

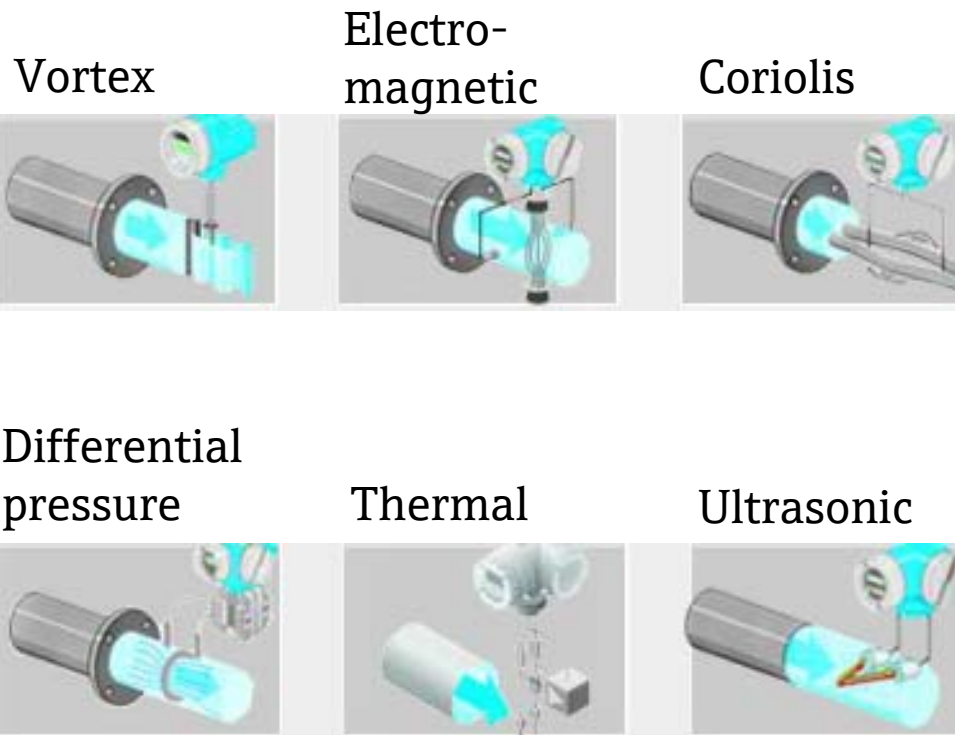
Basics of Flow Measurement

Reliable Flow
Measurement.

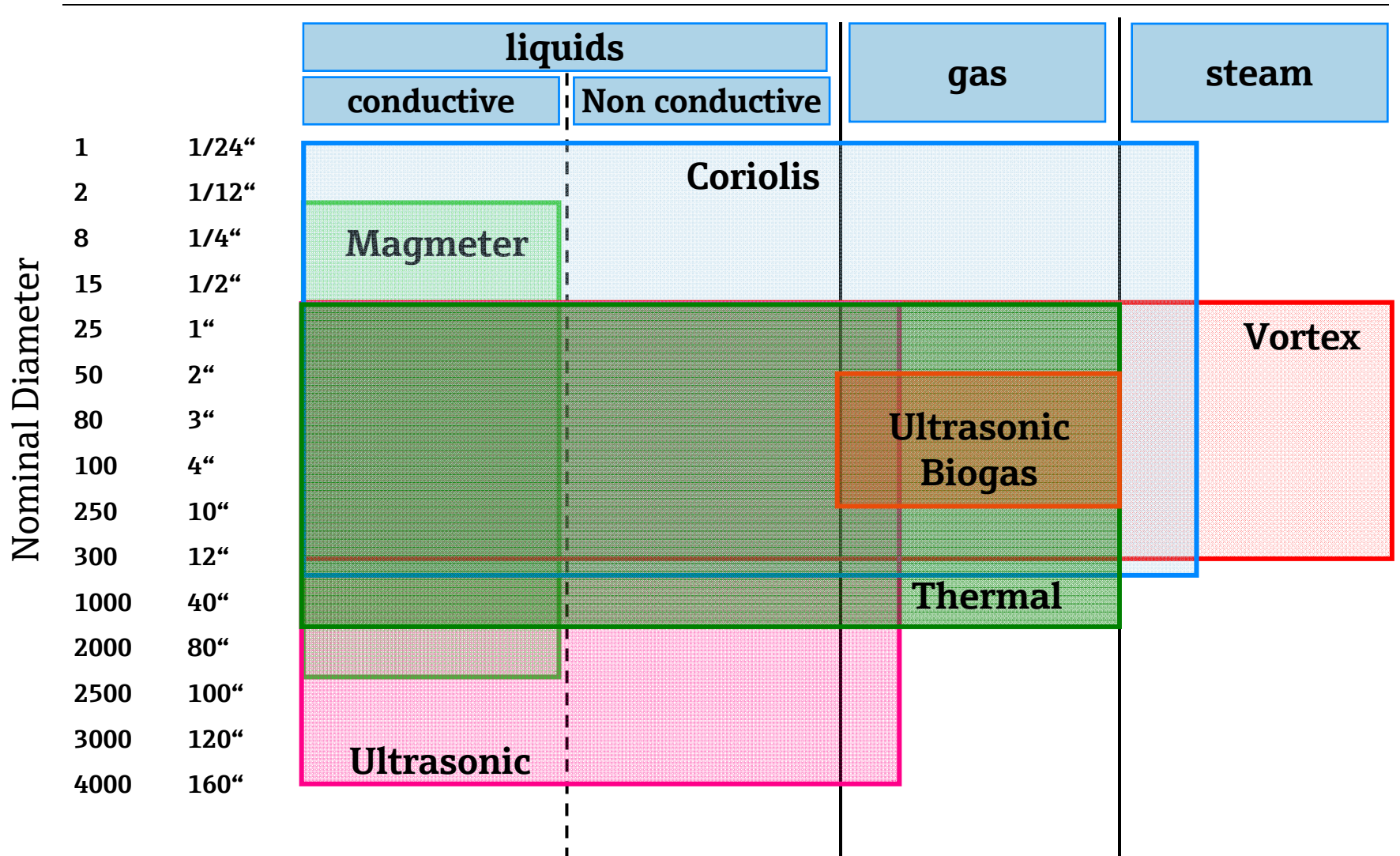
Overview

- Measuring principles
- Selection & sizing
- Device Specific Information
- Calibration

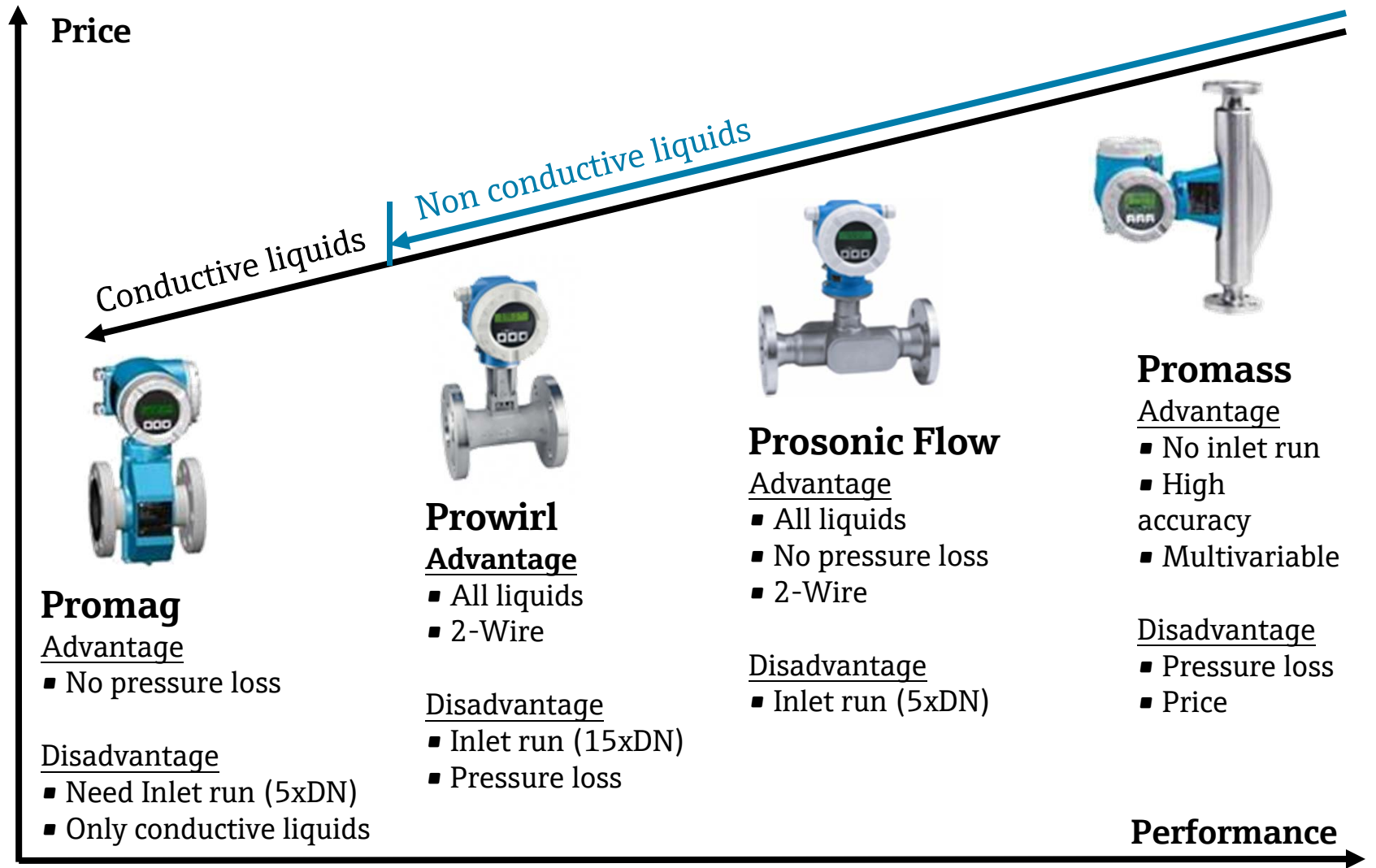
Flow measuring principles @ Endress+Hauser



