

A close-up photograph of a perforated metal surface, likely a filter or sensor component, with several water droplets of varying sizes. The background is a soft, out-of-focus blue gradient. The text is centered over the image.

# Implementing Grundfos Direct Sensors in New Products

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# Implementing Grundfos Direct Sensors in New Products



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## 1 Version History

Version:	Date:	Changes:	Initials:
01.00.00	23-09-2011	First Edition	LPED
02.00.00	04-01-2013	Revised and added: <ul style="list-style-type: none"><li>• Physical Sensor installation</li><li>• Complimentary Products<ul style="list-style-type: none"><li>○ CNV, PSU and Signal Converter</li></ul></li><li>• Information about Sedimentation</li><li>• Information about water quality</li><li>• Documents reference list added</li><li>• Illustrations updated</li></ul>	RGU LPED



## 2 Purpose

This document describes the recommendations for implementing Grundfos Direct Sensors™ in new products; as an example in heat pump systems, thermal solar systems or when used with controller devices.

In case of any additional technical questions not covered in this document, please do not hesitate to contact Grundfos Direct Sensors.

<http://www.grundfos-directsensors.com>



## 3 Electrical Interface

### 3.1 Power Supply

**Table 1:** Power Supply Recommendations

Nominal Supply Voltage	Min. Supply Voltage	Max. Supply Voltage	Max. Ripple
5.00 V <sub>DC</sub>	4.75 V <sub>DC</sub>	5.25 V <sub>DC</sub>	± 10 mV <sub>PP</sub>

Please note that the use of Switch Mode Power Supplies can cause problems with the sensor operation, dependent on the rate of the conducted and radiated electrical noise.

In general, Grundfos Direct Sensors does not recommend the use of Switch Mode Power Supplies.

### 3.2 Output Signals

Grundfos Direct Sensors™ are as standard developed to give analogue voltages as output. It is possible to communicate with all analogue sensors digitally, but this requires additional signal conditioning.

For further information on how to communicate with a Standard RS-232 Connection we refer to the Grundfos Direct Sensors Application Note: [RS232\\_interface\\_til\\_sensor\\_english.pdf<sup>1</sup>](#).

Grundfos Direct Sensors also offers a solely digital sensor using TTL levels (open drain). We refer to Table 4 and Figure 3 in this document and Application Note: [Serial communication for VFD sensor English.pdf<sup>2</sup>](#).

Observe that Grundfos Direct Sensors™ analogue output voltages are ratio-metric; the output voltage is scaled with the supply voltage.

This means that increasing the supply voltage by 5% will add 5% to the analogue output reading, likewise, decreasing the supply voltage by 5% will result in a 5% lower analogue output reading.

It is recommended to connect the sensor power supply to the same power supply used by the controller's AD converter. This will ensure power supply independence – still being within the specified limits.

It must be noted that the sensor digital output reading is *not* ratio-metric.

<sup>1</sup> The document can be found at Grundfos Direct Sensors™ Extranet. Access will be granted upon request.

<sup>2</sup> The document can be found at Grundfos Direct Sensors™ Extranet. Access will be granted upon request.

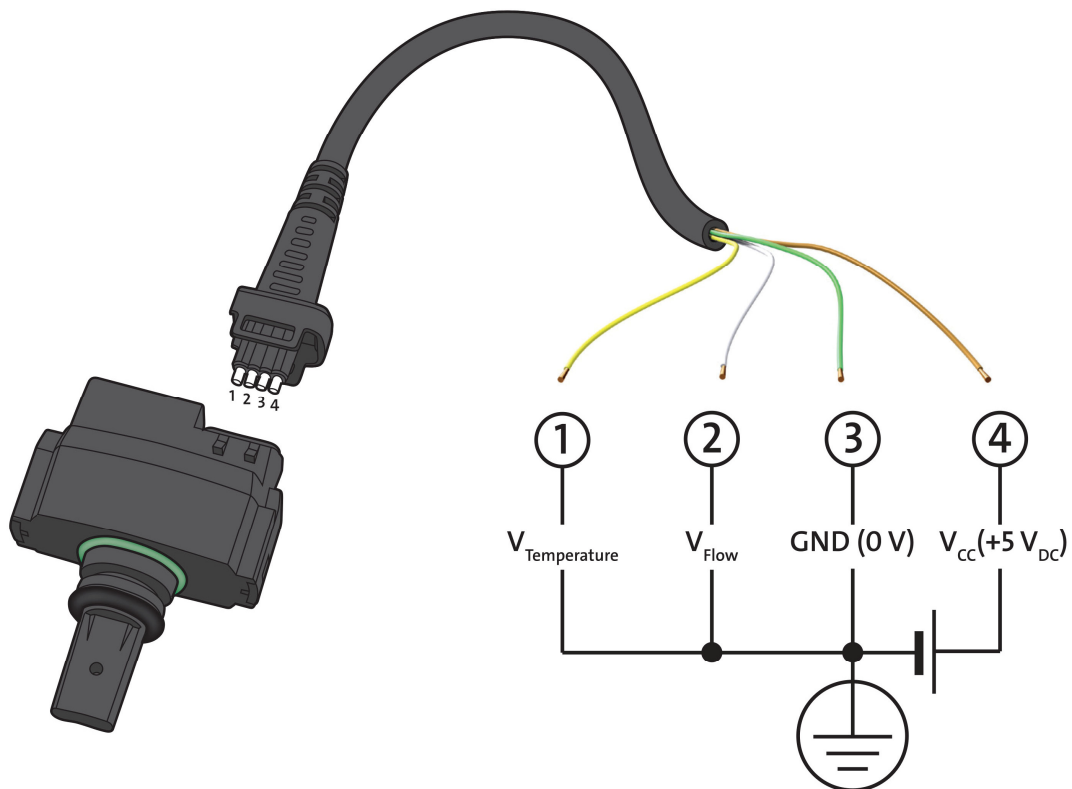
## Implementing Grundfos Direct Sensors in New Products

### 3.3 Electrical Connections

The analogue flow and temperature sensor (Vortex Flow Sensor, VFS) has a four wire electrical interface:

**Table 2:** VFS Pin Configuration and Colour Code for standard cable

Pin Number	Name	Description
1 (Yellow)	Temperature	Temperature Signal (0.5 – 3.5 V relative to GND)
2 (White)	Flow	Flow Signal (0.5 – 3.5 V relative to GND)
3 (Green)	GND	Ground connected to PE
4 (Brown)	V <sub>CC</sub>	+5V <sub>DC</sub> Supply relative to GND



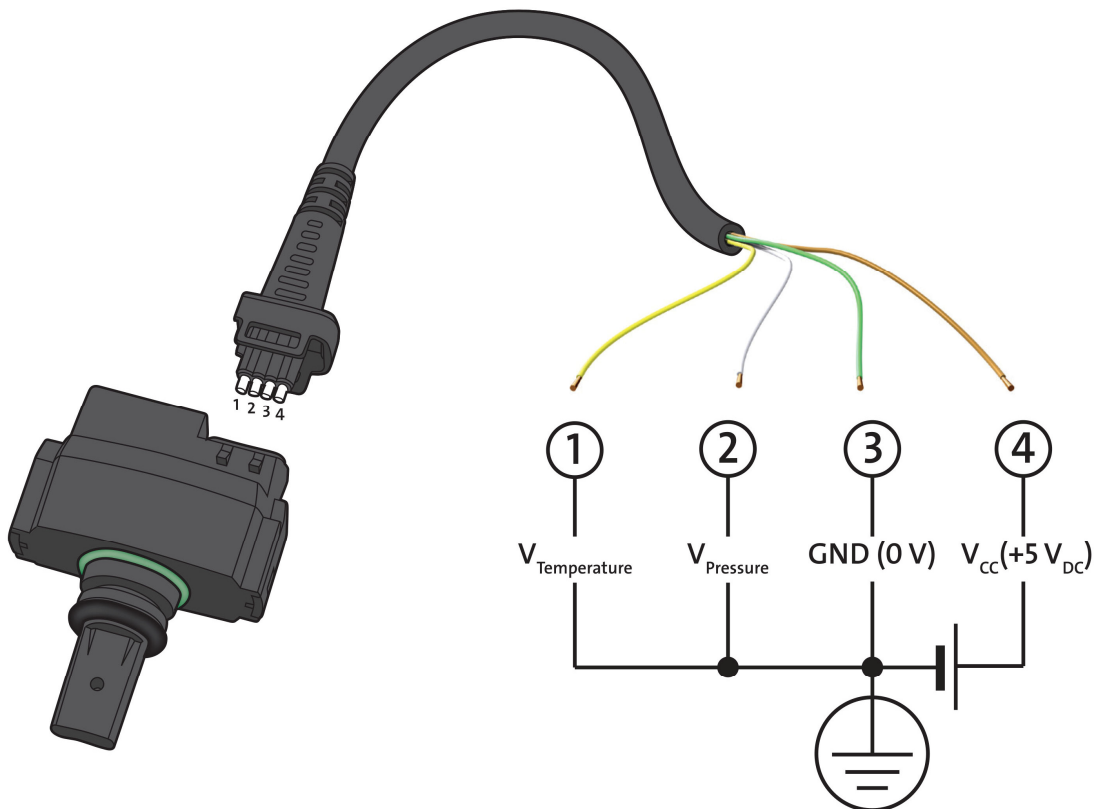
**Figure 1:** VFS Electrical Connections.

