Technical
Information
TI 040D/06/en
No. 50084974

Vortex Flow Measuring System *prowirl 77*

Reliable Flow Measurement of Gases, Steam and Liquids

Safe
- Verified electromagnetic compatibility according to IEC and NAMUR
- Every instrument hydrostatically pressure tested
- Sensor and electronics self-diagnostics with alarm function
- Proven capacitive sensor: high resistance to thermal shock, water hammer and vibration
- Sensor, meter body and bluff body made of stainless steel, NACE MR 0175 conform

Accurate
- Low measuring uncertainty: <1% o.r. (gas, steam) <0.75% o.r. (liquids)
- Wide turndown of up to 40:1
- Every flowmeter wet calibrated

Flexible
- One standard, compact flowmeter for all fluids and a complete process temperature range of –200...+400 °C
- Available in pressure ratings up to PN 160/Cl. 600
- Flanged and high pressure version with standard ISO face-to-face lengths (DN 15...150)
- Wafer version with standard 65 mm face-to-face length

Universal
- HART communication for remote reading and configuration
- Fieldbus communication via PROFIBUS-PA interface
- Operating under E+H Windows software “Commuwin II”, can be fully configured off-line
- Output signal simulation

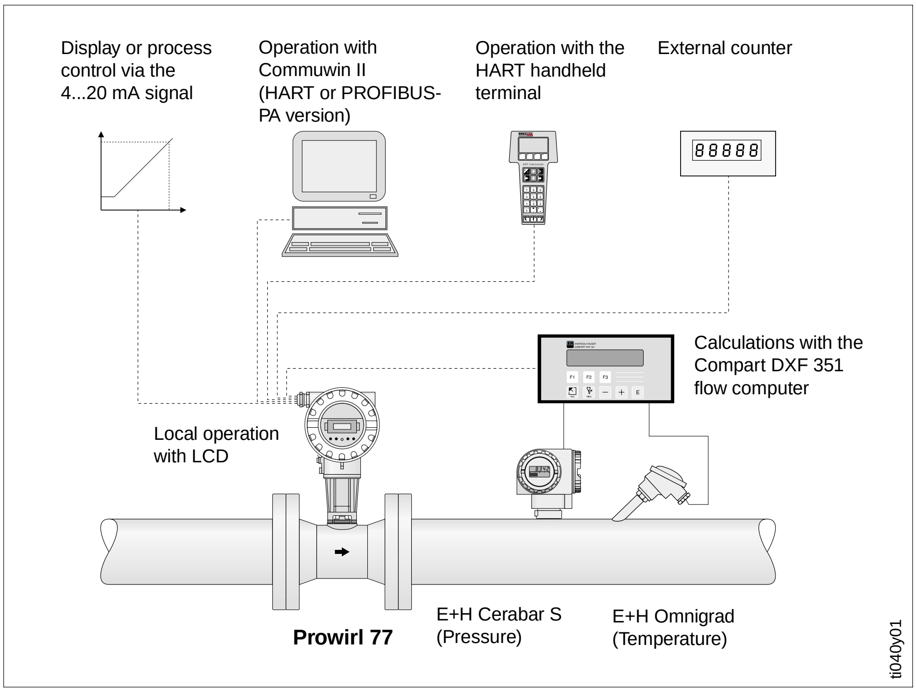
Endress+Hauser
The Power of Know How

Measuring System

Applications
The Prowirl 77 vortex flowmeter is suitable for measuring the volumetric flow of steam, gases and liquids from –200...+400 °C and up to a pressure rating of PN 160/ANSI Cl. 600.

Prowirl 77 is commonly used for utility measurements as well as in process applications in various branches as Chemicals, Petrochemicals, Power and District Heating.

Prowirl 77 measures the volumetric flow at operating conditions. The E+H Compart DXF 351 flow computer calculates the flow in mass, energy or corrected volume units from signals of Prowirl 77 and additional pressure and temperature transmitters. If the process pressure and temperature at the measuring point are constant and accurately known, Prowirl 77 can also be programmed to display the flow rate in these units.



Prowirl 77 can be used as an individual measurement instrument or as part of a process control system.

Transmitter

All Prowirl 77 transmitters have the following features:
- Self-monitoring electronics and sensor
- IP 67 / NEMA 4X ingress protection
- Built-in electromagnetic interference immunity (EMC)

Versions
The Prowirl 77 transmitter is available in the following versions:
- PFM (unscaled two-wire current pulse)
- 4...20 mA/HART
- PROFIBUS-PA

All versions can be supplied either for safe area use, or for hazardous areas as intrinsically safe (“Ex i”) or explosion proof (“Ex d”) versions (For PROFIBUS-PA, Ex i or safe area only).

PFM
This is the most basic version, with a two-wire PFM pulse output for connection to the E+H Compart DXF 351 flow computer. All settings required can be made by using DIP switches on the transmitter.

4...20 mA / HART
This version has a 4...20 mA current output signal (with optional HART digital communication). The transmitter is available with either LCD and keys for local operation or as a blind version. Instruments with display and operating keys can also be set to output either scaleable voltage pulses (Open Collector) or unscaled current pulses (PFM). After a loss of power supply the totalizer remains at the value last shown.

HART communication enables the instrument to be remotely configured and measured values to be displayed. Complete off-line configuration can also be carried out using the Windows-supported E+H Commuwin II software.

PROFIBUS-PA
With a PROFIBUS-PA version, a connection to fieldbus systems according to the IEC 1158-2 international standard at 31.25 kbit/s is possible.

Meter Body Construction

All Prowirl 77 meters have the following features:

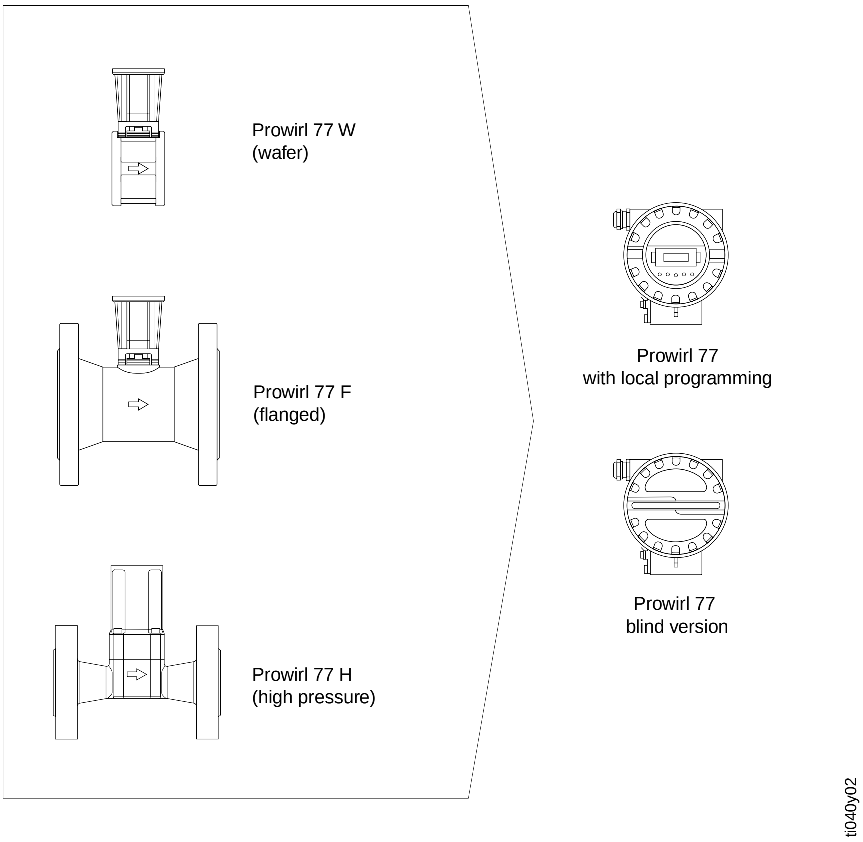
- High resistance to water hammer in steam lines due to the steady fixing of the cast bluff body.
- Quality stainless steel casting, according to NACE MR 0175, all wetted parts traceable to 3.1B
- Hydrostatically pressure tested
- TÜV preliminary testing (nominal diameters DN 15...150)

Prowirl 77 W
(Wafer, DN 15...150)
This space-saving wafer body is 65 mm wide and mounted easily with the help of a mounting set (see page 7). This enables easy and accurate centering of the meter body in the pipeline.

Prowirl 77 F
(Flange, DN 15...300, bigger nominal diameters on request)
This design offers standard ISO face-to-face lengths (DN 15...150).

Prowirl 77 H
(High pressure, DN 15...150)
This sensor is designed for the use at high process pressures up to PN 160/Cl. 600 and features standard ISO face-to-face lengths as well.

Measuring system Prowirl 77



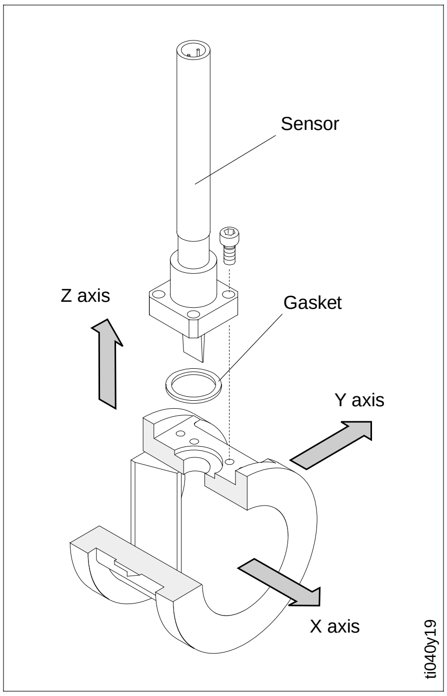
Calibration

All Prowirl 77 flowmeters are subject to wet calibration before leaving the factory.
For use as a quality-relevant measurement point (ISO 9000), Prowirl 77 is available with calibration procedures traceable to EN 45001 and corresponding internationally recognised certificates according to regulations of EA (European Organisation for the Accreditation of Laboratories).

Function

Capacitive Sensor

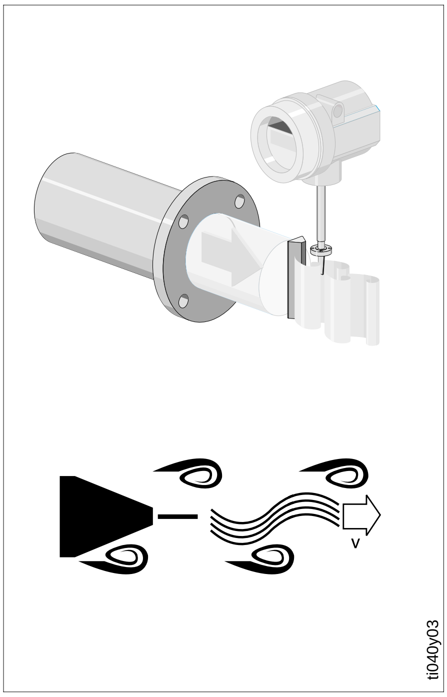
The sensor of a vortex flowmeter has a decisive effect on the efficiency, ruggedness and reliability of the entire measuring system.
The proven E+H patented capacitive measurement technique (in more than 50'000 installations world-wide) is designed into the Prowirl 77.
The sensor is mechanically balanced so that pipeline vibrations are directly eliminated and do not have to be filtered out electronically. Prowirl 77 is in every axis insensitive to vibrations up to at least 1 g in the full frequency region to 500 Hz.
These specifications also apply to the most sensitive Y axis (see Fig. below), the axis in which the sensor detects vortex shedding.



The high sensitivity of the sensor guarantees measuring ranges that start at low values even with low fluid densities, enabling a wide turndown.
The design and position of the capacitive sensor behind the bluff body ensures that it is especially resistant to water hammer and temperature shock in steam lines.

Measuring Principle

The operating principle is based on the Karman vortex street. When fluid flows past a bluff body, vortices are formed alternately on both sides of the body and are then shed by the flow. Pressure changes are created by the vortices which are detected by the sensor and converted into electrical signals. Within permissible operating limits (see "Technical Data", page 23) the vortices are shed at very regular intervals so that the frequency of shedding is proportional to the flow rate.