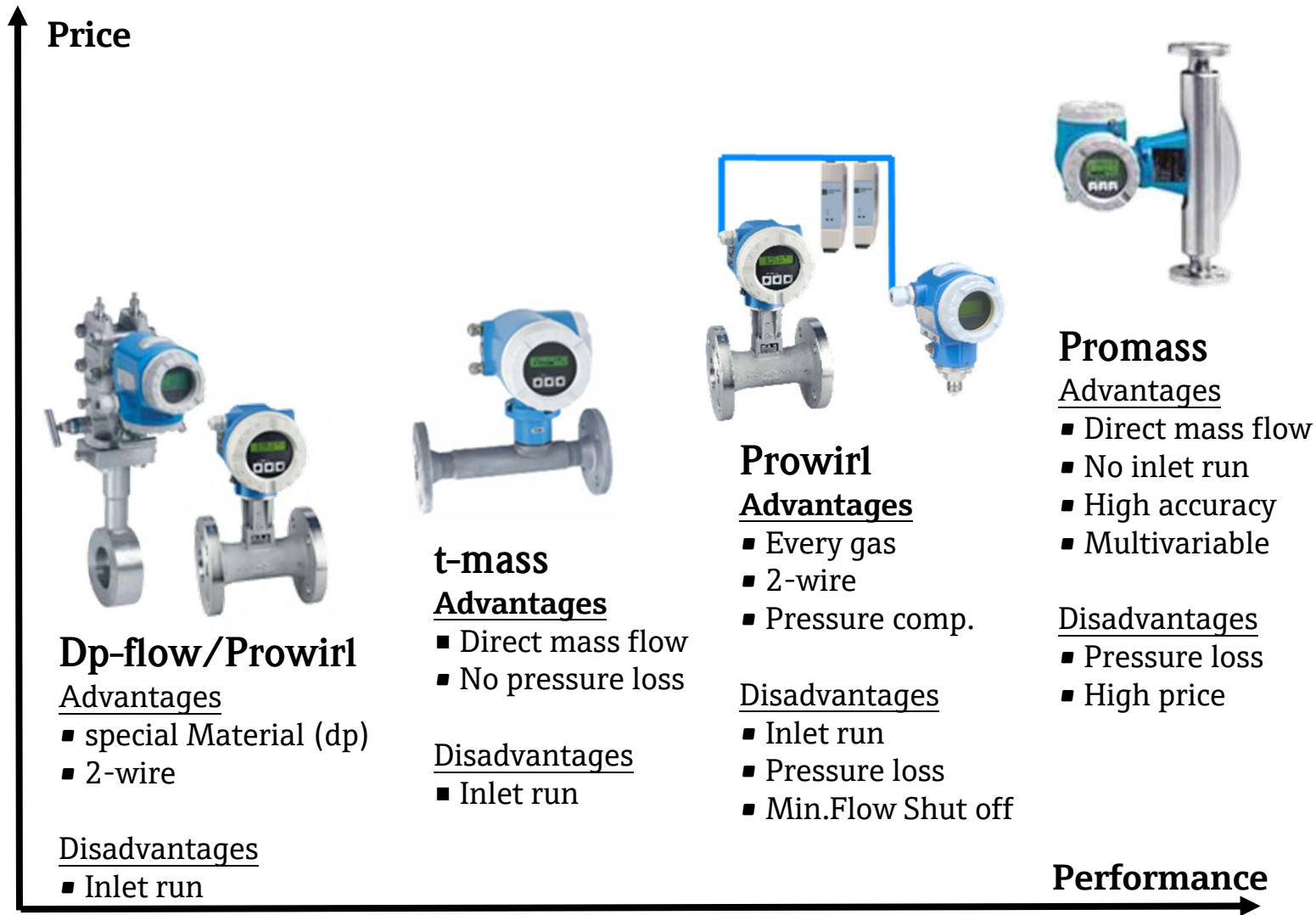
Flow Measurement - Overview



Product Portfolio for liquids



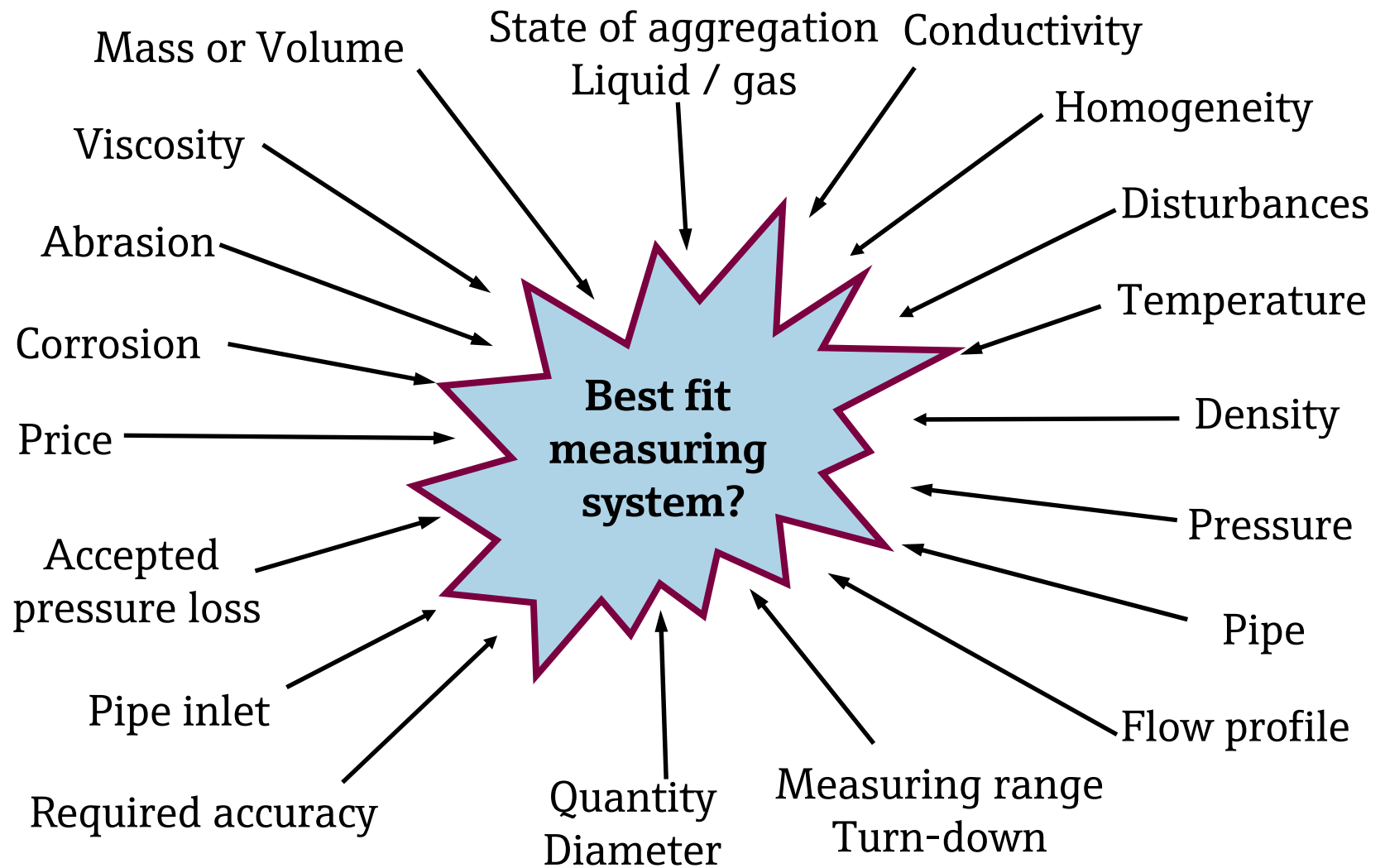
Product Portfolio for Gas



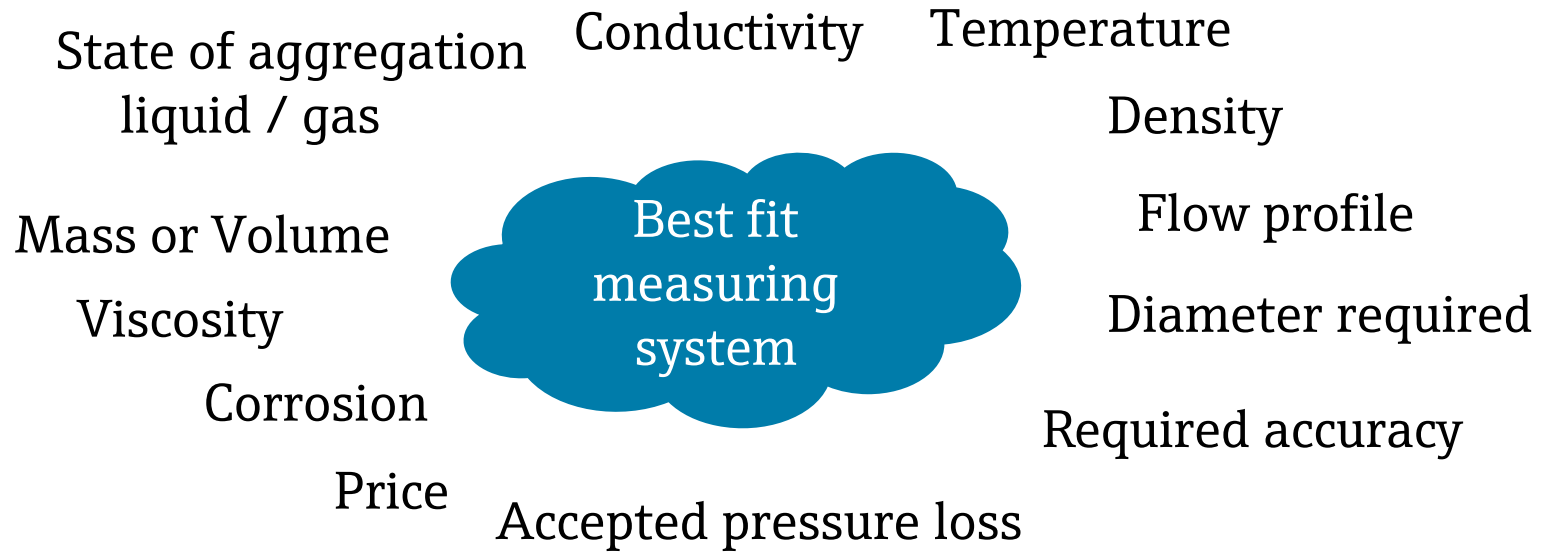
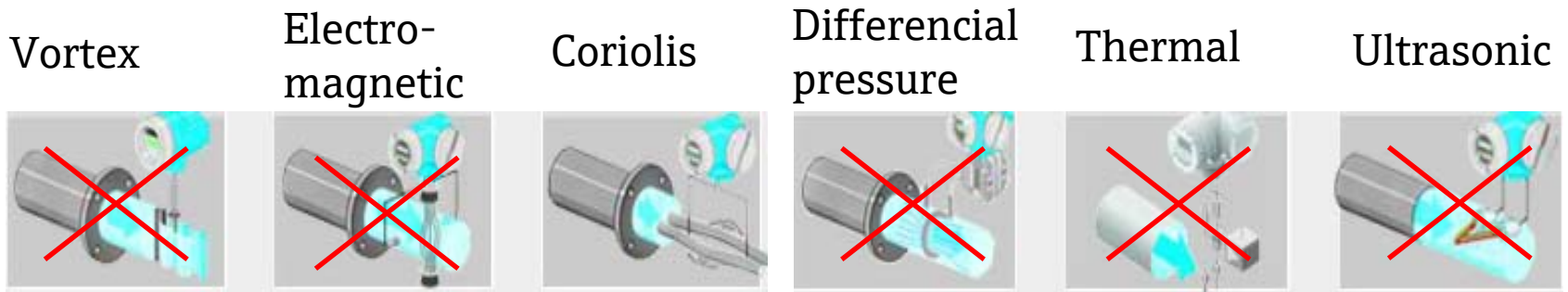
Selection & Sizing



