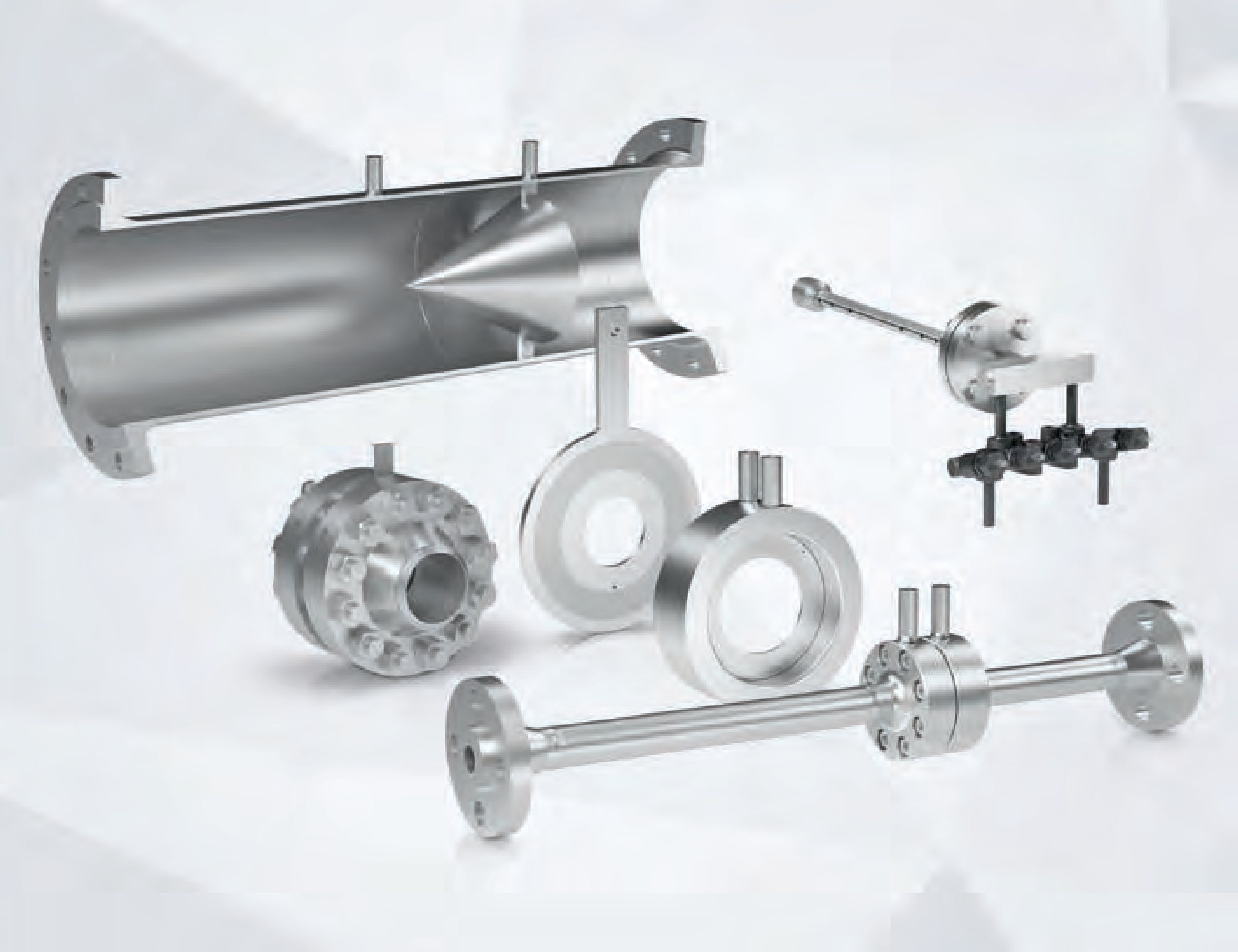

Differential Pressure Flow Measurement

Catalogue

DP Flow Elements

- Standard primary flow elements, built to international standards
- Customised flow elements for special applications
- Extensive testing and calibration services

manufactured by

SEIKO FLOWCONTROL

KROHNE

THE PARTNERS

About KROHNE

KROHNE ranks among the world's leading companies involved in the development and production of innovative and reliable process measuring technology, providing solutions for all industrial sectors around the globe. KROHNE was founded in 1921 in Duisburg, Germany. It has more than 3700 employees and has a turnover of over 484 million euros. The company has 17 production facilities and owns 44 companies and joint ventures. With an equity-to-assets ratio of 49%, the company is largely financially independent.

KROHNE is always a fair and reliable partner to its customers, business partners and employees. We provide our customers with optimal products and solutions which always meet or exceed their expectations in terms of quality, performance capability, service and design. Our customers are registered in diverse branches of industry such as chemicals, petrochemicals, water, wastewater, food, beverages, pharmaceuticals, oil and gas, power plants, pulp and paper etc.

KROHNE is an independent family-owned business, fully owned by the Rademacher-Dubbick family.

KROHNE, Duisburg, Germany

About SEIKO

SEIKO Flowcontrol is a family-owned medium-sized company, which was founded in 1968 in Austria and has since then gained considerable know-how in design and manufacturing of differential pressure (DP) flow elements. This long-time experience and the continuous extension of in-house capabilities make SEIKO a preferred supplier for flow elements in many industries. Since 2001 SEIKO manufactures all standard and project specific flow elements in their in-house production, in Czech Republic.

SEIKO is your highly reliable partner for standard as well as custom-built DP flow elements and offers high quality solutions for individual requirements in power plants, petrochemical plants and many other process industries.

In today's complex power market SEIKO Flowcontrol is a strong partner capable of providing you with competitive Flow Element Solutions to improve the profitability of your business.

SEIKO, Blatnice, Czech Republic

Dear Customer,

KROHNE and SEIKO Flowcontrol are pleased to announce their partnership; together we offer you a complete, standardised DP portfolio.

In recent years, KROHNE and SEIKO have successfully established several large international instrumentation projects together. In doing this, we found that our companies have a very similar business approach and share the same values. Both are global, family-owned enterprises that strive to offer the best measurement solution for every individual application.

Our first collaboration was in a large petrochemical project. Since then we have successfully served customers from various industries, including Energy and Power Generation, Oil & Gas as well as Chemical. While all of these industries have adopted new technologies such as ultrasonic or Coriolis, DP is still the most widely requested flow measuring principle. Already offering a self-developed DP transmitter, KROHNE was looking for a reliable partner with experience in building DP primary flow elements and metering runs.

The combination of SEIKO's deep knowledge and wide product range with KROHNE's extensive instrumentation portfolio allows us to participate in all project and plant sizes. Both companies are well known for tailor-made measurement solutions in terms of design, materials and pressure ratings. Each also operates high-end calibration facilities that guarantee accurate and reliable measurement under operating conditions, providing all appropriate documentation and certification.

We look forward to working with you and contribute our joint expertise to your instrumentation projects.

Yours sincerely,

Johann Kolar | Michael Rademacher-Dubbick | Stephan Neuburger | Attila Bilgic

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Symbol	Quantity	SI unit
C	Coefficient of discharge	–
d	Diameter of orifice (or throat) of DP flow device under operating L m conditions	m
D	Upstream internal pipe diameter (or upstream diameter of a L m classical Venturi tube) under operating conditions	m
k	Coefficient for pitot tube	–
K	Pressure loss coefficient (the ratio of the pressure loss to the dimensionless - dynamic pressure, pV2/2)	–
L	Length	m
p	Absolute static pressure of the fluid	Pa
qm	Mass flow rate	kg/s
qv	Volume flow rate	m^3/s
Re	Reynolds number	–
$Re_{(D)}$	Reynolds number referred to D	–
$Re_{(d)}$	Reynolds number referred to d	–
t	Temperature of the fluid	°C /°F
T	Time	s
v	Mean axial velocity of the fluid in the pipe	m/s
V	Volume	m^3
ß	Diameter ratio	–
Δp	Differential pressure	Pa
ε	Expansibility [expansion] factor	–
κ	Isentropic exponent	–
η	(absolute) dynamic viscosity of the fluid	Pa·s
ρ	Density of the fluid	kg/m^3
τ	Pressure ratio: $r = p_2/p_1$	–
Ø	Total angle of the divergent section	rad
M	mass	kg
l	length	m / mm
A	area	m^2
q_{max}	maximum flow	–
q_{min}	minimum flow	–

History of DP

For over 100 years, customers have used differential pressure (DP) flow measurement methods to determine the volume or mass of liquids, gases and vapours – either to control their process or sell their products. Because of considerable experience and globally accepted norms flow measurement using a DP flow element is still the most preferred technology in chemical engineering, in the area of energy supply, and in other comparable industries around the world.

Most flowmeters are volumetric and infer mass flow through calculations derived by taking other physical process measurements such as absolute pressure, differential pressure, temperature and viscosity readings. Because of the method of obtaining a mass flow output, the DP flow measurement method is described as an inferential mass flow measurement.

This includes the measurement of liquids, gases or vapours even at extreme temperatures, high pressures, high flow rates and also for corrosive media, where other direct volumetric meters are hardly applicable or not useable at all.

The DP method is very versatile, and can measure at extreme pressures – up to 420 bar/6091 psi – and at temperatures from -270°C...+1400°C (-418°F...+2552°F).

With many different forms of construction and materials available, DP flow elements can be adapted and designed to meet almost unlimited possibilities.

The design of flow elements is done according to all major design standards including latest editions of EN ISO 5167, ASME MFC-3M and PTC 19.5, API and AGA standards etc. and can be supplied with a certificate of conformity according to EU Pressure Equipment Directive 2014/68/EU.

Determination of flow

The principle of flow measurement according to the DP method of mass flow and volumetric flow measurement with a throttle device from the Bernoulli equation for the conservation of energy, first introduced by Euler in 1797:

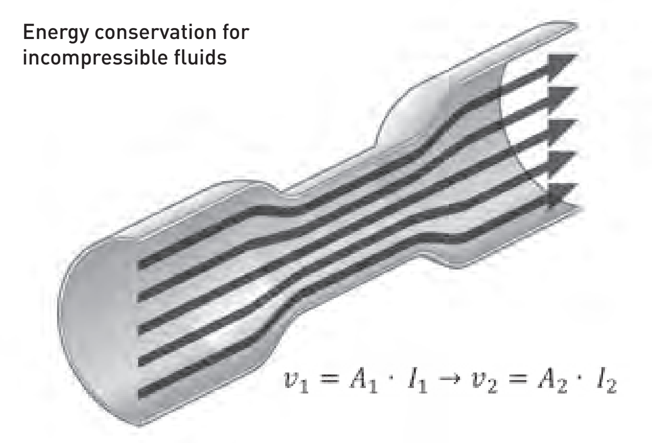
$$\frac{p}{\rho} + \frac{V_s^2}{2} + gz = constant$$

This describes the energy of a fluid in a pipe at a given point, considering that the state of the fluid remains steady. For most systems this one dimensional approach is more than sufficient and accepted.

According to the physical law of energy conservation, a restriction in the pipe introduced by a DP flow element forces an energy transformation of the fluid from potential energy (line pressure) to kinetic energy (flow velocity) in order to allow the same volume flow to pass the restriction.

In DP flow elements the cross section of the pipe is narrowed in one place to increase the flow velocity of the medium, while the total volume flow in the line remains unchanged. A differential pressure transmitter is used to measure the consequent loss of pressure energy. The pressure drop over the DP flow element is a proportional measurement of the increased flow velocity (kinetic energy) in the flow element.

Since the cross section of the flow element in the pipe is known, the DP flow measurement principle determines directly the volume flow, and with a known fluid density also the mass flow, of liquids, gases and steam in round or square shaped pipes.



Requirement for flow determination
$v_1 = v_2$ $A_1 x l_1 = A_{21} x l_2$ $A_1 x l V_1 = A_{21} x V_2$ $m_1 = \rho x v_1$

Kinetic energy (flow velocity)
$E_{kin} = {}^1/_2\, m_1 \cdot V_1^2 = {}^1/_2\, \rho \cdot v_1 \cdot V_1^2$

Potential energy (line pressure)
$E\ POT = v_1 \cdot \rho_1$

If no energy is emitted or absorbed, the sum of the energy is equal before and in the area of the constriction.

Bernoulli formula
${}^1/_2\, \rho \cdot V_1 . \rho_1 = {}^1/_2\, \rho \cdot V_2 . V_2^2 + V_1 . \rho_2$ $(because \rightarrow v_1 = v_2)$
${}^1/_2\, \rho \cdot V_1^2 + \rho_1 = {}^1/_2\, \rho \cdot V_2^2 + \rho_2 = constant$ (Bernoulli)

Due to the fact that the flow profile can change with the flow velocity, different positions of the pressure taps, internal friction of the pipe, the reduction of the pipe cross section and the compressibility of the medium, the formulae above require the adaptation with empirically proven correction coefficients.

According to EN ISO 5167 the formulae for mass flow and volume flow are:

Mass flow q_m
= mass of fluid passing through the constriction (orifice or throat) per unit of time
$q_m = \frac{C}{\sqrt{1-\beta^4}} \cdot \varepsilon \cdot \frac{\pi}{4} \cdot d^2 \cdot \sqrt{2 \cdot \Delta p \cdot \rho}$

Volume flow q_v
= volume of fluid passing through the constriction (orifice or throat) per unit of time. It is necessary to state pressure and temperature at which the volume is referenced.
$q_v = \frac{C}{\sqrt{1-\beta^4}} \cdot \varepsilon \cdot \frac{\pi}{4} \cdot d^2 \cdot \sqrt{\frac{2 \cdot \Delta p}{\rho}}$

Based on the formulae above all DP flow elements can be calculated:

- Orifice plates
- Nozzles and Venturi nozzles
- Venturi tubes

Cone meters differ slightly from the general formula and are adapted according to EN ISO 5167.

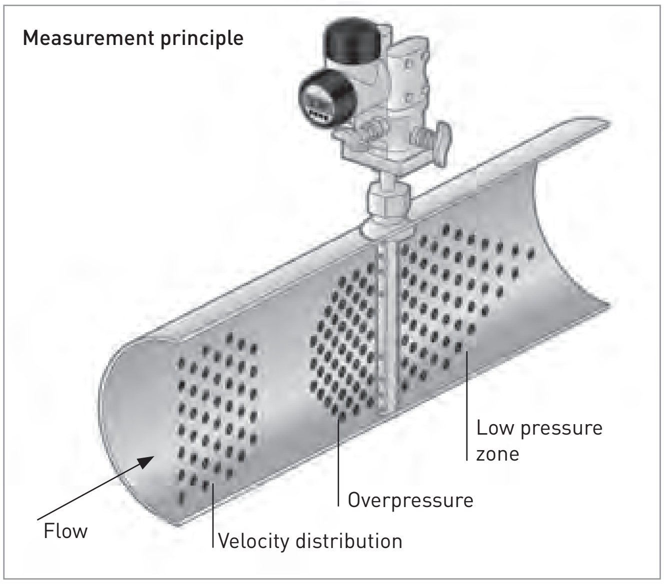
For this calculation, D^2 is used instead of d^2, and the following formula defining *β* must be taken into consideration:

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

The benefit of the Bernoulli equation is that it is simple, well defined, and accepted worldwide as a practical method for measuring flow. Differential pressure flow elements are generally specified in EN ISO 5167 parts 1-5.

Averaging pitot tube

The averaging pitot tube offers a different style of flow sensor using a differential pressure method of measurement. This technique is not standardised, but is based on many years of practical experience.



The following flow equations are used for flow measurement using a pitot tube:

Mass flow
$q_m = k \cdot \varepsilon \cdot \frac{\pi}{4} D^2 \cdot \sqrt{2 \cdot \Delta p \cdot \rho}$

Volume flow
$q_v = \frac{C}{\sqrt{1-\beta^4}} \cdot \varepsilon \cdot \frac{\pi}{4} \cdot d^2 \cdot \sqrt{\frac{2 \cdot \Delta p}{\rho}}$

Note: k is not standardised and is therefore defined by the manufacturer: ε relates to the fluid compressibility – for incompressible fluids ε =1 and for compressible fluids 0.97 < ε< 1.

Sizing of DP flow elements

DP flow elements are perfectly suited for a wide range of operating conditions because of the various mechanical designs and materials available.

In sizing a flow element several aspects have to be considered. The amount of line pressure loss at a given flow rate could be one important factor in applications where pressure is scarce or valuable.

The "pressure head loss" tabulation below shows the relationship between permanent pressure loss and the Beta-ratio of the flow element.

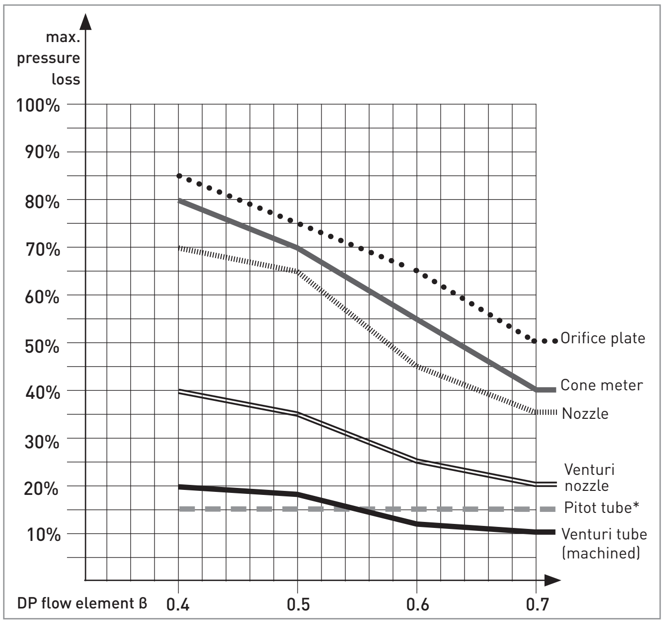
Another aspect could be the length of the required inlet and outlet straight sections of the pipework. Naturally, the overall cost of the flow metering system needs to be balanced against all other factors.

KROHNE offers an entire range of DP flow element designs assuring the best selection for the individual application requirements.

Permanent pressure head loss

The pressure drop caused by the flow constriction of the flow element recovers partially in the downstream flow. The amount of permanent pressure loss depends on the specific design of the DP flow element and the Beta-ratio factor used during the sizing. The chart below shows, for several DP flow elements, the permanent pressure loss expected, plotted against the Beta-ratio (ß, which is the ratio d/D).

The vertical axis shows the downstream pressure loss, as a percentage of the measured differential pressure, for various different styles of DP flow elements, calculated for water. A tabulation showing the identified points on the graph is also shown.



Example fluid (water)
acc. to ISO 5167
*depending on the ratio of averaging pitot tube diameter and pipeline diameter

Reynolds number

Osborne Reynolds, a British physicist and engineer, published the results of his study about the transitions of flow streams in 1883. In studying fluid mechanics he discovered that two kinds of flow exist: the more orderly "laminar flow" and the more chaotic type, termed "turbulent flow".

The Reynolds number (*Re*) is a non-dimensionless parameter relating to a certain fluid flowing in a certain pipe at a certain speed: it expresses the ratio of inertial resistance to viscous resistance for the flowing fluid. For flow measurement, it can identify a generally valid measuring range for a fluid flow. This ability simplifies the evaluation, sizing and use of DP flow elements. For the flow through a pipe the Reynolds number is given by:

$$Re = \frac{\rho D \bar{V}}{\mu}$$

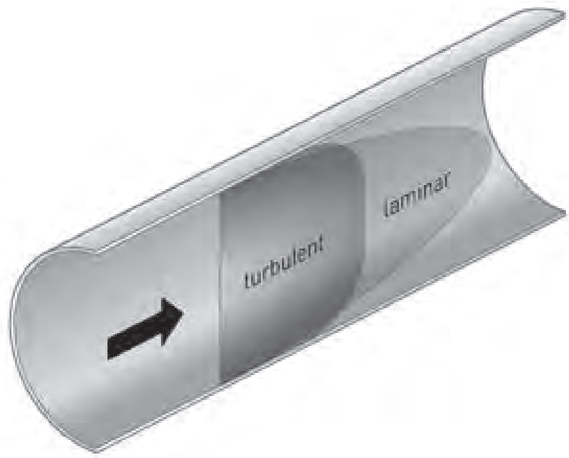
The Reynolds number provides insight on the flow profile and determines whether a fluid flow is laminar or turbulent. Very low Reynolds numbers are described as laminar. At relatively low Reynolds values the viscosity of the fluid is relatively of more importance since flow disturbances are rather diminished. In turn, at relatively large values of the Reynolds number, viscosity has less effect, and therefore the density of the fluid gains more significance.