The K-factor is used as a constant of proportionality:

$$\text{K-factor} = \frac{\text{pulses}}{\text{volume unit [dm}^3]}$$

The K-factor is a function of the geometry of the flowmeter and within application limits is independent of flow velocity and of the fluid properties viscosity and density. It is thus also independent of the type of fluid to be measured, whether it is steam, gas or liquid.
The primary measuring signal is already digital (frequency signal) and linearly proportional to the flow rate. The K-factor is determined in the factory by a wet calibration after the production process and is not subject to long-term or zero point drift. The flowmeter contains no moving parts and requires no maintenance.

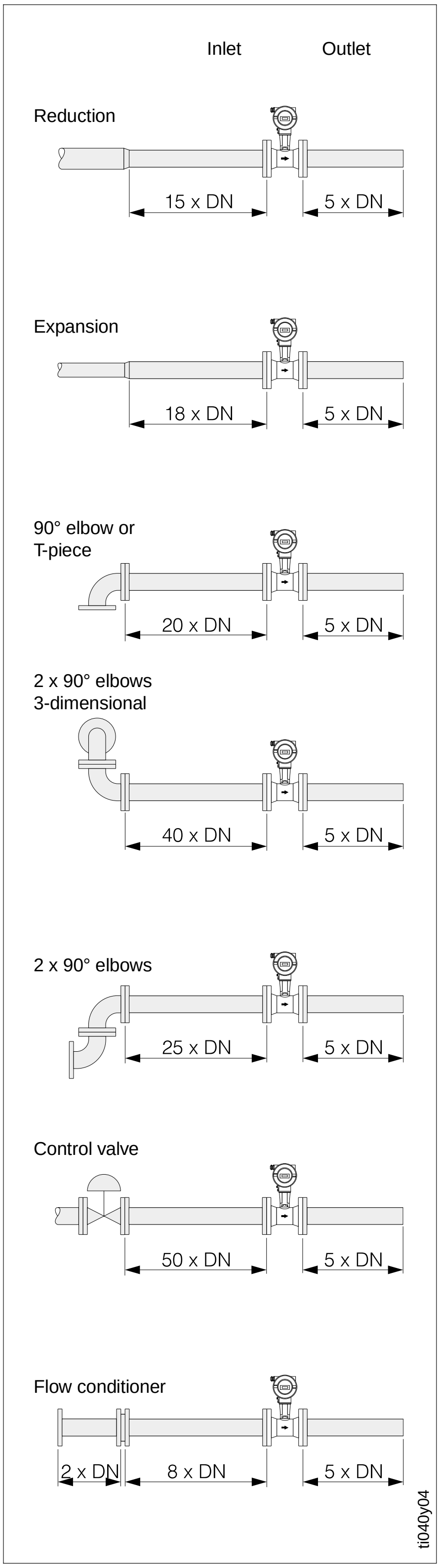
Planning and Installation

Vortex flowmeters require a fully developed flow profile as a prerequisite for accurate flow measurement. The following instructions must therefore be observed when installing Prowirl 77 in the pipeline.

Meter body inner diameters
The process piping internal diameter of a given nominal size varies depending on the class of pipe (DIN, ANSI Sch40, Sch80, JIS etc.). When ordering, part of the order code specifies the type of piping into which the meter will be installed, and this same piping type is used at the factory for the wet calibration. Both Prowirl 77 W (wafer) and Prowirl 77 F (flanged) can be used in DIN, ANSI Sch40 and JIS Sch40 piping. Sch80 piping is available for the flanged (Prowirl 77 F) and high pressure (Prowirl 77 H) version.

Inlet and Outlet Sections
Where possible, the vortex flowmeter should be mounted upstream of any flow disturbances such as elbows, reducers or control valves. The longest section of straight pipe should be between the disturbance and the flowmeter. The diagrams on the right show the minimum section of straight pipe required downstream from the disturbance as a multiple of the pipe diameter (DN). Where two or more disturbances are located upstream of the flowmeter, the longest recommended upstream pipe section is to be observed.

The section of straight pipe downstream from the flowmeter should be of sufficient length so that the vortices can develop properly.



Flow Conditioner
If it is not possible to observe the inlet sections specified above, a specially developed perforated plate flow conditioner can be installed as shown on the right. The flow conditioner is held between two piping flanges and centred with the flange bolts.
As a rule, it also reduces the inlet section required downstream from the flow disturbances to 10 x DN, maintaining full measuring accuracy.

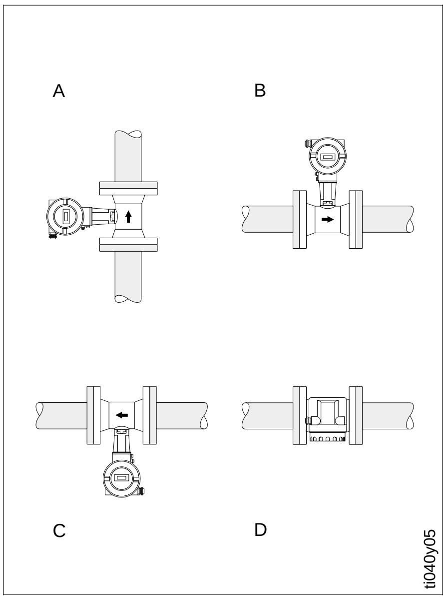
Examples when using the Flow Conditioner

Δp [mbar] = 0.0085 · ρ [kg/m^3] · v^2 [m/s]

- Example with steam:
  - p = 10 bar abs.
  - t = 240 °C ⇒ ρ = 4.39 kg/m^3
  - v = 40 m/s
  - Δp = 0.0085 · 4.39 kg/m^3 · (40 m/s)^2 = 59.7 mbar

- Example with H_2O condensate (80 °C)
  - ρ = 965 kg/m^3
  - v = 2.5 m/s
  - Δp = 0.0085 · 965 kg/m^3 · (2.5 m/s)^2 = 51.3 mbar

Planning and Installation



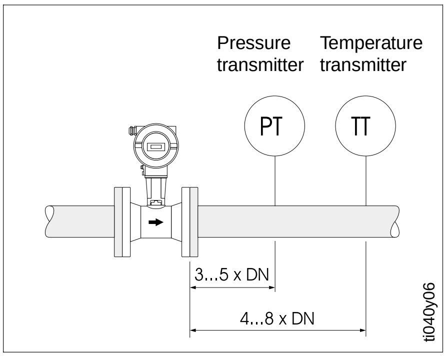
Orientation as a function of fluid temperature

Orientation

The Prowirl 77 can generally be mounted in any position in the piping. An arrow showing the direction of flow is marked on the meter body.

Liquids should flow upwards in vertical pipelines (Position A), in order to ensure that the pipeline is always full.

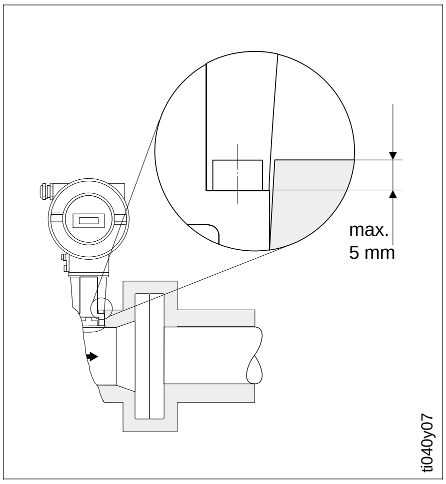
For horizontal pipelines, positions B, C and D are possible. With hot piping (e.g. steam), position C or D must be selected in order to respect the maximum permissible ambient temperature for the electronics. (For ambient temperatures, see page 24).



Mounting the pressure and temperature sensors

Pressure and Temperature Measuring Sensors

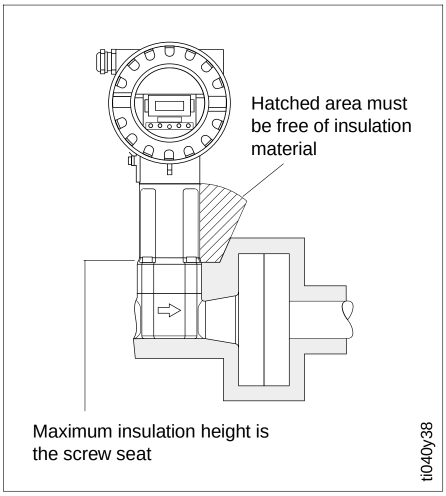
Pressure and temperature measuring instruments are to be installed downstream from Prowirl 77 so that they do not affect the proper formation of vortices.



Piping insulation wafer/flanged version

Piping Insulation Wafer/Flanged version

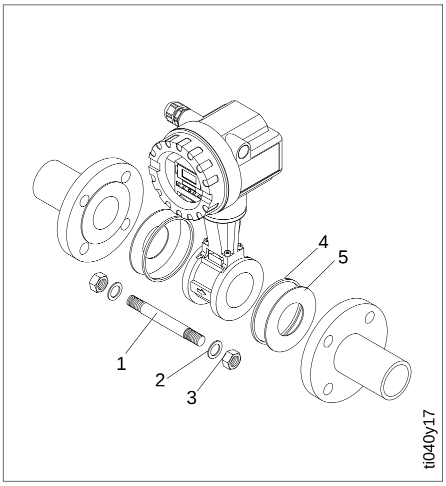
Pipeline insulation is often necessary to prevent energy loss in hot processes. When insulating Prowirl 77, ensure sufficient pipe stand surface area is exposed. The exposed area serves as a radiator and protects the electronics from overheating.



Piping insulation high pressure version

Piping Insulation High Pressure Version

The pipe stand must be free from insulation in order to guarantee temperature radiation and therefore to keep the electronics from overheating.

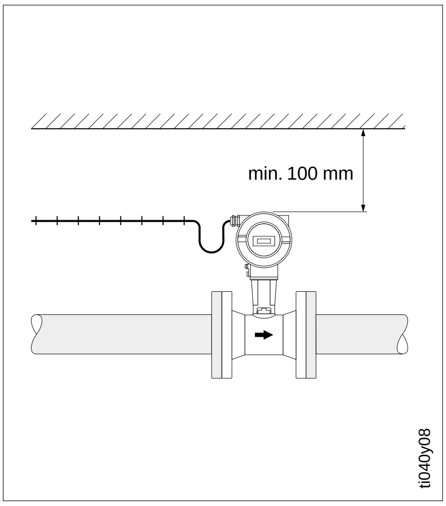


Mounting set for wafer version

Mounting Set

Wafer-style flowmeters can be accurately centred using a mounting set which consists of:

1 Bolts
2 Washers
3 Nuts
4 Centering rings
5 Gaskets



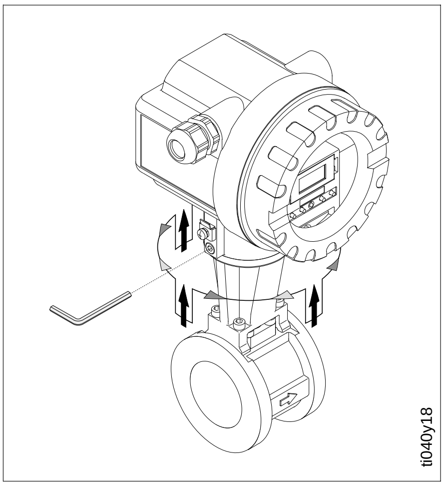
Minimum spacing

Minimum Spacing

When servicing or connecting the “Flowjack” flow simulator, it is first necessary to unplug the electronics housing from the pipe stand. When installing in the piping, observe the following cable lengths and minimum spacing:

Minimum space:
100 mm in all directions

Cable length required:
L + 150 mm



Rotating the electronics housing

Electronics Housing

The electronics housing can be rotated on the pipe stand in 90° steps so that the local display can easily be read.

The display unit itself can be turned 180° so that it can be read even when the sensor electronics are mounted from below (Position C, see page 6).