Influences on the selection of the measuring system



Best fit measuring system?



How to select the best fit flowmeter for your process?

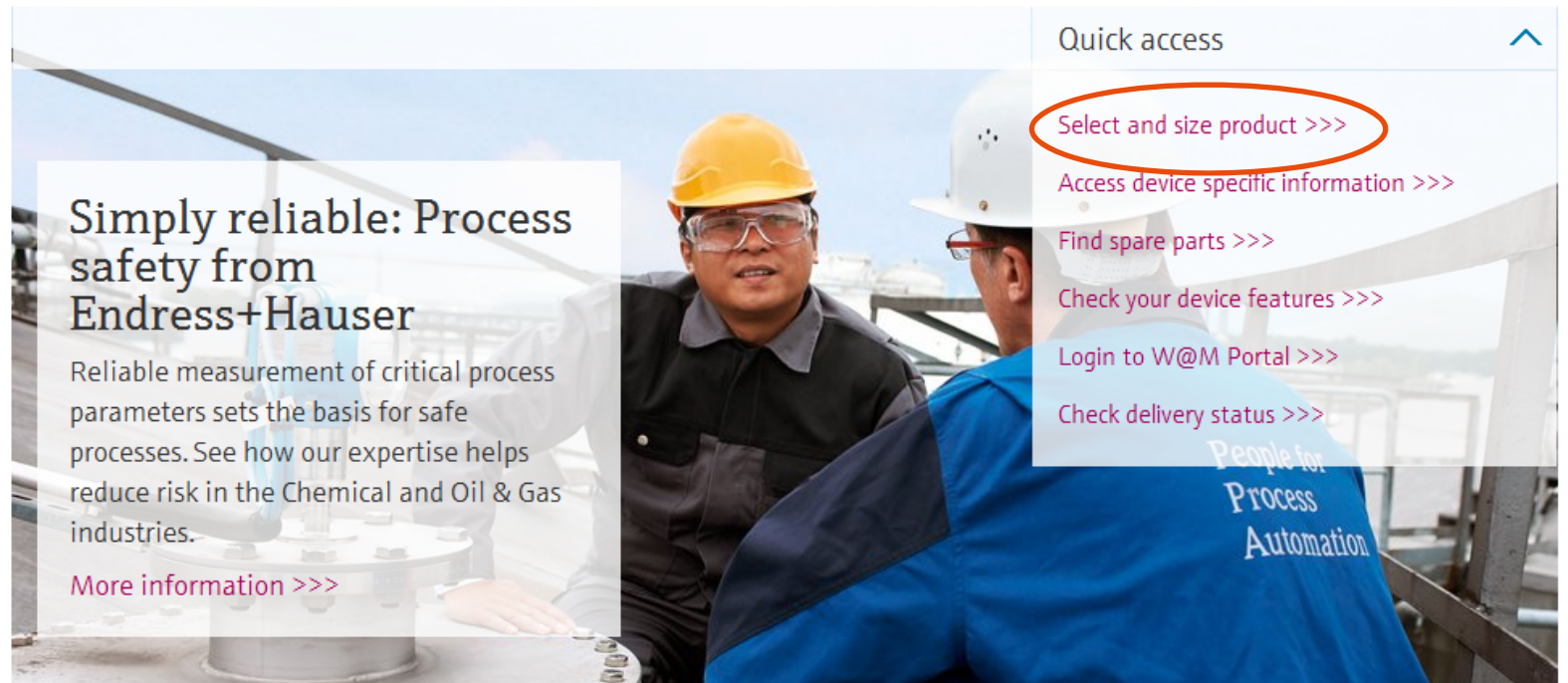
Go to www.my.endress.com → **Select & Size – Applicator**

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Endress+Hauser 

Products Solutions Services

Search Go



The screenshot shows the Endress+Hauser website interface. On the left, there is a banner for 'Simply reliable: Process safety from Endress+Hauser' with a sub-headline 'Reliable measurement of critical process parameters sets the basis for safe processes. See how our expertise helps reduce risk in the Chemical and Oil & Gas industries.' and a 'More information >>>' link. On the right, a search bar is visible with a 'Go' button. Below the search bar is a 'Quick access' menu with several options: 'Select and size product >>>' (circled in red), 'Access device specific information >>>', 'Find spare parts >>>', 'Check your device features >>>', 'Login to W@M Portal >>>', and 'Check delivery status >>>'. The background of the website features an image of two industrial workers in hard hats and safety glasses, one in a yellow helmet and one in a white helmet, standing in front of industrial equipment.

Applicator Selection

- Product selection by filling up the Application requirements

People for Process Automation

Endress+Hauser

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← Applicator

1 Selection 2 Sizing 3 Configuration

Quick start of module...

Welcome to the Endress+Hauser Applicator

The **Endress+Hauser Applicator** is a step-by-step assistant in **product selection, sizing and configuration**. Precise, reliable, simple and easy to use and **focused on your individual measurement requirements**.

Applicator offers different entry points matching your starting position and direction.
Please select your preferred starting point:

- by **Application requirements**
- by **Industry applications**
- by **Product configuration**

Your benefits using Applicator

- Quick selection and sizing of products based on your requirements
- Different entry points matching your background
- Always available 24/7

Applicator Sizing

- Product sizing by input of process conditions

People for Process Automation

Endress+Hauser **EH**

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← ▶ Applicator

1 Selection 2 Sizing 3 Configuration

Quick start of module...

Applicator offers different entry points matching your starting position and direction.
Please select your preferred starting point:

- by Application requirements
- by Industry applications
- by Product configuration
- by Sizing & documentation
- by MyApplicator settings
- by Tutorial

Your benefits using Applicator

- Quick selection and sizing of products based on your requirements
- Different entry points matching your background
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Applicator Sizing

1. Select the fluid and enter the selected sensor and transmitter from Applicator Selection
2. Enter the process conditions: Flow rate, pressure and temperature

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← Applicator ▶ Sizing ▶ Flow

1 Selection 2 Sizing 3 Configuration Choose Applicator Tool

Sizing Flow

Dimensioning of flow meters

Sizing Custody transfer Fluid properties Gas mixtures Tri-Size Chart Extended order code Conversion Calculator Unit Defaults CorDB

General parameters

Measuring task	Monitoring/Control	Principle/Sensor	Promass E (40, 80, 83)
Fluid	Oil, Palm	Transmitter	80
State/Standard	Liquid	Flow meter	Promass 80E

Process data

	minimum	nominal	maximum	Unit
Requested flow				kg/h
Pressure				bar_a
Temperature				°C

Warnings

- 1. Please enter your process data!
- 2. Hint: Select the desired unit first before input values beginning with nominal values!

Flow velocity Guideline

For dimensioning of pipe diameter it is good engineering practice to follow the following recommendations:

Fluid type	Velocity @ max. flow
Liquids (low viscosity)	2...3 m/s
Gas	15...30 m/s
Steam	25...45 m/s

- APPLICATOR Sizing applies this rules → Measuring principle depending
- If large turn-down is required → Increased max. velocity is applied
- Often the ideal flowmeter DN is smaller then the pipe DN to optimize accuracy

If the proposed flowmeter DN is larger then the pipe DN there is most likely something wrong
→ Check plausibility of engineering units

Max. Flow Velocity – Special Cases

For certain fluids max. velocities exist for safety reasons, to protect the measured product from damage/ quality loss, etc. Here a few examples:

- Oxygen gas
 - There are regulations regarding max. permitted gas flow velocity in various PIPE MATERIALS

- Slurries (Minerals in liquid)
 - Slurries must be conveyed at MIN. velocities to avoid settling that would lead to pipe blockage. But: High velocity = High abrasion!!

