Technical
Information
TI 031D/06/e
No. 50072929

Vortex Flow Measuring System *prowirl 70*

Reliable Flow Measurement of Gas, Steam and Liquids

Safe
- Electromagnetic compatibility according to IEC 801 and NAMUR
- Sensor and electronics self-diagnostics with alarm functions
- Proven capacitive DSC sensor: resistant to vibration, thermal shock and overspeeding

Flexible
- Local, manual configuration possible with closed housing, even in hazardous areas (Ex i and Ex d)
- Current output simultaneously available with pulse, alarm or limit output.
- Programmable current and pulse simulation

Accurate
- Low measuring uncertainty
  <1% of rate (gas/steam)
  <0.75% of rate (liquids)
- Wide turndown of up to 45:1
- Every flowmeter is wet calibrated

Universal
- SMART technology permits two-way digital communication via HART protocol
- E+H Rackbus interface for connection to higher level bus systems
- Meter bodies and sensors available in a wide range of materials
- One standard, compact meter for all fluids and the complete process temperature range of -200...+400°C

Endress+Hauser
Nothing beats know-how

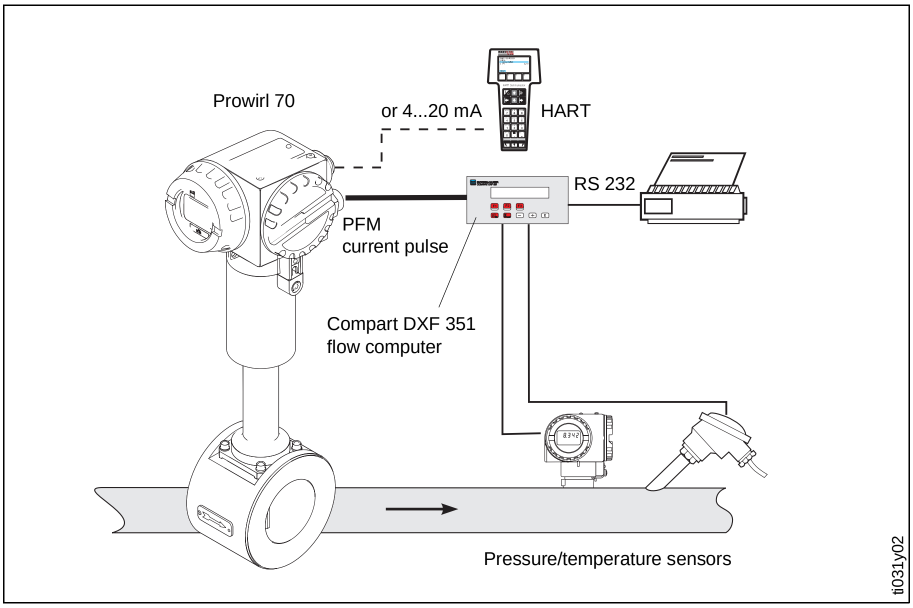
Prowirl 70 Measuring System

Applications
The Prowirl vortex flowmeter measures the volumetric flow of fluids with widely differing characteristics:
- Saturated steam
- Superheated steam
- Gases
- Low-viscosity liquids

Applications include:
- Energy production
- Chemical and petrochemical industry
- Food processing
- OEM

Prowirl measures the volumetric flow at operating conditions. If the process pressure and temperature are constant, Prowirl can be programmed to display the flow rate in mass, thermal, or corrected volume units.

In case of varying process conditions, the universal Compart DXF 351 flow computer calculates these values continually on the basis of signals from Prowirl and additional pressure and/or temperature transmitters.



Prowirl used as individual measuring location or as part of a process-control system

Measuring System
A measuring system consists of:
- Prowirl 70 transmitter (compact or remote)
- Prowirl W, F, H, or D meter body (see page 3)

The high performance, universal Prowirl 70 transmitter can be freely combined with the various, proven meter body styles. This guarantees flexibility when matching a complete meter to specific industrial process conditions.

Prowirl 70 Transmitter
The new Prowirl 70 transmitter has the following features:
- Microprocessor-controlled
- Self-monitoring and diagnosis of electronics and sensor
- Separate wiring compartment
- IP 65 protection type
- Built-in electromagnetic interference immunity (EMC)
- Programmable meter body thermal expansion coefficients
- 4...20 mA current output
- Open collector output, configurable for pulses, alarm or limit switch (not with Ex d version)
- Optional digital display with bargraph for rate and total

Local Programming
All functions can be set and all values can be read at the meter using four pushbuttons, even in hazardous areas, and without opening the housing.
Prowirl is delivered factory-programmed, but viewing or selection of the individual functions is easily done using a simple menu and the local display. Examples are:
- Engineering units
- Current output functions
- Open collector functions
- Display mode (local)
- System parameters

Digital Communication
- SMART technology permits remote programming of Prowirl 70 via HART protocol, using the HART DXR 275 handheld.
- With the E+H Intensor protocol, Prowirl 70 can be run with the Commutec system, making the system integration to Modbus, Profibus and FIP systems possible.

Using the Commuwin II program or a Commubox modem, the measured values and functions can be read or changed via a PC.

Meter Body Construction

Prowirl F (Flanged, DN 15...300)
This design offers the following advantages:
- An anchored and welded bluff body assures high resistance to water hammer in steam lines.

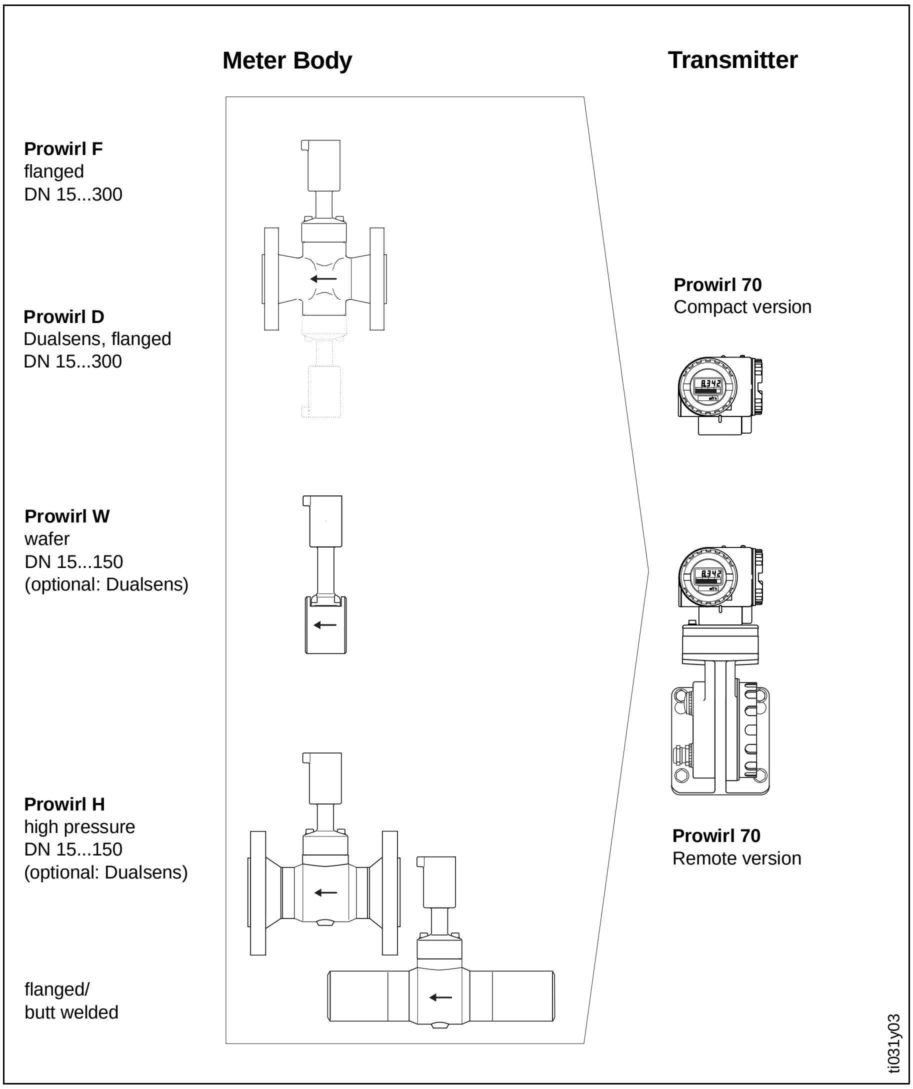
DN 15...150:
- Quality stainless steel casting
- Dye-penetrant tested
- Burst pressure >700 bar
- Standardised DVGW/ISO meter lengths

DN 200...300:
Welded design, standard with slip-on flanges.

Prowirl W (Wafer, DN 15...150)
This space saving wafer version is centered easily with the help of a mounting set. All nominal diameters have the same 65 mm width (see page 6).

Prowirl D (Dualsens, DN 15...300)
For special requirements, the Prowirl vortex meter is available with two independent sensors and electronics. Both sensors are built into the same meter body and, therefore, share the same K factor.
Applications:
- For facilities with high redundancy requirements.
- For processes where two separate flowmeters would normally be required, one for control and one for alarm purposes.
- For the measurement of liquid and gas in the same pipeline (single phase only), without reprogramming the transmitter.
- For higher signal resolution over two different measurement ranges.

Prowirl H (High Pressure DN 15...150)
Specially developed meter body and sensor for use at high pressures and for high safety requirements.
- Flange version (DIN: PN 64, 100, 160, 250 and ANSI: Class 600, 900, 1500)
- Butt-weld version (ANSI Class 1500)

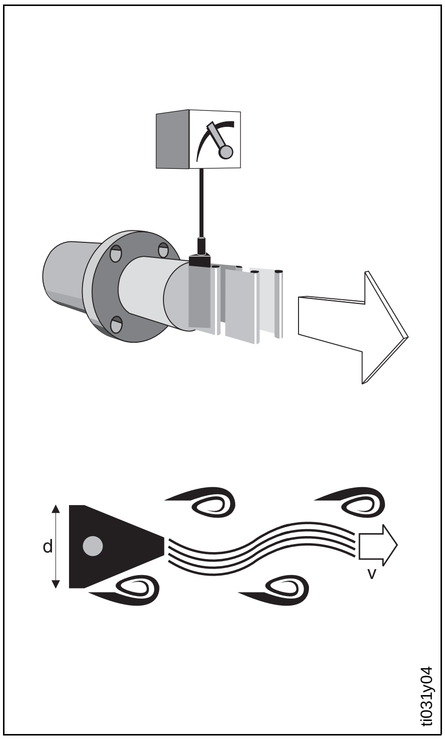


Measuring system
Prowirl 70

Function

Measuring Principle

The operating principle is based on the Karman vortex street. When a fluid flows past a bluff body, vortices are alternately formed on the sides of that body and are then detached or shed by the flow. The frequency of vortex shedding is proportional to the mean flow velocity and, therefore, to the volumetric flow (with Re > 4000).
Alternating pressure changes caused by the vortices are transmitted via lateral port holes in the bluff body.
The DSC sensor is located within the bluff body and is well protected from water hammer and temperature or pressure shocks.
The capacitive DSC sensor detects the pressure pulses and converts them into electrical signals.