Measuring Ranges Nominal Diameters

Selecting the Nominal Diameter
The Prowirl 77 vortex flowmeter determines the volumetric flow (e.g. m^3/h) under operating conditions. Steam quantities are generally given in kg or t, gas quantities in Nm^3 (corrected to standard conditions of 0 °C and 1.013 bar).
For conversion to operating volume and determining the nominal diameter, measuring range and pressure loss the following tables give a first overview.

Note!
If the flowmeter is operated in the upper or lower end of the measuring range, the limits of the measuring range should be determined exactly using either the equations or the E+H design software Applicator. Your E+H Sales Organisation will be pleased to help design a measuring system for your particular application with reference to the characteristics of the fluid and operating conditions.

"Applicator" sizing Software
All important transmitter data is contained in this E+H software for the most efficient design of the measuring system. The equations used for calculating the properties of steam are the latest available according to the IAPS (International Association for the Properties of Steam).
The Applicator software can easily carry out the following calculations:
- Converting the operating volume of gas into a corrected volume
- Converting into a mass flow of steam (based on temperature and/or pressure)
- Calculating using viscosity
- Calculating pressure loss across the flowmeter
- Simultaneously displaying calculation examples for various nominal diameters
- Determining measuring ranges

Applicator is available on Internet or as CD-ROM for local PC installation.

Measuring Ranges Water / Air

The following tables are given as guideline for measuring ranges for a typical gas (air, at 0 °C and 1.013 bar) and a typical liquid (water, at 20 °C).

In the column "K-Factor" the possible range for the K-Factor with respect to nominal diameter and version is given.

Prowirl 77 W (Wafer)					
DN DIN/ANSI	**Air** (at 0 °C, 1.013 bar) [m^3/h]		**Water** (20 °C) [m^3/h]		**K-Factor** [pulses/dm^3]
	$\dot{V}_{min}$	$\dot{V}_{max}$	$\dot{V}_{min}$	$\dot{V}_{max}$	min./max.
DN 15 / ½"	4	35	0.19	7	245...280
DN 25 / 1"	11	160	0.41	19	48...55
DN 40 / 1½"	31	375	1.1	45	14...17
DN 50 / 2"	50	610	1.8	73	6...8
DN 80 / 3"	112	1370	4.0	164	1.9...2.4
DN 100 / 4"	191	2330	6.9	279	1.1...1.4
DN 150 / 6"	428	5210	15.4	625	0.27...0.32

Prowirl 77 F (Flange) / Prowirl 77 H (High pressure; up to DN 150 / 6")					
DN DIN/ANSI	**Air** (at 0 °C, 1.013 bar) [m^3/h]		**Water** (20 °C) [m^3/h]		**K-Factor** [pulses/dm^3]
	$\dot{V}_{min}$	$\dot{V}_{max}$	$\dot{V}_{min}$	$\dot{V}_{max}$	min./max.
DN 15 / ½"	3	25	0.16	5	390...450
DN 25 / 1"	9	125	0.32	15	70...85
DN 40 / 1½"	25	310	0.91	37	18...22
DN 50 / 2"	42	510	1.5	62	8...11
DN 80 / 3"	95	1150	3.4	140	2.5...3.2
DN 100 / 4"	164	2000	5.9	240	1.1...1.4
DN 150 / 6"	373	4540	13.4	550	0.3...0.4
DN 200 / 8"	715	8710	25.7	1050	0.1266...0.1400
DN 250 / 10"	1127	13740	40.6	1650	0.0677...0.0748
DN 300 / 12"	1617	19700	58.2	2360	0.0364...0.0402

Measuring Ranges Saturated Steam

Example of Calculation

To determine:
Measuring range of saturated steam with a nominal diameter DN 100 at an operating pressure of 12 bar abs.

Additional information from the table:
- Saturated steam temperature = 188 °C (at 12 bar)
- Density = 6.13 kg/m^3 (at 12 bar)

Calculation:
Min. and max. values for the measuring range can be found from the following table:
at 12 bar abs. ⇒ 461...12226 kg/h

Operating pressure [bar abs]	Measuring ranges for various nominal diameters in [kg/h] *											
	DN 15 min...max	**DN 25** min...max	**DN 40** min...max	**DN 50** min...max	**DN 80** min...max	**DN 100** min...max	**DN 150** min...max	**DN 200** min...max	**DN 250** min...max	**DN 300** min...max	T_{sat} [°C]	ρ_{sat} [kg/m^3]
0.5	1.8...7.8	5.6...39	16...95	27...158	60...356	103...616	235...1401	452...2689	714...4258	1024...6107	81.3	0.31
1	2.5...15	7.7...74	22...182	37...303	83...680	143...1178	325...2679	625...5143	985...8104	1412...11623	99.6	0.59
1.5	3.0...22	9.3...108	27...266	45...443	100...994	173...1722	393...3916	755...7518	1189...11812	1705...16943	111	0.86
2	3.5...28	11...141	31...348	51...580	114...1301	198...2254	450...5126	864...9841	1363...15521	1955...22262	120	1.13
3	4.2...41	13...207	37...506	62...848	138...1902	239...3295	544...7495	1045...14387	1647...22663	2362...32506	134	1.65
4	4.8...54	15...271	42...666	70...1111	158...2492	274...4317	623...9820	1196...18851	1884...29668	2702...42554	144	2.16
5	5.4...67	16...334	47...822	78...1370	176...3074	304...5325	692...12113	1328...23253	2095...36672	3005...52601	152	2.67
6	5.8...80	18...397	51...976	85...1627	191...3651	332...6324	754...14386	1448...27616	2282...43540	3274...62451	159	3.17
7	6.3...92	19...459	55...1129	92...1882	206...4224	357...7317	811...16644	1557...31950	2456...50408	3523...72302	167	3.67
8	6.7...105	20...521	59...1281	98...2136	219...4793	380...8303	864...18888	1659...36258	2615...57138	3750...81955	170	4.16
10	7.4...129	23...644	65...1584	109...2642	244...5928	422...10269	961...23360	1845...44842	2909...70735	4173...101459	180	5.15
12	8.1...154	25...767	71...1886	119...3145	266...7058	461...12226	1049...27811	2013...53388	3174...84196	4553...120766	188	6.13
15	9.0...191	28...951	79...2337	132...3898	296...8746	513...15150	1167...34463	2241...66157	3532...104249	5066...149529	198	7.59
25	11.6...314	35...1567	102...3852	169...6424	380...14414	659...24969	1499...56799	2877...109034	4534...171825	6504...246457	224	12.51

* Values in this table are based on flanged version.
For the wafer version, both the minimum and maximum values are up to 30% higher.

Measuring Ranges Superheated Steam

The start of the measuring range for superheated steam and gases is dependent on their density. In addition the density of superheated steam is a function of both pressure and temperature as shown in the table on the right. Normally the flow is given in units of mass, then the density is required for the conversion into volumetric flow.

P	Density of steam [kg/m³]		
[bar abs]	150 °C	200 °C	250 °C
0.5	0.26	0.23	0.21
1.0	0.52	0.46	0.42
1.5	0.78	0.70	0.62
2.0	1.04	0.93	0.83
2.5	1.31	1.16	1.04
3.0	1.58	1.39	1.25
3.5	1.85	1.63	1.46
4.0	2.12	1.87	1.68
5.0		2.35	2.11
6.0		2.84	2.54
7.0		3.33	2.97
8.0		3.83	3.41
10.0		4.86	4.30
12.0		5.91	5.20
15.0		7.55	6.58
20.0			8.98
25.0			11.49

Volumetric/Mass Flow ($\dot{V}/\dot{m}$)

$$\dot{m}\,[kg/h] = \dot{V}\,[m^3/h] \cdot \rho\,[kg/m^3]$$

$$\dot{V}\,[m^3/h] = \frac{\dot{m}\,[kg/h]}{\rho\,[kg/m^3]}$$

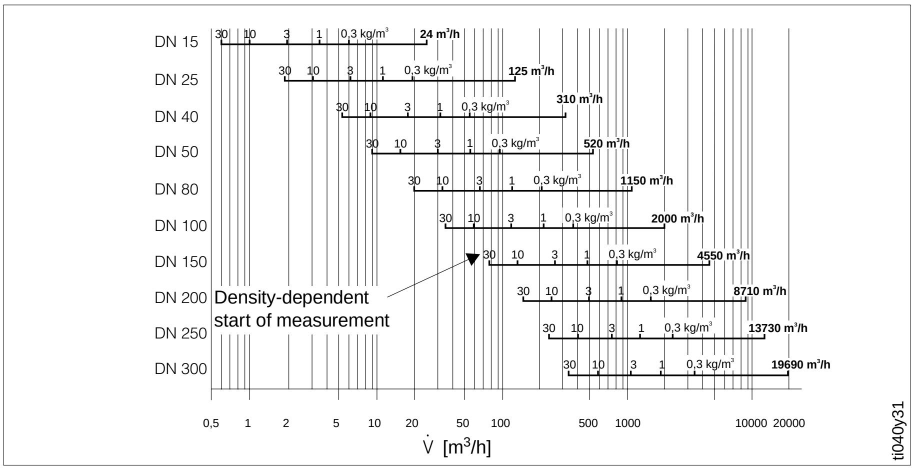
Example for Superheated Steam

To determine:
Nominal diameter (DN) to measure superheated steam at 200 °C and 10 bar abs at a flow rate of 4 t/h.

Calculation:
a) Convert t/h ⇒ m^3/h using the density of steam (4.86 kg/m^3) from the table above.

b) Select the nominal diameter in the steam/gas measuring range diagram below for $\dot{V}$ = 823 m^3/h ⇒ DN 80. For density ρ = 4.86 kg/m^3 the lower range value is 42 m^3/h. This gives a measuring range of 42...1150 m^3/h or 204...5590 kg/h.

$$\dot{V}\,[m^3/h] = \frac{\dot{m}}{\rho} = \frac{4000\,kg/h}{4.86\,kg/m^3} = 823\,m^3/h$$



Measuring Ranges Gas

Corrected/Operating Density (ρ_N/ρ)
The lower range value for a gas is dependent on its density. For ideal gases the equations given below are used for the conversion between corrected and operating densities:

$$\rho\,[kg/m^3] = \frac{\rho_N\,[kg/Nm^3] \cdot P\,[bar\,abs] \cdot 273.15\,K}{T\,[K] \cdot 1.013\,[bar\,abs]}$$

$$\rho_N\,[kg/Nm^3] = \frac{\rho\,[kg/m^3] \cdot T\,[K] \cdot 1.013\,[bar\,abs]}{P\,[bar\,abs] \cdot 273.15\,K}$$

The equation given above under “Measuring Ranges Superheated Steam” can be used for converting mass into volumetric flow.