- Milk, Blood and similar
 - Sensitive liquid products should be conveyed with “reasonable” velocity → Customer will/should provide guidance

Procedure of the sizing process

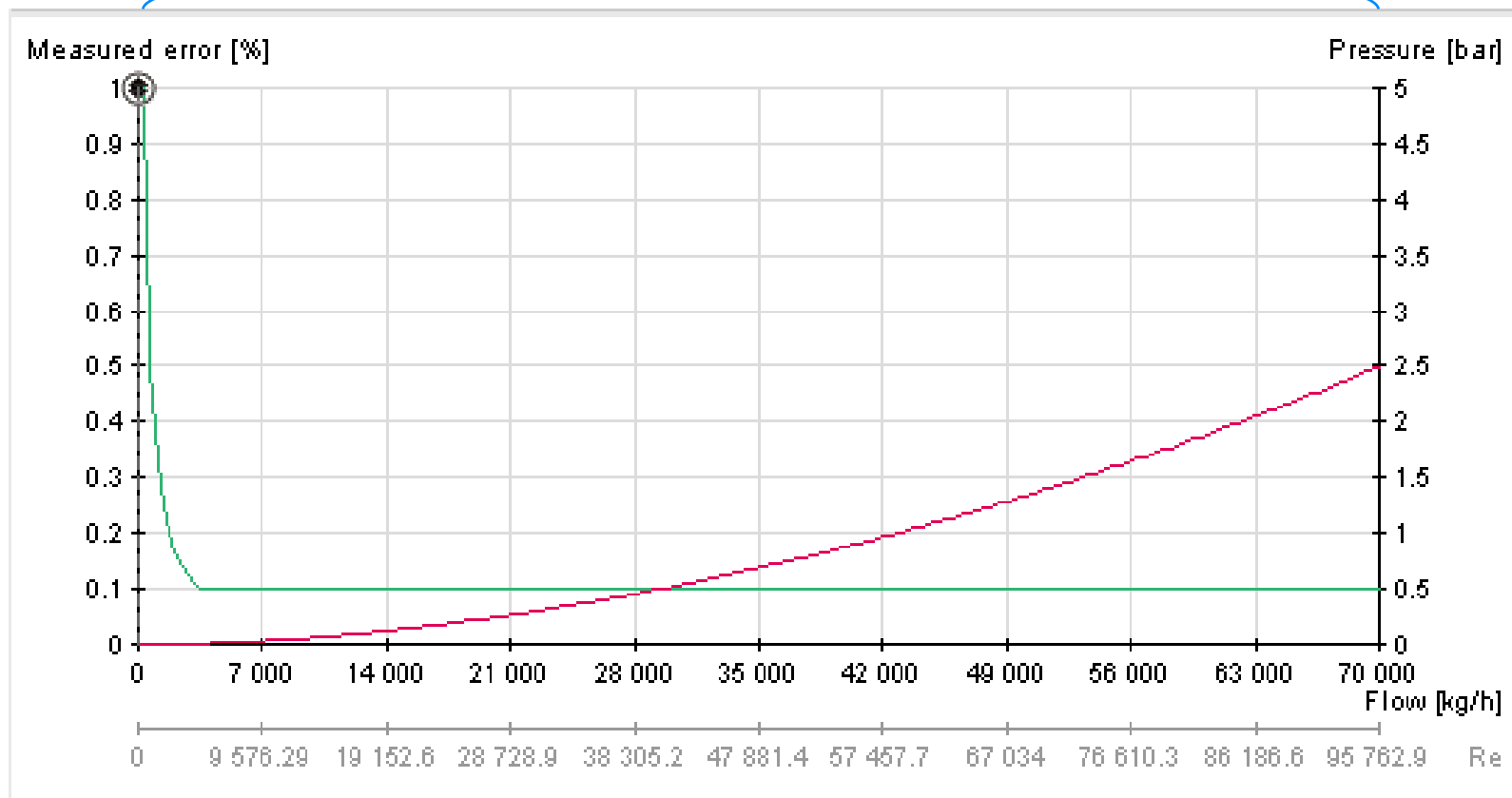
Sizing is the compromise of:

Accuracy at minimum flow rate
vs.
Pressure loss at maximum flow rate

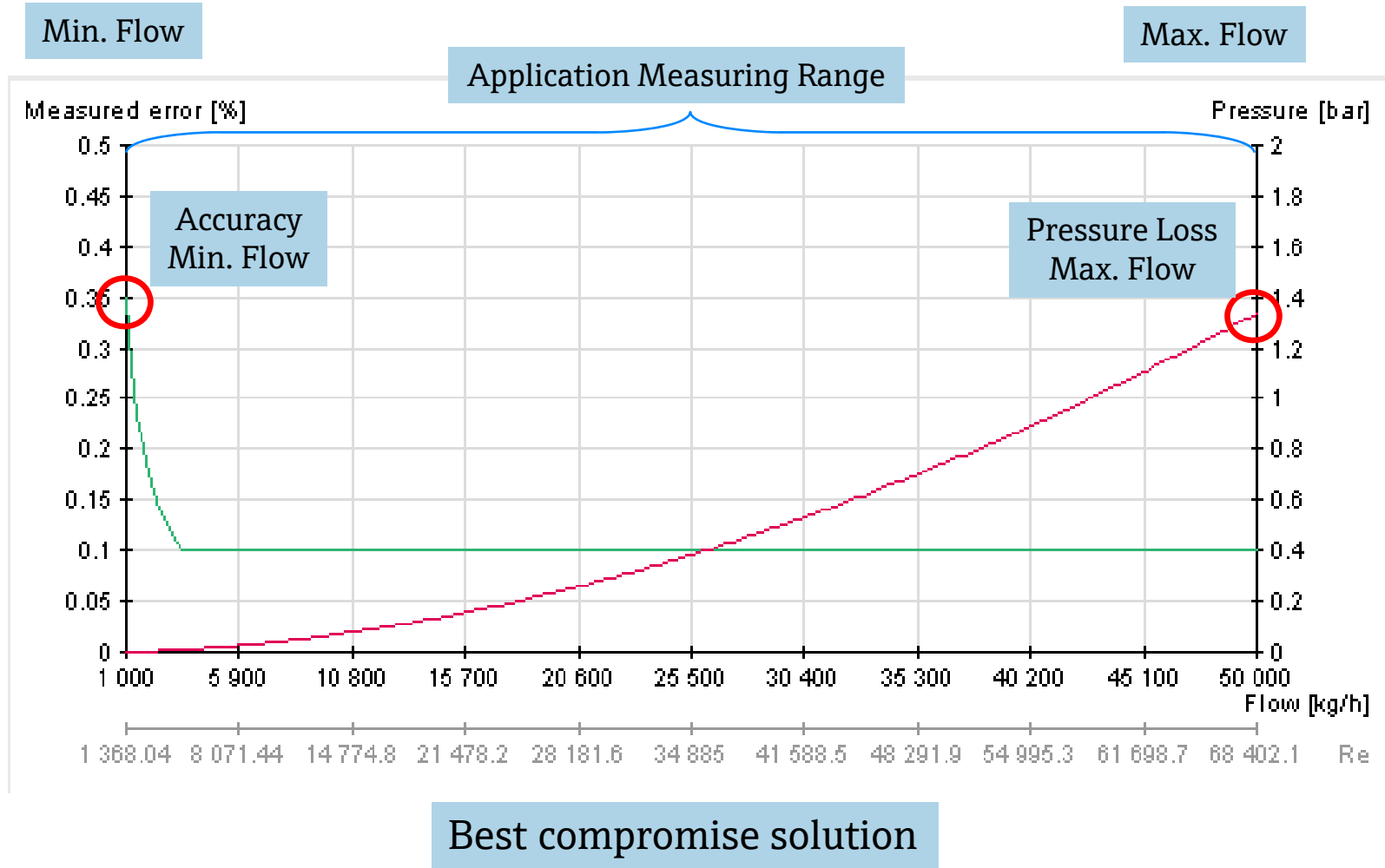
- For a reliable sizing the following information must be available:
- The measured fluid
- Flowmeter model to be sized
- Minimum and maximum flow rate to be measured
- The process condition (min. and max. pressure / temperature)
- Observe possible velocity limitations