It is important to consider the Reynolds number when specifying or sizing DP flow elements. All empirical tests are based on the assumption that the flow elements are geometrically similar. This is ensured by considering all flow element dimensions in direct or indirect relation to the effective pipe diameter D, and this is ensured by reference to the Reynolds number.

Fluid properties have also influence on the proportionality factors C and ε, used in the formulae expressed in EN ISO 5167. The law of similarity offers here the solution to combine dynamic viscosity (μ), density (ρ), flow velocity (v) into one dimensionless value *Re*. The flow dynamics in a given flow element can be shown to depend only on *Re* and D: this allows the comparison of the measurement results of different dimensions as long as the *Re* are similar.

Reynolds numbers are divided in three ranges:
- Re < 2000 = laminar flow
- Re 2000 ≤ 4000 = transitional flow
- Re > 4000 = turbulent flow

Turbulent and laminar flow in a pipe



The flow profile of flowmeters and pipe conditions are influenced by many variables and make the evaluation of these variables more complex. The Reynolds number is used to evaluate the combination of three factors:

- Fluid medium properties (density ρ and viscosity μ)
- Flow rate
- Geometric aspects

If an application exceeds the recommended Reynolds number, it is still possible to calibrate the DP flow element in the specific target Reynolds number range (see page 14). For more details and questions please contact our technical support.

Measurement uncertainty

In order to receive a complete measuring result, the measured flow value is combined with another figure, the measurement uncertainty u: this contains information on the accuracy of the measurement result. The measurement uncertainty is a characteristic numerical value which is obtained from measurements and is used together with the reported flow rate to define a range of flow which will cover the true value of the flow.

The measurement uncertainty of a DP flow measurement depends on many factors. DP low elements have – according to ISO 5167 – the following uncertainty factors of the calculated discharge coefficient.

Measurement uncertainty of different DP flow elements

The following table shows the typical uncertainties of the calculated discharge coefficient for the various DP primary flow elements.

	Beta-ratio	Uncertainty of discharge coefficient
Orifice plate	0.1-0.2	$(0.7-\beta)$%
	0.2-06	0.5%
	0.6-0.75	(1.667/3-0.5)%
Nozzles		
Venturi nozzle	0.316 - 0.775	$(1.2 + 1.5\beta^4)$%
ISA 1932 nozzle	≤ 0.6	0.8%
	> 0.6	$(2.\beta-0.4)$%
Long radius nozzle	all	2.0%
Venturi tubes		
Venturi cast	all	0.7%
Venturi machined	all	1%
Venturi rough-welded sheet-iron	all	1.5%
Cone meter	< 0.75	5%
	> 0.75	> 5%
Wedge meter	0.377-0.791	> 6%
Pitot tube*	n.a.	< 1%

*not standardised

Additional to the measurement uncertainty of the DP flow element and the density based on the process conditions, the uncertainty introduced by the DP transmitter chosen has to be considered.

The uncertainty of the discharge coefficient can be decreased under some circumstances by a wet calibration, such as offered by independent calibration laboratory. Venturi Calibration Services, a commercial calibration service provider. The following uncertainties for the flow coefficient are achievable:

- For DN80...1400 / 3"...56"
  - Gravimetric method (mass flow against time, to a weigh tank): uncertainty of flow coefficient ~0.15% to ~0.25%
  - Volumetric method (against a calibrated electromagnetic flowmeter): uncertainty of flow coefficient ~0.25% to ~0.35%
- For DN15...100 / 1/2"...4"
  - Volumetric method (against a calibrated electromagnetic flowmeter): uncertainty of flow coefficient ~0.3% to ~0.4%

The calculation and the assessment of the measurement uncertainty are part of the KROHNE service.

Turndown ratio

The turndown ratio – also known as rangeability – indicates the range of flow which is measured by a flowmeter with an acceptable accuracy. It refers to the width of the operational range of DP flow elements and is the ratio of minimum to maximum measurement capacity.

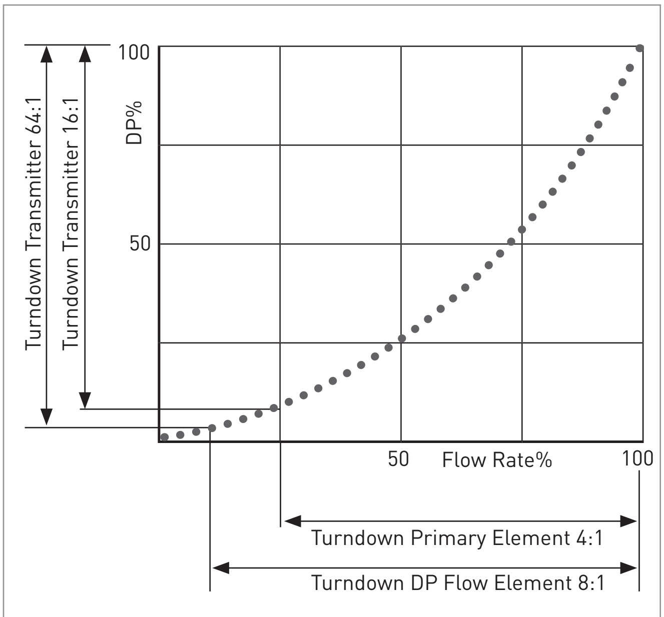
Turndown ratio compares the high end of a measurement range to the low end and is calculated using the simple formula:

$$turndown\ ratio\ (TD) = q_{max}\ /\ q_{min}$$

Unlike other measurement principles the process of DP flow measurement is not linear but quadratic. The flow rate is proportional to the square root of the measured differential pressure. For example, when a flow rate of 50% exists, only 25% differential pressure can be expected instead of 50%.

In most applications, only one differential pressure transmitter is used to cover 100% of the DP range between q_{min} and q_{max}.

The diagram below shows the relationship and the turndown ratio between flow rate and measured signal.



A typical conservative interpretation for DP flow elements is between 3:1 and 10:1. The realistic turndown of a DP flow element is related to DP, Reynolds number as well as the quality and number of used DP transmitter. It is important that the relation does not become too big. If the dynamics is too big, either the measurement uncertainty outside of the operating area is acceptable or split range is used.

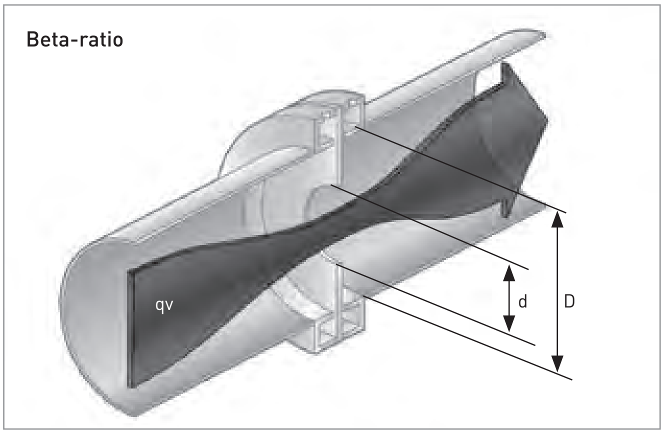
Split range describes a method when a second DP transmitter with a lower nominal measurement range is used to obtain a higher accuracy at low flow. A so called split-range configuration uses one DP transmitter to cover 100%...25% flow whereas a second DP transmitter covers the remaining 5%...0%.

Square root-extracted output

In order to assure a linear flow to signal output, it is necessary to pull the square-root from the DP transmitter signal. KROHNE DP transmitter can be configured to provide square root signal output to provide a linear signal to the flow rate.

Beta

DP flow elements are defined by the Beta-ratio, *ß*, which is the ratio between the inner diameter of the pipe (D) and the throttle opening (d). A small Beta value (e.g.: 0.2) implies a significant restriction, which consequently causes a high pressure loss.



Formula to determine a Beta-ratio:

$$\beta = \frac{d}{D}$$

Limits of application for DP flow elements

Each DP flow element or throttle device is only applicable according to standard in a certain range and is restricted by the diameter of the DP flow element *(d)*, the upstream internal pipe diameter *(D)*, the minimum and maximum Beta-ratio *(ß)* and the Reynolds numbers:

	Orifices			Nozzles			Venturi			Pitot tube
	Single**** pressure taps	Flange pressure taps	D- & D/2-pressure taps	ISA 1932 nozzle	Long radius nozzle	Venturi nozzle	Venturi tube*	Venturi tube**	Venturi tube***	
d_{min} [mm]	12.5	12.5	12.5	15	10	50	20	20	80	10
D_{min} [mm]	50	50	50	50	50	65	200	5	200	50
D_{max} [mm]	1000	1000	1000	500	600	500	1200	250	1200	12000
$ß_{min}$	0.1	0.1	0.1	0.3	0.2	0.316	0.4	0.4	0.4	-
$ß_{max}$	0.75	0.75	0.75	0.8	0.8	0.775	0.7	0.75	0.7	-
$Re_{D.min}$	≥ 5000 for 0.1≤ ß ≤ 0.56 ≥ 16000xß^2 for ß > 0.56	≥ 5000 and Re ≤ 170xß^{2}xD (D in mm)	≥ 5000 for 0.1≤ ß ≤ 0.56 ≥ 16000xß^2 for ß > 0.56	≥ 7x10^4 for 0.3 ≤ ß ≤ 0.44 ≥ 2x10^4 for 0.44 ≤ ß ≤ 0.8	1x10^4	1.5x10^5	2x10^5	2x10^5	2x10^5	Inde-pendent
$Re_{D.max}$	∞	∞	∞	1x10^7	1x10^7	2x10^6	2x10^6	1x10^6	2x10^6	Inde-pendent

* classical Venturi tube: rough welded sheet-iron

** classical Venturi tube: machined / SEIKO standard

*** classical Venturi tube: cast

**** also applicable for ring chamber taps

Other options and limits are possible but are very likely to be in need of calibration as they exceed the standard. Nearly half of the installed flow elements are successfully operating outside the limits of the ISO 5167 standard.

The constriction ratio of averaging pitot tubes depends on the diameter of the pitot tube and the inside diameter of the pipeline. Typically, the different diameters of the pitot tube are selected according to the following structure:

Pitot tube profile	Nominal size	Mounting flange*	Length sealing surface to pipe outside diameter**
10	DN50-100	DN15	80 mm
22	DN125-900	DN32	100 mm
32	DN1000-2000	DN40	100 mm
50	>DN2000 or engineered	DN80	120 mm

* mounting flange diameter can differ for higher pressure ratings

** without additional extension for bigger insulation thickness

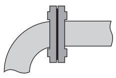
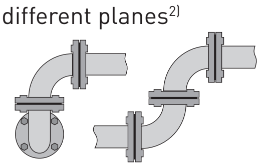
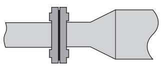
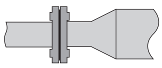
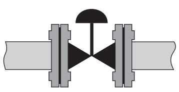
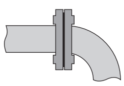
Inlet and outlet section

The DP flow element is placed between two straight sections of cylindrical pipe, of constant diameter and of specified minimum length. The pipe is considered to be straight when the deviation from a straight line does not exceed 0.4% over its length. The flow element shall be installed in a pipeline at a position such that the flow conditions immediately upstream of the DP flow element approximate those of swirl-free, fully developed pipe flow.

The minimum straight lengths of the inlet and outlet section vary with the type and design of the DP flow element and the type of disturbance. To provide a desired accuracy the clause 6 of the standard EN ISO 5167-2, EN ISO 5167-3 and EN ISO 5167-4 describes a certain inlet and outlet section length. Additionally, application-related values can be found in the specific flow calculations which will be made for each measurement element.

A shortening of the inlet or outlet section is possible, however, the uncertainty of the flow coefficient increases by 0.5%.

Critical distances to different installation disturbances and further detailed information are to be found in EN ISO 5167 "Measurement of fluid flow by means of pressure differential devices – Part 1: Orifice plates, nozzles and Venturi tubes inserted in circular cross-section conduits running full".

	Orifices				Nozzles				Classic Venturi tube			Cone meter		Pitot tube
ß	0.2	0.4	0.6	0.75	0.2	0.4	0.6	0.8	0.3	0.5	0.75	0.45 ≤ ß < 0.6	0.6 ≤ ß ≤ 0.75	
one 90°- bend[1)] 	6	16	42	44	10	14	18	46	8	9	16	3	6	7
≥ 2...90°- bend in different planes[2)] 	34	50	65	75	34	36	48	80	8	10	22	3	6	10
Diffuser of 0.5 D...D over a length of 1 D...2 D 	6	12	26	36	16	16	22	54						
Constriction / Diffuser of 0.75 D to D over a length of 1 D 									2.5	2.5	6.5			7
Regulator / valve fully open[3)] 	12	12	14	24	12	12	14	30	2.5	3.5	5.5			20
Outlet side[4)] 	4	6	7	8	4	6	7	8	4	4	4	2	2	3-5

All values in multiples of nominal line size (x DN)

[1)] 90°- bend: applies for orifice plates and Venturi tubes only, not for T-pieces.

[2)] Orifice plates: applies to two 90° bends on perpendicular planes, which are placed less than 5.D to each other.

[3)] Applies only for a ball valve with free pipe cross section or completely open valve/slider; not for other control valves.

[4)] Since the length in the outlet section is measured from the minus taps, Venturi tubes may already be covered by the diffuser either wholly or in part.

All values in the table above are according to the international standards – except pitot tubes which are according to manufacturer information and experience.

As long as certain distances (in multiples of D) between the DP device and upstream disturbances are kept, the uncertainties stated in the standard are valid. Distances are defined for each DP flow element in the standard ISO 5167. No extra uncertainties need to be added.

DP flow elements

DP flowmeters consist of a primary and a secondary element. The DP flow element produces a drop in pressure where the flow velocity increases.

The most common DP flow elements are:
- Orifice plates
- Averaging pitot tubes
- Flow nozzles
- Venturi tubes

Orifice plates are cost-effective, widely used and easy to install and assemble. However, the other DP flow elements are also used across almost all industries and applications.

In addition to the standard designs like orifice plates, orifice flange assemblies, meter runs and pitot tubes, KROHNE offers cone meters, Venturi tubes and wedge meters for customer specific product solutions in more difficult media and circumstances. Depending on the application and accuracy requirements each DP flow element has its advantages and can be the most suitable in a specific situation, compared to the other options.

The various designs and diameters (Beta-ratio) of the DP flow element cross section allows an optimal adjustment of pressure loss and generated differential pressure, after consideration of all process conditions.

The secondary element is the differential pressure transmitter. It is designed to measure the differential pressure as accurately as possible. In particular, it is important that the differential pressure measurement is not affected by changes in the fluid pressure, temperature or other properties such as ambient temperature.

Industries:
- Oil and gas
- Chemical
- Petrochemical
- Heating, ventilation and air conditioning (HVAC)
- Power
- Metal and mining

Your advantages at a glance:
- Worldwide standardised flow measurement principle according to ISO 5167
- All measurement uncertainties under operational conditions are known and can be calculated
- Volume or mass flow measurement of liquids, gases or vapour
- Primary elements manufactured by SEIKO Flowcontrol
- Medium temperatures: -250...+1400°C / -418...2552°F
- Process pressure up to 420 bar / 5800 psi
- Line sizes from DN15...12000 / 1/2...470"
- Pressure and temperature compensation available as options
- Wet calibration up to DN3000 / 120", larger sizes on request
- Optimisation according to a given specification, e.g. short inlet / outlet, low pressure loss, small overall uncertainty, etc.
- Large choice of materials for corrosive and non-corrosive media

Today, DP flowmeters are being constantly improved and adapted to meet the requirements of modern processes, and KROHNE is helping to lead the way.

For a general overview see page 38-39 (selection list) and for more information please contact our KROHNE experts – they are looking forward to helping you choose.

Orifice plates

Orifice plates are, because of their proven technology and globally accepted design standards, the most used DP flow elements, providing easy installation and simple maintenance. They also offer the most economical DP flow measurement devices.

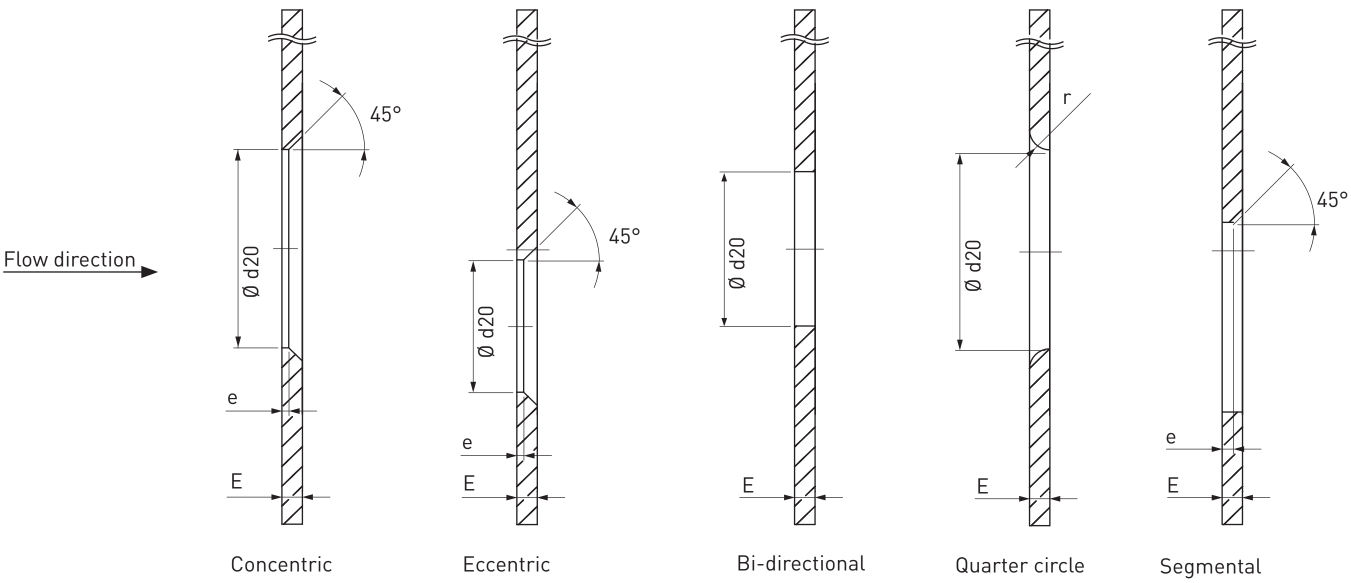
Orifice plates work by restricting the flow of the liquid, gas or steam. According to the Bernoulli equation, the flow velocity increases at the restriction and the line pressure drops. The difference in pressure at the measuring point compared to the upstream line pressure gives the measurement that leads to the flow velocity of the medium.

Highlights:
- Suitable for clean or dirty fluids, gases or vapours (depending on design)
- High operating temperatures (depending on orifice material)
- High operating pressures
- The standard material is stainless steel. Other materials on request
- Typical permanent pressure loss between 50...85% of the generated differential pressure
- Uncertainty of the discharge coefficient between 0.5% and 0.75% depending on Beta

The volume flow is calculated based on flow velocity and the cross-section area of the pipe: $qv = v \cdot A$. The diameter ratio $ß = d/D$ is chosen for each measuring point, allowing each one to be optimised for specific requirements, including shorter inlet and outlet sections, lower pressure loss and smallest overall uncertainty.

Various designs of orifice plate exist for different application requirements. The majority of applications are satisfied using a concentric square-edged design.

Orifice plates with a conical or quarter-circle bore are suitable for low velocity and high-viscosity fluids and are also effective for low-density gases. Neither design is suitable for dirty fluids, as these could cause worn edges and require shorter maintenance intervals between.



Segmented and eccentric orifice plates are mainly used for two-phase flow of liquids with dirt or solid contents. The bore is either placed at the top or at the bottom of the pipe, depending on the application.

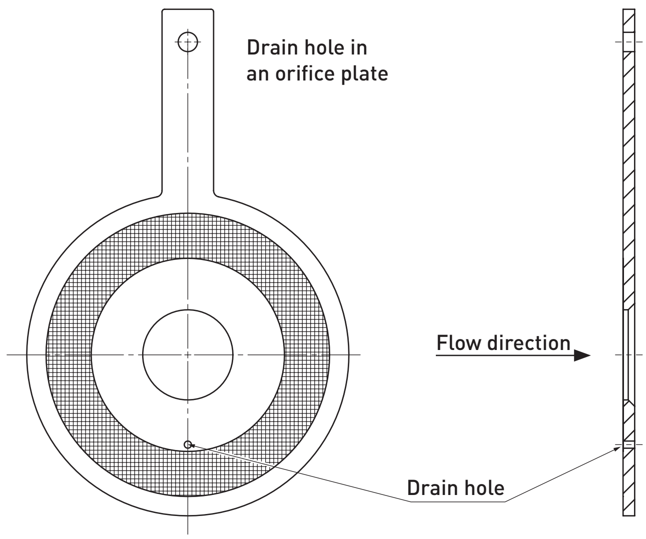
Segment orifice plate

Eccentric orifice plate

In some instances, a vent or drain hole might be placed in the orifice plate to allow drainage of condensate in gas flows, or venting of entrained gas in fluids.

