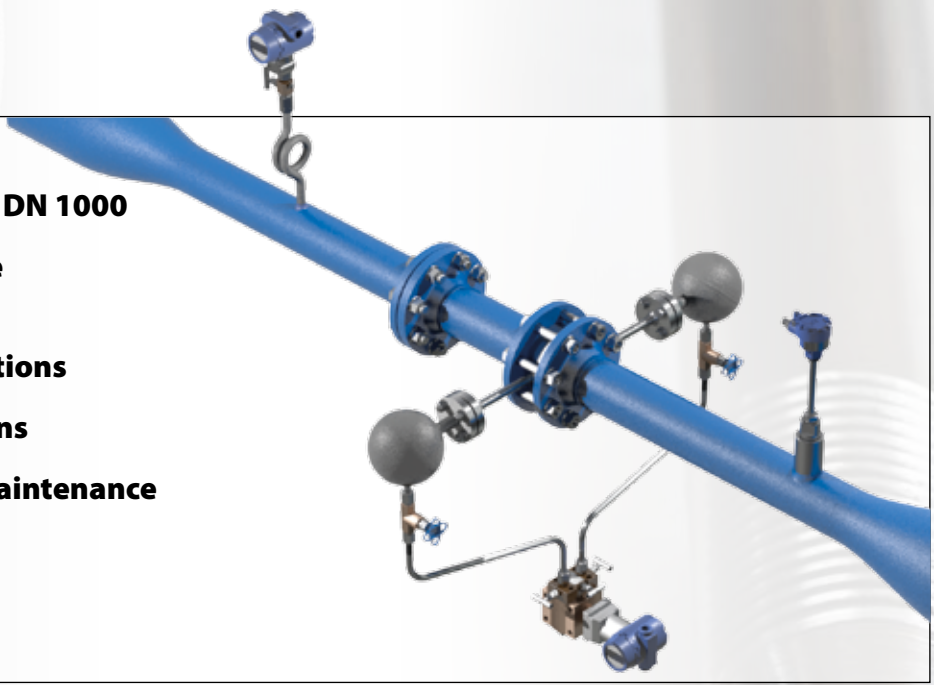
JSP Industrial Controls

Measurement of flow

Primary devices (orifice plates, nozzles, Venturi tubes)

- ☑ **Measurement of flow up to nominal diameter DN 1000**
- ☑ **Wide ranges of pressure and temperature**
- ☑ **Spot or chamber extractions**
- ☑ **Complete measuring runs**
- ☑ **Simple assembly and maintenance**



ООО «ТИ-СИСТЕМС» ИНЖИНИРИНГ И ПОСТАВКА ТЕХНОЛОГИЧЕСКОГО ОБОРУДОВАНИЯ
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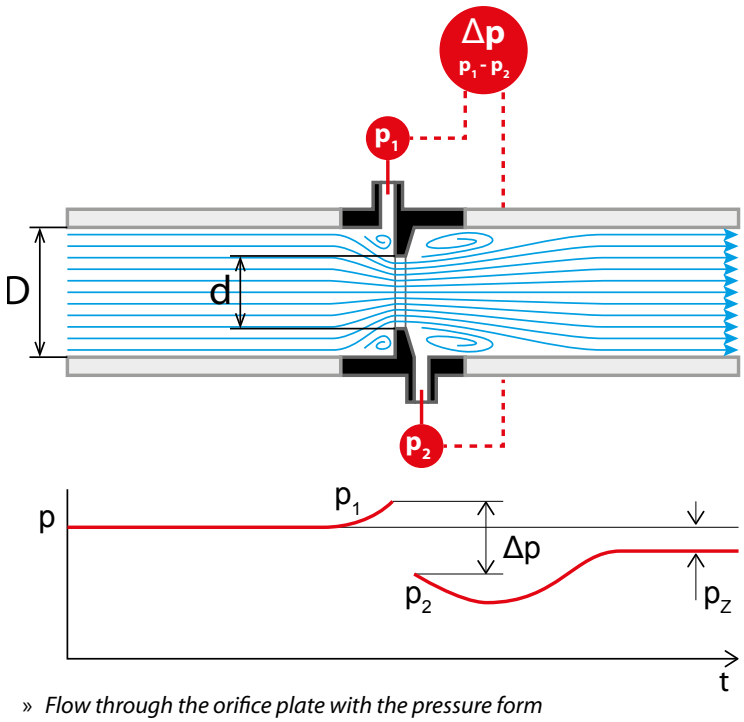
[introduction]

MEASUREMENT OF FLOW BY MEANS OF PRIMARY DEVICES

The measuring method consists in installing a primary device (orifice plate, nozzle, or Venturi tube) in the conduit which causes a difference in static pressure in front of and behind a throttling device. The instantaneous flow is directly proportional to the root of the difference in pressures. This difference in static pressures is measured with a pressure differential device.

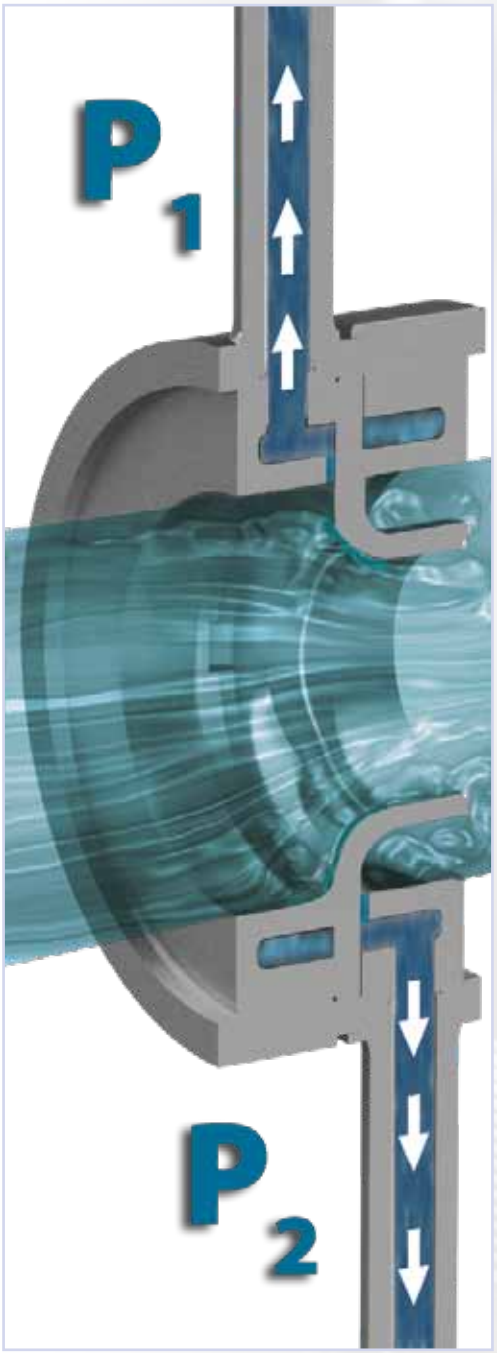


» *Flow through the orifice plate with the pressure form*

General equation and basic concepts

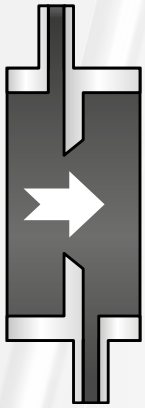
$$Q_V = \frac{C}{\sqrt{1-\beta^4}} \cdot \varepsilon \cdot \frac{\pi \cdot d^2}{4} \cdot \sqrt{2 \cdot \frac{p_1 - p_2}{\rho}}$$

- Q_v *volumetric flow rate*
- C *flow coefficient*
- β *ratio of diameters (β=d/D)*
  d … throttling device opening diameter
  D … conduit internal diameter
- ε *expansion coefficient*
  for fluids ε=1
  for gases ε<1
- Δp *(p1 – p2) difference in pressures in front of and behind the throttling device*
- ρ *medium density*
- Re *Reynolds number dimensionless parameter expressing the inertia forces to frictional forces ratio*
- Ra *mean arithmetic roughness*
- P_z *permanent pressure loss*