Accuracy vs. Pressure Loss Promass 83F DN50

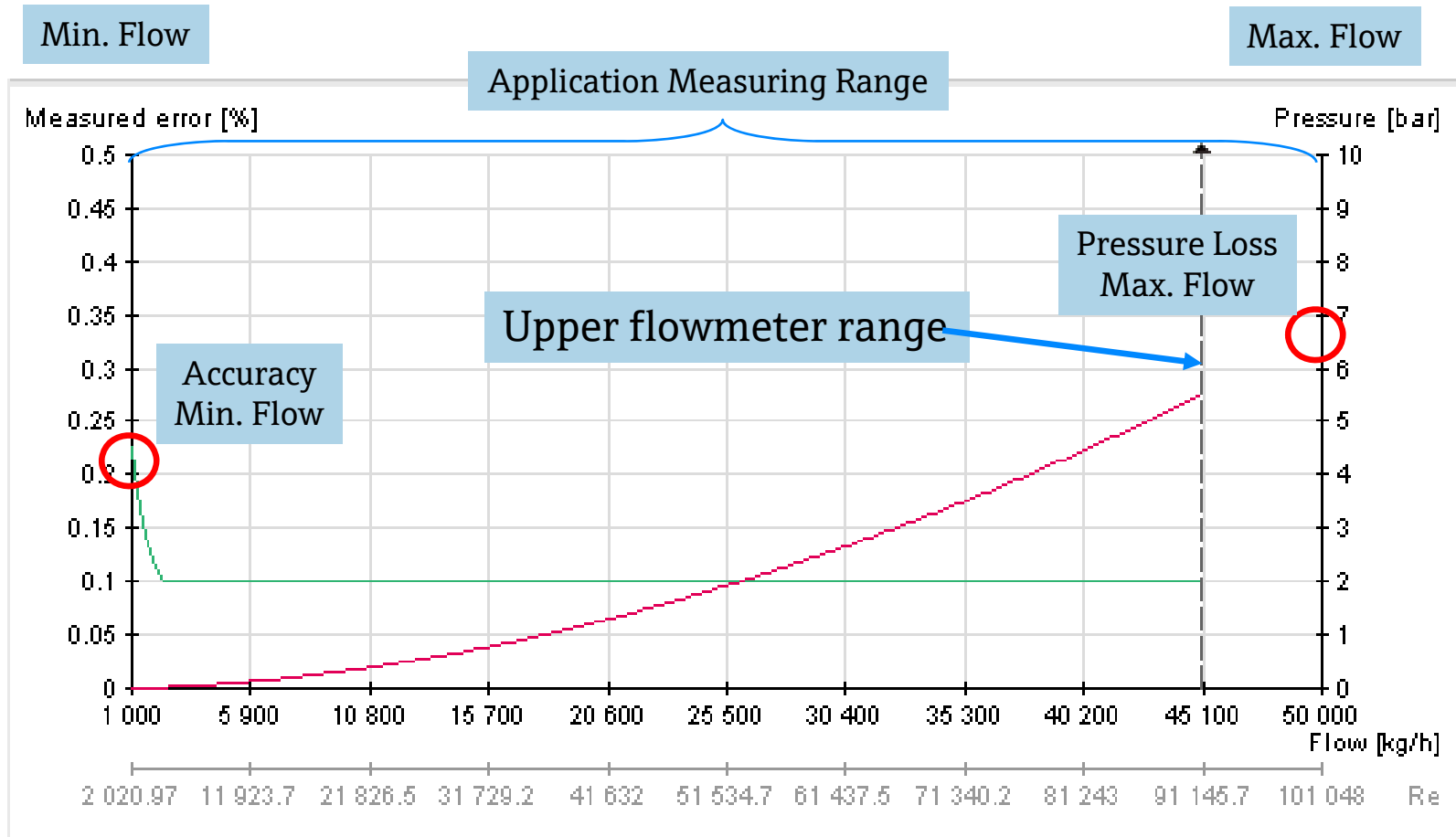
Full Flowmeter Measuring Range



Accuracy vs. Pressure Loss for Ideal DN

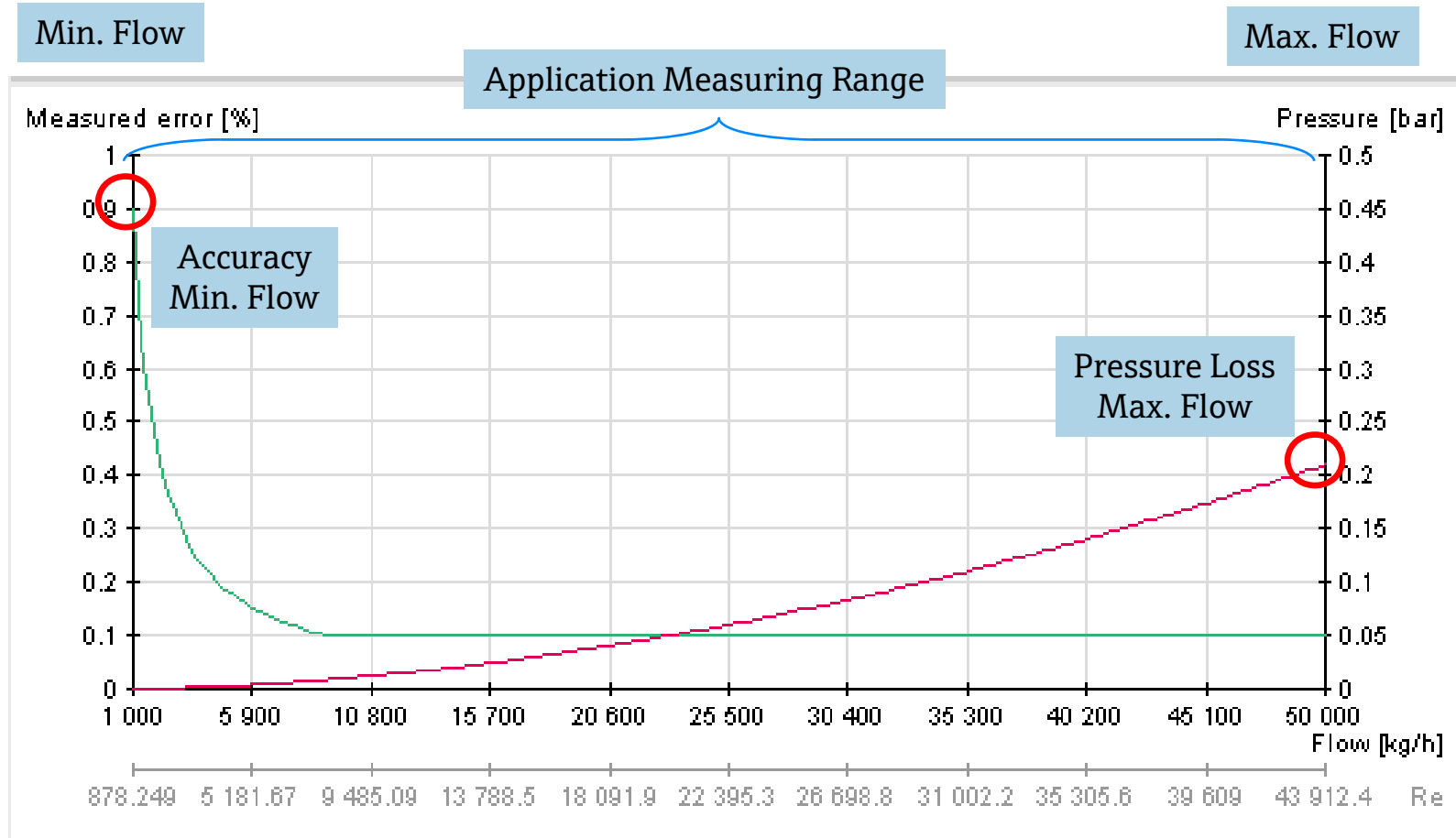


Accuracy vs. Pressure Loss for DN 40



Optimized solution for high accuracy

Accuracy vs. Pressure Loss for DN 80



Optimized solution for low pressure loss

TriSize Function for Comparison of DN

Trisize Display			
	Next smaller size	Current size	Next bigger size
Meter Size / Pressure rating	DN 40 / PN 40 EN 1092-1 B1 / 1.4404/316L	DN 50 / PN 40 EN 1092-1 B1 / 1.4404/316L	DN 80 / PN 40 EN 1092-1 B1 / 1.4404/316L
Minimum	0 l/h	0 l/h	0 l/h
Maximum	5.251E+4 l/h	8.169E+4 l/h	2.101E+5 l/h
Pressure	0.0022 bar	7.359E-4 bar	1.526E-4 bar
Pressure loss at req. Flow nom.	0.2567 bar	0.0513 bar	0.0081 bar
Pressure loss at req. Flow max.	5.041 bar	1.008 bar	0.1584 bar
Velocity (meas. tube) at req. Flow min.	0.5709 m/s	0.2616 m/s	0.1078 m/s
Velocity (meas. tube) at req. Flow nom.	5.76 m/s	2.61 m/s	1.078 m/s
Velocity (meas. tube) at req. Flow max.	28.5 m/s	13.0 m/s	5.391 m/s
Measured error Vol. at req. Flow min.	0.26 %	0.41 %	1.05 %
Measured error Vol. at req. Flow nom.	0.1 %	0.1 %	0.11 %
Measured error Vol. at req. Flow max.	0.1 %	0.1 %	0.1 %
Measured error Mass at req. Flow min.	0.26 % / 0.26 %	0.41 % / 0.41 %	1.05 % / 1.05 %
Measured error Mass at req. Flow nom.	0.1 % / 0.05 %	0.1 % / 0.05 %	0.11 % / 0.11 %
Measured error Mass at req. Flow max.	0.1 % / 0.05 %	0.1 % / 0.05 %	0.1 % / 0.05 %
Reynolds No. at req. Flow min.	1.732E+4	1.172E+4	7 526
Warnings/Messages	Cavitation may occur at max. conditions. This could interfere with accurate measurement results. To avoid cavitation either the diameter or pressure has to be increased or the flowrate or temperature has to be decreased. Pressure loss bigger than nom. pressure. Please increase the nom. pressure or the meter size.		

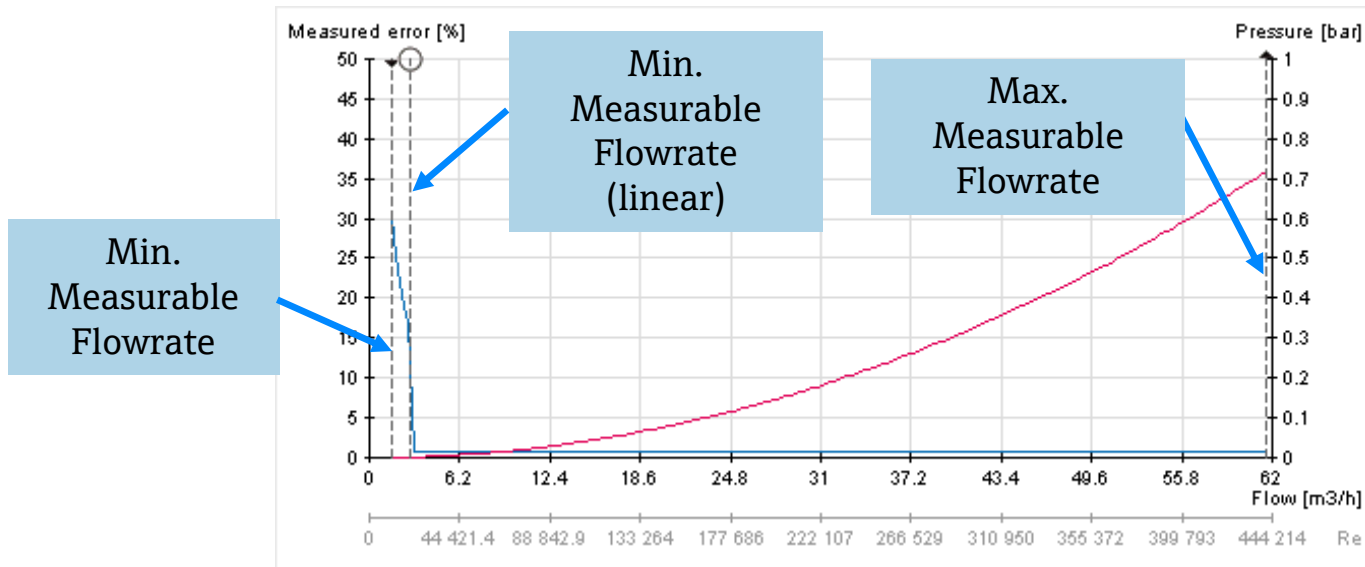
Pressure Loss

vs.

