0.6	1	1.5	0.5

General tolerances for welded constructions according to ISO 13920

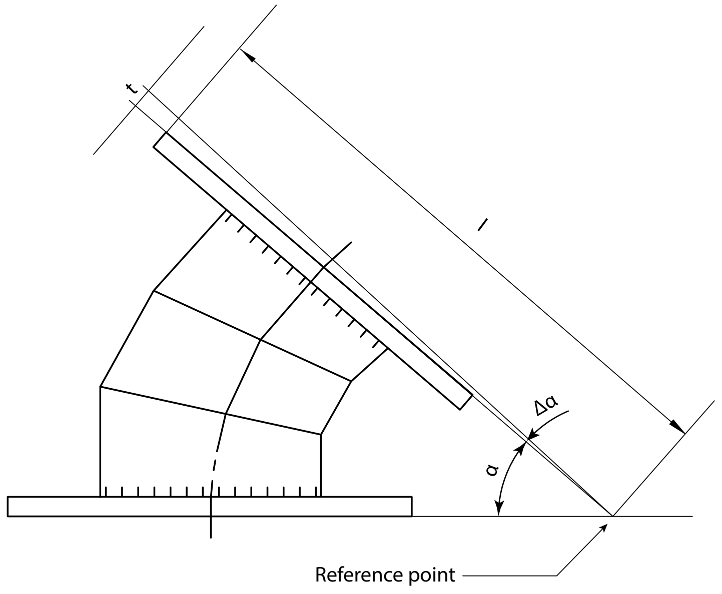
Linear dimensions

NOMINAL DIMENSIONS l (in mm)											
Accuracy class	**2 to 30**	**> 30 to 120**	**> 120 to 400**	**> 400 to 1000**	**> 1000 to 2000**	**> 2000 to 4000**	**> 4000 to 8000**	**> 8000 to 12000**	**> 12000 to 16000**	**> 16000 to 20000**	**> 20000**
	Tolerances t (in mm)										
A	± 1	± 1	± 1	± 2	± 3	± 4	± 5	± 6	± 7	± 8	± 9
B		± 2	± 2	± 3	± 4	± 6	± 8	± 10	± 12	± 14	± 16
C		± 3	± 4	± 6	± 8	± 11	± 14	± 18	± 21	± 24	± 27
D		± 4	± 7	± 9	± 12	± 16	± 21	± 27	± 32	± 36	± 40

Angular dimensions

	NOMINAL DIMENSIONS l (in mm) Shortest side length				NOMINAL DIMENSIONS l (in mm) Shortest side length		
Accuracy class	**< 400**	**> 400 to 1000**	**> 1000**	**Classe de tolérance**	**< 400**	**> 400 to 1000**	**> 1000**
	Tolerances Δα (in degrees and minutes)				**Calculated and rounded tolerances t (in mm/m)[1]**		
A	± 20’	± 15’	± 10’	A	± 6	± 4.5	± 3
B	± 45’	± 30’	± 20’	B	± 13	± 9	± 6
C	± 1°	± 45’	± 30’	C	± 18	± 13	± 9
D	± 1°30’	± 1°15’	± 1°	D	± 26	± 22	± 18

(1) The value indicated in millimeters per meter corresponds to the tangent value of the general tolerance. It should be multiplied by the length, in meters, of the shortest side.



5. NON-DESTRUCTIVE TESTING AND PRODUCT INSPECTION

Non-Destructive Testing or NDT brings together all the processes and techniques that provide **information on the integrity and health of a material or part** without damaging it. It is for materials what medical imaging is for the human body.

NDT (applied to forged, rolled, cast and welded parts) highlights all the defects that might alter the availability, safety of use and / or more generally the conformity of a part for its intended use.

Two types of defects are searched:

- surface defects such as cracks, holes, splits, pittings…
- internal defects such as porosities, blisters, inclusions, blind cracks, variations in thickness due to wear or corrosion…

Additional checks verifying the chemical nature of the materials used and the mechanical strength of the parts may also help.

For this intent, the **main control techniques** we are proposing are:

- Visual Testing - VT,
- Penetrant Testing - PT,
- Radiographic Testing - RT,
- Ultrasonic Testing - UT,
- Leak tightness Testing - LT,
- PMI / Ferrite rate,
- Hydrostatic test.

While some of these controls are imposed by construction codes or regulatory requirements, we are also able to take into account the specific requirements of our customers. To serve this purpose, we have:

- examination procedures validated by Cofrend level 3 certified staff according to EN ISO 9712 or ASNT-TC-1A level 3,
- Cofrend level 2 certified examiners according to EN ISO 9712 or ASNT -TC-1A level 2,
- the main construction codes specifying the examination methods and applicable acceptance criteria (ASME V, ASME VIII, ASME B31.1, ASME B31.3, CODAP / CODETI, NF EN 13480 / NF EN 13445, RCC-M, RCC-MRx, etc.).

CHEMICAL ANALYSIS OF MATERIALS / CHECKING THE MECHANICAL STRENGTH OF THE PARTS

PMI TEST (Positive Identification of Materials)

This test method enables to:

- identify and analyze the composition of a metal or alloy: the respective proportions of the main chemical elements (Mn, P, Si, Cr, Ni, Al, Mo, Cu, Cb, V, Ti, Co, Sn, W, etc.) are measured and compared to a materials database to define the material grade of the controlled part,
- confirm the grade of the material used (traceability with the material certificate).

It can be carried out very quickly on any metal part or weld without damaging the part.

Standard: ASTM A 751.

FERRITE RATE

Controlling the ferrite index of an austenitic and duplex stainless steel weld allows to control the risk of hot cracking, the risk of high temperature embrittlement, low temperature mechanical properties or to confirm corrosion resistance.

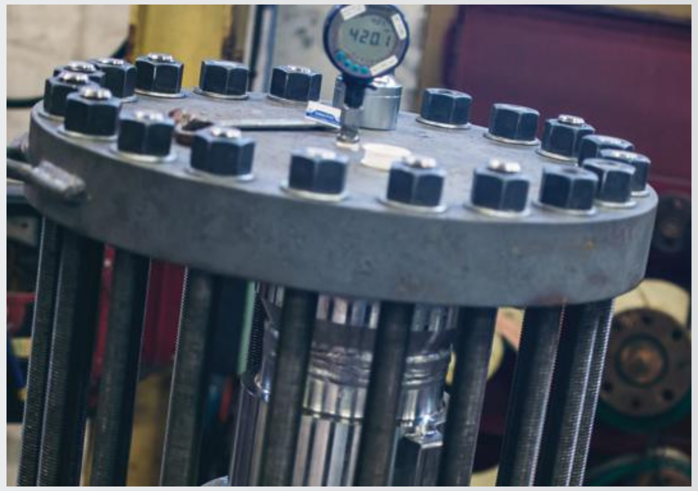
Standard: NF EN ISO 8249.

HYDROSTATIC TEST

The hydrostatic test **verifies the structural integrity of pressure equipment**, by pressurizing a fluid at a given pressure for a defined period of time.

A **visual examination** before, during and after the test ensures that the equipment does not allow any leak and does not deform under stress.

Our pressure gauges are class 0.5 and the tests can be carried out using water or air, up to test pressures of 3000 bars.



NDT TABLE AND DETAILS

Method	Defects highlighted	advantages	Limits	Examination stage	Standards / Qualification[2]
Visual Testing - VT	Emerging discontinuities (splits, scratches, porosities, cracks, etc.)	Economical, fast	Can only detect surface defects of significant size	All stages	NF EN 13018, NF EN 13927, ASME Section V article 9
Dye-penetrant (PT)[1]	Emerging discontinuities (splits, cracks, porosities, pittings, etc.)	Reliable detection of small surface defects	Can only detect emerging discontinuities	Weld beads (intermediate or final) or machined parts	NF EN ISO 3452-1 to NF EN ISO 3452-4, NF EN ISO 23277, ASME Section V article 6
X-ray or gamma radiography (RT)	Cavities or foreign materials included in the part	Detection of all types of internal defects	Significant cost linked to controlled thicknesses, complexity of implementation	Weld beads	NF EN ISO 5579, NF EN ISO 17636-1, ASME section V article 2
Ultrasonic (US)	Deep defect in the material resulting in a discontinuity of the mechanical properties (crack, inclusion, porosity, etc.)	Detection of all types of internal defects, not limited to metallic materials	Significant cost for single parts	Raw material, weld beads and machined parts	NF EN ISO 16810, NF EN ISO 16827, NF EN 17640, ASME section V article 5
Leak tightness (LT)	Leak tightness defect which allows a leak	Detection of defects passing through the material, even very small	Can only detect passing through defects	Finished parts	NF EN 13625, NF EN ISO 20485, NF EN 1593, ASME section V article 10

[1] Products used for this test comply with PMUC (Products and Materials Used in Nuclear Power Plant) requirements for nuclear applications.

