Monitoring of relevant process parameters using fluid sensors

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Notes on this webinar

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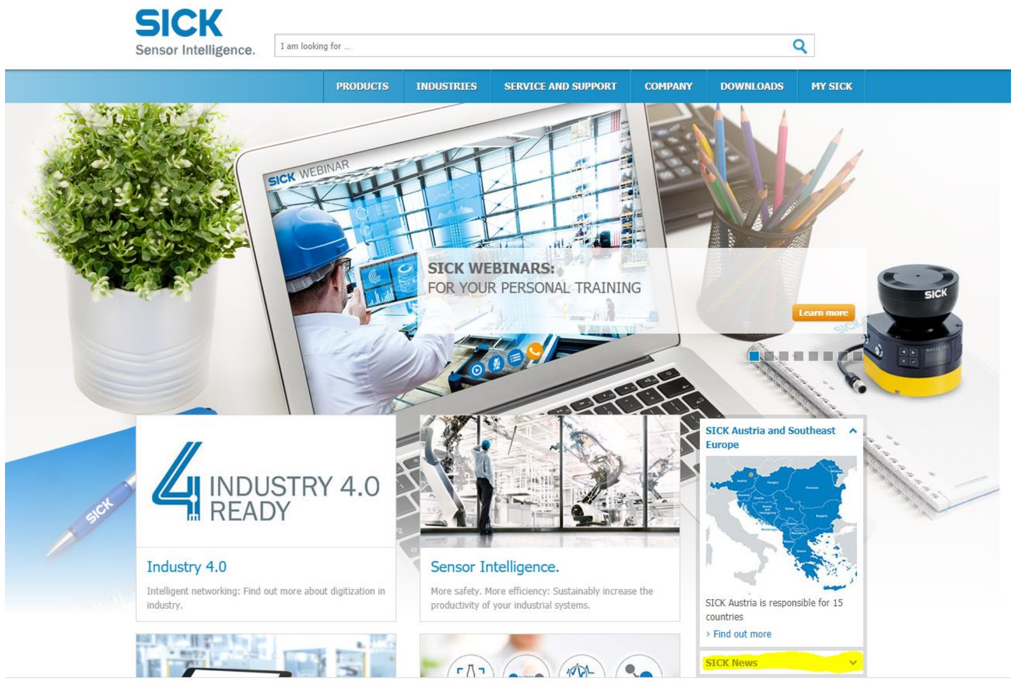


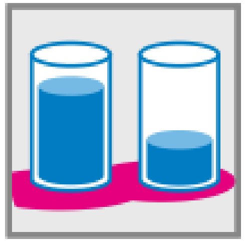
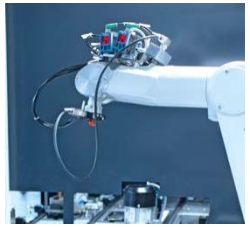
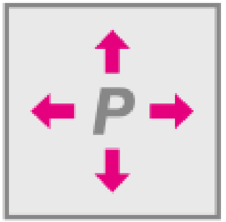


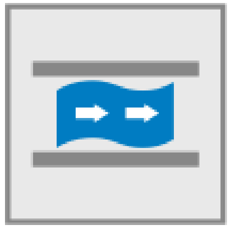

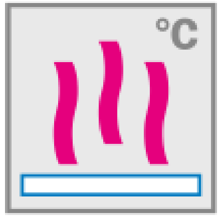

- **Technology update as the basis for increasing efficiency for the relevant process parameters:**
  - Level and point level measurement
  - Universal pressure measurement in liquids and gases
  - Flow measurement technology
  - Temperature measurement for liquids and gases
- **Technology selection**
- **Process connections**
- **Outlook 80 Ghz radar technology**

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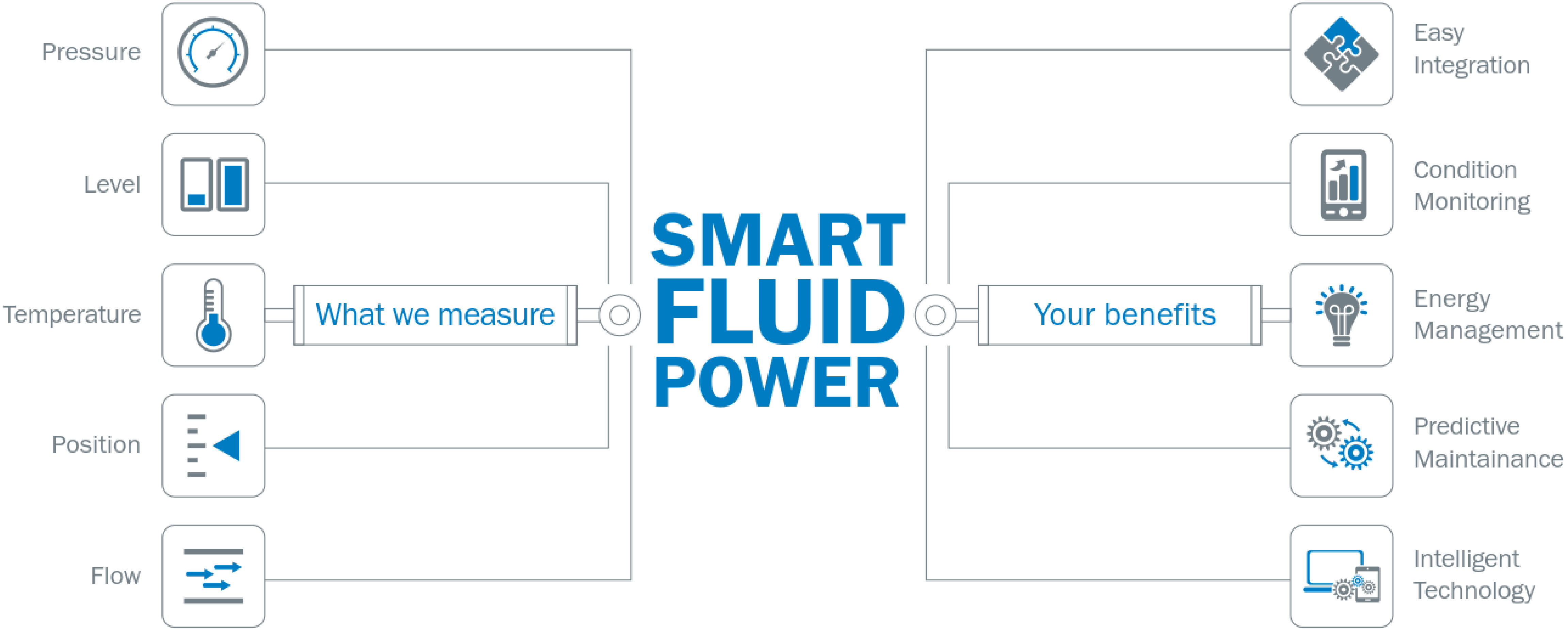
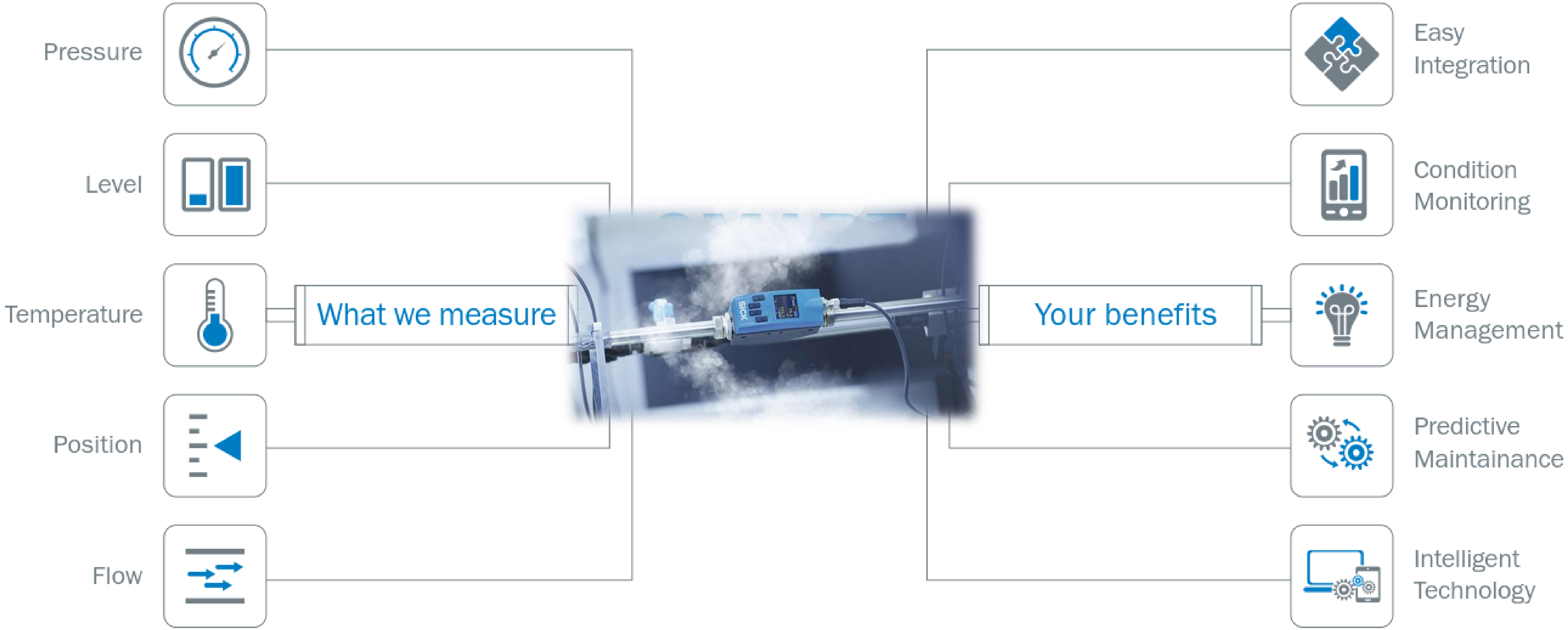
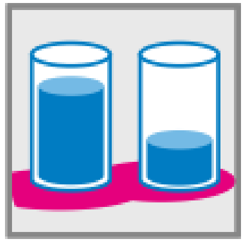



Pressure
Level
Temperature
Position
Flow
What we measure
Your benefits
Easy Integration
Condition Monitoring
Energy Management
Predictive Maintainance
Intelligent Technology

Level and point level measurement

Overview of technologies



Level measurement for all possibilities of liquids and bulk goods:

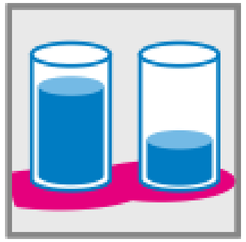
- Guided Radar Wave (TDR)
- Ultrasonic
- Capacitive
- Hydrostatic
- Free space radar (e.g. 80 GHz)

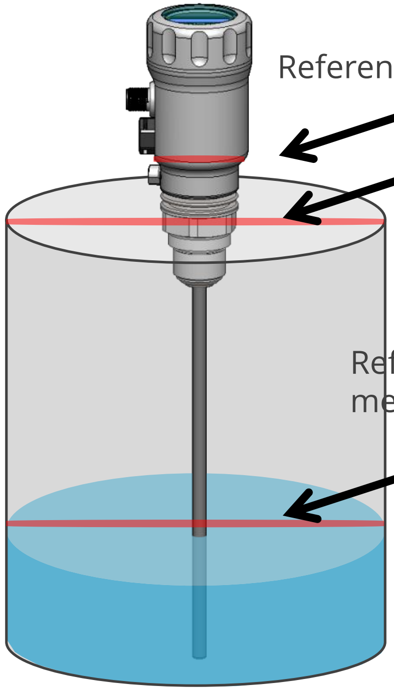
Point level measurement:

- vibration
- Visually
- Capacitive impedance spectroscopy

Level measurement

Guided Radar Wave (TDR)





Reference pulse

Output pulse

Reflection on the medium

ToF measurement → distance

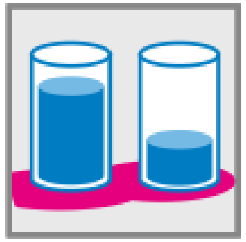
Reflection on the medium

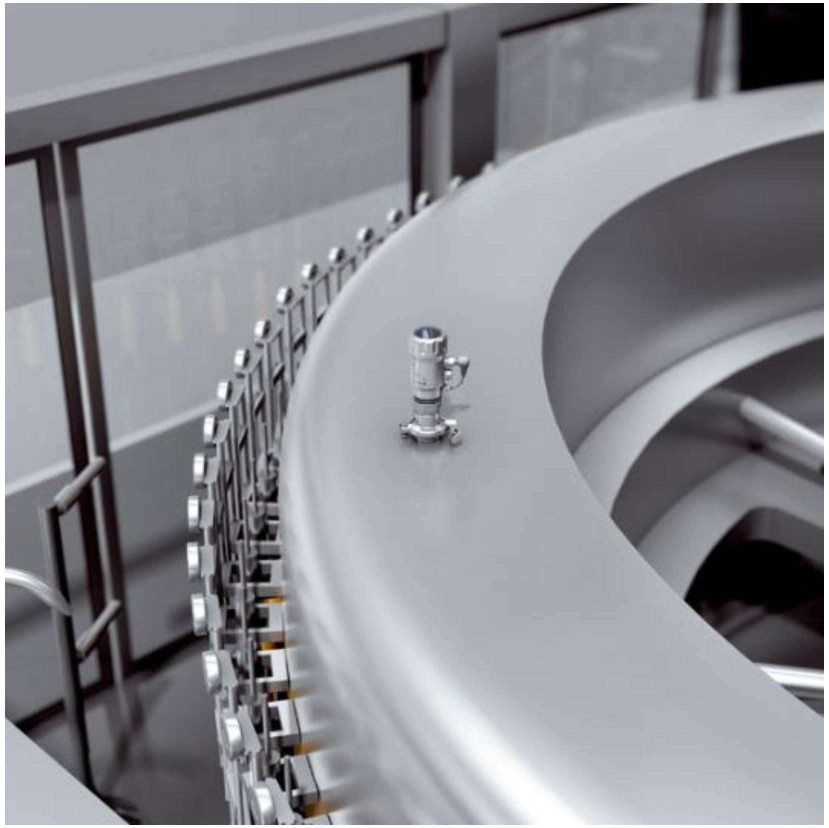
Output pulse

Reference pulse

Level measurement

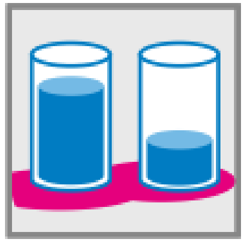
Guided Radar Wave (TDR)





Level measurement

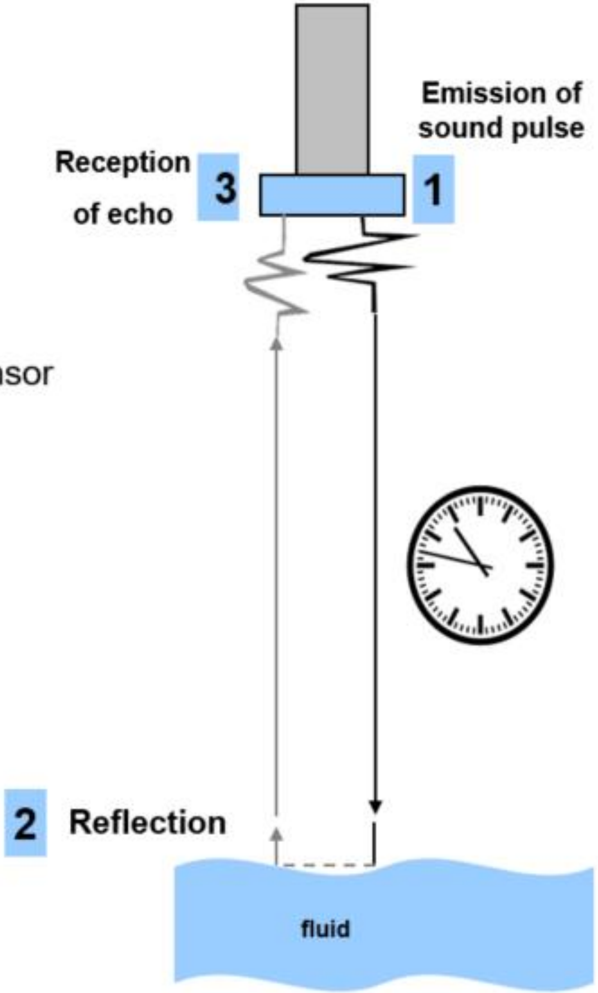
Ultrasonic



Ultrasonic sensors work based on time of flight principle

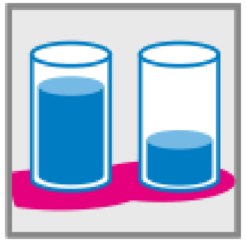
1. Emission of sound pulse
2. Reflection
3. Reception of echo

Based on the run time of the emitted sound pulse the sensor determines the distance between the fluid and the sensor



Level measurement

Ultrasonic



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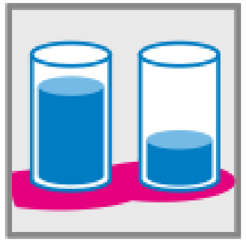
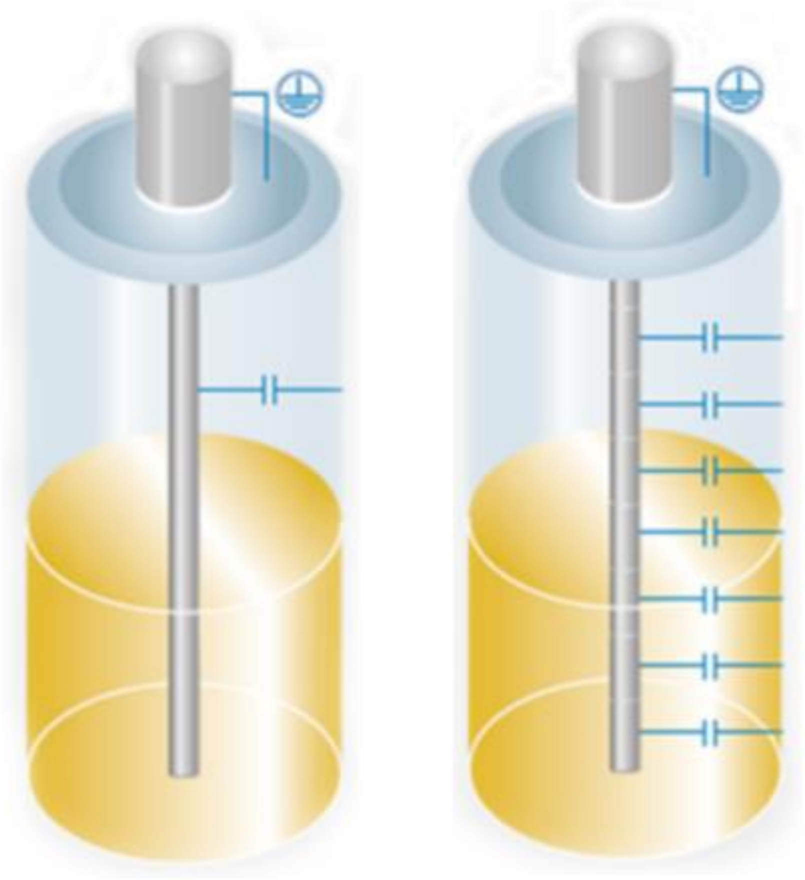
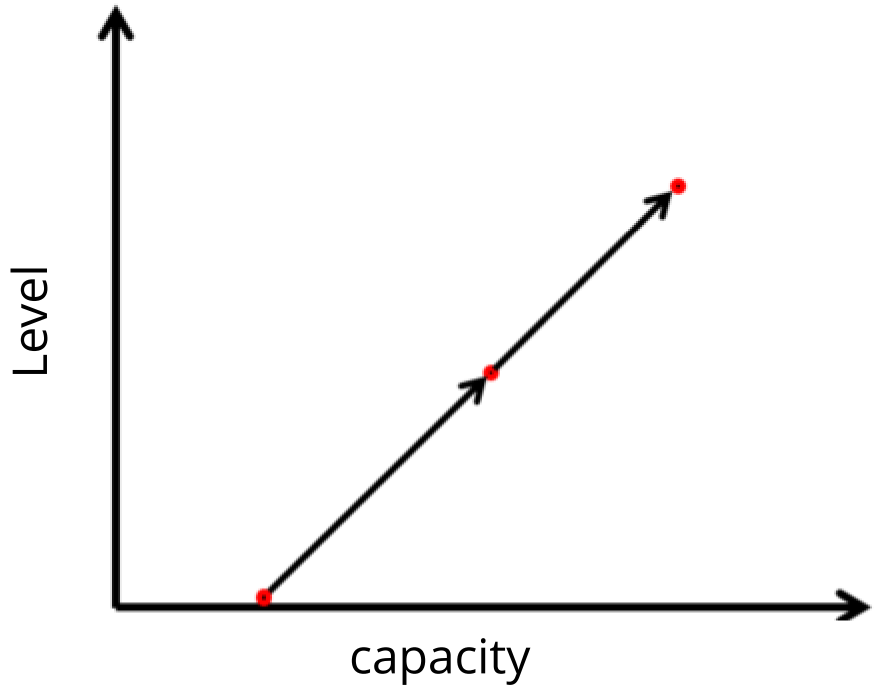
Level measurement

Capacitive

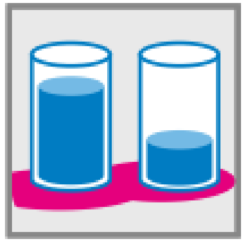






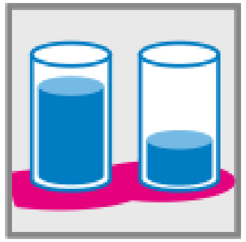
Level measurement

Capacitive



Level measurement

Hydrostatic open tank



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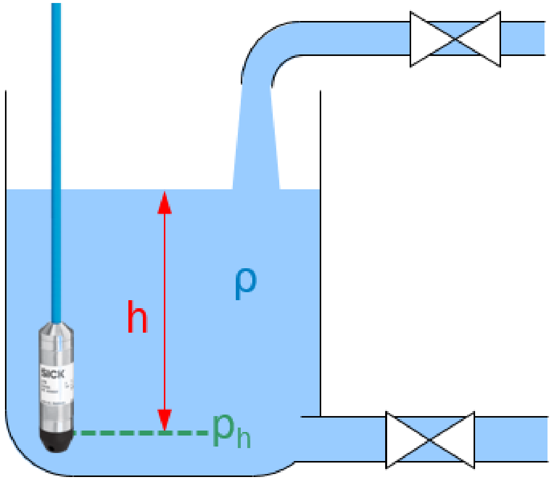
Because of its mass any liquid is creating pressure. This pressure depends on the height of the liquid level and it can be used for level measurement.

Open tank



$$h = \frac{p_h}{\rho \cdot g}$$

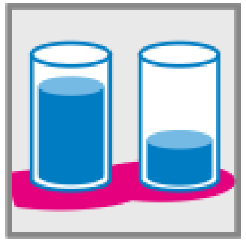
- h height of level above pressure sensor
- p_h gauge pressure in depth h
- ρ density of liquid
- g acceleration of gravity (9,81 m/s^2).