Accuracy

Special Case: Vortex Flowmeter

- Vortex flowmeter have a low-end measuring limitation due to the physical principle
- Sizing is therefore more critical because it is necessary to ensure the meter NEVER falls below the minimum measurable flow rate



Measuring Range Prowirl 72F DN50 for Water

Device Specific Information

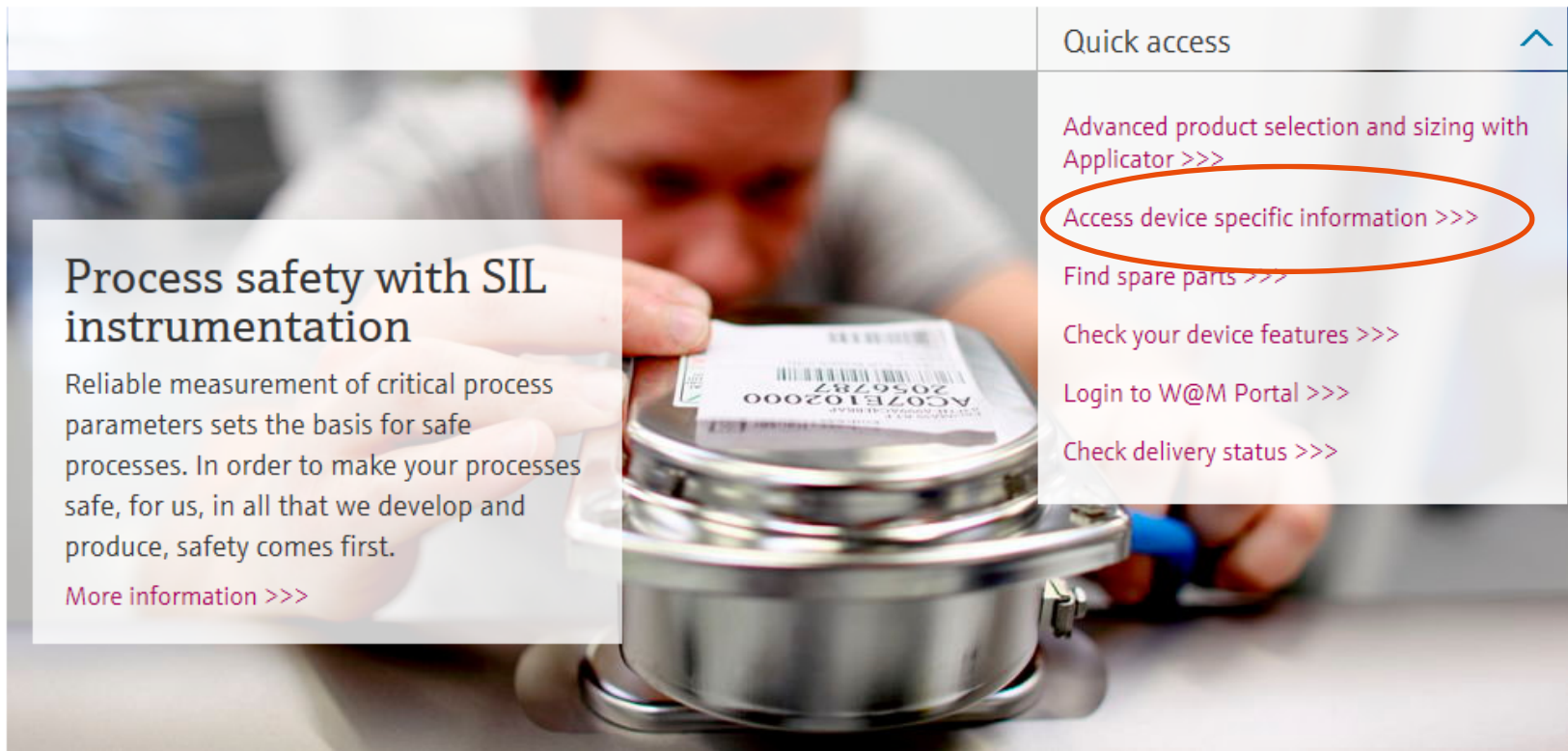
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Process safety with SIL instrumentation

Reliable measurement of critical process parameters sets the basis for safe processes. In order to make your processes safe, for us, in all that we develop and produce, safety comes first.

[More information >>>](#)

Quick access 


- [Advanced product selection and sizing with Applicator >>>](#)
- [Access device specific information >>>](#)
- [Find spare parts >>>](#)
- [Check your device features >>>](#)
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Device Specific Information

Device Viewer


Select the type of information you need and enter the requested information in the respective fields

device information and technical documentation
 device information and technical documentation incl. device specific documents
 selected documents of all devices per order

Serial number 

Overview Documents Spare Parts More Product Information Device Integration

Device details	
Serial number	EB0DF202000
Order code	9B2B1H-1014/0
Short description	Prosonic Flow B 200, 9B2B1H, DN100 4"
Device type	Flow, Ultrasonic



- Obtain device information by entering serial number or order number

What's in Device Specific Information?

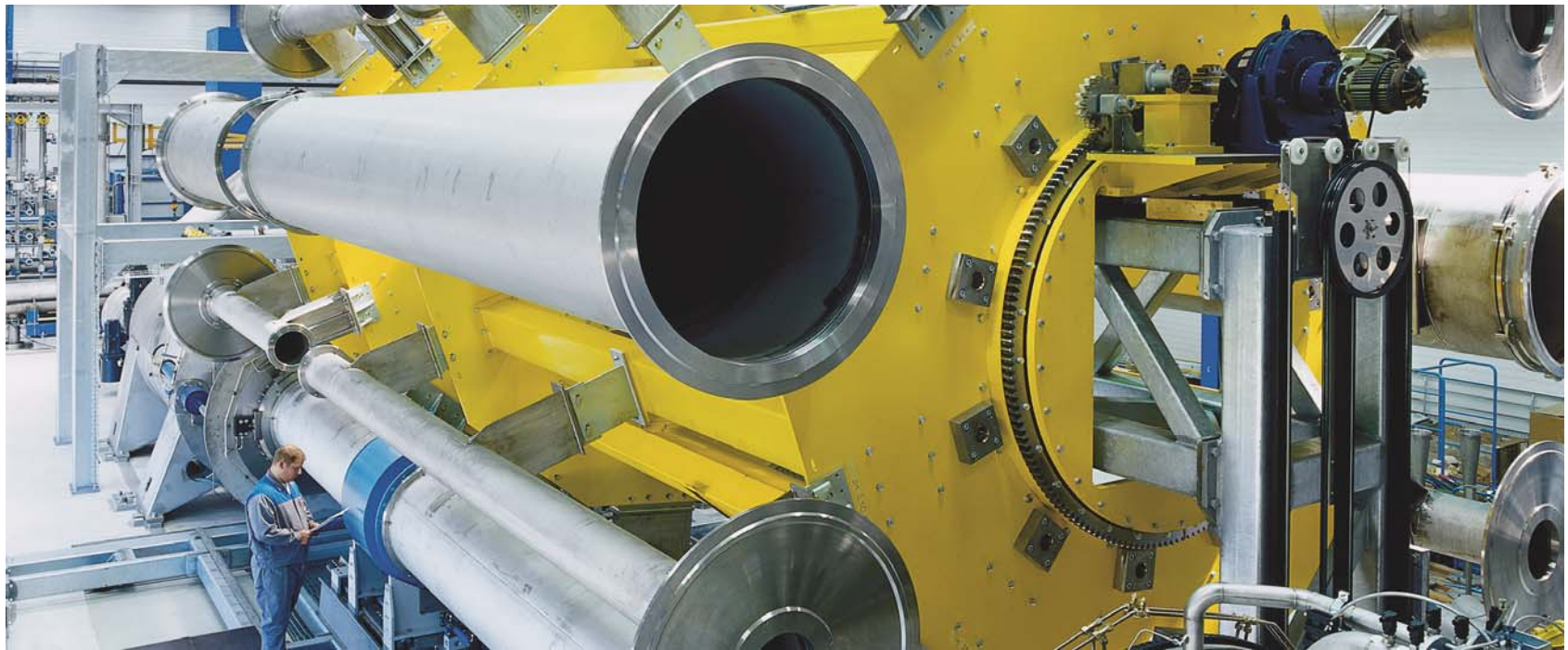
Overview	Documents	Spare Parts	More Product Information	Device Integration
Device details				
Serial number	EB0DF202000			
Order code	9B2B1H-1014/0			
Short description	Prosonic Flow B 200, 9B2B1H, DN100 4"			
Device type	Flow, Ultrasonic			
Supplier	Endress+Hauser			



- Device details
- Calibration certificates
- Spare Parts
- Device manuals and technical information

Manufacturing data	Overview	Documents	Spare Parts	More Product Information	Device Integration	
Export as pdf	Start multiple file download					
Product Status	Calibration protocols	Overview	Documents	Spare Parts	More Product Information	Device Integration
Phase out date	Gas flow calibration document	Spare parts for Prosonic Flow B 200, 9B2B1H, DN100 4"				
Spare sensor until	Gas flow calibration document	Order code	9B2B1H-AACCCA2D231			
Spares availability	Parameter information	Product status	● Available			
New alternative	Parameter setting					
Maintenance advice	Parameter setting					