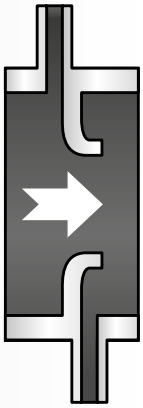


» *Cross section of a chamber nozzle*

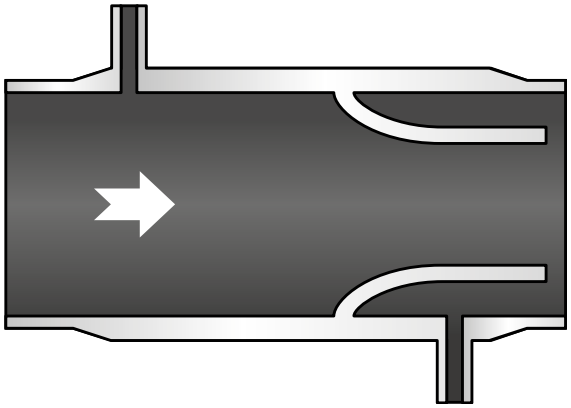
MOST FREQUENTLY USED TYPES OF THROTTLING DEVICES SPEC. BY EN ISO 5167



» *Orifice plate*

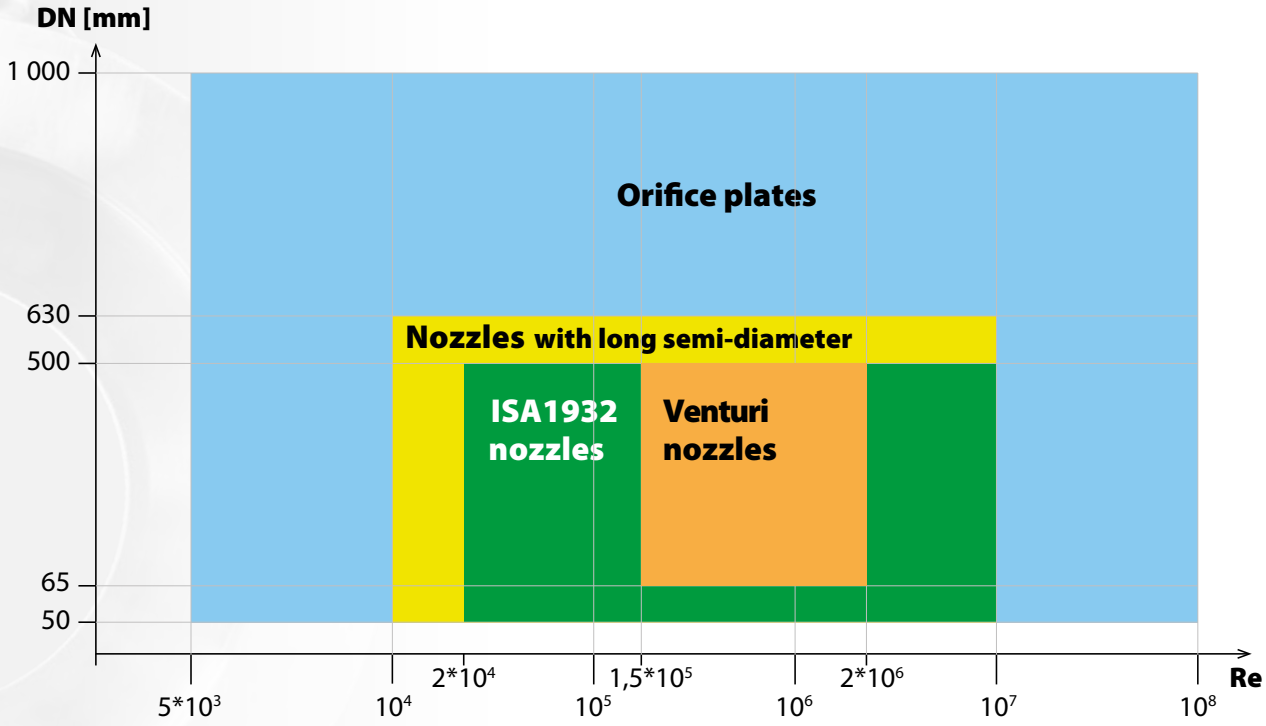


» *ISA1932 Nozzle*



» *Long semi-diameter nozzle*

Area of use of orifice plates and nozzles acc. to EN ISO 5167

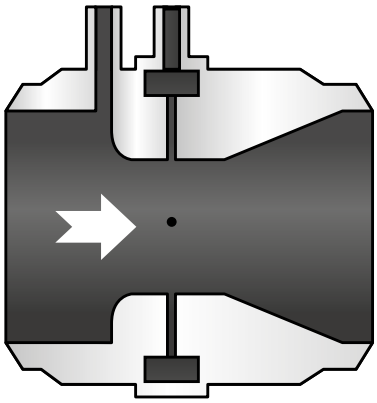


Advantages of measuring with throttling devices

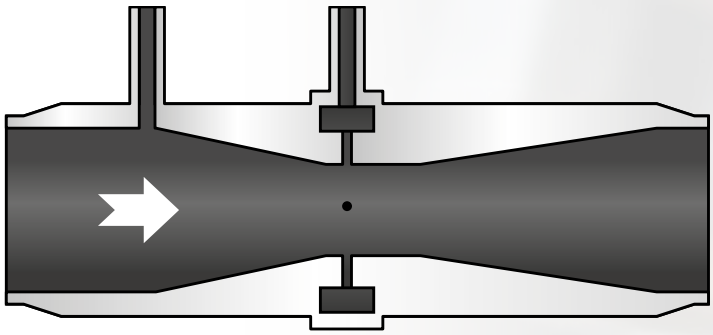
- Proven and elaborated method supported by a number of technical standards and numerous control Measurements
- Wide range of conduit diameters
- Wide range of measured media (regarding states, corrosiveness, conductibility, impurities, etc.)
- Wide ranges of pressures and temperatures of the measured medium
- Simple assembly, maintenance, and parameter verification
- Measuring for favourable prices

Basic conditions

- Single-phase medium not changing at a pressure change
- Steady (non-pulsating) flow
- Flow remaining subsonic throughout the measuring section
- Conduit diameter running full



» *Venturi nozzle*

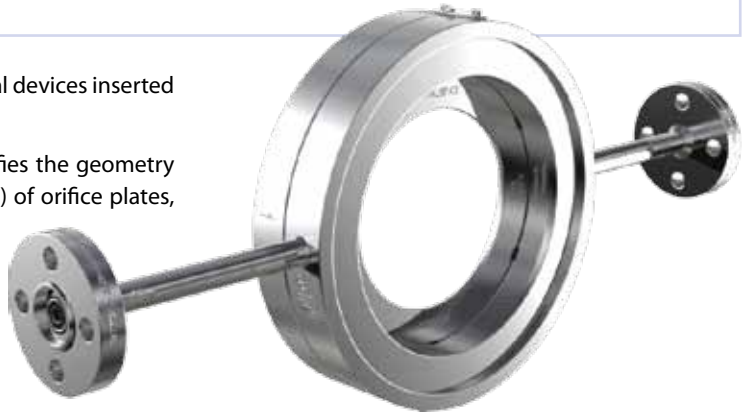


» *Venturi tube*

Complete measuring circle:

1. Static pressure measuring device with a condensation loop
2. Straight conduit sections in front of and behind the throttling device
3. Wafer type orifice plate with the extraction angle of 180°
4. Condensation vessels
5. Temperature measuring device
6. Pressure differential device with a valve set

EN ISO 5167 STANDARD



Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full.

The EN ISO 5167 standard, consisting of four parts, specifies the geometry and method of use (installation and operating conditions) of orifice plates, nozzles and Venturi tubes.

- EN ISO 5167-1: General principles and requirements
- EN ISO 5167-2: Orifice plates
- EN ISO 5167-3: Nozzles and Venturi nozzles
- EN ISO 5167-4: Venturi tubes

Requirements on conduits

- Most of the requirements on conduits apply to the provision of the correct fluid **velocity profile** in front of and behind a throttling device.
- The standard assumes **rotationless flow** (max 2°) and an acceptable velocity profile (the ratio of local axial velocity to the maximum axial velocity in every profile corresponds to the velocity ratio at the end of a very long 100D section within 5%).
- **Conduit straightness** – maximum permissible deviation of the conduit straightness 0.4 %.
- **Conduit circularity** – a visual check is sufficient except for the 2D section in front of and behind the primary device.
- **Conduit dimensions**
  – Conduit internal diameter accuracy in front of and behind the orifice plate (nozzle)
  – Orifice plate (nozzle) centring against the conduit
  – Length of straight sections in front of and behind the orifice plate
  – Roughness of the conduit inner wall
- Straight welded pipes may be used on condition that spot extractions of the primary device and the tube seam plane form an angle of at least 30°.
- Spirally welded pipes may be used only if having smooth inner walls.

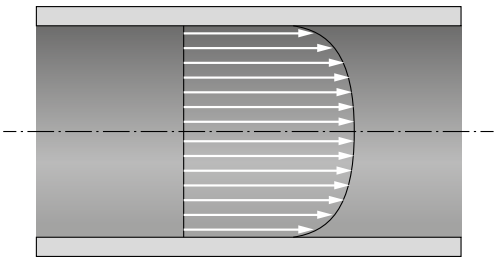
Surface roughness

The inner wall of the conduit along the 10D length in front of the primary device must be of the specified maximum (and, for some cases, also minimum) surface roughness Ra.

- For orifice plates the specified Ra limits depend on the Reynolds number ReD, on the ratio of diameter b = d/D, and on the conduit internal diameter D.
- For nozzles the specified Ra limits depend on the ratio of diameter b = d/D and the conduit internal diameter D.
- For Venturi tubes the specified Ra limits depend on diameter D, only within 2D length.

Requirements on the primary device installation in the conduit

- Straight sections of the conduit between the orifice plate and conduit fittings in required length.
- Conduit internal diameter in sections in front of and behind the primary device in required length.
- Orifice plate (nozzle) centred against the conduit.
- Roughness of the conduit inner wall in front of the orifice plate as required.
- Meeting requirements of the Government regulation no. 26/2003 Coll. on pressure equipment.
- Meeting requirements for invoicing purposes – verified design and execution.
- Meeting requirements on suitable installation of measuring devices.
- Qualified and authorised assembly company.



» *Velocity profile at turbulent fluid flow*

REQUIREMENTS OF GOV. REG. 26/2003 COLL. ON PRESSURE EQUIPMENT

Pressure conduits incl. installed components (throttling devices) shall be assessed with respect to Pressure Equipment Directive 97/23/EC. This Directive is applied through Act no. 22/1997 Coll. and Government regulation 26/2003 Coll. in the Czech Republic and through Government regulation 329/2003 Coll. in Slovakia.

Government regulation 26/2003 Col. specifies technical requirements on pressure equipment with the maximum permissible pressure higher than 0.5 bar. Such equipment includes, among other, conduits and parts thereof intended for transport of fluids.

Fluids are divided into two groups acc. to their properties:

- **Group 1** includes dangerous fluids (flammable, toxic, explosive, harmful, etc.) in compliance with § 2, art. 8 letters a) to g) of Act no. 157/1998 Coll. on chemical substances.
- **Group 2** includes all other fluids not specified in Group 1.

Fluids of both groups are further divided into:

- Gases, liquefied gases, gases dissolved under pressure, steam and fluids with vapour pressure at the highest operating temperature EXCEEDING common atmospheric pressure (1.013 bar) by more than 0.5 bar.
- Fluids with vapour pressure at the highest operating temperature NOT EXCEEDING common atmospheric pressure (1.013 bar) by more than 0.5 bar.

Pressure devices are divided into four categories acc. to Government regulation 26/2003 Coll.:

- **Category I** - EC declaration of conformity upon internal production control, in NP* absence, CE product marking.
- **Category II** - EC declaration of conformity upon internal production control, NP supervision of the final assessment, CE product marking including NP's identification number.
- **Category III** - EC testing of the NP's proposal and product quality assurance, EC certificate of NP's proposal testing issued by the NP, CE product marking including NP's identification number.
- **Category IV** - EC testing of the NP's type and product quality assurance, EC certificate of type testing issued by the NP, CE product marking including NP's identification number. **Not applied to conduits.**

The equipment category is determined with the use of a graph for the given equipment type and fluid group. The conduit category is determined upon nominal internal diameter DN and the maximum permissible pressure PS, or upon their product, in some cases also upon fluid temperature.

No requirements are specified by Government regulation 26/2003 Coll. for equipment not falling into any of the categories. However, such equipment must be safe, and designed and manufactured in compliance with proper technical practice. Such equipment must not bear the CE marking and has no EC declaration issued.

* … NP – notified person

EC declaration acc. to Directive of the European Parliament and of the Council 97/23/EC on pressure equipment

implemented by Act no. 22/1997 Coll. and Government reg. no. 26/2003 Coll.

The EC declaration shall be issued by the manufacturer for a particular product.

Category I

- EC declaration in NP absence (e.g. TÜV)
- CE product marking

Category II

- EC declaration with NP presence (e.g. TÜV)
- CE product marking incl. NP's ID no.