## Implementing Grundfos Direct Sensors in New Products

The analogue pressure and temperature sensors (Relative Pressure Sensor, RPS and Differential Pressure Sensor, DPS) have a four wire electrical interface:

**Table 3:** RPS and DPS Pin Configuration and Colour Code for standard cable

Pin Number	Name	Description
1 (Yellow)	Temperature	Temperature Signal (0.5 – 3.5 V relative to GND)
2 (White)	Pressure	Pressure Signal (0.5 – 3.5 V relative to GND)
3 (Green)	GND	Ground connected to PE
4 (Brown)	V <sub>CC</sub>	+5V <sub>DC</sub> Supply relative to GND



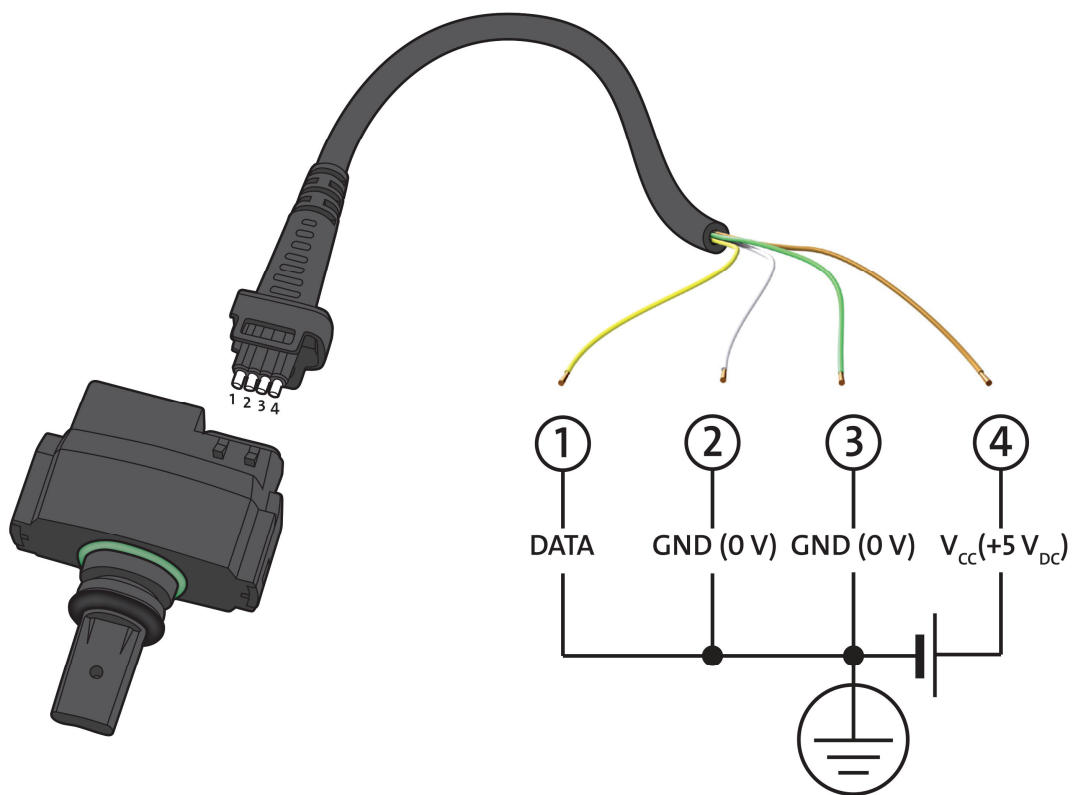
**Figure 2:** RPS and DPS Electrical Connections.

## Implementing Grundfos Direct Sensors in New Products

The digital flow and temperature (VFD) and the digital pressure and temperature sensors (RPD and DPD) have a four wire electrical interface:

**Table 4:** VFD, RPD and DPD Pin Configuration and Colour Code for standard cable

Pin Number	Name	Description
1 (Yellow)	DATA	Bi-directional data, Open-drain
2 (White)	GND	Ground connected to PE
3 (Green)	GND	Ground connected to PE
4 (Brown)	V <sub>CC</sub>	+5V <sub>DC</sub> , Supply relative to GND



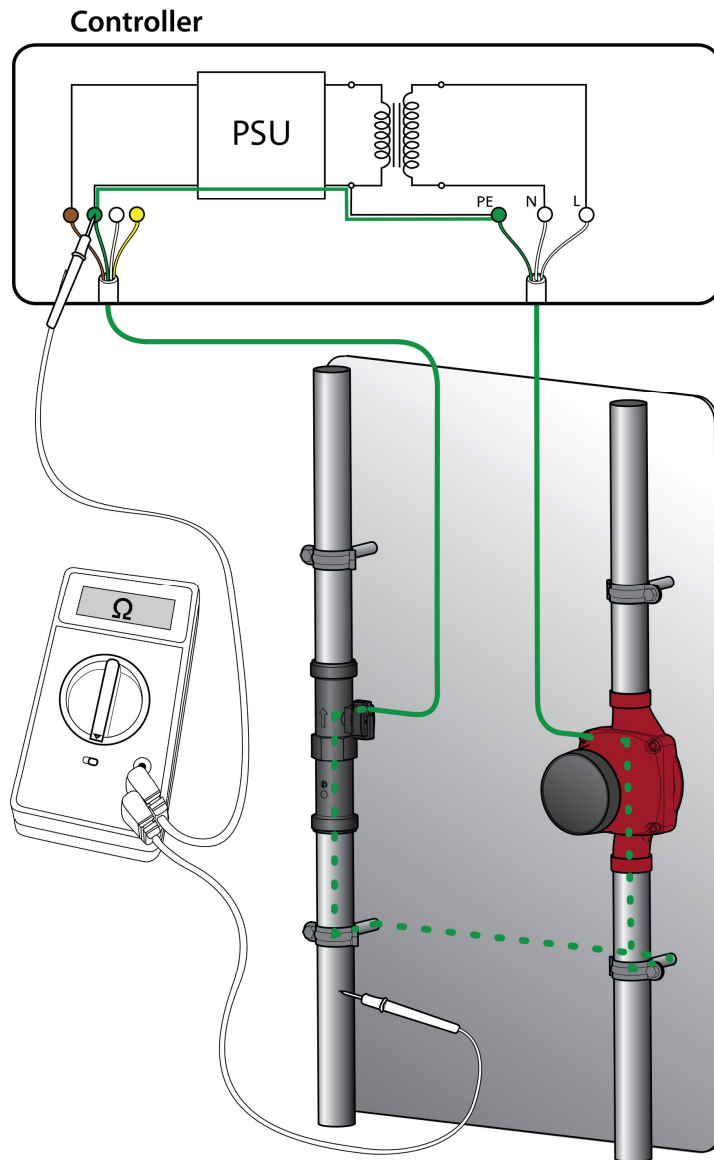
**Figure 3:** VFD, RPD and DPD Electrical Connections.



# Implementing Grundfos Direct Sensors in New Products

## 3.4 Grounding Technique

Using proper grounding technique is essential for correct sensor functionality. An erroneous sensor ground potential will lead to incorrect measurements.