Orifice plates can be designed with RF (raised face) or RTJ (ring-type joint) sealing faces. Raised face (RF) is the most common sealing option and is highly reliable when used under normal pressure and temperature conditions.

RTJ is used for pressure classes above 600 lb. With an RTJ design an orifice plate can be fitted between flanges with a ring-type joint. The cross section profile of the plate is designed to fit inside the groove of the RTJ flanges and is used as flange sealing.



RF (raised face) orifice plate

RTJ (ring-type joint) orifice plate

Mounting and assembly of DP flow elements

In general two different construction types of DP flow elements are distinguished.

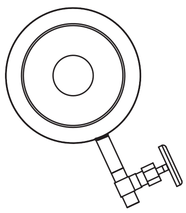
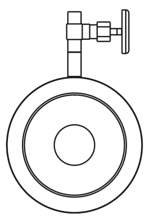
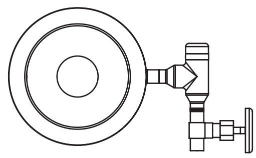
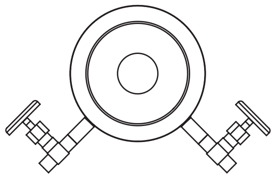
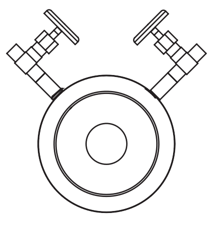
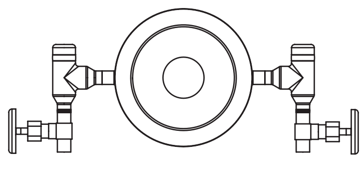
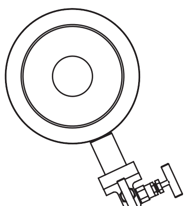
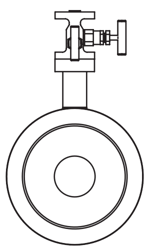
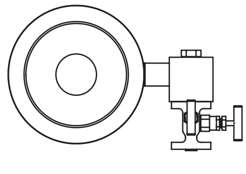
Separate type
Here the differential pressure transmitter is mounted a distance away from the DP flow element: this is also referred to as “field mounting”. The connection between flow element and transmitter is done by impulse pipes, also known as impulse lines. Typically the DP flow element is equipped with shut-off valves and the transmitter is mounted on a 3- or 5-valve manifold.

The advantage of a separate version is that high process temperatures can be decoupled through the impulse pipes so that the transmitter is not damaged. Also the transmitter can be installed in an accessible position, or one where the display is clearly readable.

Compact type (or integral type)
Here the differential pressure transmitter is directly mounted onto the DP flow element. Typically the flow element is equipped with a flange plate or with oval flange adaptors to allow a primary shut-off. Most common fittings use 3- or 5-valve manifolds.

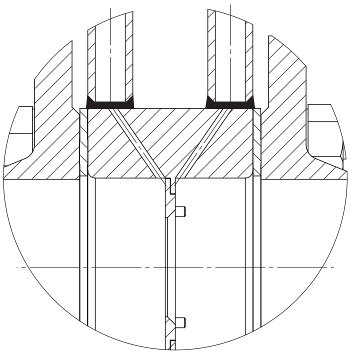
The advantage of a compact versions is that no additional work for installing impulse pipes is required and that possible mistakes thereby are avoided. Further this type of construction is better for measuring points with a low range of differential pressure, which can be affected badly through the use of long impulse pipes.

Arrangement of pressure taps according to application

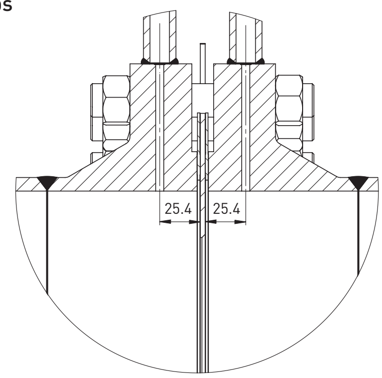
	Liquid	Gas	Steam
Separate 0°			
Separate 90° / 180°			
Compact			

Orifice plates according to ISO 5167 / ASME FMC-3M can be designed with different kinds of pressure taps, depending on the type of assembly.

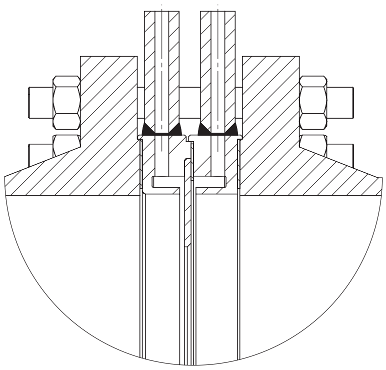
Corner taps



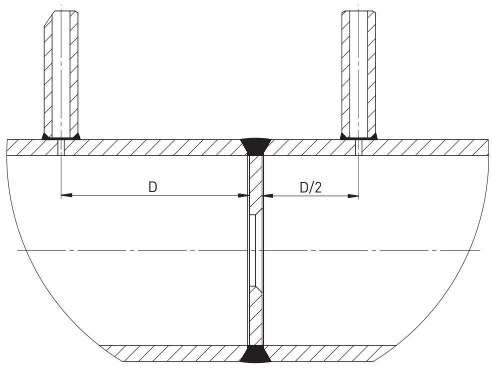
Flange taps



Corner taps with annular chamber



D-D/2 taps



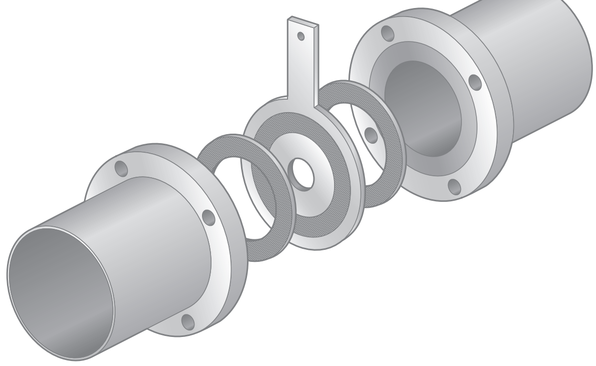
Corner taps are pressure taps with single drillings and are located right in front of and behind the orifice plate. Another style uses corner taps with an annular chamber. This type of construction has annular chambers positioned directly in front of and behind the orifice plate. The idea is that the generated differential pressure will be averaged over the entire diameter around the orifice for a more smooth and stable measurement.

Flange taps with single drillings are located in the weld-neck flanges of the orifice assembly. According to ISO 5167 the taps have to be placed one inch (25.4 mm) in front of and behind the orifice plate.

D-D/2 taps have to be placed one diameter width in front and a half diameter width behind the orifice plate. Often this kind of installation is affected by several mistakes, for example, through the wrong placement of the taps or by non-removal of the burr which is located on the inside of the pipe, caused during drilling the taps. In general this is not used very often.

Orifice plates are in most cases assembled and installed between flanges. Either the pipe flanges already exist or can be ordered as part of an orifice assembly. Flanges have to fit to the orifice and to the pipe where the orifice plate is to be installed.

A typical orifice assembly

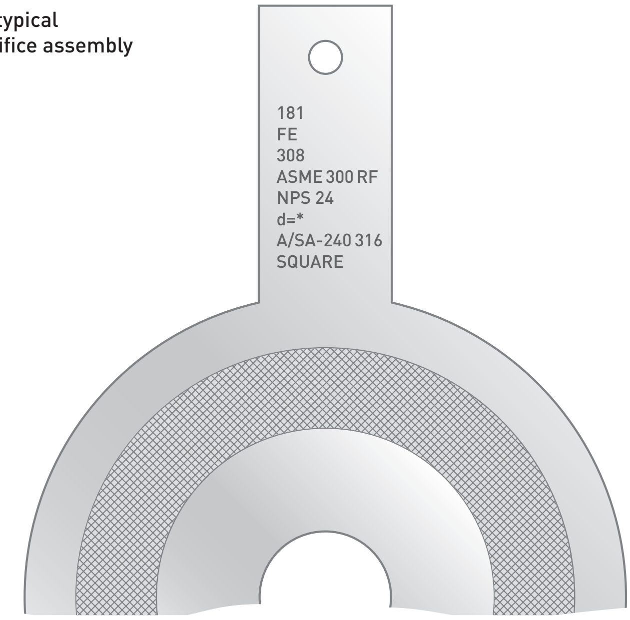


Name plate

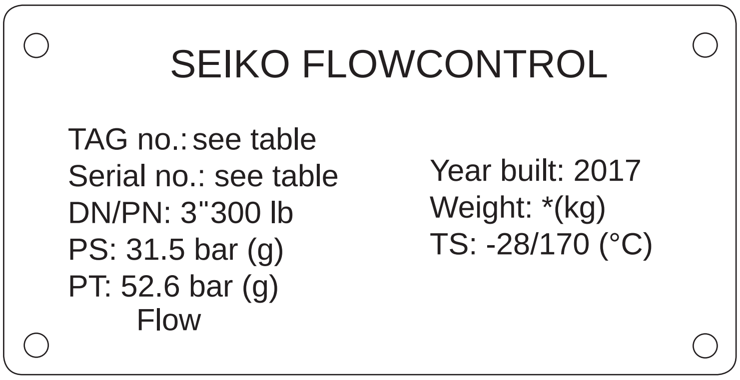
Orifice plates have a standardised marking on the handle.

It includes:
- Customer identification number (TAG, KKS, etc.)
- Used materials
- Serial number
- Flow direction
- Throttle opening diameter
- Outside diameter

A typical
orifice assembly



All other products have the same information on a stainless steel tag plate, which are specified according to the Pressure Equipment Directive, and approved by TÜV:



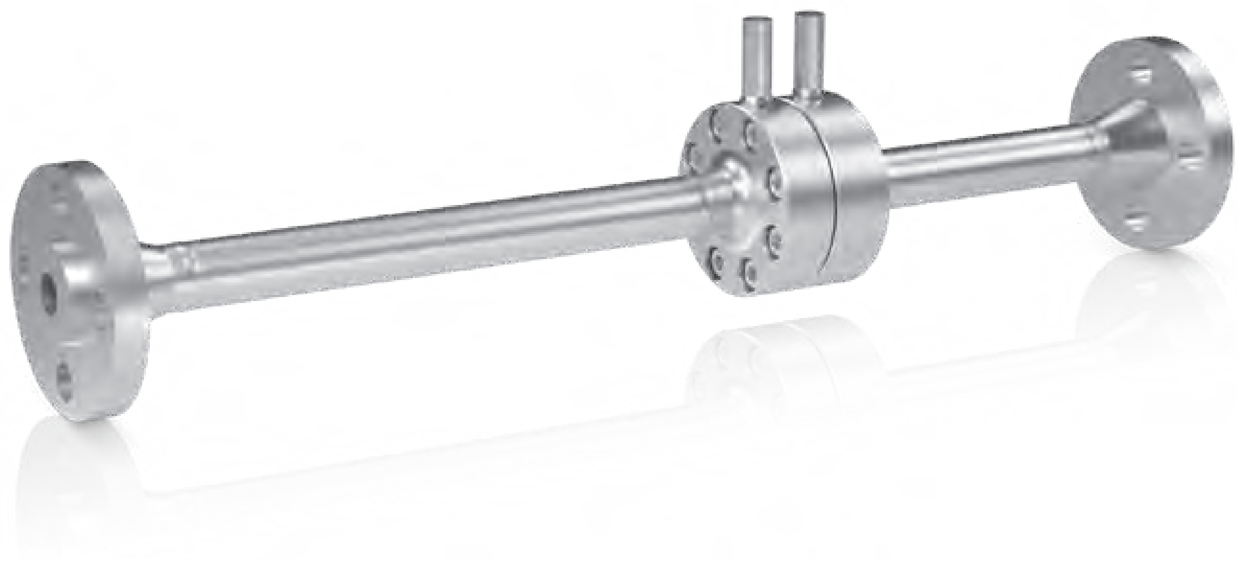
Manufacturer:	SEIKO Flowcontrol Ges.m.b.H.
Tag no.:	system number
Serial no.:	fabrication number
DN:	nominal size
PS:	(bar)
PT:	(bar)
Year built:	2017
Weight:	weight in kg
TS:	(°C)

Orifice meter run assembly

In small diameter lines, the errors that might be caused by the surface roughness of the plant pipework, or any misalignment of flange welds around the orifice, can be very significant. To ensure the accuracy of the measurement section, a complete meter run assembly is typically used. Often these meter runs are equipped with annular chambers to ensure a reliable and exact flow measurement, even for small diameter lines (< DN50/2").

All meter runs are available with a wet calibration and can be equipped with different types of orifice plates or nozzles. The meter runs are manufactured according to ISO 5167, diameters < DN50 are standardised according to ISO TR15377.

OPTIBAR MR 4300



An orifice meter run assembly with corner taps and integrated annular chambers, built to worldwide standards according to DIN EN ISO 5167-2004/ASME MFC-3M. The whole assembly is available with flow rig calibration for increased accuracy.

Pitot tube

The averaging pitot tube offers a simple, cost-efficient flow measurement solution which can be trusted to deliver accurate results with an excellent long-term stability in specific applications.

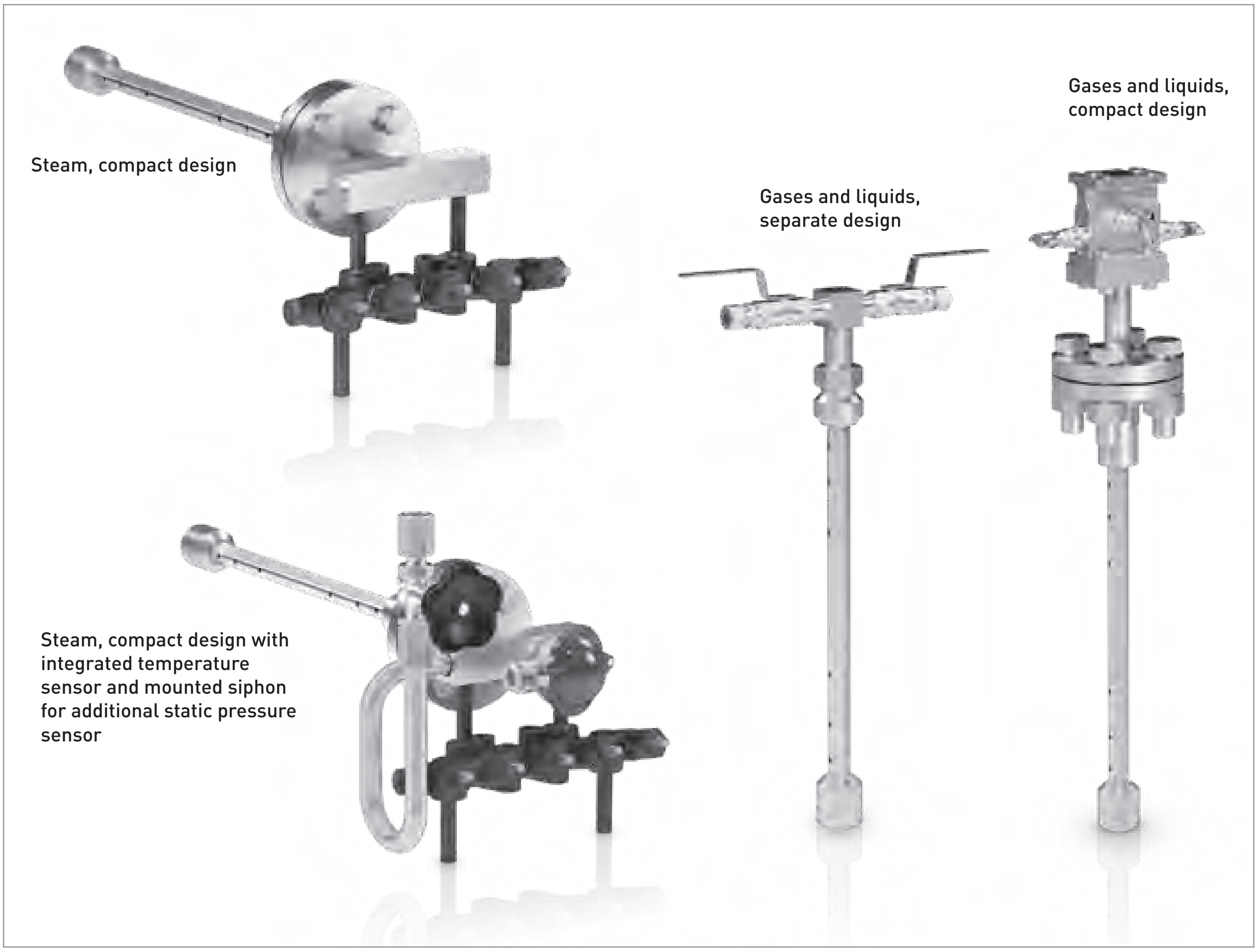
An averaging pitot tube consisting of two chambers is placed across the pipe perpendicular to the direction of the flow. The upstream chamber faces the flow and a downstream chamber is placed at the back of the probe. The impact of the medium against the upstream chamber causes an overpressure that adds to the static pressure in the pipe. A lower pressure is present in the downstream chamber, and the pressure differential depends on the flow rate and the shape of the pitot tube. A differential pressure transmitter measures the pressure difference between the two chambers and converts this into an output signal.

Highlights:

- Suitable for clean fluids: liquids, gases, vapours and steam.
- Temperature range: up to +450°C / +842°F
- Pressurerating up to 100 bar / 1450 psi
- Applications that demand a low net pressure loss
- Standard material 1.4571 / 316Ti
- Ideal for retrofitting flow measurement into existing pipelines
- Line sizes DN50…12000
- Uncertainty of 1%
- Low requirements for inlet and outlet sections
- Bi-directional flow by design

Averaging pitot tubes are not standardised.

Averaging pitot tube in different configurations



Venturi

Classical Venturi tubes offer very accurate flow measurement and produce a very low permant pressure loss. Venturis are very robust, have therefore a very long service life and require very little maintenance.

Venturis incorporate a tapered inlet and outlet section with a parallel throat section in between. There are several integral pressure taps which link to the two annular chambers around the flow tube: the flow measurement is derived from this differential pressure.

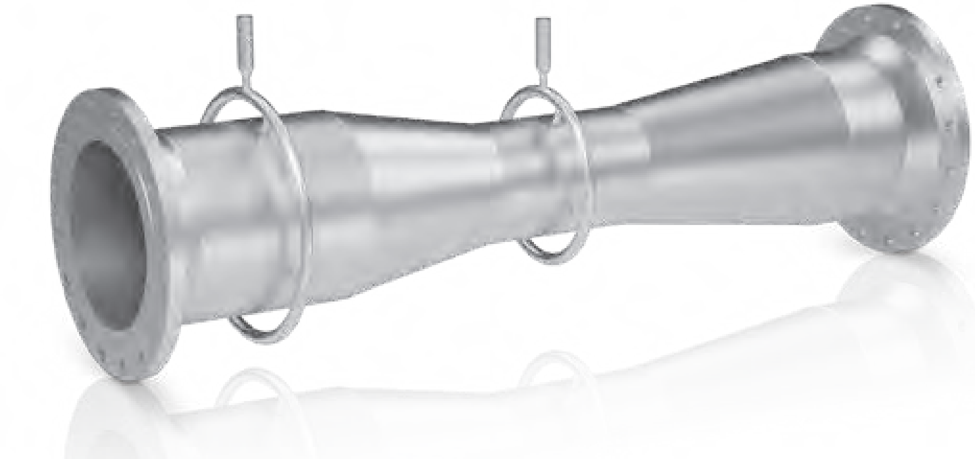
Venturis have a low requirement of straight inlet and outlet sections. The ends are flanged or weld-prepared.