Category III

- EC declaration with NP presence (e.g. TÜV)
- EC certificate issued by NP
- CE product marking incl. NP's ID no.

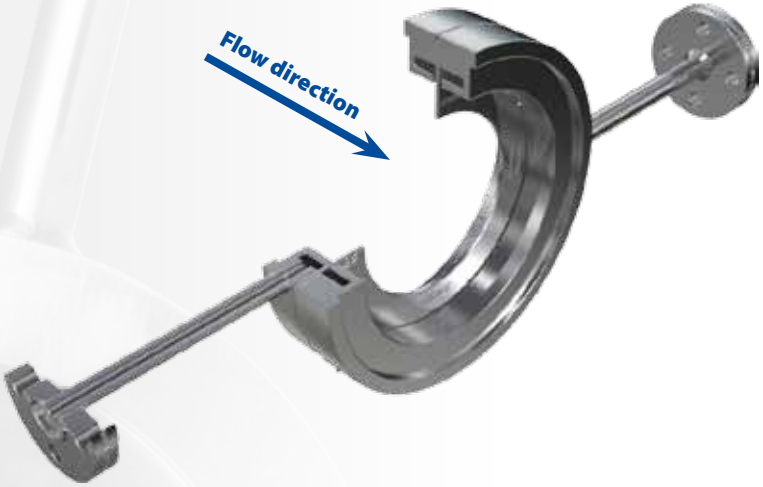
Documents for EC declaration

- Drawing documentation
- Strength calculations
- Welding documents (WPS, WPQR, welder's certificate)
- Pressure test (categories II and III with NP presence)
- Penetration test
- X-ray weld test
- Material certificates complying with Directive 97/23/EC

» *EC declaration acc. to Directive of the European Parliament and of the Council 97/23/EC (implemented by Act no. 22/1997 Coll. and Government reg. no. 26/2003 Coll.)*

[orifice plates] acc. to EN ISO 5167-2

WAFER TYPE ORIFICE PLATES **CB / C4B / CK**



» *Sectional view of a chamber extraction orifice plate (CK)*

» *Sectional view of a chamber extraction four-hole orifice plate (C4B)*

» *Sectional view of a chamber extraction centric orifice plate (CB)*

CB, C4B

- Installed between flanges.
- Nominal internal diameter DN15 to DN1000 (DN40 to DN1000 for C4B).
- Nominal pressure PN6 to PN320.
- Material 1.7335, 1.7715, 1.7380, 1.4541, 1.4571.
- Complying with ISO 5167-1 and ISO 5167-2.
- Documentation for certification acc. to PED 97/23/EC.

CK

- Installed between flanges.
- Nominal internal diameter DN50 to DN300.
- Nominal pressure PN6 to PN160.
- Material P265GH/1.4541, 1.4541, 1.4571.
- Complying with ISO 5167-1 and ISO 5167-2.
- Documentation for certification acc. to PED 97/23/EC.

Description

Parameters and design of the CK orifice plates with chamber extractions and CB orifice plates with spot extractions fully comply with EN ISO 5167-1/2. If the maximum error of the flow (heat) measurement is to be determined, installation of the orifice plate into the conduit and parameters of the straight conduit sections in front of and behind the orifice plate must comply with EN ISO 5167-2.

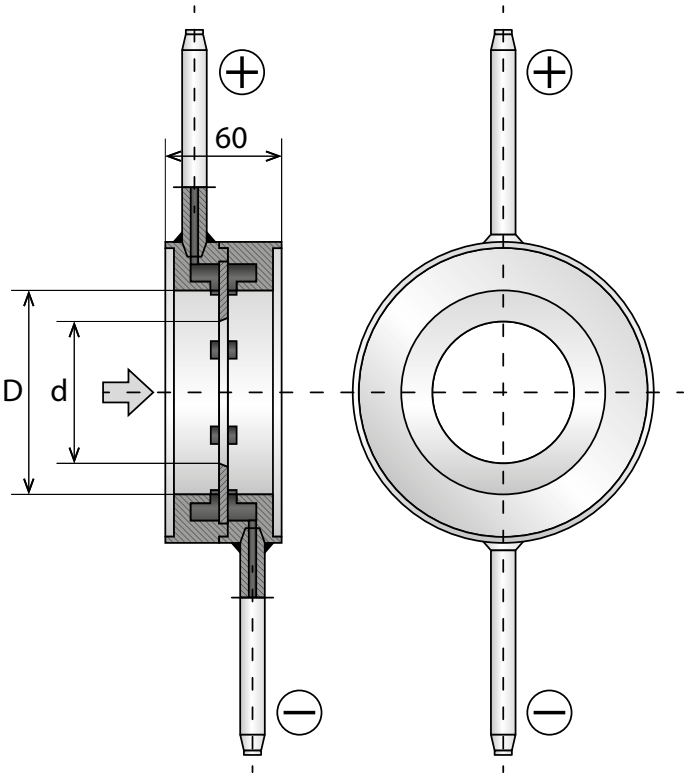
Orifice plates (both chamber and spot types) are designed for installation between flanges in circular cross-section conduit. They are made of various materials with several types of sealing surfaces, with optional angle and ending of extraction pipes. The orifice plates may not be used for oxygen without being degreased. Degreasing is not provided by the manufacturer! Certificate of welded joint tightness pressure test is submitted only upon customer's demand.

The chamber extraction orifice plate consists of a two-piece frame with welded-on extraction pipes and an orifice disc. The disc is placed between the two parts of the flange and sealed on the lower pressure side (-) with soft sealing. Pressure is extracted from each piece of the frame through a ring-shaped chamber connected with the inner conduit space by extraction apertures. The disc is replaceable.

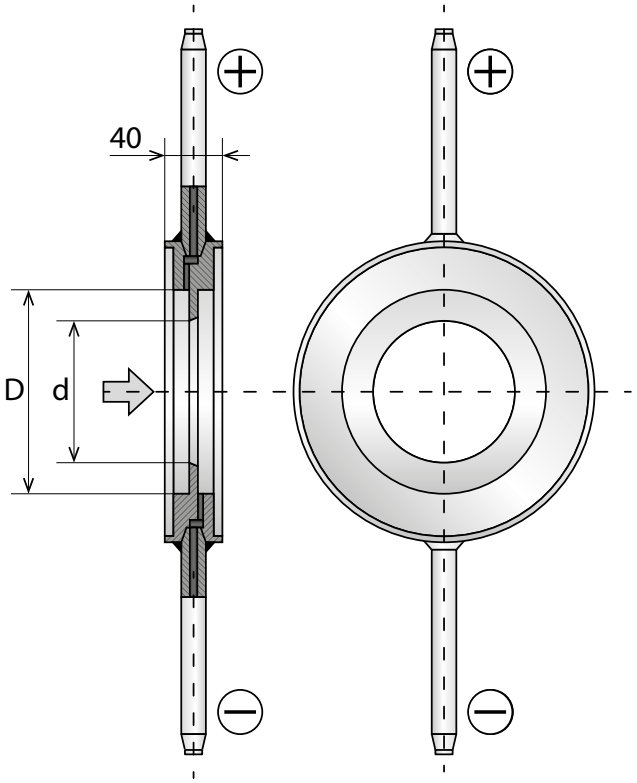
The spot extraction orifice plate consists of a single-piece frame with welded-on extraction pipes. The orifice disc forms part of the frame and is not replaceable independently. Pressure is extracted through openings in front of and behind the disc leading into extraction pipes.

… WAFER TYPE ORIFICE PLATES CB / C4B / CK

Dimensional drawings



» *Wafer type chamber extraction orifice plate (CK)*



» *Wafer type spot extraction orifice plate (CB)*

Technical parameters

Design:
CB – spot extraction centric orifice plate
C4B – Spot extraction four-hole orifice plate
CK – chamber extraction centric orifice plate

Nominal internal diameter:
CB – DN15 to DN1000
C4B – DN40 to DN1000
CK – DN50 to DN300

Nominal pressure:
CB, C4B – PN6 to PN320
CK – PN6 to PN160
depending on nominal internal diameter

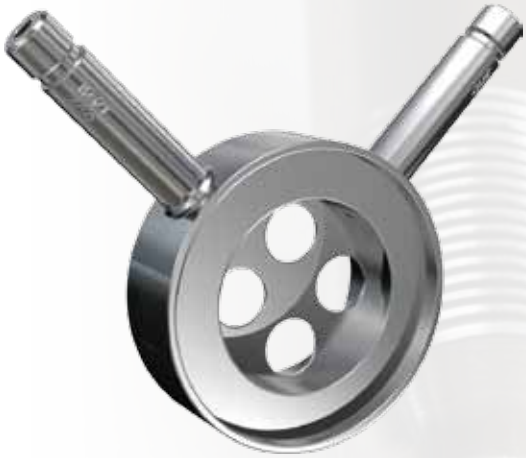
Medium temperature:
Up to 600 °C depending on material

Material:
Frame P265GH, orifice disc 1.4541
1.4541
1.4571
1.7335 (13CrMo4-5/13CrMo4-4)
1.7715 (14MoV6-3)
1.7380 (10CrMo9-10)
depending on the design

Optional accessories:
Assembly flanges (neck-shaped or flat)

Standards:
Government regulation no. 26/2003 Coll.
EN ISO 5167-1, EN ISO 5167-2, EN 10204
EN 13480-1, EN 13480-2
EN 13480-3, EN 13480-4
EN 1092, EN 287-1
EN ISO 15614-1
EN ISO 9712

Pressure extractions:
– Extraction angle 0 to 180°
– Double or triple extractions
– Various endings of extraction pipes (p. 17)



» *Spot extraction four-hole orifice plate C4B*

SOCKET WELD ORIFICE PLATES **CBV / CKV**

» *Sectional view of a chamber extraction orifice plate (CKV)*

CBV

- Welded into conduit.
- Nominal internal diameter DN50 to DN600.
- Nominal pressure PN6 to PN320.
- Weldment material P235GH, 1.5415, 1.7715, 1.7335, 1.7380, 1.4903, 1.4541, 1.4571.
- Complying with ISO 5167-1/2.
- Documentation for certification acc. to PED 97/23/EC.

CKV

- Welded into conduit.
- Nominal internal diameter DN50 to DN300.
- Nominal pressure PN6 to PN320.
- Weldment material P235GH, 1.5415, 1.7715, 1.7335, 1.7380, 1.4903, 1.4541, 1.4571.
- Complying with ISO 5167-1/2.
- Documentation for certification acc. to PED 97/23/EC.

