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

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

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

Universal
- HART communication for remote reading and configuration
- Fieldbus communication via PROFIBUS-PA interface
- Operating under E+H Windows software “Commewin 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.

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.

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 ensure 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:

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

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.
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**

\[ \Delta \rho \text{ [mbar]} = 0.0085 \cdot \rho \text{ [kg/m}^3\text{]} \cdot v^2 \text{ [m/s]} \]

- Example with steam:
  \[ \rho = 10 \text{ bar abs.} \]
  \[ t = 240 \; ^\circ\text{C} \Rightarrow \rho = 4.39 \; \text{kg/m}^3 \]
  \[ v = 40 \text{ m/s} \]
  \[ \Delta \rho = 0.0085 \cdot 4.39 \; \text{kg/m}^3 \cdot (40 \text{ m/s})^2 \]
  \[ = 59.7 \text{ mbar} \]

- Example with \(\text{H}_2\text{O}\) condensate (80 °C)
  \[ \rho = 965 \; \text{kg/m}^3 \]
  \[ v = 2.5 \text{ m/s} \]
  \[ \Delta \rho = 0.0085 \cdot 965 \; \text{kg/m}^3 \cdot (2.5 \text{ m/s})^2 \]
  \[ = 51.3 \text{ mbar} \]
Planning and Installation

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).

Pressure and Temperature Measuring Sensors
Pressure and temperature measuring instruments are to be installed down-stream from Prowirl 77 so that they do not affect the proper formation of vortices.

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

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. m³/h) under operating conditions. Steam quantities are generally given in kg or t, gas quantities in Nm³ (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)

<table>
<thead>
<tr>
<th>DN</th>
<th>Air (at 0 °C, 1.013 bar)</th>
<th>Water (20 °C)</th>
<th>K-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[m³/h]</td>
<td>[pulses/dm³]</td>
<td>[m³/h]</td>
</tr>
<tr>
<td></td>
<td>min.</td>
<td>max.</td>
<td>min.</td>
</tr>
<tr>
<td>DN 15 / ½”</td>
<td>4</td>
<td>35</td>
<td>0.19</td>
</tr>
<tr>
<td>DN 25 / 1”</td>
<td>11</td>
<td>160</td>
<td>0.41</td>
</tr>
<tr>
<td>DN 40 / 1½”</td>
<td>31</td>
<td>375</td>
<td>1.1</td>
</tr>
<tr>
<td>DN 50 / 2”</td>
<td>50</td>
<td>610</td>
<td>1.8</td>
</tr>
<tr>
<td>DN 80 / 3”</td>
<td>112</td>
<td>1370</td>
<td>4.0</td>
</tr>
<tr>
<td>DN 100 / 4”</td>
<td>191</td>
<td>2330</td>
<td>6.9</td>
</tr>
<tr>
<td>DN 150 / 6”</td>
<td>428</td>
<td>5210</td>
<td>15.4</td>
</tr>
</tbody>
</table>

### Prowirl 77 F (Flange) / Prowirl 77 H (High pressure; up to DN 150 / 6”)

<table>
<thead>
<tr>
<th>DN</th>
<th>Air (at 0 °C, 1.013 bar)</th>
<th>Water (20 °C)</th>
<th>K-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[m³/h]</td>
<td>[pulses/dm³]</td>
<td>[m³/h]</td>
</tr>
<tr>
<td></td>
<td>min.</td>
<td>max.</td>
<td>min.</td>
</tr>
<tr>
<td>DN 15 / ½”</td>
<td>3</td>
<td>25</td>
<td>0.16</td>
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<tr>
<td>DN 25 / 1”</td>
<td>9</td>
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<td>DN 40 / 1½”</td>
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<td>0.91</td>
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<tr>
<td>DN 50 / 2”</td>
<td>42</td>
<td>510</td>
<td>1.5</td>
</tr>
<tr>
<td>DN 80 / 3”</td>
<td>95</td>
<td>1150</td>
<td>3.4</td>
</tr>
<tr>
<td>DN 100 / 4”</td>
<td>164</td>
<td>2000</td>
<td>5.9</td>
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<tr>
<td>DN 150 / 6”</td>
<td>373</td>
<td>4540</td>
<td>13.4</td>
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<tr>
<td>DN 200 / 8”</td>
<td>715</td>
<td>8710</td>
<td>25.7</td>
</tr>
<tr>
<td>DN 250 / 10”</td>
<td>1127</td>
<td>13740</td>
<td>40.6</td>
</tr>
<tr>
<td>DN 300 / 12”</td>
<td>1617</td>
<td>19700</td>
<td>58.2</td>
</tr>
</tbody>
</table>
Example of Calculation