Vortex measuring principle

$$\text{Vortex frequency} = \frac{St \cdot v}{d}$$

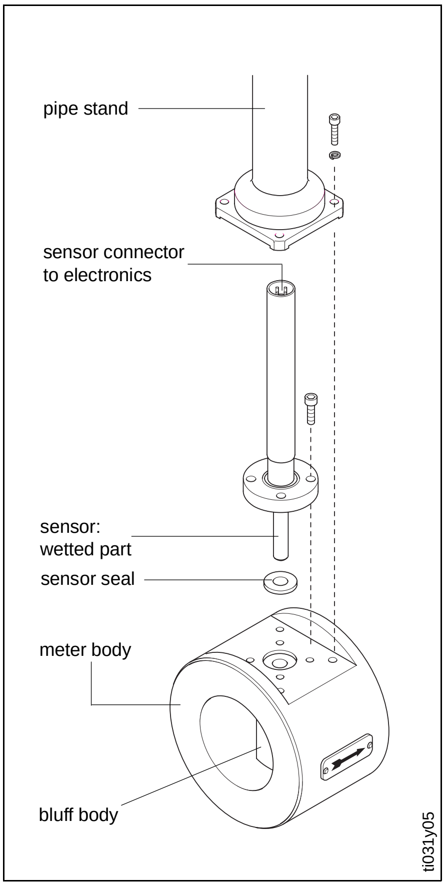
St = Strouhal number
v = velocity of medium
d = width of bluff body

The sensor preamplifier processes the sinusoidal sensor signal into a flow-proportional pulse frequency.
This is then converted by the transmitter (or flow computer) into a standard output signal.

The same sensor and electronics are used for all nominal diameters, fluids, and process temperatures. The sensor signal is galvanically isolated in the preamplifier from the output signal.

DSC Sensor Vibration Compensation

With Prowirl's DSC sensor, the general sensitivity of vortex meters to pipeline vibration has been eliminated. Using primary, built-in vibration compensation, pipeline vibration with amplitudes of up to 1g and frequencies to 500 Hz will not affect the measurement, regardless of the axis of acceleration. The compensation is permanent, and no adjustments are neccessary.



DSC sensor (standard version).
The Prowirl High Pressure version is equipped with a special titanium DSC sensor with a second containment.

Planning and Installation

The following installation recommendations are to be observed when installing Prowirl in the pipeline. In order to maintain the specified accuracy for all fluids and process conditions, the inner diameters of the meter or meter flange and the process piping should be identical. Specification of the correct process piping inner diameter or standard (DIN, ANSI Schedule 10/40/80 etc.) will avoid the need for calculated K factor corrections.

Inlet and Outlet Sections

An undisturbed flow profile is a pre-requisite for accurate vortex flow measurement. This can be ensured through sufficient inlet and outlet pipe sections.

- Inlet sections: min. 10 x DN
- Outlet sections: min. 5 x DN

Where flow disturbances such as pipe elbows, reducers, valves, etc. are located upstream of the vortex meter, longer upstream pipe sections are required.
If possible any valves should be installed after the flowmeter.

Note:
Where two or more disturbances are located upstream of the meter, the longest recommended upstream pipe section is to be observed.

Flow Conditioner

With limited space and large pipes, it is not always possible to have the inlet sections given above.
The specially developed perforated plate flow rectifier can reduce the inlet path to 10 x DN.
The flow rectifier is held between two piping flanges and centred with the flange bolts.
It rectifies distorted flow profiles efficiently with very little pressure loss.

Flow conditioner pressure loss calculation:

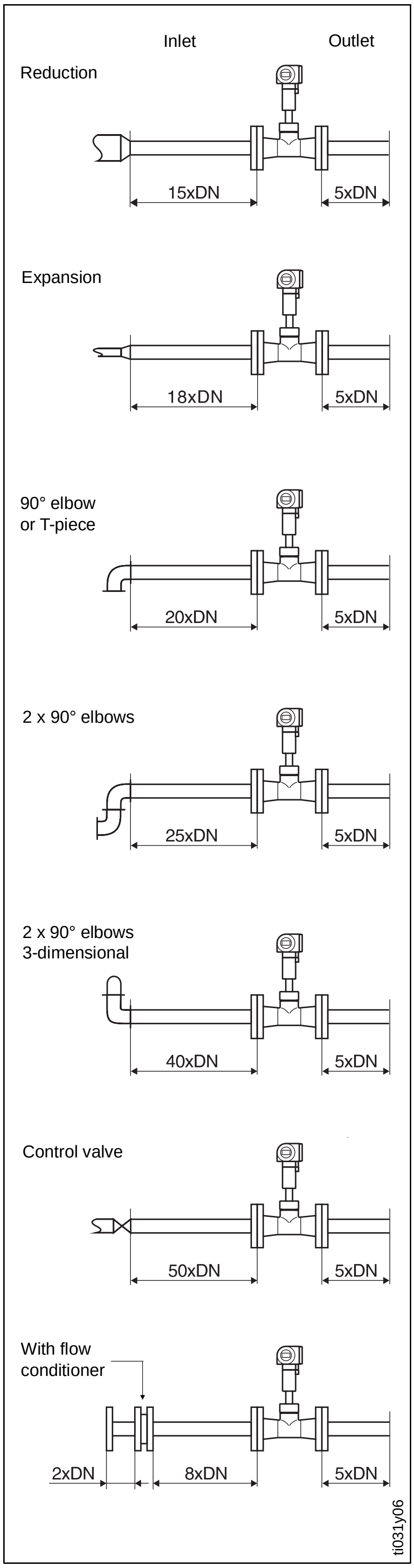
Δp [mbar] = 0.0085 · ρ [kg/m^3] · v^2 [m/s]

- Example with steam:

p = 10 bar abs.; t = 240 °C $\Rightarrow \rho$ = 4.39 kg/m^3
v = 40 m/s
Δp = 0.0085 · 4.39 kg/m^3 · (40 m/s)^2 = 59.7 mbar

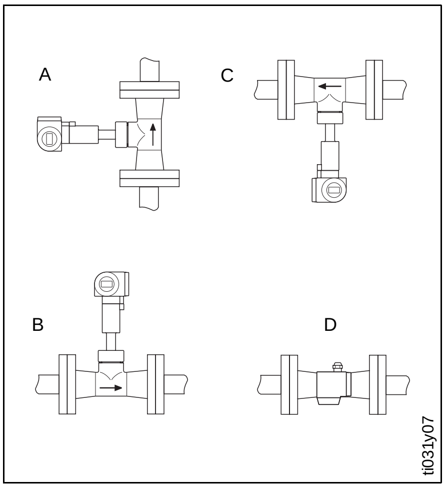
- Example with H_2O condensate (80 °C)

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



Inlet and outlet piping requirements

Planning and Installation



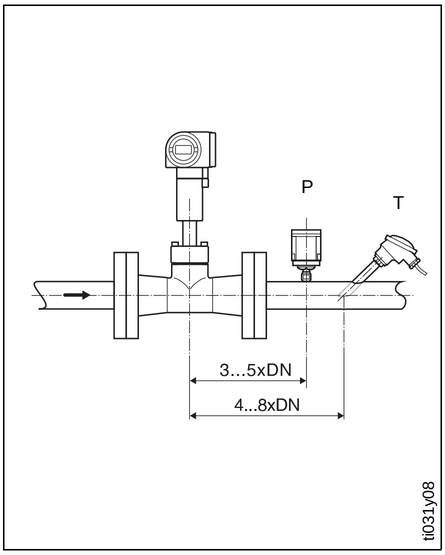
Orientation and process temperature

Installation Site

The Prowirl measuring system can basically be mounted in any position, although for extremes of process temperatures, the following orientations are recommended:

High process temperatures (e.g. steam):
- Horizontal pipeline: install according to C or D
- Vertical pipeline: install according to A

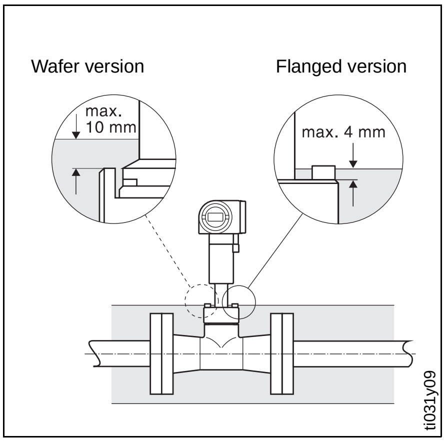
Low process temperatures (e.g. cryogenics):
- Horizontal pipeline: install according to B or D
- Vertical pipeline: install according to A



Pressure and temperature transmitter location

Pressure and temperature transmitters are to be positioned downstream of the meter, so that optimum vortex shedding is not affected (see adjacent figure).

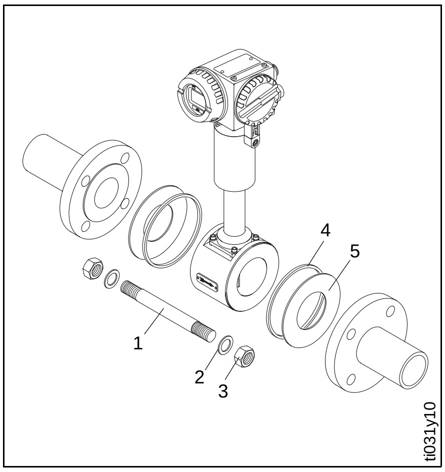
Note!
- For liquid measurement, ensure the pipeline is always full. Therefore, flow should be upward in vertical pipelines.
- Install a gas separator if gas bubbles are expected.
- Free-standing pipes subject to strong vibration (>1g) should be supported upstream and downstream of the meter.
- Keep within the maximum specified ambient and process temperatures (see page 22).



Pipeline insulation

Pipeline Insulation

Pipeline insulation is necessary to prevent energy loss in hot and cryogenic processes. When insulating Prowirl, ensure sufficient pipe stand surface area is exposed (see adjacent figure). The exposed area serves as a radiator and protects the electronics from extreme heat or cooling. This applies to both compact and remote versions.



Mounting set for wafer version (Prowirl W)

Mounting Set

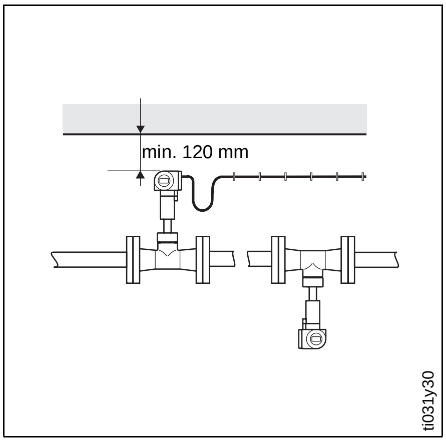
Accurate centering of wafer-style meters, essential for specified accuracy, is achieved with the use of a mounting set which consists of:

1 Bolts
2 Washers
3 Nuts
4 Centering rings
5 Gaskets

Planning and Installation

Minimum Spacing
In service cases it may be neccessary to unplug the electronics housing from the pipe stand. When installing, observe the following spacing:

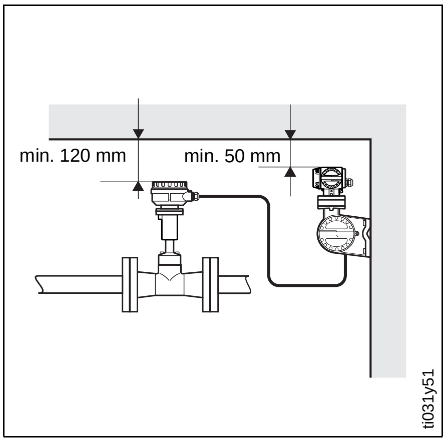
- Minimum space required to unplug the electronics housing: 120 mm; all other sides 100 mm
- Allowing 150 mm of slack cable will permit the above without having to disconnect the wiring.