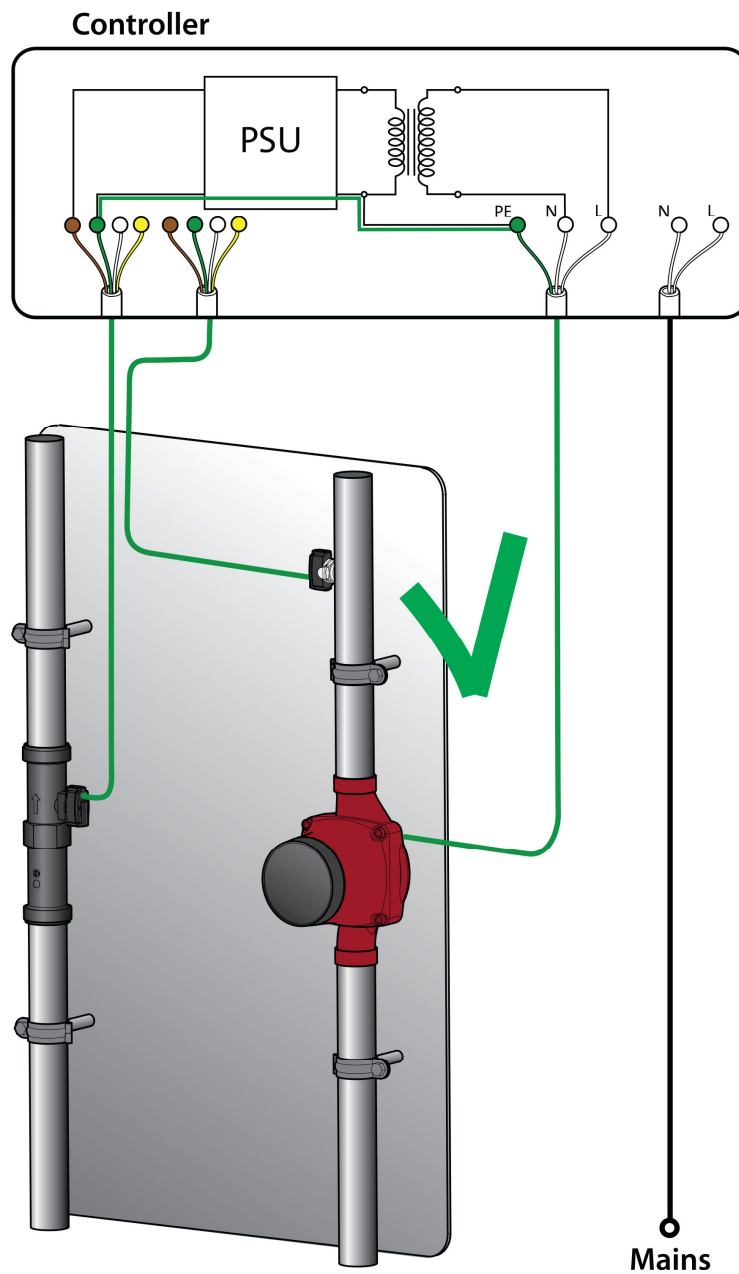
- Current path by sensor, wiring and controller
- ..... Current path by fluid, pump house, piping and mechanical fixture

**Figure 4:** Reading at the Multimeter must be less than 10  $\Omega$ . The illustration shows Grundfos standard colour-coded cable.

## Implementing Grundfos Direct Sensors in New Products

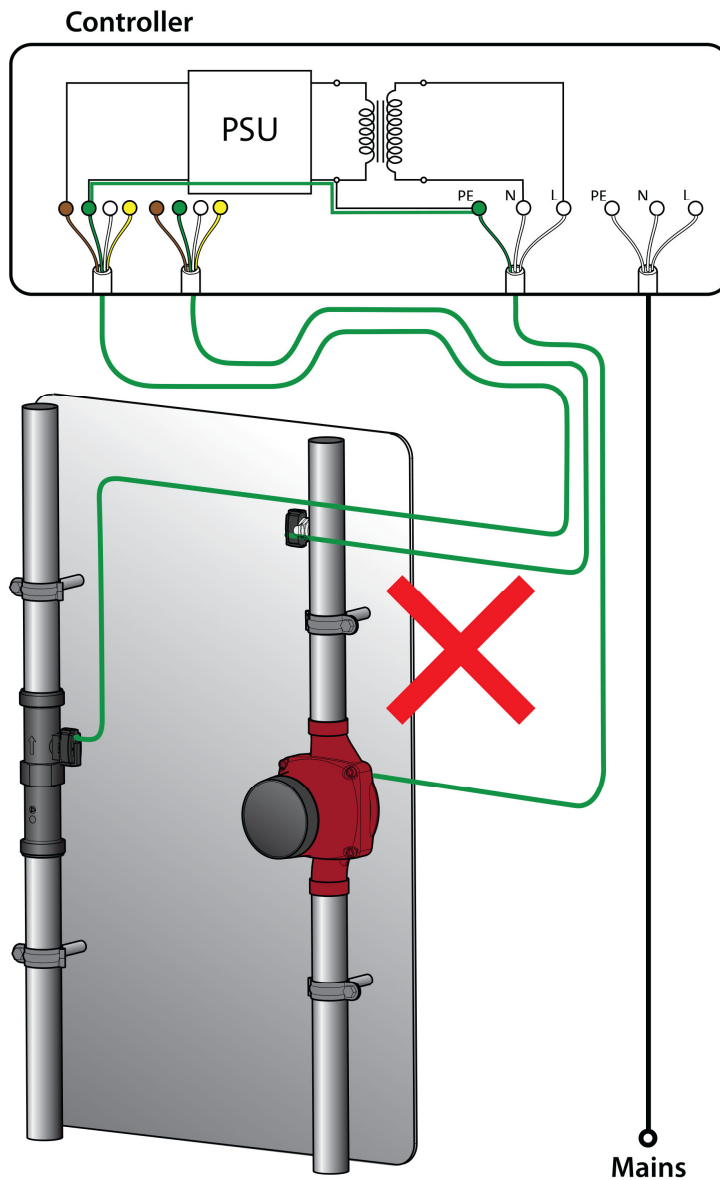
### Wiring Technique

Always use the correct wiring path, thus avoiding radiated electrical noise. Please note, not all electrical connections are shown in the figure.



**Figure 5:** Correct Wiring Technique.

## Implementing Grundfos Direct Sensors in New Products



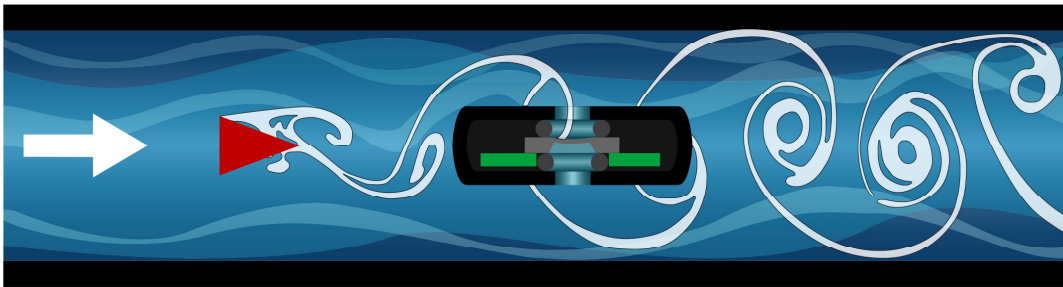
**Figure 6:** Incorrect Wiring Technique. Avoid unshielded transformers. Avoid cross-coupling between mains inlet and internal high voltage wires. Please note, not all electrical connections are shown in the figure.

### 4 Operational Principles

This chapter explains the basic operating principles of the Grundfos Direct Sensors Vortex Flow Sensor (VFS) and Relative Pressure Sensor (RPS).

#### 4.1 Vortex Flow Sensor

The Grundfos Direct Sensors™ VFS is an integrated flow and temperature measurement system designed and validated for harsh aqueous environments. The flow measurement is based on the Vortex Principle. The system elements include a flow-pipe with an integrated bluff body and a differential pressure detector. When a bluff body is placed in a flow inside a pipe, a series of vortices will be generated periodically on each side of the bluff body. These vortices propagate downstream giving rise to periodic pressure variations which can be detected by the differential pressure detector. The frequency of the pressure variations is proportional to the volume flow through the pipe.