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

Calculation:
Min. and max. values for the measuring range can be found from the following table:

at 12 bar abs. ⇒ 461...12226 kg/h

<table>
<thead>
<tr>
<th>Operating pressure [bar abs]</th>
<th>DN 15 min...max</th>
<th>DN 25 min...max</th>
<th>DN 40 min...max</th>
<th>DN 50 min...max</th>
<th>DN 80 min...max</th>
<th>DN 100 min...max</th>
<th>DN 150 min...max</th>
<th>DN 200 min...max</th>
<th>DN 250 min...max</th>
<th>DN 300 min...max</th>
<th>T sat [°C]</th>
<th>ρ sat [kg/m³]</th>
</tr>
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<tr>
<td>0.5</td>
<td>1.8...7.8</td>
<td>5.6...39</td>
<td>16...95</td>
<td>27...158</td>
<td>60...356</td>
<td>103...616</td>
<td>235...1401</td>
<td>452...2689</td>
<td>714...4258</td>
<td>1024...6107</td>
<td>81.3</td>
<td>0.31</td>
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<td>2.5...15</td>
<td>7.7...74</td>
<td>22...182</td>
<td>37...303</td>
<td>83...680</td>
<td>143...1178</td>
<td>325...2679</td>
<td>625...5143</td>
<td>985...8104</td>
<td>1412...11623</td>
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<td>0.59</td>
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<td>1.5</td>
<td>3.0...22</td>
<td>9.3...108</td>
<td>27...266</td>
<td>45...443</td>
<td>100...994</td>
<td>173...1722</td>
<td>393...3916</td>
<td>755...7518</td>
<td>1189...11812</td>
<td>1705...16943</td>
<td>111</td>
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<td>11...141</td>
<td>31...348</td>
<td>51...580</td>
<td>114...1301</td>
<td>198...2254</td>
<td>450...5126</td>
<td>864...9841</td>
<td>1363...15521</td>
<td>1955...22626</td>
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<td>1.13</td>
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<td>3</td>
<td>4.2...41</td>
<td>13...207</td>
<td>37...506</td>
<td>62...848</td>
<td>138...1902</td>
<td>239...3296</td>
<td>544...7495</td>
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<td>15...271</td>
<td>42...666</td>
<td>70...1111</td>
<td>158...2492</td>
<td>274...4317</td>
<td>623...9820</td>
<td>1196...18851</td>
<td>1884...29668</td>
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<td>5</td>
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<td>16...334</td>
<td>47...822</td>
<td>78...1370</td>
<td>176...3074</td>
<td>304...5325</td>
<td>692...12113</td>
<td>1328...23253</td>
<td>2095...36672</td>
<td>3005...52601</td>
<td>152</td>
<td>2.67</td>
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<td>5.8...80</td>
<td>18...397</td>
<td>51...976</td>
<td>85...1627</td>
<td>191...3651</td>
<td>332...6324</td>
<td>754...14386</td>
<td>1448...27616</td>
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<td>219...4793</td>
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<td>1659...36258</td>
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<td>65...1584</td>
<td>109...2642</td>
<td>244...5922</td>
<td>422...10269</td>
<td>961...23360</td>
<td>1845...44842</td>
<td>2909...70735</td>
<td>4173...101459</td>
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<td>25...767</td>
<td>71...1886</td>
<td>119...3145</td>
<td>266...7058</td>
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<td>1048...27811</td>
<td>2013...53388</td>
<td>3174...84196</td>
<td>4553...120766</td>
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<td>6.13</td>
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<tr>
<td>15</td>
<td>9.0...191</td>
<td>28...951</td>
<td>79...2337</td>
<td>132...3898</td>
<td>296...8746</td>
<td>513...15150</td>
<td>1167...34463</td>
<td>2241...66157</td>
<td>3532...104249</td>
<td>5066...149259</td>
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<td>7.59</td>
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<tr>
<td>25</td>
<td>11.6...314</td>
<td>35...1567</td>
<td>102...3852</td>
<td>169...6424</td>
<td>380...14414</td>
<td>659...24969</td>
<td>1499...56799</td>
<td>2877...109034</td>
<td>4534...171825</td>
<td>6504...246457</td>
<td>224</td>
<td>12.51</td>
</tr>
</tbody>
</table>