Minimum spacing compact version

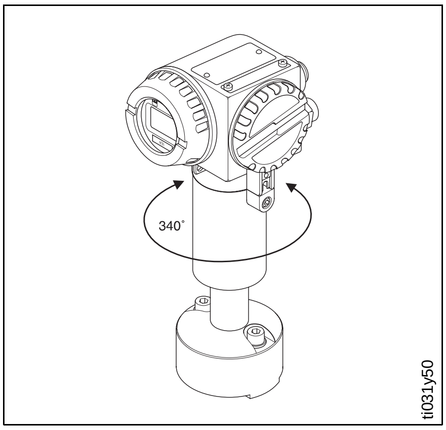
The following minimum spacing requirements apply to the remote version:

- Remote transmitter housing: 50 mm
- Flow meter: 120 mm



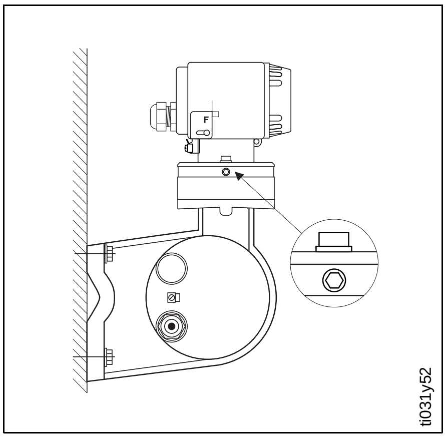
Minimum spacing remote version

Compact version
The housing can be rotated 340°, permitting display viewing in all mounted positions.
Within the housing, the display itself can be rotated in 90° steps.



Electronics housing compact version

Remote version
Both the remote transmitter housing and the meter housing can be rotated 340°.



Remote transmitter housing

Measuring Ranges, Nominal Diameters

Selecting the Nominal Diameter

The following are used to determine the measuring range and nominal diameter:

- Tables (e.g. for saturated steam measuring ranges)
- Measuring range diagrams (for superheated steam, gases, and liquids)
- "Applicator" software

The Prowirl vortex flowmeter determines the volumetric flow under operating conditions (e.g. m^3/h), i.e. the effective volume at a particular operating pressure (e.g. 20 bar).

Gas volumes are highly dependent on pressure and temperature.
Gas quantities are, therefore, usually given at standard temperature and pressure (Nm^3 at 1.013 bar, 0 °C) and steam quantities in kg or tons.
Calculating the volumes under operating conditions is done using the following equations and tables (see following pages).

"Applicator" Design Software

All important transmitter data are 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 IAPS (International Association for the Properties of Steam).

The Applicator software makes light work of the following calculations:

- Conversion of the operating volume of gas into a corrected volume
- Conversion to the mass flow of steam using temperature and/or pressure variables
- Calculation with viscosity included
- Calculation of pressure drop accross the flowmeter
- Simultaneous display of calculations for various nominal diameters
- Determining measuring ranges

The software runs on any IBM compatible PC.

Calculations Flow Values

The actual values for maximum and minimum flow depend mainly on the following factors:

- The Reynolds number (describing the flow condition) must be above 4000
- The fluid density determines the upper and lower flow limits as described below ("Minimum and Maximum Volumetric Flow Q_{min}/Q_{max}")
- Cavitation must be avoided (for liquids)

On the following pages different tables are given for various typical applications. Those tables can be used as a guideline for a first estimate of the measuring range. Please contact your Endress+Hauser sales organisation for exact dimensioning of the meter for your specific application.

Minimum and Maximum Volumetric Flow (Q_{min}/Q_{max})

Fluid density: 1 kg/m³ ≤ ρ ≤ 12.0 kg/m³

- DN 15: $Q_{min} = \frac{di^2 \cdot 0.0226}{\sqrt{\rho}}$ $\quad Q_{max} = di^2 \cdot 0.130$
- DN 25...300: $Q_{min} = \frac{di^2 \cdot 0.017}{\sqrt{\rho}}$ $\quad Q_{max} = di^2 \cdot 0.212$

Fluid density: ρ > 12.0 kg/m³

- DN 15: $Q_{min} = \frac{di^2 \cdot 0.022}{\sqrt{\rho}}$ $\quad Q_{max} = di^2 \cdot 0.130$ for $\rho \le 33$ kg/m³

  $Q_{max} = \frac{di^2 \cdot 0.746}{\sqrt{\rho}}$ for $\rho > 33$ kg/m³
- DN 25...300: $Q_{min} = \frac{di^2 \cdot 0.017}{\sqrt{\rho}}$ $\quad Q_{max} = \frac{di^2 \cdot 0.746}{\sqrt{\rho}}$

where
ρ = density in kg/m³
Q = volumetric flow in m³/h
di = internal diameter of pipe in mm

Measuring Ranges Meter Bodies

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

Your E+H sales organisation will be pleased to help you select and dimension a flowmeter for your specific application.

Prowirl W (wafer)

Nominal diameter DIN	**Air** (at 0 °C, 1.013 bar) [m^3/h]			**Water** (20 °C) [m^3/h]			**K-Factor** [pulses/dm^3]
	Q_{min}	Q_{max}	f-range (Hz)	Q_{min}	Q_{max}	f-range (Hz)	min/max
DN 15	4.0	25.4	455.4...2903.5	0.151	4.99	15.9...529.8	389.4...430.4
DN 25	10.6	150	183.6...2504.2	0.38	18.0	6.7...283.8	57.1...63.1
DN 40	27.7	394	112.8...1586.9	0.998	47.3	4.8...189.3	13.8...15.2
DN 50	44.3	630	87.4...1251.3	1.6	75.6	3.2...139	6.8...7.5
DN 80	102	1443	56.7...801.7	3.65	173	2.1...89	1.9...2.1
DN 100	171	2432	43.7...621.5	6.16	292	1.6...69.3	0.87...0.97
DN 150	379	5381	29.5...418.4	13.6	646	1.1...46.59	0.266...0.294
Nominal diameter ANSI (Sch 40)							
DN 15	4.0	25.4	455.4...2903.5	0.151	4.99	15.9...526	389.4...430.4
DN 25	10.6	150	183.6...2504.2	0.380	18.0	6.3...278.8	57.1...63.1
DN 40	25.0	355	121.5...1691.2	0.898	42.6	4.3...188.2	16.3...18.0
DN 50	41.1	584	92.7...1314	1.48	70.1	3.3...146.3	7.7...8.5
DN 80	90.5	1287	60.5...858	3.26	154	2.2...95.3	2.3...2.5
DN 100	156	2219	46.2...657.7	5.62	266	1.7...73.2	1.014...1.12
DN 150	354	5036	30.6...434.2	12.8	604	1.1...48.3	0.295...0.326

Prowirl F (flange DN 15...150) / Prowirl H (high pressure DN 15...150)

Nominal diameter (all standards)	**Air** (at 0 °C, 1.013 bar) [m^3/h]			**Water** (20 °C) [m^3/h]			**K-Factor** [pulses/dm^3]
	Q_{min}	Q_{max}	f-range (Hz)	Q_{min}	Q_{max}	f-range (Hz)	min/max
DN 15	3.94	24.9	455.4...2903.5	0.15	4.92	15.9...523.8	389.4...430.4
DN 25	8.8	125	196...2784.7	0.317	15.0	7.1...311.9	76.2...84.2
DN 40	21.6	308	127.8...1813.8	0.78	36.9	4.6...202	20.1...22.3
DN 50	36.1	513	95...1353.8	1.3	61.6	3.4...150.4	9.0...10.0
DN 80	81	1151	64.1...908.8	2.92	138	2.3...101.3	2.7...3.0
DN 100	140	1994	48...681.6	5.05	239	1.7...75.9	1.16...1.29
DN 150	319	4537	31.2...453.8	11.5	545	1.2...50.5	0.34...0.38

(The measuring ranges for DN 50 and DN 150 of the high pressure version differ slightly from the given table values)

Prowirl F (flange DN 200...300)

Nominal diameter DIN	**Air** (at 0 °C, 1.013 bar) [m^3/h]			**Water** (20 °C) [m^3/h]			**K-Factor** [pulses/dm^3]
	Q_{min}	Q_{max}	f-range (Hz)	Q_{min}	Q_{max}	f-range (Hz)	min/max
DN 200	627	8916	22.9...325.8	27.6	1070	1...36.2	0.125...0.138
DN 250	1001	14218	18.1...257	55.3	1707	1...28.6	0.0618...0.0683
DN 300	1414	20094	14.9...211	93.3	2412	0.98...23.5	0.0336...0.042
Nominal diameter ANSI (Sch 40)							
DN 200	615	8743	22.5...329.2	26.8	1050	0.98...36.6	0.129...0.142
DN 250	1000	14218	17.3...263.9	55.5	1707	0.94...29.4	0.066...0.074
DN 300	1377	19575	14.5...219.7	89.7	2350	0.94...24.5	0.0372...0.0436

Measuring Ranges Saturated Steam

Example of Calculation

To determine:
Measuring range for saturated steam with a nominal diameter DN 100 at an operating pressure of 12 bar abs. and 140 bar abs.

