

## Technical Information

# Proline Prowirl 72F, 72W, 73F, 73W

## Vortex Flow Measuring System

Reliable flow measurement of gas, steam and liquids



### Application

For the universal measurement of the volume flow of gases, steam and liquids.

With integrated T-measurement, the mass flow of steam, water (as per IAPWS-IF97 ASME), natural gas (as per AGA NX-19), compressed air and other gases and liquids can be measured.

Maximum range of applications thanks to:

- Fluid temperature range from  $-200...+400$  °C
- Pressure ratings up to PN250/Cl 1500

Approvals for hazardous areas:

- ATEX, FM, CSA, TIIS

Connection to all common process control systems:

- HART, PROFIBUS PA, FOUNDATION Fieldbus

Relevant safety aspects:

- Pressure Equipment Directive
- Up to SIL 2

### Your benefits

The robust **Prowirl sensor**, tried and tested in over 100,000 applications offers:

- High resistance to:
  - Vibrations (over 1 g in all axes)
  - Temperature shocks ( $> 150$  K/s)
  - Contaminated media
  - Water hammer
- No maintenance, no moving parts, no zero-point drift.
- Software initial settings save time and costs

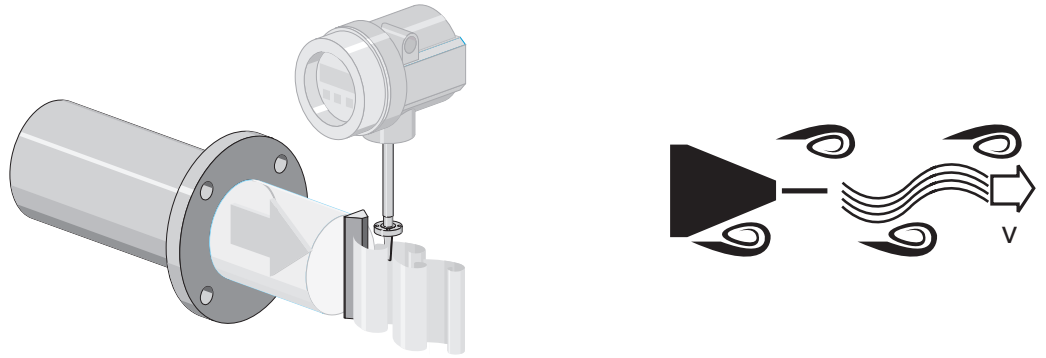
In addition, Prowirl devices offer the following possibilities:

- Complete saturated steam or liquid-mass measuring point in one single device
- Calculation of the mass flow from the measured variables volume flow and temperature in the integrated flow computer
- External pressure value read-in for superheated steam and gas applications (optional)
- External temperature value read-in for delta heat measurement (optional)

## Function and system design

### Measuring principle

Vortex meters work on the principle of the Karman vortex street. When fluid flows past a bluff body, vortices are alternately formed on both sides with opposite directions of rotation. These vortices each generate a local low pressure. The pressure fluctuations are recorded by the sensor and converted to electrical pulses. The vortices develop very regularly within the permitted application limits of the device. Therefore, the frequency of vortex shedding is proportional to the volume flow.



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The K-factor is used as the proportional constant:

$$\text{K-Factor} = \frac{\text{Pulses}}{\text{Unit Volume [dm}^3\text{]}}$$

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Within the application limits of the device, the K-factor only depends on the geometry of the device. It is independent of the fluid velocity and the fluid properties viscosity and density. In this way, the K-factor is also independent of the type of matter that is to be measured, regardless of whether this is steam, gas or liquid. The primary measuring signal is already digital (frequency signal) and linear to the flow. After production, the K-factor is determined in the factory by means of calibration and is not subject to long-time or zero-point drift. The device does not contain any moving parts and does not require maintenance.

### The capacitive sensor

The sensor of a vortex flowmeter has a major influence on the ability, robustness and reliability of the whole measuring system.