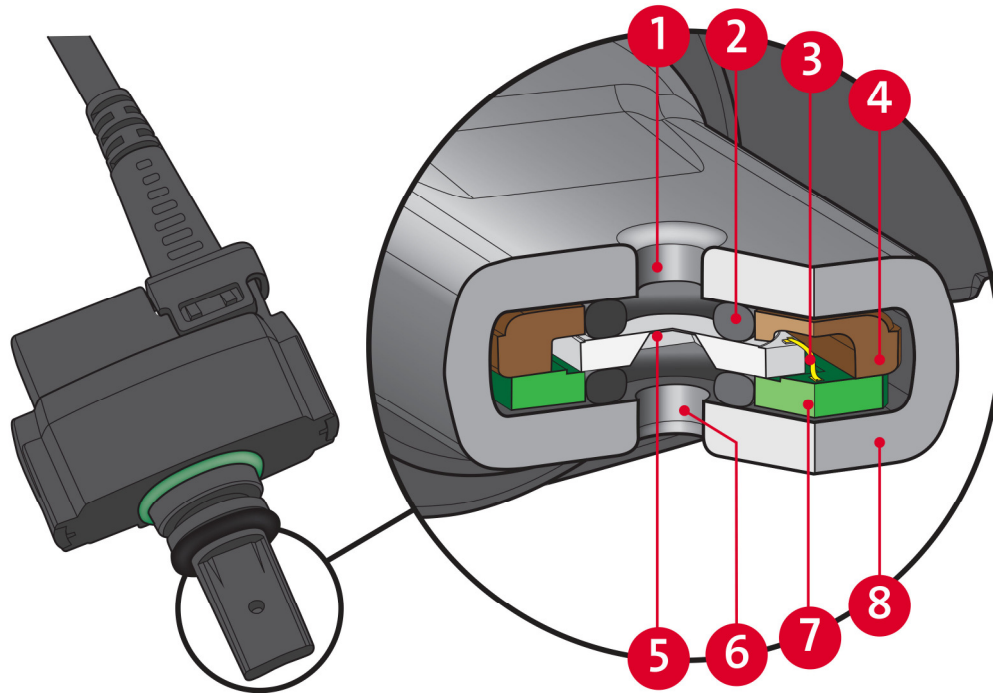


**Figure 7:** VFS Operational Principle.

The bluff body is designed to optimise the pulse strength of the pressure variations at the position of the differential pressure detector. The bluff body is an integrated part of the injection moulded flow tube or supplied as a composite insert solution, whereas the differential pressure sensor is mounted at the top of the flow pipe with a clip. Flow ranges are set by the tube diameter and parameters within the signal processing. The differential pressure detector key elements are a silicon bulk, micro-machined chip and a microprocessor-based signal-conditioning circuit, both mounted on the same PCB. The conditioning circuit converts the pressure reading to a signal proportional to the volume flow through the pipe. The electronics are protected by an IP class 44 composite housing.

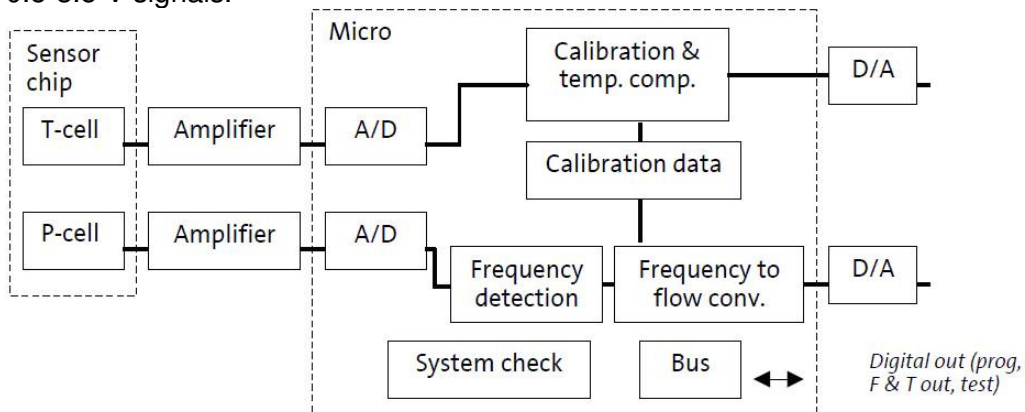
The chip has a square membrane, which deflects due to pressure. Strain gauges are incorporated in a Wheatstone bridge configuration on stress intensive positions on the membrane. The pressure and temperature sensitive area (the membrane region) is coated on both sides by an extremely corrosion and diffusion resistive thin film (Silicoat®). The coating provides direct environmental robustness of the chip. The separation of the fluid and fluid-free zones is provided by O-ring sealing. The sealing is centred on the membrane and is symmetrical on both sides of the chip to ensure minimum stress-coupling from the packaging.

## Implementing Grundfos Direct Sensors in New Products



**Figure 8:** Cross Section of Sensor Chip and Sealing (VFS). 1: Measurement Port, 2: O-Ring, 3: Bonded Gold Wire, 4: Guide, 5: Silicoat DIE, 6: Measurement Port, 7: Printed Circuit Board, 8: Sensor Housing.

The non-compensated signals from the pressure and temperature detection circuits are fed into a microprocessor and converted to the digital regime after amplification. The microprocessor employs algorithms to compensate for individual variations in the offset and sensitivity of the sensor cells and eliminates the temperature dependency of the pressure detector. The frequency is converted to a flow based on calibration data, which are dependent on the geometry of the flow tube. On the output terminals the calibrated signals are reconverted to analogue, ratio-metric 0.5-3.5 V signals.



**Figure 9:** Electrical Block Diagram (VFS).

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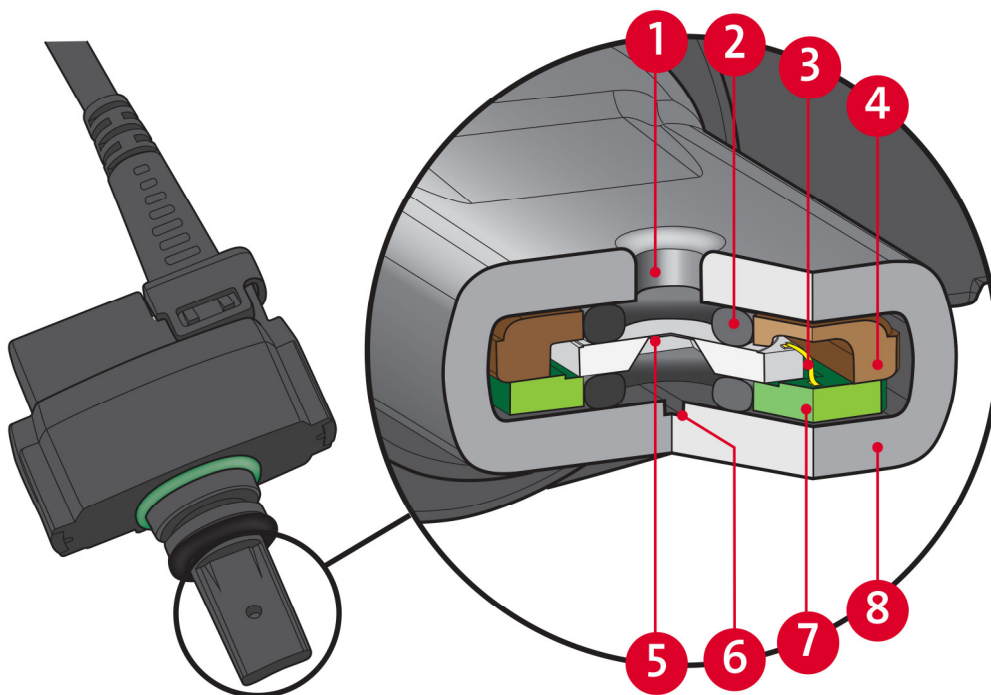


## Implementing Grundfos Direct Sensors in New Products

### 4.2 Pressure Sensor

The Grundfos RPS and DPS is an integrated pressure and temperature measurement system designed, verified and validated for harsh aqueous environments. The interior elements are a silicon bulk, micro-machined chip and a microprocessor-based signal conditioning circuit on the same PCB. The electronics are protected by an IP Class 44 composite housing, which in turn provides the pressure inlets directly to the silicon chip.

