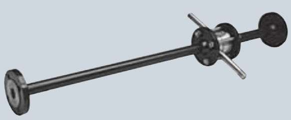
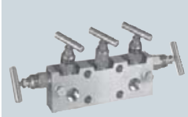
Primary differential pressure devices to DIN EN ISO 5167

		Nominal diameters	Nominal pressure
	**Orifice plates with annular chambers**	EN: DN 50 ... DN 1 000 ASME: 2 inch … 40 inch	EN: PN 6 ... PN 100 ASME: Class 150 … 600
	**Orifice plates with single tappings**	EN: DN 50 ... DN 500 ASME: 2 inch … 20 inch	EN: PN 6 ... PN 315 ASME: Class 150 … 2 500
	**Metering pipes**		
	• Orifice plate with annular chambers, mounted between flanges	EN: DN 10 ... DN 50 ASME: ½ inch … 2 inch	EN: PN 10 ... PN 100 ASME: Class 150 … 600
	• Orifice plate with single tappings, mounted between flanges	EN: DN 10 ... DN 50 ASME: ½ inch … 2 inch	EN: PN 10 ... PN 160 ASME: Class 150 … 2 500

Further products for the complete setup for flow measurements with a primary differential pressure device,	
e.g. an orifice plate	
+	
For **compensation vessels**, see Chap. 2 For **threaded flange pairs**, see Chap. 2	
+	
For **initial shut-off valves**, see Chap. 2	
+	
For **valve manifolds**, see Chap. 2, e.g. 5-spindle valve manifold or	
Valve manifold combination DN 8 for vapor measurement	
+	
For **SITRANS P DS III differential pressure transmitter**, see Chap. 2 Possible measuring cells: 20, 60, 250, 600 and 1 600 mbar	

Overview

Primary differential pressure devices are standardized mechanical flow sensors, often also referred to as differential pressure transducers.

Through constriction of the line diameter in the pressure device, the flow rate creates a differential pressure that is converted with the help of a differential pressure transmitter into a proportional current signal or flow value. The assignment of differential pressure to flow is created by means of a "calculation of the primary differential pressure device".

Primary differential pressure devices are suitable for single-phase media such as gas, vapor and liquids without solid components.

On lines with small nominal diameters (DN 10 to DN 50) the measurements are influenced by the wall roughness and diameter tolerances of the pipes, far more so than by large nominal diameters. These influences are counteracted by using metering pipes with fitting inlet and outlet pipe sections made of precision pipes. The flow coefficient C for exact measurements with metering pipes must be determined by means of calibration.

Requirement when ordering a primary differential pressure device

The orifice plate calculation and the classification according to the pressure equipment directive (PED) must be quoted when placing an order. The complete data of the measuring point are thus required. Details of installation conditions, flow conditions, corrosiveness/resistance and properties of the media are needed in addition. Pressure conditions, permissible pressure losses and accuracy requirements must be considered.

You must enclose a completed "Questionnaire for calculation of a primary differential pressure device to DIN EN ISO 5167" with the order (see page 4/317).

More information is available under "Pressure equipment directive 97/23/EC" and "Calculation of primary differential pressure devices".

Technical description

Benefits

- Primary differential pressure devices are suitable for universal use across the globe
- Primary differential pressure devices are very robust and can be used in a wide range of nominal diameters
- Suitable for high temperature and pressure ranges
- No wet calibration required as they use an internationally standardized flow rate measurement procedure
- The differential pressure transmitter can be used over a long distance from the measuring location
- The differential pressure method is well known and has a large installed base
- The SITRANS P differential pressure transmitter is easy to parameterize again if process data change. They are adapted by recalculating and assigning new parameters to the transmitter or, in the case of the version orifice plate with annular chamber, by using a new orifice disk

Application

Power stations

Measurement of steam, condensate and water.

Petrochemical industry

Measurement of water, steam and liquid and gas hydrocarbons.