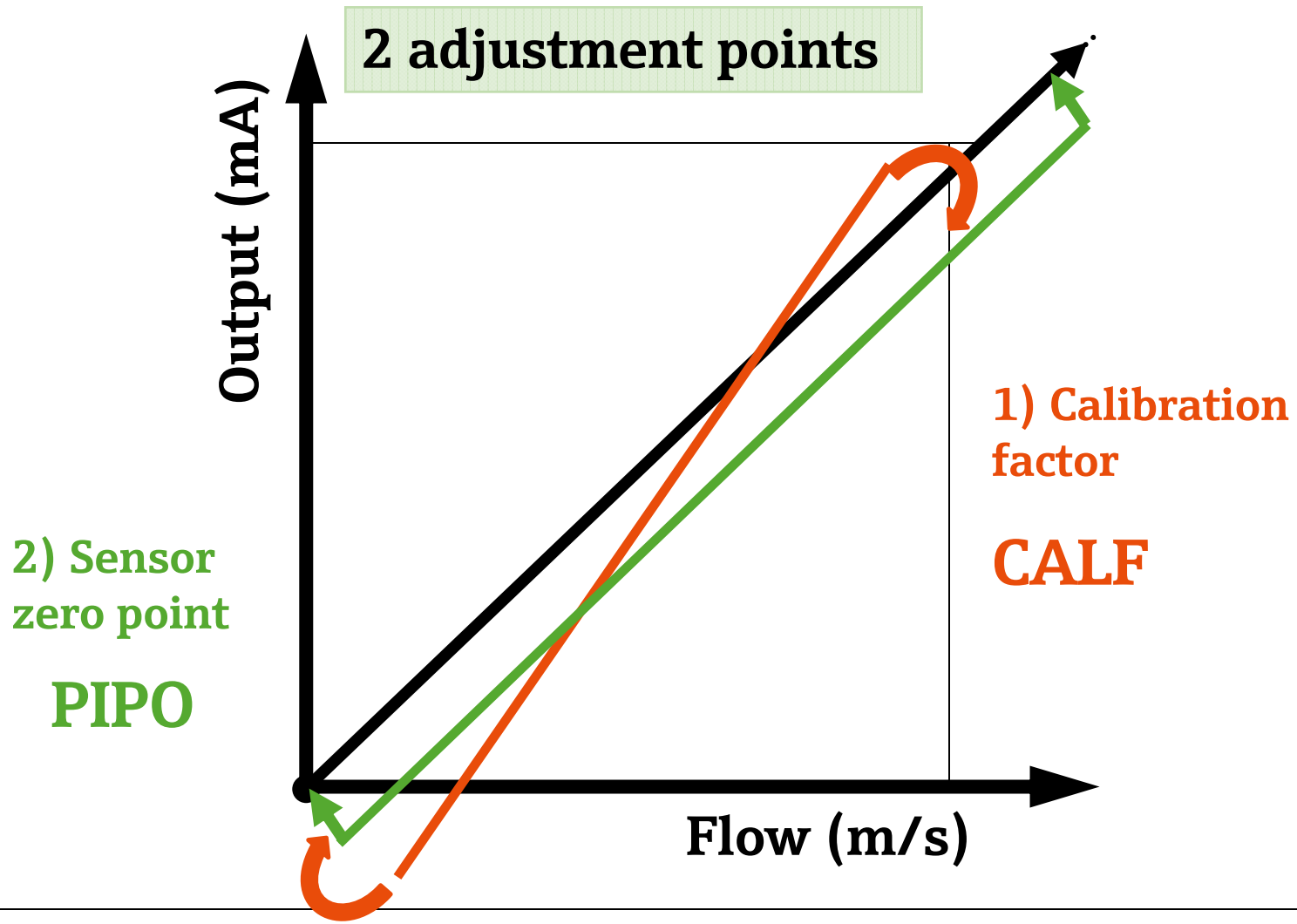
Calibration



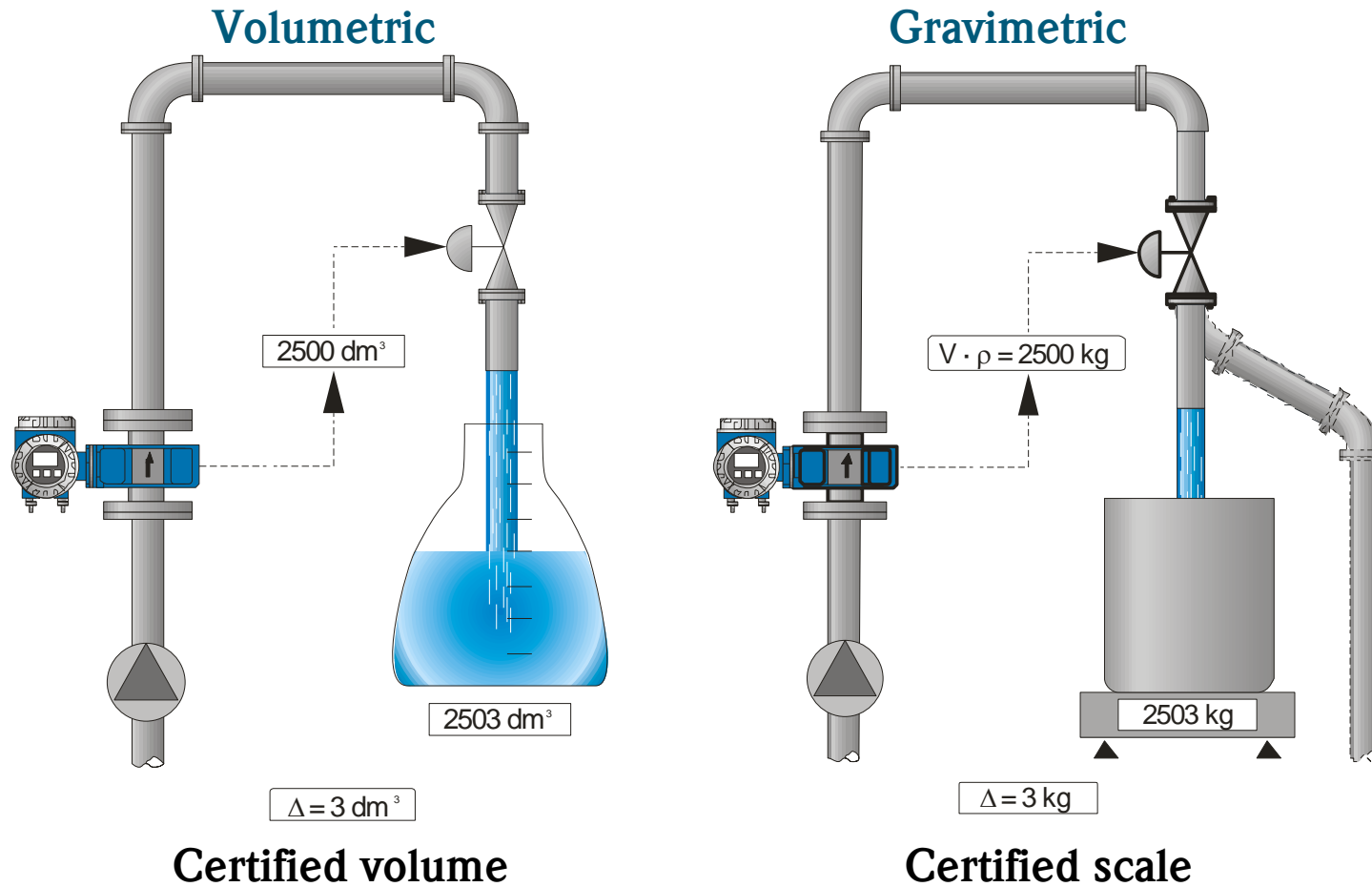
Calibration

- Calibration, the last step in production
- All new flow meters are being calibrated (exception, clamp on Ultrasonic)
- Elimination of deviations between individual units
- Balancing measuring result and specification
- Electronical correction at two points: Zero - Max.
- At zero = zero point adjustment (PIPO)
- At max. = calibration factor (CALF)

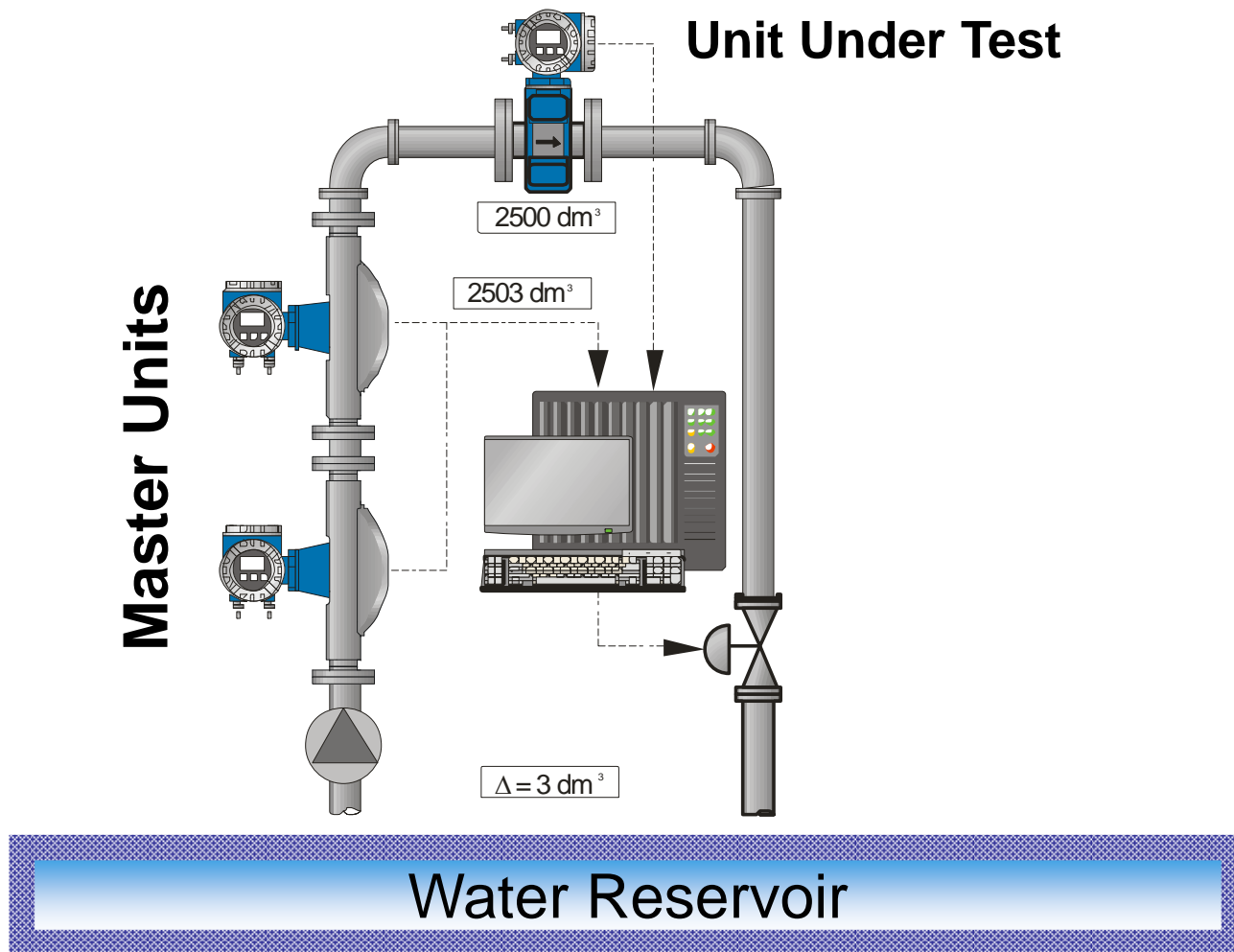
Electronical adjustment



Calibration methods – primary calibration method



Calibration methods – secondary calibration method



Approved calibration methods acc. to ISO 17025

- ISO/IEC 17025 is an internationally accepted standard covering “general requirements for the competence of testing and calibration laboratories”
- ISO 4185: Standard for calibration with gravimetric references

Primary Calibration Method		Secondary Calibration Method
	Coriolis	
Weight scale Flying-Start- Stop (diverter)		Master meter
Weight scale Standing-Start-Stop		

As by E+H

Secondary methods must inherently have higher uncertainties than any primary calibration method. Reproducibility of master does add to uncertainty.