Corrected/Operating Volumes (V_N/V)
The flow of gases is often given in corrected volumes. For ideal gases the equations given below are used for conversion between corrected and operating volumes:

$$\dot{V}\,[m^3/h] = \frac{\dot{V}_N\,[Nm^3/h] \cdot T\,[K] \cdot 1.013\,[bar\,abs]}{273.15\,K \cdot P\,[bar\,abs]}$$

$$\dot{V}_N\,[Nm^3/h] = \frac{\dot{V}\,[m^3/h] \cdot 273.15\,K \cdot P\,[bar\,abs]}{T\,[K] \cdot 1.013\,[bar\,abs]}$$

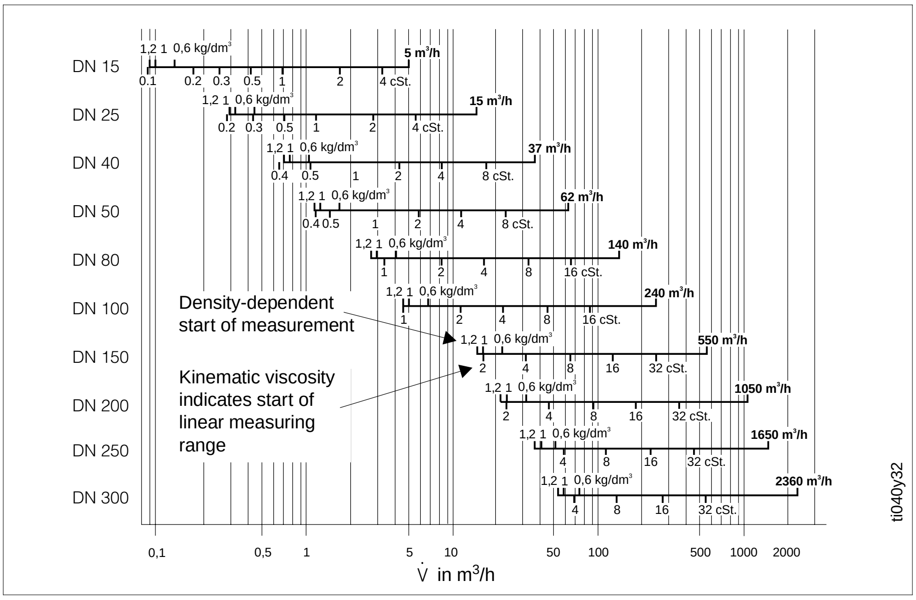
P = operating pressure
T = operating temperature

Measuring Ranges Liquids

Example for Liquids

To determine:
Nominal diameter (DN) to measure a liquid with a density of 0.8 kg/dm^3 and a kinematic viscosity of 2 cSt at a flow rate of 40 m^3/h.

Calculation:
Select the nominal diameter in the liquids measuring range diagram below for V = 40 m^3/h ⇒ DN 50.
For ρ = 0.8 kg/dm^3 and a kinematic viscosity of 2 cSt. the lower range-value is 1.5 m^3/h and the linear measuring range starts at 5.6 m^3/h. This gives a measuring range of 1.5...62 m^3/h or 1200...49600 kg/h.



Pressure Loss

Pressure Loss:
Δp [mbar] = coefficient C · density ρ [kg/m^3]
Determine the C coefficient from the diagram below

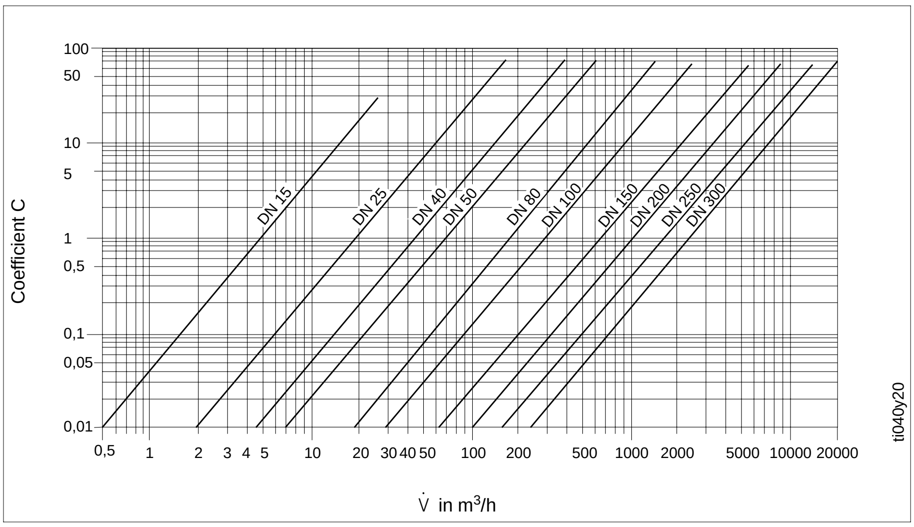
Example for Saturated Steam

To determine:
Pressure loss for a saturated steam flow of 8 t/h (12 bar abs.) with a nominal diameter DN 100.

Calculation:
Convert kg/h ⇒ m^3/h using the density of steam (6.13 kg/m^3) from the table on page 10.

$$\dot{V}\ [m^3/h] = \frac{\dot{m}}{\rho} = \frac{8000\,kg/h}{6.13\,kg/m^3} = 1305\,m^3/h$$

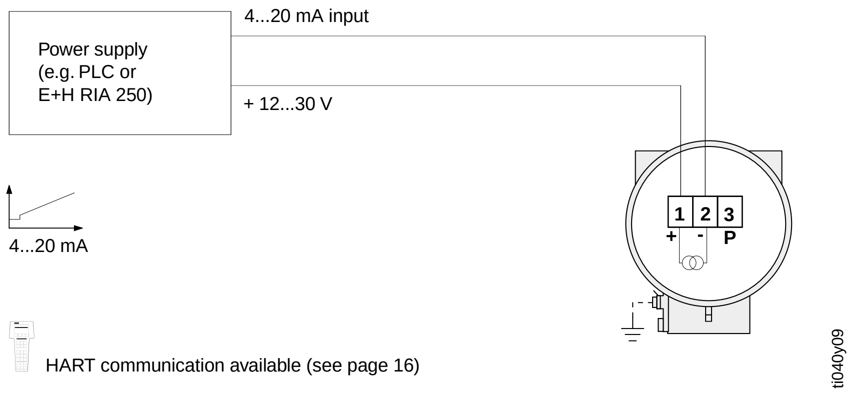
$\dot{V}$ = 1305 m^3/h and DN = 100 ⇒ C = 20
Δp = C·ρ = 20 · 6.13 kg/m^3 ⇒ 123 mbar



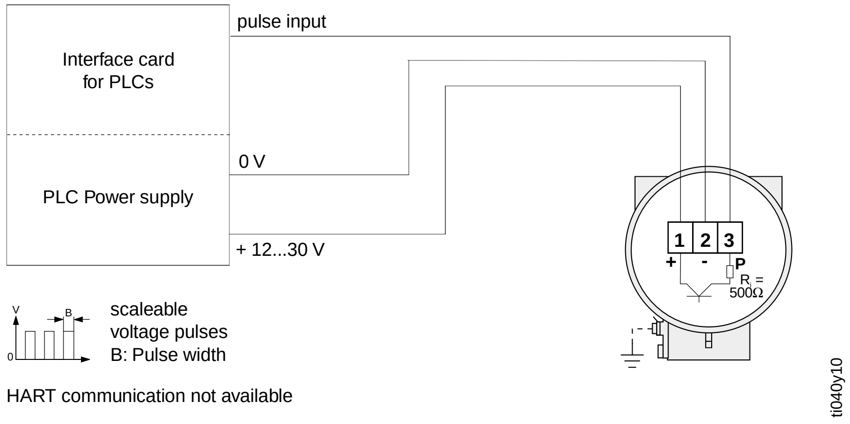
Electrical Connection

Safe Area Version

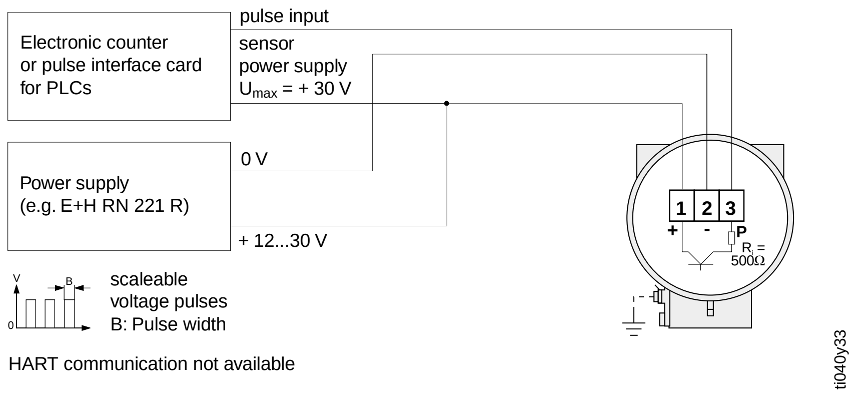
Connection 4...20 mA



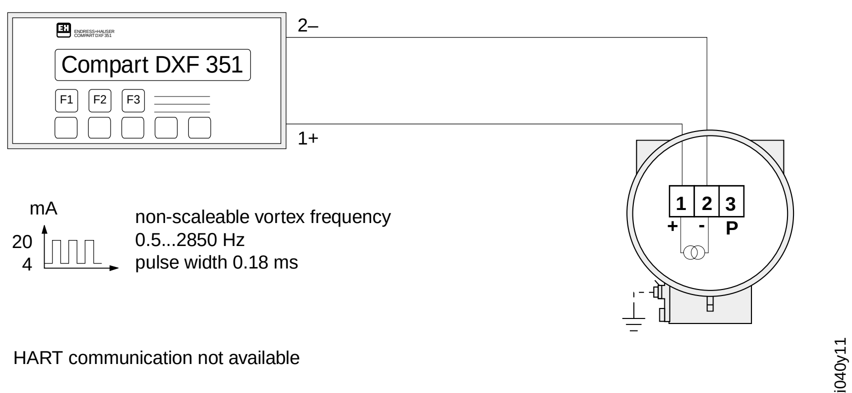
Pulse output to PLC with galvanically *not isolated* inputs



Pulse output to electronic counter with sensor power supply or PLC with *galvanically isolated* inputs



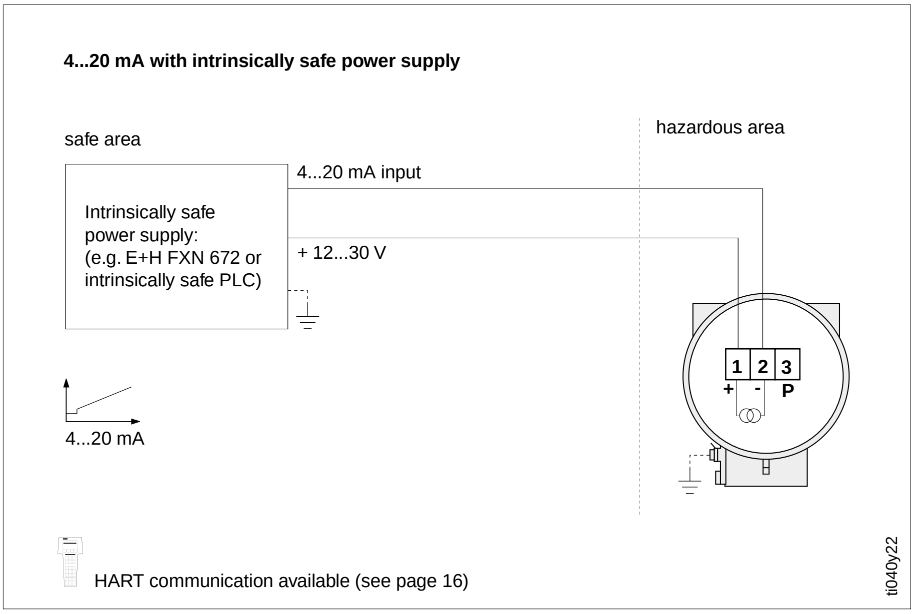
PFM pulses, non-scaleable, two-wire connection to E+H flow computer DXF 351