[2] The inspectors undergo an annual assessment of their visual acuity according to NF EN ISO 18490 as operators certified COFREND level 2 according to EN ISO 9712.

CALIBRATION

For specific applications, we can have our devices calibrated by an approved laboratory (COFRAC, ISO 17025, etc.). This calibration can be carried out using different fluids (water, air, hydrocarbon) to be as close as possible to the customer process. It ensures optimum measurement accuracy.

CUSTOMER INSPECTION OR INDEPENDENT THIRD PARTY INSPECTION

All of the control steps and tests can be validated by a third party or directly by the customer.

6. CLEANING AND SURFACE TREATMENT

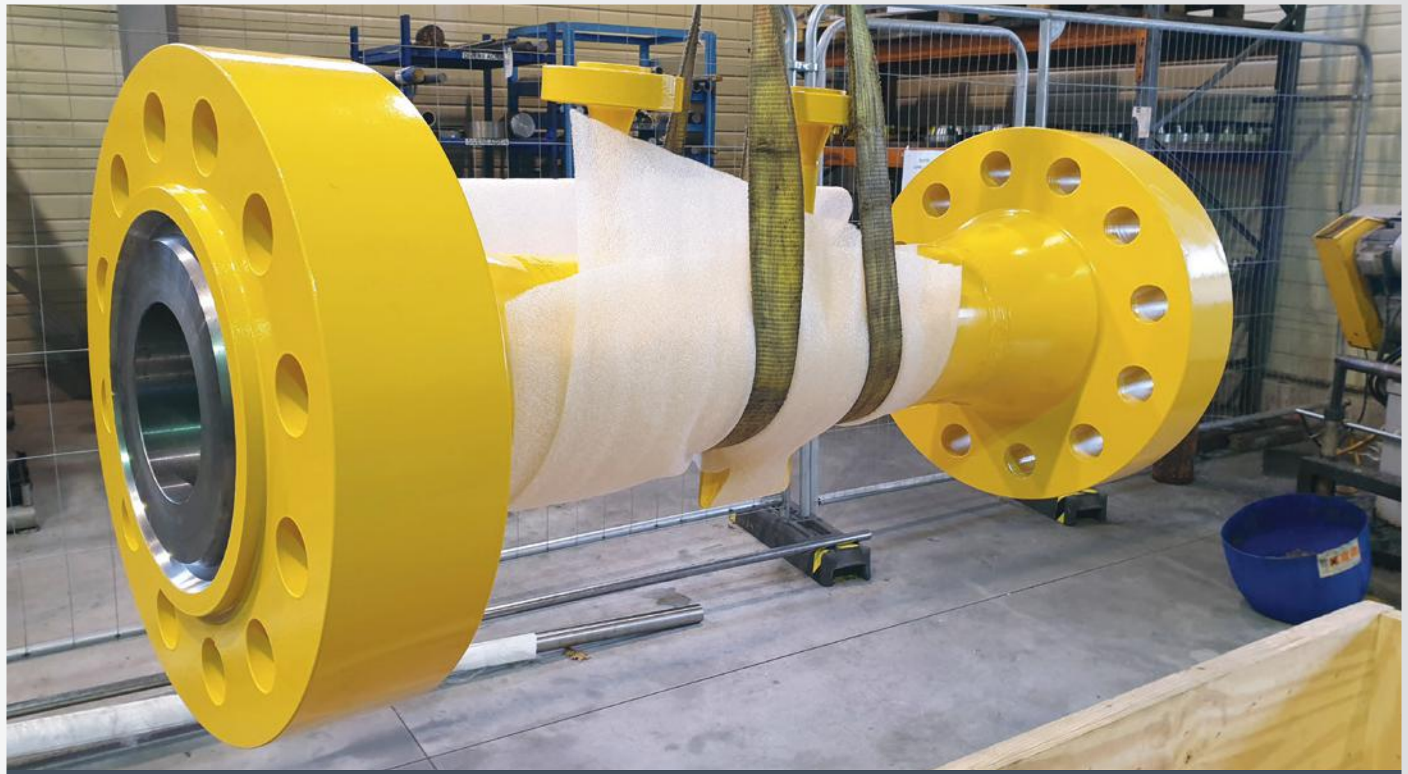
CLEANING

Depending on your needs, we are able to offer our customers the following parts cleaning services.

DEGREASING	PICKLING / PASSIVATING	SHOT BLASTING / SANDBLASTING
Several cleaning levels are carried out, from the simplest to the most demanding: - clean and dry, - for cryogenic application, - for Oxygen service.	The thin film of chromium oxide, present over the entire surface of stainless steel and which enables its resistance to corrosion, can be damaged as a result of welding or machining operations.	This operation consists in mechanically cleaning the parts either to improve their appearance or to make the surface condition compatible with the grip of a subsequent treatment (painting for example).
The contamination type, location and degree of the parts to be treated are evaluated in order to choose the most appropriate cleaning agent, cleaning, inspection and control procedures.	Pickling is used to completely remove oxides and expose stainless steel; the passivation process is then carried out to recreate a protective layer of sufficient and homogeneous thickness which provides protection against corrosion.	

PROTECTION AND COATING

Depending on customer specifications, parts can be painted or coated with a special coating to withstand local climatic conditions and all risks of external aggression.



The ACQPA, Association for the Certification and Qualification in Anticorrosion Painting, **certifies anticorrosion paint systems intended for the protection of metal structures** corresponding to the «high durability» class of standard NF EN ISO 12944-1. The certification is focusing on:

- the protection against corrosion of paint systems applied to metal structures,
- the stability of appearance and color against UV radiation (for parts of structures exposed to natural light).

The certification class corresponds to **the ability of the paint system to withstand the environment** to which it is exposed according to standard NF EN ISO 12944-2: for an atmospheric environment, from a very low corrosivity classified C1 to a very high corrosivity in an industrial environment C5I or in a marine environment C5M.

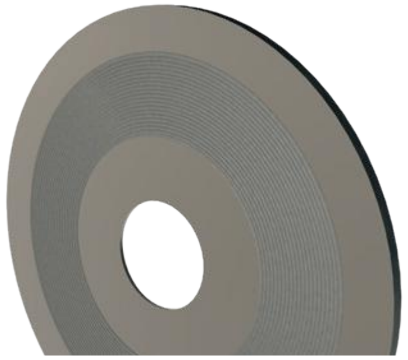
For structures falling under the C5M corrosivity category with parts subject to the combined effect of the atmosphere and seawater (e.g. offshore), C5Mm classification applies.

The paint system is therefore selected taking into consideration the external environment but also the temperature of the fluid as well as the material of the part to be protected. Depending on the system, the topcoat can be tinted (RAL to be defined) to meet customer requirements.

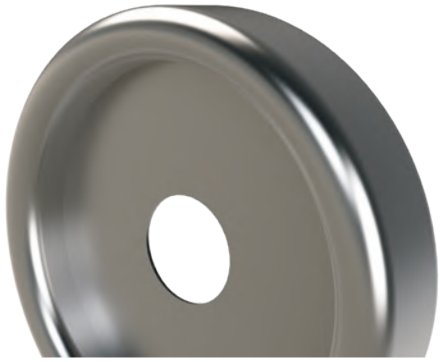
Finally, we are able to call on **FROSIO certified examiners to provide advice, monitoring and inspection** of the paint systems used.