Solution: PremiumCal – calibration excellence!

- Improved accuracy from $\pm 0.05\%$ to the **new level of $\pm 0.015\%$**
- Through the advancement and progression of two existing rigs each in Reinach and Greenwood
- Accredited to ISO/IEC 17025 by the Swiss accreditation body (SAS) in Bern (August 2007)
- March 2009: A2LA accreditation for second, identical PremiumCal rigs in Greenwood USA, same uncertainty!

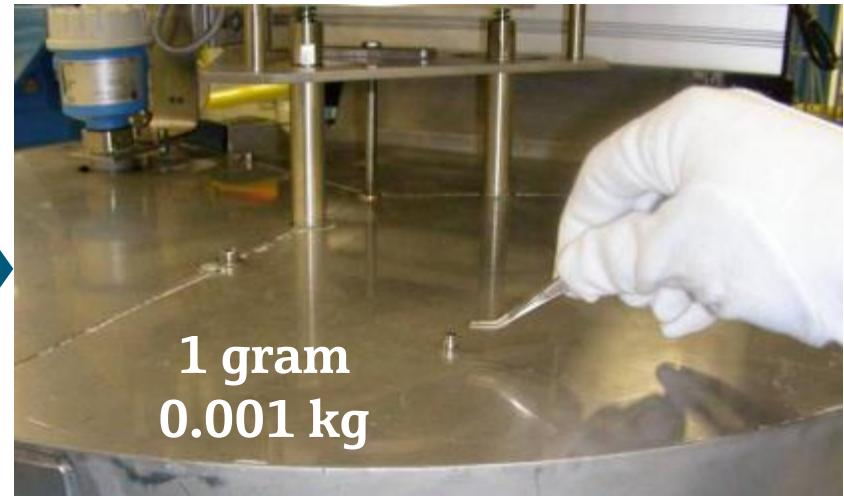


Official inauguration of the new PremiumCal calibration rig in Reinach Switzerland, February 2008, with the crew.

Solution: new high-performance calibration rig

- The most accurate, accredited production calibration rigs in the world
- Depending on the calibration method, measuring uncertainty calculated with between 30 (gravimetric) and 60 (volumetric) parameters
- A lot of engineering know how needed (26 technicians and engineers)
- Deviation in 1000 liters = 1 glass of Champagne (0.015%)

Placing of a 1-gram weight on the 400-kg weighing tank during calibration



PremiumCal - the summit of uncertainty

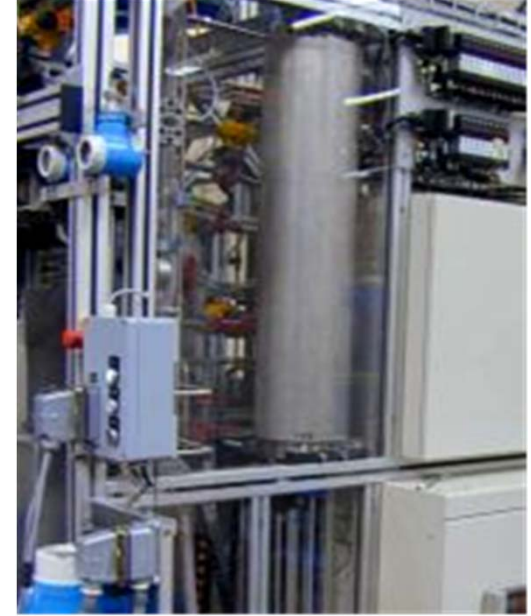
- FCP 7.1.5 (4-t scales) 0.015% gravimetric
- FCP 7.1.5 (400-kg scales) 0.015% gravimetric
- FCP 6.5 (pipe prover) 0.021% volumetric



4-t scales
DN 100 to 250



400-kg scales
DN 15 to 150



pipe prover
DN 8 to 15

Solution: high-tech rig ($\pm 0.015\%$)

- Electro polished certified weights accuracy class F2 with 0.8 g/50 kg $\rightarrow \pm 0.0016\%$
- Class F2 weights : normally used for the weighing of precious metals or gem stones
- Spring-mounted weighing trays
- Load cells: OIML class C6
- The rig is calibrated fully automated every two weeks.



Traceability chain of Endress+Hauses



±0,000001%

Standard Kilo at (BIPM) Paris

Measuring uncertainty = +/- 0.000001%
+/- 10 microgram



±0,0001%

National Standard Kilo of METAS

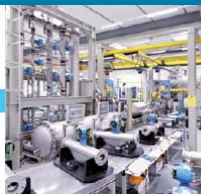
Measuring uncertainty = +/- 0.0001%
+/- 0.5g/500 kg, duplicate No 38



±0,0016%

Gravimetric scale of E+H Flowtec

Traceable weights of OIML class F2
+/- 0.8g/50 kg = 0.0016%



±0,015%

PremiumCal rigs in Reinach and Greenwood

Measuring Uncertainty +/- 0.015%
accredited acc. to ISO 17025



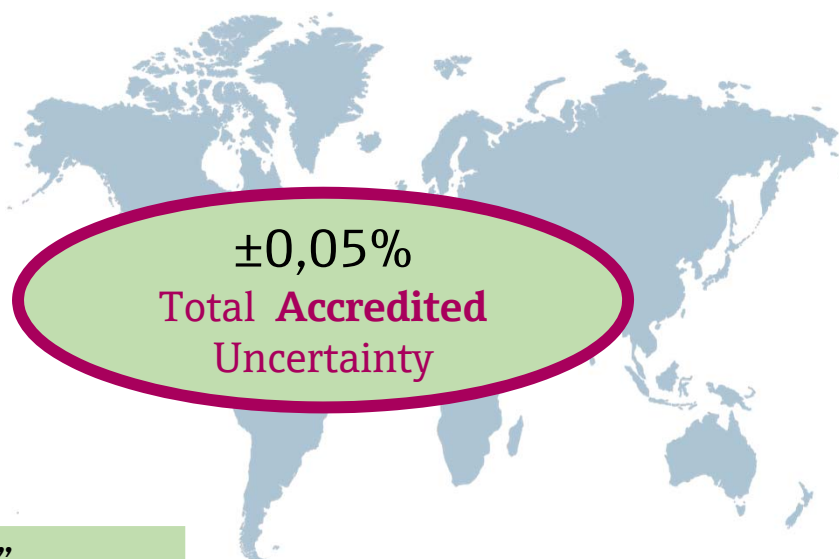
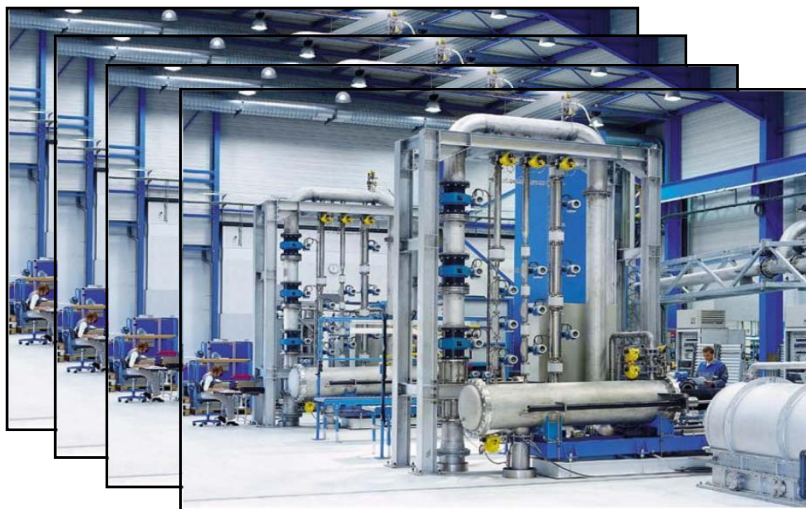
±0,05%

Meter accuracy

Promass 83/84F DN 08 – 400
Premium Calibration +/-0.05%

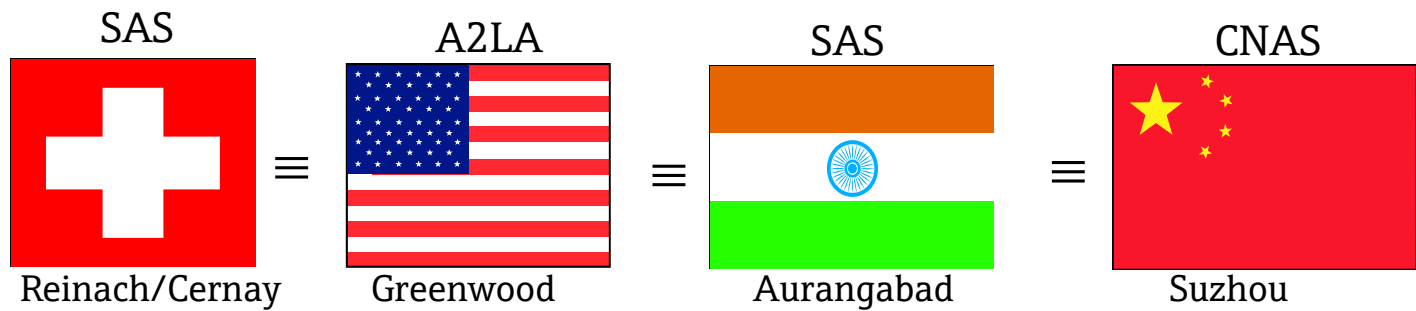
11

Endress+Hauser: World wide use of primary calibrations



$\pm 0,05\%$
Total Accredited
Uncertainty

“Accredited calibration stands (ISO 17025)”
in all production locations used by Endress+Hauser
for all produced Coriolis meters.



Any Questions?



Thank you very much for your attention