Calculation:
Min. and max. values for the measuring range can be found from the following table:
at 12 bar abs. ⇒ 395...12227 kg/h
at 140 bar abs. ⇒ 2642...78911 kg/h

Supplementary information from table:
- Saturated steam temp. = 188 °C (at 12 bar); 337 °C (at 140 bar)
- Density = 6.13 kg/m^3 (at 12 bar) 87.0 kg/m^3 (at 140 bar)

Operating pressure [bar abs.]	Measuring ranges for various nominal widths 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	2.5...7.7	5.6...38.6	13.7...95.0	22.8...158	51.2...355	88.7...616	202...1401	396...2753	632...4390	893...6205	81.3	0.31
1	3.4...14.7	7.7...73.9	18.9...182	31.6...303	70.8...680	123...1178	279...2680	548...5267	874...8399	1236...11870	99.6	0.59
1.5	4.2...21.5	9.3...108	22.9...266	38.1...443	85.6...994	148...1722	337...3916	663...7697	1057...12274	1494...17346	111	0.86
2	4.8...28.1	10.6...141	26.2...348	43.6...580	97.9...1301	170...2254	386...5126	758...10075	1209...16066	1709...22706	120	1.13
3	5.8...41.1	12.9...207	31.6...508	52.8...848	118...1902	205...3295	467...7496	917...14732	1462...23492	2067...33200	134	1.65
4	6.6...53.9	14.7...271	36.2...666	60.4...1111	136...2492	235...4317	534...9820	1050...19300	1674...30777	2366...43495	144	2.16
5	7.3...66.5	16.4...334	40.2...822	67.1...1370	151...3074	261...5326	593...12115	1166...23810	1859...37968	2628...53659	152	2.67
6	8.0...78.9	17.8...397	43.8...976	73.1...1627	164..3651	284...6325	646...14388	1271...28278	2026...45094	2863...63729	159	3.17
7	8.6...91.3	19.2...459	47.2...1129	78.6...1883	176...4224	306...7318	695...16646	1367...32716	2179...52170	3080...73730	165	3.97
8	9.1...104	20.4...521	50.2...1281	83.8...2137	188...4794	326...8305	741...18893	1456...37131	2322...59211	3281...83680	170	4.16
10	10.2...128	22.7...645	55.9...1584	93.2...2642	209...5929	326...10270	824...23362	1619...45915	2582...73219	3649...103000	180	5.15
12	11.1...153	24.8...767	61...1886	102...3146	228...7058	395...12227	899...27813	1767...54663	2817...87169	3981...123000	188	6.13
15	12.3...189	27.6...951	67.9...2338	113...3899	254...8749	440...15156	1001...34477	1967...67760	3136...108000	4433...153000	198	7.6
25	15.8...312	38.5...1567	94.6...3853	158...6425	354...14416	613...24972	1395...56807	2742...112000	4372...178000	6179...252000	224	12.5
30	17.6...382	44.1...1880	108...4621	170...7242	406...17290	703...30135	1523...64909				234	15
35	19.2...446	49.6...2196	122...5399	191...8462	456...20200	795...35209	1712...75837				243	17.5
40	21.3...511	54.9...2365	135...5815	212...9115	505...21759	880...37926	1896...81689				250	20.1
45	23.3...578	60.2...2514	148...6181	232...9688	553...23128	965...40311	2078...86826				257	22.7
50	25.4...645	65.4...2657	161...6532	252...10238	601...24442	1048...42602	2257...91760				264	25.4
64	31.0...842	79.8...3035	196...7460	307...11693	734...27914	1279...48653	2755...105000				280	33.1
80	37.4...1082	96.3...3440	237...8457	371...13255	886...31643	1544...55154	3325...119000				295	42.5
100	45.6...130.4	118...3928	289...9657	453...15137	1081...36135	1884...62982	4058...136000				311	55.4
120	54.3...1466	140...4415	344...10854	540...17013	1288...40613	2245...70788	4835...152000				325	70
140	63.9...1634	165...4922	405...12099	635...18965	1516...45274	2642...78911	5691...170000				337	87
160	74.9...1816	193...5470	475...13447	744...21078	1776...50318	3096...87704	6668...189000				347	108
180	87.7...2016	226...6075	556...14934	871...23408	2079...55881	3623...97400	7804...210000				357	133
200	102...2235	264...6734	648...16555	1061...25948	2426...61944	4229...108000	9108...233000				366	163
220	119...2465	305...7427	751...18259	1177...28619	2810...68321	4898...119000	10550...256000				374	198

* This table is given as guideline for measuring ranges of Prowirl 70 F (flanged), and Prowirl 70 H (high pressure).

[Framed box] Measuring range for the standard Prowirl H high-pressure version

Measuring Ranges Superheated Steam and Gas

Density is an important parameter for many calculations, e.g. in corrected volumes. The density of steam as a function of temperature and pressure can be determined from the following table.

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

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

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

P [bar abs]	Density of steam [kg/m³] 150 °C	200 °C	250 °C	300 °C	350 °C	400 °C
0.5	0.26	0.23	0.21	0.20	0.17	0.16
1.0	0.52	0.46	0.42	0.38	0.35	0.32
1.5	0.78	0.70	0.62	0.57	0.52	0.49
2.0	1.04	0.93	0.83	0.76	0.69	0.65
2.5	1.31	1.16	1.04	0.95	0.87	0.81
3.0	1.58	1.39	1.25	1.14	1.05	0.97
3.5	1.85	1.63	1.46	1.33	1.22	1.13
4.0	2.12	1.87	1.68	1.52	1.40	1.29
5.0		2.35	2.11	1.91	1.75	1.62
6.0		2.84	2.54	2.30	2.11	1.95
7.0		3.33	2,97	2.69	2.46	2.27
8.0		3.83	3.41	3.08	2.82	2.60
10.0		4.86	4.30	3.88	3.54	3.26
12.0		5.91	5.20	4.67	4.26	3.92
15.0		7.55	6.58	5.89	5.36	4.93
20.0			8.98	7.79	7.21	6.62
25.0			11.49	10.11	9.11	8.33
30.0			14.17	12.32	11.05	10.07
35.0			17.03	14.61	13.02	11.84
40.0				16.99	15.05	13.63
50.0				22.07	19.26	17.30
64.0				30.08	25.53	22.66
80.0				41.22	33.93	29.15
100.0					44.60	37.86
120.0					58.40	47.44
140.0					75.70	58.04
160.0					102.42	70.08
180.0						83.96
200.0						100.53
220.0						121.20
240.0						148.39
250.0						166.28

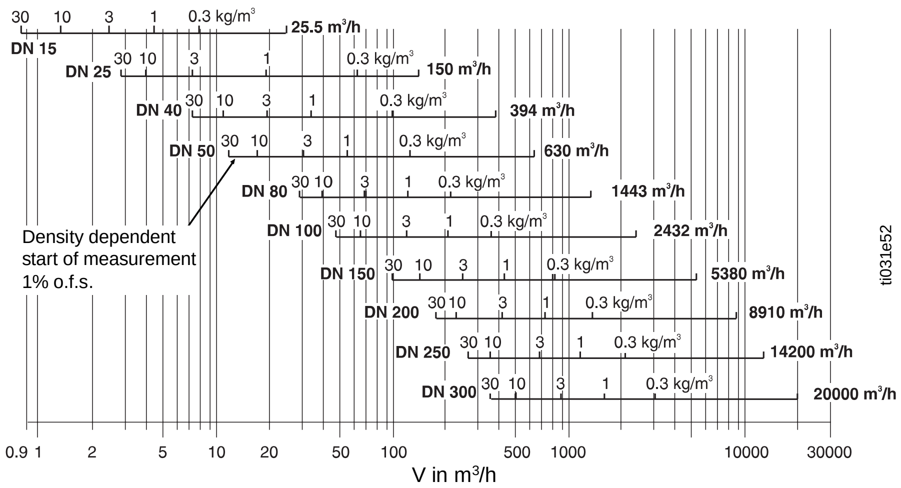
Example for Superheated Steam

To determine:
Nominal diameter to measure superheated steam at 250 °C and 15 bar abs. at a flowrate of 10 t/h.
Calculation:
a) Convert t/h ⇒ m^3/h using the density of steam (6.58 kg/m^3) from the table.

$$V\,[m^3/h] = \frac{\dot{m}}{\rho} = \frac{10000\,kg/h}{6.58\,kg/m^3} = 1520\,m^3/h$$

b) Select the nominal diameter in the steam/gas measuring range diagram below for V = 1520 m^3/h ⇒ DN 100.
For ρ = 6.58 kg/m^3 the initial value for the measuring range is 90 m^3/h as the initial value is dependent on the density. This gives a measuring range of 90...2430 m^3/h or 590...15990 kg/h.

Note: This diagram serves as a guideline for a quick estimation of Prowirl measuring ranges. Your E+H sales organisation will be pleased to help you select and dimension a flowmeter for your application.



The below formulaes show the convertions from operating- to corrected volume and density, and vice-versa.

Corrected/Operating Volume (V_C/V_O)

$$V_O\,[m^3/h] = \frac{V_C\,[Nm^3/h] \bullet T_O\,[K]}{273.15\,K \bullet P_O\,[bar\ abs.]}$$

$$V_C\,[Nm^3/h] = \frac{V_O\,[m^3/h] \bullet 273.15\,K \bullet P_O\,[bar\ abs.]}{T_O\,[K] \bullet 1.013\,bar}$$

Corrected/Operating Density (ρ_C/ρ_O)

$$\rho_O\,[kg/m^3] = \frac{\rho_C\,[kg/Nm^3] \bullet P_O\,[bar\ abs.] \bullet 273.15\,K}{T_O\,[K]}$$

$$\rho_C\,[kg/Nm^3] = \frac{\rho_O\,[kg/m^3] \bullet T_O\,[K]}{P_O\,[bar\ abs.] \bullet 273.15\,K}$$

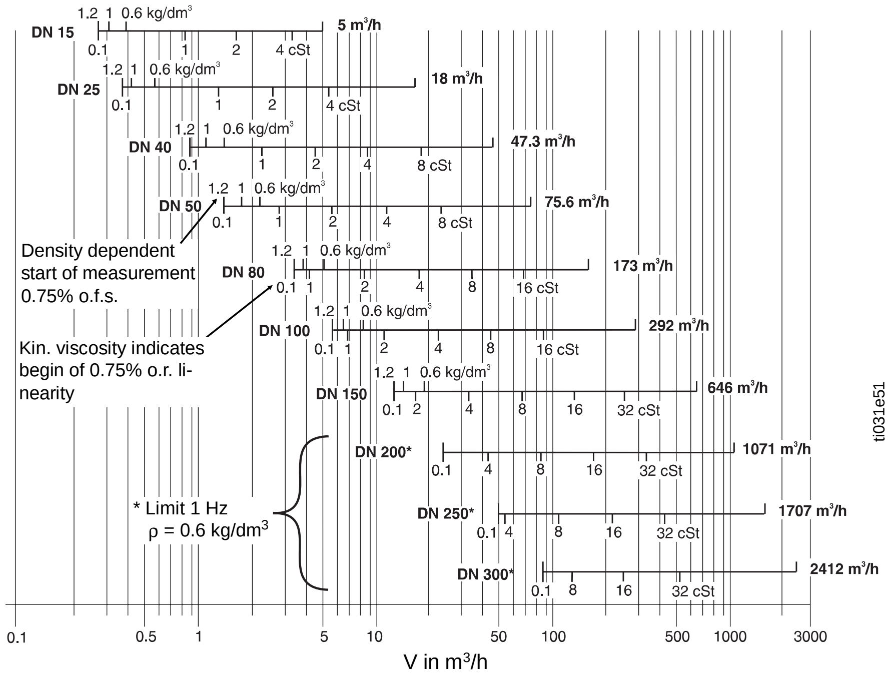
T_O = operating temperature
P_O = operating pressure

Measuring Ranges Liquids

Example for Liquids
To determine:
Nominal diameter (DN) for measuring a flow of 50 m^3/h of liquid with a density of 0.8 kg/dm^3 and a kinematic viscosity of 2 cSt.