Rule of thumb

h [m] ≈ p [bar] * 10

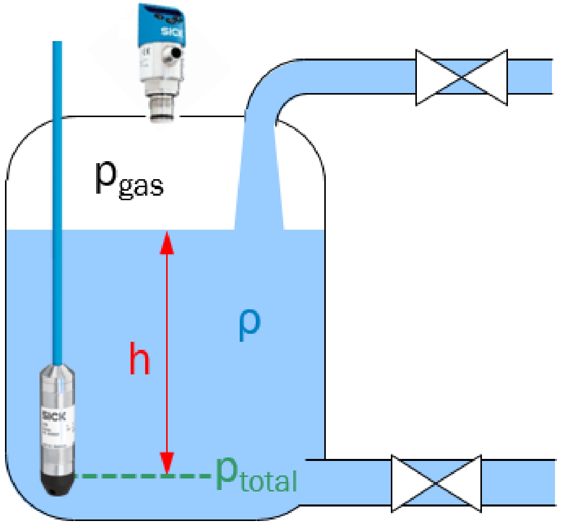
Level measurement

Hydrostatic closed/pressurized tank



In a pressurised tank the pressure of the gas above the liquid excerts pressure on the liquid's level. For the calculation of the level this pressure must be subtracted to obtain the hydrostatic pressure.

Closed/Pressurized tank



$$h = \frac{p_{total} - pgas}{\rho \cdot g}$$

h height of level above pressure sensor

p_{total} total gauge pressure in depth h

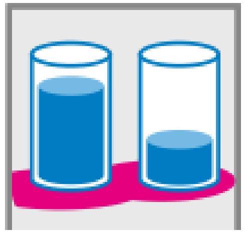
p_{gas} gauge pressure of gas above level

ρ density of liquid

g acceleration of gravity (9,81 m/s^2).

Level measurement

Hydrostatic closed/pressurized tank



Attention:

The accuracy of hydrostatic level measurement in pressurized tanks is higher than in open tanks. This is because in pressurized tanks the combined accuracy of 2 pressure sensors has to be taken into account.

Open tank:
One pressure sensor

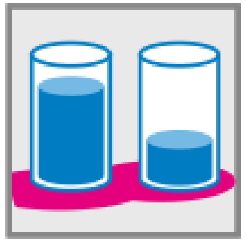
$$h = \frac{p_h}{\rho \cdot g}$$

Pressurized tank:
Two pressure sensors

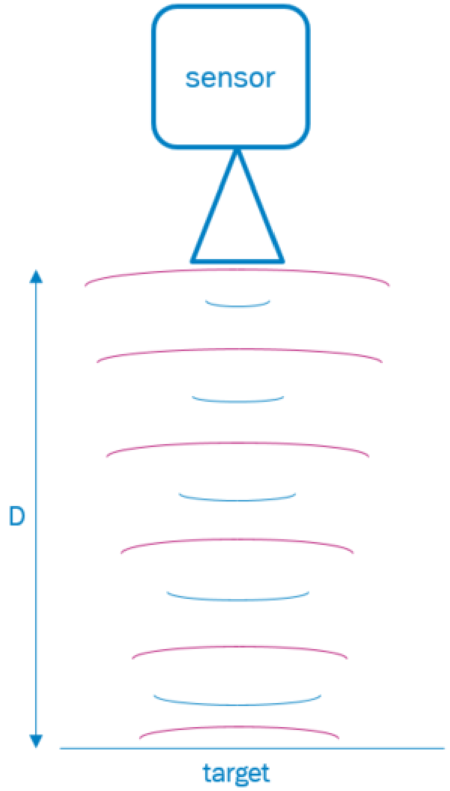
$$h = \frac{p_{total} - p_{gas}}{\rho \cdot g}$$

Level measurement

Radar free space (e.g. 80 GHz)



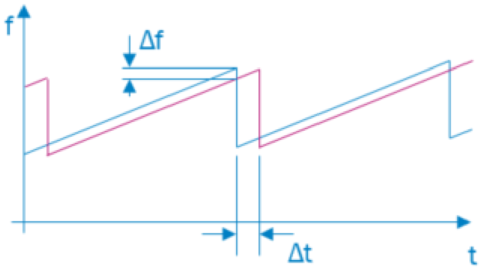
- FMCW (Frequency Modulated Continuous Wave) radar technology



1. Radar signal gets emmitted by antenna
2. Radar signal gets reflected by target back to antenna
3. Time between emmitting and receiving the signal (travel time) is directly proportional to distance to target

$$D = \frac{c_{gas\ phase} \cdot \Delta t}{2}$$

4. Since such short times are difficult to measure accurately FMCW uses Frequeny Modulation and mixes both signals

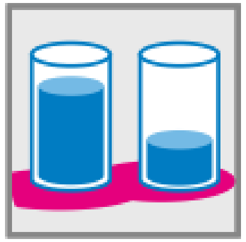


$$\Delta f \sim \Delta t$$

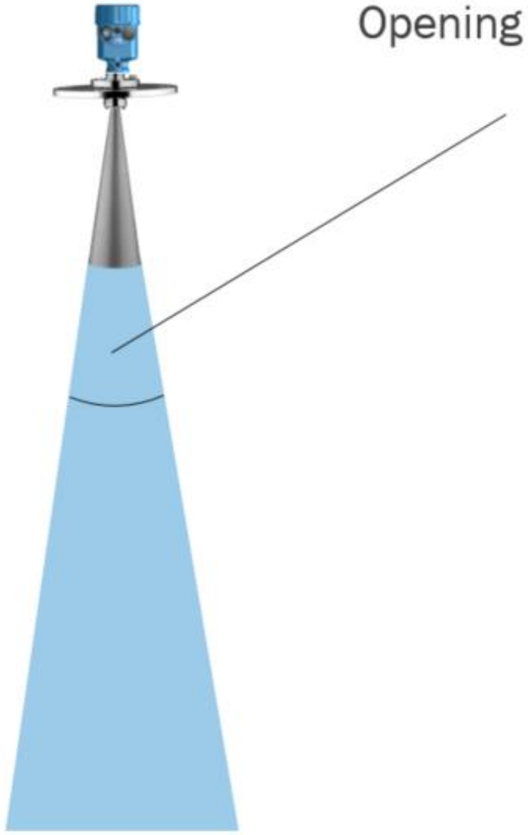
5. The resulting frequency is the difference of the frequency of both signals and indirectly corresponds to the time difference which indicates the distance

Level measurement

Radar free space (e.g. 80 GHz)



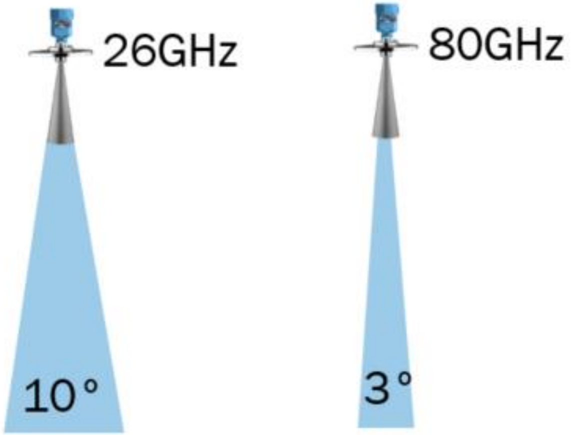
- 80GHz – the meaning of the frequency



Opening angle:

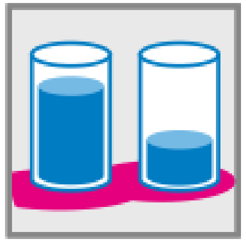
$$\propto = 70° \cdot \frac{speed\ of\ light}{antenna\ diameter \times frequency}$$

→ For same antenna size:
As higher the frequency as better the focusing
As better the focusing as less disturbances



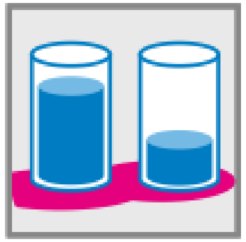
Level measurement

Radar free space (e.g. 80 GHz)



Level and point level measurement

Overview of technologies



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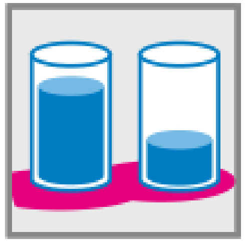
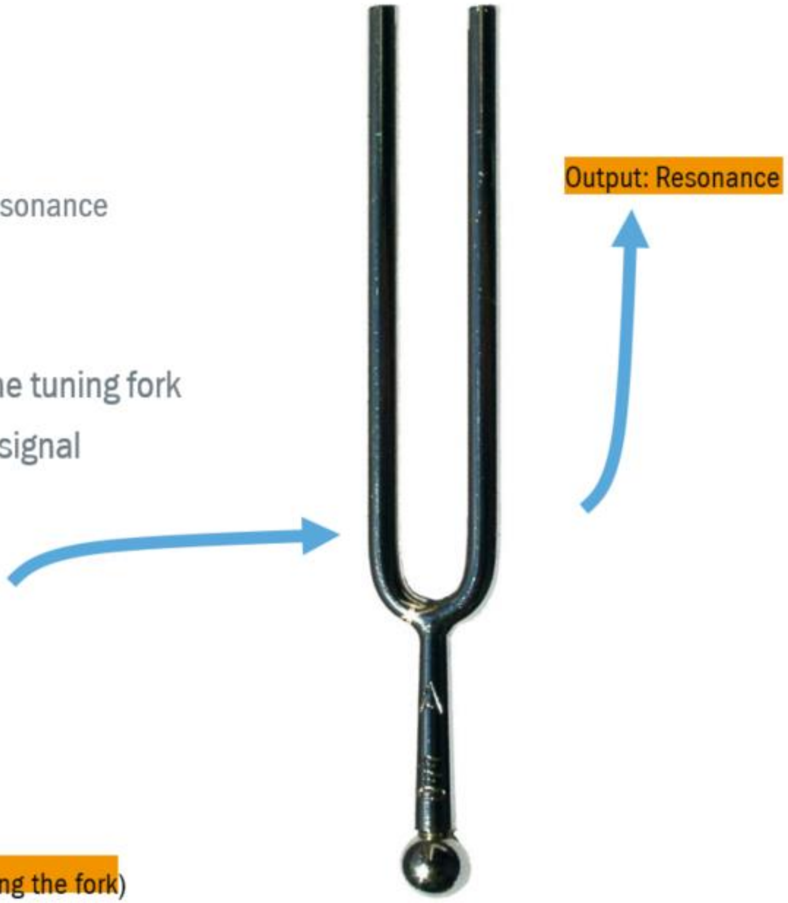
Point level measurement:

Vibration

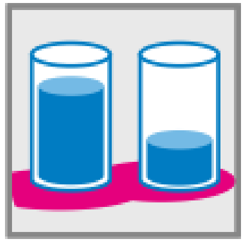


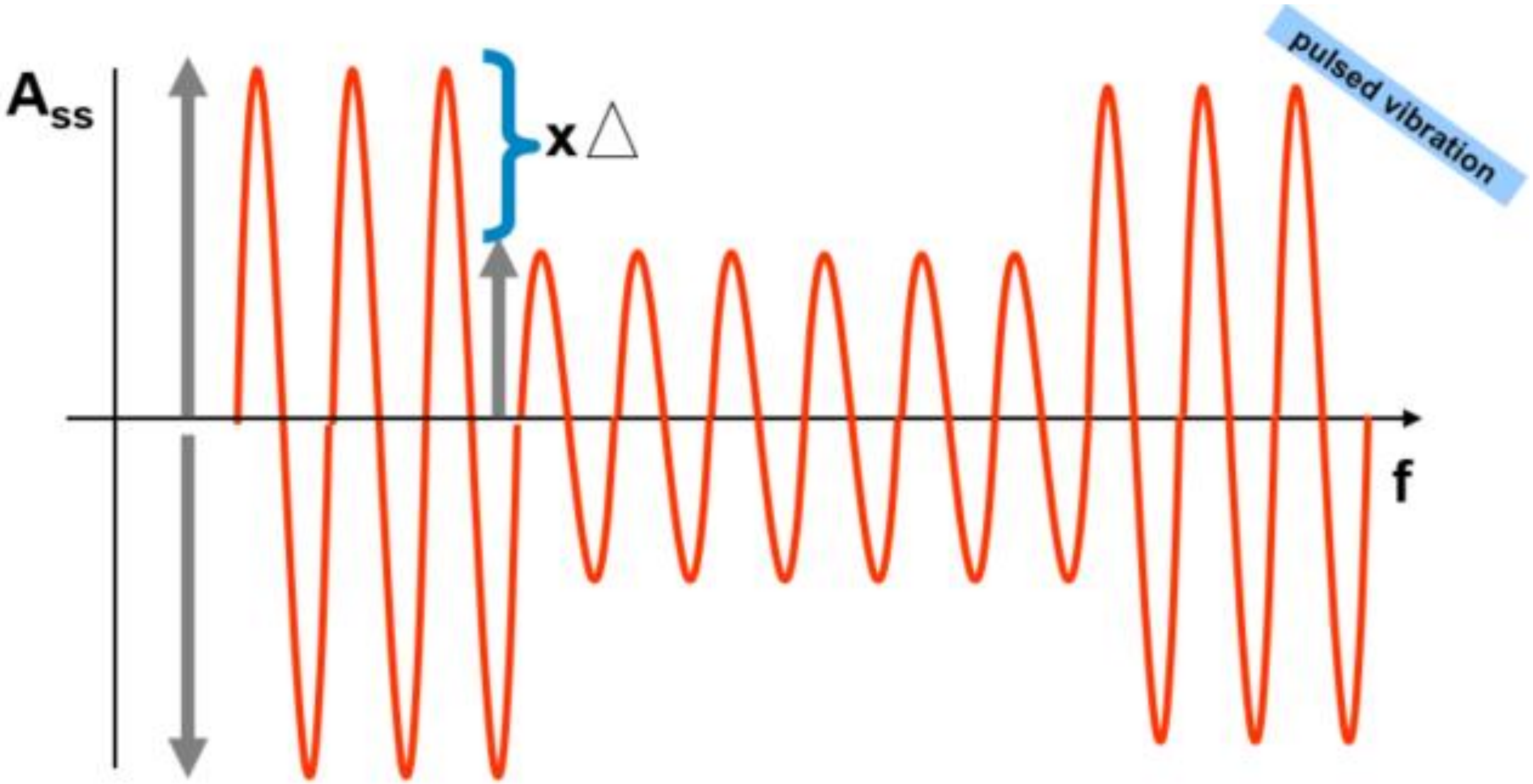
- Tuning fork technology
  - Acoustic technology
    - A fork vibrates in resonance frequency
    - Immersing the fork in substance changes the resonance
- Background
  - Liquids or solids influence the resonance of the tuning fork
  - Changes to the resonance trigger a switching signal
- Structure with piezo elements



Point level measurement:

Vibration





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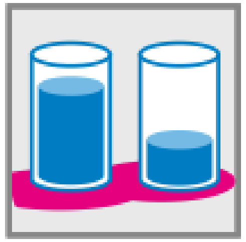
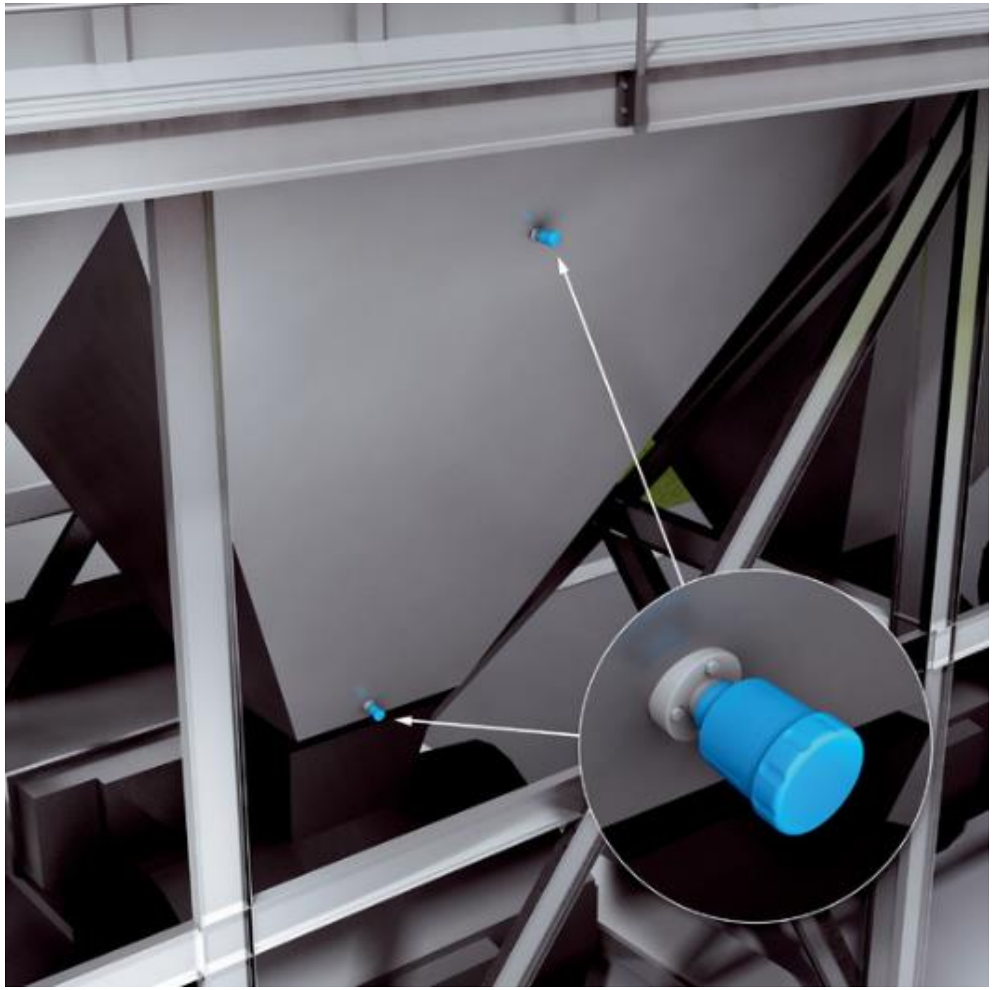
Point level measurement:

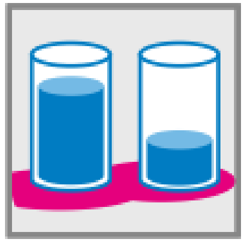
Vibration

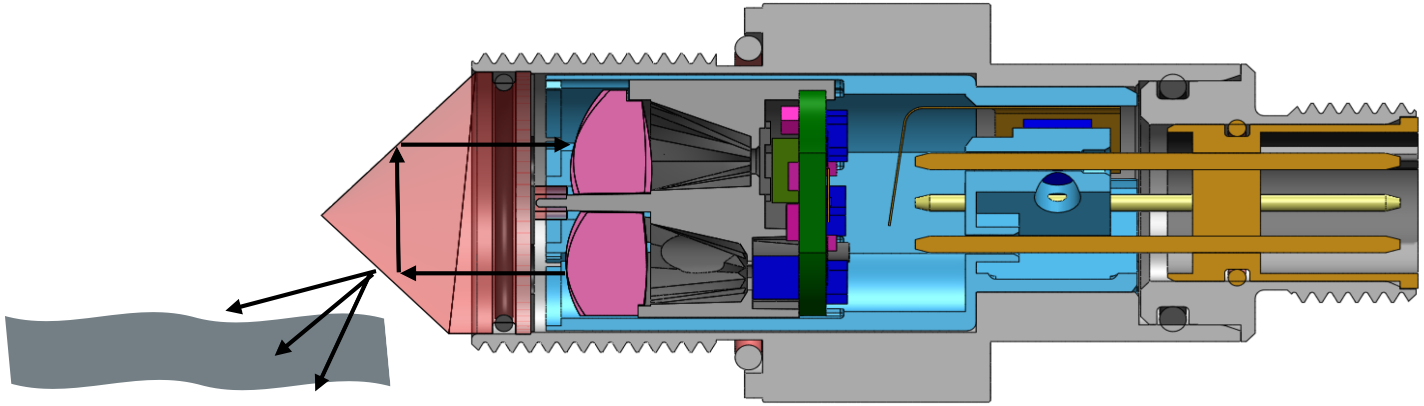




Point level measurement:

Optical





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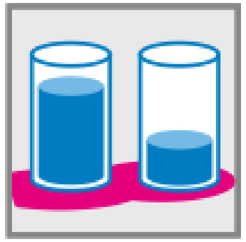
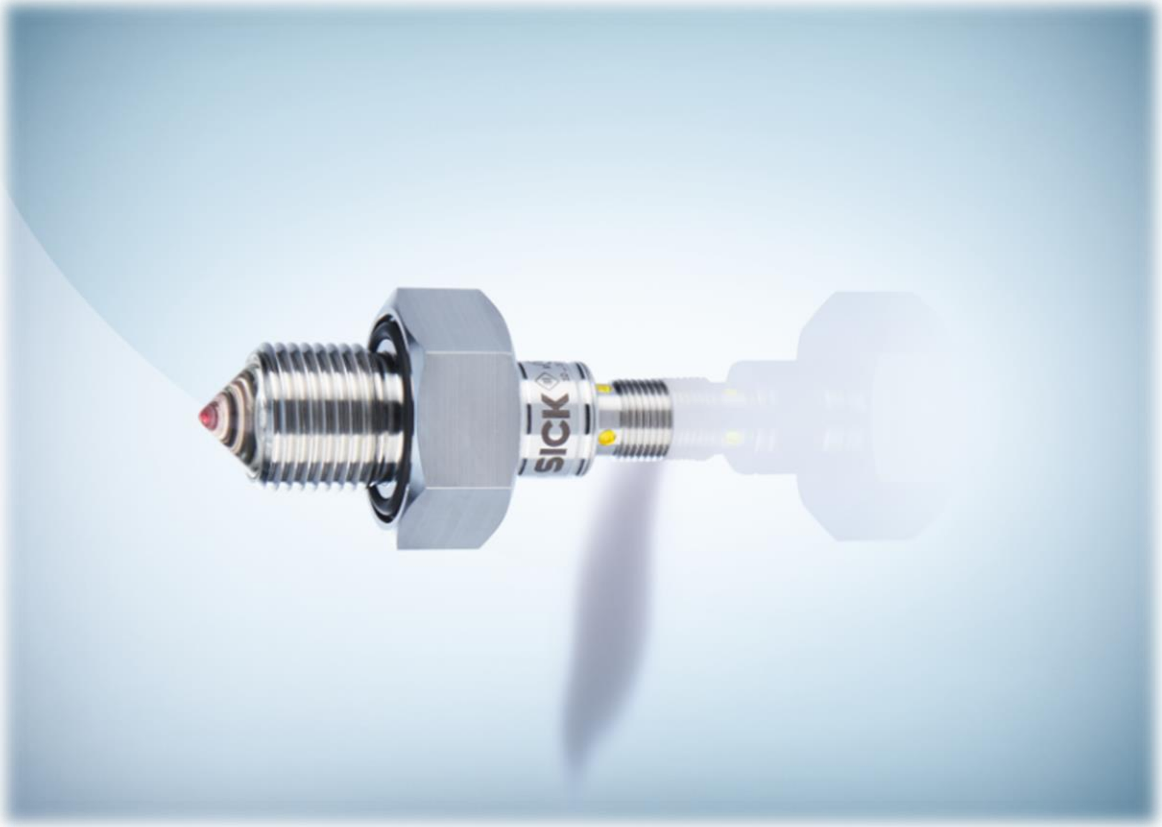
Optical