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

Additional information from the table:
• Saturated steam temperature
  = 188 °C (at 12 bar)
• Density = 6.13 kg/m³ (at 12 bar)
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.

**Volumetric/Mass Flow (V/m)**

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

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

**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 \(\Rightarrow\) m³/h using the density of steam (4.86 kg/m³) from the table above.

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

b) Select the nominal diameter in the steam/gas measuring range diagram below for \(\dot{V} = 823 \text{ m}^3\text{/h} \Rightarrow\) DN 80.

For density \(\rho = 4.86 \text{ kg/m}^3\) the lower range value is 42 m³/h. This gives a measuring range of 42...1150 m³/h or 204...5590 kg/h.

**Corrected/Operating Density (ρN/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:

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

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

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

**Corrected/Operating Volumes (VN/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:

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

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

P = operating pressure
T = operating temperature
Example for Liquids

To determine:
Nominal diameter (DN) to measure a liquid with a density of 0.8 kg/dm³ and a kinematic viscosity of 2 cSt at a flow rate of 40 m³/h.

Calculation:
Select the nominal diameter in the liquids measuring range diagram below for \( V = 40 \text{ m}^3/\text{h} \) ⇒ DN 50. For \( \rho = 0.8 \text{ kg/dm}^3 \) and a kinematic viscosity of 2 cSt the lower range-value is 1.5 m³/h and the linear measuring range starts at 5.6 m³/h. This gives a measuring range of 1.5...62 m³/h or 1200...49600 kg/h.

Pressure Loss

Pressure Loss:
\[ \Delta p [\text{mbar}] = \text{coefficient } C \cdot \text{density } \rho [\text{kg/m}^3] \]
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 ⇒ m³/h using the density of steam (6.13 kg/m³) from the table on page 10.

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

\[ \dot{V} = 1305 \text{ m}^3/\text{h} \text{ and DN } = 100 \Rightarrow C = 20 \]

\[ \Delta p = C \cdot \rho = 20 \cdot 6.13 \text{ kg/m}^3 \Rightarrow 123 \text{ mbar} \]
Electrical Connection

Safe Area Version

Connection 4...20 mA

Power supply
(e.g. PLC or E+H RIA 250)

4...20 mA input

+ 12...30 V

4...20 mA

HART communication available (see page 16)

Pulse output to PLC with galvanically not isolated inputs

Interface card for PLCs

pulse input

PLC Power supply

0 V

+ 12...30 V

scaleable voltage pulses
B: Pulse width

HART communication not available

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

Electronic counter or pulse interface card for PLCs

pulse input

sensor power supply

U_{max} = + 30 V

0 V

+ 12...30 V

scaleable voltage pulses
B: Pulse width

HART communication not available

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

Compart DXF 351

mA

non-scaleable vortex frequency

0.5...2850 Hz

pulse width 0.18 ms

HART communication not available
Electrical Connection

Ex i version

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

4...20 mA with intrinsically safe power supply

- Intrinsically safe power supply: (e.g. E+H FXN 672 or intrinsically safe PLC)
- 4...20 mA input
- +12...30 V

4...20 mA with non-intrinsically safe power supply

- Power supply: (e.g. PLC or E+H RIA 250)
- 4...20 mA input
- +12...30 V
- Intrinsically safe galvanic isolator or ungrounded barrier (e.g. Stahl 9002/13-280-093-00)

4...20 mA with separate power supply by intrinsically safe transmitter supply unit

- Input board: (e.g. PLC, display, recorder)
- 0/4...20 mA
- +12...30 V
- Intrinsically safe transmitter supply unit (e.g. E+H RN 221 Z)

HART communication available (see page 16)