Note: This diagram serves as a guideline for a quick estimation of Prowirl measuring ranges. Your E+H sales organisation will be pleased to help select and dimension a flowmeter for your application.

Calculation:
Select the nominal diameter from the measuring range diagram for liquids
V = 50 m^3/h $\Rightarrow$ DN 50.
For ρ = 0.8 kg/dm^3 and a kinematic viscosity of 2 cSt, the initial value of the measuring range is 1.8 m^3/h.
This results in a measuring range of 1.8...75.6 m^3/h or 1440...60480 kg/h.



Pressure Drop

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 80.

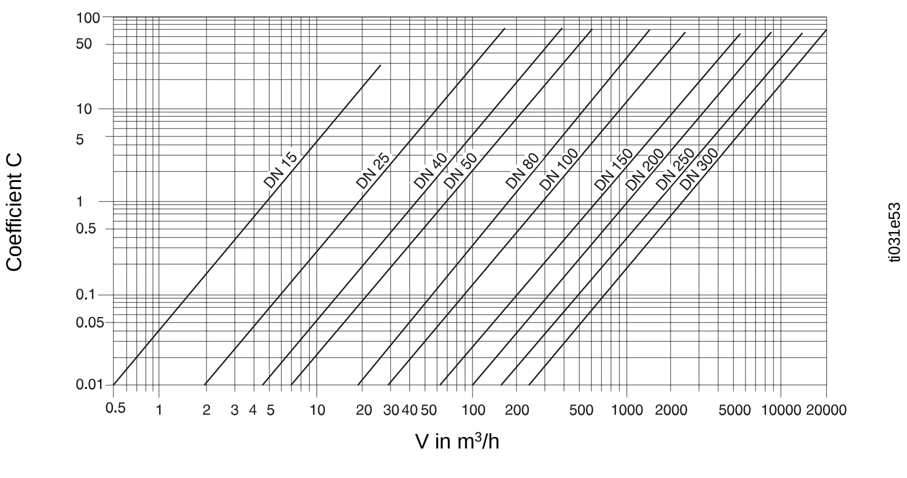
Calculation:
Convert kg/h $\Rightarrow$ m^3/h using steam density (6.13 kg/m^3) from page 11.

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

Pressure drop:
Δp [mbar] = coefficient C $\cdot$ density ρ [kg/m^3]

Determine the C coefficient from the following table:
For V = 1305 m^3/h and DN = 80 $\Rightarrow$ C = 55
Δp= C $\cdot$ ρ = 55 $\cdot$ 6.13 kg/m^3 $\Rightarrow$ 337 mbar

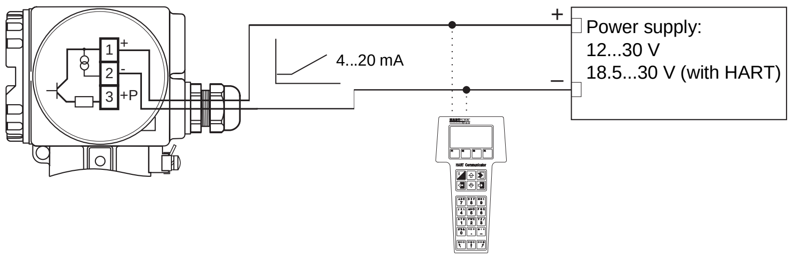
Note: This diagram serves as a guideline for a quick estimation of Prowirl measuring ranges. Your E+H sales organisation will be pleased to help you select and dimension a flowmeter for your application.



Electrical Connection

Safe area version

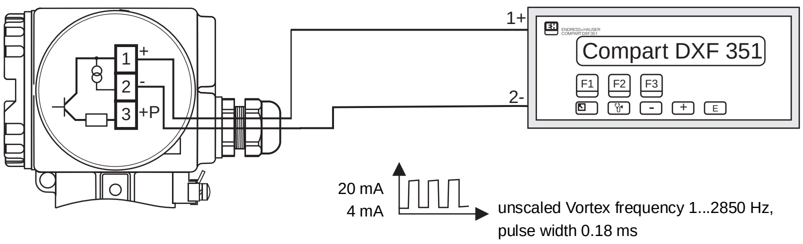
Connection 4...20 mA



Operation with HART handheld unit possible.
Minimum 250 Ω load resistance needed for HART communication.

ti031y43

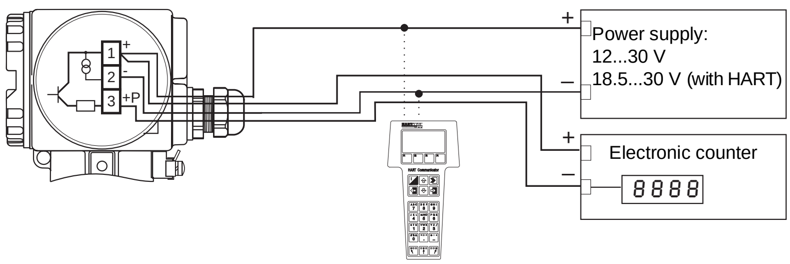
Connection PFM 2 wire current pulses



Operation with HART handheld unit not possible when using PFM output.

ti031y44

Multiple outputs 4...20 mA and Open Collector



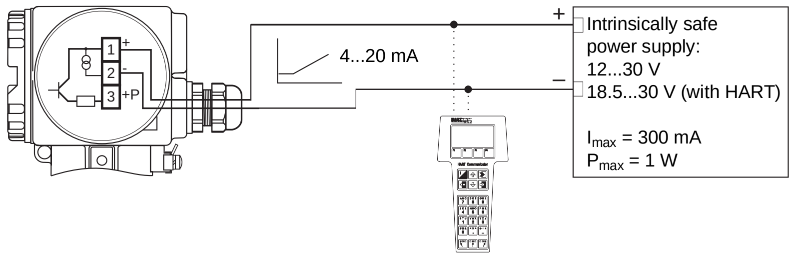
Operation with HART handheld unit possible.
Minimum 250 Ω load resistance needed for HART communication.

ti031y45

Electrical Connection

Ex i version

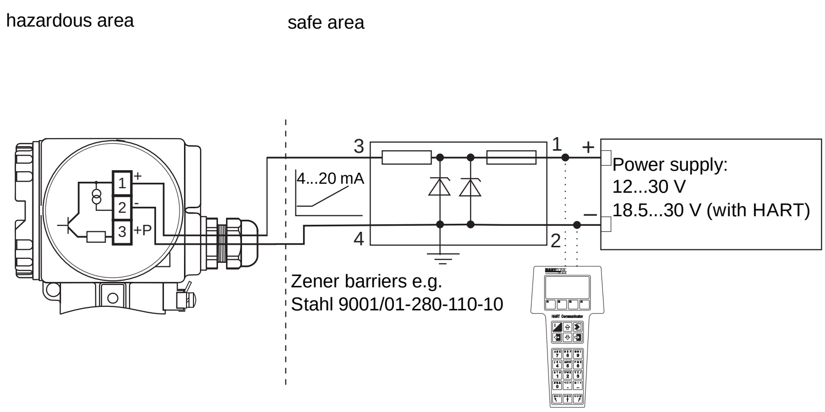
Connection 4...20 mA with intrinsically safe power supply



Operation with HART handheld unit possible.
Minimum 250 Ω load resistance needed for HART communication.

ti031y46

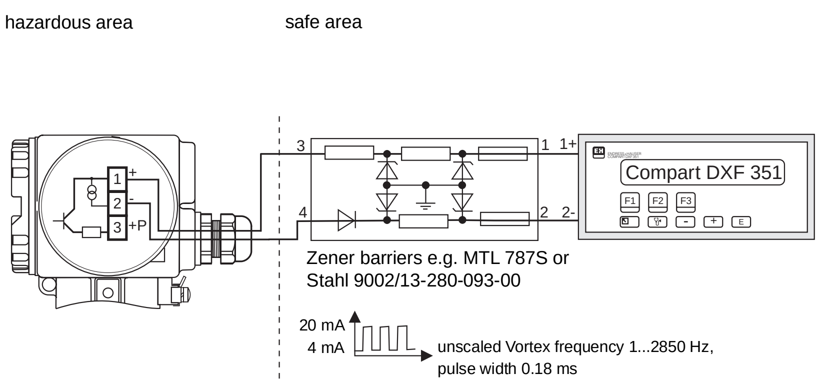
Connection 4...20 mA with non intrinsically safe power supply and barriers



Operation with HART handheld unit possible.
Minimum 250 Ω load resistance needed for HART communication.
Note: The above barrier is applicable for a completly isolated loop. Otherwise the zener barriers shown below must be used.

ti031y47

Connection PFM 2 wire current pulses with Compart flow computer and barriers



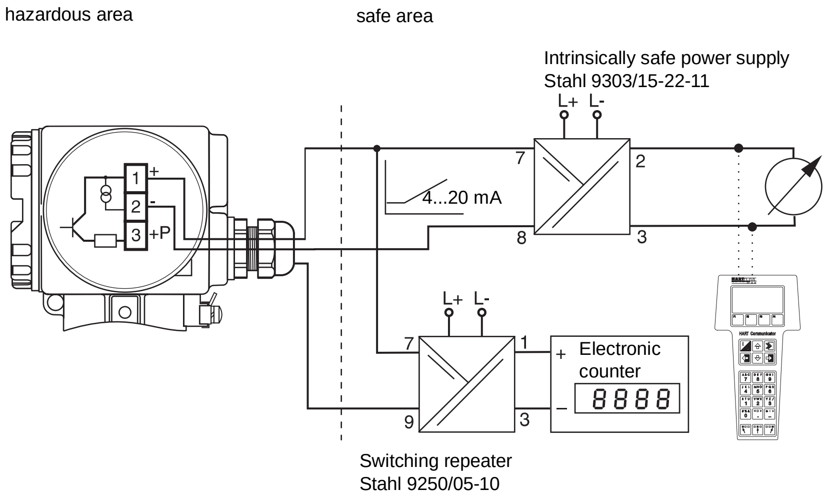
Operation with HART handheld unit not possible when using PFM output.

ti031y48

Electrical Connection

Ex i version

Multiple outputs 4...20 mA and Open Collector with intrinsically safe power supply

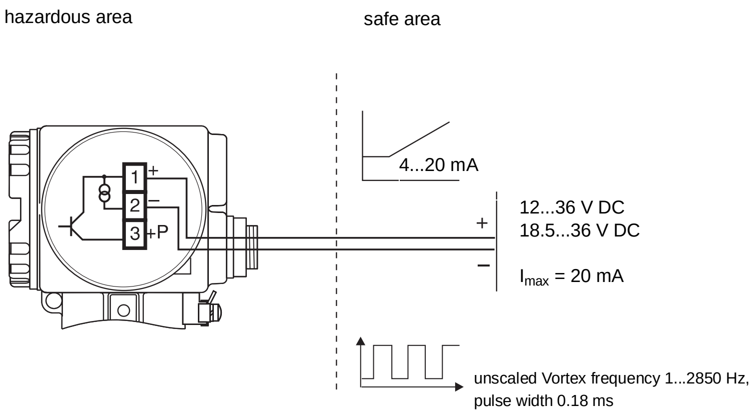


Operation with HART handheld unit possible.
Minimum 250 Ω load resistance needed for HART communication.