7. GENERAL INFORMATION ON ORIFICE PLATES

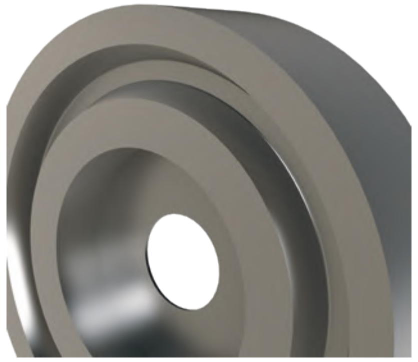
RF OR RTJ SEALING



RF (raised face)

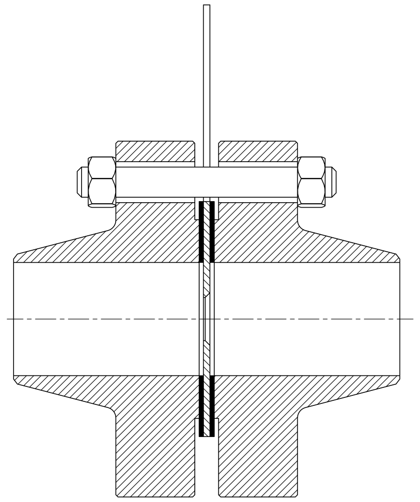


Male RTJ

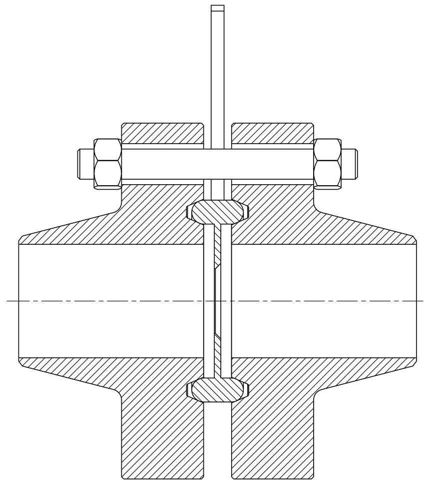


Female RTJ

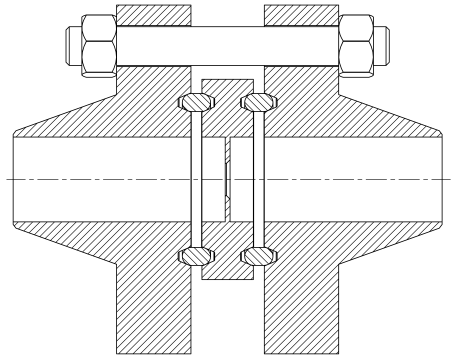
MOUNTING EXAMPLE



RF orifice plate



Male RTJ orifice plate

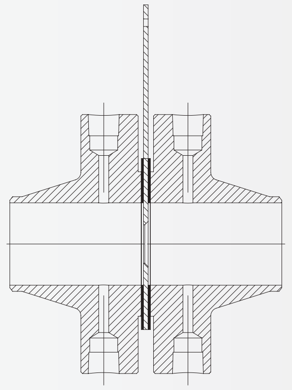


Female RTJ orifice plate

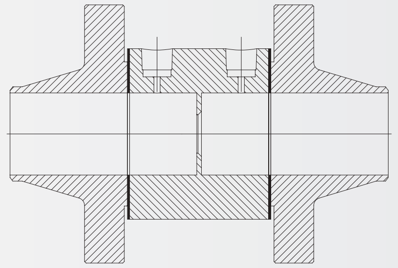
PRESSURE TAP STANDARDIZED[1]

ΔP
25/25

FLANGE PRESSURE TAP (1"/1")



Orifice flange



Orifice carrier 1"/1" (monoblock)

ADVANTAGES

Orifice flange

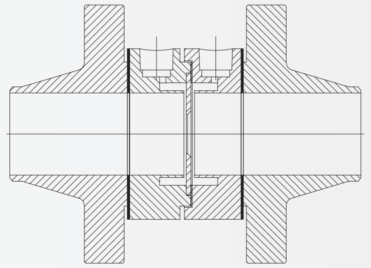
- Easily interchangeable measuring element
- Plate / flange materials may be different

Orifice carrier 1"/1" (monoblock)

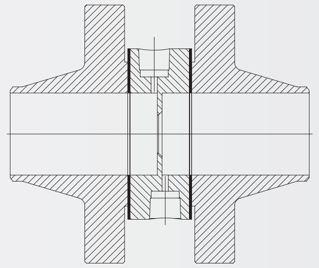
- Measuring element machined from a single block
- Pressure tappings integrated within the carrier
- Ease of assembly: orifice carrier either mounted between simple flanges or welded to the piping

ΔP
0/0

CORNER[2] PRESSURE TAPS (0/0)



Annular chamber



Orifice carrier 0/0 (monoblock)

ADVANTAGES

Annular chamber

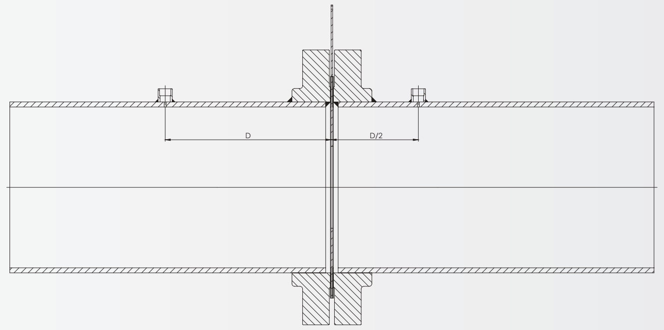
- Mounting between simple flanges (welding-neck, slip-on…)
- Plate / annular chamber materials may be different
- Averaged upstream and downstream pressure; used for better accuracy

Orifice carrier 0/0 (monoblock)

- Measuring element machined from a single block (different thicknesses possible)
- Pressure tappings integrated within the carrier
- Ease of installation: orifice carrier either mounted between simple flanges or welded to the piping

ΔP
D-D/2

D AND D/2[3] PRESSURE TAPS



ADVANTAGES

- Plate mounted between flanges (welding-neck, slip-on…)
- Pressure taps on the pipe
- Used for diameters > ND150

The sections above are showing the different types of pressure taps. For the sake of representation, the diagrams are showing an orifice plate. To find out which pressure taps are suitable for the selected flow measurement element, refer to the product data sheet.

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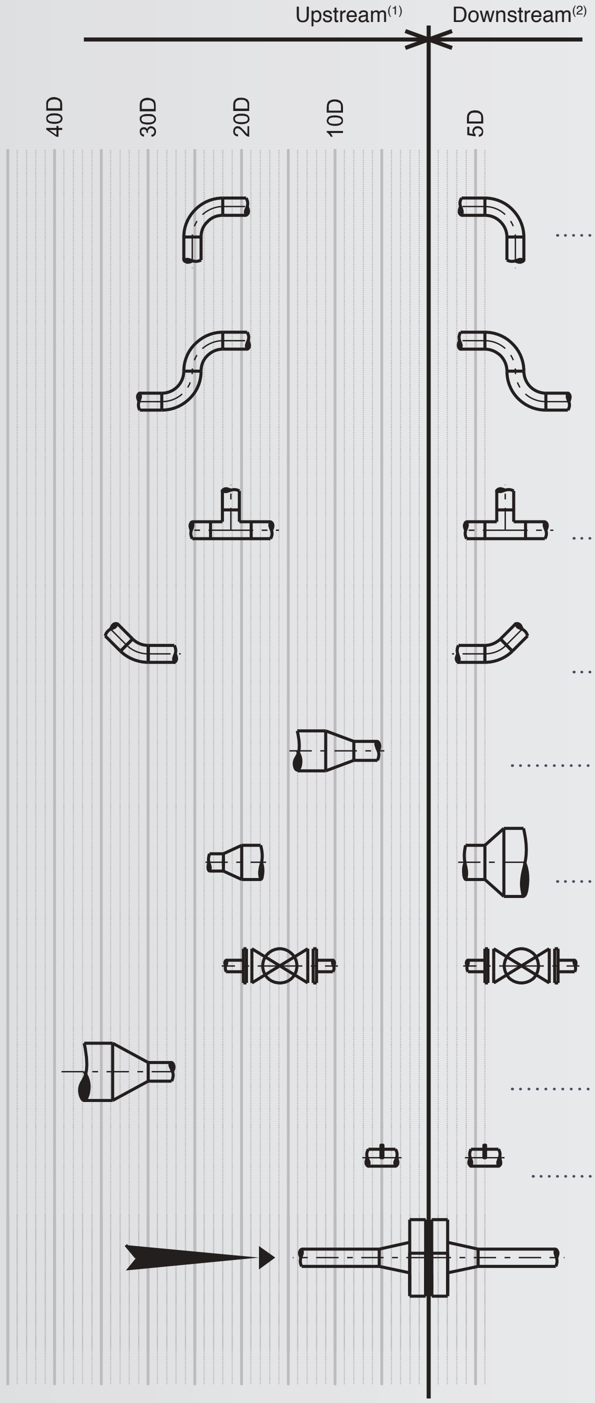
[1] To check the applicable standards, see page 56.
[2] For installation of ISA1932 nozzle with corner pressure taps, see the corresponding technical datasheet on page 19.
[3] For installation of long radius nozzle with D-D / 2 pressure taps, see the corresponding technical datasheet on page 20.