Highlights:
- Suitable for clean, dirty or abrasive fluids
- Temperature: -270...+1400°C / -454...+2552°F
- Any pressure rating available
- All kinds of material grades are possible
- Exceptional long-term accuracy
- Flanged type, or ends prepared for welding
- Line sizes: >1" or DN25...2000 are possible
- Uncertainty of C according to the standards is 0.7%, 1.0% or 1.5% - depending on the Reynolds number

Outside the standard Reynolds number range the uncertainty of C is a maximum of 3.0%.

A wet calibration reduces the overall uncertainty by establishing the actual, as manufactured discharge coefficient over the meter operating range of Reynolds numbers. Calibrated uncertainty of C is 0.15...0.25%. Venturis are produced to worldwide standards, according to EN ISO 5167, ASME MFC-3M and ASME PTC 19.5, which define the flow calculations.

Venturi tube



Nozzles

Nozzles are used for high velocity, non-viscous, erosive flows – flows that would wear or damage an orifice plate. Nozzles are also used where orifice plates would be inadequate, and long-term repeatability as well as reliable flow metering are required. Nozzles are particularly suitable for steam applications.

Typically nozzles have a large capacity and a high accuracy with high velocity flows, plus the required straight inlet section is much shorter than that needed for an orifice plate. The discharge coefficient of a nozzle allows for an approximately 55% higher flow rate than an orifice plate with a similar Beta-ratio and differential pressure.

Unlike orifices, nozzles do not rely on a sharp edge (which can degrade over time) and have a lower pressure loss; however greater precision is required in production.

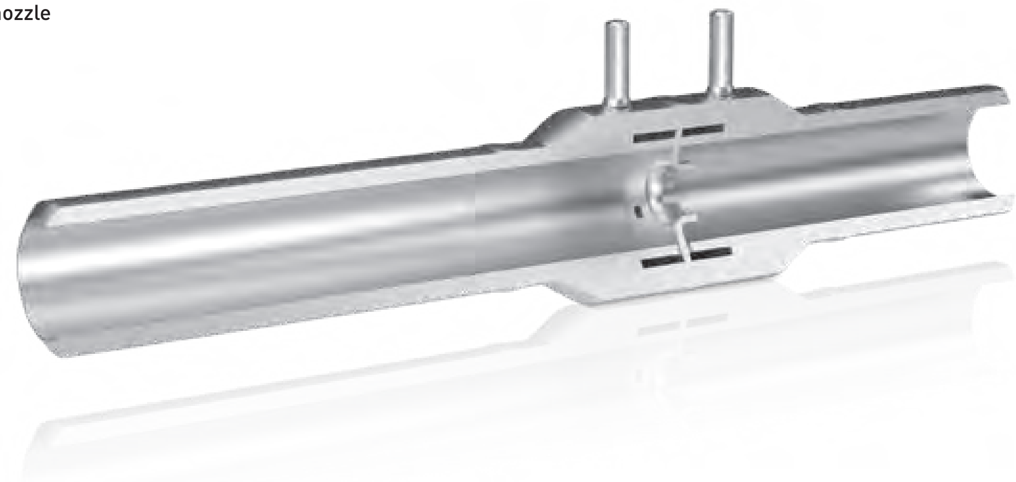
Highlights:
- Suitable for clean, dirty or abrasive fluids, gases or vapours
- Measuring of superheated steam
- Temperature: -270...+1400°C / -454...+2552°F
- Pressure up to 750 bar / 10870 psi
- All kinds of material grades are available
- Great long-term accuracy
- Measures flow rates ~55% higher than an equivalent orifice plate at a similar Beta-ratio
- Line sizes <DN500 (other dimension possible)
- Uncertainty of C, according to standards:
- ISA 1932 nozzle: 0.8...1.2%
  - Long radius nozzle: 2.0%
  - Venturi nozzle: 1.2...1.74%
  - Uncertainty of C when calibrated: 0.15...0.25%

Nozzles are specified in international standards according to EN ISO 5167 and ASME MFC.

ISA 1932 nozzle

ISA 1932 nozzles have a smooth centrical inlet leading to a throat section with a sharp outlet. The length of the ISA nozzle depends on the Beta-ratio. The lower the Beta-ratio, the shorter the length. The ISA 1932 nozzle can also be clamped between flanges (within the bolt circle).

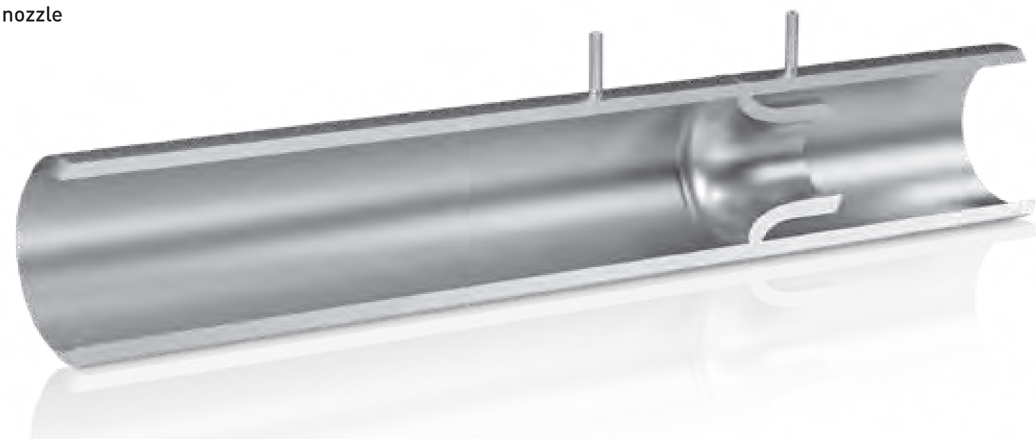
ISA 1932 nozzle



Long radius nozzle

Long radius nozzles are manufactured according to ASME. There are two types: high beta (0.25 ⩽ ß ⩽ 0.8) and low beta nozzles (0.20 ⩽ ß ⩽ 0.5). These nozzles have a smooth elliptical inlet leading to a throat section with sharp outlet. The length of the nozzle depends on the Beta-ratio. The lower the ratio the shorter the length. The long radius nozzle is available as complete meter run with a weld-in section.

Long radius nozzle



Venturi nozzle

The Venturi nozzle is an attractive solution for measurements with high accuracy where a low residual pressure loss is required. This type of nozzle has the same features as the ISA 1932 nozzle, except that the residual pressure loss is lower.

The profile of the Venturi nozzle is axially symmetrical. It consists of a convergent section, with a rounded profile, a cylindrical throat and a divergent diffuser section. A Venturi nozzle can be designed with a truncated diffuser as a more cost-effective alternative. The divergent portion may be truncated by up to 35% of its length. At large sizes there is the possibility to manufacture the unit with a sheet metal downstream cone.

When the divergence angle is smaller than 15°, the relative value of the pressure loss can be accepted as being generally between 5...20%. A Venturi nozzle is the best solution if shorter upstream lengths and lower costs are required, compared to a Venturi tube.

Venturi nozzle

Cone meter

The Cone meter was developed to measure clean, dirty or abrasive fluids, gases or vapours when accuracy, reduced maintenance and low cost are requested. Cone meters are especially suitable for measuring wet gases, such as wet or saturated steam in horizontal pipe lines.

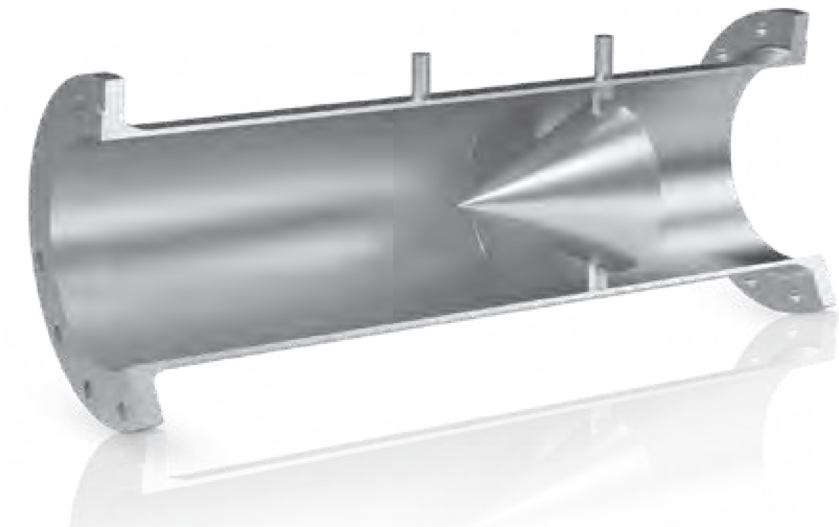
A cone is placed in the centre of the pipe to condition the flow profile prior to measurement. Through this the fluid velocity is "straightened" and a more stable signal is created. The DP is measured between the pressure upstream at the meter wall and the pressure downstream, at the centre of the cone base.

Cone meters are particularly suitable when the inlet section is very short and therefore unfit for any other DP flow elements, which would require longer inlet and outlet sections for accurate flow measurement.

Highlights:
- Suitable for clean, dirty or abrasive fluids, gases or vapours
- Measures liquids under challenging flow conditions (swirl / turbulent)
- Measures steam reliably under high-pressure conditions
- Temperature: -270...+1400°C / -454...+2552°F
- Uncertainty of C for an uncalibrated DP cone: 5%
- Uncertainty of C when calibrated: up to 0.5% of reading and 0.1% repeatability
- Inlet run pipe length reduced by up to 70%
- Design flexibility – operates in line sizes from 0.5 to 120" (DN12 to DN3000)
- Low total cost of ownership with low maintenance and long-life

Cone meter designs were standardised worldwide according to EN ISO 5167-5.

Cone meter



Norms/standards

There exist a variety of standards to cover any specific requirements worldwide.

ISO

"ISO" The International Organization for Standardization (ISO) promotes proprietary, industrial and commercial standards. It is the world's largest developer of voluntary international standards and facilitates world trade by developing common standards between nations. ISO was founded in 1947. SEIKO uses the following ISO norms in relation to DP flow elements:

- **ISO 5167** – general norm (for orifices, nozzles, Venturi, cone meter)

- **ISO TR/15377** – a complement to ISO (for orifices <50mm, with a vent or drain hole, quarter-circle nozzles and eccentric orifice plates)

ASME

"ASME" is an American norm of the American Society of Mechanical Engineers (ASME) which promotes art, science and practice of multidisciplinary engineering and allied sciences worldwide by using education, training and professional development, codes and standards, research, conferences and publications, government relations, and other forms. The following standards (norms) are relevant:

- **ASME MFC-3M** – specifies the geometry and method of use (installation and flowing conditions) for pressure differential devices; comparable to ISO-5167

- **ASME MFC-7M** – "Measurement of Gas Flow by Means of Critical Flow Venturi Nozzle" only for steady flow of single-phase gases

- **ASME PTC 6** – "Essentials – PTC (Performance Test Code) 6 - Testing Steam Turbines."

- **ASME PTC 19.5** – ASME general documents on "Measurement of Process Parameters and Associated Phenomena" for flow measurement

GOST & RD – CIS and Russian standard

"GOST" is a set of technical interstate standards developed in 1918 by the Russian Federation and stands for 'State Union Standard'. These operate under the auspices of the Commonwealth of Independent States (CIS).

Gost-R is a collection of national standards of the Customs Union (TR CU Certificate) and allows the unhindered circulation of goods within the CU. The certificate confirms the compliance of the product characteristics with standards. These certificates are valid in the Customs Union countries, which comprise Belarus, Kazakhstan and Russia.

- **GOST 8.586** – comparable to ISO 5167

- **RD 50-411-83 - GSI**. Methodical instructions. Flow rate of liquids and gases. The method of measurement with help of special orifices comparable to ISO/TR 15377.

VDI

VDI, the Association of German Engineers founded in 1856, promotes the advancement of technology and represents the interests of engineers and of engineering businesses in Germany.

- **VDI/VDE 2041** – description of orifice and nozzles for special applications in comparison to DIN 1952

The primary flow elements (orifice plates, orifice flange assemblies, meter runs, nozzles, wedge meters and classic Venturis) are manufactured according to the following internationally accepted standards:

- EN ISO 5167/ISO/TR 15377
- ASME MFC
- ASME PTC6
- BS 1042
- DIN 19206
- UNI 10023

Calculation standard

SEIKO uses two different calculation norms: ASME B31.3 and EN 13480. The strength calculation ASME B31.3 is one of the most requested ASME codes and contains requirements for piping, cover materials, components, design, fabrication, assembly, erection, examination, inspection and testing. The strength calculation EN 13480 was created by the technical committee CEN/TC 267 *"Metallische industrielle Rohrleitungen"* (Industrial Piping and Pipelines). This document also includes a definition of the requirements for the design, manufacture, installation and testing of industrial pipelines made of metal materials, for safe operating conditions. All standard products are calculated with these strength calculations and technical codes.

There are several different calculation programmes, using software according to the standards listed above, available to fulfil any customer specific requirements:

- InstruCalc Instrument Sizing Suite
  - ISO 5167
  - AGA 3
  - The Flow Measurement Engineering Handbook. Third Edition

- Conval by F.I.R.S.T.
  - ISO 5167
  - ISO/TR 15377
  - VDI/VDE 2041
  - ASME MFC-3M
  - AGA 3
  - ASME PTC 19.5
  - ASME PTC 6
  - ASME MFC-7M

- Flow Consultant (trademark of R.W.Miller)
  - ISO 5167
  - ASME MFC-3M
  - AGA-3
  - ASME PTC 19.5
  - The Flow Measurement Engineering Handbook. Third Edition

- Raskhod-RU
  - GOST 8.586

- Raskhodomer ISO
  - RD 50-411-83

Certificates

SEIKO is certified for all common national and international standards for the manufacture of high pressure piping components according to PED and ASME regulations. The SEIKO Quality System based on ISO 9001 is subject to regular internal and external audits of our own operations and sub-suppliers, to ensure that we fulfil all the applicable quality, safety and environmental standards required by our industrial customers, for material and engineering services.

List of Certificates:

- EN ISO 9001 – Quality Management norm

- EN ISO 14001 – Environmental Management norm

- OHSAS 18001 – Management of Health and Safety norm

- ASME "S" Stamp – ASME Boiler and Pressure Vessel Code – manufacture and assembly of power boilers

- EAC Certificate for the Customs Union EAC

- TR CU – Technical Regalement Conformity Certificate TRCU
  - 010 – Safety of machines and equipment
  - 032 – Safety of pressure vessels

- KTA – *Kerntechnischer Ausschuss – Sicherheitskriterien für Kernkraftwerke*
  - 3201.3 – Components of the Reactor Coolant Pressure Boundary of Light Water Reactors
  - 3211.3 – Pressure and Activity Retaining Components of Systems Outside the Primary Circuit
  - 1408.3 – Quality Assurance for Weld Filler Materials and Welding Consumables for Pressure and Activity Retaining Systems in Nuclear Power Plants
  - 1401 – General Requirements Regarding Quality Assurance

- EN ISO 3834-2 – Quality requirements for fusion welding of metallic materials

- DGRL / PED-Mod.: A, A1, D1, E1, B1 + D, B1+F, E, G, and H, H1-

- Welding Certificates
  - IWI (International Welding Inspector)
  - EWE (European Welding Engineer)
  - IWT (International Welding Technologist)

- Other
  - ASNTC NDT Level III
  - EN/PED Level III

PED

The Pressure Equipment Directive (PED) defines the standards for design, fabrication and conformity assessment of pressure equipment over one litre in volume and having a maximum pressure more than 0.5 bar gauge.

The PED covers a broad range of products such as vessels, heat exchangers, steam generators, boilers, industrial piping, safety devices and pressure accessories. Design according to the PED is mandatory throughout the EU to achieve CE certification, which enables free trade movement and placing products on the European market without local technical or legislative barriers.

This procedure allows automatic classification for products used on liquids and stable gases. PED for unstable gases can only be available on request.

PED conformity/CE marking is not applicable for common orifice plates without flanges, or for pitot tubes, but is required under the conditions of PED for multistep orifices, orifices or nozzles with a ring chamber, orifice assemblies and flowmeters such as meter runs, Venturi / ISA 1932 / long radius nozzles, cone meters and wedge meters.

For PED conformity a classification according to flange dimensions (DN/PN, TS, PS) is required.
CE marking will be done if design data are available.

Nuclear industry

As for other industries, nuclear (nuclear power plants, research reactors, fuel cycle and marine propulsion) is mainly using the differential pressure flow measurement method to determine the volume or mass flow of liquids, gases and vapours to control its processes.

KROHNE Nuclear, the nuclear industry division of the KROHNE Group develops appropriate solutions for flow measurement considering the application together with the process data, the specific requirements and the customer's expectations.

DP flow elements are an integral part of the KROHNE Nuclear product portfolio and therefore benefit from the more than 40 years of experience in the nuclear industry for safety-related and non-safety-related flow measurement applications.

Being certified by most of the nuclear authorities, operators or contractors worldwide, KROHNE Nuclear offers nuclear dedicated design, fabrication, examination, testing, qualification and documentation always with the highest consideration for safety.

- Design and fabrication in accordance with the main nuclear standards (e.g. ASME Section III, KTA and RCC-M).
- Qualification and test reports available according to IEEE 323, IEEE 344 and RCC-E, others on request. KROHNE Nuclear will support with the facilitation of qualifications or test programs.
- Project executions and related documentations are managed by nuclear dedicated regional teams located in Germany, France, Russia, China, India, USA, Korea and Japan.

DP flow elements function purely mechanically and do not have any moving parts, thus they are extremely robust. Therefore DP flow elements can be manufactured from almost any material, chosen depending on the specifications, operating environment and customer requirements.

SEIKO uses standard materials for manufacturing DP flow elements, according to ASTM and ASME norms. Furthermore SEIKO offers material in accordance with EN ISO 15156-3, NACE MR 0175 and NACE MR 0103 for the petrochemical industry.

All pressure retaining materials and components can be documented with a certificate of material 3.1 or 3.2 according to EN 10204:2004.

- Carbon steel
- Stainless steel
- Duplex / Superduplex
- Nickel-based materials
- Martensitic steel
- Heat resistant steel

Carbon steel

Carbon is the principal element in steel which is responsible for hardness – as the carbon content increases, the hardness increases, however ductility and weldability decreases. Overall, steel is considered to be plain or carbon steel when no specification of the minimum content is given, or when any element is added to obtain a desired effect.

High-carbon steel is extremely strong but more brittle. This composition allows a better response to heat treatment and longer service life than medium-carbon steels. High-carbon steels have superior surface hardness resulting in high wear resistance.

Carbon steel is more prone to corrosion than galvanised steel, aluminium, or stainless steel.

Stainless steel / CrNi

Stainless steel is a mix of iron, chromium, nickel, carbon, and other materials. The principal benefit is a resistance to corrosion and/or oxidation. Series 300 stainless steels are chrome-nickel, non-hardening, and austenitic (non-magnetic). Series 400 steels can be chrome, hardenable martensitic or non-hardenable ferritic (both magnetic).

The appearance of stainless steel products with a mill finish may not be suitable for some applications. The appearance can be improved by sand blasting.

CrNi steel is most frequently used for industrial process engineering.

- 304 – is the most favoured type. It contains chromium as well as nickel to provide an excellent balance between corrosion resistance and process ability.
- 304L – the reduced carbon amount makes 304L easier to weld, but reduces hardness.
- 310/310S – excellent oxidation resistance and better corrosion resistance than 304. 310S resists corrosion especially in welded parts.
- 316 – the most preferred material worldwide for primary flow elements is CrNi steel 316L. This shows better corrosion and pitting resistance as well as greater strength at high temperatures than 304.
- 316L – extra low carbon amount to avoid precipitation of carbide due to welding.
- 409 – combines good elevated temperature corrosion resistance with medium strength and increased workability. It can easily be formed using all commonly employed practices.

Duplex / Super-duplex

Duplex is a stainless and austenitic steel which has very good resistance against pitting corrosion. This special steel is applicable for the oil and gas industry, chemical industry, petrochemical industry, offshore, nuclear industry, and the pulp and paper industry.

Duplex steels have good oxidation resistance due to the high chromium content: they suffer from embrittlement if exposed to temperatures above about 400°C.

Superduplex with PREN > 40 also has excellent resistance against pitting corrosion and crevice corrosion at increased temperature, plus excellent resistance against stress corrosion cracking in chloride-containing and sour gas environments.

Hastelloy®

Through the combination of nickel, chromium, iron and a high amount of molybdenum this alloy gains an exceptional resistance to oxidation and is compatible with a variety of chemicals, for example: contaminated, reducing mineral acids, chlorides and organic as well as inorganic chloride-contaminated media.

It has also been found to be exceptionally resistant to stress corrosion cracking in petrochemical applications.