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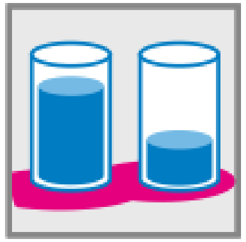
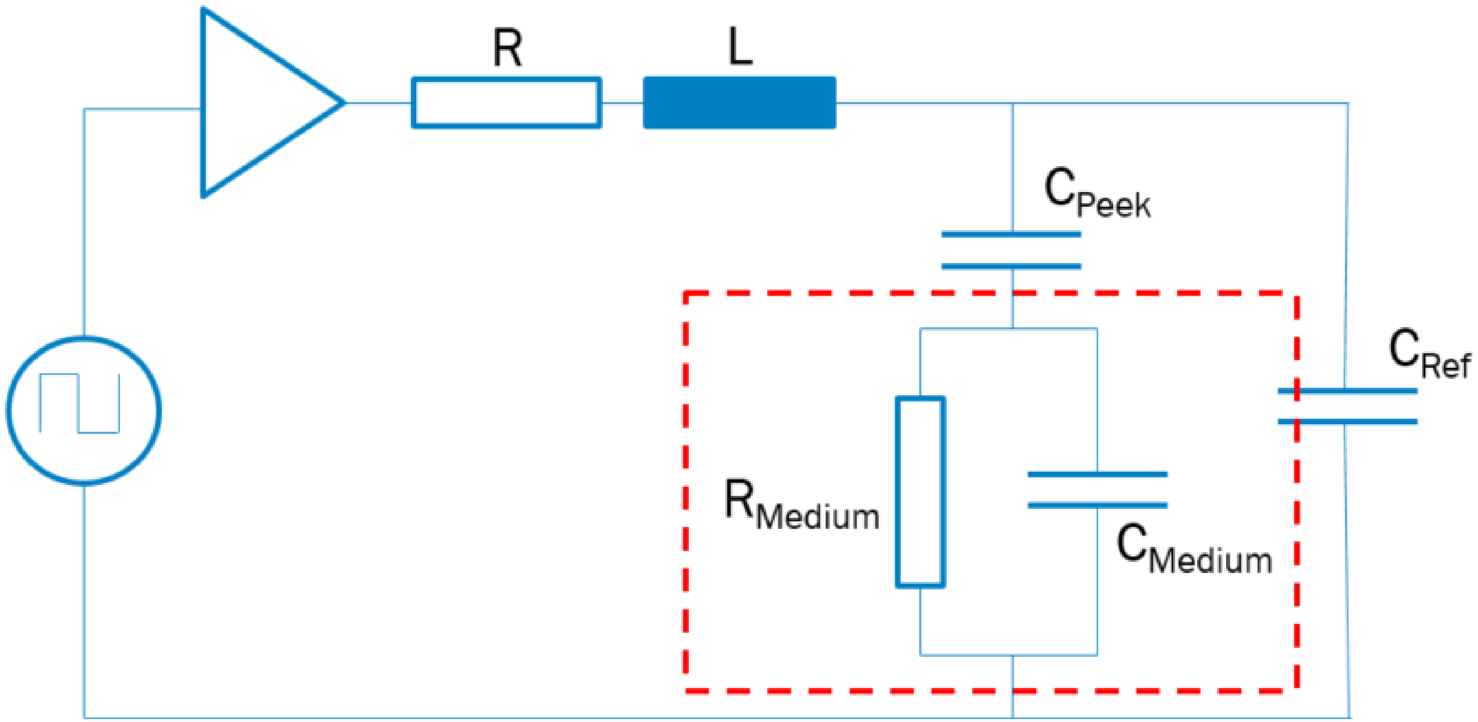
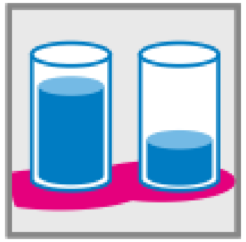
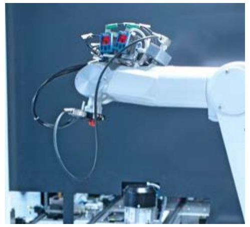
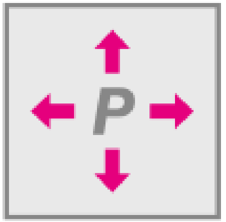
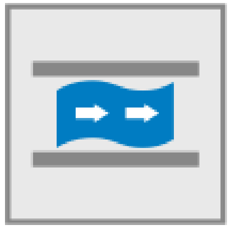
Point level measurement:

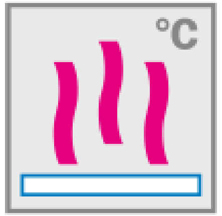
Capacitive impedance spectroscopy







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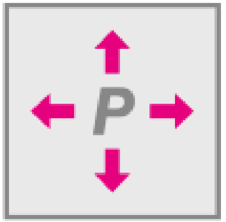
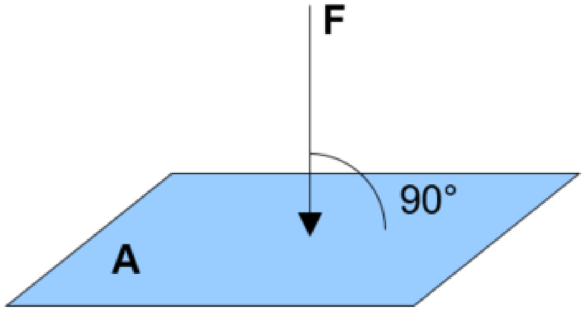
Pressure





$$p = \frac{F}{A}$$

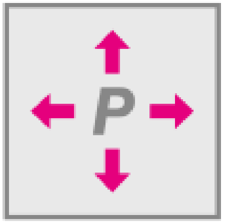
$$[p] = \frac{N}{m^2} = \text{Pa (Pascal)}$$

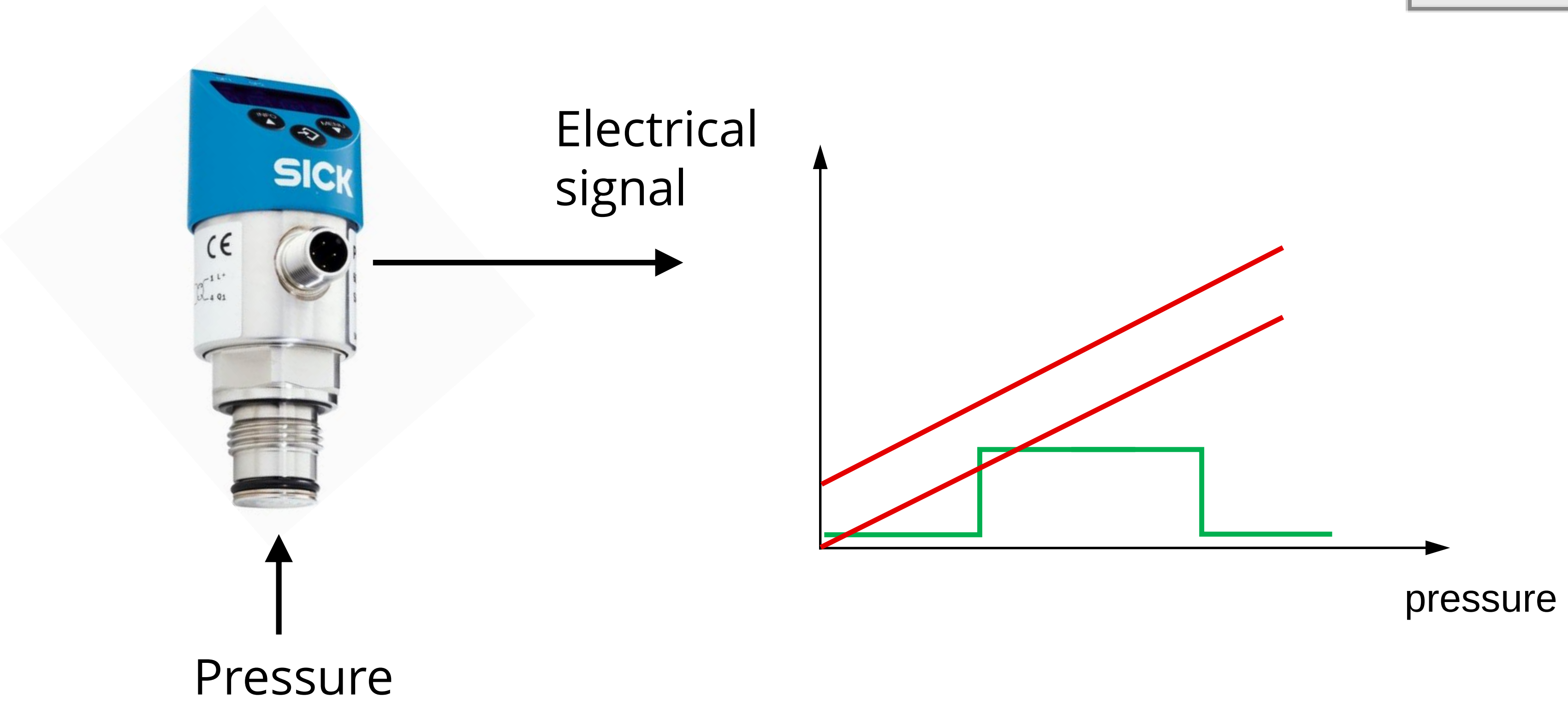
French scholar Blaise Pascal
(June 19, 1623 to Aug. 19, 1662)

Pressure
Unit

- 1 bar = **100 000 Pa**
- 1 psi = 1 lbf / in² = **6.895 Pa**
- 1 MPa = **1 000 000 Pa** = 10 bar
- 1 kg(f)/cm² = **98067 Pa** = 0,981 bar