8. STRAIGHT LENGTHS REQUIREMENTS FOR FLOW MEASUREMENT BETWEEN PRESSURE DIFFERENTIAL DEVICES AND FITTINGS ACCORDING TO ISO 5167

ORIFICE PLATE DIAPHRAGM (β=0.5)

Straight lengths values given below are valid for a β = d / D of 0.5. For other β values, refer to the ISO 5167-2 standard.



Single 90° bend

Two 90° bends in the same plane S(3) ≤ 10D

Single 90° tee

Single 45° bend

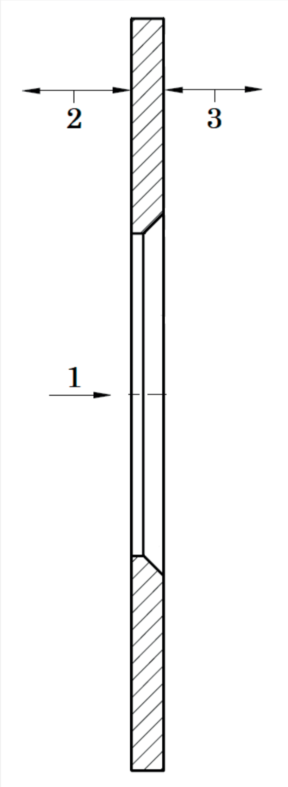
Concentric reducer from 2D to D over a length of 1.5D to 3D

Concentric expander from 0.5D to D over a length of D to 2D

Full bore ball valve or gate valve fully open

Abrupt symmetrical reduction

Thermowell diameter ≤ 0.03D



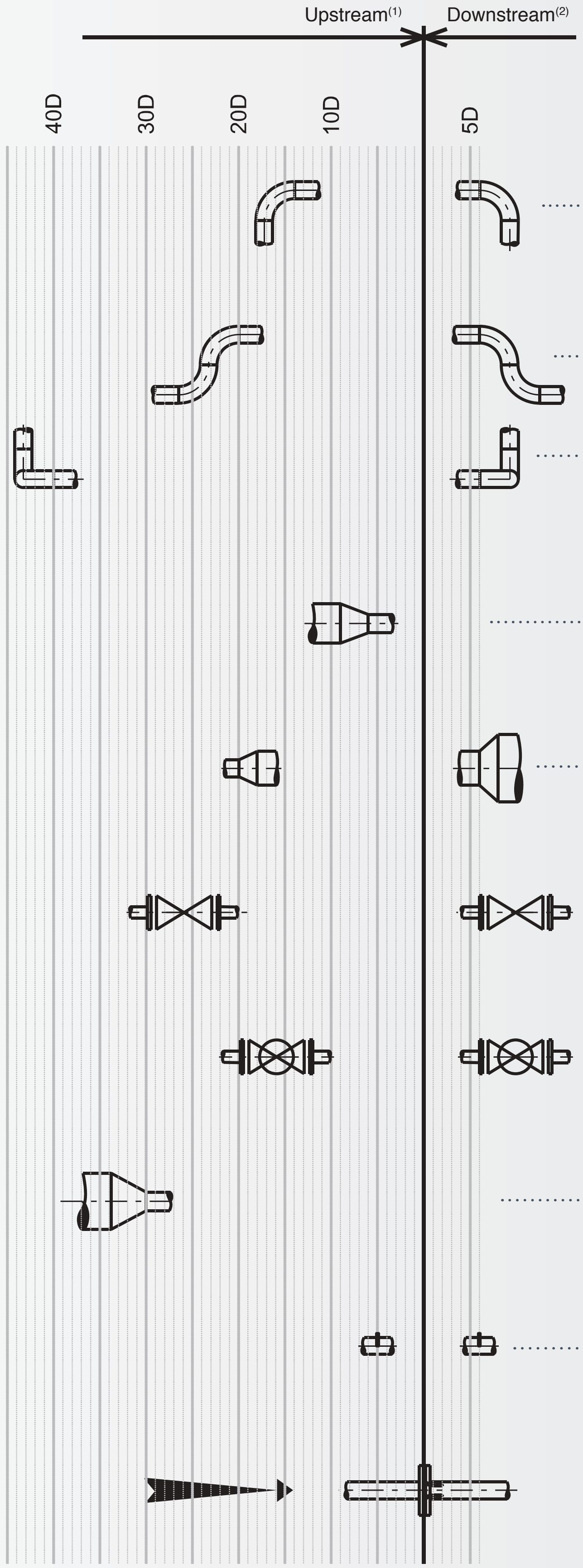
1: flow direction
2: upstream straight length
3: downstream straight length

---

(1) Distance from the downstream end of the curved portion of the nearest bend or of the curved or conical portion of the reducer or the expander to the upstream face of the orifice plate itself. (2) Distance from the upstream end of the curved portion of the nearest bend or of the curved or conical portion of the reducer or the expander to the upstream face of the orifice plate itself. (3) S, distance between the two bends measured from the downstream end of the curved portion of the upstream bend to the upstream end of the curved portion of the downstream bend.

NOZZLE AND VENTURI-NOZZLE (β=0.5)

Straight lengths values given below are valid for a β = d / D of 0.5. For the other β values, refer to the ISO 5167-3 standard.



Single 90° bend

Two 90° bends in the same plane

Two 90° bends in different planes

Concentric reducer from 2D to D over a length of 1.5D to 3D

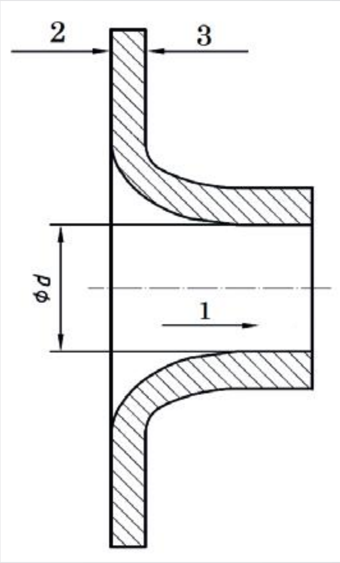
Concentric expander from 0.5D to D over a length of D to 2D

Globe valve fully open

Full bore ball valve or gate valve fully open

Abrupt symmetrical reduction

Thermowell diameter ≤ 0.03D



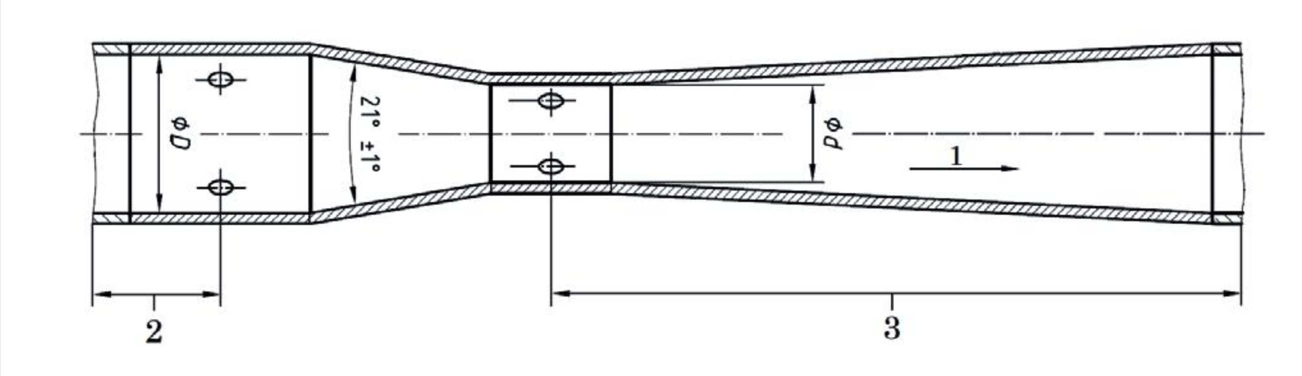
1: flow direction
2: upstream straight length
3: downstream straight length