INCOLOY® Alloy 825

Alloy 825 is an alloy of high-corrosion resistant material. It is titanium stabilised and completely austenitic. Incoloy Alloy 825 is primarily available for pipes, pipe accessories and flanges. It has good mechanical properties from cryogenic temperatures (from –150°C/-238°F) to moderately high temperatures.

Incoloy Alloy 825 is mainly used in offshore applications and in the chemical industry. It is also used for heat exchangers, phosphoric and sulphuric acid plants, sodium hydroxide thickeners and in the nuclear industry.

Monel Alloy 400

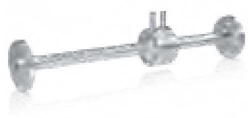
Alloy 400 is a nickel-copper alloy and has an excellent resistance against neutral and alkaline salts. In general Alloy 400 is a very versatile corrosion-resistant material. It is free from stress corrosion cracking and resists pitting in most fresh and industrial water applications. It is one of the few materials that can be used with hydrofluoric acid or hydrogen fluoride or their combination. It is also used on systems designed for oxygen services. The alloy is the standard material used in the production of salt.

The alloy is used extensively in many corrosive applications in the oil and gas industry as well as the chemical processing industry. Alloy 400 is one of the most widely used materials for marine applications, ship-building and seawater desalination plants.

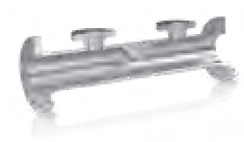
Heat resistant steel

For applications with high pressure and increased temperatures, heat-resistant steel is used.

Heat-resistant steel 1.4841 is mainly used in industrial furnaces, waste incineration plants, thermal treatment plants, and in the petrochemical industry. Heat-resistant steel is available for tubes and pipes, fittings and flanges, and accessories.

		Orifice plate		
		Square-edged	¼ circle	Meter run
				
Page		42	43	47
Pipe size mm		25…600	25…600	15…100
		≥1	(>1)	(>0.5)
Steam		x	x	x
Gas	Clean	x	o	x
	Dirty	–	–	–
Liquid	Clean	x	x	x
	High viscosity	–	x	o
	Low viscosity	x	–	o
	Dirty	o	o	o
	Corrosive	o	o	o
	Very corrosive	–	–	–
	Fibrous slurries	–	–	–
	Abrasive slurries	–	–	–
Bi-directional flow		SD	–	SD
Flow velocity	Steam	<90 m/s	<90 m/s	<90 m/s
	Liquid	<5 m/s	<5 m/s	<5 m/s
	Gases	<50 m/s	<50 m/s	<50 m/s
High temperature		x	x	x
Pressure loss		high	high	high
Long-term stability		intermediate	intermediate	intermediate
Cryogenic (temperature up to -270°C/518°F		x	x	x
Partially filled pipes		–	–	–
Typical accuracy, uncalibrated (incl. transmitter)		±0.5…2% URV	±0.5…2% URV	±0.5…2% URV
Typical Re or viscosity		Re >5,000	Re <100,000	Re >5,000

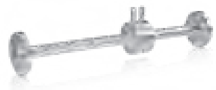
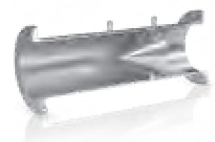
o = Normally applicable (worth consideration)
x = Designed for this application (generally suitable)
– = Not applicable
SD = Special designs
URV = Upper range value

Cone meter	Wedge meter	Nozzle	Venturi tube	Pitot tube
				
48	52	51	50	49
50...1800	>50	>50	>50	>25
(>2)	(>2)	(>2)	(>2)	(>1)
x	x	x	x	x
x	o	x	x	x
o	o	o	SD	SD
x	x	x	x	x
o	x	–	o	–
x	x	x	x	o
o	x	o	o	SD
x	x	x	x	o
o	x	o	o	–
o	x	–	x	–
o	x	o	o	–
–	x	x	SD	x
<90 m/s	<90 m/s	<90 m/s	<90 m/s	<60 m/s
<5 m/s	<5 m/s	<5 m/s	<5 m/s	<4 m/s
<50 m/s	<50 m/s	<50 m/s	<50 m/s	<40 m/s
x	x	x	x	x
low	low	high	low	low
high	high	given	high	high
x	x	x	x	o
–	–	–	–	–
5%	±6%	–	–	–
Re >8,000	Re >10,000	Re >10,000	Re >20,000	Re >40,000

PRODUCT SELECTION LIST

	OPTIBAR OP 1100	OPTIBAR OP 1110	OPTIBAR OP 3100 / 3200	OPTIBAR OP 4100
				
	Orifice plate RF	Orifice plate RTJ	Orifice plate with carrier ring	Orifice plate with integrated annular chamber
Page	42	43	44	45
Medium	Gas, liquid and steam	Gas, liquid and steam	Gas, liquid and steam	Gas, liquid and steam
Type	separate	separate	compact, separate	separate
Sizing	EN ISO 5167: 2003; ASME MFC-3M 2007; AGA 3; ASME PTC 19.5 2004; GOST 8.586; RD 50-411-83	EN ISO 5167: 2003; ASME MFC-3M 2007; AGA 3; ASME PTC 19.5 2004; GOST 8.586; RD 50-411-83	EN ISO 5167: 2003; ASME MFC-3M 2007; AGA 3; ASME PTC 19.5 2004; GOST 8.586; RD 50-411-83	EN ISO 5167: 2003; ASME MFC-3M 2007; AGA 3; ASME PTC 19.5 2004; GOST 8.586; RD 50-411-83
Uncertainty / Accuracy	Uncertainty of C: ±0.5...0.8%	Uncertainty of C: ±0.5...0.8%	Uncertainty of C: ±0.5...0.8%	Uncertainty of C: ±0.5...0.8%
Turndown ratio (calibrated)	6:1 (12:1)	6:1 (12:1)	6:1 (12:1)	6:1 (12:1)
Pressure loss	40...95%	40...95%	40...95%	40...95%
Max. pressure*	300...2500 lb	300...2500 lb	PN10...100	PN10...100
Max. temperature*	+400°C/+752°F	+400°C/+752°F	+400°C/+752°F	+400°C/+752°F
Line size*	1...24"	1...24"	DN50...600	DN50...600
Material DP flow element*	316L	316L	1.4404	1.4404
Material mounting parts*	n.a.	Soft steel, 316L	P305GH, 1.4404	P305GH, 1.4404
Optional temperature probe	no	no	no	no

* Different specifications are available on request

OPTIBAR OP 5100	OPTIBAR OP 5110	OPTIBAR MR 4300	OPTIBAR MR 6300	OPTIBAR PT 2000
				
Orifice assembly with flanges RF	Orifice assembly with flanges RTJ	Orifice meter run assembly	Cone meter	Averaging pitot tube
46	46	47	48	49
Gas, liquid and steam	Gas, liquid and steam	Gas, liquid and steam	Gas, liquid and steam	Gas, liquid and steam
separate	separate	compact, separate	compact, separate	compact, separate
EN ISO 5167: 2003; ASME MFC-3M 2007; AGA 3; ASME PTC 19.5 2004; GOST 8.586; RD 50-411-83	EN ISO 5167: 2003; ASME MFC-3M 2007; AGA 3; ASME PTC 19.5 2004; GOST 8.586; RD 50-411-83	EN ISO 5167: 2003; ASME MFC-3M 2007; AGA 3; ASME PTC 19.5 2004; GOST 8.586; RD 50-411-83	EN ISO 5167	KROHNE standard
Uncertainty of C: ±0.5...0.8%	Uncertainty of C: ±0.5...0.8%	Uncertainty of C: ±0.5...0.8% calibrated: ±0.3....0.4%	Uncertainty of C: ±5% calibrated: ±0.25....0.35%	<±1% uncalibrated; <±0.5% calibrated**
6:1 (12:1)	6:1 (12:1)	6:1 (12:1)	6:1 (12:1)	5:1 (7:1)
40...95%	40...95%	40...95%	3,5...75%	5...12%
300...2500 lb	600...2500 lb	150...600 lb PN10...100	150...600 lb	PN...100
+400°C/+752°F	+400°C/+752°F	+400°C/+752°F	+400°C/+752°F	+400°C/+752°F
1...24"	1...24"	1/2...4"; DN15...10	4...24"	2...50"; DN50...2000
316L	316L	316L / 1.4404	316L	316L
SA105, 316L	SA105, 316L	316L / 1.4404	SA105	A105, 316L, 16Mo3
no	no	no	no	yes

** assembled as meter run

OPTIBAR OP 1100

OPTIBAR OP 1100 is an orifice plate with RF sealing faces for mounting between measuring flanges according to ASME 16.36/16.5/16.47 A

Orifice plates with a raised face (RF) design are the simplest and most common type of DP flow element. RF orifice plates can be used for non-critical pressure conditions and are easy to replace. The plate and handle are a one-piece seamless construction.

RF orifice plates are sealed with a flat gasket. The raised face has a serrated texture to increase the gripping and retaining force. These orifice plates are used with orifice flange unions and placed with an additional gasket between flanges fitted with pressure taps (ASME 16.36/16.5/16.47 A).

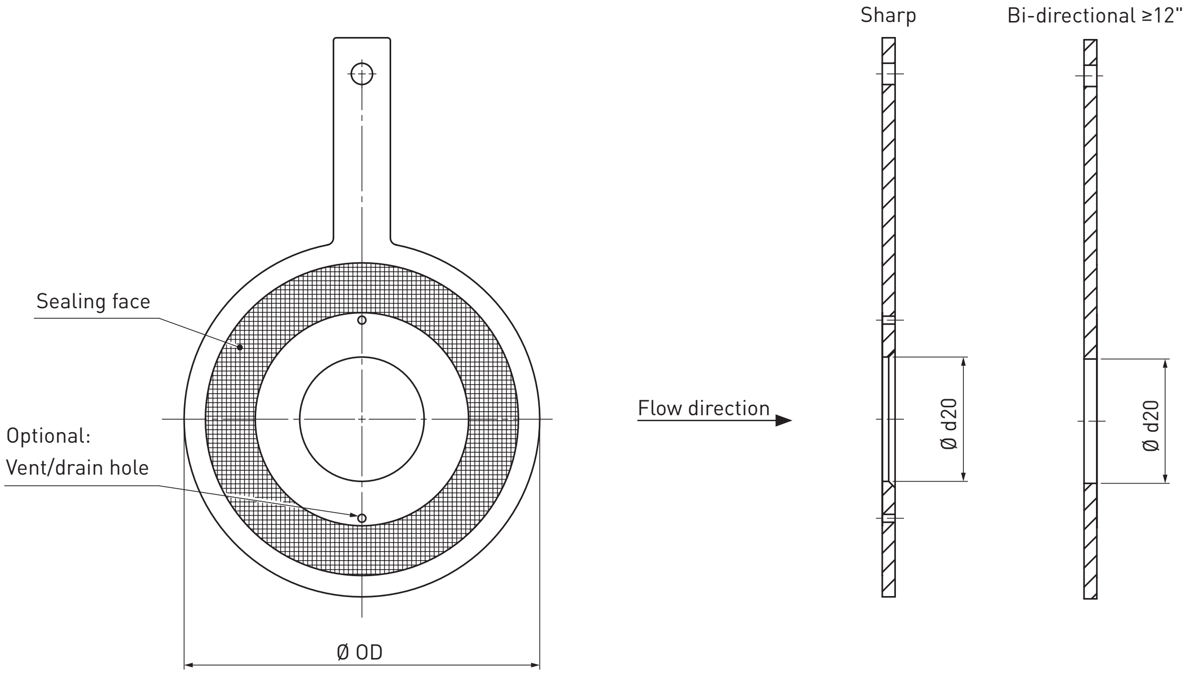
The RF orifice plate is available with a sharp edge on the up-stream side and a 45° edge on the downstream side, or with a bi-directional cross section profile. It is recommended for clean liquids, gases and steam flows.

Specification:

- Nominal size: 1...24"
- Pressure rating: 300...2500 lb
- Temperature range: < +400°C / +752°F
- Uncertainty of C: 0.5....0.8%
- Repeatability of measurement: 0.1%
- Standard material: stainless steel 1.4404/316L

Benefits:

- Cost-effective DP flow element according to EN ISO 5167
- Easy handling and simple installation
- Lowest uncertainty of discharge coefficient
- High Reynolds numbers are permissible according to the standards



OPTIBAR OP 1110

OPTIBAR OP 1110 is an orifice plate with RTJ sealing faces for mounting between measuring flanges according to ASME 16.36/16.5

Orifice plates with a ring-type joint (RTJ) design are used for higher pressure conditions and mainly used in the oil and gas industry. RTJ orifice plates incorporate an octagonal integral gasket for mounting between ring type joint flanges and therefore do not need an additional gasket.

The cross section profile of an orifice plate ring type-joint (RTJ) is designed to fit inside the recess of the RTJ flanges and is used as flange sealing. The octagonal RTJ gaskets are softer than the flange material, so that the orifice is sealed reliably and cleanly when tightened with bolts. The bolt pressure deforms the gasket and a metal-to-metal seal is created.

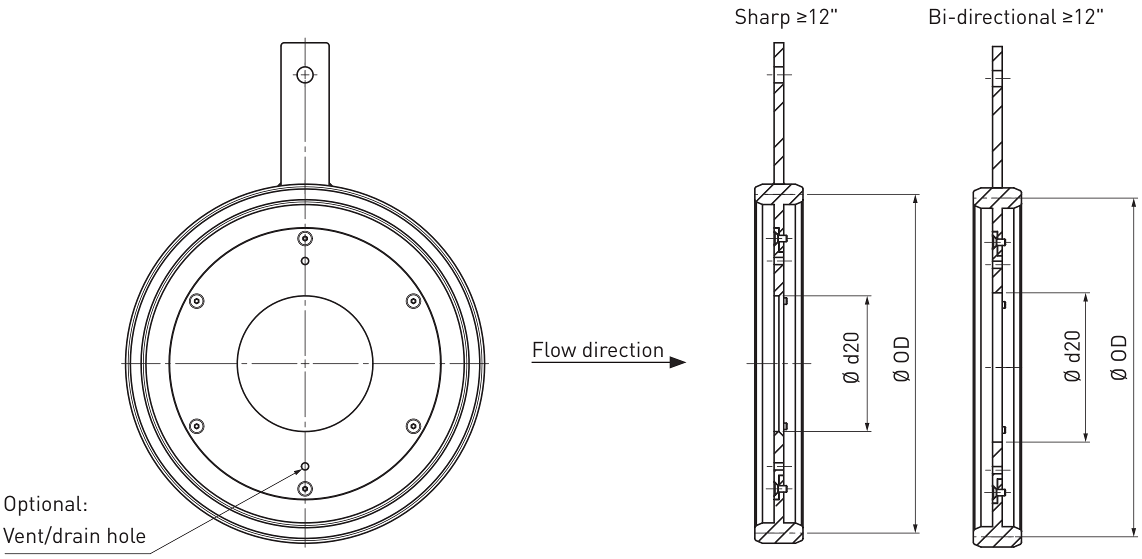
The orifice plate RTJ is available with a sharp cross section profile. It is recommended for clean liquids, gases and steam flows.

Specification:

- Nominal size: 1...24"
- Pressure rating: 600...2500 lb
- Temperature range: < +400°C / +752°F
- Uncertainty of C: 0.5....0.8%
- Repeatability of measurement: 0.1%
- Standard material: stainless steel 1.4404/316L; soft steel (HB < 110)

Benefits:

- Cost-effective DP flow element according to EN ISO 5167
- Easy handling and simple installation
- Lowest uncertainty of discharge coefficient
- High Reynolds numbers are permissible according to the standards



OPTIBAR OP 3100 / 3200

OPTIBAR OP 3100/3200 are orifice plates in a carrier ring, with corner taps and flat sealing faces
OP 3100 – separate type / OP 3200 – compact type

Orifice plates with corner taps are used for the flow measurement of both aggressive and non-aggressive gases, steam and liquids.

The corner taps allow the measurement of the differential pressure before and after the orifice constriction. Such orifice plates with a carrier ring are frequently installed in Europe.

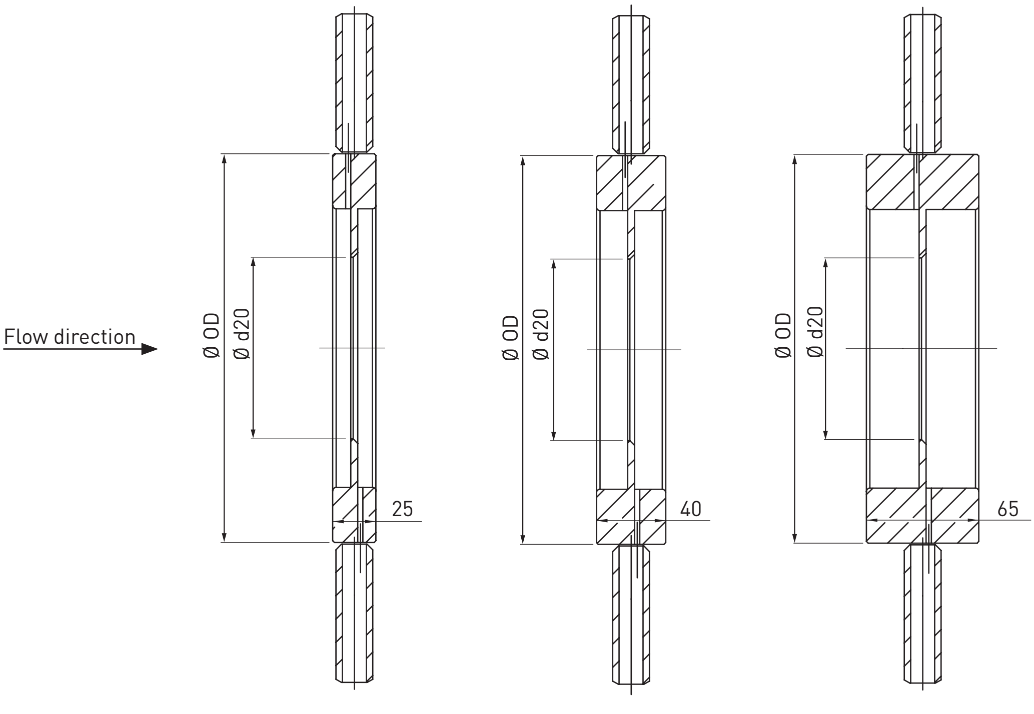
The carrier ring and orifice plate are made of one solid piece of metal, without any mechanical joints or welding. This design can be installed between standard flanges according to EN 1092-1 on horizontal or vertical pipelines. Standard gaskets are used, which are not included.

Specification:

- Nominal size: DN50…600
- Pressure rating: PN10…100
- Temperature range: < +400°C / +752°F
- Uncertainty of C: 0.5….0.8%
- Repeatability of measurement: 0.1%
- Design: separate or compact
- Standard material: stainless steel 1.4404/316L

Benefits:

- Cost-effective DP flow element according to EN ISO 5167
- Easy to clean
- Suitable for media which become resinous and can accumulate
- High Reynolds numbers are permissible according to the standards



OPTIBAR OP 4100

OPTIBAR OP 4100 is an orifice assembly with corner taps and integrated annular chambers

Orifice plates with an annular chamber have a carrier ring which is split into two parts. The ring chambers provide an average of the pressure around the orifice to reduce the effects of flow disturbances, and a better averaged measurement of flow can be achieved.

As a result, a more stable pressure signal can be measured under difficult process conditions as the measurement is less susceptible to perturbations. Suitable for liquid, gas and steam flow measurement.

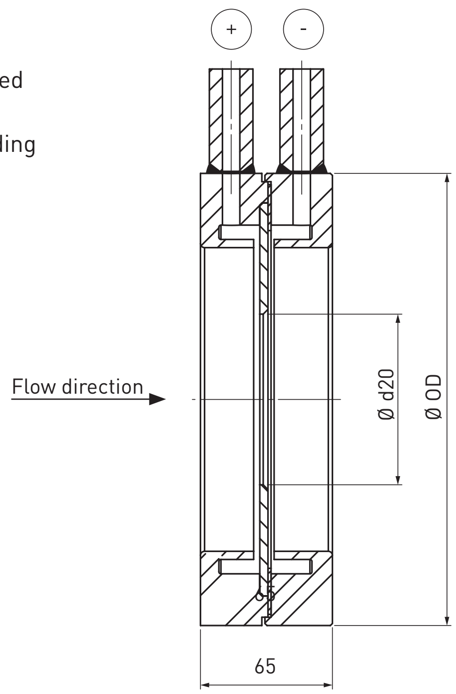
These orifice plates with annular chambers are intended for installation between flanges according to EN 1092-1 on horizontal or vertical pipelines. Using a split ring chamber design the orifice plate can be replaced.