Description

The measuring run set consists of an orifice plate with spot or chamber extractions and integrated sections of max. 2D in front of and behind the orifice plate. Parameters and design of the orifice plate and straight sections fully comply with EN ISO 5167-1/2. The set is welded to the follow-up technology on both ends.

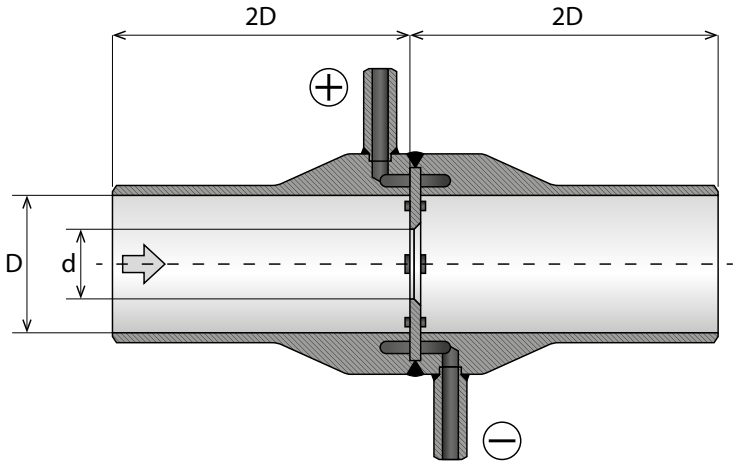
The chamber extraction orifice plate consists of a two-piece frame with welded-on extraction pipes and an orifice disc. The disc is placed between the two parts of the flange and sealed with a joining weld. Pressure is extracted from each piece of the frame through a ring-shaped chamber connected with the inner conduit space by extraction apertures. The set is non-dismantable and in case of a defect it must be replaced as a whole.

The spot extraction orifice plate consists of a single-piece pipe with welded-on extraction pipes. The orifice disc is socket welded. Extraction is performed through openings in front of and behind the disc leading into extraction pipes welded to the main pipe.

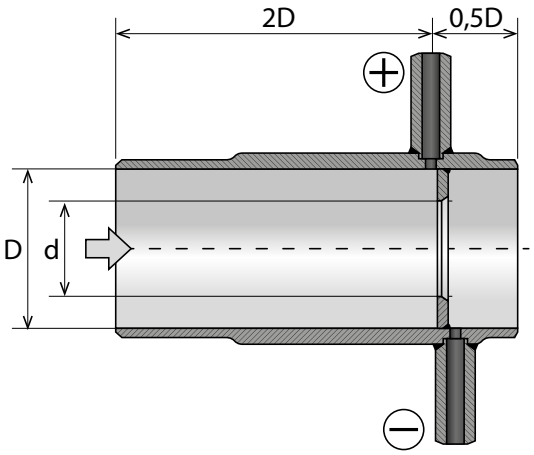
The straight sections are formed by seamless steel pipes with an accurate internal diameter. The straight section in front of the orifice plate is made in a standard length 2D and forms a part of the socket welded orifice plate set. The straight section behind the orifice plate is made in a standard length 2D for chamber extraction orifice plate and 0.5D for spot chamber orifice plate. The set is provided with a weld-on edge on both ends for welding to the follow-up technology.

Parameters and design of the CKV chamber extraction orifice plate as well as CBV spot extraction orifice plate fully comply with EN ISO 5167-1/2. If the maximum error of the flow (heat) measurement is to be determined, installation of the orifice plate into the conduit and parameters of the straight conduit sections in front of and behind the orifice plate must comply with EN ISO 5167-2.

Dimensional drawings



» *Socket weld chamber extraction orifice plate (CKV)*



» *Socket weld spot extraction orifice plate (CBV)*

Technical parameters

Design:
CBV – socket weld spot extraction orifice plate
CKV – socket weld chamber extraction orifice plate

Nominal internal diameter:
CBV – DN50 to DN600
CKV – DN50 to DN300

Nominal pressure:
PN6 to PN320 depending on nominal internal diameter

Medium temperature:
Up to 600 °C depending on material

Material:
P235GH
1.5415
1.7335 (13CrMo4-5/13CrMo4-4)
1.7715 (14MoV6-3)
1.7380 (10CrMo9-10)
1.4903 (P91)
1.4541
1.4571

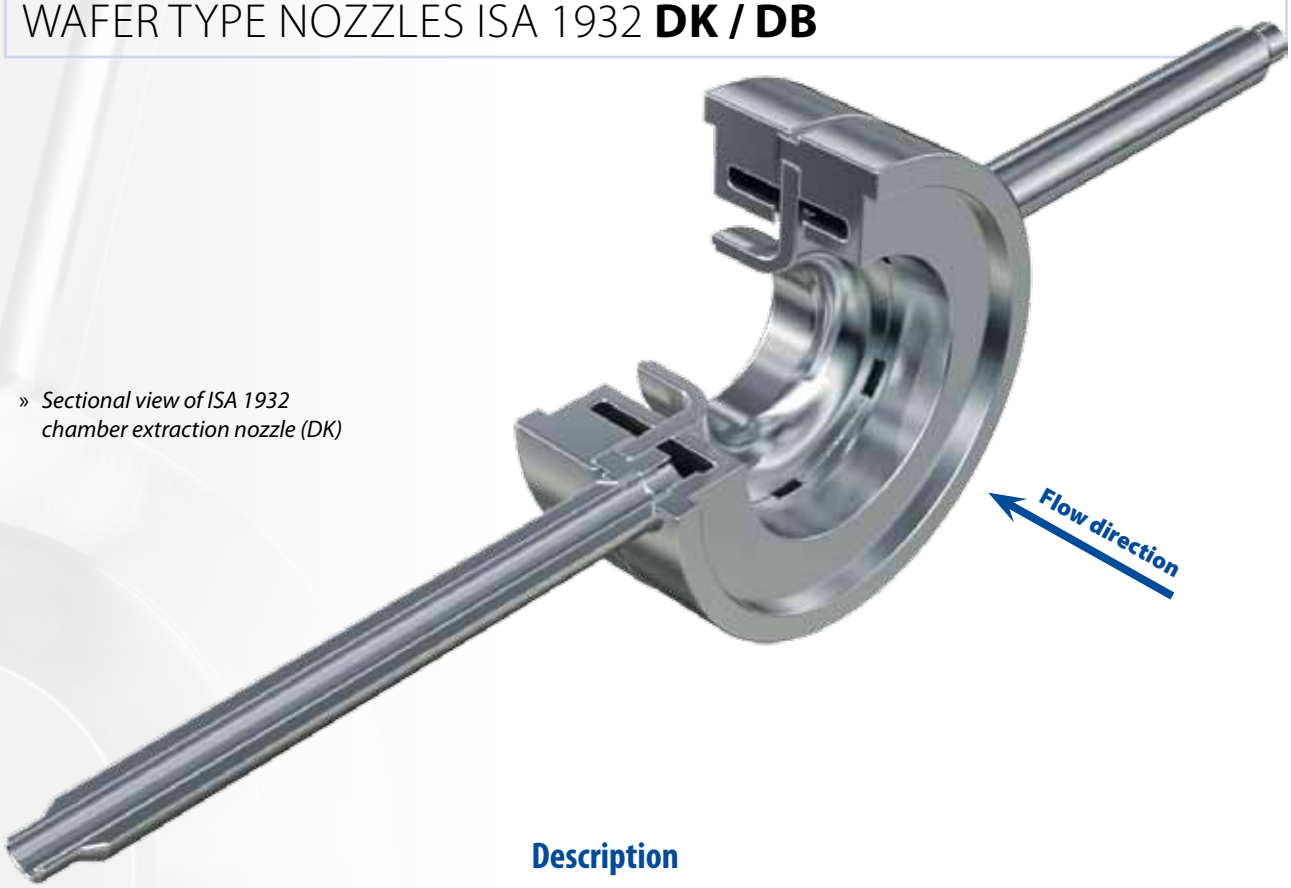
Standards:
Government regulation no. 26/2003 Coll.
EN ISO 5167-1, EN ISO 5167-2, EN 10204
EN 13480-1, EN 13480-2
EN 13480-3, EN 13480-4
EN 1092, EN 287-1
EN ISO 15614-1
EN ISO 9712

Pressure extractions:
– Extraction angle 0 to 180°
– Double or triple extractions
– Various endings of extraction pipes (p. 17)

» *Socket weld chamber extraction orifice plate (CKV)*

[measuring nozzles] acc. to EN ISO 5167-3

WAFER TYPE NOZZLES ISA 1932 **DK / DB**



» *Sectional view of ISA 1932 chamber extraction nozzle (DK)*

- Installed between flanges.
- Nominal internal diameter DN50 to DN300 (up to DN500 spot extractions).
- Nominal pressure PN6 to PN250.
- Material P235GH, 1.5415, 1.7715, 1.7335, 1.4541, 1.4571.
- Complying with ISO 5167-1/3.
- Documentation for certification acc. to PED 97/23/EC.

Description

The measuring run set consists of a nozzle with spot or chamber extractions, a straight section in front of the nozzle, a straight section behind the nozzle, a free flange, and accessories (fasteners, sealing). Parameters and design of the nozzle and straight sections fully comply with EN ISO 5167-1/3. The set is welded to the follow-up technology on both ends.

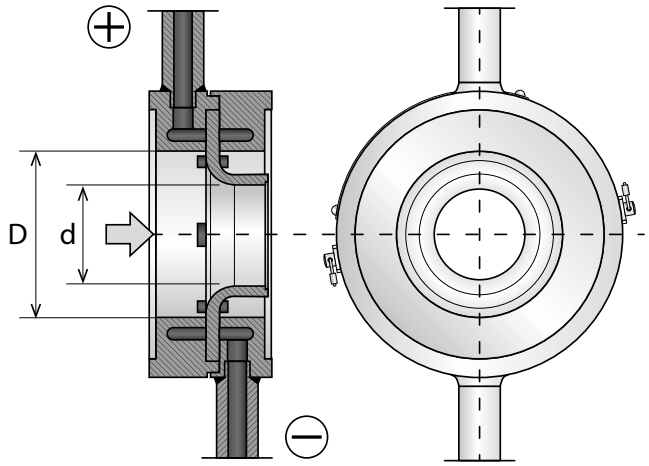
The chamber extraction nozzle consists of a two-piece frame with welded-on extraction pipes and a nozzle disc. The disc is placed between the two parts of the flange and on the lower pressure side (-) with soft sealing. Pressure is extracted from each piece of the frame through a ring-shaped chamber connected with the inner conduit space by extraction apertures. The chamber nozzle disc is replaceable.