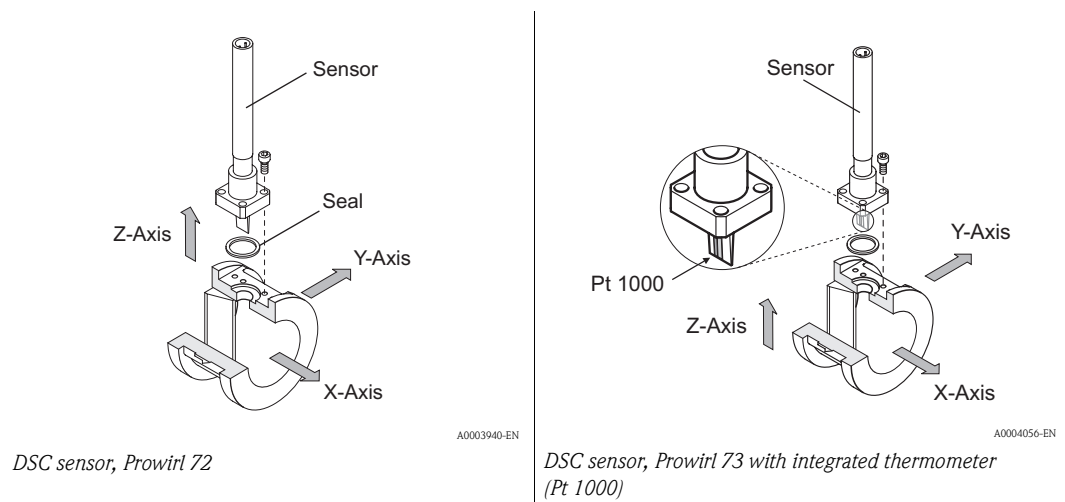
The robust DSC sensor - with an integrated temperature sensor (Pt 1000) with Prowirl 73 - is burst-tested and vibration and temperature-shock-tested (temperature shocks of 150 K/s).

The Prowirl uses the tried-and-tested capacitive measuring technology of Endress+Hauser applied in over 100,000 vortex measuring points worldwide.

The DSC sensor (Differential Switched Capacitance) patented by Endress+Hauser has complete mechanical balancing. It only reacts to the measured variable (vortex), not to vibrations. Even in the event of pipe vibrations, the smallest of flows can be reliably measured at low density thanks to the unimpaired sensitivity of the sensor.

Thus, the wide turndown is also maintained even in the event of harsh operating conditions. Vibrations up to 1 g, in frequencies up to 500 Hz in every axis (X, Y, Z), do not affect the flow measurement.

Thanks to its design, the capacitive sensor is also particularly mechanically resistant to temperature shocks and water hammer in steam lines.



### Temperature measurement (Prowirl 73)

In addition to the volume flow, the measuring device also measures the fluid temperature.

The temperature is measured by means of a Pt 1000 temperature sensor which is located in the paddle of the DSC sensor, i.e. directly in the fluid (Fig. Pt 1000).

### Flow computer (Prowirl 73)

The electronics of the measuring device have an integral flow computer. With the aid of this flow computer other process variables can be calculated from the primary measured variables (volume flow and temperature), e.g.:

- The mass flow and heat flow of saturated steam and water in accordance with IAPWS-IF97/ASME
- The mass flow and heat flow of superheated steam (at constant pressure or pressure read in via HART/PROFIBUS PA/FOUNDATION Fieldbus) in accordance with IAPWS-IF97/ASME
- The mass flow and corrected volume flow of other gases (at a constant pressure or pressure read in via HART/PROFIBUS PA/FOUNDATION Fieldbus, e.g. compressed air or optional natural gas AGA NX-19)
- The mass flow of any liquid (linear equation)
- Delta heat between saturated steam and condensate (second temperature read in via HART) in accordance with IAPWS-IF97/ASME
- Delta heat between warm water and cold water (second temperature read in via HART) in accordance with IAPWS-IF97/ASME
- In saturated steam measurements, the pressure of the steam can also be calculated from the measured temperature and output in accordance with IAPWS-IF97/ASME

### Diagnostic options (Prowirl 73)

Extensive diagnostic options, such as retracing fluid and ambient temperatures, extreme flows etc., are also optionally available for the measuring device.