Specification:

- Nominal size: DN50...600
- Pressure rating: PN10...100
- Temperature range: < +400°C / +752°F
- Uncertainty of C: 0.5....0.8%
- Repeatability of measurement: 0.1%
- Design: separate or compact
- Standard material:
  - Carrier ring: carbon steel P305GH (1.0436)
  - Orifice plate: stainless steel 1.4404/316L
  - P305GH (1.0436); Orifice plate: stainless steel
  - X2CrNiMo17-12-2 (1.4404)

Benefits:

- Pressure values are averaged within integral annular chambers
- The orifice plate is removable and easily replaced without replacing the carrier assembly
- High Reynolds numbers are permissible according to the standards



OPTIBAR OP 5100 / 5110

The OPTBAR OP 5100 / 5110 is an orifice assembly with measuring flanges according to ASME 16.36, having flange taps and RF / RTJ sealing faces

Orifice flanges are simple devices with welding neck fittings, and are used for securely holding an orifice plate in a pipe.

The orifice flange assembly includes the orifice plate, a pair of flanges with integrated taps, a set of gaskets, bolts and nuts and a jack screw to assist separating the flanges for orifice inspection. Jack screws are included for both designs.

Design can be with RF or RTJ weld-neck flanges. The RTJ design is for higher pressures. The orifice plates are centred between the bolts, within very close tolerances to the standards.

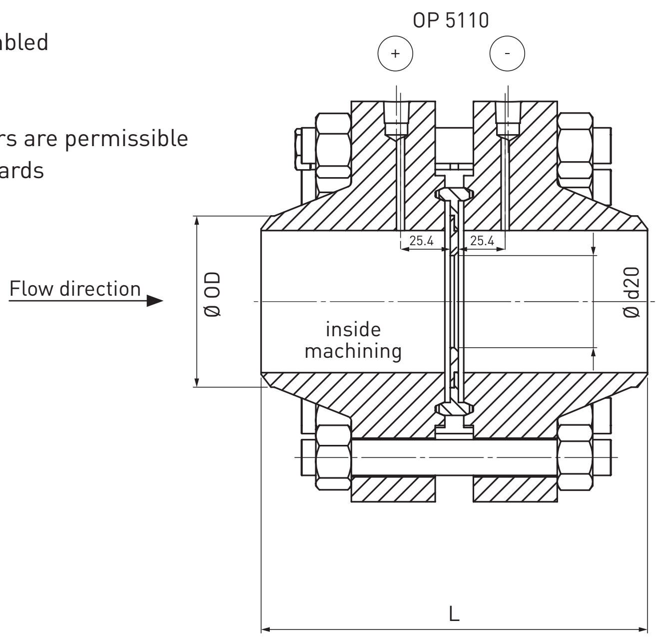
Depending on customer requirements, the typical 1/2 inch or 3/4 inch taps have BWE, thread or flange connections. Taps can be equipped optionally with condensate chambers and shut-off valves.

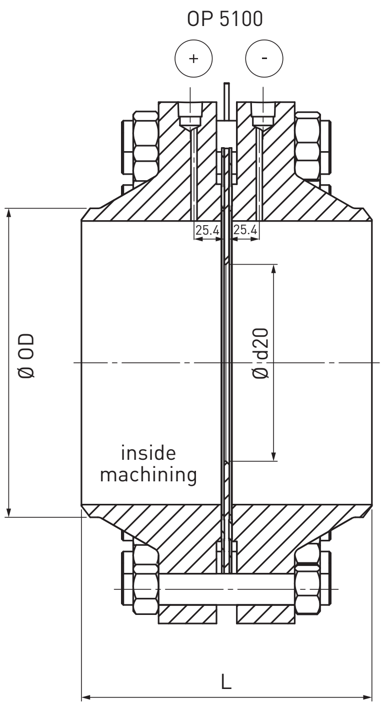
Specification:

- Nominal size: 1...24"
- Pressure rating:
  - OP 5100 (RF): 300...2500 lb
  - OP 5110 (RTJ): 600...2500 lb
- Temperature range: < +400°C / +752°F
- Uncertainty of C: 0.5....0.8%
- Repeatability of measurement: 0.1%
- Design: separate or compact
- Standard material:
  - Flange: carbon steel 1.0426/SA 105 or stainless steel 1.4404/316L
  - Orifice carrier ring: soft or stainless steel (RTJ)
  - Orifice plate: stainless steel 1.4404/316L

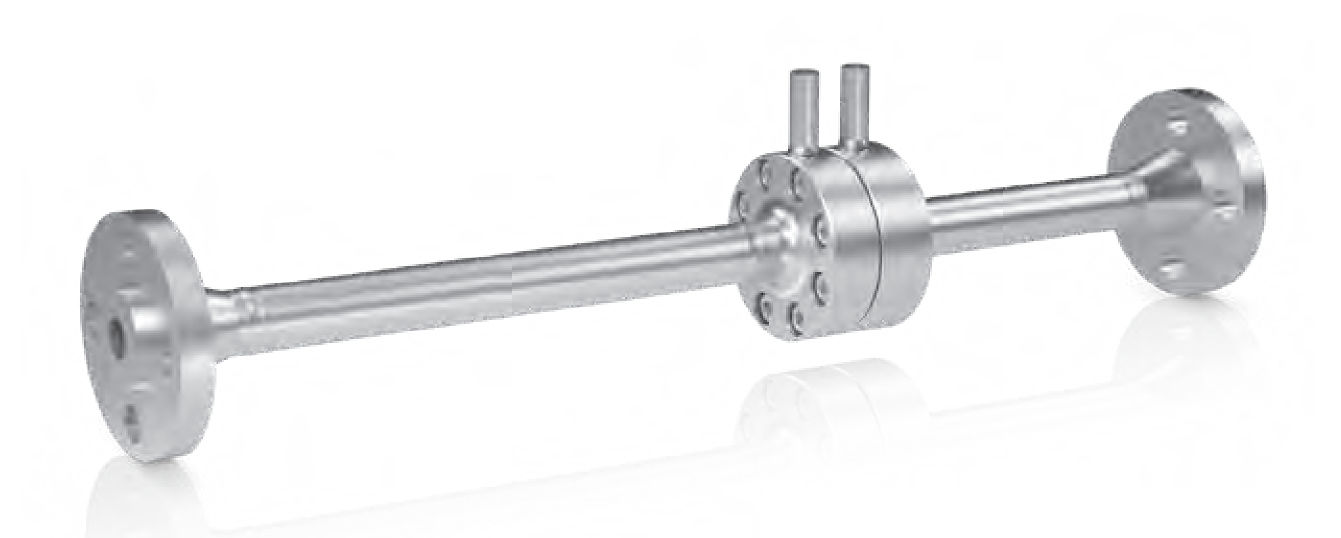
Benefits:

- Completely pre-assembled
- Accurate results
- Low maintenance
- High Reynolds numbers are permissible according to the standards





OPTIBAR MR 4300



OPTIBAR MR 4300 is an orifice plate meter run assembly with corner taps and integrated annular chambers

For applications demanding a high accuracy flow measurement from the flow element, the inlet and outlet pipe sections must be included to provide a complete meter run assembly. Meter runs are especially suitable for small nominal sizes.

The meter run assembly can be delivered complete with end flanges to suit the site pipework. Meter run assemblies should be calibrated for best accuracy, in certified calibration laboratories. The inlet and outlet sections are designed and manufactured according to DIN 19214.

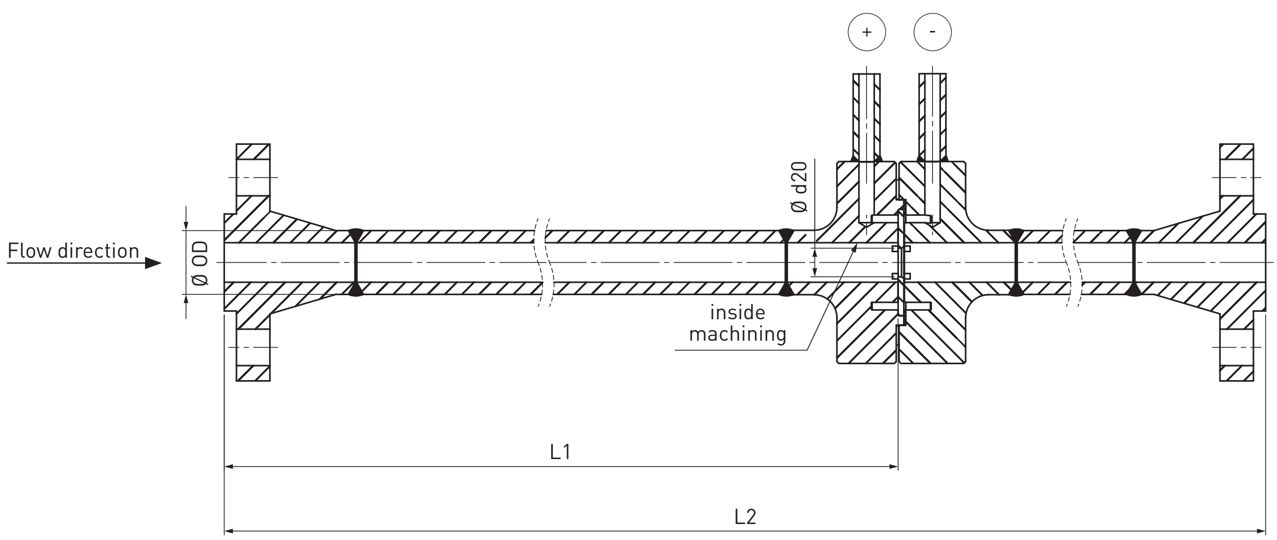
If required these assemblies can be water-calibrated for increased accuracy.

Specification:

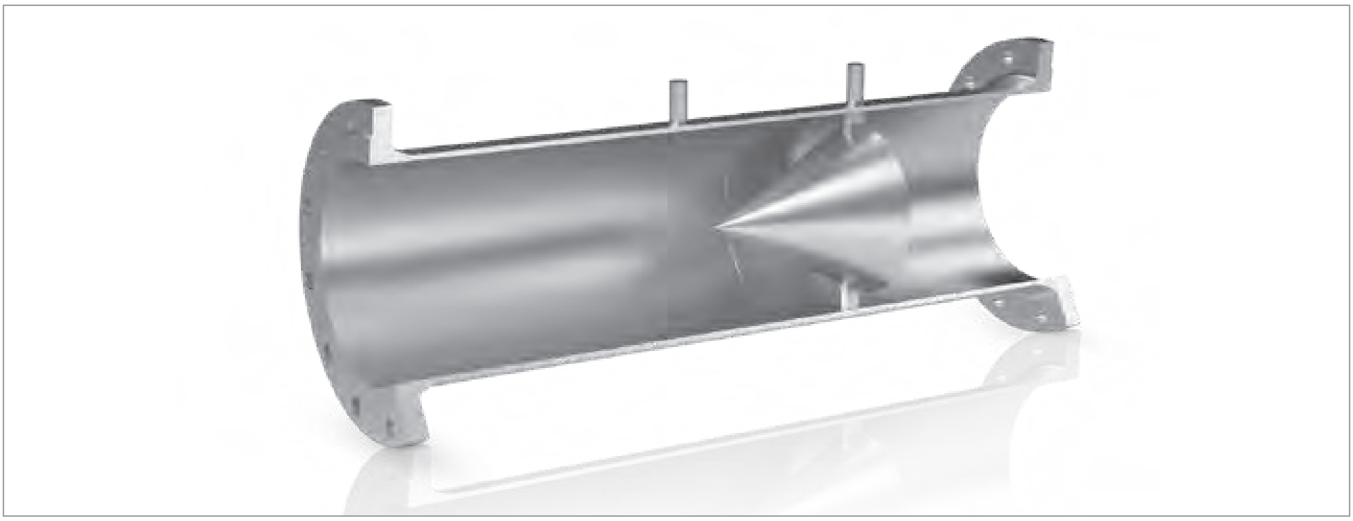
- Nominal size: 1/2...4" / DN15...100
- Pressure rating: 150...600 lb / PN10...100
- Temperature range: < +400°C / +752°F
- Uncertainty of C: 0.5....0.8% / calibrated: 0.3....0.4%
- Repeatability of measurement: 0.1%
- Design: separate or compact
- Standard material: stainless steel 1.4404/316L

Benefits:

- Completely pre-assembled
- Reduces flow disturbances
- Inlet and outlet sections are manufactured according to standards and therefore ensure minimum measurement uncertainties.



OPTIBAR MR 6300



OPTIBAR MR 6300 is a cone meter run assembly with single taps

Cone meters are installed into a closed pipeline usually welded in an assembly creating a meter run, used to determine the flow rate in a full pipe (mass flow or volumetric flow rate). The installation of a cone meter causes a pressure difference between the upstream and downstream side.

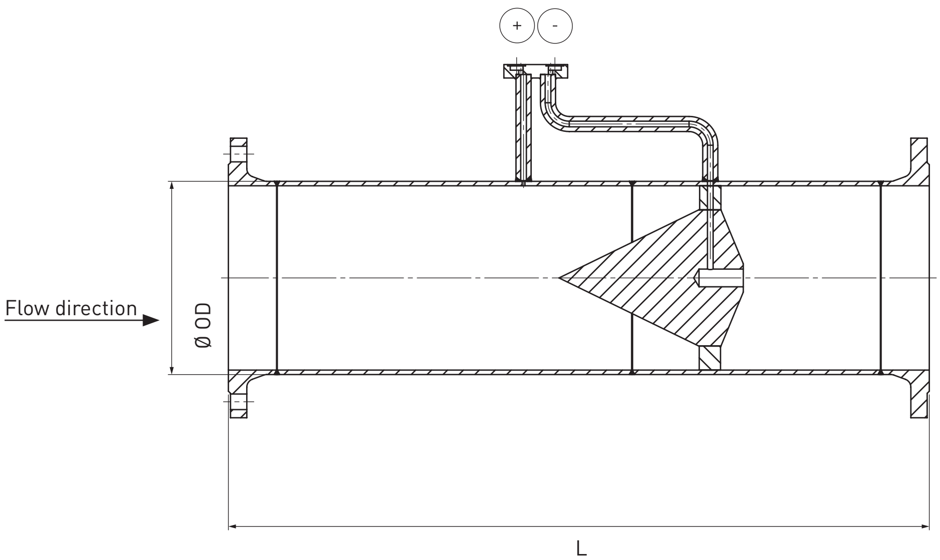
The rate of flow can be determined from the measured value of this pressure difference plus the meter geometry if the fluid characteristics are known. The cone meter is made up of a pipe section of diameter D which houses the restriction element of diameter dc, the supported structure for the single element and the taps to enable the differential pressure measurement.

A cone meter may be manufactured from any material and in any way, provided that it remains in accordance with the standard.

Depending on customer requirements, the typical 1/2 inch or 3/4 inch taps can have either a butt or socket weld, a screw thread or a flanged connection. Taps may be equipped with condensate chambers and shut-off valves.

Specification:
- Nominal size: 4...12"
- Pressure rating: 150...600 lb
- Temperature range: < +400°C / +752°F
- Uncertainty of C: 5% uncalibrated / 0.25....0.35% calibrated
- Repeatability of measurement: 0.1%
- Design: compact or separate
- Standard material: stainless steel 1.4404/316L

Benefits:
- Low maintenance and long life
- Suitable for tight-fit and retrofit installations
- Offers the shortest possible upstream & downstream straight length requirement for installation



OPTIBAR PT 2000

Averaging pitot tube

Averaging pitot tubes measure clean fluids, gases and steam by sensing the difference between the impact pressure of the flow and the static line pressure. Unlike a conventional single-point pitot tube (which has the limitation of being a point-velocity device), averaging pitot tubes have multiple impact-sensing ports across the pipe diameter and produce an averaged differential pressure across the flow profile.

The outer impact tube has a number of pressure sensing holes facing upstream that are positioned at equal annular points in accordance with a log-linear distribution. The "impact pressure" developed at each upstream hole by the flowing medium is averaged in two stages: firstly, within the outer impact tube and secondly (and more accurately) within a second, internal averaging tube. This pressure is presented to the DP cell as the high pressure component of the DP output.

The averaging pitot tube is a versatile and cost-effective solution for difficult metering problems.

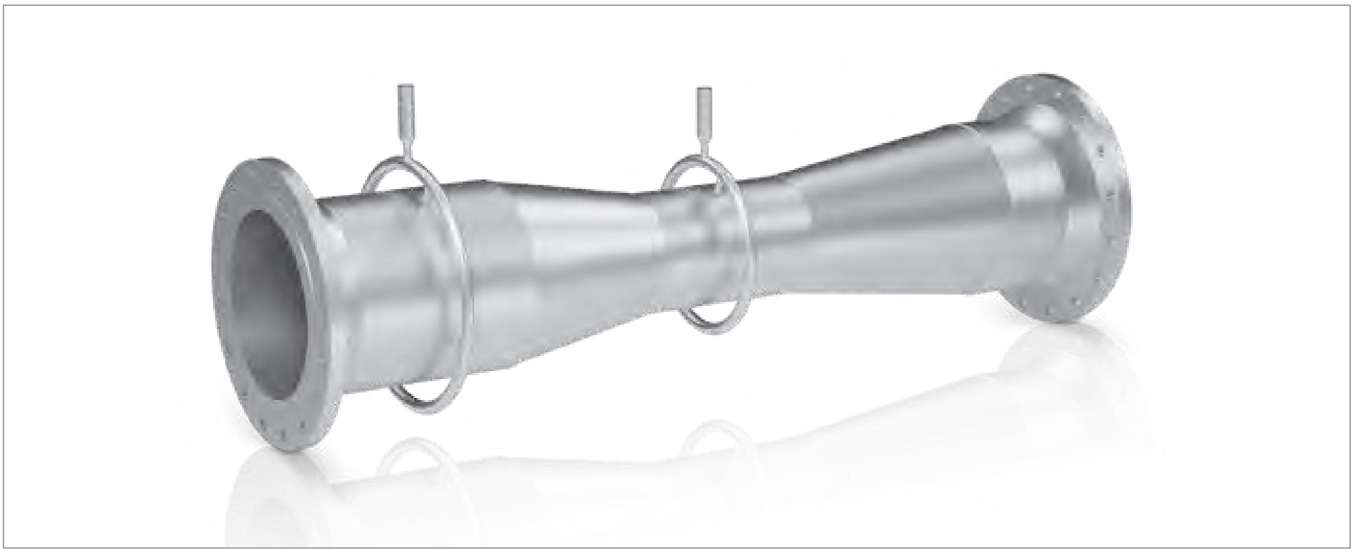
Specification:

- Nominal size: DN50...12000 / 2...800"
- Pressure rating: PN40...100
- Temperature range: -200...+450°C / -328...+842°F
- Uncertainty: <1% / calibrated <0.5%
- Repeatability of measurement: 0.1%
- Design: compact or separate
- Standard material: stainless seel 1.4404/316L

Benefits:

- No separation of the pipeline
- Lower pressure loss than all other DP flow elements
- Easy and fast installation

Venturi



Engineered products

SEIKO Flowcontrol not only offers standardised products but is also able – because of extensive experience in project-orientated business – to manufacture customer-specific solutions. Special custom-built DP flow elements – like wedge meters, Venturi, cone meters, ISA1932 and Venturi nozzles – are completely manufactured in-house and are applicable in industries like oil & gas, power generation and petrochemical plants.

Venturi tubes provide users with high accuracy measurements of fluids in clean as well as dirty media. The Venturi tube is a low-pressure-drop metering device and thanks to its angled inlet and outlet cones (which help control the pressure recovery) it is one of the most efficient differential pressure meters available.

Also a Venturi tube is a perfect solution for high and low pressure measurements if limited straight upstream and downstream lengths are available. The design consists of a cylindrical inlet, a convergent cone section, a cylindrical bore, and a divergent conical section.

A Venturi tube can be created in a shorter design – the divergent portion may be truncated by up to 35% of its length without significantly modifying the permanent pressure loss. At large sizes and for low pressure applications a welded Venturi will be the best answer.