The spot extraction nozzle consists of a single-piece frame with welded-on extraction pipes. The disc is part of the frame and is non-replaceable. Extraction is performed through openings in front of and behind the disc leading into extraction pipes.

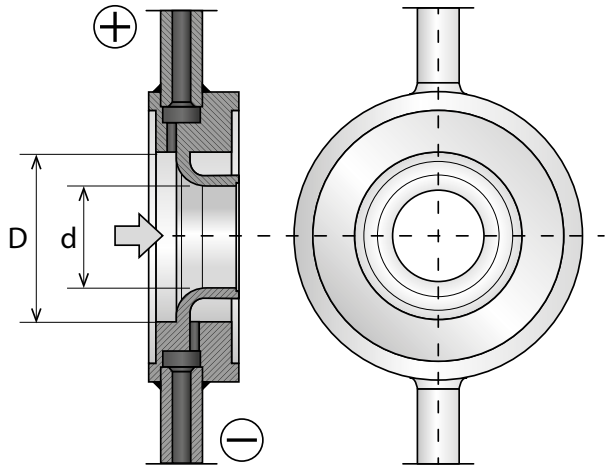
Parameters and design of the DK chamber extraction nozzle as well as DB spot extraction nozzle fully comply with EN ISO 5167-1/3. If the maximum error of the flow (heat) measurement is to be determined, installation of the nozzle into the conduit and parameters of the straight conduit sections in front of and behind the nozzle must comply with EN ISO 5167-3.

… WAFER TYPE NOZZLES ISA 1932 DK / DB

Dimensional drawings



» *Wafer type chamber extraction nozzle ISA 1932 (DK)*



» *Wafer type spot extraction nozzle ISA 1932 (DB)*

Technical parameters

Design:
DB – chamber extraction nozzle 1932
DK – spot extraction nozzle 1932

Nominal internal diameter:
DB – DN50 to DN500
DK – DN50 to DN300

Nominal pressure:
PN6 to PN250
depending to nominal internal diameter

Medium temperature:
Up to 600 °C depending on material

Material:
Frame P265GH, disc 1.4541
1.4541
1.4571
1.5415
1.7335 (13CrMo4-5/13CrMo4-4)
1.7715 (14MoV6-3)
depending on design

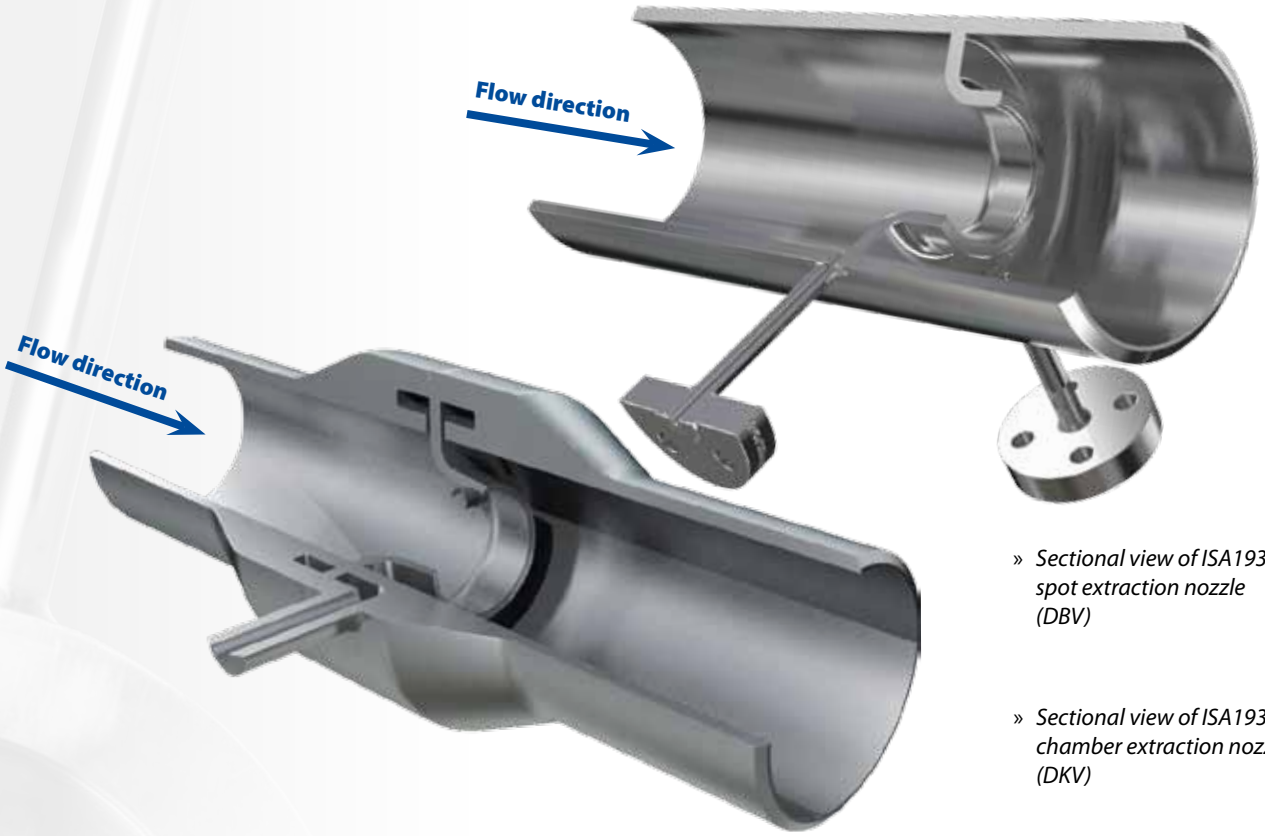
Standards:
Government regulation no. 26/2003 Coll.
EN ISO 5167-1
EN ISO 5167-3
EN 10204
EN 13480-1
EN 13480-2
EN 13480-3
EN 13480-4
EN 1092-1
EN 287-1
EN ISO 15614-1
EN ISO 9712

Straight section length:
– Usually 10D in front of and 8D behind the nozzle,
– Optionally 2D in front of and 2D behind the nozzle (standard for DN200 and higher)

Pressure extraction:
– Extraction angle 0 to 180°
– Double or triple extractions
– Various endings of extraction pipes (p. 17)

» *Chamber extraction nozzle ISA 1932 (DK)*

SOCKET WELD NOZZLES **DKV / DBV**



» *Sectional view of ISA1932 spot extraction nozzle (DBV)*

» *Sectional view of ISA1932 chamber extraction nozzle (DKV)*

- Welded into conduit.
- Design:
  ISA1932 with chamber extractions
  ISA1932 with spot extractions with long semi-diameter
- » Nominal internal diameter DN50 to DN300 (DKV), DN50 to DN600 (DBV).
- Nominal pressure PN6 to PN320.
- Material P235GH, 1.7715, 1.7335, 1.7380, 1.4903, 1.4541, 1.4571.
- Complying with ISO 5167-1-3.
- Documentation for certification acc. to PED 97/23/EC.

Description

The socket weld nozzle set consists of a nozzle and integrated pipe sections with the maximum length of 2D in front of and behind the nozzle. Parameters and design of the nozzle and straight sections fully comply with EN ISO 5167-1/3. The set is welded to the follow-up technology on both ends.

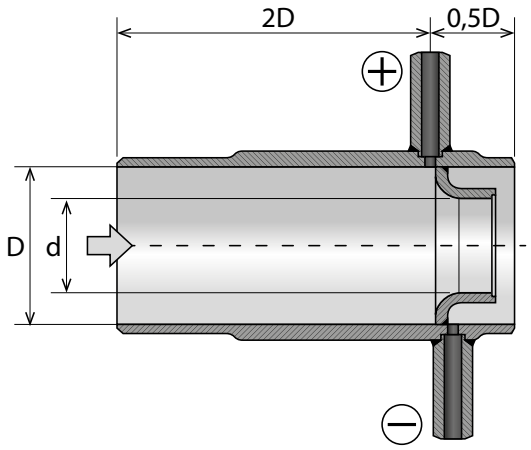
The ISA 1932 chamber extraction nozzle consists of a two-piece frame with welded-on extraction pipes and a nozzle disc. The disc is placed between the two parts of the frame and sealed with a joining weld. Pressure is extracted from each piece of the frame through a ring-shaped chamber connected with the inner conduit space by extraction apertures. The set is non-dismantable and in case of a defect it must be replaced as a whole.

The ISA 1932 spot extraction nozzle or long semi-diameter nozzle consists of a single-piece pipe with welded-on extraction pipes. The orifice disc is socket welded. Extraction is performed through openings in front of and behind the disc leading into extraction pipes welded to the main pipe.

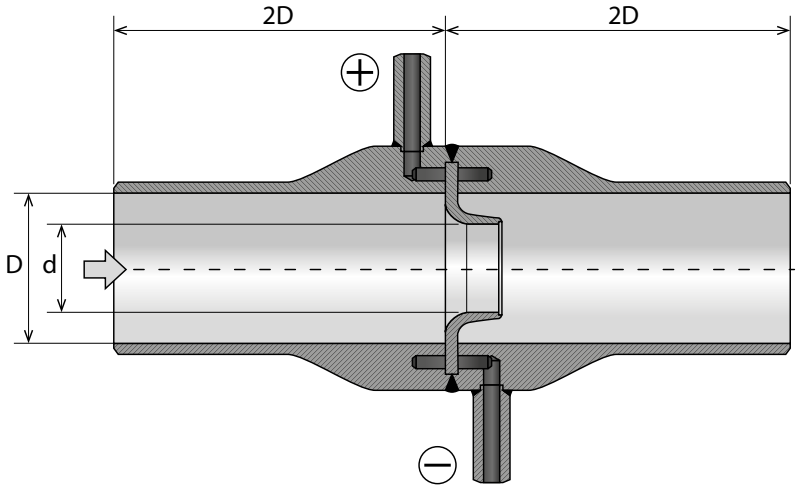
The straight sections are made of seamless steel pipes with an accurate internal diameter. The straight section in front of the nozzle is made in a standard length 2D. The straight section behind the nozzle is made in a standard length 0.5D for spot extraction nozzle, 2D for spot chamber nozzle, and 1D for long semi-diameter nozzle. The set is provided with a weld-on edge on both ends for welding to the follow-up technology.

Parameters and design of the DKV chamber extraction nozzle as well as DBV spot extraction nozzle fully comply with EN ISO 5167-1/3.