---

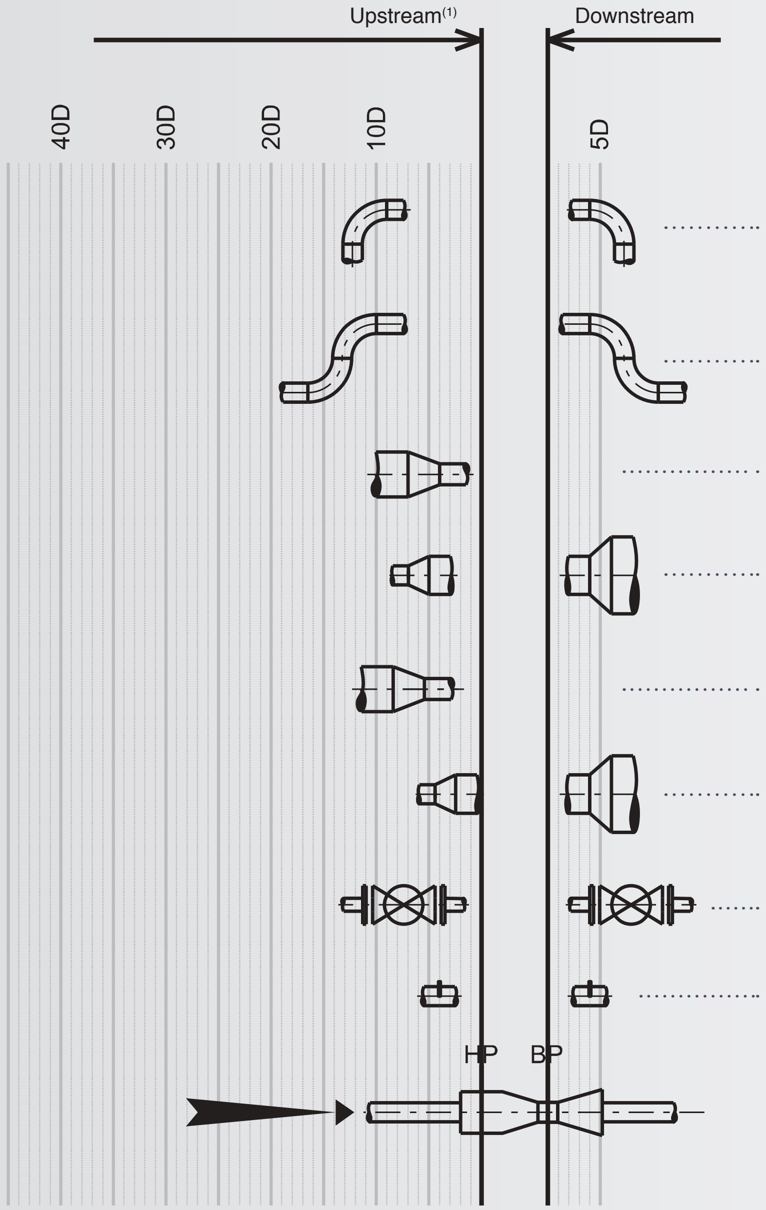
(1) Distance from the downstream end of the curved portion of the nearest bend or of the curved or conical portion of the reducer or the expander to the upstream face of the nozzle itself.
(2) Distance from the upstream end of the curved portion of the nearest bend or of the curved or conical portion of the reducer or the expander to the upstream face of the nozzle itself.

VENTURI TUBE (β=0.5)

The values of straight lengths given below are valid for a value of β = d / D of 0.5. For the other β values, refer to the ISO 5167-4 standard.



1: flow direction
2: upstream straight length
3: downstream straight length



Single 90° bend

Two 90° bends in the same plane or in different planes

Reducer from 1.33D to D over a length of 2.3D

Expander from 0.67D to D over a length of 2.5D

Reducer from 0.75D to D over a length of 3.5D

Concentric expander from 0.75D to D over a length of D

Full bore ball valve or gate valve fully open

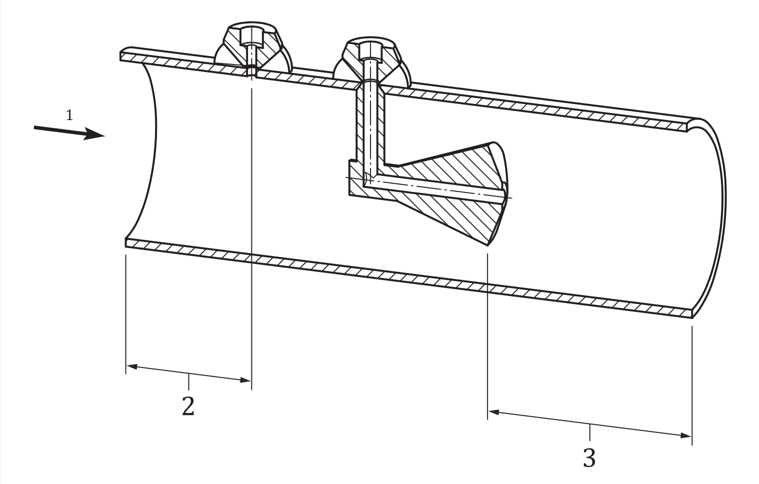
Thermowell diameter ≤ 0.13D

---

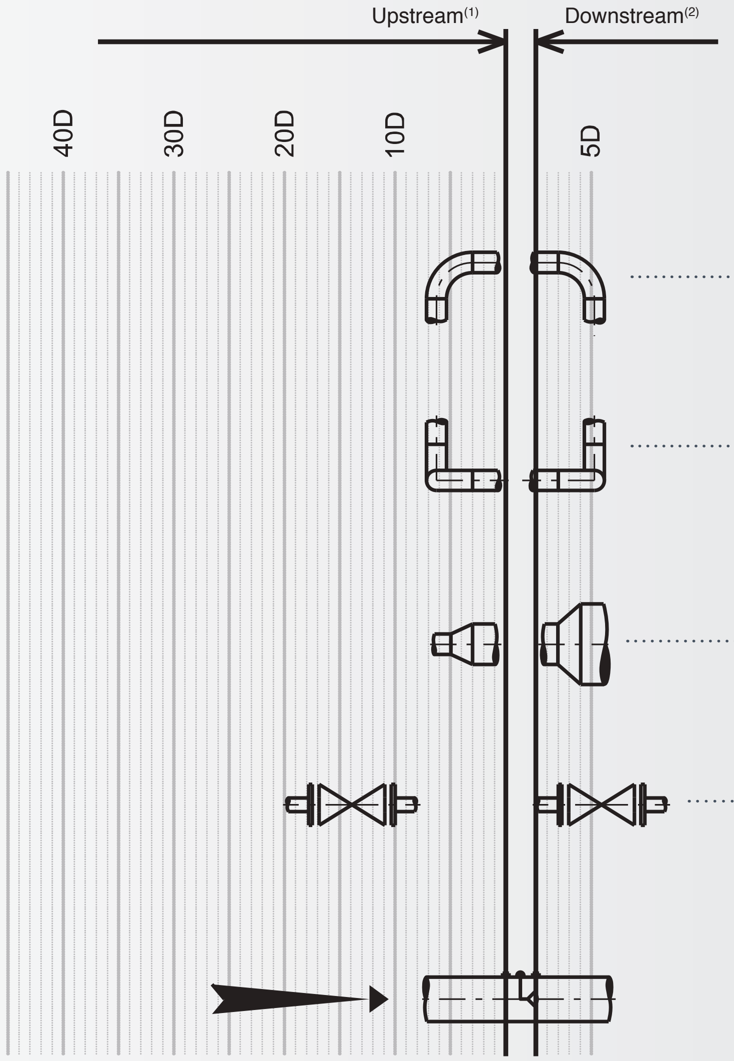
(1) Distance from the downstream end of the curved portion of the nearest bend or of the curved or conical portion of the reducer or the expander to the plane of the upstream pressure tap of the venturi itself.

CONE METER (0.45 ≤ β < 0.6)

Straight lengths values given below are valid for a β = d / D between 0.45 and 0.6. For other β values, refer to the standard ISO 5167-5.