Specification:

- Uncertainty of 0.7 or 1.5% up to 3% depending on the operating conditions
- Low pressure loss: ~5...10% of calculated DP
- Standard size: DN1200 / 48"
- Sizes up to DN6000 possible
- Pressure rating: any
- Temperature range: -270...+1400°C / -418°F to +2552°F
- Design: compact

Benefits:

- High long-term accuracy
- Long life – excellent resistance to wear
- No maintenance costs
- Low requirement of straight inlet & outlet sections

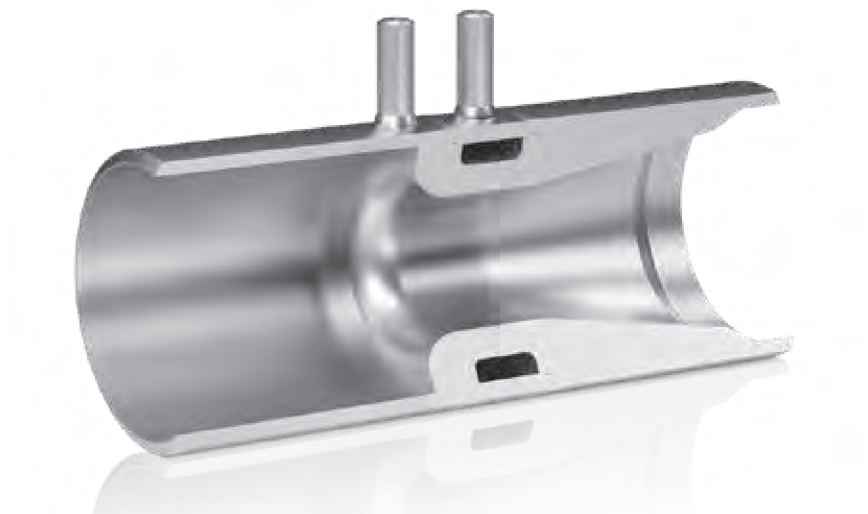
Material:

- Available in wide variety of materials

Application:

- All kinds of gases, liquids and steam
- Low pressure applications
- More efficient, less energy loss
- Bi-directional measurement possible

Nozzle



Nozzles are used for high velocity and erosive flows of viscous as well as non-viscous fluids, which would wear off or damage an orifice plate in industries like power plants, petrochemicals, chemicals, paper and pulp. Nozzles are particularly recommended for steam applications.

Typically nozzles have a very good accuracy with high flow rates. The required straight inlet section is significantly shorter than that needed for an orifice, and the discharge coefficient of the nozzle is such that a nozzle can measure approximately 55% higher flow rates than an orifice plate with a similar Beta-ratio and design differential pressure.

ISA 1932 nozzles have a smooth circular inlet leading to a throat section with sharp outlet. The length of the ISA nozzle depends on the Beta-ratio. The lower the ratio the shorter the length. The ISA 1932 nozzle can also be clamped between flanges (within the bolt circle).

Specification:

- Typical uncertainty for ISA 1932 nozzles: 0.8...1.2%
- Typical uncertainty for long radius nozzles: <2%
- Typically pressure loss is between 30% and 60% of the generated DP (actual value depends on the Beta-ratio)
- Nominal size: 1/2...48"
- Pressure rating: any
- Temperature range: -270...+1400°C/ -454°F... +2552°F
- Design: compact

Benefits:

- Good long-term accuracy
- No maintenance costs
- Easy handling when installed

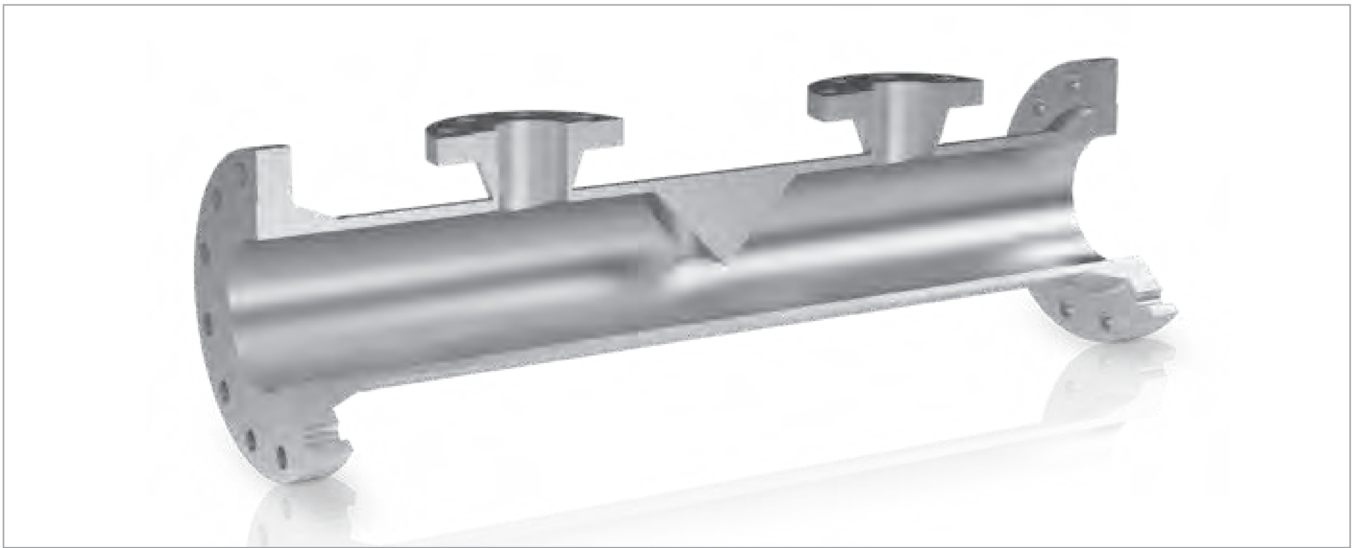
Material:

- Available in wide variety of metals and plastics

Application:

- Any media (high velocity, non-viscous, viscous, erosive flows etc.)
- Very good accuracy with high velocity flows

Wedge meter



Wedge meters are adaptable to almost any process condition or installation requirement and are ideal for slurries, or highly viscous and abrasive fluids, or even media with a tendency to foul.

Within the DP flow element range wedge meters provide accurate measurements and have resisted conditions that would normally wear the sensitive measurement surfaces found on an orifice plate, turbine, cone meter or positive displacement meter. They have the widest flow range of any DP-based flow device and only require short upstream and downstream straight pipe lengths.

Wedge meters are suitable for applications where available upstream and downstream straight pipe lengths do not fulfil requirements of common DP flow elements like orifice plates. In addition, the linear performance down to Reynolds numbers as low as 500 allows its application with high viscosity fluids.

Specification:

- Stable performance down to Reynolds numbers as low as 500
- Bi-directional flow capability
- Accuracy of uncalibrated wedge meters: <6%
- Nominal size: 2...24"
- Pressure rating: 750 bar
- Temperature range: -270°C...1400°C /-454°F...+2552°F
- Design: compact

Benefits:

- No critical surface dimensions
- Durable – excellent long term stability
- No dead zones for a secondary phase to build-up (remote seal element)
- High temperature/pressure limits
- Flowpath can be coated/clad to enhance physical or chemical resistance

Material:

- Available in a wide variety of materials

Application:

- Adaptable to almost any process condition
- Applicable to highly viscous, slurry type, or contaminated line fluid applications, including difficult-to-meter, air entrained liquids, as well as particulate entrained, high viscosity liquids, or slurry solutions

Ideal for different media: for example raw sewage, sludge, tar sands, pulp mash, cement, liquid asphalt or molten sulphur

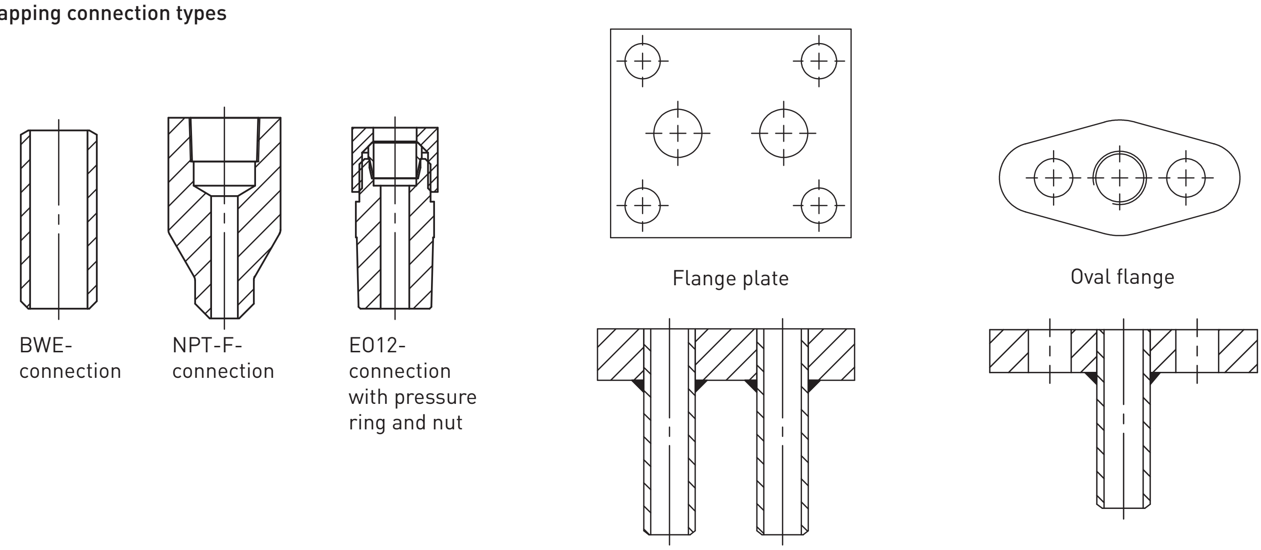
Equipment for DP flow elements

All DP flow elements can be equipped with a wide range of optional accessories to optimally meet all the requirements of the measuring point. Therefore many variations can be configured, extending from simple screw connections to complex direct mounts with flange plates and manifolds.

Pressure tap connections

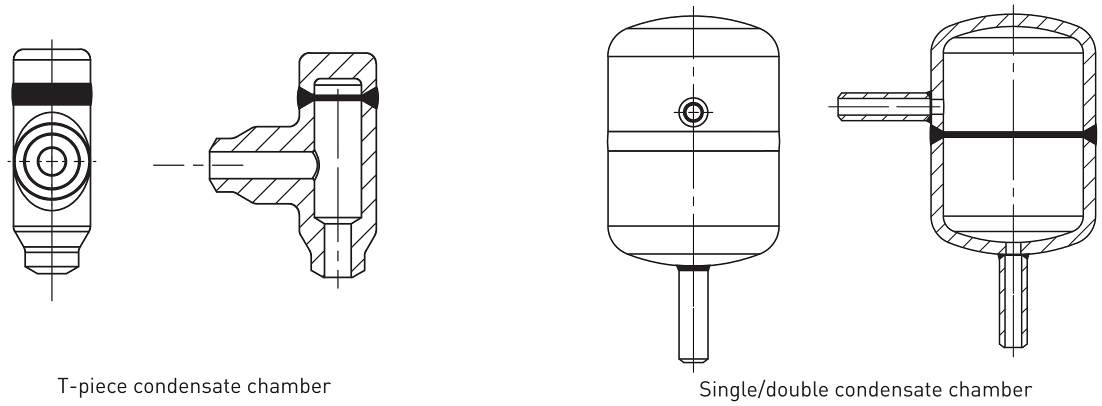
Depending on customer requirements, the typical 1/2 inch or 3/4 inch tappings have a butt or socket weld, screw thread or flange connection. Tappings may be equipped with condensate chambers and shut-off valves.

Tapping connection types



Condensate chambers

Condensate chambers are used in the measurement of steam or other vapours which condense to a liquid state, in order to create a barrier between the main line and the secondary instruments. There are single/double and T-piece condensate chambers available.



Shut-off valves/manifolds

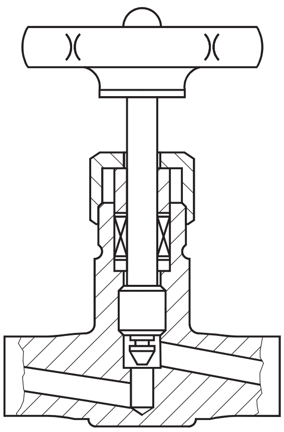
There is also a wide range of valves and manifolds available for use next to the pressure taps, suitable for the many different types of primary elements available. These are made from carbon or stainless steel: the valves are forged and their inner parts are made of stainless steel and used to shut off the pressure tap connections.

Shut-off valves from Bolin

AV3

A compact forged shut-off valve, with turned seat and internal spindle thread, for temperatures up to 250°C

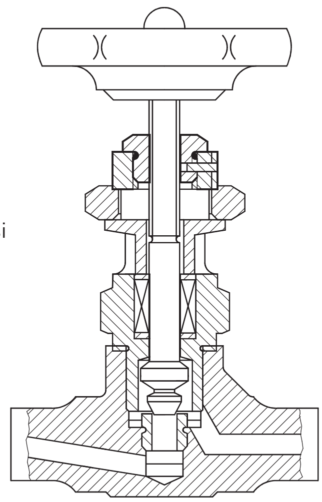
DN: max. 8
PN: max. 400 bar / 5,801.5 psiT max. +250°C /+482°F
CV ≈ 0.5 (DN5)



AV7

A compact forged shut-off valve, with turned seat and external spindle thread, for higher temperatures up to 400°C.

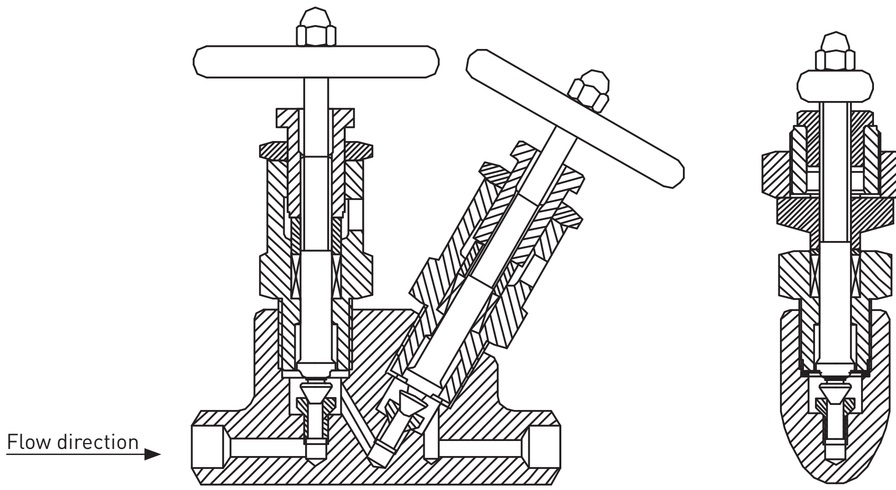
DN: max. 8
PN: max. 400 bar/ 5,801.5 psi
T max. +400°C /+752°F
CV ≈ 0.5 (DN5)



The SEIKO DAV Valve is a TÜV Austria proved double-shut-off device which is a "2 in 1 valve" and often used for high pressure applications. Due to its compact design there is less space required for further installations.

SEIKO doublestop valve

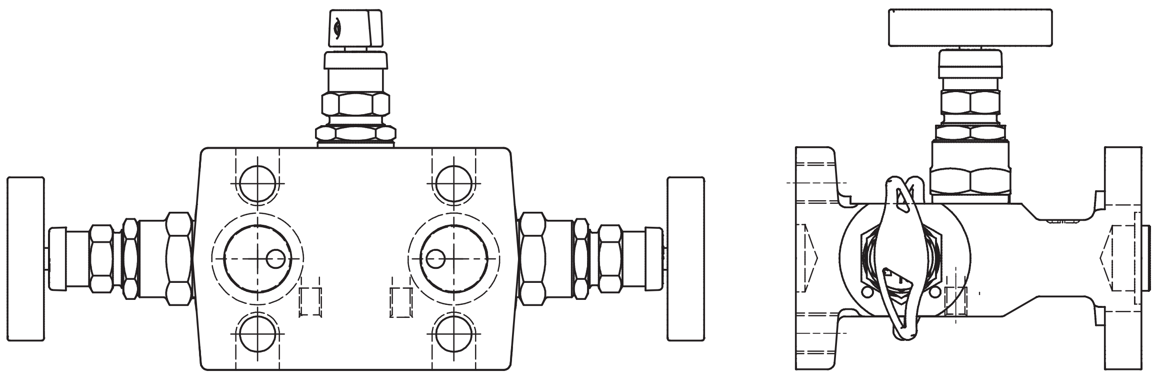
Type: DAV 5320
With external spindle thread
Material 1.4404/316L
or C22.8/SA105
PN: 320 bar
T: max. +450°C / +842°F



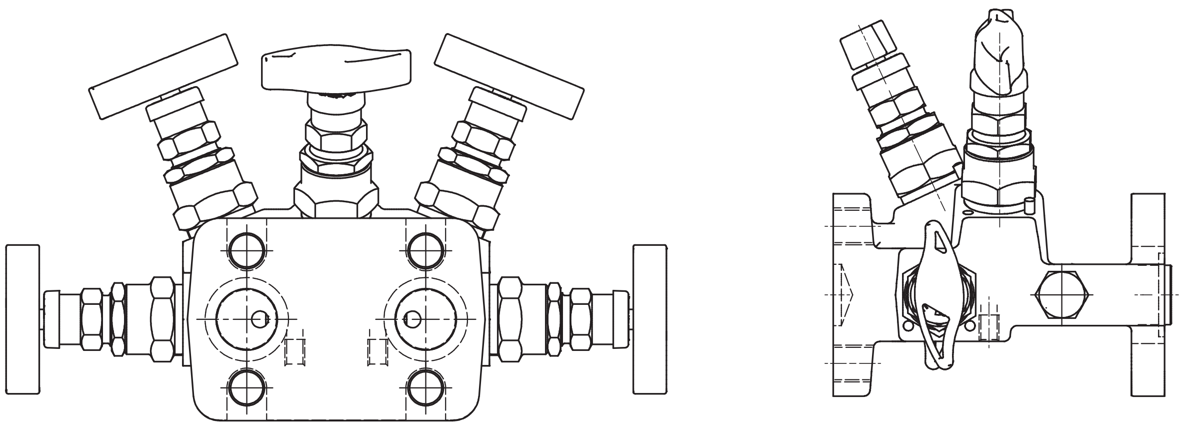
Manifolds

Manifolds offer a compact solution compared to a combination of individual valves. Different variations are possible. For our compact type DP flow elements we are using 3- or 5-valve manifolds as primary shut-off. Those manifolds have an IEC A flange and are used as a double flange version to fit directly onto any DP flow element which is equipped with oval flange adaptors or with a flange plate. The DP transmitter can be directly fitted to the other side of the manifold.

3 Valve manifold direct mount



5 Valve manifold direct mount



OPTIBAR range for differential pressure flow measurement

The OPTIBAR range includes a variety of modular transmitters, application-specific diaphragm seals, DP flow elements, accessories, valves and manifolds.

Highlights:
- All measurement uncertainties under operating conditions are known and can be calculated
- Volume or mass flow measurement of liquids, gases or steam
- Integrated absolute pressure measurement
- Optimisation of measuring points according to a given specification, e.g. short inlet/outlet, low pressure loss, small overall uncertainty, etc.
- NACE compliant materials
- Compliant to PED 2014/68/EU with CE marking
- Large choice of materials for corrosive and non-corrosive media
- 4...20 mA HART® 7, FOUNDATION™ fieldbus, PROFIBUS® PA as communication options
- SIL2/3 certified by TÜV Rheinland
- Smallest measuring span 10 mbar / 0.145 psi gauge

The newest member of the KROHNE OPTIBAR family is unparalleled when it comes to versatility and robustness. The completely newly developed piezoresistive differential pressure measuring device provides not only the exact differential pressure under any operating conditions but also simultaneously measures the static pressure in the process line.