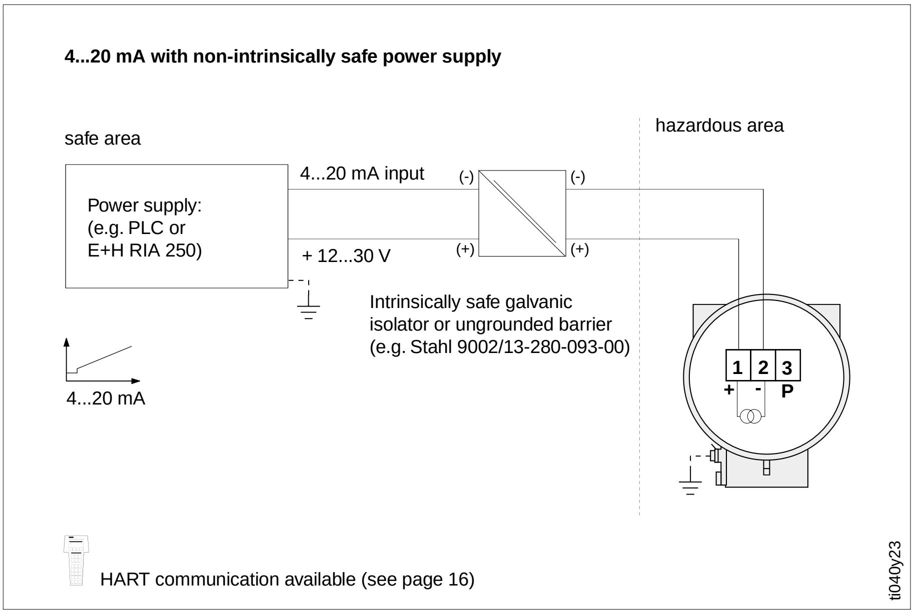


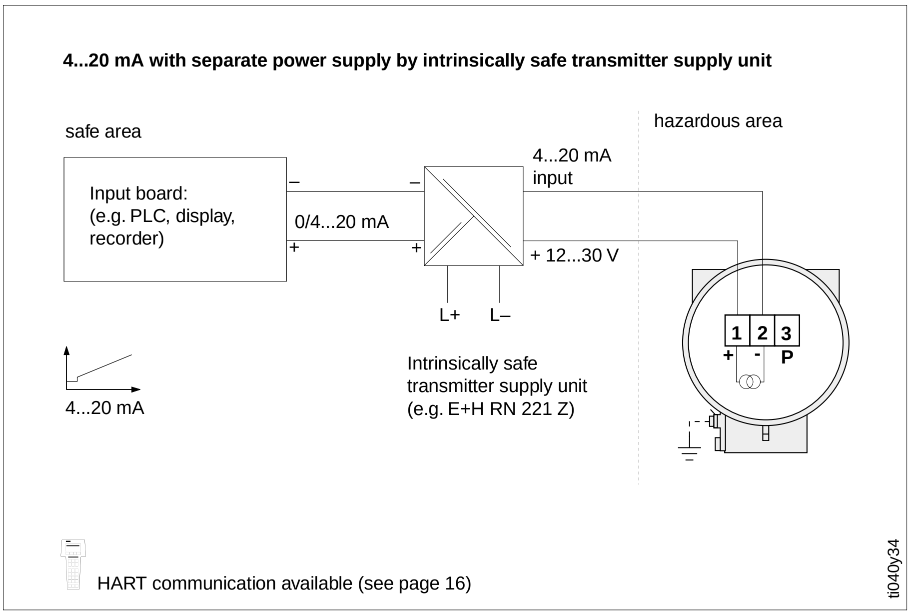
Electrical Connection

Ex i version

Caution!
Ground potential equalisation must exist between the safe and hazardous areas.





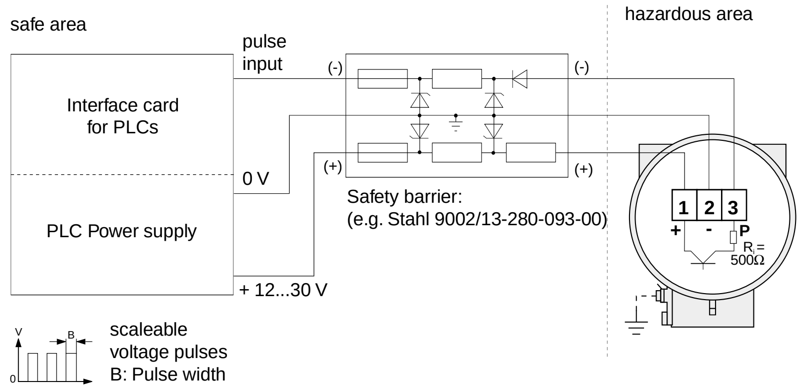


(continued next page)

Electrical Connection

Ex i version

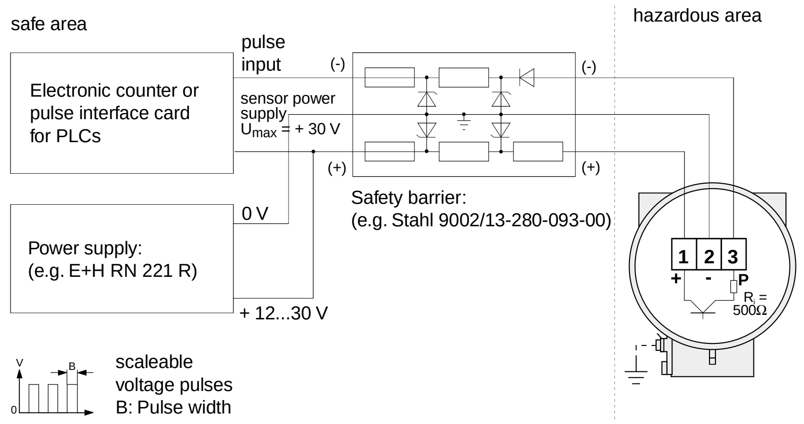
Pulse output to not intrinsically safe PLC with galvanically *not isolated* inputs



HART communication not available

ti040y21

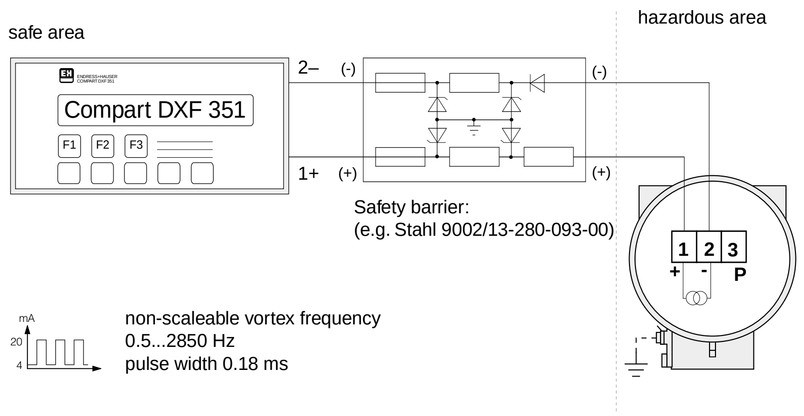
Pulse output to electronic counter with sensor power supply or not intrinsically safe PLC with *galvanically isolated* inputs



HART communication not available

ti040y35

PFM pulses, non-scaleable, two-wire connection to E+H flow computer DXF 351



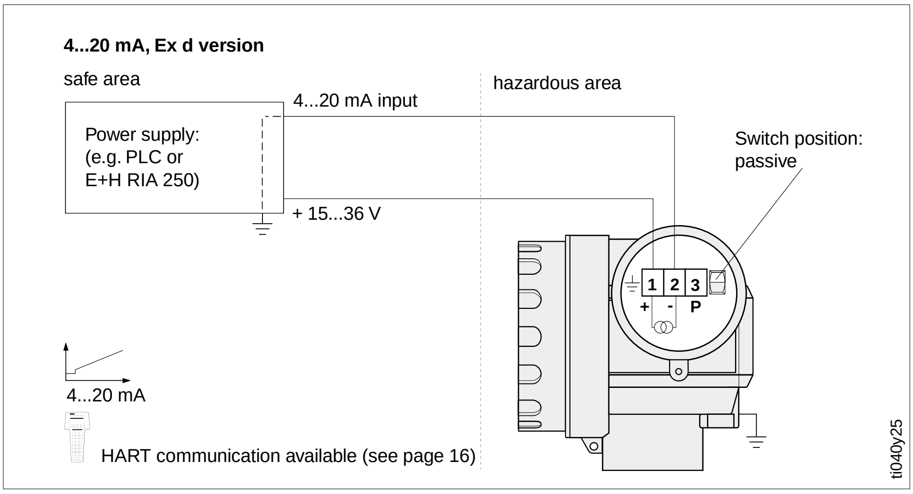
HART communication not available

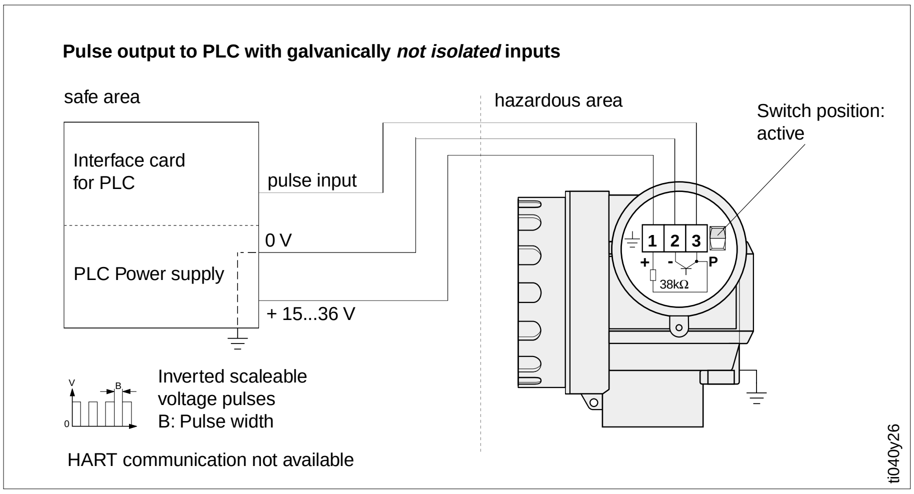
ti040y24

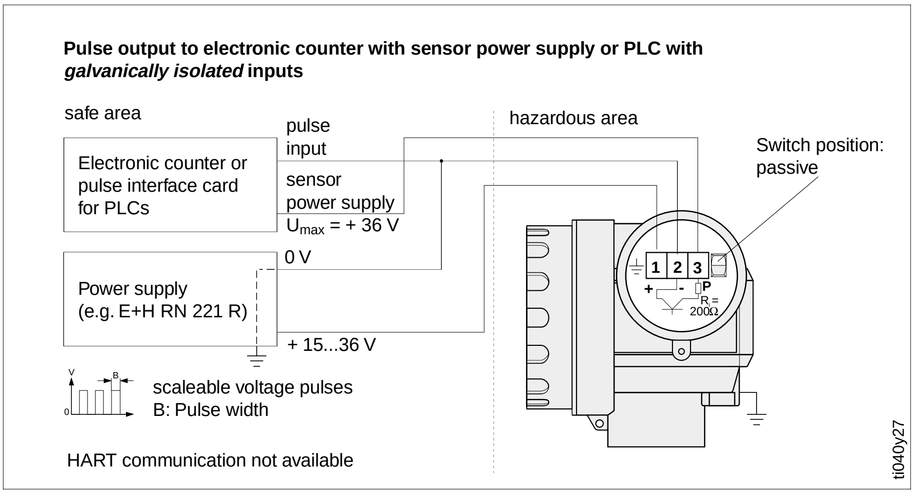
Electrical Connection

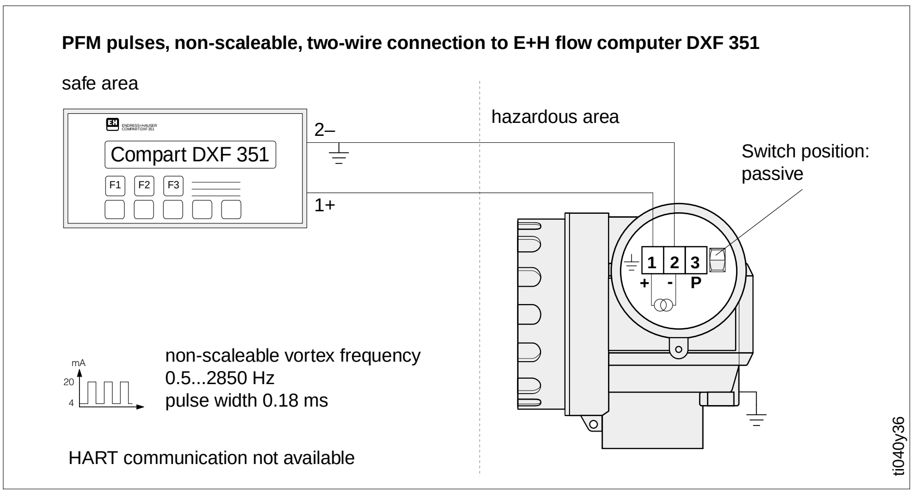
Ex d version

Caution!
Ground potential equalisation must exist between the safe and hazardous areas.