(continued next page)
Electrical Connection

Ex i version

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

- Safe area
  - Interface card for PLCs
  - PLC Power supply
  - Pulse input
  - 0 V
  - 12...30 V
  - Safety barrier: (e.g. Stahl 9002/13-280-093-00)
  - Voltage pulses scaleable
  - B: Pulse width

- Hazardous area

HART communication not available

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

- Safe area
  - Electronic counter or pulse interface card for PLCs
  - Power supply: (e.g. E+H RN 221 R)
  - Pulse input
  - 0 V
  - 12...30 V
  - Safety barrier: (e.g. Stahl 9002/13-280-093-00)
  - Voltage pulses scaleable
  - B: Pulse width

- Hazardous area

HART communication not available

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

- Safe area
  - Compart DXF 351
  - Non-scaleable vortex frequency
    - 0.5...2850 Hz
    - Pulse width 0.18 ms

- Hazardous area

HART communication not available
Electrical Connection

**Ex d version**

4...20 mA, Ex d version

Power supply: (e.g. PLC or E+H RIA 250)

4...20 mA input

- 15...36 V

Switch position: passive

HART communication available (see page 16)

---

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

Interface card for PLC

PLC Power supply

0 V

+ 15...36 V

Switch position: active

HART communication not available

---

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

Electronic counter or pulse interface card for PLCs

Power supply (e.g. E+H RN 221 R)

0 V

+ 15...36 V

Switch position: passive

HART communication not available

---

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

Compartment DXF 351

Switch position: passive

Non-scaleable vortex frequency: 0.5...2850 Hz

Pulse width: 0.18 ms

HART communication not available

---

Caution:

Ground potential equalisation must exist between the safe and hazardous areas.
**Electrical Connection**

**Load**

\[
R_L = \frac{U_S - U_R}{I_{\text{max}}} = \frac{U_S - 12}{0.022}
\]

- \(R_L\) = load resistance
- \(U_S\) = power supply voltage (12...30 V DC)
- \(U_R\) = terminal voltage Prowirl 77 (min. 12 V DC)
- \(I_{\text{max}}\) = output current (22 mA)

**HART**

**HART connection**

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.
Dimensions and Weights

Prowirl 77 W

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

Water 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.

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## Dimensions and Weights

### Prowirl 77 F

**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**
- **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.

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## Dimensions and Weights

### Prowirl 77 H

#### Ex d version

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

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<th>D [mm]</th>
<th>H [mm]</th>
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</table>
## Dimensions and Weights

### Flow Conditioner DIN

![Flow Conditioner Diagram]

#### Material
316L (1.4435)

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.

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<th>Pressure rating</th>
<th>Centering diameter [mm]</th>
<th>D1 / D2</th>
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## Dimensions and Weights

### Flow Conditioner

**ANSI**

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**Material**

316L (1.4435)

---

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.
## Technical Data

### Applications

<table>
<thead>
<tr>
<th>Designation</th>
<th>Flow measuring system “Prowirl 77”</th>
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</thead>
</table>

### 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: \( \nu_{\text{max}} = 9 \text{ m/s} \)
  - Gas / steam: \( \nu_{\text{max}} = 75 \text{ m/s} \)
  - (DN 15: \( \nu_{\text{max}} = 46 \text{ m/s} \))

- **Lower range value:**
  - depends on the fluid density and the Reynolds number, \( \text{Re}_{\text{min}} = 4000 \), \( \text{Re}_{\text{lnear}} = 20000 \)

  - DN 15/25: \( \nu_{\text{min}} = \frac{\nu_{\text{max}}}{\sqrt{\rho}} \text{ m/s, with } \rho \text{ in kg m}^{-3} \)
  - DN 40...300: \( \nu_{\text{min}} = \frac{7}{\sqrt{\rho}} \text{ m/s, with } \rho \text{ in kg m}^{-3} \)

### 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<sub>max</sub> = 100 Hz)  
Standard and Ex i: U<sub>max</sub> = 30 V, I<sub>max</sub> = 10 mA, R<sub>i</sub> = 500 Ω  
Ex d, switch to "passive": U<sub>max</sub> = 36 V, I<sub>max</sub> = 10 mA, R<sub>i</sub> = 200 Ω  
Ex d, switch to "active": U<sub>max</sub> = 36 V, R<sub>i</sub> = 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  