1: flow direction
2: upstream straight length
3: downstream straight length



Single 90° bend

Two 90° bends in perpendicular planes

Concentric expander from 0.75D to D(3)

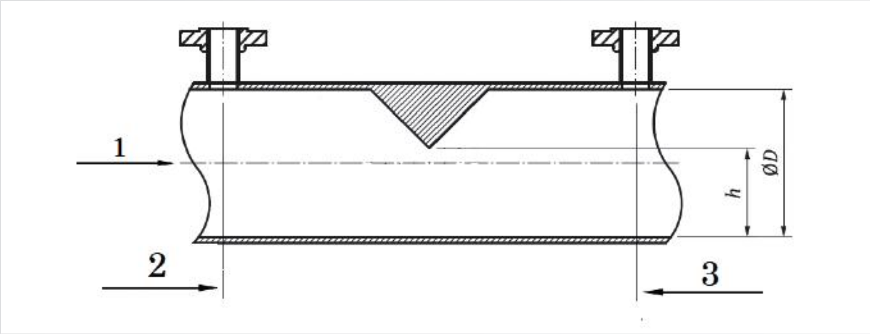
Valve partially closed

---

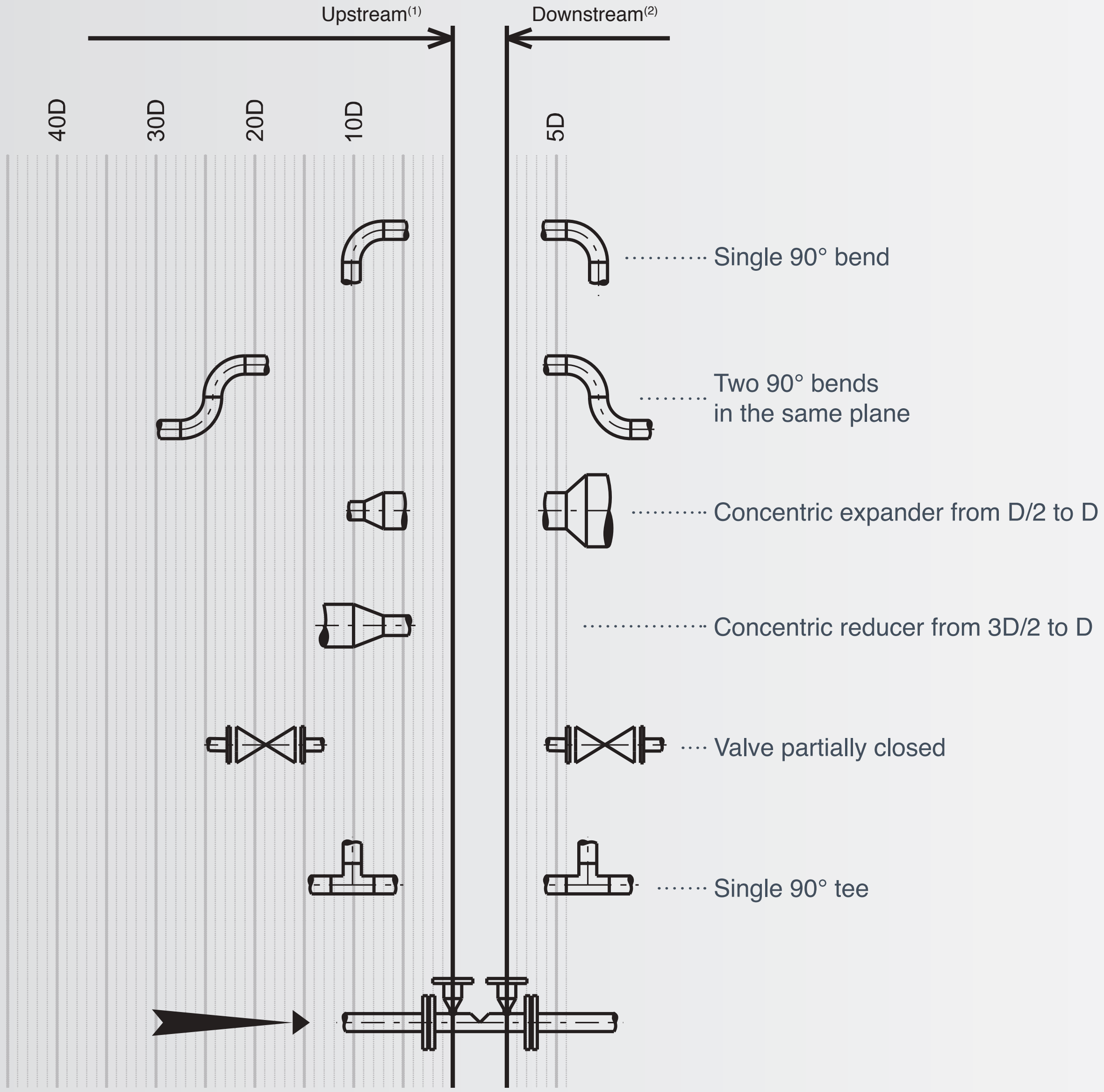
(1) Distance from the downstream end of the curved portion of the nearest bend or of the curved or conical portion of the reducer or the expander to the plane passing through the axis of the upstream pressure tap of the cone meter itself.
(2) Distance from the plane section of the beta edge of the cone meter to the upstream end of the curved part of the nearest bend or reducer / expander.
(3) Additional uncertainty up to 0.5 %.

WEDGE METER (h/D=0.5)

The straight length values given below were carried out with a flowmeter whose h / D value is equal to 0.5. In the absence of other tests, it is considered that these data are also valid for values of h / D between 0.2 and 0.6 (refer to ISO 5167-6).



1: flow direction
2: upstream straight length
3: downstream straight length



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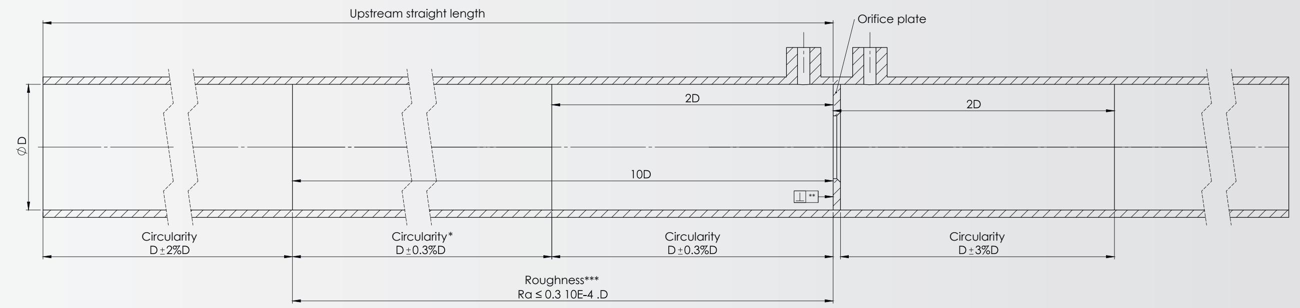
(1) D Distance from the downstream end of the curved portion of the nearest bend or of the curved or conical portion of the reducer or the expander to the plane of the upstream pressure tap of the wedge meter itself.
(2) Distance from the upstream pressure tap of the wedge meter to the upstream end of the curved part of the nearest bend or reducer / expander.

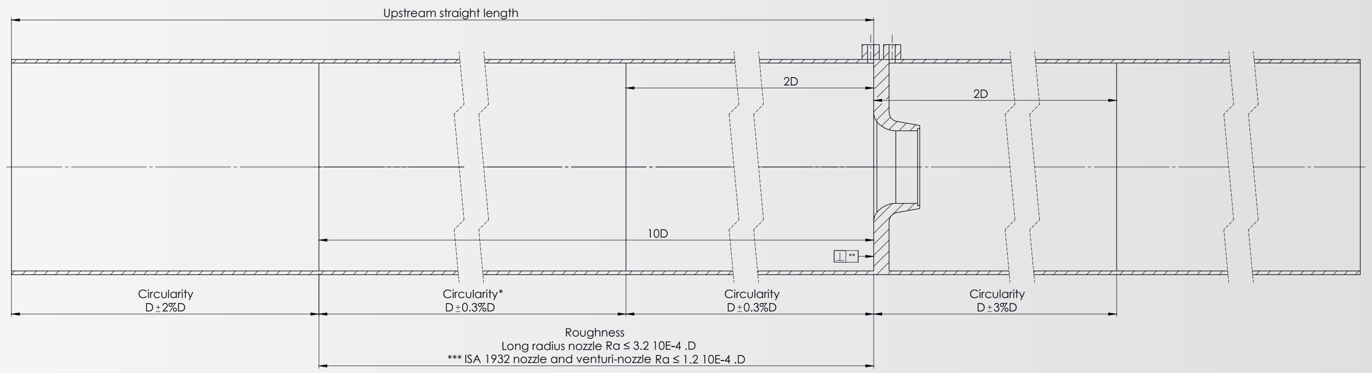
9. CIRCULARITY AND ROUGHNESS REQUIREMENTS ACCORDING TO ISO 5167 STANDARD

ORIFICE PLATE - METER RUN ACCORDING TO ISO 5167-2 STANDARD



* on upstream length between 2.D and 10.D, no additional uncertainty of the discharge coefficient if the maximum circularity tolerance remains less than 0.3%D
** the primary element must be perpendicular to the axis of the pipe with a maximum tolerance of 1°
*** value changing according to β and ReD – contact us