Chemical industry

Measurement of various liquid and gas media.

Design

Orifice plate with annular chambers

The version orifice plate with annular chambers comprises two support rings which are connected to the inside of the pipe over an annular chamber and an annular gap. Tapping sockets direct the differential pressure from the support rings to the differential pressure transmitter over shut-off fittings and differential pressure lines.

The orifice disk is inserted between the support rings together with a gasket.

Orifice plate with single tappings

In the version of the orifice plate with single tappings the orifice plate is a single unit. The inside of the tube is connected to the tapping sockets by two single tappings.

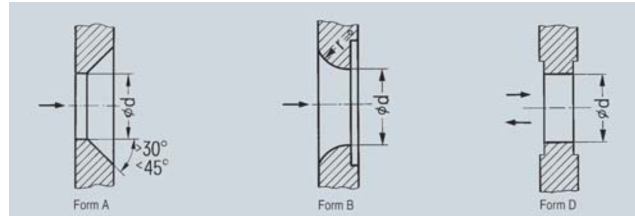
Both types of orifice plate are installed between two flanges in the pipeline.

Function

Mode of operation

The orifice plate creates a differential pressure. The pressure is transferred through the vertical columns of medium in the differential pressure lines to the measuring cell of the differential pressure transmitter. The transmitter converts the pressure signal with square-root characteristic into a flow-proportional current or into a digital signal, e.g. PROFIBUS.

Types of primary differential pressure devices



Shapes of the orifice disk aperture

The primary differential pressure devices are manufactured according to DIN EN ISO 5167. According to this, the application range of the standard orifice disk aperture form A is limited by the Reynolds number. The limits depend on the diameter ratio β = d/D. (D: internal diameter of pipe).

In the case of Reynolds numbers from approx. 500 to 2.5×10^5 and DN 40 to DN 150, the orifice disk aperture form B (quarter circle) can be used for slightly less accurate measurements. The profile radius r depends on the diameter ratio ß and results from the calculation of the diameter of the orifice disk aperture d.

The cylindrical orifice disk aperture form D is used for measurements in both flow directions.

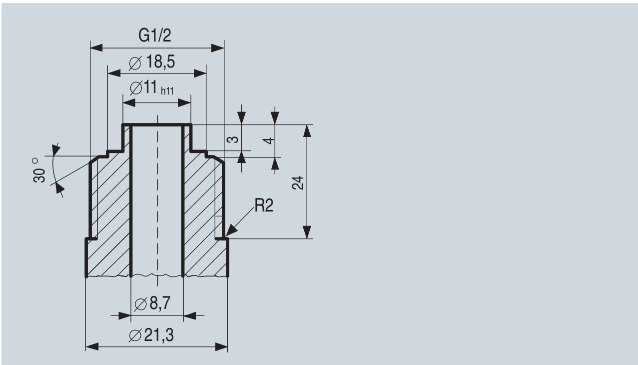
Tapping sockets

Type of threaded connections and welding connections dependent on the measured medium and the nominal pressure of the shut-off fitting

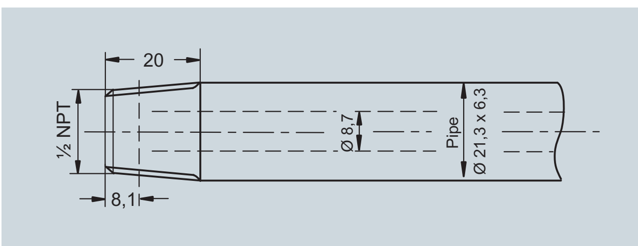
The type of socket connections depends on the measured medium and the nominal pressure of the shut-off fittings; the socket length depends on the nominal diameter (pipe diameter) of the primary differential pressure device and the operating temperature (because of the thermal insulation!). If using with high temperatures and stronger insulations, please quote the insulation thickness and the required length of the tapping sockets when placing an order. The socket position depends on the measured medium and the flow direction.