ti031y49

Ex d version

Connection 4...20 mA or PFM current pulse

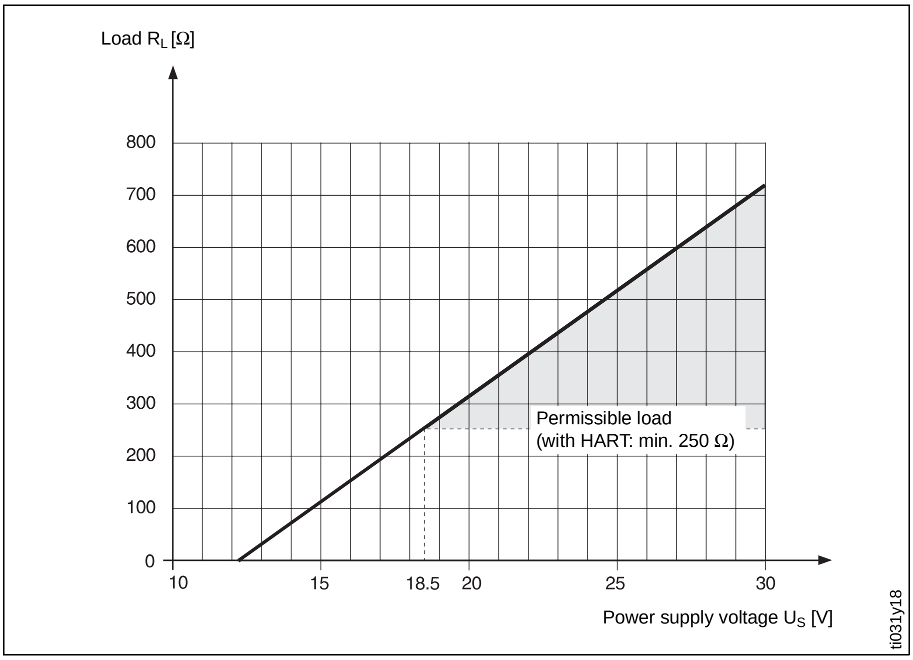


Note: 4...20 mA or PFM current pulse software selectable.
Open Collector not available with Ex d.

ti031y53

Electrical Connection

Current output load



$$R_L = \frac{U_S - U_{Kl}}{I_{max} \cdot 10^{-3}} = \frac{U_S - 12}{0.025}$$

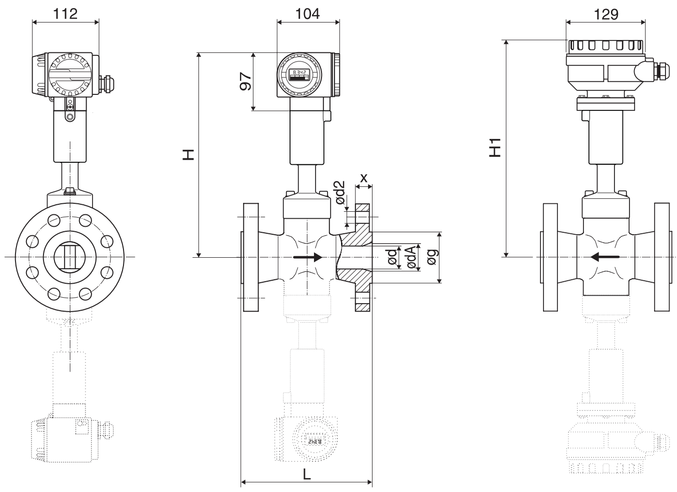
R_L = load resistance
U_S = power supply voltage (12...30 V DC)
U_{Kl} = terminal voltage Prowirl (min. 12 V DC)
I_{max} = output current (25 mA)

Note:
Where data transfer takes place over the 4...20 mA line via HART protocol (→ hand-held device), the minimum load resistance is 250 **Ω.**

The supply voltage must be high enough to supply 12 V DC at the Prowirl terminals. The above diagram shows the required supply voltage for varying load resistance.

Dimensions

Prowirl 70 F/D (Flanged / Dualsens) DN 15...150



Remote version

(For dimensions of the remote transmitter see page 20)

(Dotted section: flanged Dualsens version)

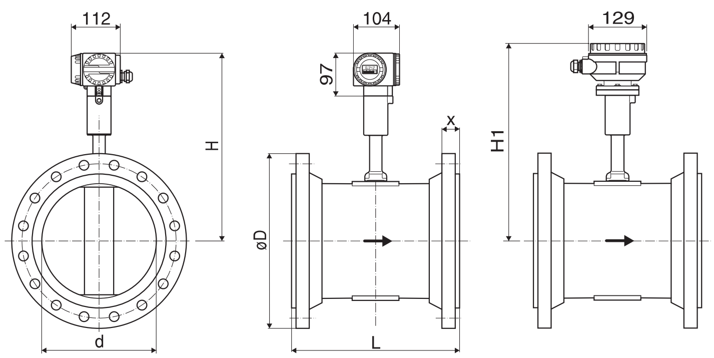
ti031y20

DN	Pressure rating		d	dA	n x d2	g	x	L	H	H1	Weight
15 (½")	PN 40	DIN	13.9	17.3	4 x 14	45	17	200	343	360	5 kg
	Cl 150	ANSI Sch 40		15.7	4 x 15.9	34.9	17				
	Cl 300			15.7	4 x 15.9	34.9	17				
	Cl 150	ANSI Sch 80		13.9	4 x 15.9	34.9	17				
	Cl 300			13.9	4 x 15.9	34.9	17				
25 (1")	PN 40	DIN	24.3	28.5	4 x 14	68	19	200	347	364	8 kg
	Cl 150	ANSI Sch 40		26.7	4 x 15.9	50.8	19				
	Cl 300			26.7	4 x 19		19				
	Cl 150	ANSI Sch 80		24.3	4 x 15.9		19				
	Cl 300			24.3	4 x 19		19				
40 (1½")	PN 40	DIN	38.1	43.1	4 x 18	88	21	200	355	372	11 kg
	Cl 150	ANSI Sch 40		40.9	4 x 15.9	73	21				
	Cl 300			40.9	4 x 22.2		21				
	Cl 150	ANSI Sch 80		38.1	4 x 15.9		21				
	Cl 300			38.1	4 x 22.2		21				
50 (2")	PN 40	DIN	49.2	54.5	4 x 18	102	24	200	335	352	13 kg
	Cl 150	ANSI Sch 40		52.6	4 x 19	92.1	24				
	Cl 300			52.6	8 x 19		24				
	Cl 150	ANSI Sch 80		49.2	4 x 19		24				
	Cl 300			49.2	8 x 19		24				
80 (3")	PN 40	DIN	73.7	82.5	8 x 18	138	30	200	346	363	20 kg
	Cl 150	ANSI Sch 40		78	8 x 19	127	30				
	Cl 300			78	8 x 22.2		30				
	Cl 150	ANSI Sch 80		73.7	8 x 19		30				
	Cl 300			73.7	8 x 22.2		30				
100 (4")	PN 16	DIN	97	107.1	8 x 18	158	33	250	360	377	27 kg
	PN 40	DIN		107.1	8 x 22	162	33				
	Cl 150	ANSI Sch 40		102.4	8 x 19	157.2	33				
	Cl 300			102.4	8 x 22.2		33				
	Cl 150	ANSI Sch 80		97	8 x 19		33				
	Cl 300			97	8 x 22.2		33				
150 (6")	PN 16	DIN	146.3	159.3	8 x 22	212	38	300	386	403	55 kg
	PN 40	DIN		159.3	8 x 26	218	38				
	Cl 150	ANSI Sch 40		154.2	8 x 22.2	215.9	38				
	Cl 300			154.2	12 x 22.2		38				
	Cl 150	ANSI Sch 80		146.3	8 x 22.2		38				
	Cl 300			146.3	12 x 22.2		38				

(all dimensions in mm)

Dimensions

Prowirl 70 F/D (Flanged / Dualsens) DN 200...300



- DIN version:
  To VSM G 18696-18700 with identical connection dimensions as according to DIN 2501
- ANSI version:
  As slip-on-flange according to ANSI B 16.5 Schedule 40

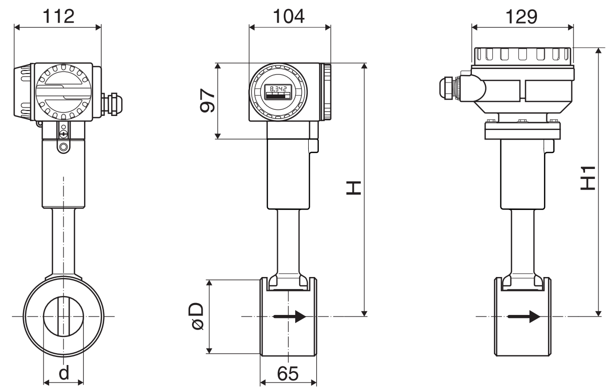
Remote version

(For dimensions of the remote transmitter see page 20)

ti031y21

DN	Pressure rating	L [mm]	D [mm]	x [mm]	d [mm]	H [mm]	H1 [mm]	Weight [kg]
200 (8")	PN 10	300	340	30	205.1	400.5	417.5	39
	PN 16		340	30	205.1			39
	PN 25		360	36	205.1			47
	PN 40		375	40	205.1			55
	Cl 150		342.9	30.8	203.1			45
	Cl 300		381.0	43.5	203.1			70
250 (10")	PN 10	380	395	32	259	425.5	442.5	60
	PN 16		405	36	259			60
	PN 25		425	40	259			72
	PN 40		450	48	259			93
	Cl 150		406.4	32.6	253			75
	Cl 300		444.5	50.1	253			112
300 (12")	PN 10	450	445	32	307.9	451.0	468	85
	PN 16		460	36	307.9			85
	PN 25		485	44	307.9			106
	PN 40		515	52	307.9			106
	Cl 150		482.6	34.2	303.9			112
	Cl 300		520.7	53.2	303.9			156