The chip has a square membrane, which deflects due to pressure. Strain gauges are incorporated in a Wheatstone bridge configuration on stress intensive positions on the membrane. The pressure and temperature sensitive area (the membrane region) is coated on both sides by an extremely corrosion and diffusion resistive thin film (Silicoat®). The coating provides direct environmental robustness of the chip. The separation of the fluid and fluid-free zones is provided by O-ring sealing. The sealing is centred on the membrane and is symmetrical on both sides of the chip to ensure minimum stress-coupling from the packaging.

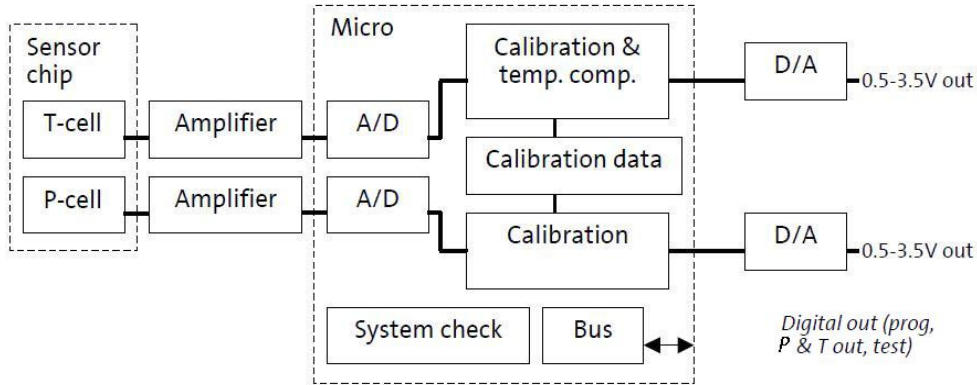


**Figure 10:** Cross Section of Sensor Chip and Sealing (RPS). 1: Measurement Port, 2: O-Ring, 3: Bonded Gold Wire, 4: Guide, 5: Silicoat DIE, 6: Pressure Channel, 7: Printed Circuit Board, 8: Sensor Housing.

The non-compensated signals from the pressure and temperature detection circuits are fed into a microprocessor and converted to the digital domain after amplification. The microprocessor employs algorithms to compensate for individual variations in the offset and sensitivity of the sensor cells and eliminates the temperature de-

## Implementing Grundfos Direct Sensors in New Products

pendence of the pressure cell. On the output terminals, the calibrated signals are re-converted to analogue ratio-metric 0.5-3.5V signals.



**Figure 11:** Electrical Block Diagram (RPS/DPS).

## 5 Mechanical Recommendations

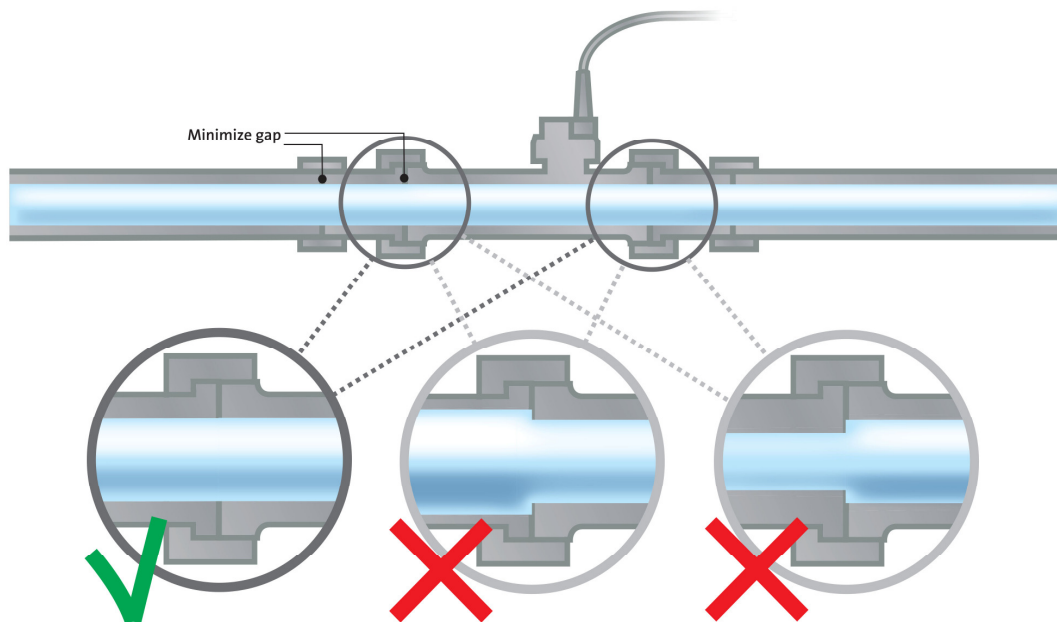
This chapter gives recommendations on how to design the surrounding piping. Ensure that the sensor flow-pipe and sensor are mounted in the correct flow direction. Please note the “Flow Indicator Arrow” casted on the flow pipe.

### 5.1 Vortex Flow Sensor

To secure optimal measuring conditions for the Vortex Flow Sensor, the following conditions are recommended.

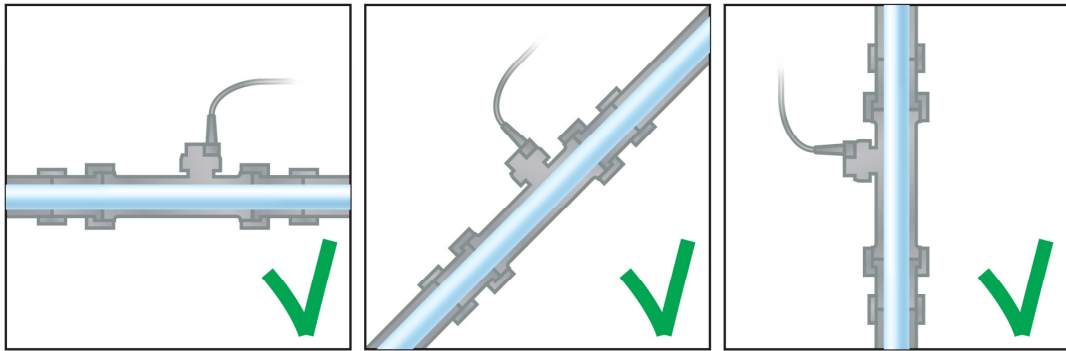
Please note, it is of utmost importance to avoid mechanical stress during sensor mounting and when mounting other peripheral mechanical equipment to the sensor.

During mounting of the sensor in the flow-pipe, please do not use any kind of grease or organic lubricant. Plain water, soapy water or silicone-based lubricants can be used if necessary, though lubrication should be confined to the sensor-tip and O-ring region. Do not submerge the sensor entirely (IP44).