- With threaded connection G½ DIN ISO 228/1, connection dimensions to DIN 19207 Form V, for liquids and gases up to PN 160, for steam up to PN 100
- With threaded connection ¼-14 NPT male, for version to ASME up to class 600
- With threaded connection ¾-14 NPT male, for version to ASME from class 900 to 1500
- With ferrule for pipe Ø 12 mm, S series
- With welding connection Ø 21.3 mm for liquids, gases and steam up to PN 400 or Ø 24 mm for liquids, gases and steam over PN 400

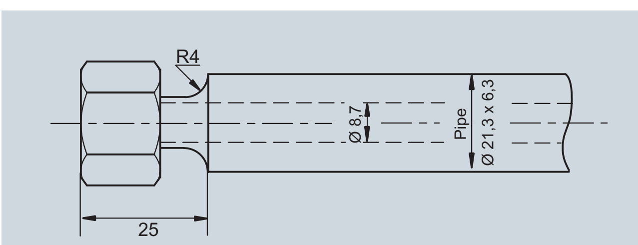
Other connections on request.



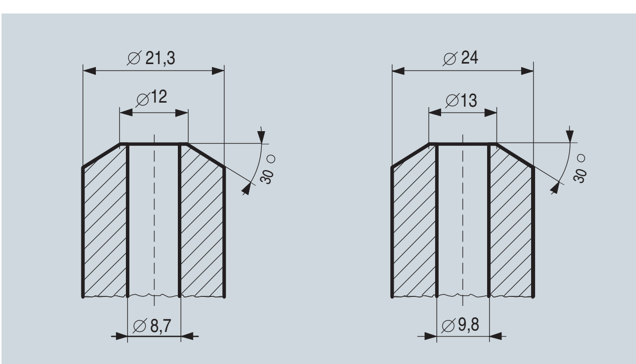
Threaded connections of tapping sockets for liquids and gases up to PN 160, for steam up to PN 100, dimensions in mm



Threaded connection ½-14 NPT male, dimensions in mm



Ferrule for pipe Ø 12 mm, S series, dimensions in mm

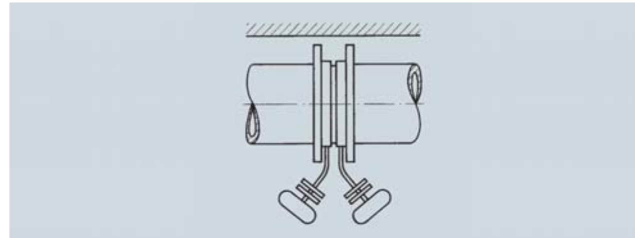


Welding connections of tapping sockets, dimensions in mm
left: Ø 21.3 mm for liquids, gases and steam up to PN 400
right: Ø 24 mm for liquids, gases and steam over PN 400

Position of the tapping sockets

The arrangement of the tapping sockets is optional when measuring liquids and gases; the compensation vessels must be at the same height when measuring steam.

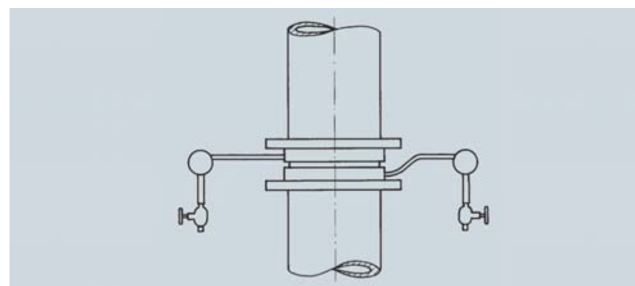
- Horizontal steam lines



Horizontal pipe in front of a wall with primary differential pressure device and valve combination; with annular chamber orifice plate or single part orifice plate with special length of 65 mm

In the case of horizontal steam lines, straight sockets are arranged opposite each other or, if the pipe is close to a wall, bent sockets on one side.