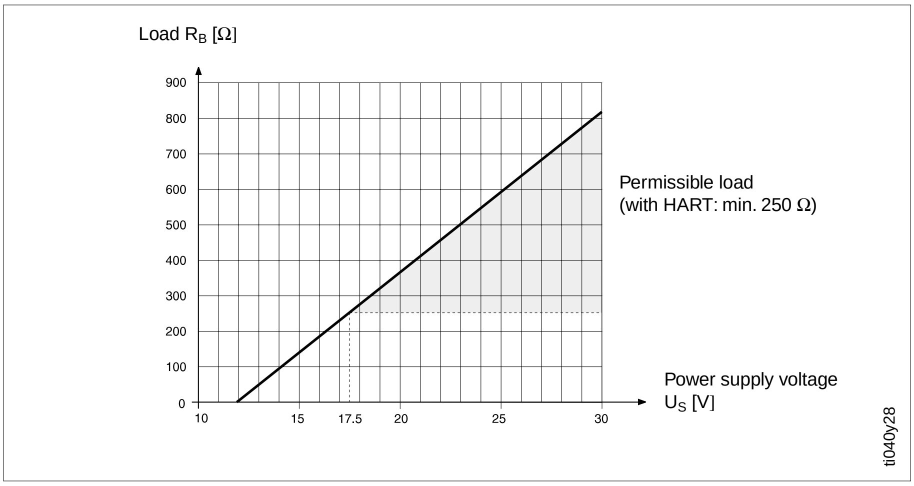






Electrical Connection

Load

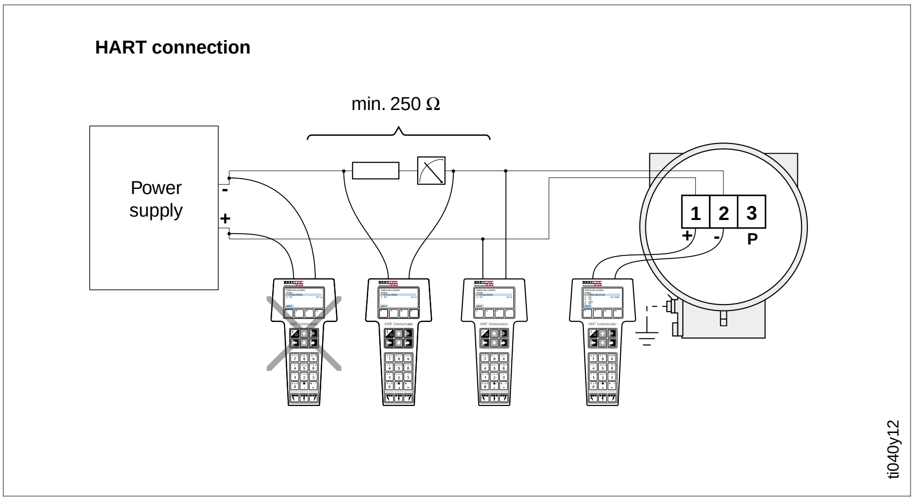


$$R_B = \frac{U_S - U_{Kl}}{I_{max} \cdot 10^{-3}} = \frac{U_S - 12}{0.022}$$

R_B = load resistance
U_S = power supply voltage (12...30 V DC)
U_{Kl} = terminal voltage Prowirl 77 (min. 12 V DC)
I_{max} = output current (22 mA)

HART

Note!
Power supply 17.5...30 V (20.5...36 V for Ex d).
If the power supply has an internal resistance of min. 250 Ω, the power supply can range between 12 and 30 V (15...36 V for Ex d version). In this case the HART handheld can be connected directly to the power supply.

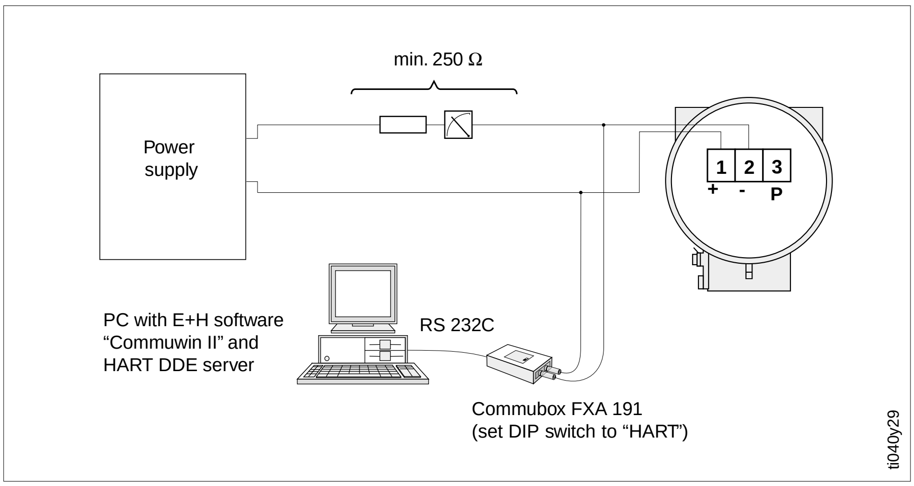


Special notes for the connection of the Ex versions can be found in the Ex documentation.

Commuwin II

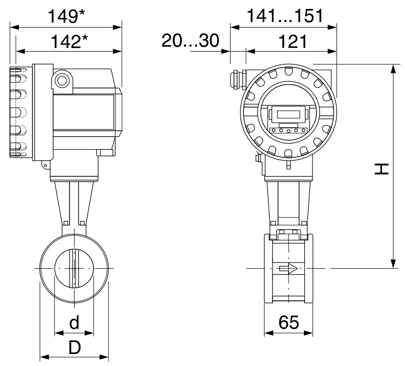
The Prowirl 77 can be connected to the RS 232C serial interface of a personal computer via the E+H Commubox FXA 191. The flowmeter can then be operated remotely using E+H "Commuwin II" software and HART DDE server.
Connection via the 4...20 mA signal wiring and the load are analogue to the HART handheld. For the Ex versions see also the Ex documentation.

Note!
Power supply 17.5...30 V (20.5...36 V for Ex d).
If the power supply has an internal resistance of min. 250 Ω, the power supply can range between 12 and 30 V (15...36 V for Ex d version). In this case the Commubox can be connected directly to the power supply.



Dimensions and Weights

Prowirl 77 W

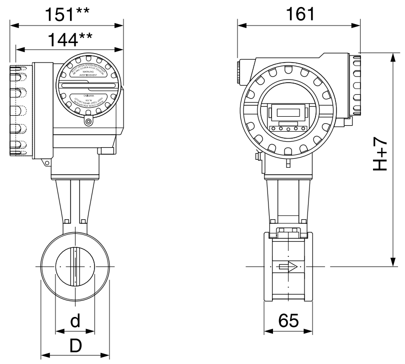


Dimensions:
*149 mm with glass cover
*142 mm blind version

Wafer version for flanges according to:
- DIN 2501, PN 10...40
- ANSI B16.5, Cl. 150/300, Sch40
- JIS B2238, 10K/20K, Sch40

Mounting kits for self centering mounting between flanges (see page 6) can be ordered with the instrument.

Ex d version



Dimensions:
**151 mm with glass cover
**144 mm blind version

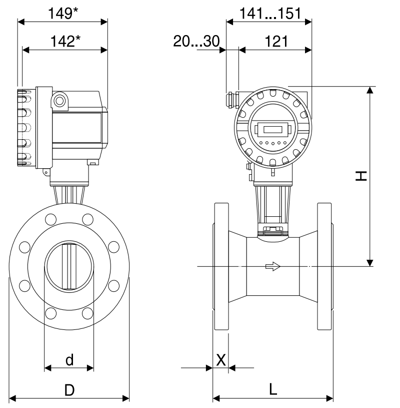
For the high/low temperature option, H increases by 40 mm and the weight by approx. 0.5 kg.

The Ex d version is approx. 0.5 kg heavier than the standard version.

DN		**d**	**D**	**H**	**Weight**
DIN / JIS	ANSI	[mm]	[mm]	[mm]	[kg]
15	½"	16.50	45.0	247	3.0
25	1"	27.60	64.0	257	3.2
40	1½"	42.00	82.0	265	3.8
50	2"	53.50	92.0	272	4.1
80	3"	80.25	127.0	286	5.5
100	4"	104.75	157.2	299	6.5
150	6"	156.75	215.9	325	9.0

Dimensions and Weights

Prowirl 77 F

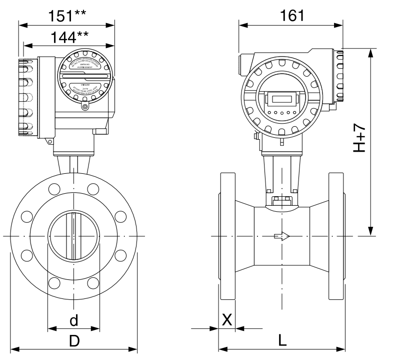


(ISO/DVGW for DN 15...150)

Dimensions:
*149 mm with glass cover
*142 mm blind version

Flanges:
- DIN 2501, raised face acc. to DIN 2526 form C
- ANSI B16.5
- JIS B2238

Ex d version



Dimensions:
**151 mm with glass cover
**144 mm blind version

For the high/low temperature option, H increases by 40 mm and the weight by approx. 0.5 kg.

The Ex d version is approx. 0.5 kg heavier than the standard version.

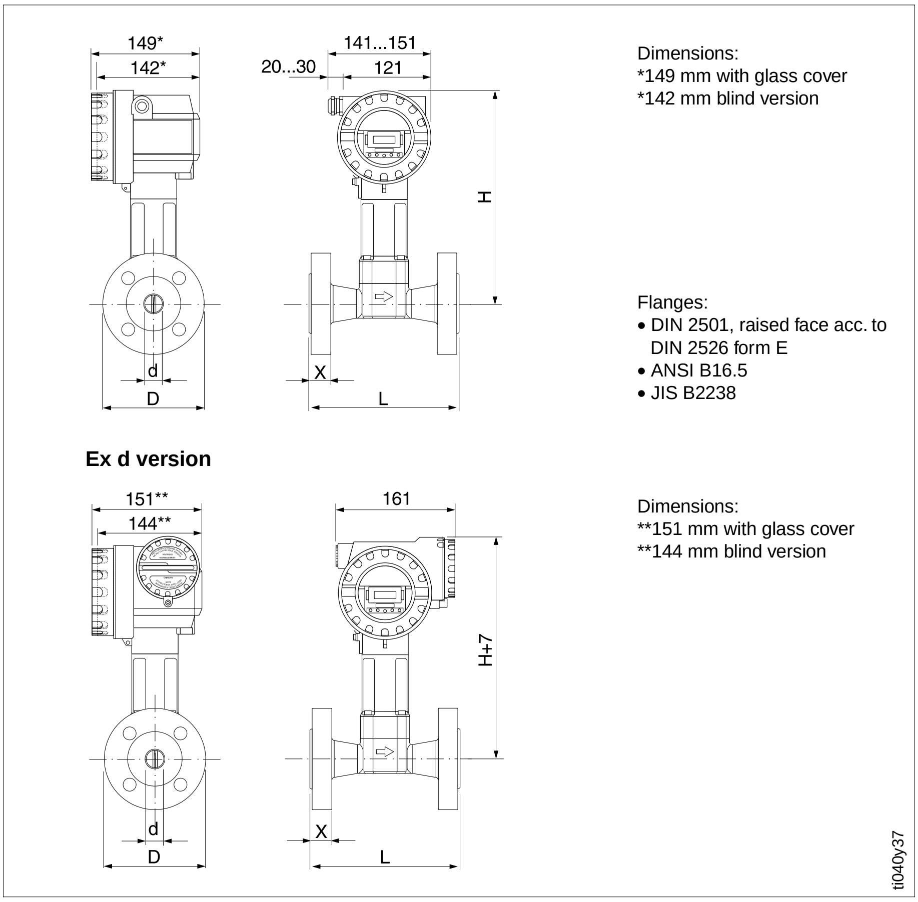
DN	Standard	Pressure rating	d [mm]	D [mm]	H [mm]	L [mm]	X [mm]	Weight [kg]
	DIN	PN 40	17.3	95.0				
	ANSI SCHED 40	Cl. 150	15.7	88.9				
		Cl. 300	15.7	95.0				
15 / ½"	ANSI SCHED 80	Cl. 150	13.9	88.9	248	200	17	5
		Cl. 300	13.9	95.0				
	JIS SCHED 40	Cl. 20K	16.1	95.0				
	JIS SCHED 80	Cl. 20K	13.9	95.0				
	DIN	PN 40	28.5	115.0				
	ANSI SCHED 40	Cl. 150	26.7	107.9				
		Cl. 300	26.7	123.8				
25 / 1"	ANSI SCHED 80	Cl. 150	24.3	107.9	255	200	19	7
		Cl. 300	24.3	123.8				
	JIS SCHED 40	Cl. 20K	27.2	125.0				
	JIS SCHED 80	Cl. 20K	24.3	125.0				
	DIN	PN 40	43.1	150				
	ANSI SCHED 40	Cl. 150	40.9	127				
		Cl. 300	40.9	155.6				
40 / 1½"	ANSI SCHED 80	Cl. 150	38.1	127	263	200	21	10
		Cl. 300	38.1	155.6				
	JIS SCHED 40	Cl. 20K	41.2	140				
	JIS SCHED 80	Cl. 20K	38.1	140				