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### 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 F and 77 W](image)

Pressure-temperature curve of Prowirl 77 H:

![Pressure-temperature curve of Prowirl 77 H](image)

**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)

<table>
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<th>Material</th>
<th>Details</th>
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<td><strong>Sensor</strong></td>
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</tr>
<tr>
<td>– <strong>Sensor</strong></td>
<td>Stainless steel wetted parts:</td>
</tr>
<tr>
<td></td>
<td>– Standard and high/low temperature sensor: 316L (1.4435), complying to NACE MR0175</td>
</tr>
<tr>
<td></td>
<td>– High pressure sensor: A637 (2.4668) (Inconel 718), complying to NACE MR0175</td>
</tr>
<tr>
<td><strong>Pipe stand</strong></td>
<td>Stainless steel, 304L (1.4308)</td>
</tr>
<tr>
<td><strong>Gaskets</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Graphite</td>
</tr>
<tr>
<td></td>
<td>Viton</td>
</tr>
<tr>
<td></td>
<td>Kalrez</td>
</tr>
<tr>
<td></td>
<td>Gylon (PTFE)</td>
</tr>
<tr>
<td><strong>Cable entries</strong></td>
<td>Power supply and signal cable (outputs):</td>
</tr>
<tr>
<td></td>
<td>Cable entry PG 13.5 (5...11.5 mm) or</td>
</tr>
<tr>
<td></td>
<td>Thread for cable entries:</td>
</tr>
<tr>
<td></td>
<td>( \frac{1}{2} )&quot; NPT, G( \frac{1}{2} )&quot;</td>
</tr>
<tr>
<td><strong>Process connections</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Wafer</strong></td>
<td>Mounting set (see page 7) for flanges:</td>
</tr>
<tr>
<td></td>
<td>– DIN 2501, PN 10...40</td>
</tr>
<tr>
<td></td>
<td>– ANSI B16.5, Class 150/300, Sch40</td>
</tr>
<tr>
<td></td>
<td>– JIS B2238, 10K/20K, Sch40</td>
</tr>
<tr>
<td><strong>Flange</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>– DIN 2501, PN 10...40, raised face acc. to DIN 2526 form C</td>
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<tr>
<td></td>
<td>– ANSI B16.5, Class 150/300, Sch40/80</td>
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<tr>
<td></td>
<td>(Sch80 DN 15...150)</td>
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<tr>
<td></td>
<td>– JIS B2238, 10K/20K, Sch40/80</td>
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<tr>
<td></td>
<td>(Sch80 DN 15...150)</td>
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<tr>
<td><strong>High pressure</strong></td>
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</tr>
<tr>
<td></td>
<td>– DIN 2501, PN 64...160, raised face acc. to DIN 2526 form E</td>
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<tr>
<td></td>
<td>– ANSI B16.5, Class 600, Sch80</td>
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<tr>
<td></td>
<td>– JIS B2238, 40K, Sch80</td>
</tr>
</tbody>
</table>

### User interface

#### Operation procedure

- 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 Commuin 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

<table>
<thead>
<tr>
<th>Ex-approval</th>
<th>ATEX/CENELEC</th>
<th>Ex i / IS:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>II2G, EEx ib IIC T1...T6 (not PROFIBUS-PA)</td>
<td>II2G, EEx ib/ia IIC T1...T6 (only PROFIBUS-PA)</td>
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<tr>
<td>ATEX</td>
<td>II3G, EEx nA IIC T1...T6 X</td>
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<tr>
<td>FM</td>
<td>CI I/II/III Div 1, Groups A...G</td>
<td></td>
</tr>
<tr>
<td>CSA</td>
<td>Class I Div 1, Groups A...D</td>
<td>Class II Div 1, Groups E...G</td>
</tr>
<tr>
<td></td>
<td>Class III Div 1</td>
<td></td>
</tr>
</tbody>
</table>

**Ex d / XP (not for PROFIBUS-PA):**

| ATEX/CENELEC | II2G, EEx [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 fulfills 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 I3G/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 Normenausschuss für Mess- und Regeltechnik in der Chemischen Industrie
- NACE National Association of Corrosion Engineers