- Vertical steam lines



Vertical steam line with primary differential pressure device and valve combination

In the case of vertical and inclined steam lines, the lower socket is bent upwards so that the connection flanges and compensation vessels are also at the same height in this case.

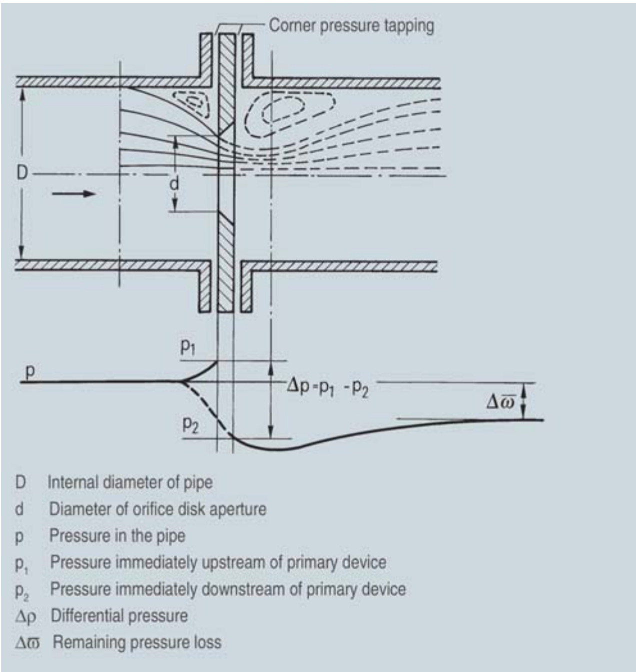
Extract from DIN 19205, Part 1, August 1988

No.	Pipe position and flow direction			Position of the tapping sockets		Application
1	Horizontal		→	180°		With compensation vessels
2 [1) 2)]				0°		
3 [1) 2)]						
4	Vertical	Rising	↑	90°		
5		Falling	↓			
6		Rising	↑	180°		
7		Falling	↓			
10	Horizontal		→	<γ [3)]		Without compensation vessels
11	Horizontal, vertical		→ ↓ ↑	180°		
13	Vertical		↓ ↑	90°		

1) Not possible with orifice plates with single tappings (overall length 40 mm). Special length of 65 mm is possible.
2) Only possible with orifice plates with annular chambers (overall length 65 mm) with bent-up tapping sockets.
3) Angle γ is dependent on the nominal pressure and nominal diameter in accordance with DIN 19205.

Technical description

Principle of the differential pressure method



Principle of the differential pressure method: Pressure curve at a pipe restriction

A primary differential pressure device is installed at the measuring point to measure the flow. This restricts the pipe and has two connections for sampling the differential pressure. If the properties of the primary device and the medium are known such that the equation below can be evaluated, the differential pressure is a measure of the absolute flow. No comparison measurements are required; the flow measurement can be checked independent of the device manufacturer.

The differential pressure method is based on the law of continuity and Bernoulli's energy equation.

According to the law of continuity, the flow of a moving medium in a pipeline is the same at all points. If the cross-section is reduced at one point, the flow velocity must increase at this point. According to Bernoulli's energy equation, the energy content of a flowing medium is constant and is the total of the static (pressure) and kinetic (movement) energies. An increase in the flow rate therefore results in a reduction in the static pressure (see the figure "Principle of the differential pressure method: Pressure curve at a pipe restriction"). This pressure difference Δp, the so-called differential pressure, is a measure of the flow.

In general the following equation applies: $q = c\sqrt{\Delta p}$

Where:

- q: flow (q_m, q_v) mass flow or volume flow
- Δp: Differential pressure
- c: Factor depending on the dimensions of the pipeline, the type of constriction, the density of the flowing medium etc.

According to this equation, the differential pressure created by the constriction is proportionally equal to the square of the flow (see the figure "Relationship between flow q and differential pressure Δp").