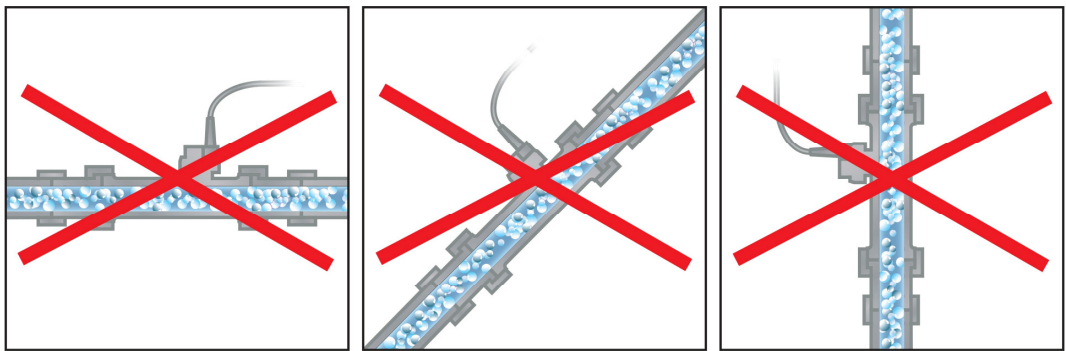


**Figure 12:** Mechanical Guideline for Flow Sensor Installation - Dimensions.

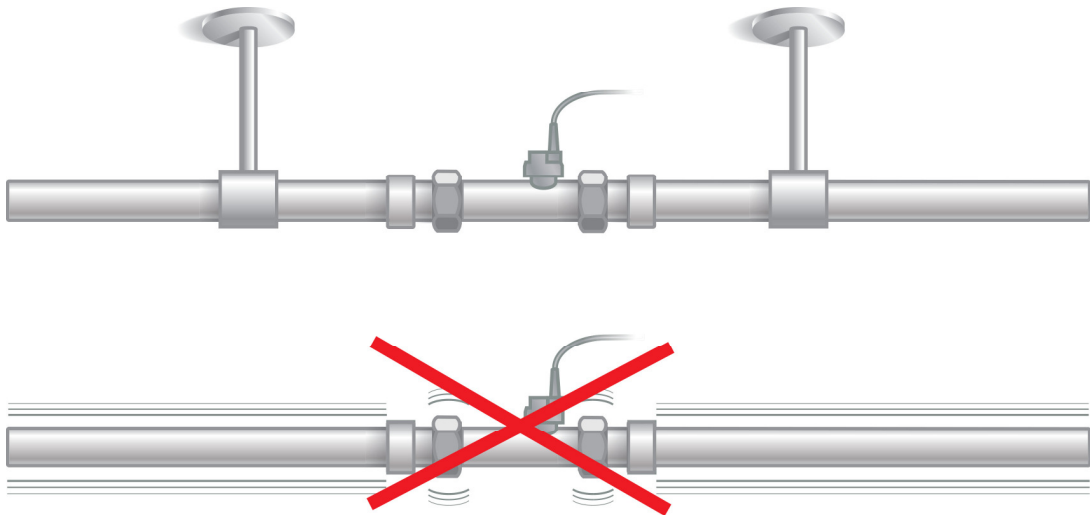
## Implementing Grundfos Direct Sensors in New Products



**Figure 13:** Correct Flow Sensor Installation - Orientation.

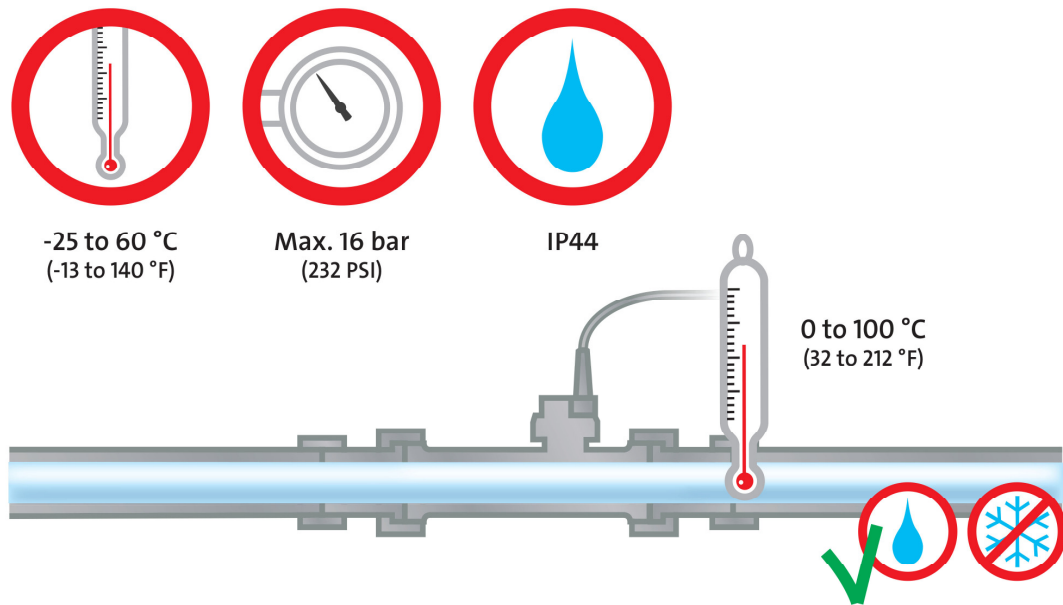


**Figure 14:** Incorrect Flow Sensor Installation – Avoid air in fluid.



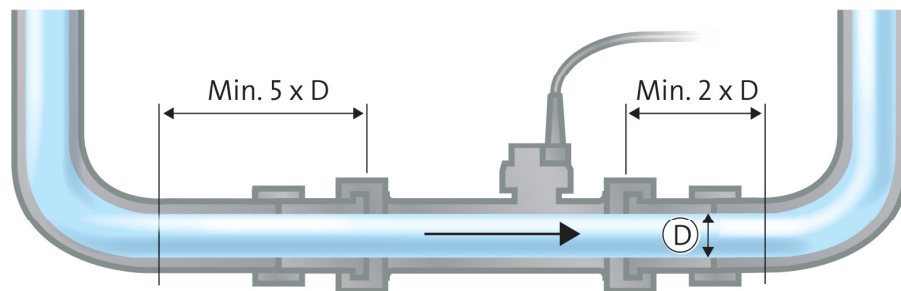
**Figure 15:** Flow Sensor Mechanical Installation – Vibrations.

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**Figure 16:** Flow Sensor Operating Conditions.

Grundfos Direct Sensors recommends the following generic piping distances before and after the sensor placement.