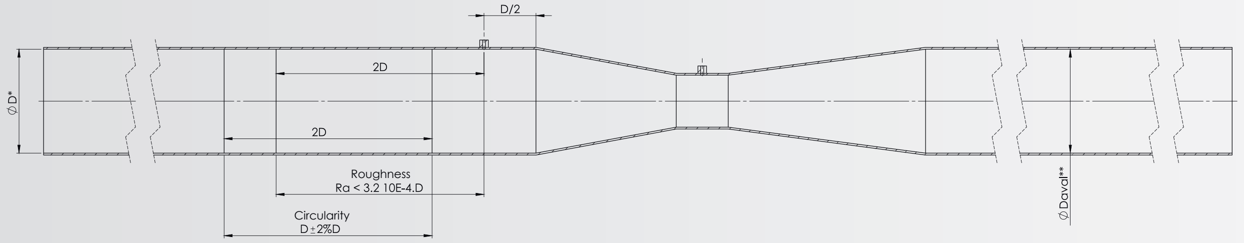
NOZZLE - METER RUN ACCORDING TO ISO 5167-3 STANDARD



* on upstream length between 2.D and 10.D, no additional uncertainty of the discharge coefficient if the maximum circularity tolerance remains less than 0.3%D
** the primary element must be perpendicular to the axis of the pipe with a maximum tolerance of 1°
*** value changing according to β and ReD – contact us

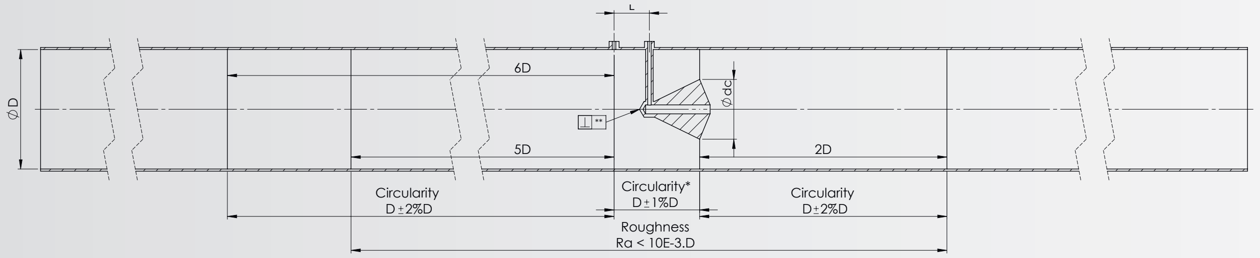
For the venturi-nozzle, the diameter of the pipe immediately downstream of the element must be greater than 90 % of the diameter at the end of the diverging part.

VENTURI - METER RUN
ACCORDING TO ISO 5167-4 STANDARD



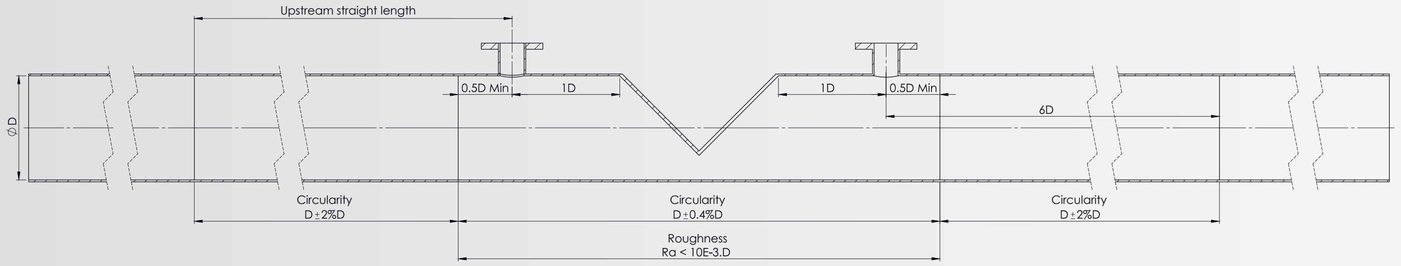
* the primary element must be perpendicular to the axis of the pipe with a maximum tolerance of 1°
** the diameter of the pipe immediately downstream of the venturi must be greater than 90% of the diameter at the end of the diverging part

CONE METER - METER RUN
ACCORDING TO ISO 5167-5 STANDARD



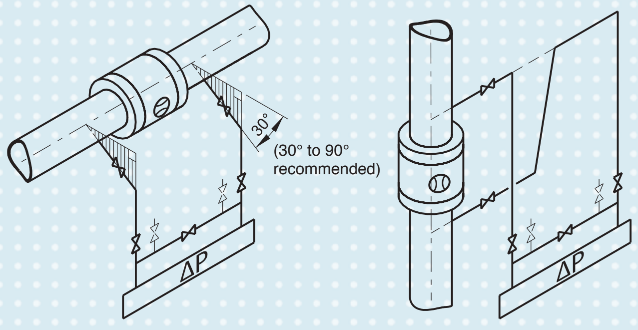
* over a length between the plane section of the upstream pressure tap and the plane section at the maximum circumference of the cone, no additional uncertainty of the discharge coefficient if the maximum circularity tolerance remains less than 1%D
** the measuring cone nose must be perpendicular to the axis of the pipe (in the vertical and horizontal direction) with a maximum tolerance of 2°

WEDGE METER - METER RUN
ACCORDING TO ISO 5167-6 STANDARD



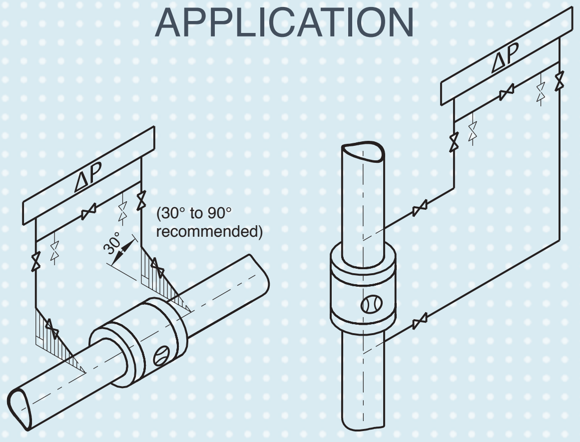
10. TRANSMITTER ASSEMBLY
ACCORDING TO APPLICATIONS

LIQUID
APPLICATION



The pressure taps must face downwards and the transmitter must be mounted below so that any air present in the fluid remains in the piping and does not influence the measurement.

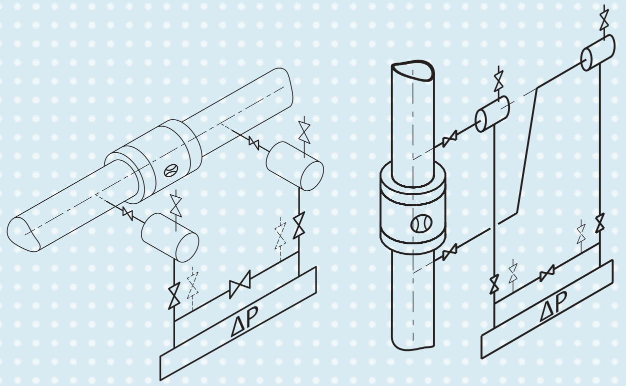
GAS
APPLICATION



The pressure taps must face upwards and the transmitter must be mounted above so that any condensate present in the fluid remains in the piping and does not influence the measurement.

STEAM
APPLICATION

Two condensate pots must be provided and installed at the same level. The transmitter should be positioned below. The condensate pots must be filled with water before commissioning.