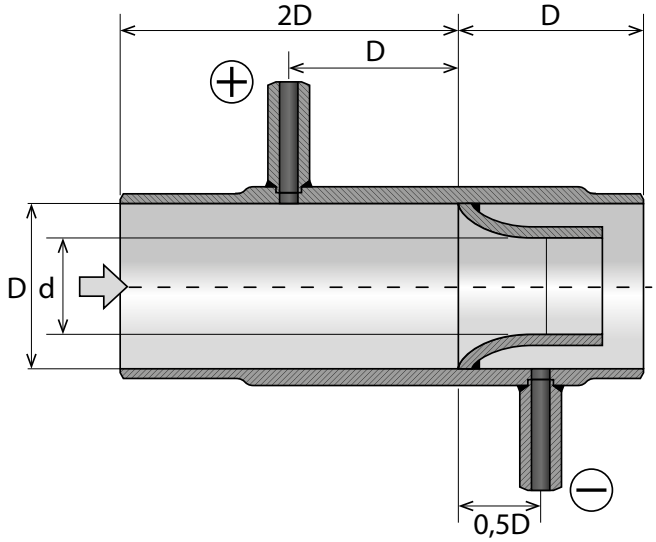
Dimensional drawings



» *Socket weld spot extraction nozzle ISA1932 (DBV)*



» *Socket weld chamber extraction nozzle ISA1932 (DKV)*



» *Socket weld spot extraction long semi-diameter nozzle (DBV)*

Technical parameters

Design:
DKV – socket weld chamber extraction nozzle ISA1932
DBV – socket weld spot extraction nozzle:
– ISA1932
– with long semi-diameter:
with a high ratio of diameters
with a low ratio of diameters

Nominal internal diameter:
DKV – DN50 to DN300
DBV – DN50 to DN600

Nominal pressure:
PN6 to PN320 depending on nominal internal diameter

Medium temperature:
Up to 600 °C depending on material

Material:
P235GH
1.5415
1.7335 (13CrMo4-5/13CrMo4-4)
1.7715 (14MoV6-3)
1.7380 (10CrMo9-10)
1.4903
1.4541
1.4571

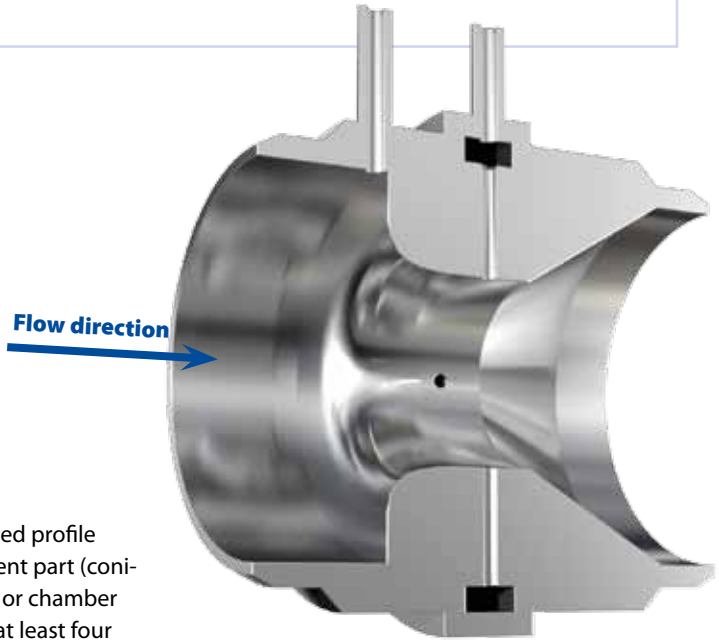
Standards:
Government regulation no. 26/2003 Coll.
EN ISO 5167-1
EN ISO 5167-3
EN 10204
EN 13480-1:2003
EN 13480-2:2003
EN 13480-3:2003
EN 13480-4:2003
EN 1092
EN 13480-1
EN 287-1
EN ISO 15614-1
EN ISO 9712

Straight section length:
– Usually 2D in front of and 0.5D behind the nozzle (2D in front of and 2D behind the nozzle for chamber extractions up to DN300)
– Optional as arranged with the manufacturer

Pressure extraction:
– Extraction angle 0 to 180°
– Double or triple extractions
– Various endings of extraction pipes (p. 17)

VENTURI NOZZLE

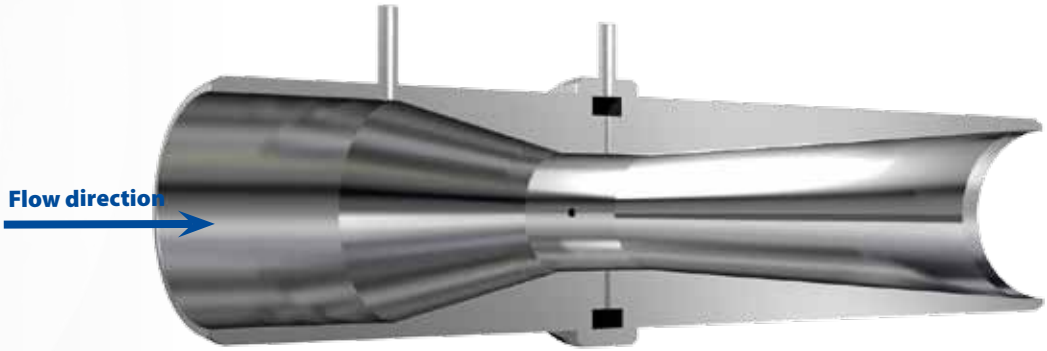
- Nominal internal diameter DN50 to DN500.
- Maximum pressure PN320.
- Maximum temperature (acc. to material) 550 °C.
- Material: carbon steel P265GH; 1.7335; 1.7715; 1.4541 (or other material).
- Extraction angle 0 to 180°
- Double or triple pressure extractions



Description

The Venturi nozzle consists of a convergent part with a rounded profile (identical to ISA 1932 nozzle), a cylindrical neck, and a divergent part (conical diffuser). The front pressure extraction may be of the spot or chamber type. The rear pressure extraction (in the neck) must contain at least four separate pressure extractions brought o a ring-shaped chamber or a circular extraction. The Venturi nozzle has a lower pressure loss than other nozzles.

[standard Venturi tube] acc. to EN ISO 5167-4



- Nominal internal diameter DN50 to DN500.
- Maximum pressure PN320.
- Maximum temperature 550 °C (acc. to material).
- Material: carbon steel P265GH; 1.7335; 1.7380; 1.7715; 1.4541 (or other material).
- Extraction angle 0 to 180°, or double.

Description

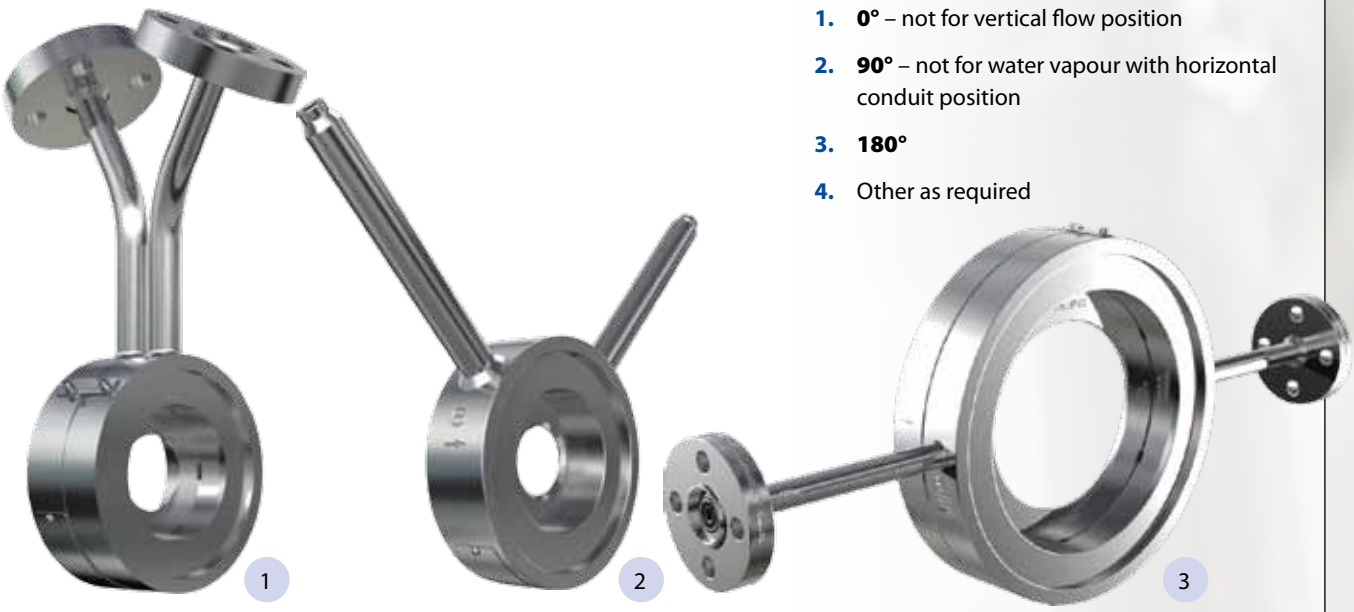
A primary device with the lowest pressure loss of all throttling devices. Pressure losses are the result of turbulences causing fluid friction; it is minimal in the Venturi tube since the transition from a bigger to a smaller diameter is continuous.

Whole rings are used for pressure extraction (chamber type) from which average pressure is obtained along the whole conduit section.

Thanks to the Venturi tube design the straight sections in front of and behind an obstacle do not have to be as long as with an orifice plate. Venturi tube also has a self-cleaning function making it more resistant to corrosion and deposits than other throttling devices, leading to lower maintenance costs.

[extraction design]

ANGLE BETWEEN EXTRACTIONS



1. **0°** – not for vertical flow position
2. **90°** – not for water vapour with horizontal conduit position
3. **180°**
4. Other as required

EXTRACTION TERMINATION

1. **Flanges**
   DN10/PN100 to PN250
   EN 1092-1, type 11F or 11B
2. **For welding**
   16x2 mm
   20x5.5 mm
   14x2 mm
   14x2.5 mm
3. **Tube for a cutting ring**
   12x1.5 mm
   14x2.5 mm
4. **Male thread**
   G1/2"
   G1/2" manometric
   M20x1,5 manometric
   M20x1,5L (left)
   1/2" NPT

complete measuring runs

Incl. approving the TCM gauge type for invoicing measurement

ORIFICE MEASURING RUNS **CMT** (WITH CENTRIC ORIFICE) **CMT4** (WITH 4HOLE ORIFICE)

In order to ensure accurate flow measurement, the fluid flow entering the primary device must be stabilised and other conditions of geometrical and mechanical accuracy specified by EN ISO 5167 must be met. Thus the whole run, incl. the primary device, must be manufactured as a set meting all requirements on the gauge quality and accuracy.