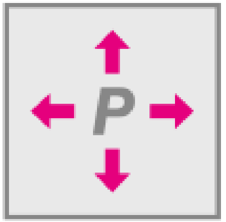
Pressure

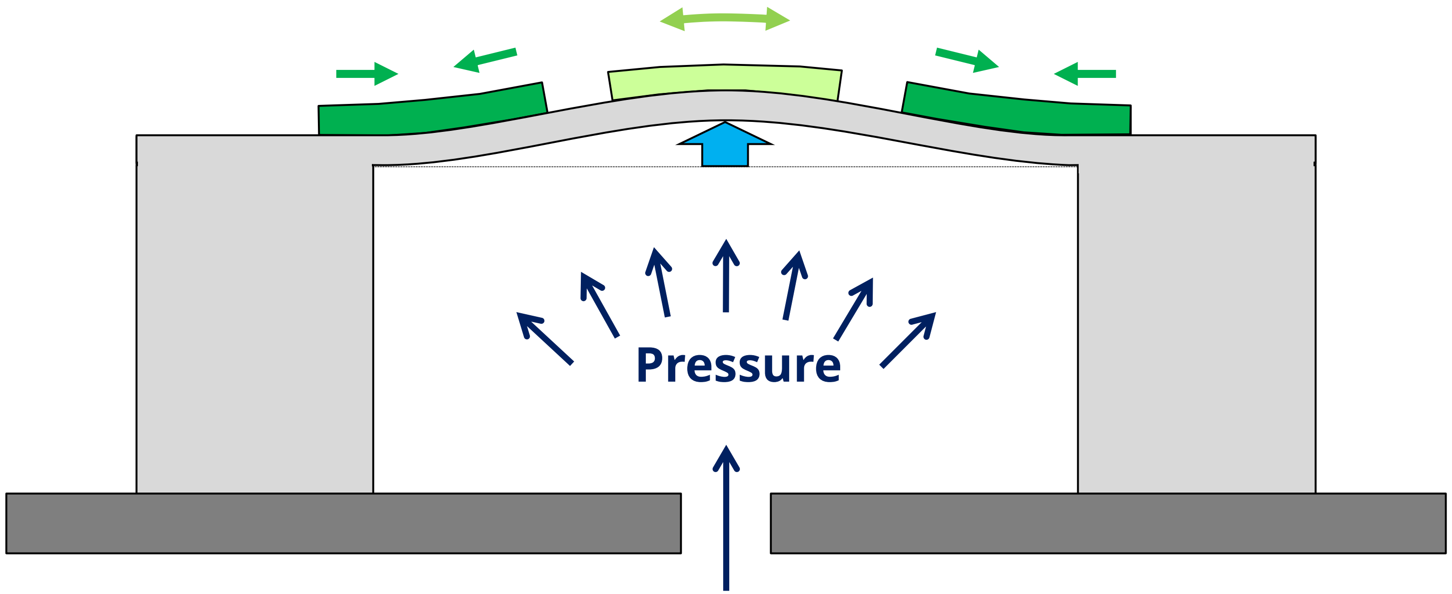


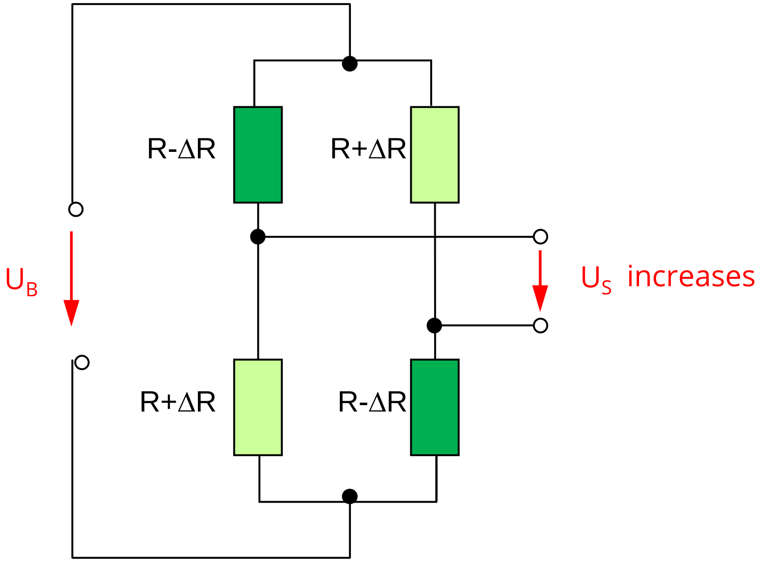


- Pressure transmitter → analog output signal
- Pressure switch → digital output signal

Pressure

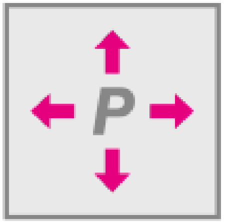






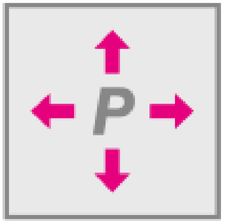
Pressure

Processconnection



Pressure

Application control of workpiece clamping



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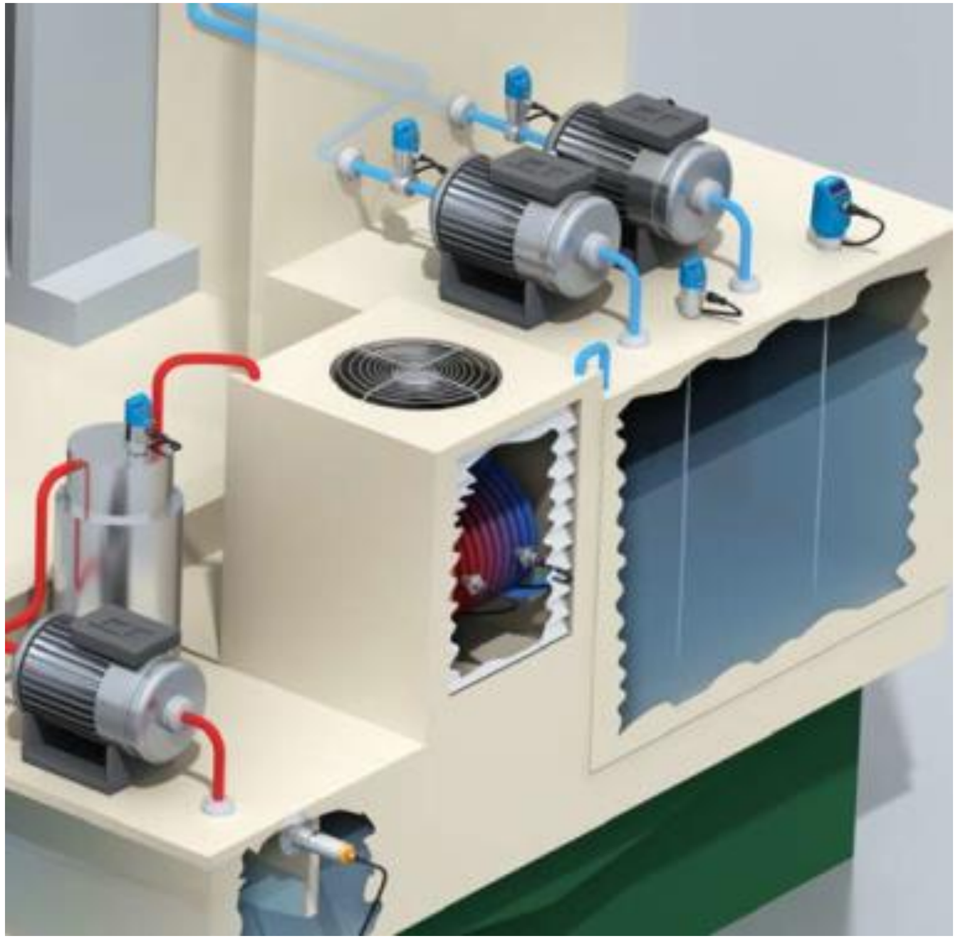


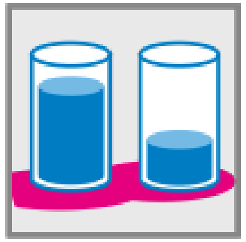
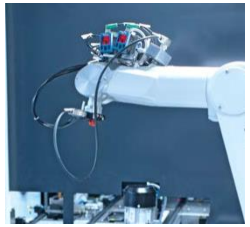
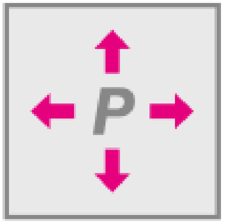

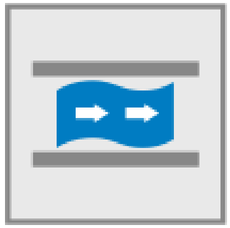

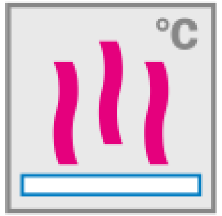

SICK
Sensor Intelligence.

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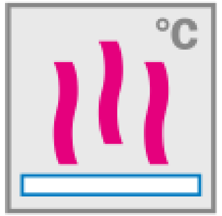
    - Flow measurement technology
    - Temperature measurement for liquids and gases
- **Technology selection**
- **Process connections**
- **Outlook 80 Ghz radar technology**

Temperature



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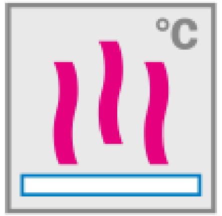
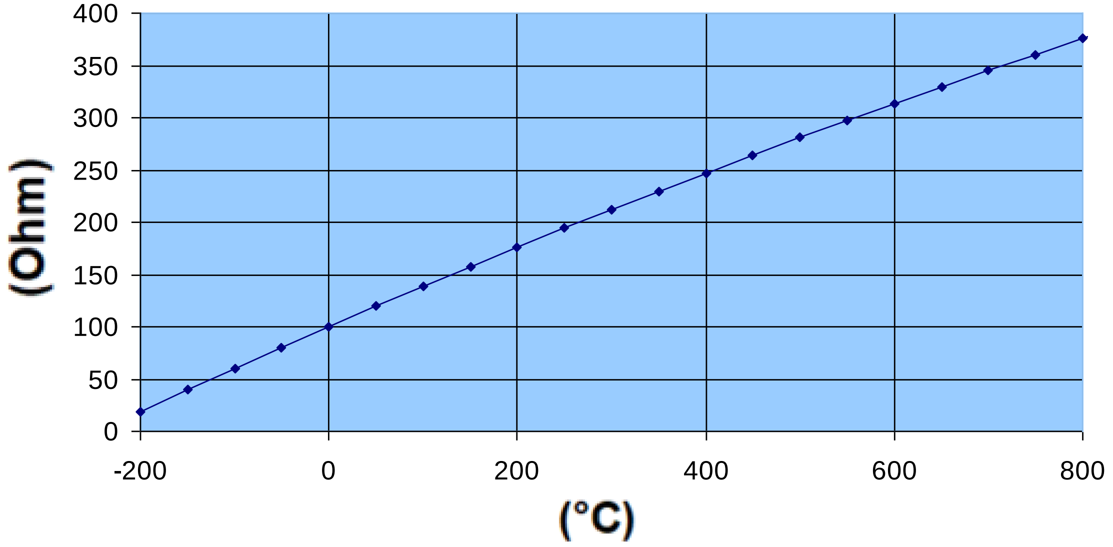
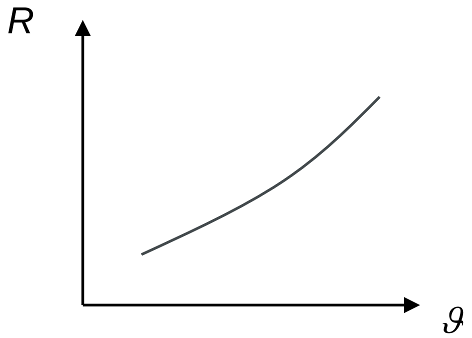
Anders Celsius