Prowirl 70 W (Wafer) DN 15...150



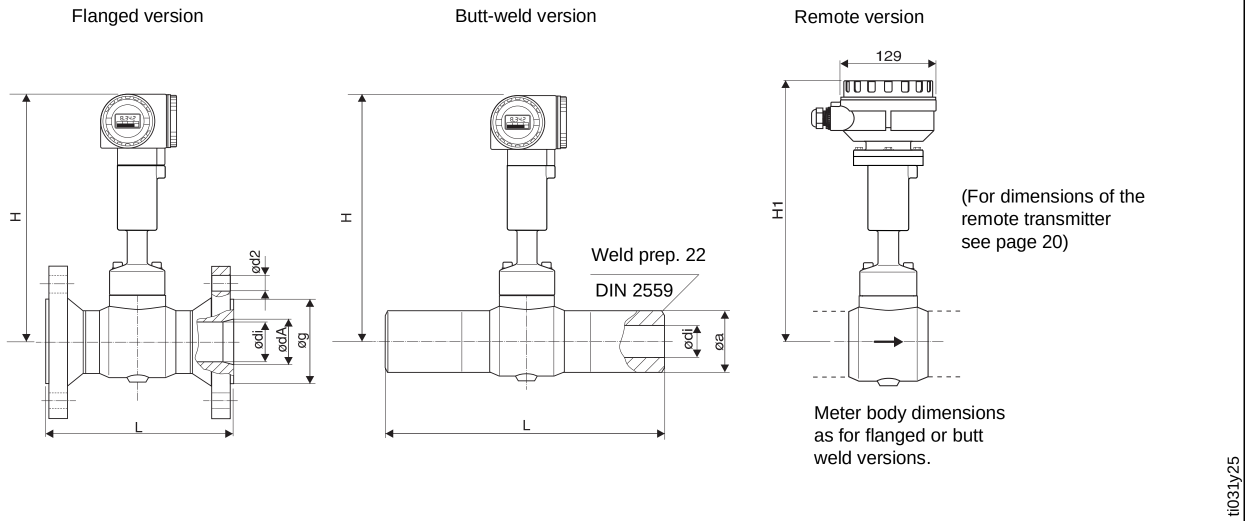
Remote version

(For dimensions of the remote transmitter see page 20)

ti031y22

DN		d	D	H	H1	Weight
DIN	ANSI	[mm]	[mm]	[mm]	[mm]	[kg]
15	½"	14	45	340	357	3.5
25	1"	26.6	64	349	366	4
40 –	– 1½"	43.1 40.9	89.3 82.0	316	333	4.5
50 –	– 2"	54.5 52.5	99.3 92.0	321	338	5
80 –	– 3"	82.5 77.9	135.3 127.0	342	359	6
100 –	– 4"	107.1 102.3	155.3 157.2	357	374	9
150 –	– 6"	159.3 154.1	210.3 215.9	387	404	17

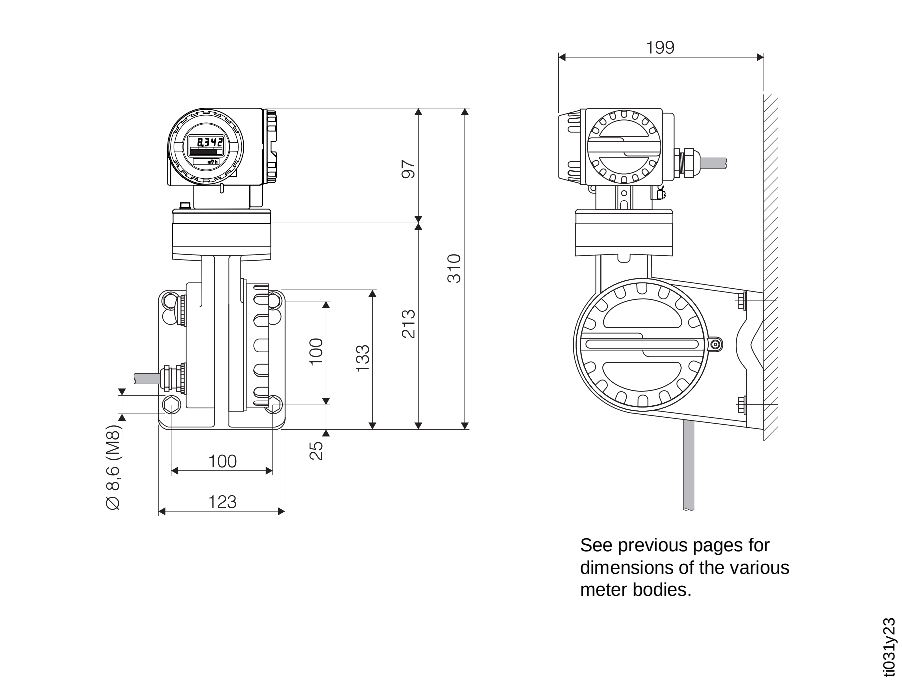
Dimensions Prowirl 70 H
(High Pressure Version) DN 15...150



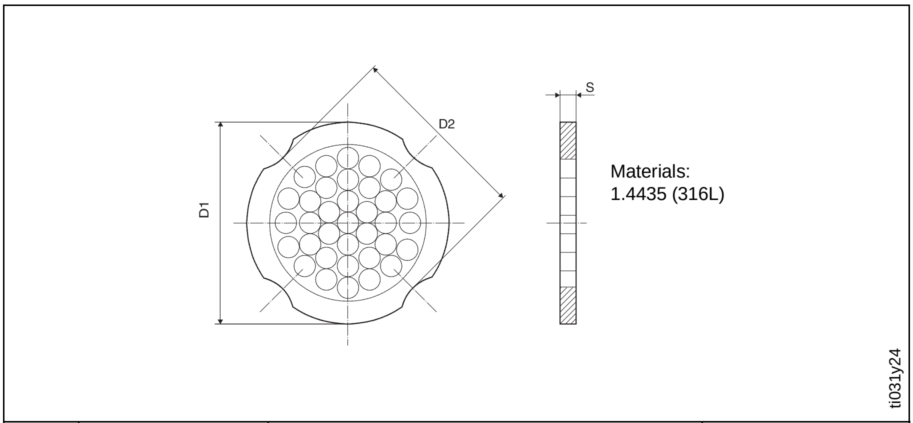
DN	Pressure rating DIN/ANSI	di [mm]	dA [mm]	n x d2 [mm]	g [mm]	L [mm]	a [mm]	H [mm]	H1 [mm]	Pipe standard Flange norm	Weight [kg]
15 ½"	PN 64	14.0	17.3	4 x ø14	45	219		346	363	DIN 2637	11
	PN 100		17.3	4 x ø14	45	219				DIN 2637	11
	PN 160		17.3	4 x ø14	45	219				DIN 2638	11
	PN 250		16.1	4 x ø18	45	248				DIN 2628	14
	Cl 600		14.0	4 x ø15.7	35.1	246				ANSI B 16.5	10
	Cl 900		14.0	4 x ø22.3	35.1	262				ANSI B 16.5	12
	Cl 1500		14.0 (14.0)	4 x ø22.3	35.1	262 (248)	(21.3)			ANSI B 16.5	12 (8)
25 1"	PN 64	24.3	28.5	4 x ø18	68	234		346	363	DIN 2637	13
	PN 100		28.5	4 x ø18	68	234				DIN 2637	13
	PN 160		27.9	4 x ø18	68	234				DIN 2638	13
	PN 250		26.5	4 x ø22	68	248				DIN 2628	15
	Cl 600		24.3	4 x ø19	50.8	254.4				ANSI B 16.5	12
	Cl 900		24.3	4 x ø25.4	50.8	287.7				ANSI B 16.5	16
	Cl 1500		24.3 (24.3)	4 x ø25.4	50.8	287.7 (248)	(33.4)			ANSI B 16.5	16 (8)
40 1½"	PN 64	38.1	42.5	4 x ø22	88	242		350	367	DIN 2637	15
	PN 100		42.5	4 x ø22	88	242				DIN 2637	15
	PN 160		41.1	4 x ø22	88	246				DIN 2638	16
	PN 250		38.1	4 x ø26	88	278				DIN 2628	20
	Cl 600		38.1	4 x ø22.2	73	270.2				ANSI B 16.5	14
	Cl 900		38.1	4 x ø28.4	73.1	305.8				ANSI B 16.5	19
	Cl 1500		38.1 (38.1)	4 x ø28.4	73.1	305.8 (278)	(48.3)			ANSI B 16.5	19 (8)
50 2"	PN 64	47.7	54.5	4 x ø22	102	242		341	358	DIN 2636	16
	PN 100		53.9	4 x ø26	102	254				DIN 2637	19
	PN 160		52.3	4 x ø26	102	268				DIN 2638	19
	PN 250		47.7	8 x ø26	102	288				DIN 2628	22
	Cl 600		49.3	8 x ø19	92.1	276.6				ANSI B 16.5	16
	Cl 900		49.3	8 x ø25.4	91.9	344				ANSI B 16.5	29
	Cl 1500		49.3 (47.7)	8 x ø25.4	91.9	344 (288)	(60.3)			ANSI B 16.5	29 (8)
80 3"	PN 64	73.7	81.7	8 x ø22	138	265		347	364	DIN 2636	21
	PN 100		80.9	8 x ø26	138	277				DIN 2637	25
	PN 160		76.3	8 x ø26	138	293				DIN 2638	27
	PN 250		79.6	8 x ø30	138	325				DIN 2628	40
	Cl 600		73.7	8 x ø22.2	127	299				ANSI B 16.5	25
	Cl 900		73.7	8 x ø25.4	127	349				ANSI B 16.5	36
	Cl 1500		73.7 (73.7)	8 x ø31.7	127	380.4 (325)	(95.7)			ANSI B 16.5	48 (12)
100 4"	PN 64	97.3	106.3	8 x ø26	162	310		359	376	DIN 2636	30
	PN 100		104.3	8 x ø30	162	334				DIN 2637	38
	PN 160		98.3	8 x ø30	162	354				DIN 2638	40
	PN 250		98.6	8 x ø33	162	394				DIN 2628	63
	Cl 600		97.3	8 x ø25.4	157.2	369.4				ANSI B 16.5	37
	Cl 900		97.3	8 x ø31.7	157.2	408				ANSI B 16.5	56
	Cl 1500		97.3 (97.3)	8 x ø35.0	157.2	427 (394)	(125.7)			ANSI B 16.5	70 (20)
150 6"	PN 64	131,8	157.1	8 x ø33	218	436		375	392	DIN 2636	80
	PN 100		154.1	12 x ø33	218	476				DIN 2637	96
	PN 160		143.3	12 x ø33	218	502				DIN 2638	100
	PN 250		142.8	12 x ø36	218	566				DIN 2628	151
	Cl 600		146.3	12 x ø28.4	215.9	493				ANSI B 16.5	105
	Cl 900		146.3	12 x ø31.7	215.9	538				ANSI B 16.5	130
	Cl 1500		146.3 (146.3)	12 x ø38.1	215.9	602 (566)	(168.3)			ANSI B 16.5	172 (52)