JSP, s.r.o., manufactures and supplies measuring runs in compliance with ISO 5167. Orifice plate measuring runs may be supplied with metrological certification for invoicing measurements (TCM gauge type approved acc. to §9 of Act no. 505/1990 Coll. on metrology, as amended). An EC declaration for pressure equipment is issued for orifice plate measuring runs according to the parameter of the medium measured in compliance with Government regulation no. 26/2003 Coll. (to PED 97/23/EC).

Measuring runs made by JSP are type approved with a centric orifice plate CMT and four-hole orifice plate CMT4. Only type-approved pressure differential devices, pressure measuring devices, thermometers, and evaluation units may be used with a measuring run form invoicing measurements.

When measuring runs entered the market with specified gauges, discrepancies in installation of orifice plates and their subsequent use were minimised. The measuring unit design enables assembly and disassembly of key parts of the gauge to be performed with flange joints. In terms of design, the run is divided into three sections: inlet section where the flowing medium calms down, measuring part (primary device), and outlet section. The set is welded to the follow-up technology on both ends.

- Complying with EN ISO 5167-1/2.
- Optional straight section length.
- Optional design of section joining.
- Type approval for invoicing measurements
  TCM 142/10-4780 for CMT
  TCM 142/15-5291 for CMT4
- Documentation for certification acc. to PED 97/23/EC.

Throttling device selection

Advantages of using orifice plates:

- Lower purchase cost
- Wide range of nominal internal diameters
- Wide range of Reynolds number
- Simple and cheaper change of a gauge (disc) due to a change in parameters of the medium measured
- Simpler operation

Advantages of using nozzles:

- Lower pressure loss
- Longer working life at measuring fluids containing abrasive particles
- More suitable for non-dismantable (welded) installation into a conduit
- Used particularly for higher medium temperature and pressure
- Shorter straight conduit sections in front of a primary device

Spatial requirements around throttling devices and straight sections

An orifice plate (nozzle) type and necessary straight conduit sections must be selected with respect to spatial conditions in the place of installation (room, bridge).

The distance of the installed measuring device from walls, ceiling, floor, parallel conduits, and other obstacles must be taken into account.

Sufficient space must be provided for:

- Straight sections in front of/behind the primary device
- Pressure extractions from the primary device and follow-up fittings
- Trouble-free connection of measuring devices
- Inserting the temperature measuring device into the collar
- Possible installation of insulation
- Conduit hangers
- Workers performing the assembly and future maintenance

Installation of a pressure differential device

Optimal installation of a pressure differential device depends on the type of the medium measured.

- **Gases** - extractions from an orifice, device installed upwards from the conduit.
- **Fluids** - extractions from an orifice plate slantwise downwards from the conduit (not directly downwards due to possible clogging of the extraction with impurities), device installed under extractions.
- **Measuring through a condenser (steam)** - extractions from an orifice plate horizontally, device installed under extractions.

Installation of pressure static device

Static pressure is usually measured in front of an orifice plate (nozzle). Pressure may be extracted behind the device if the mathematic element is able to take into account a pressure loss on the orifice plate (nozzle).

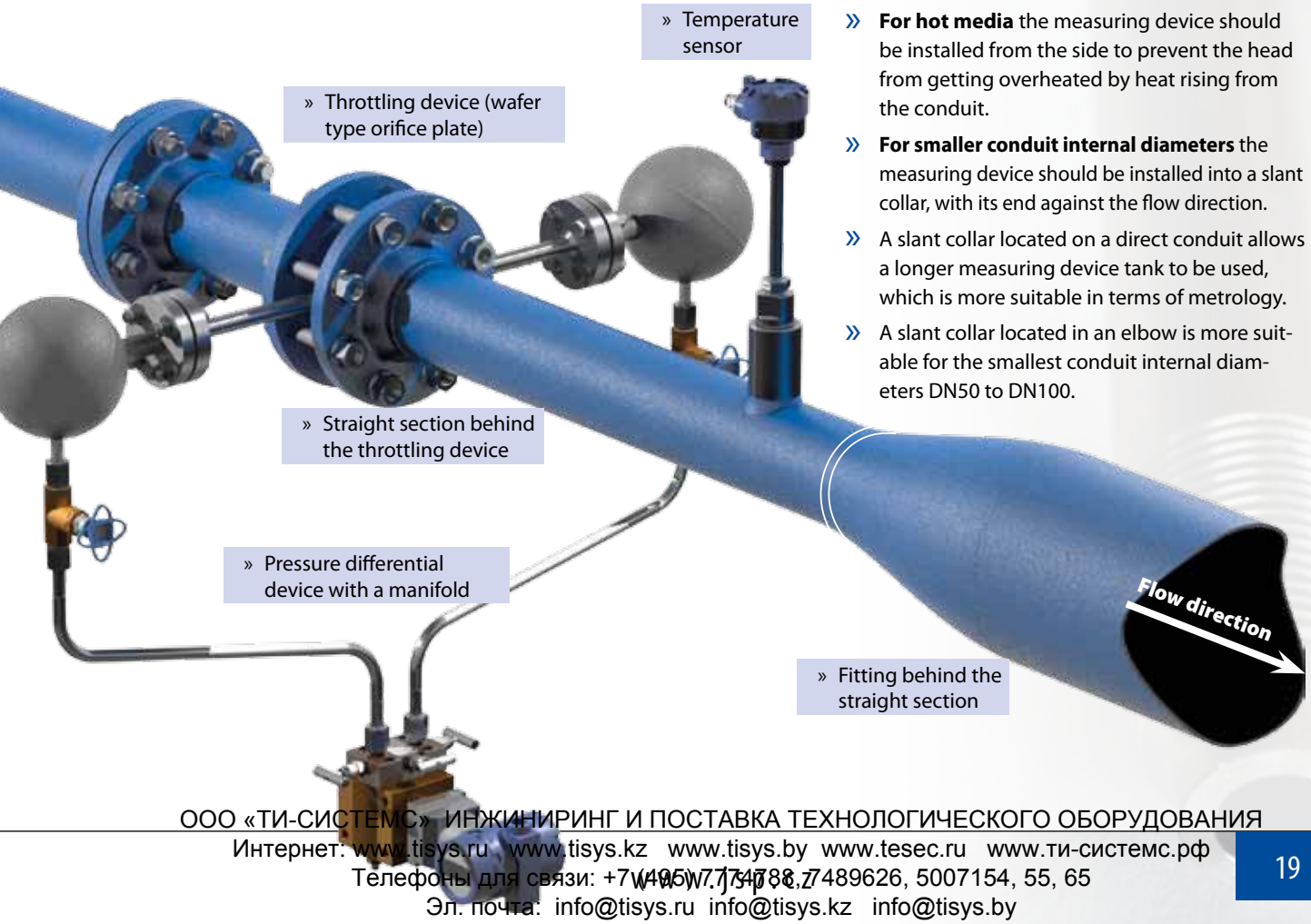
A suitable installation of a pressure static device is selected according to the type of the medium measured.

- **Steam** - into the conduit side or top; through a condensation loop or vessel at higher temperature.
- **Gases** - into the conduit top.
- **Fluids** - into the conduit side.

Installation of a temperature sensor

A temperature sensor is usually installed behind an orifice plate (nozzle).

- Due to vibration stress measuring devices are not recommended to be installed immediately behind flow disturbing elements (orifice plate, nozzle, valve, narrowing, etc.).
- **For hot media** the measuring device should be installed from the side to prevent the head from getting overheated by heat rising from the conduit.
- **For smaller conduit internal diameters** the measuring device should be installed into a slant collar, with its end against the flow direction.
- A slant collar located on a direct conduit allows a longer measuring device tank to be used, which is more suitable in terms of metrology.
- A slant collar located in an elbow is more suitable for the smallest conduit internal diameters DN50 to DN100.



FITTINGS

Connecting, closing, and protection fittings are used within measuring circuit sets, allowing the measuring circuits to be separated from operating technology, ensuring correct measuring and protecting measuring devices.

Condensation vessel

These serve for separating pressure differential devices (or pressure sensor) from high temperature of the fluid measured. They must be installed in a way ensuring the same surface level of the condensate in both vessels.

Condensation loops

These serve for connecting and separating pressures measuring devices from high temperature of the fluid measured. For high temperature of the fluid measured (above 250 °C) and high ambient temperature (above 50 °C) it is recommended to add a tube (TR 20x2.5) at least 0.5 m long in front of a condensation loop in order to improve cooling. A condensation loop must end with a closing valve.

Closing valves and manifolds

A closing valve serves for disconnecting a measuring circuit from a service conduit in case of a defect or reconstruction. The valve location must be chosen in a way preventing the occurrence of air cushions (the spindle axis must run horizontally). For impulse conduits up to 20 m long, an internal diameter 12-14 mm should be chosen; the upper limit is used for low pressure.

Manifolds are used for disconnecting pressure differential devices (connecting valves), for interconnecting pressure inlets for setting the device zero (interconnecting valve), and for desludging impulse conduits (flush valves – only in five-way manifold).