The above diagrams explain the **arrangements of the ΔP device according to the different types of fluids**. For the sake of representation, those diagrams are showing standard flow measurement primary elements. All flow measurement primary elements can be considered instead.

11. SPECIAL APPLICATION **RANGEABILITY OR TURNDOWN RATIO UP TO 1:36**

The flow rate value is calculated with the following **formula**:

$$Q = K\sqrt{\Delta P}$$

Q	flow
K	constant taking into account the fluid and piping specificities
ΔP	differential pressure

The uncertainty of the flow rate is minimal at 100% of the maximum flow rate (Qmax) for which the differential pressure device is designed. The operating range of the differential pressure transmitter must also be selected in order to be as close as possible to the differential pressure measured at the maximum flow rate.

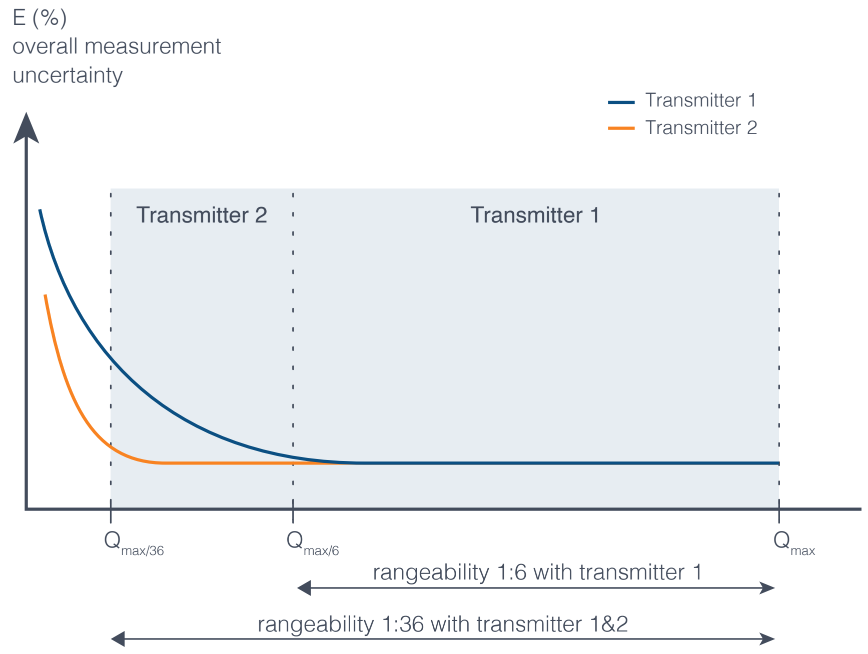
The turndown ratio of a flowmeter is also refered to as its rangeability. It corresponds to the ratio between the maximum and the minimum mesurable flow rates with a minimum measurement uncertainty. Thus, the higher rangeability, the more capable is the flowmeter to accurately measure flow rates well below the maximum flow rate.

In general, differential pressure flowmeters have a rangeability of 1: 6, i.e. it will keep good measurement accuracy for flow values ranging from 100 % down to 16 % (i.e. Qmax / 6) of the maximum flow.

If the measurement uncertainty must remain low over a wider flow range, it is necessary to mount two differential pressure transmitters in parallel: the first will measure 100 % to 16 % of the maximum flow while the second will take over for the lower range of flow rates from 16 to 2% of the maximum flow.

Thus, the differential pressure flowmeter can reliably and with great accuracy measure flow rates ranging from 2 to 100 % of the maximum measurable flow rate. We refer to a rangeability of 1:36.

Flowmeter rangeability



12. ELECTRICAL ENVIRONMENT **PROTECTION MODES / ATEX**

SIL (SAFETY INTEGRITY LEVEL)

The safety functions of measuring instruments are intended to reduce process-related risks, which may constitute a danger to humans, the environment and material goods. SIL (Safety Integrity Level) certification indicates the **operational safety level of safety-related systems according to IEC 61508 / NF EN 61508 standard.** This standard deals with functional safety of electrical, electronic, programmable electronic systems. There are four safety integrity levels: SIL1 to 4 (4 is the higher SIL level which means a greater process hazard).

The on-site risk assessment allows estimation of the desired SIL level.

CORRESPONDENCE BETWEEN PERFORMANCE AND SIL

Safety Integrity Level	**PFD (Probability of Failure on Demand) per year Operation on demand**	**RRF (Risk Reduction Factor)**	**PDF (Probability of Dangerous Failure) / hour continuous operation**
1	10^{-1} to 10^{-2}	10 to 100	10^{-5} to 10^{-6}
2	10^{-2} to 10^{-3}	100 to 1 000	10^{-6} to 10^{-7}
3	10^{-3} to 10^{-4}	1 000 to 10 000	10^{-7} to 10^{-8}
4	10^{-4} to 10^{-5}	10 000 to 100 000	10^{-8} to 10^{-9}

EXPLOSIVE ATMOSPHERE: ATEX (FOR EUROPE) AND IECEX (INTERNATIONAL) CERTIFICATION

Directive 2014/34/EU gives a definition of explosive atmosphere: **a mixture with air, under atmospheric conditions, of flammable substances in the form of gases, vapours, mists or dusts in which, after ignition has occurred, combustion spreads to the entire unburned mixture.**
Equipment or protection systems intended for use in explosive atmospheres must comply with this directive.

ATEX ZONES / EQUIPMENT CATEGORIES

The classification of explosion risk areas on a site is the responsibility of the head of the facility. A distinction is made between areas with gas or vapor and areas with dust.

Area	Hazard	Equipment category	Equipment Protection Level (EPL)
Gas / vapor (G)			
Area 0	Explosive atmosphere existing for 1000 hours/year or longer in normal operation = **permanent, long-term or frequent danger**	1G Protection level: very high	Ga
Area 1	Explosive atmosphere existing for 10 to 1000 hours/year, in normal operation = **occasional danger**	2G (or 1G) Protection level: high	Gb
Area 2	Explosive atmosphere existing less than 10 hours/year, only in the event of a malfunction **= rare or short-term danger**	3G (or 2G or 1G) Protection level: normal	Gc
Dust (D)			
Area 20	Explosive atmosphere existing for 1000 hours/year or longer in normal operation = **permanent, long-term or frequent danger**	1D	Da
Area 21	Explosive atmosphere existing for 10 to 1000 hours/year, in normal operation = **occasional danger**	2D (or 1D)	Db
Area 22	Explosive atmosphere existing less than 10 hours/year, only in the event of a malfunction **= rare or short-term danger**	3D (or 2D or 1D)	Dc

PROTECTION MODES

Mode	Symbol	Gas / Dust area	Equipment categories	Principle
Intrinsic safety	ia ib ic	0 / 20 1 / 21 2 / 22	1G / 1D 2G / 2D 3G / 3D	Limited energy input; prevents the formation of arcs or electric sparks
Explosion-proof (or ADF)	d	1	2G	Robust enclosure which resists to internal explosion and prevents flame spreading outside
Increased safety	e	1	2G	Components inside the enclosure must not produce arcs, sparks or dangerous temperatures

The most widely used protection modes for Deltafluid temperature sensors are ia and d.

GAS GROUPS

Group	Reference gas	Dangerousness
I	Methane (mining)	+
IIA	Propane	++
IIB	Ethylene	+++
IIC	Hydrogen/Acetylene	+++

DUST GROUPS

Group	Type of dust	Dangerousness
IIIA	Combustible fibers	+
IIIB	Non-conductive dust	++
IIIC	Conductive dust	+++

ATEX MARKING

II	equipment group	Equipment group	I – mines II – surface activities
2G	equipement category	Equipement category	1 : zone 0/20 2 : zone 1/21 3 : zone 2/22 G : gas D : dust
Ex	explosion protection	Explosion protection	ATEX marking
d e	protection mode(s)	Protection mode(s)	i : intrinsic safety d : explosion-proof e : increased safety
IIC	gas or dust group	Gas or dust group	IIA / B / C (gas) IIIA / B / C (dust)
Gb	protection level	Protection level	Ga / b / c (gas) Da / b / c (dust)
T4	temperature class	Maximum allowable surface temperature	T1 : 450 °C T2 : 300 °C T3 : 200 °C T4 : 135 °C T5 : 100 °C T6 : 85 °C

Deltafluid

MEASURING UP TO YOUR EXPECTATIONS

Our business activities

ISO 9001
BUREAU VERITAS
Certification

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