**Measuring system**

The measuring system comprises a sensor and a transmitter.  
 Two versions are available:

- Compact version: sensor and transmitter form a mechanical unit.
- Remote version: sensor is mounted separate from the transmitter.

Sensor

- Prowirl F (flanged version)
- Prowirl W (wafer version)

Transmitter

- Prowirl 72
- Prowirl 73

**Input**

**Measured variable**

**Prowirl 72**

- Volumetric flow (volume flow) is proportional to the frequency of vortex shedding after the bluff body.
- The volume flow or, if process conditions are constant, the mass flow or corrected volume flow can be output as the output variables.

**Prowirl 73**

- Volumetric flow (volume flow) is proportional to the frequency of vortex shedding after the bluff body.
- The temperature can be output directly and is used to calculate the mass flow for example.
- The measured process variables volume flow, temperature or the calculated process variables mass flow, heat flow or corrected volume flow can be output as the output variables.

**Measuring range**

The measuring range depends on the fluid and the nominal diameter.

**Start of measuring range**

Depends on the density and the Reynolds number ( $Re_{min} = 4,000$ ,  $Re_{linear} = 20,000$ ).  
 The Reynolds number is dimensionless and is the ratio of inertial forces to viscous forces of the fluid. It is used for characterizing the flow. The Reynolds number is calculated as follows:

$$Re = \frac{4 \cdot Q [m^3/s] \cdot \rho [kg/m^3]}{\pi \cdot di [m] \cdot \mu [Pa \cdot s]}$$

*Re = Reynolds number; Q = flow; di = internal diameter;  $\mu$  = dynamic viscosity,  $\rho$  = density*

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$$DN\ 15...25 \rightarrow v_{min.} = \frac{6}{\sqrt{\rho [kg/m^3]}} [m/s] \quad DN\ 40...300 \rightarrow v_{min.} = \frac{7}{\sqrt{\rho [kg/m^3]}} [m/s]$$

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**Full scale value**

- Gas/steam:  $v_{max} = 75$  m/s (DN 15:  $v_{max} = 46$  m/s)
- Liquids:  $v_{max} = 9$  m/s

Note!

By using the selection and planning program "Applicator", you can determine the exact values for the fluid you use. You can obtain the Applicator from your Endress+Hauser sales center or on the Internet under [www.endress.com](http://www.endress.com).

**Measuring range for gases [m<sup>3</sup>/h or Nm<sup>3</sup>/h]**

In the case of gases, the start of the measuring range depends on the density. With ideal gases, the density [ $\rho$ ] or corrected density [ $\rho_N$ ] can be calculated using the following formulae:

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

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The following formulae can be used to calculate the volume [Q] or corrected volume [Q<sub>N</sub>] in the case of ideal gases:

$$Q \text{ [m}^3\text{/h]} = \frac{Q_N \text{ [Nm}^3\text{/h]} \cdot T \text{ [K]} \cdot 1.013 \text{ [bar abs]}}{P \text{ [bar abs]} \cdot 273.15 \text{ [K]}} \quad Q_N \text{ [Nm}^3\text{/h]} = \frac{Q \text{ [m}^3\text{/h]} \cdot P \text{ [bar abs]} \cdot 273.15 \text{ [K]}}{T \text{ [K]} \cdot 1.013 \text{ [bar abs]}}$$

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*T* = Operating temperature, *P* = operating pressure

## Output

**Prowirl 72**

By means of the outputs in the 4...20mA/HART version of Prowirl 72, the volume flow and, if process conditions are constant, the calculated mass flow and corrected volume flow can be output via the current output and optionally via the pulse output or as a limit value via the status output.