Impulse conduit

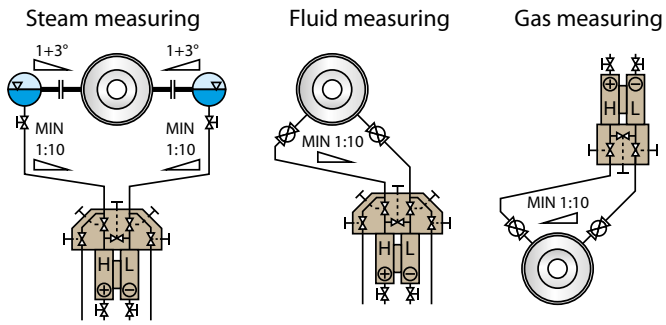
This serves for connecting pressure differential devices (or pressure measuring devices) to orifice plate extractions. To ensure the fastest and undistorted transfer of the pressure differential, the following general rules should be observed:

- The impulse conduit must be as short as possible (max. 50 m); a long impulse conduit may cause an undesired signal delay particularly in gas pressure measuring due to gas compressibility
- The impulse conduit diameter must be sufficient to prevent the effect of friction and possible clogging
- The impulse conduit slant must be at least 10 cm/m
  - Upwards from the device for fluids
  - Downwards from the device for gases
- Fluid temperature in both impulse conduits must be identical
- The conduit must be protected against sediment deposition and occurrence of air cushions (slanting, desludging vessels, purge vessels)
- The conduit must be protected against freezing

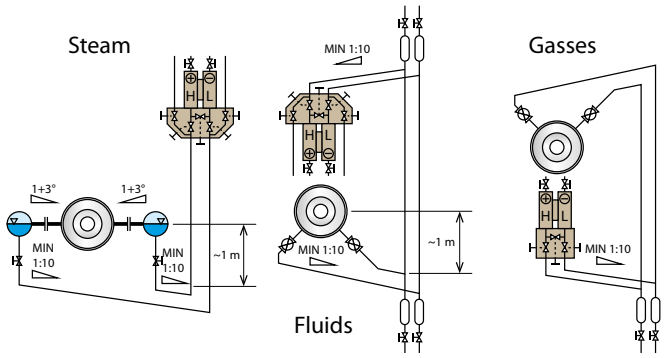
MEASURING DEVICES

Differential pressure device

For measuring fluids, or steam through condensate, it is recommended to be installed under the throttling device (orifice plate) so that gases can return to the service conduit (see Fig. 10). With this location of the device the measuring is reliable and always ready to be performed. The impulse conduit is always filled with a fluid (condensate). If the device cannot be installed under the orifice plate, due to spatial conditions, it may be installed above the orifice plate; however, this arrangement is not recommended. With this arrangement a loop running 1 m below the orifice plate is recommended to be made on the impulse conduit (see Fig. 11). The loop will prevent a water column in the impulse conduit from getting separated and filled with air during technology shutdown (pressure drop). Bleed vessels must be installed at the highest point of the impulse conduit (see Fig. 11). For gas measuring the device should be installed above the orifice plate so that condensate returns to the service conduit (see Fig. 10). In case of an inverse assembly, bleed vessels must be installed at the lowest point (see Fig. 11).



» *Fig. 10 – Recommended installation of a differential pressure device*



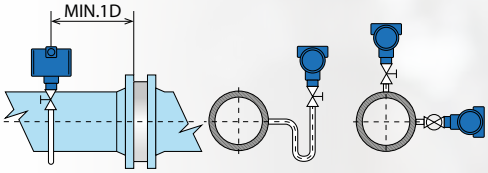
» *Fig. 11 – Unadvisable installation of a differential pressure device*

Temperature measuring device

It may be installed into the service conduit in front of/behind the throttling device; required distances from an orifice plate must be kept. A temperature measuring device is recommended to be installed behind an orifice plate. For conduits of smaller internal diameters the temperature measuring device should be installed with the use of a slant collar into an elbow against the flow direction. Due to vibration stress it is not recommended to install the measuring device immediately behind flow disturbing elements (orifice plate, nozzle, valve, elbow, narrowing, etc.) or by equipment causing conduit vibrations (pumps, fans, engines, etc.). For measuring higher temperatures the temperature measuring device should be installed into the conduit from the side to prevent the head from getting overheated by heat rising from the conduit (see Fig. 13). If the device is installed slantwise, the end of the thermometer tank must be directed against the fluid flow (see Fig. 13).

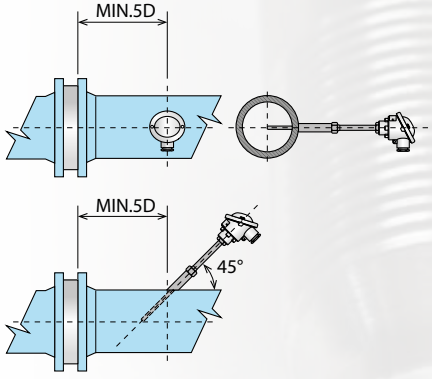
Pressure measuring device

If the measured fluid temperature exceeds the maximum permissible value of the pressure measuring device installed, the device should be installed as close to the service conduit as possible. For measuring gas pressure it is installed above the conduit and for measuring fluid pressure in the conduit side (see Fig. 12). Extractions do not get clogged with impurities or condensate (in measuring gas pressure) in measuring devices installed in this way.



» *Fig. 12 – Pressure measuring device installation*

For measuring overheated steam pressure the device is connected with condensation loops (see Fig. 12). For steam temperature exceeding 250 °C it is recommended to add a tube at least 0.5 m long in front of a condensation loop in order to improve cooling, or to connect the device with a condensation vessel. If the pressure measuring device cannot be installed directly by the conduit, interconnection through an impulse conduit must be made. The same conditions apply to the connection of the device as to the connection of a pressure differential device. The pressure extraction from the service conduit is recommended to be connected in front of an orifice plate. Separate extraction is possible, but not recommended within 1D from the orifice plate. Pressure extraction may also be connected to impulse pressure differential extraction. However, there is a risk of the pressure differential to get influenced by a possible minor leakage in the branch and, thus, the whole measurement. The pressure extraction can be placed also behind the orifice. Evaluating device of flow measurement has to then allow addition of the orifice pressure drop to the flow calculation.



» *Fig. 13 – Temperature sensor installation*

[OrCal software]

Program for calculating primary devices

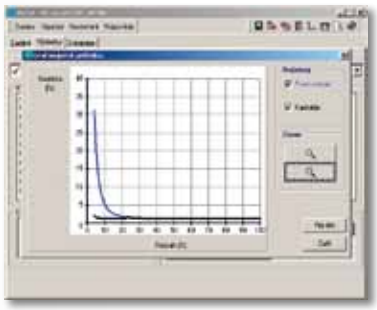
- Calculations performed acc. to EN ISO 5167.
- Designing and optimising measuring circuits.
- Designing cascade connection of pressure differential devices in a circuit.
- Evaluating flow uncertainties in the whole measurement range.
- Printing a calculation certificate.
- Archiving of the calculation in a database.
- Administering database users.
- Compatible with OS WIN8, WIN7, Vista and XP.

Application

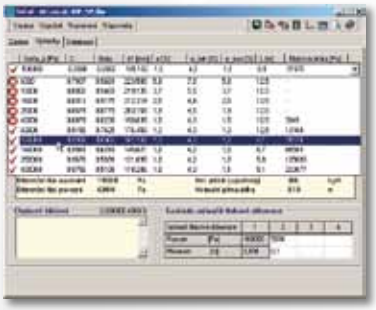
The program is intended for calculating orifice plates, nozzles, and Venturi tubes (primary devices) in compliance with EN ISO 5167 which defines the calculation method and conditions of use of the primary devices at operating conditions. It is possible to enter values required for calculations at standard conditions while respecting the measuring circuit configuration in terms of devices and materials used and the measuring run location. For known fluids the program calculates, upon operating conditions entered, their physical properties required for the calculation. Resulting values are recalculated to standard conditions so that they can be used for manufacturing a primary device, or a whole measuring run. The program output is a calculation certificate. An optional part of the certificate is graphic presentation of the flow uncertainty in the whole measurement range. If cascade connection of two or more pressure differential devices is used, this fact is taken into account in the graphic presentation. The program allows one or more calculation databases to be controlled with defined access rights for individual users.

Screenshots

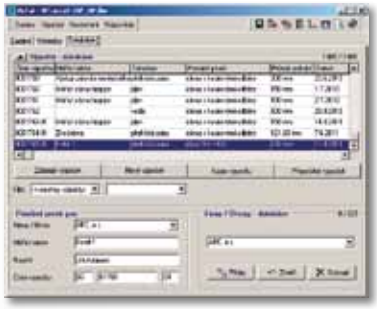
» *Entering input data*



» *Graphic presentation of the flow uncertainty - cascade*



» *Result display - brief*



» *Calculation database*

» *Result display – in detail*

» *Context help*

Calculation of a primary device may be divided into several steps:

- Entering input data
- Calculating + evaluating results and selecting an optimal solution
- Calculating in compliance with:
  EN ISO 5167-1
  EN ISO 5167-2
  EN ISO 5167-3
  EN ISO 5167-4
- Designing and optimising measuring circuits
- Designing cascade connection of pressure differential devices in a circuit
- Evaluating flow uncertainties in the whole measurement range
- Printing a calculation certificate
- Archiving of the calculation in a database
- Administering database users
- Saving the calculation in the database

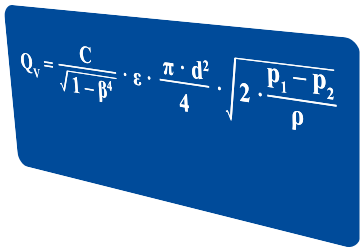
[JSP solution]

100%-guaranteed reliable measurement

[1] Order

» Every primary device is custom-made.

» Filling in a form for the product calculation and specification.



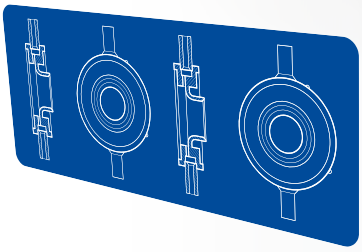
[2] Calculation

» Defining the measured medium parameter.

» Selecting a primary throttling device.

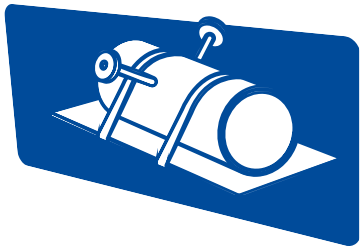
» Pre-calculating the primary device parameter and its installation.

[3] Project



» Assessing the possibility of installing the primary device into the conduit route.

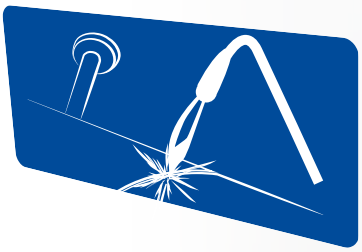
» Measurement project.



[4] Delivery

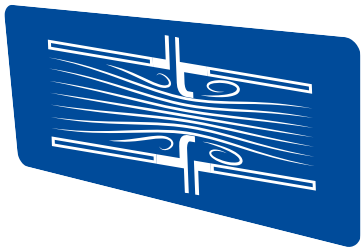
» Throttling devices are usually delivered on a pallet, smaller orifice plates may be delivered in cardboard boxes.

[5] Installation



» Installing the primary device into the conduit route.

» Installing measuring devices.

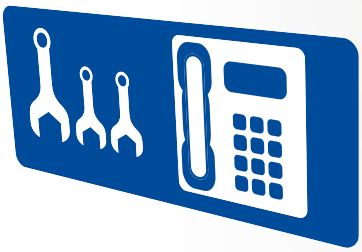


[6] Commissioning

» Functional test, non-destructive tests (pressure, X-ray, penetration).

» Providing necessary documentation (EC declaration, TCM, WPQR, etc.).

[7] Post-warranty service



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SIGNIFICANT REFERENCE DELIVERIES ALL OVER THE WORLD

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