(Continued on next page)

DN	Standard	Pressure rating	d [mm]	D [mm]	H [mm]	L [mm]	X [mm]	Weight [kg]
50 / 2"	DIN	PN 40	54.5	165	270	200	24	12
	ANSI SCHED 40	Cl. 150	52.6	152.4				
		Cl. 300	52.6	165				
	ANSI SCHED 80	Cl. 150	49.2	152.4				
		Cl. 300	49.2	165				
	JIS SCHED 40	Cl. 10K	52.7	155				
		Cl. 20K	52.7	155				
	JIS SCHED 80	Cl. 10K	49.2	155				
		Cl. 20K	49.2	155				
80 / 3"	DIN	PN 40	82.5	200	283	200	30	20
	ANSI SCHED 40	Cl. 150	78	190.5				
		Cl. 300	78	210				
	ANSI SCHED 80	Cl. 150	73.7	190.5				
		Cl. 300	73.7	210				
	JIS SCHED 40	Cl. 10K	78.1	185				
		Cl. 20K	78.1	200				
	JIS SCHED 80	Cl. 10K	73.7	185				
		Cl. 20K	73.7	200				
100 / 4"	DIN	PN 16	107.1	220	295	250	33	27
		PN 40	107.1	235				
	ANSI SCHED 40	Cl. 150	102.4	228.6				
		Cl. 300	102.4	254				
	ANSI SCHED 80	Cl. 150	97	228.6				
		Cl. 300	97	254				
	JIS SCHED 40	Cl. 10K	102.3	210				
		Cl. 20K	102.3	225				
	JIS SCHED 80	Cl. 10K	97	210				
		Cl. 20K	97	225				
150 / 6"	DIN	PN 16	159.3	285	319	300	38	51
		PN 40	159.3	300				
	ANSI SCHED 40	Cl. 150	154.2	279.4				
		Cl. 300	154.2	317.5				
	ANSI SCHED 80	Cl. 150	146.3	279.4				
		Cl. 300	146.3	317.5				
	JIS SCHED 40	Cl. 10K	151	280				
		Cl. 20K	151	305				
	JIS SCHED 80	Cl. 10K	146.3	280				
		Cl. 20K	146.3	305				
200 / 8"	DIN	PN 10	207.3	340	348	300	43	63
		PN 16						62
		PN 25	206.5	360				68
		PN 40		375				72
	ANSI SCHED 40	Cl. 150	202.7	342.9				64
		Cl. 300		381				76
	JIS SCHED 40	Cl. 10K		330				58
		Cl. 20K		350				64
250 / 10"	DIN	PN 10	260.4	395	375	380	49	88
		PN 16		405				92
		PN 25	258.8	425				100
		PN 40		450				111
	ANSI SCHED 40	Cl. 150	254.5	406.4				92
		Cl. 300		444.5				109
	JIS SCHED 40	Cl. 10K		400				90
		Cl. 20K		430				104
300 / 12"	DIN	PN 10	309.7	445	398	450	53	121
		PN 16		460				129
		PN 25	307.9	485				140
		PN 40		515				158
	ANSI SCHED 40	Cl. 150	304.8	482.6				143
		Cl. 300		520.7				162
	JIS SCHED 40	Cl. 10K		445				119
		Cl. 20K		480				139

Dimensions and Weights

Prowirl 77 H

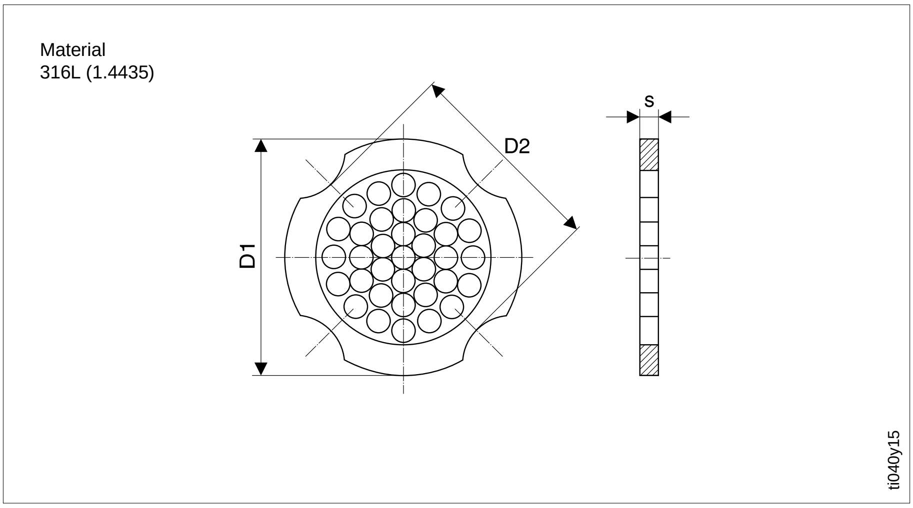


The Ex d version is approx. 0.5 kg heavier than the standard version.

DN	Standard	Pressure rating	d [mm]	D [mm]	H [mm]	L [mm]	X [mm]	Weight [kg]
15 / ½"	DIN	PN 160	17.3	105	288	200	22.4	7
	ANSI SCHED 80	Cl. 600	13.9	95.3				6
	JIS SCHED 80	Cl. 40K	13.9	115				8
25 / 1"	DIN	PN 100 PN 160	28.5 27.9	140 140	295	200	26.4	11 11
	ANSI SCHED 80	Cl. 600	24.3	124				9
	JIS SCHED 80	Cl. 40K	24.3	130				10
40 / 1½"	DIN	PN 100 PN 160	42.5 41.1	170 170	303	200	30.9	15 15
	ANSI SCHED 80	Cl. 600	38.1	155.4				13
	JIS SCHED 80	Cl. 40K	38.1	160				14
50 / 2"	DIN	PN 64 PN 100 PN 160	54.5 53.9 52.3	180 195 195	310	200	32.4	17 19 19
	ANSI SCHED 80	Cl. 600	49.2	165.1				14
	JIS SCHED 80	Cl. 40K	49.2	165				15
80 / 3"	DIN	PN 64 PN 100 PN 160	81.7 80.9 76.3	215 230 230	323	200	38.2	24 27 27
	ANSI SCHED 80	Cl. 600	73.7	209.6				22
	JIS SCHED 80	Cl. 40K	73.7	210				24
100 / 4"	DIN	PN 64 PN 100 PN 160	106.3 104.3 98.3	250 265 265	335	250	48.9	39 42 42
	ANSI SCHED 80	Cl. 600	97	273.1				43
	JIS SCHED 80	Cl. 40K	97	240				36
150 / 6"	DIN	PN 64 PN 100 PN 160	157.1 154.1 146.3	345 355 355	359	300	63.4	86 88 88
	ANSI SCHED 80	Cl. 600	146.3	355.6				87
	JIS SCHED 80	Cl. 40K	146.6	325				77

Dimensions and Weights

Flow Conditioner DIN



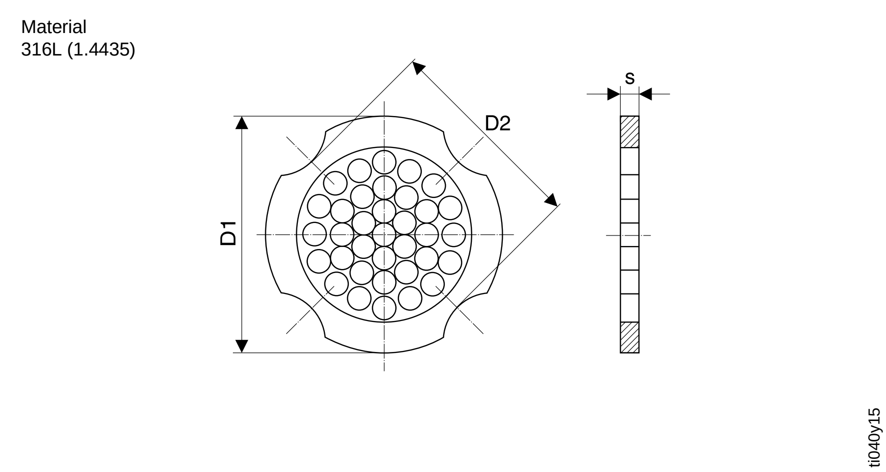
Explanation of entries in column D1 / D2:

D1: The flow conditioner is clamped between bolts at its outer diameter.
D2: The flow conditioner is clamped between bolts at the indentures.

DIN					
DN	**Pressure rating**	**Centering diameter** [mm]	**D1 / D2**	**s**	**Weight** [kg]
15	PN 10...40 PN 64	54.3 64.3	D2 D1	2.0	0.04 0.05
25	PN 10...40 PN 64	74.3 85.3	D1 D1	3.5	0.12 0.15
40	PN 10...40 PN 64	95.3 106.3	D1 D1	5.3	0.3 0.4
50	PN 10...40 PN 64	110.0 116.3	D2 D1	6.8	0.5 0.6
80	PN 10...40 PN 64	145.3 151.3	D2 D1	10.1	1.4 1.4
100	PN 10/16 PN 25/40 PN 64	165.3 171.3 252.0	D2 D1 D1	13.3	2.4 2.4 2.4
150	PN 10/16 PN 25/40 PN 64	221.0 227.0 252.0	D2 D2 D1	20.0	6.3 7.8 7.8
200	PN 10 PN 16 PN 25 PN 40 PN 64	274.0 274.0 280.0 294.0 309.0	D1 D2 D1 D2 D1	26.3	11.5 12.3 12.3 15.9 15.9
250	PN 10/16 PN 25 PN 40 PN 64	330.0 340.0 355.0 363.0	D2 D1 D2 D1	33.0	25.7 25.7 27.5 27.5
300	PN 10/16 PN 25 PN 40/64	380.0 404.0 420.0	D2 D1 D1	39.6	36.4 36.4 44.7

Dimensions and Weights

Flow Conditioner ANSI



Explanation of entries in column D1 / D2:

D1: The flow conditioner is clamped between bolts at its outer diameter.
D2: The flow conditioner is clamped between bolts at the indentures.