(...) for butt-weld version

Dimensions Remote Transmitter Housing



Flow Conditioner

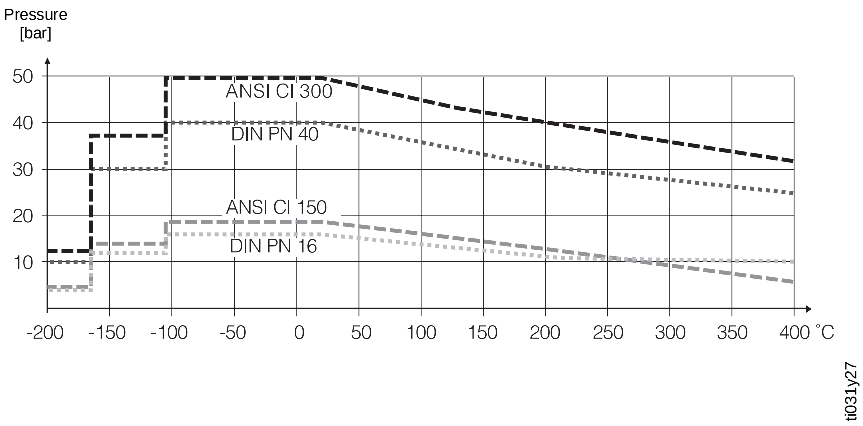


DN	Pressure rating DIN/ANSI		Centering diameter [mm] DIN D1	DIN D2	ANSI D1	ANSI D2	s	Weight [kg] DIN	Weight [kg] ANSI
15 (½")	PN 10...40 PN 64	Cl 150 Cl 300	– 64.3	54.3 –	51.1 56.5	– –	2.0	0.04 0.05	0.03 0.04
25 (1")	PN 10...40 PN 64	Cl 150 Cl 300	74.3 85.3	– –	– 74.3	69.2 –	3.5	0.12 0.15	0.12 0.12
40 (1½")	PN 10...40 PN 64	Cl 150 Cl 300	95.3 106.3	– –	– –	88.2 97.7	5.3	0.3 0.4	0.3 0.3
50 (2")	PN 10...40 PN 64	Cl 150 Cl 300	– 116.3	110.0 –	– 113.0	106.6 –	6.8	0.5 0.6	0.5 0.5
80 (3")	PN 10...40 PN 64	Cl 150 Cl 300	– 151.3	145.3 –	138.4 151.3	– –	10.1	1.4 1.4	1.2 1.4
100 (4")	PN 10/16 PN 25/40 PN 64	Cl 150 Cl 300	– 171.3 –	165.3 – 176.5	– 182.6	176.5 –	13.3	2.4 2.4 2.7	2.7 2.7
150 (6")	PN 10/16 PN 25/40 PN 64	Cl 150 Cl 300	– – 252.0	221.0 227.0 –	223.9 252.0	– –	20.0	6.3 7.8 7.8	6.3 7.8
200 (10")	PN 10 PN 16 PN 25 PN 40 PN 64	 Cl 150 Cl 300	274.0 – 280.0 – 309.0	– 274.0 – 294.0 –	 – 309.0	 274.0 –	26.3	11.5 12.3 12.3 15.9 15.9	 12.3 15.8
250 (10")	PN 10/16 PN 25 PN 40 PN 64	Cl 150 Cl 300	– 340.0 – 363.0	330.0 – 355.0 –	340.0 363.0	– –	33.0	25.7 25.7 27.5 27.5	25.7 27.5
300 (12")	PN 10/16 PN 25 PN 40/64	Cl 150 Cl 300	– 404.0 420.0	380.0 – –	404.0 420.0	– –	39.6	36.4 36.4 44.7	36.4 44.6

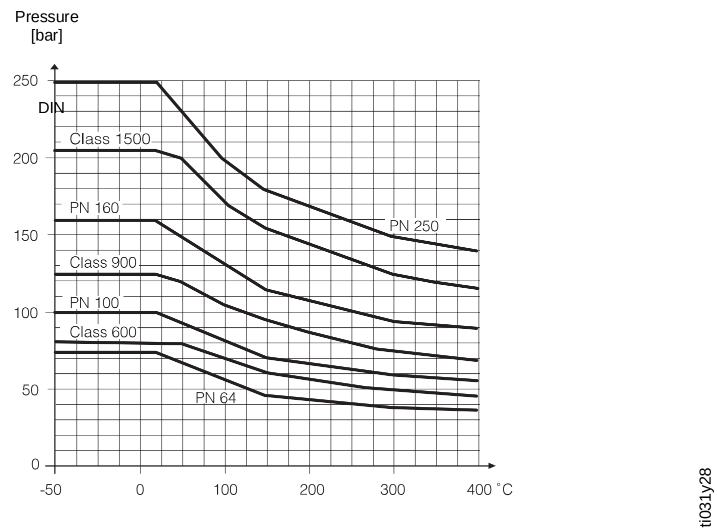
Technical Data

Pressure and Temperature Load Diagrams

Flanged Version (DN 15...150)

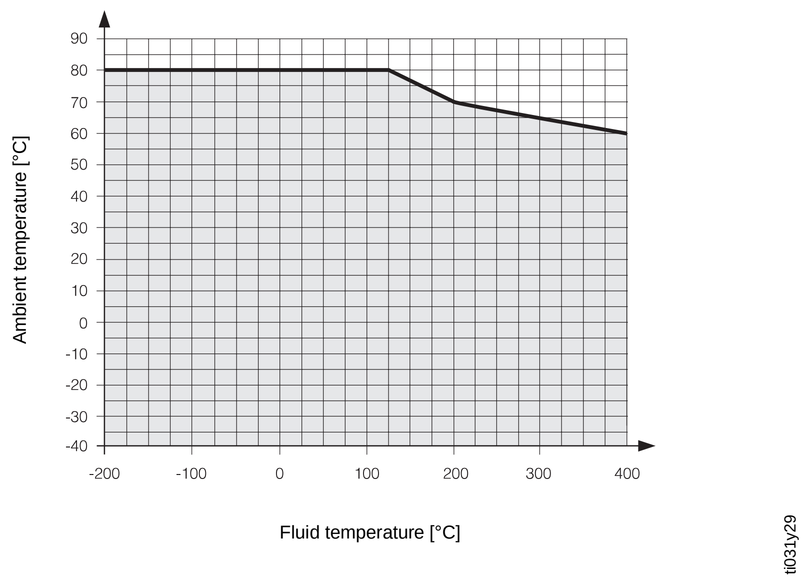


High Pressure Version (DN 15...150)



Ambient vs. fluid temperatures

For instruments in hazardous areas, please note the temperature limitations given in the corresponding Ex-documentation.



Prowirl W/F/H/D Sensor

Prowirl W ⇒ wafer version
Prowirl F ⇒ flanged version
Prowirl H ⇒ high pressure version
Prowirl D ⇒ Dualsens version

Nominal diameter	W:	DN 15...150 (DIN/ANSI)
	F:	DN 15...300 (DIN/ANSI)
	H:	DN 15...150 (DIN/ANSI)
	D:	DN 15...300 (DIN/ANSI)
		Larger diameters on request
Nominal pressure	W:	PN 10...40 (DIN 2501), Class 150...300 (ANSI B16.5)
	F/D:	PN 10...40 (DIN 2501), Class 150...300 (ANSI B16.5)
	H:	PN 64, 100, 160, 250 (DIN 2636/2637/2638/2628); Class 600, 900, 1500 (ANSI B16.5) Butt-weld version, Class 1500
Permissible process temperature	W/F/D:	-200...+400 °C
	H:	-50...+400 °C; optional for -120 °C min. temperature
Materials		
• Wetted parts materials: Measuring pipe (DN 15...150)	F/D:	1.4552 (A351 CF8C)
	W:	1.4571 (316Ti) *
	H:	1.4571 (316Ti)
Measuring pipe (>DN 150)	F/D:	1.4571 (316Ti)
Bluff body (DN 15...150)	F/D:	1.4552 (A351 CF8C)
	W:	1.4435 (316L) *
	H:	1.4435 (316L)
Bluff body (>DN 150)	F/D:	1.4435 (316L)
		* Materials for meter and bluff body of the wafer type (W) are being changed to the cast stainless material 1.4552. This change will be completed for all sizes by mid 1997.
Sensor	W/F/D:	1.4435 (316L)
	H:	Titanium Gr. 5
Sensor seal	W/F/D:	Graphite; optional Kalrez, Viton, EPDM
	H:	Graphite with impregnated steel
• Pipe stand material		Stainless steel

Mounting set (for Prowirl W, wafer version)

Available for all pressure ratings from DIN PN 10...40 or ANSI Class 150 and 300.

Centering rings	2 pcs., stainless steel 1.4301
Bolts	1.7258 galvanised: -50...+400 °C (40 bar) A2-70: -200...+400 °C (40 bar)
Hex nuts	1.7258 galvanised: -50...+400 °C A2-70: -200...+400 °C
Washers	Galvanised steel (DIN 125 A): to +400 °C; A2 DIN 125 A: -200 °C...+400 °C
Gaskets	Graphite, Viton

Technical Data

Prowirl 70 Transmitter

Housing material	Cast aluminum, painted
Protection type	Compact version: IP 65 (DN 60529) Remote version: IP 67
Ambient temperature	-40...+80 °C (depending on process temperature) (see page 21)
Vibration immunity	1g to 500 Hz (in all directions)
Electromagnetic compatibility (EMC)	IEC 801 part 3: E = 10 V/m (80 MHz...1GHz); IEC 801 part 6: Uo = 10 V (9 kHz...80 MHz)
Power supply	12...30 V DC (without HART, INTENSOR) 18.5...30 V DC (with HART, INTENSOR)
Cable glands	PG 13.5
Threads for cable glands	M20 x 1.5 or ½" NPT or G ½"
Power consumption	<1 W
Galvanic isolation	Between process and outputs
Current output	4...20 mA analogue current output, full-scale value and time constant may be set PFM current pulse programmable, pulse width 0.18 ms
Open collector output	I_{max} ≤10 mA, U_{max} = 30 V, R_i = 900 Ω (HART: only to R_L ≥10 kΩ) • Pulse output; pulse scaling selectable, f_{max} = 100 Hz, 50/50 duty cycle • Alarm contact • Limit switch; on/off points selectable
Display	LC display; 4 character with decimal point. Bar graph for analogue display of flowrate in %
Communication	HART protocol via current output, INTENSOR protocol via current output
Data storage	DAT memory module stores all programmed data (without battery)
Hazardous area approvals • Intrinsically safe	CENELEC EEx ib IIC T6 FM IS Cl. I, II, III Div. 1 Gr. A-G CSA IS Cl. I; Div. 1/Div. 2 Gr. A-D, Cl. II; Div. 1/Div. 2 Gr. E-F, Cl. III; Div. 1/Div. 2
• Explosion proof	CENELEC EEx d IIC T6 FM XP Cl. I Div. 1 Gr. A-D CSA XP Cl. I Gr. B-D, Cl. II Gr. E-G, Cl. III Note: Remote version has no Ex d

Accuracy limits (measuring system)

Liquids	<0.75% o.r. at Re_D >20000 <0.75% o.f.s. at Re_D 4000...20000
Gas/steam	<1% o.r. at Re_D >20000 <1% o.f.s. at Re_D 4000...20000
Current output	Temperature coefficient <0.03% o.f.s./°C
Maximum flow velocity	Liquids: v_{max} = 9 m/s Gas/steam: v_{max} = 75 m/s; DN 15: v_{max} = 46 m/s
Reproducibility	±0.2% o.r.

Supplementary Documentation

- ☐ System Information Prowirl (SI 015D/06/e)
- ☐ Operating Instructions Prowirl (BA 018D/06/e)
- ☐ Technical Information Flow Computer Compart DXF 351 (TI 032D/06/e)
- ☐ Ex Documentation Prowirl CENELEC (EX 002D/06/A2)
- ☐ Ex Documentation Prowirl FM (EX 008D/06/A2)
- ☐ Ex Documentation Prowirl CSA (EX 009D/06/D2)

Subject to modification

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