**Prowirl 73**

By means of the outputs in the 4...20mA/HART version of Prowirl 73, the following measured variables can generally be output:

	Current output	Frequency output	Pulse output	Status output
<b>Volume flow</b>	If configured	If configured	If configured	Limit value*
<b>Temperature</b>	If configured	If configured	–	Limit value
<b>Mass flow</b>	If configured	If configured	If configured	Limit value*
<b>Corrected volume flow</b>	If configured	If configured	If configured	Limit value*
<b>Heat flow (performance)</b>	If configured	If configured	If configured	Limit value*
<b>Saturation steam pressure (only for saturated steam)</b>	If configured	If configured	If configured	Limit value*
<b>Operating pressure (if read in externally)</b>	If configured	If configured	If configured	Limit value*

\* Limit value for flow or totalizer

If configured, the calculated measured variables density, specific enthalpy, saturation steam pressure (for saturated steam), Z-factor and flow velocity can also be shown on the local display for Prowirl 73.

**Output signal**

**Prowirl 72**

*Current output:*

- 4...20 mA with HART,
- Full scale value and time constant (0...100 s) can be set

*Pulse/status output:*

- Open collector, passive, galvanically isolated
  - Non-Ex, Ex d version:  
 $U_{\max} = 36 \text{ V}$ , with 15 mA current limiting,  $R_i = 500 \Omega$
  - Ex i and Ex n version:  
 $U_{\max} = 30 \text{ V}$ , with 15 mA current limiting,  $R_i = 500 \Omega$

The pulse/status output can be configured as:

- Pulse output:
  - Pulse value and polarity can be selected (5...2,000 ms)
  - Pulse width can be configured (0.005...2s)
  - Pulse frequency max. 100 Hz
- Status output:
  - Can be configured for error messages or flow limit values
- Vortex frequency:
  - Direct output of unscaled vortex pulses 0.5...2,850 Hz  
 (e.g. for connecting to an RMC 621 flow computer)
  - Pulse ratio 1:1

*PROFIBUS PA interface:*

- PROFIBUS PA in accordance with EN 50170 Volume 2, IEC 61158-2 (MBP), galvanically isolated
- Current consumption = 16 mA
- Error current FDE (Fault Disconnection Electronic) = 0 mA
- Data transmission rate: supported baudrate = 31.25 kBit/s
- Signal encoding = Manchester II
- Function blocks: 1 x Analog Input, 1 x totalizer
- Output data: volume flow, calculated mass flow, corrected volume flow, totalizer
- Input data: positive zero return (ON/OFF), totalizer control
- Bus address can be set at the device via DIP switches

*FOUNDATION Fieldbus interface:*

- FOUNDATION Fieldbus H1, IEC 61158-2, galvanically isolated
- Current consumption = 16 mA
- Error current FDE (Fault Disconnection Electronic) = 0 mA
- Data transmission rate: supported baudrate = 31.25 kBit/s
- Signal encoding = Manchester II
- Function blocks: 2 x Analog Input, 1 x Discrete Output
- Output data: volume flow, calculated mass flow, corrected volume flow, totalizer
- Input data: positive zero return (ON/OFF), totalizer reset
- Link Master (LM) functionality is supported

**Prowirl 73***Current output:*

- 4...20 mA with HART,
- Full scale value and time constant (0...100 s) can be set

*Frequency output, pulse/status output:*

- Frequency output (optional): open collector, passive, galvanically isolated
  - Non-Ex, Ex d version:  
 $U_{\max} = 36 \text{ V}$ , with 15 mA current limiting,  $R_i = 500 \Omega$
  - Ex i and Ex n version:  
 $U_{\max} = 30 \text{ V}$ , with 15 mA current limiting,  $R_i = 500 \Omega$

The pulse/status output can be configured as:

- Frequency output:
  - End frequency 0...1,000 Hz ( $f_{\max} = 1,250 \text{ Hz}$ )
- Pulse output:
  - Pulse value and polarity can be selected (5...2,000 ms)
  - Pulse width can be configured (0.005...2s)
  - Pulse frequency max. 100 Hz
- Status output:
  - Can be configured for error messages or flow values, temperature values, pressure limit values
- Vortex frequency:
  - Direct output of unscaled vortex pulses 0.5...2,850 Hz  
 (e.g. for connecting to an RMC 621 flow computer)
  - Pulse ratio 1:1