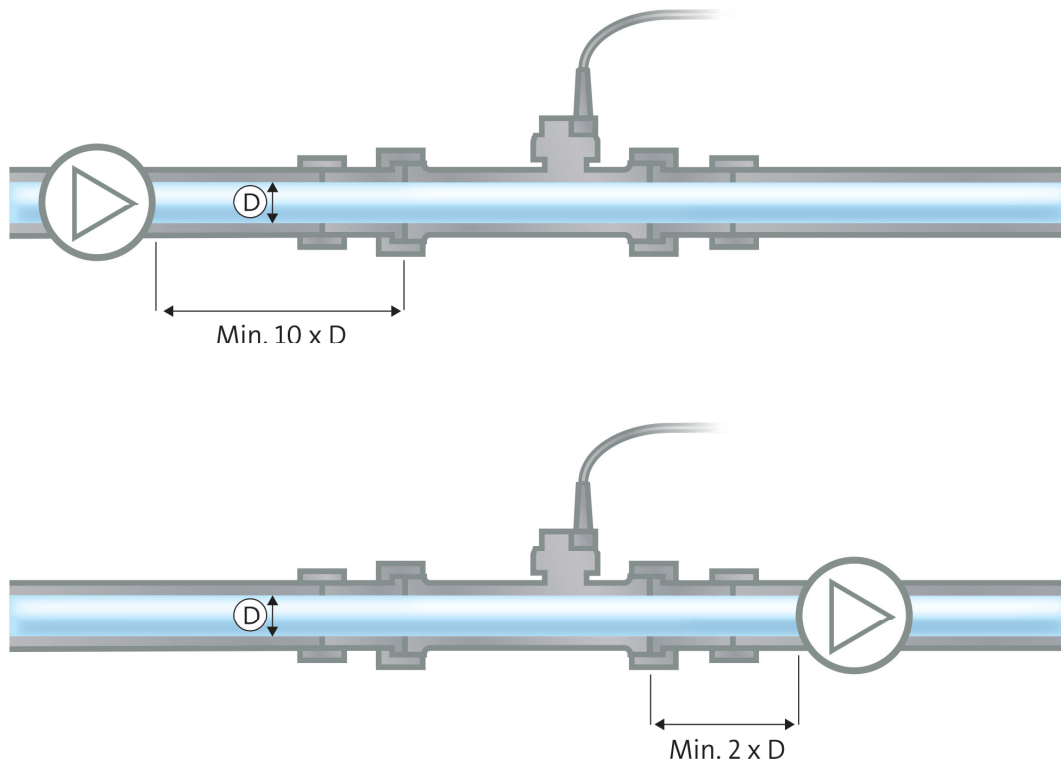


**Figure 17:** Mechanical guideline for flow sensor installation – Distance to bends.

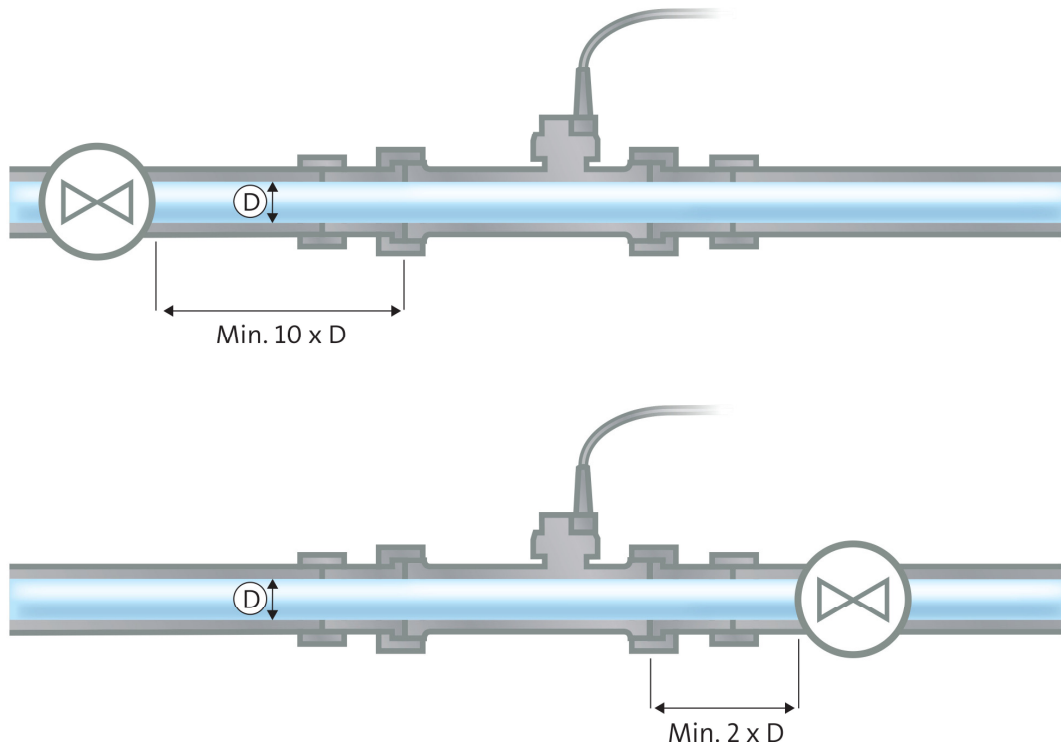
If possible, it is recommended to mount the sensor at the inlet side of pumps or valves.



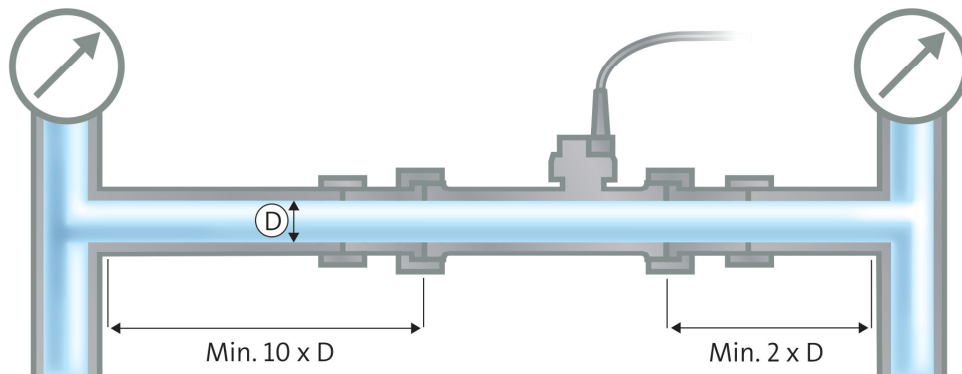
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**Figure 18:** Mechanical guideline for flow sensor installation – Distance to pump.



**Figure 19:** Mechanical guideline for flow sensor installation – Distance to valve.

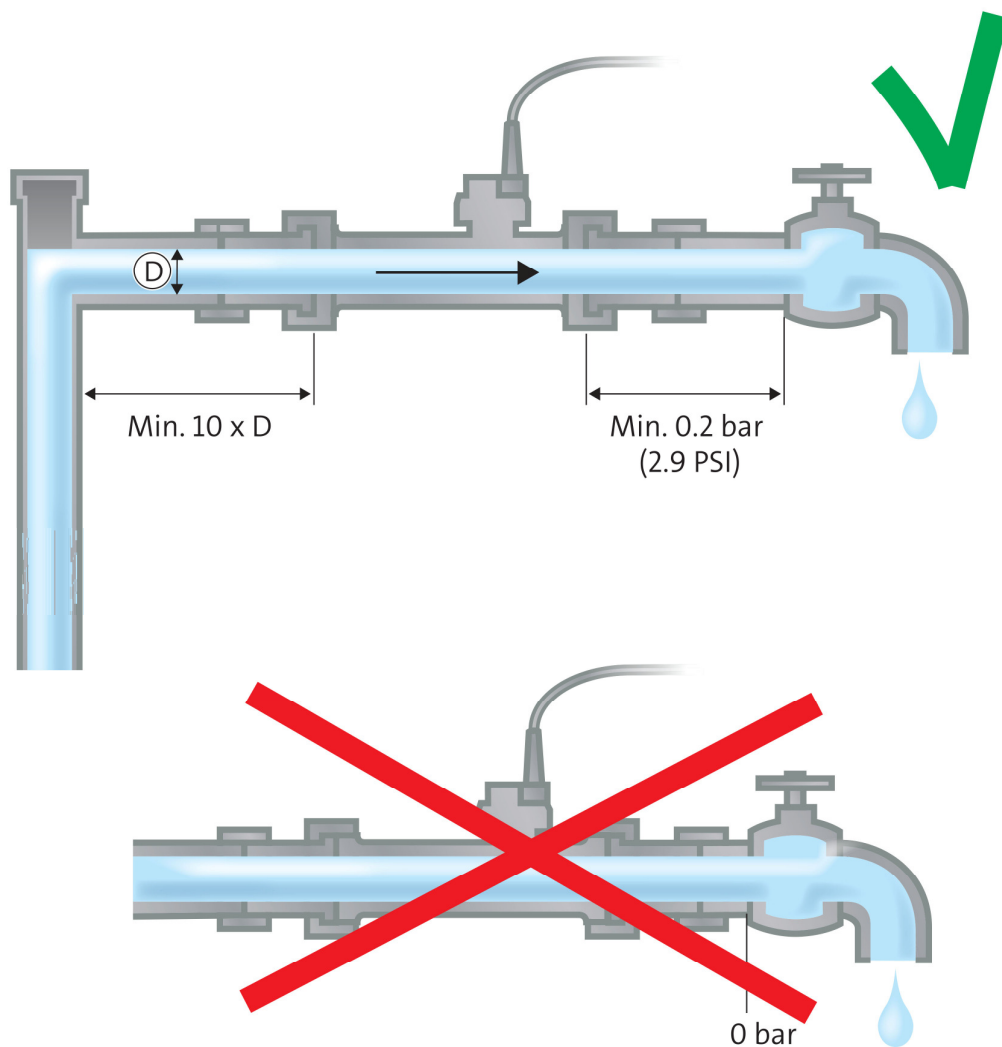


**Figure 20:** Mechanical guideline for flow sensor installation – Distance to T-connector.

### 5.2 Cavitation

It is of extreme importance to avoid flashing, cavitation and water hammer at the sensor. Any condition that tends to contribute to the release of vapour from the liquid shall be avoided by proper system design and operation of the sensor within the rated flow rate range.

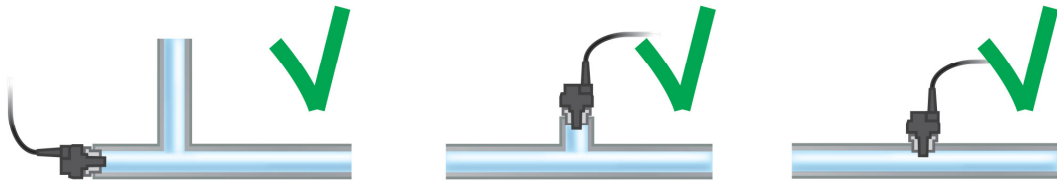
In case of an open system, special care regarding cavitation has to be taken. As a rule of thumb always ensure min. 200 mBar pressure drop after the sensor.



**Figure 21:** Mechanical guideline for flow measurement in open systems – Minimum pressure drop.

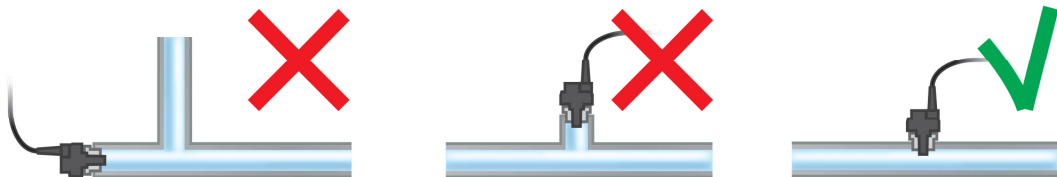
## 5.3 Pressure Sensor

For correct pressure measurement only, the sensor can be placed in a T-connector or similar.