Temperature

Platinum resistance

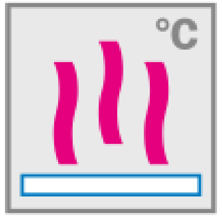


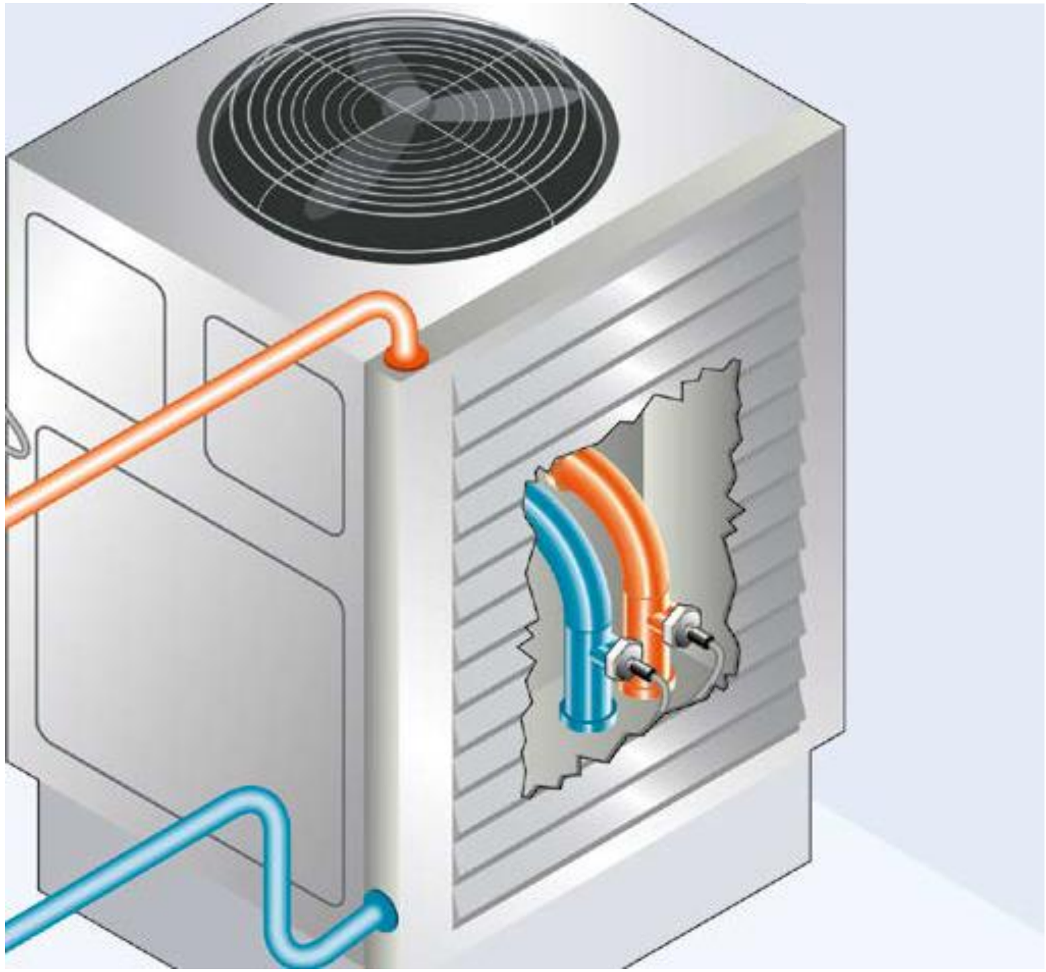


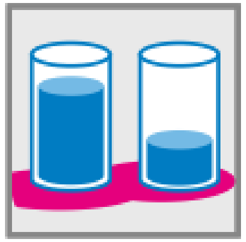
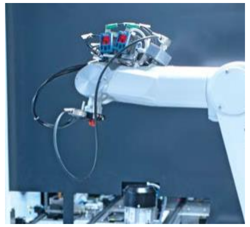
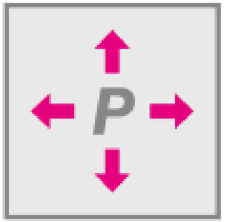


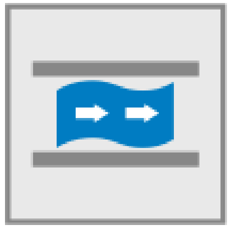
Temperature

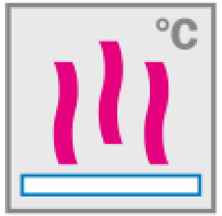
Application coolant temperature control









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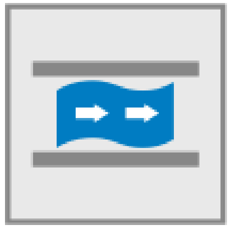
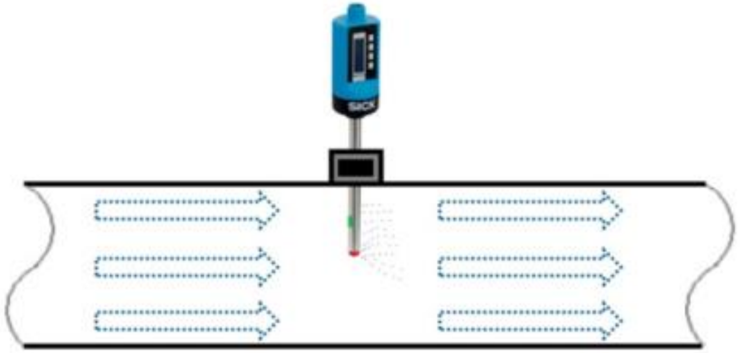
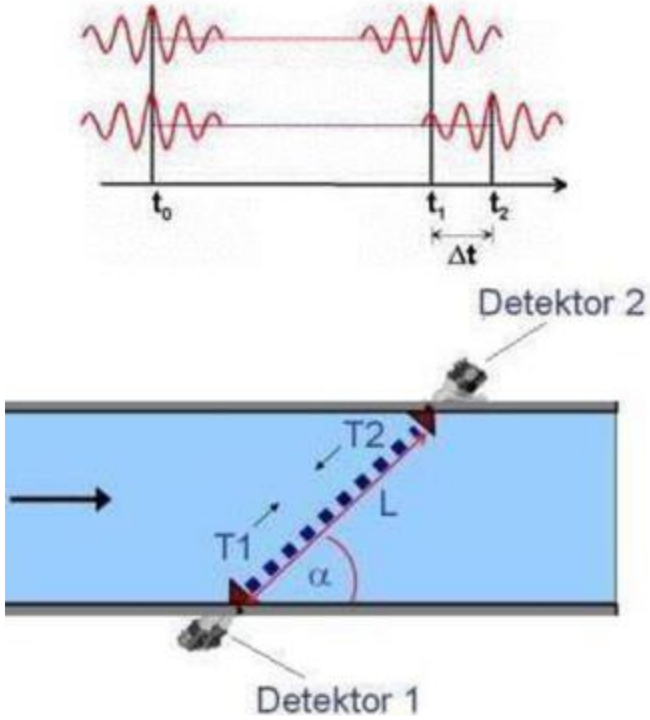
Flow



$$\Delta T = T_H - T_M = \text{Constant}$$

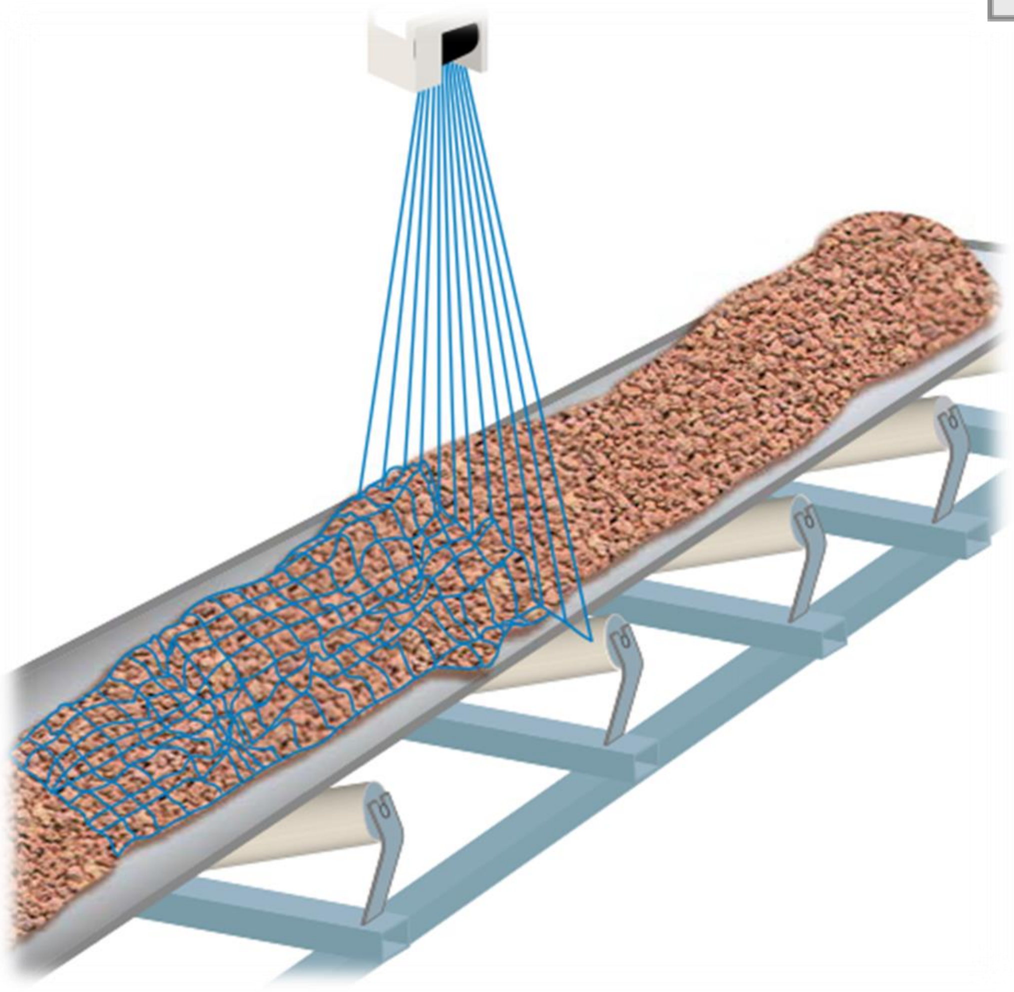


Physics



Flow

Application volume information



Flow

Application volume information

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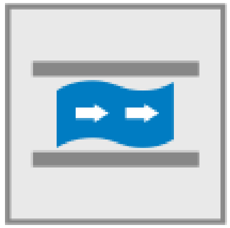
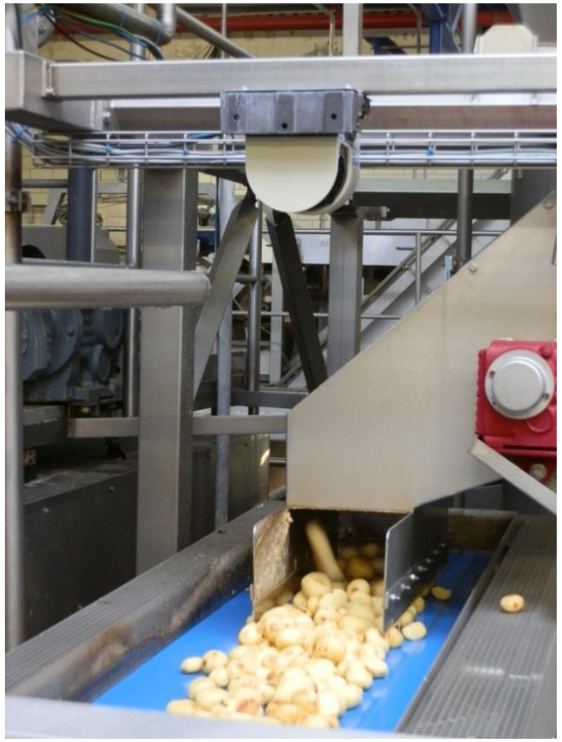
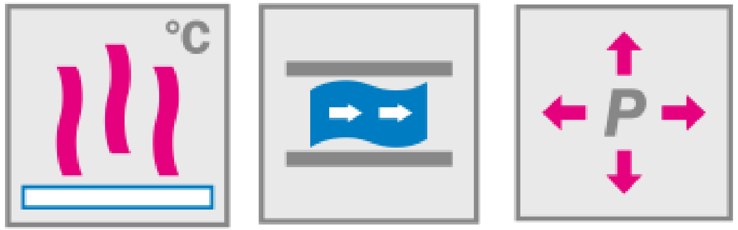
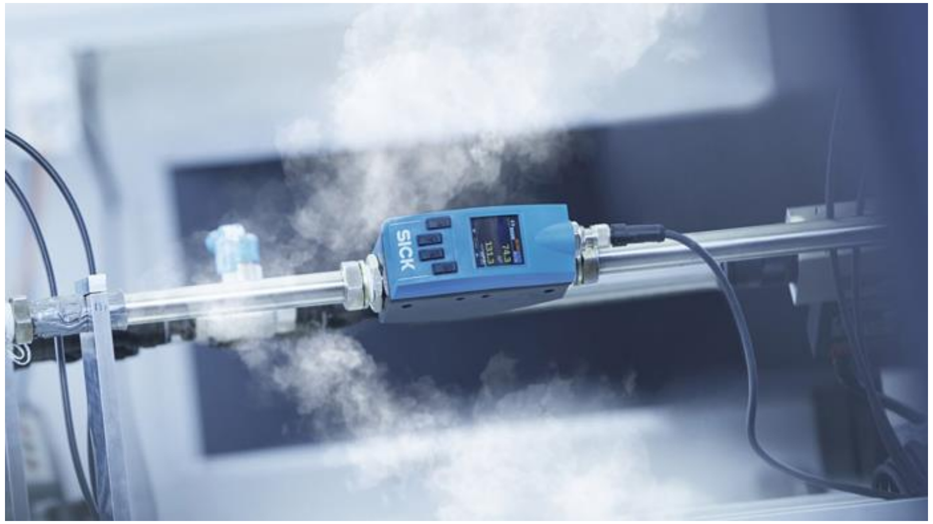