ANSI					
DN	**Pressure rating**	**Centering diameter** [mm]	**D1 / D2**	**s**	**Weight** [kg]
½"	Cl. 150 Cl. 300	51.1 56.5	D1 D1	2.0	0.03 0.04
1"	Cl. 150 Cl. 300	69.2 74.3	D2 D1	3.5	0.12 0.12
1½"	Cl. 150 Cl. 300	88.2 97.7	D2 D2	5.3	0.3 0.3
2"	Cl. 150 Cl. 300	106.6 113.0	D2 D1	6.8	0.5 0.5
3"	Cl. 150 Cl. 300	138.4 151.3	D1 D1	10.1	1.2 1.4
4"	Cl. 150 Cl. 300	176.5 182.6	D2 D1	13.3	2.7 2.7
6"	Cl. 150 Cl. 300	223.9 252.0	D1 D1	20.0	6.3 7.8
8"	Cl. 150 Cl. 300	274.0 309.0	D2 D1	26.3	12.3 15.8
10"	Cl. 150 Cl. 300	340.0 363.0	D1 D1	33.0	25.7 27.5
12"	Cl. 150 Cl. 300	404.0 420.0	D1 D1	39.6	36.4 44.6

Technical Data

Applications	
Designation	Flow measuring system “Prowirl 77”
Function	Measurement of volumetric flow rate of saturated steam, superheated steam, gases and liquids. With constant process temperature and pressure, Prowirl 77 can also output flow rates in units of mass, energy and corrected volumes.
Operation and system design	
Measurement principle	The Prowirl 77 vortex flowmeter operates on the physical principle of Karman vortex shedding.
Measurement system	The “Prowirl 77” instrument family consists of: • Transmitter: Prowirl 77 “PFM” Prowirl 77 “4...20 mA/HART” Prowirl 77 “PROFIBUS-PA” • Meter body: Prowirl 77 W wafer version, DN 15...150 Prowirl 77 F flanged version, DN 15...300, bigger nominal diameters on request Prowirl 77 H high pressure version, DN 15...150
Input variables	
Measured variables	The average flow velocity and volumetric flow rate are proportional to the frequency of vortex shedding behind the bluff body.
Measuring range	The measuring range is dependent on the fluid and the pipe diameter (see page 8 ff). • Full scale value: – Liquids: v_{max} = 9 m/s – Gas / steam: v_{max} = 75 m/s (DN 15: v_{max} = 46 m/s) • Lower range value: – depends on the fluid density and the Reynolds number, Re_{min} = 4000, Re_{linear} = 20000 DN 15 / 25: $v_{min} = \frac{6}{\sqrt{\rho}}$ m/s, with ρ in $\frac{kg}{m^3}$ DN 40...300: $v_{min} = \frac{7}{\sqrt{\rho}}$ m/s, with ρ in $\frac{kg}{m^3}$
Output variables PROFIBUS-PA	
Output signal	*PROFIBUS-PA interface:* PROFIBUS-PA according to EN 50170 Volume 2, IEC 1158-2, galvanically isolated
Current consumption	Current consumption = 12 mA
Permissible power voltage	Non intrinsically safe = 9 V...32 V Intrinsically safe = 9 V...24 V
FDE (Fault Disconnection Electronic)	0 mA
Speed of transmission	Baud rate used: 31.25 kBit/s
Signal encoding	Manchester II

Technical Data

Output variables	
Output signal	• 4...20 mA, optional with HART Full scale value and time constant are adjustable • PFM: two-wire current pulse output unscaled vortex frequency 0.5...2850 Hz, pulse width 0.18 ms • Scaleable pulse output (pulse width 0.05...2 s, f_{max} = 100 Hz) Standard and Ex i: U_{max} = 30 V, I_{max} = 10 mA, R_i = 500 Ω Ex d, switch to "passive": U_{max} = 36 V, I_{max} = 10 mA, R_i = 200 Ω Ex d, switch to "active": U_{max} = 36 V, R_i = 38 kΩ
Signal on alarm	The following applies for the duration of a fault: • LED: does not light up • Current output: programmable (3.6 mA, 22 mA or supplies values despite error) • Open collector / pulse output: not live and no longer supplies pulses • Totaliser: remains at the last value calculated
Load	see graph on page 16
Galvanic isolation	The electrical connections are galvanically isolated from the sensor.
Measuring accuracy	
Reference conditions	Error limits based on ISO/DIN 11631: • 20...30 °C, 2...4 bar • Calibration rig traceable to national standards
Measured error	Liquids < 0.75% o.r. for Re >20000 < 0.75% o.f.s. for Re 4000...20000 Gas / steam < 1% o.r. for Re >20000 < 1% o.f.s. for Re 4000...20000 Current output temperature coefficient < 0.03% o.f.s./Kelvin
Repeatability	≤ ±0.25% o.r.
Operating conditions	
Orientation	Any position (vertical, horizontal) For limitations and other recommendations see page 6
Inlet / outlet sections	Inlet section: >10 x DN Outlet section: > 5 x DN (For detailed information on the relationship between pipe installation and pipe internals see page 5)
Ambient temperature	–40...+60 °C When mounting in the open, it is recommended that it is protected from direct sunlight by an all-weather cover, especially in warm climates with high process temperatures.
Ingress protection	IP 67 (NEMA 4X)
Shock and vibration resistance	At least 1 g in every axis over the full frequency range up to 500 Hz
Electromagnetic Compatibility (EMC)	To EN 50081 Part 1 and 2 / EN 50082 Part 1 and 2, and NAMUR industrial standard

Process conditions

Process temperature

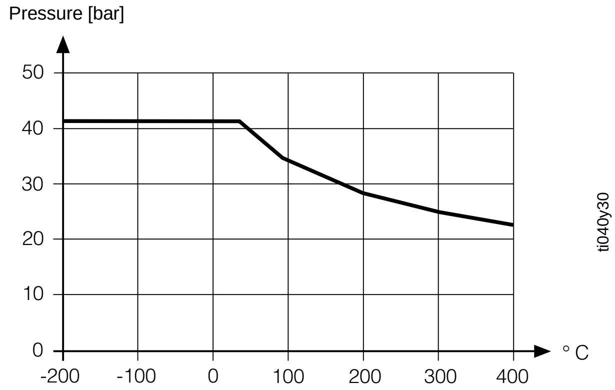
- Fluid: Standard sensor –40...+260 °C
  High/low temperature sensor –200...+400 °C
  Wafer type instruments of sizes DN 100 (4") and DN 150 (6") may not be mounted in orientation according to position B (see page 6) for fluid temperatures above 200 °C.
- Seal:

Graphite	–200...+400 °C
Viton	– 15...+175 °C
Kalrez	– 20...+220 °C
Gylon (PTFE)	–200...+260 °C

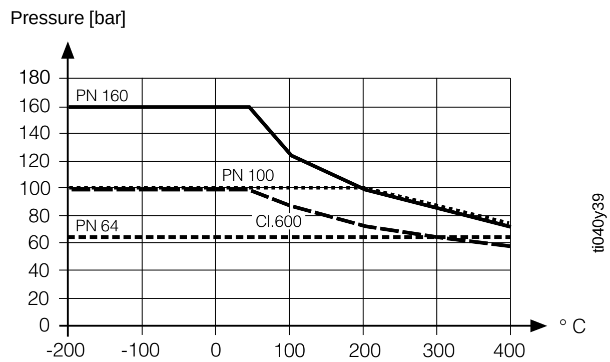
Process pressure limits

DIN: PN 10...40
ANSI: Class 150 / 300
JIS: 10K / 20K

Pressure-temperature curve of Prowirl 77 F and 77 W:



Pressure-temperature curve of Prowirl 77 H:



Pressure loss

Dependent on nominal diameter and fluid (see page 11)

Mechanical construction

Construction / dimensions	See pages 17 ff.
Weight	See pages 17 ff.

Technical Data

Mechanical construction (continued)	
Materials:	
Transmitter housing	Powder-coated die-cast aluminium
Sensor *– Wafer / flange*	Stainless steel, A351-CF3M (1.4404), complying to NACE MR0175
– Sensor	Stainless steel wetted parts: – Standard and high/low temperature sensor: 316L (1.4435), complying to NACE MR0175 – High pressure sensor: A637 (2.4668) (Inconel 718), complying to NACE MR0175 non-wetted parts: – CF3 (1.4306)
– Pipe stand	Stainless steel, 304L (1.4308)
Gaskets	Graphite Viton Kalrez Gylon (PTFE)
Cable entries	Power supply and signal cable (outputs): Cable entry PG 13.5 (5...11.5 mm) or Thread for cable entries: M20 x 1.5 (8...11.5 mm) ½" NPT G½"
Process connections	Wafer: Mounting set (see page 7) for flanges: – DIN 2501, PN 10...40 – ANSI B16.5, Class 150/300, Sch40 – JIS B2238, 10K/20K, Sch40 Flange: – DIN 2501, PN 10...40, raised face acc. to DIN 2526 form C – ANSI B16.5, Class 150/300, Sch40/80 (Sch80 DN 15...150) – JIS B2238, 10K/20K, Sch40/80 (Sch80 DN 15...150) High pressure: – DIN 2501, PN 64...160, raised face acc. to DIN 2526 form E – ANSI B16.5, Class 600, Sch80 – JIS B2238, 40K, Sch80
User interface	
Operation procedure *Display* *Communication*	• Local operation using 4 keys for programming all functions in the E+H operating matrix. • LCD 4-character with 3 decimal points 2-character with exponent Bargraph as flow indicator in % • LED for status indication • HART operation with the DXR 275 handheld terminal or Commuwin II. • PROFIBUS-PA
Power supply	
Power supply / frequency	12...30 V DC (with HART: 17.5...30 V DC) Ex d: 15...36 V DC (with HART: 20.5...36 V DC) PROFIBUS-PA: 9...32 V DC, current consumption 12 mA
Power consumption	<1 W DC (incl. sensor)
Power failure	• LED → off • The totalizer remains at the value last shown. • All programmed data remain in the EEPROM

Certificates and approvals	
Ex-approval	*Ex i / IS:* ATEX/CENELEC Ⓔ II2G, EEx ib IIC T1...T6 (not PROFIBUS-PA) Ⓔ II2G, EEx ib/ia IIC T1...T6 (only PROFIBUS-PA) ATEX Ⓔ II3G, EEx nA IIC T1...T6 X FM CI I/II/III Div 1, Groups A...G CSA Class I Div 1, Groups A...D Class II Div 1, Groups E...G Class III Div 1 *Ex d / XP (not for PROFIBUS-PA):* ATEX/CENELEC Ⓔ II2G, EEx d [ib] IIC T1...T6 FM CI I/II/III Div 1, Groups A...G CSA Class I Div 1, Groups A...D Class II Div 1, Groups E...G Class III Div 1 – Electrical connection diagrams can be found on page 13 ff. – Further information on the Ex-approvals is given in the separate Ex documentation.
CE mark	By attaching the CE mark, Endress+Hauser confirms that Prowirl 77 has been successfully tested and fulfils all legal requirements of the relevant EC directives.

Ordering		
Accessories	• Mounting set for wafer • Replacement parts according to the separate price list • Compart DXF 351 flow computer • Flow conditioner	
Supplementary documentation	• Operating Manual Prowirl 77 “PFM”	BA 034D/06/en
	• Operating Manual Prowirl 77 “4...20 mA/HART”	BA 032D/06/en
	• Operating Manual Prowirl 77 “PROFIBUS-PA”	BA 037D/06/en
	• System Information Prowirl	SI 015D/06/en
	• System Information Prowirl 77	SI 021D/06/en
	• Ex documentation	
	ATEX II2G/CENELEC Zone 1	XA 017D/06/a3
	ATEX II3G/CENELEC Zone 2	XA 018D/06/a3
	FM: Standard	EX 016D/06/a2
	CSA: Standard	EX 017D/06/D2

External standards and guidelines

EN 60529	Degree of protection (IP ingress protection)
EN 61010	Protection Measures for Electronic Equipment for Measurement, Control, Regulation and Laboratory Procedures
EN 50081	Part 1 and 2 (interference emission)
EN 50082	Part 1 and 2 (interference immunity)
NAMUR	Normenarbeitsgemeinschaft für Meß- und Regeltechnik in der Chemischen Industrie
NACE	National Association of Corrosion Engineers

Subject to modification

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