Integration

The orifice plate is installed between two flanges in the pipeline. Using compensation vessels (for steam) and initial shut-off valves the differential pressure of the high-pressure side and low-pressure side is directed through differential pressure lines to a multiple valve manifold and on to the differential pressure transmitter. For media with extreme pressure and temperature fluctuations it makes sense to take an additional measurement of the pressure and temperature in order to correct the flow signal of the transmitter in a subsequent correction computer.

Selection of mounting point

The flow measuring regulations DIN EN ISO 5167 do not only consider the design of primary differential pressure devices, but also assume that their installation is in accordance with the standard so that the specified tolerances can be retained. Installation in accordance with the standard should already be considered when planning the pipeline. Particular attention must be paid to ensure that the primary device can be fitted in a sufficiently long straight section of pipe. Bends, valves and similar must be fitted so far upstream of the primary device that they no longer have a detrimental effect. Primary devices with a large diameter ratio are particularly sensitive to interferences.

Design of measuring point

The design of the measuring point depends on the medium and on the spatial conditions. The designs for gas and water only differ in the arrangement of the tapping sockets (see the figure "Measuring setup"); compensation vessels must additionally be provided for steam.

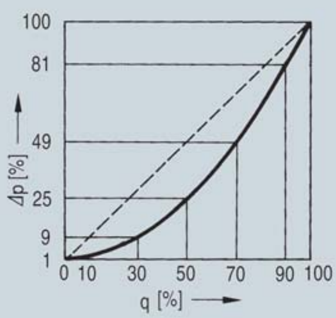
Options

Further versions that are available on request:

- Other nominal diameters and nominal pressures to EN and ASME
- Other lengths, special lengths
- Other materials
- Sealing face with recess or groove
- Flushing rings
- Other tapping sockets, multiple tappings
- Material acceptance test certificates or cold water pressure tests

Characteristic curves

The orifice plate has a square-law relationship between differential pressure and flow. A square-root transmitter is required therefore to create a linear flow characteristic.



q	0	1	3	5	8	10	15	20	30	40	50	60	70	80	90	100 %
Δp	0	0.01	0.09	0.25	0.64	1	2.25	4	9	16	25	36	49	64	81	100 %