*PROFIBUS PA interface:*

- PROFIBUS PA in accordance with EN 50170 Volume 2, IEC 61158-2 (MBP), galvanically isolated
- Current consumption = 16 mA
- Error current FDE (Fault Disconnection Electronic) = 0 mA
- Data transmission rate: supported baudrate = 31.25 kBit/s
- Signal encoding = Manchester II
- Function blocks: 4 x Analog Input, 2 x totalizer
- Output data: volume flow, mass flow, corrected volume flow, heat flow, temperature, density, specific enthalpy, calculated steam pressure (saturated steam), operating Z-factor, vortex frequency, electronics temperature, Reynolds number, velocity, totalizer
- Input data: positive zero return (ON/OFF), totalizer control, pressure, display value
- Bus address can be set at the device via DIP switches

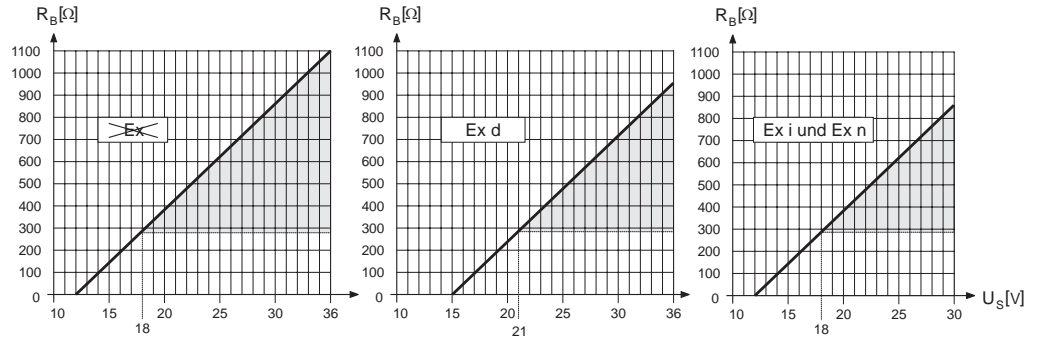
*FOUNDATION Fieldbus interface:*

- FOUNDATION Fieldbus H1, IEC 61158-2, galvanically isolated
- Current consumption = 16 mA
- Error current FDE (Fault Disconnection Electronic) = 0 mA
- Data transmission rate: supported baudrate = 31.25 kBit/s
- Signal encoding = Manchester II
- Function blocks: 6 x Analog Input, 1 x Discrete Output, 1 x Analog Output
- Output data: volume flow, mass flow, corrected volume flow, heat flow, temperature, density, specific enthalpy, calculated steam pressure (saturated steam), operating Z-factor, vortex frequency, electronics temperature, Reynolds number, velocity, totalizer 1 + 2
- Input data: positive zero return (ON/OFF), totalizer reset, pressure
- Link Master (LM) functionality is supported

**Signal on alarm**

- Current output: error response can be selected (e.g. in accordance with NAMUR Recommendation NE 43)
- Pulse output: error response can be selected
- Status output: "not conducting" in event of fault (open circuit)

**Load**



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The area shaded gray refers to the permitted load (for HART: min. 250 Ω)

The load is calculated as follows:

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

$R_B$  Load, load resistance

$U_S$  Supply voltage: non-Ex = 12...36 V DC; Ex d = 15...36 V DC; Ex i and Ex n = 12...30 V DC

$U_{Kl}$  Terminal voltage: non-Ex = min. 12 V DC; Ex d = min. 15 V DC; Ex i and Ex n = min. 12 V DC

$I_{max}$  Output current (22.6 mA)

**Low flow cut off**

Switch points for low flow cut off can be selected as required

**Galvanic isolation**

All electrical connections are galvanically isolated from one another.

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