Highlights:
- Extremely quick step response times < 125 ms
- Universal modularity across the entire OPTIBAR process series
- Resistant to temperature shocks
- Extensive diagnostic and parameterisation functions on the display module or the user-friendly and free DTM

Complete measuring points

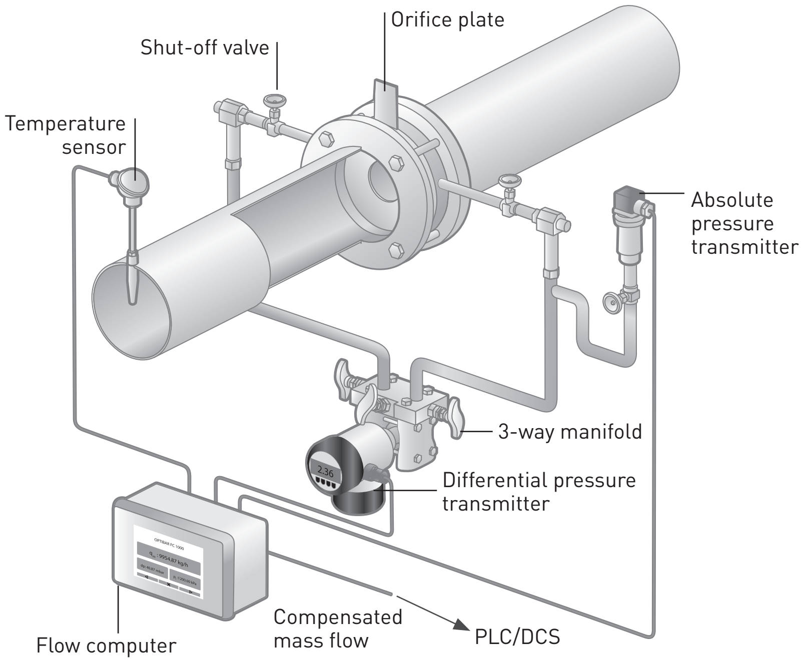
KROHNE will provide you with all necessary instruments for your flow measurement point: from DP flow elements, up to a flow computer for gas, liquid and steam calculations.

For measurement uncertainties due to changing process conditions, the flow computer holds appropriate algorithms for all DP flow elements. By adding temperature and pressure sensors, density compensation or gross and net energy calculations are also possible.

When commissioning a complete measuring point from us, investment costs like DP flow element design, component assembly up to pre-parametrisation of the differential pressure transmitter and flow computer are all low. And there are no additional costs for piping, installation and testing at the measuring point*.

KROHNE's approach to design also guarantees that up to 70% of potential leakage points will be eliminated, cutting service and maintenance costs.

Complete DP flow measuring point for compensated volume/mass flow



*only applicable to compact, close-coupled installations.

OPTIBAR DP 7060 C

The OPTIBAR DP 7060 is a differential pressure transmitter for precise relative gauge and differential pressure measurement. The completely newly developed piezoresistive sensor provides not only the exact differential pressure under any operating conditions, but also simultaneously measures the static pressure in the process line. Due to the high overload resistance it is suitable for applications with high static pressure.

Through standardised process connections the compatibility to most DP flow elements and accessories on the market is ensured. It can be combined with all KROHNE/SEIKO DP flow elements to ensure an accurate and reliable measurement.

The extremely compact measuring cell has a robust and precise response to temperature changes and, with step response times of just 125 ms, it provides measurements fast enough for reliable and stable process control.

Specification:
- 10 mbar...16 bar / 0.44...232 psi up to PN 400/5800 psi
- Communication 4...20 mA; HART® 7; PROFIBUS® PA; FOUNDATION™ fieldbus
- SIL2/3
- Ex Approvals: ATEX / IECEx Ex ia; Ex d; Ex d
- Turndown up to 100:1
- Display turnable in 90° steps
- Repeatability of measurement: 0.1%
- Reference accuracy DP: <±0.065%
- Total performance 0.2%
- Temperature range
  - Process: -40...+85°C / -40...+185°F
  - Ambient: -40...+80°C / -40...+176°F

Benefits:
- 3D linearisation
- Integrated static pressure sensor
- Event logger/measurement data storage

Total 3D linearisation / Technology Icon

Application-specific measurement uncertainty is caused by changing process conditions and depends on the variability of each respective application. The measurement uncertainty stated by the manufacturer is only given for the specified process conditions.

Three factors which affect measurement uncertainty:
- Linearity of the differential pressure signal (DP)
- Influence on the ambient temperature (T)
- Influence on the static pressure (SP)

total 3D
linearisation

To keep the measurement error or measurement uncertainty as low as possible the differential pressure sensor is multidimensionally linearised during production. Only the combination of all three factors – differential pressure, static pressure and ambient temperature – which all must be considered together, is decisive.

For the 3D linearisation, specified operating ranges are targeted. An example is presented for a 500 mbar DP measuring cell:
- Differential pressure (DP): -500...+500 mbar
- Temperature (T): -40...+85°C / -40...+185°F
- Static pressure (SP): 0...160 bar / 0...230.6 psi

SEIKO production

SEIKO Flowcontrol is a trusted partner that provides the experience and technical know-how to deliver the optimum DP flow element to solve any application challenges. The product range of SEIKO Flowcontrol includes standard as well as engineered products depending on customer requirements and operating environment. A complete range of DP flow elements is available, which includes orifice plates, orifice flanges, meter run assemblies, compact orifice flowmeters, restriction orifices, flow nozzles including throat tap nozzles, Venturi tubes, cone meters and wedge meters.

SEIKO Flowcontrol is well known for design, manufacturing and supply of high quality flow measurement products for standard and individual requirements in power plants, petrochemical plants, the oil & gas industry and many other process industries worldwide. Many international projects and extensive experience with state-of-the-art flow elements for combined-cycle power plants (CCPP or CCGT), with advanced gas turbines, or waste heat from industrial processes using heat recovery steam generators (HSRG) make SEIKO a skilful and competent partner for you.

Flow elements are carefully designed and tested in accordance with AGA, NORSOK, NACE, CRN, PED and ASME standards. From the well-head to the final customer product SEIKO flow elements can be found at each stage of production, processing, transportation, storage, refining and distribution for both liquid, gas and slurry media.

Manufacturing of standard and project specific flow elements completely in-house

Design work is done at the manufacturing plant in Blatnice according to all major standards including the latest editions of DIN EN ISO 5167, ASME MFC-3M and PTC 19.5, API and AGA standards etc. All DP flow elements can be supplied with a certificate of conformity according to the EU Pressure Equipment Directive 2014/68/EU.

SEIKO Flowcontrol also has an extensive warehouse. Over 1500 tons ASME and EN materials are available in stock. A wide variety of special materials for power plants, particularly for use at high temperatures and pressures, allow for high flexibility in production and delivery:

- X10CrMoVNb9-1 (1.4903)/ SA182F91
- 11CrMo9- 10 (1.7383)/ SA182F2
- 15NiCuMoNb5 (1.6368)
- 16Mo3 (1.5415)
- P305GH (1.0436) SA105.

The welding department is highly qualified to EN and ASME standard and the staff hold an impressive number of personal welding performance and welding procedure certifications like IWI (International Welding Inspector), EWE (European Welding Engineer) and IWT (International Welding Technologist).

Mechanical fabrication is done with a wide range of CNC machinery including saws, plasma cutting for carbon steel up to 50 mm (1.97 inch), standard lathes and special lathes for small pieces, press and three dimensional milling machines for big and small flanges and special fittings. To be up to date SEIKO constantly expands the machinery, for example with a waterjet cutting machine, a sand blasting machine with a cabin of a capacity of 200 m^3/7.063 cft, a welding robot and a shearing machine for sheets up to 25 mm (3x6m)/0.98"

Quality & safety: non-destructive tests in-house and documentation

SEIKO in-house capabilities include a wide variety of tests. All requested non-destructive tests can be carried out and verified with a full set of documentation:

- Visual testing (VT)
- Dimensional and alignment check
- Magnetic particles (MT), include pressure and leakage test
- Radiographic (RT), ultrasonic (UT) and dye-penetration (PT) testing
- Hardness test (HAT)
- Positive material identification (PMI)
- Purity control

Pressure tests up to 700 bar/10.1552 psi can be executed for flow elements and pipes of a length of max.10.5 m/34.5 ft.

Documentation can include design and flow calculations, dimensional drawings, quality plan, material certificates and traceability, welding and test schedules, dimensional and alignment reports, PWHT-report, corrosion protection, packing and dispatch inspection reports.

Customers can also choose to have a surface preparation and a conservation of equipment for corrosion protection, e.g. by application of paint or preservative oils and other rust inhibitors. In the final assembly meter runs can be mounted optionally with shut-off valves, condensate chambers, manifolds, etc.

Highlights:

- SEIKO uses “SolidWorks” CAD systems for engineering design work, which includes comprehensive 3D graphics, scale 1:1, collision warning and weight calculations
- Over 1500 tons of ASME & EN materials are in stock, including pipes, flanges & solid bars up to 24"
- Mechanical fabrication is done in a state-of-the-art machining centre
- The SEIKO welding department is qualified to EN and ASME standards and holds an impressive number of personal welding performance and welding procedure certifications
- Post-weld heat-treatment for meter runs up to 10 m/32.8 ft length can be done in our electrically heated temperature-controlled ovens
- All non-destructive tests can be done in-house including positive material identification (PMI)
- Pressure tests up to 700 bar/10.1552 psi will be executed in the new pressure test rig for flow elements and pipes for a length of max. 10.5 m/34.5 ft
- Surface preparation and conservation of equipment for corrosion protection

SEIKO is your reliable partner for custom-built DP flow elements and offers high quality solutions for individual requirements in many industries.

Venturi Calibration Services

The VENTURI CALIBRATION SERVICES (VCS) flowmeter calibration laboratory – accredited according to EN ISO / IEC 17025 – uses a process known as "wet calibration" to test flowmeters under good flow conditions on its flow rigs.

VENTURI CALIBRATION SERVICES is located in the Czech Republic, and was established in 2011, based on previous long-term experience. The calibration laboratory provides a fully equipped facility to measure the actual flow in its water flow calibration rigs.

VENTURI CALIBRATION SERVICES provides services in flow calibration in accordance with EN ISO 5167 and ASME PTC-6, ASME PTC 19.5. VCS has built the biggest hot-water calibration plant in Europe, with the newest generation of instrumentation and automation equipment, completely made of stainless steel components.

VCS specialises in meters with a differential pressure output, for example – orifice plates, Venturi meters, ISA nozzles and ASME PTC-6. Calibration is also carried out on most other types of equipment including electromagnetic, turbine, ultrasonic and other volume and mass flowmeters.

The VCS water calibration rig is supplied by a 150000 litre storage reservoir, delivering flow rates up to 5200 m^3 per hour, in pipe diameters from 80 mm up to 1200 mm. The accuracy of each flowmeter is obtained by comparing its measurement performance against a known value which is provided by a reference device such as a weigh tank, or a master flowmeter.

Laboratory parameters

	Rig I (Main rig)	Rig II (Small rig)
Test medium	Water with max. temperature of 80°C or 176°F Flow capacity: 100...5200 m^3/h or 1.44 m^3/s or 1.140k UK-gallons	Water with max. temperature of 80°C or 176°F Flow capacity: 100...5200 m^3/h or 1.44 m^3/s or 1.140k UK-gallons
Max. pressure difference	6000 mbar > 87 psi	6000 mbar > 87 psi
Min. pressure difference	5 mbar > 0.07 psi	5 mbar > 0.07 psi
Max. system pressure	9 bar A. > 130 psi	9 bar A. > 130 psi
Length of test section	46 metres (may get extended on special request up to 75 metres)	8 metres
Available length for meter runs	39 metres (may get extended on special request up to 68 metres)	5 metres
Capacity of etalon weigh tank	35000 kg or 38.5 tn	No etalon tank yet!
Size of a meter to be calibrated	DN80...1400 or 3...56"	DN15...100 or ½...4"
Expanded uncertainty of "C" (Coefficient of Discharge)	0.22...0.5% ... using comparison method	0.22...0.5% ... using comparison method
	0.09...0.15% ... using gravimetric method	

A calibration is performed to have a lower measurement uncertainty, when the DP flow element exceeds the standard or when the uncertainty according to standard is too large for the customers' requirements. The calibrated measurement results are documented in a calibration protocol.

Example for calibration at VCS

Fluid	LP Steam	IP Steam	HP Steam
Oper. T	250°C	425°C	550°C
Oper. P	12 bar A.	51 bar A.	180 bar A.
FE	Cl. venturi tube	Cl. venturi tube	Cl. venturi tube
Min. Q.	≤1 kg/s	3.2 kg/s	6.3 kg/s
min. Δp	1.2 mbar	2.5 mbar	2.5 mbar
Pressure Ratio	0.9999 τ	0.99995 τ	0.9999 τ
Max. Q.	28 kg/s	100 kg/s	200 kg/s
Velo. in pipeline	75 m/s	61 m/s	52 m/s
max. Δp	1200 mbar	2500 mbar	2500 mbar
Pressure Ratio	0.95098 τ	0.95098 τ	0.95098 τ
~dw perm.	100 mbar	200 mbar	200 mbar
D_{20}	300 mm	350 mm	300 mm
d_{20}	178	204	207
Beta	≤0.6	≤0.6	≤0.7
$Re_{Dmax.}$	6.6×10^6	14.2×10^6	2.7×10^7
$Re_{Dmin.}$	2.2×10^5	4.5×10^5	8.4×10^5
Turn Down Δp	1:1000	1:1000	1:1000
Uncert. [1)]	~ 5%	~ 4%	~ 3.5%
Uncert. [2)]	~ 3%	~ 2%	~ 2%
Uncert. [3)]	≤ 0.3%	≤ 0.25%	≤ 0.2%

[1)] Uncalibrated, Standard "C", 2-3 Transmitters, No Flowcomputer
[2)] Calibrated with Oper. ReD, 2-3 Transmitters, No Flowcomputer
[3)] Calibrated with Oper. ReD, 2-3 Transmitters, Flowcomputer for C/ReD/τ

Headquartered in Duisburg, Germany, KROHNE has a large network of development and production sites which specialise in manufacturing different parts of our product range:

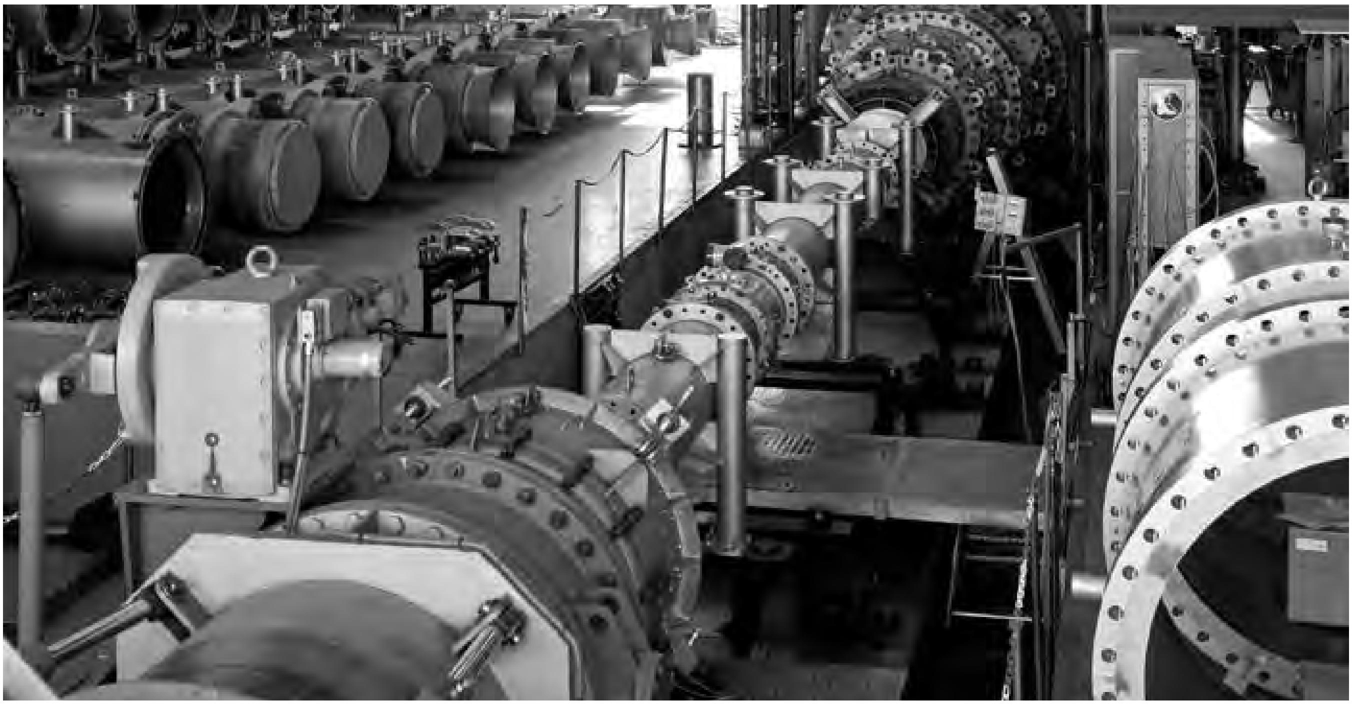
- Beverly, MA, USA (completion mid 2018): electromagnetic, variable area and mass flowmeters, radar and guided radar level transmitters
- Breda, the Netherlands: oil & gas metering and proving systems, custody transfer products, leakage detection and localisation systems, flow computers, asset management systems
- Brevik, Norway: tank monitoring and alarm systems, fuel consumption and bunkering monitoring systems
- Bogotá, Colombia (joint venture): metering systems
- Chengde, China (joint venture): variable area, Vortex, DP, turbine flowmeters, flow controllers, level transmitters, temperature instruments
- Dordrecht, the Netherlands: electromagnetic, ultrasonic and multiphase flowmeters, oil & gas metering and proving systems
- Duisburg, Germany: variable area and Vortex flowmeters, analysis sensors and systems
- Kuala Lumpur, Malaysia: oil & gas metering skids
- Malmö, Sweden: temperature assemblies, sensors and transmitters
- Minden, Germany: pressure and differential pressure devices
- Pune, India (joint venture): Vortex, variable area and electromagnetic flowmeters, flow controllers and switches, mechanical level transmitters
- Romans-sur-Isère, France: radar and guided radar level transmitters, mechanical level transmitters, level switches, flow controllers and switches
- Samara, Russia: ultrasonic, Vortex and electromagnetic flowmeters; radar, guided radar and mechanical level transmitters
- São Paulo, Brazil (joint venture): electromagnetic flowmeters
- Shanghai, China (joint venture): electromagnetic flowmeters
- Shanghai, China: electromagnetic and mass flowmeters, radar and guided radar level transmitters
- Wellingborough, United Kingdom: mass flowmeters

At KROHNE, we have a thorough quality and sustainable development policy applied and integrated into all levels of organisation. Available certifications and declarations include:

- Quality management: all KROHNE feeder factories are ISO 9001 certified
- Certified calibration standards (see chapter "Calibration")
- Welding certifications (ISO 3834)
- Certified environmental management system (ISO 14001)
- Industry-related certifications: ATEX, IECEx, FM, NEPSI, EHEDG, HART®, FOUNDATION™ fieldbus ITK, GOST, EAC, SIL, Achilles JQS, NSF, OHSAS etc.

For more information about quality management and certifications, please visit **www.krohne.com**

Headquarters of KROHNE in Duisburg, Germany



The world's most precise volumetric calibration rig for flowmeters up to DN3000/120"

Calibration from KROHNE: Certainty you can count on

Calibration is one of KROHNE's core areas of expertise. If you buy a KROHNE product, you will get a measuring device that performs most accurate with low uncertainty under real process conditions.

To achieve this, we operate more than 140 calibration facilities for volume flow, mass flow, level, temperature, density and pressure to (wet-)calibrate any device we manufacture. For example, every flowmeter is wet-calibrated using water or air as standard before leaving our facilities.

We can also provide customer-specific calibration such as:
- Carry out multipoint calibrations
- Vary different parameters such as temperatures, viscosity, pressures etc.
- Use the actual medium or similar fluid
- Build or emulate customer-specific flow geometries
- Use piping provided by the customer

For calibration we only use direct comparison of measurands (e.g. we calibrate our Coriolis mass flowmeters with a gravimetric weighing system). Our calibration rigs are the most accurate used in any measurement device production worldwide: the accuracy of the reference is usually 5 to 10 times better than that of the meter under test.

This goes for small as well as for very large sizes: KROHNE operates the world's most precise volumetric calibration rig for flowmeters up to DN3000 / 120" with a certified accuracy of 0.013%. The reference vessel is a 44 m / 144 ft high tank containing almost 0.5 million litres / 132,000 gal (US) of water which allows for a maximum flow rate of 30,000 m^3/h, or 7,925,000 gal (US)/h.

Certified technology for fiscal & custody transfer applications

Our meters can be calibrated and certified according to various standards such as OIML, API, Measuring Instruments Directive (MI-001, 002, 004, 005), GOST, etc. The standards we use for calibration are ISO/IEC 17025 accredited and traceable to international or national standards. Regular inspections by national metrology institutes, round robin tests and alignments with national and international metrological standards according to ISO 9000 and EN 45000 guarantee the quality and comparability of our calibration rigs. Staff performing the calibrations are trained and given regular refresher training to ensure quality and continuity.

KROHNE – Products, Solutions and Services

- Complete product portfolio: flow, level, temperature, pressure, process analytics
- Application-specific system solutions for various industries
- Services for instrumentation projects

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