**Figure 22:** Mechanical guideline for pressure measurement only – Sensor placement.

For correct temperature operation, the sensor should be placed directly in the fluid.



**Figure 23:** Mechanical guideline for temperature measurement – Sensor placement.

### 6 Complimentary Products

Depending on conditions at the installation site, it may be necessary to extend the sensor cable. In The Declaration of Conformity, Grundfos Direct Sensors states that the sensor fulfils the Low Voltage Directive (EN 61010) and the EMC Directive (EN 61326-1 and EN61326-2-3). Therefore, Grundfos Direct Sensors™ can be supplied with cables up to 2.9 m in length.

If cable lengths longer than 2.9m are required or conversion of the sensor output signals is necessary, Grundfos Direct Sensors recommends the use of CNV, PSU and Signal Converter. The SI 010 CNV is for DIN Rail and Wall mounting.

#### 6.1 CNV, PSU and Signal Converter

The SI 010 CNV offers power supply, signal amplification and signal conversion for Grundfos Direct Sensors™ flow and pressure sensors.



CNV - Supply Voltage	115/230 V <sub>AC</sub> or 24 V <sub>DC</sub>
CNV - Supply Voltage for 2 Sensors	+5 V <sub>DC</sub>
Signal Input 1	0.5–3.5 V <sub>DC</sub> or 0.5–4.5 V <sub>DC</sub>
Signal Input 2	0.5–3.5 V <sub>DC</sub> or 0.5–4.5 V <sub>DC</sub>
Signal Output 1	4–20 mA or 1–5 V <sub>DC</sub> or 2–10 V <sub>DC</sub>
Signal Output 2	4–20 mA or 1–5 V <sub>DC</sub> or 2–10 V <sub>DC</sub>

**Figure 24:** The CNV PSU and Signal Converter inputs and outputs.



## 7 Fluid

All Grundfos Direct Sensors™ are coated with a proprietary and extremely durable coating (Silicoat®), enabling accurate, cost effective and robust measurements. Grundfos Direct Sensors™ are not to be used for Gas measurement.

### **Flow measurements:**

Conductive and non-conductive fluid may be used.

### **Pressure measurements:**

Conductive and non-conductive fluid may be used.

### **Temperature measurements:**

The use of non-conductive fluid will lead to minor errors in the temperature measurements. However, this can be omitted by the use of proper software filter in the controller. Please contact Grundfos Direct Sensors for more detailed information.

### 7.1 Liquids

All Grundfos Direct Sensors™ are designed for operation in water and harsh aqueous environments.

### 7.2 Water Quality

Grundfos Direct Sensors™ have been tested and approved for operation in fluid containing high particle levels. The following section outlining water quality should therefore be read as a general precaution in minimising the risk of sensor failure due to excessive sedimentation and obtaining long-term sensor operation.

In some instances, factors related to the water quality of a system can have such an influence that the occurrence of sedimentation in the sensor measurement port of the VFS and RPS may have a detrimental effect on the accuracy of the flow or pressure signal of the sensor. This phenomena usually covers water heating systems where the media is limited to normal water used in oxygen depleted, closed-circuits for heating purposes. For these systems, Grundfos Direct Sensors recommends the use of sensors with FKM O-rings.

#### 7.2.1 Organic Content

Organic Content within the media, in the form of grease, oil, lubricants or similar pollutants that may be related to the installation and commissioning of the system, can have an influence on the amount of foreign particles that build-up within the sensor measurement port.

During commissioning of the system, it is recommended that the system in which the sensors are to be operational in is thoroughly flushed to minimise the presence

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of organic content. Flushing of the system may be performed while the sensor is mounted in the Flow Pipe, though caution should be exercised as not to exceed the maximum, specified flow limit of the sensor.

Likewise, the use of lubricants to assist in mounting the sensor in the flow pipe should also be avoided. Grundfos Direct Sensors are manufactured with a slip-coating on the outer O-ring to aid mounting in the flow pipe. Therefore, the use of additional lubricants to assist mounting the sensor in the flow pipe is deemed unnecessary.

Grundfos Direct Sensors recommends that the Total Organic Carbon (TOC) content of the media be no greater than 25mg/L.

### 7.2.2 pH-Value

Generally, the particle composition of the sedimentation that can be present within a sensor used in closed-circuit heating applications is a combination of iron-oxide and calcium particles. Adjusting the pH-value of the filling media may be necessary to avoid excessive corrosion within the system.

Grundfos Direct Sensors recommends that the system media have a pH-value greater than 8.

Media below this value should be treated to increase the pH-value which will help minimise the amount of corrosion within the system and the eventual presence of excessive iron-oxide particles.

### 7.2.3 Iron-Oxide Content

As the amount of Iron-Oxide (Fe/O) particles present in the water has a direct influence on the amount of particles that are able to deposit in the sensor measurement port, it should be ensured that consideration be given to the causes of corrosion within the system that can lead to excessive Fe/O particles.

As mentioned in the following section, this can be effectively handled by addressing the pH-value of the media for prevention of excessive corrosion as well as flushing the system effectively.

Grundfos Direct Sensors recommends that the Fe content of the media be no greater than 10 mg/L.

### 7.2.4 Calcium and Magnesium (Total Hardness)

The sedimentation typically present in sensors used in heating applications is a combination of Fe/O and Ca. The sum of the calcium and magnesium ions in the filling water is influential on the amount of sediments present within the sensor measurement port in the initial operational phase after sensor installation. Consideration to the filling media's total hardness should be given during installation and commissioning.

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Grundfos Direct Sensors recommends that the total hardness of the filling media be no greater than 100mg/L.

### 7.2.5 Recommended Values

The following table outlines the critical factors the customer should be aware of when taking water quality into consideration when using Grundfos Direct Sensors™.

**Table 5:** Recommended Water Quality Values

Subject	Value	Unit
pH	>8	
Total Organic Carbon (TOC)	<25	mg/L
Suspended Solids (SS)	<25	mg/L
Iron (Fe)	<10	mg/L
Calcium (Ca) and Magnesium (Mg) – Total Hardness	<100	mg/L

If you have any questions related to this document regarding water quality for your application, please do not hesitate to contact Grundfos Direct Sensors for further information.

### 7.3 Glycol

Grundfos Direct Sensors™ are designed for flow measurements within glycol or any other additives. However, Grundfos Direct Sensors do not recommend higher concentration than 42% glycol in water.

The temperature must be higher than 30 °C and the kinematic viscosity must be less than 2 mm<sup>2</sup>/s (cSt).

It should be noted that glycol will increase the viscosity at low temperature. Hence, the detectable minimum flow will increase.

### 7.4 Oil

For aqueous fluid, Grundfos Direct Sensors recommend the use of EPDM O-rings.

If oil is present within the fluid, Grundfos Direct Sensors recommend the use of FKM (Viton) O-rings.



## 8 Environment

### 8.1 Condensation

As a standard, Grundfos Direct Sensors™ are designed for non-condensing environments. Upon request, gel-filled sensors for condensing environments can be supplied.

Grundfos Direct Sensors general recommendation is to use gel-filled sensors in systems where the fluid temperature is lower than the ambient temperature.

### 9 Trouble-free Operations

For trouble-free operation and optimal lifetime, the following should be taken into account:

- In general the sensor is not a serviceable item:
  - Do not try to clean the sensor membrane
  - Do not tamper or splice the cable
- Evacuation by pressurised air or nitrogen may damage the sensor membrane
- Be aware of the maximum allowed system pressure
- Use the sensor only for the recommended installation – observe standard common practices for flow, pressure and temperature sensors and low voltage electronics
- Too high flow, typically 25% higher than  $q_{\max}$  will lead to cavitation, which will destroy the sensor membrane
- In general avoid flashing, cavitation and water hammer
- Freezing liquid will destroy the Sensor Membrane
- Read the appropriate Data Sheet
- Read the appropriate Instruction Manual



### 10 Documents Reference List

The following documents can be found at Grundfos Direct Sensors™ Extranet. Access will be granted upon request.

*RS232\_interface\_til\_sensor\_english.pdf*

*Serial communication for VFD sensor English.pdf*

*Grundfos Direct Sensors Water Quality Guidelines V01.00.00.pdf*