Good energy management

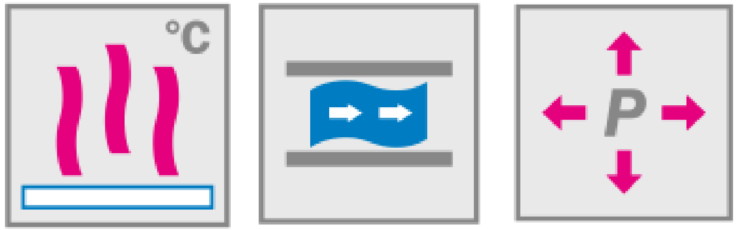
New Innovation





Good energy management

New Innovation → FTMg



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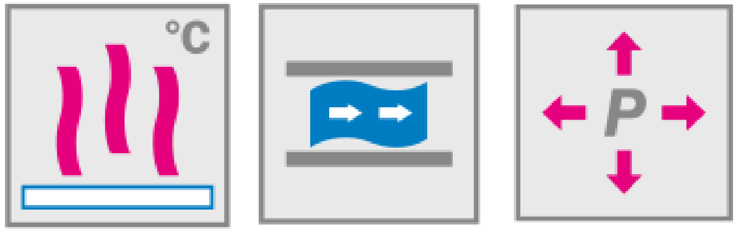
Sensor Intelligence.

Good energy management

New Innovation → FTMg



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Pressure

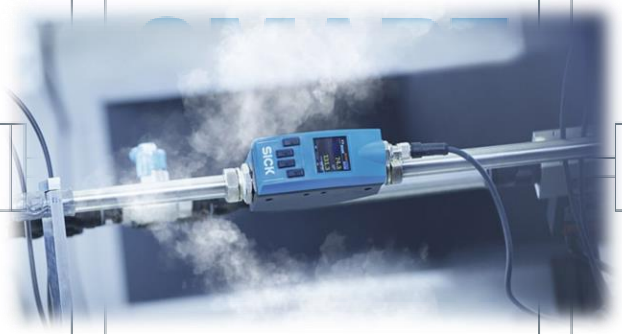
Level

Temperature

Position

Flow

What we measure



Your benefits

Easy Integration

Condition Monitoring

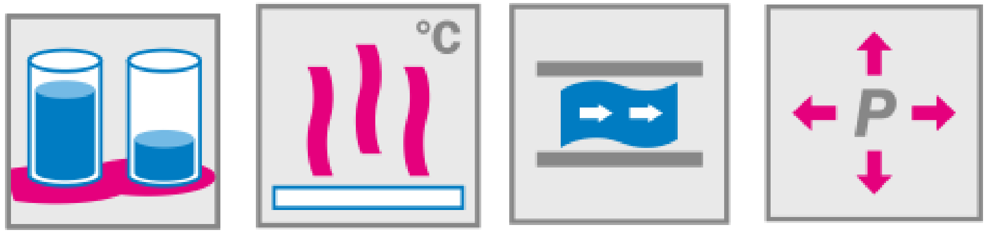
Energy Management

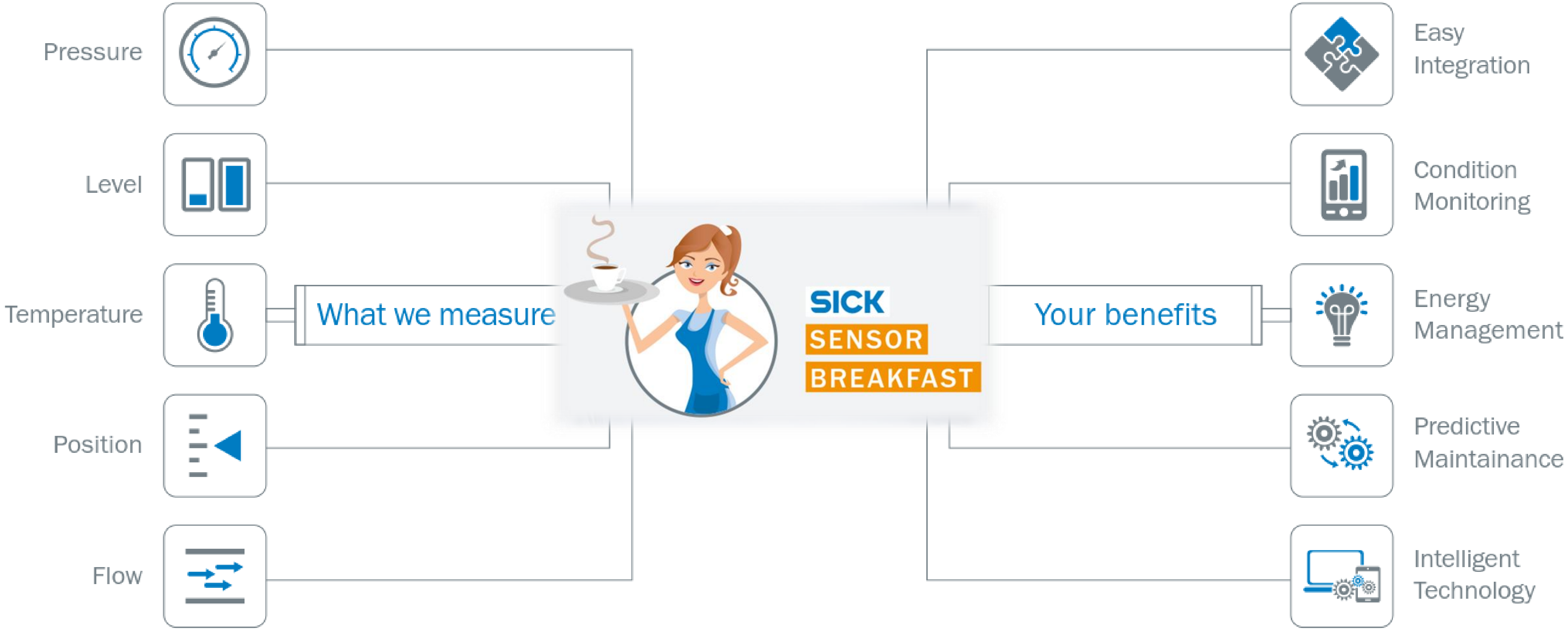
Predictive Maintainance

Intelligent Technology

Good energy management

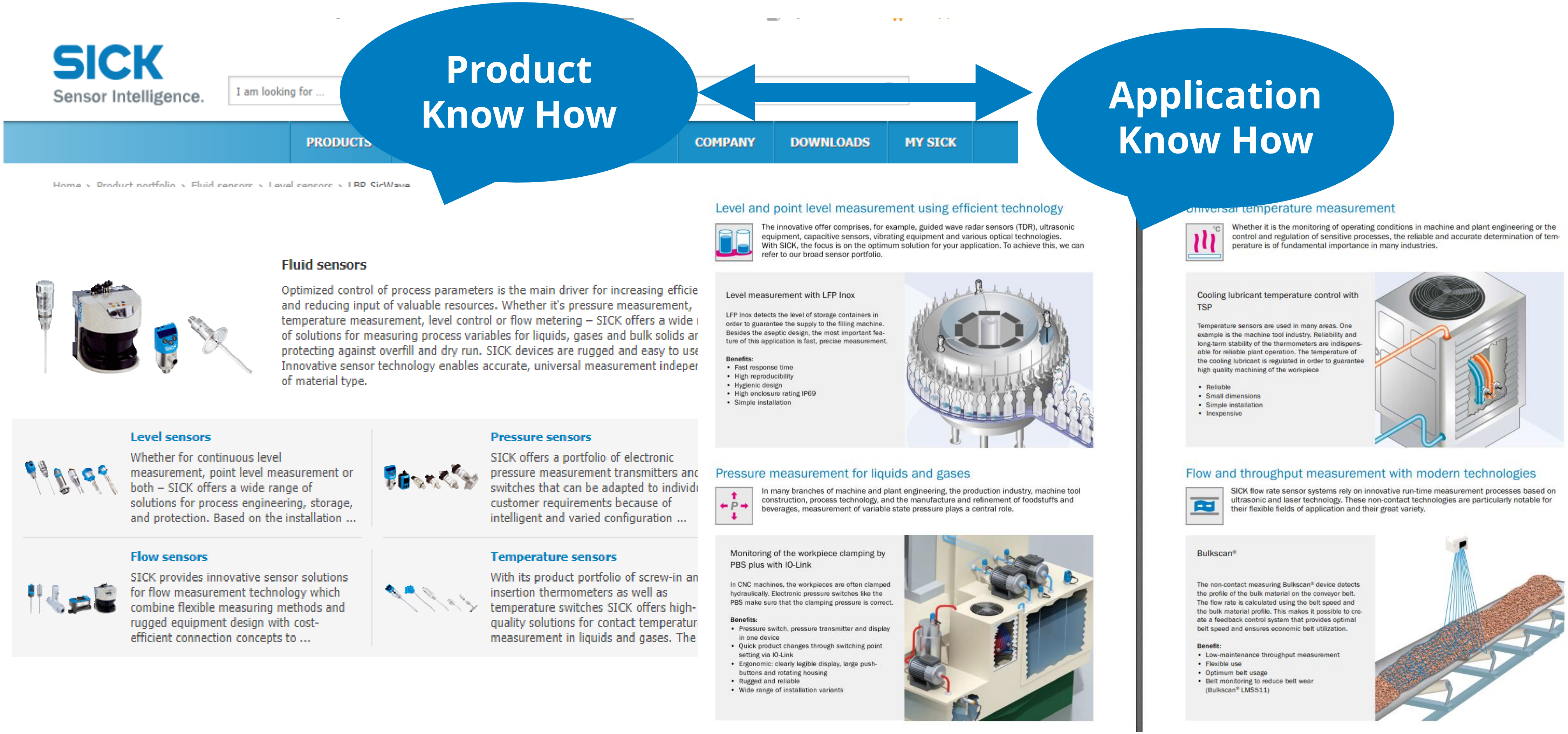
Sensor breakfast





Online configurator

https://www.sick.com/



Thank you for your attention!

Bernhard Wieser

bernhard.wieser@sick.at

www.sick.at