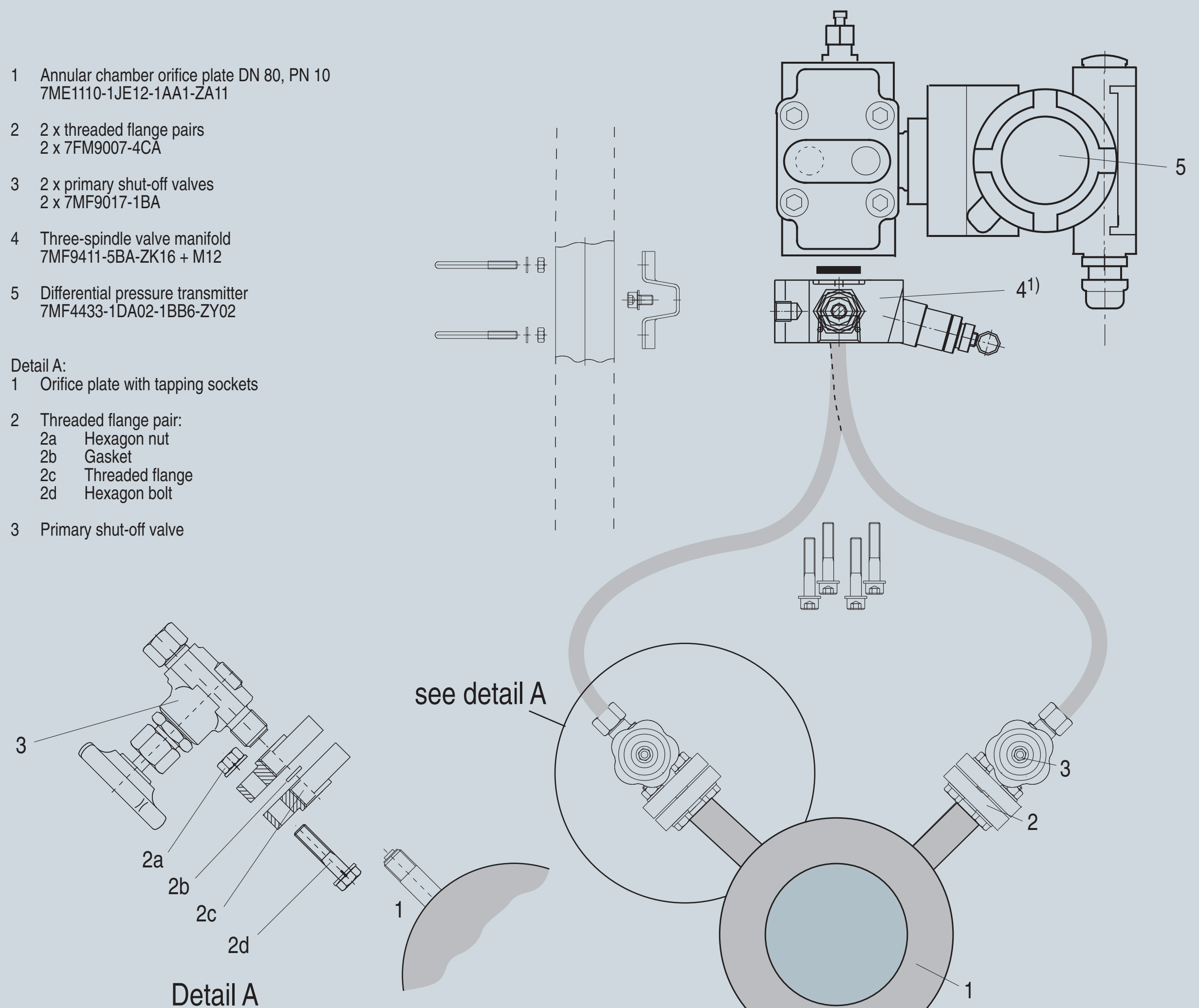
Setting range for application point of square-rooted charateristic for SITRANS P differential pressure transmitter

Relationship between flow q and differential pressure Δp

More information

- Standards
- Instruction Manual SITRANS P
- Installation Instructions

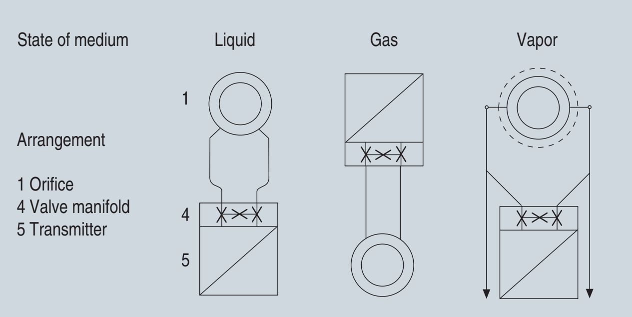
Technical description



Note: The transmitter is mounted on the valve manifold.
The valve manifold is mounted on the pipe (or wall).

1) Pipe union of the differential pressure line on the valve manifold must be provided by the customer.
(screwed gland ½ NPT to 12 mm (0.47 in) differential pressure line; 12 mm (0.47 in) differential pressure line must be provided by the customer)

Design of measuring point with gas measurement as example (non-corrosive, non-hazardous)



Measuring setup

Technical specifications

The technical properties of the orifice plates depend on the device:

- Nominal diameters
- Nominal pressure
- Materials
- Mass
- Temperature limits

Accessories

- Compensation vessels
- Threaded flange pairs
- Primary shut-offs
- Valve manifold
- Differential pressure lines (to be provided by the plant owner)
- Gaskets, bolts, screws (to be provided by the plant owner)
- Differential pressure transmitter