Basics of Flow Measurement

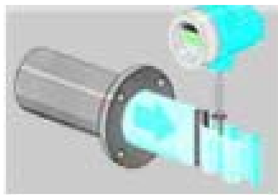
Endress+Hauser
People for Process Automation

Overview

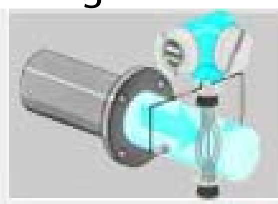
- Measuring principles
- Selection & sizing
- Device Specific Information
- Calibration

Flow measuring principles @ Endress+Hauser

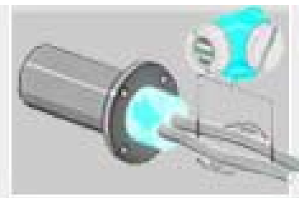
Vortex



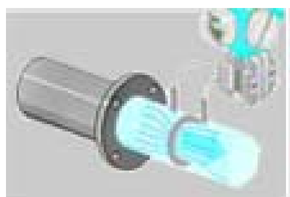
Electro-
magnetic



Coriolis

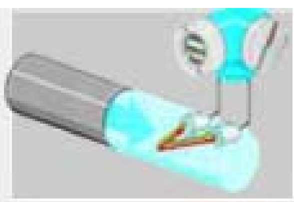


Differential
pressure

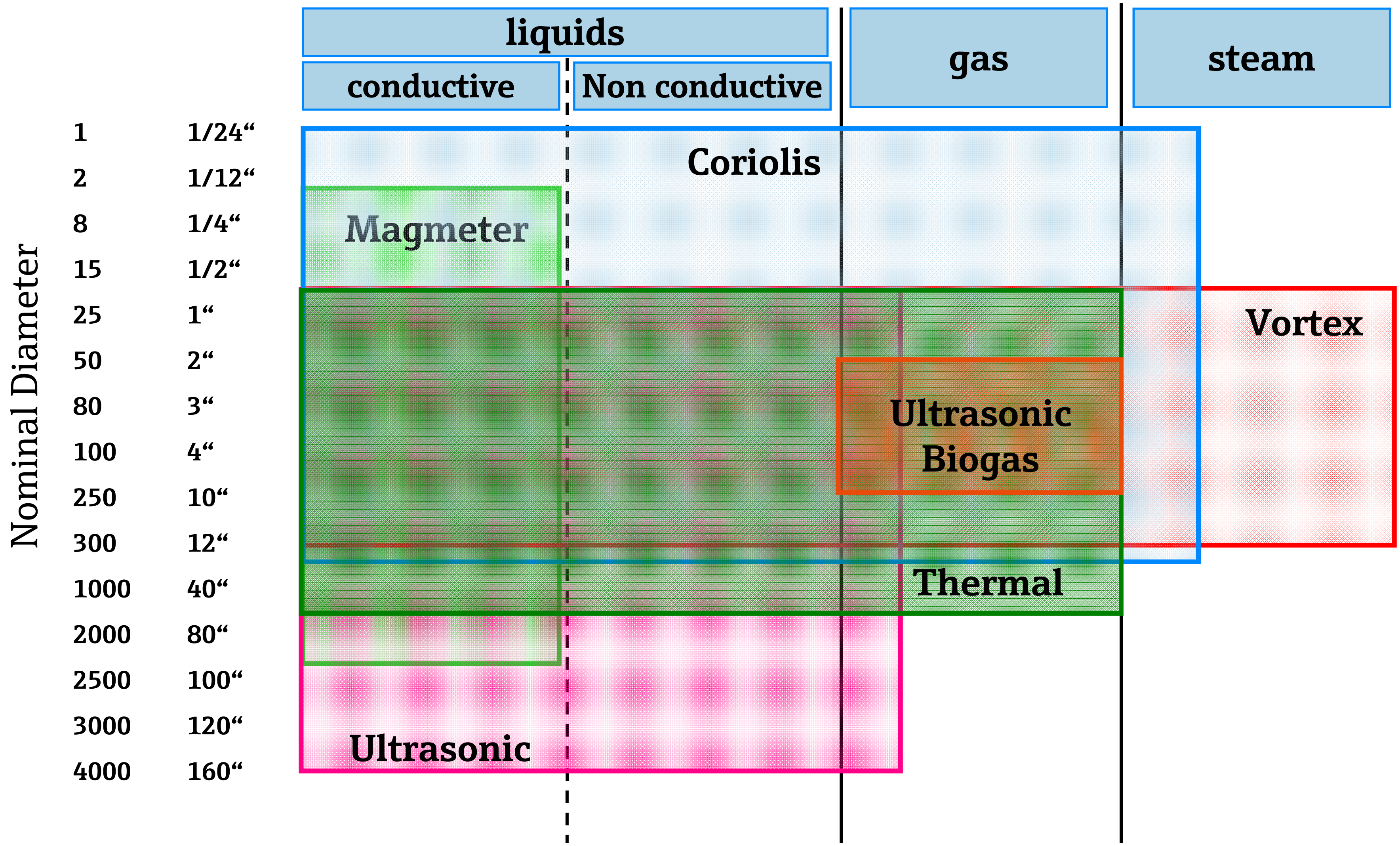


Thermal

Ultrasonic



Flow Measurement - Overview



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Product Portfolio for liquids

Price

Non conductive liquids

Conductive liquids

Promag
Advantage
- No pressure loss

Disadvantage
- Need Inlet run (5xDN)
- Only conductive liquids

Prowirl
Advantage
- All liquids
- 2-Wire

Disadvantage
- Inlet run (15xDN)
- Pressure loss

Prosonic Flow
Advantage
- All liquids
- No pressure loss
- 2-Wire

Disadvantage
- Inlet run (5xDN)

Promass
Advantage
- No inlet run
- High accuracy
- Multivariable

Disadvantage
- Pressure loss
- Price

Performance

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Product Portfolio for Gas

Price

Dp-flow/Prowirl

Advantages
- special Material (dp)
- 2-wire

Disadvantages
- Inlet run

t-mass

Advantages
- Direct mass flow
- No pressure loss

Disadvantages
- Inlet run

Prowirl

Advantages
- Every gas
- 2-wire
- Pressure comp.

Disadvantages
- Inlet run
- Pressure loss
- Min.Flow Shut off

Promass

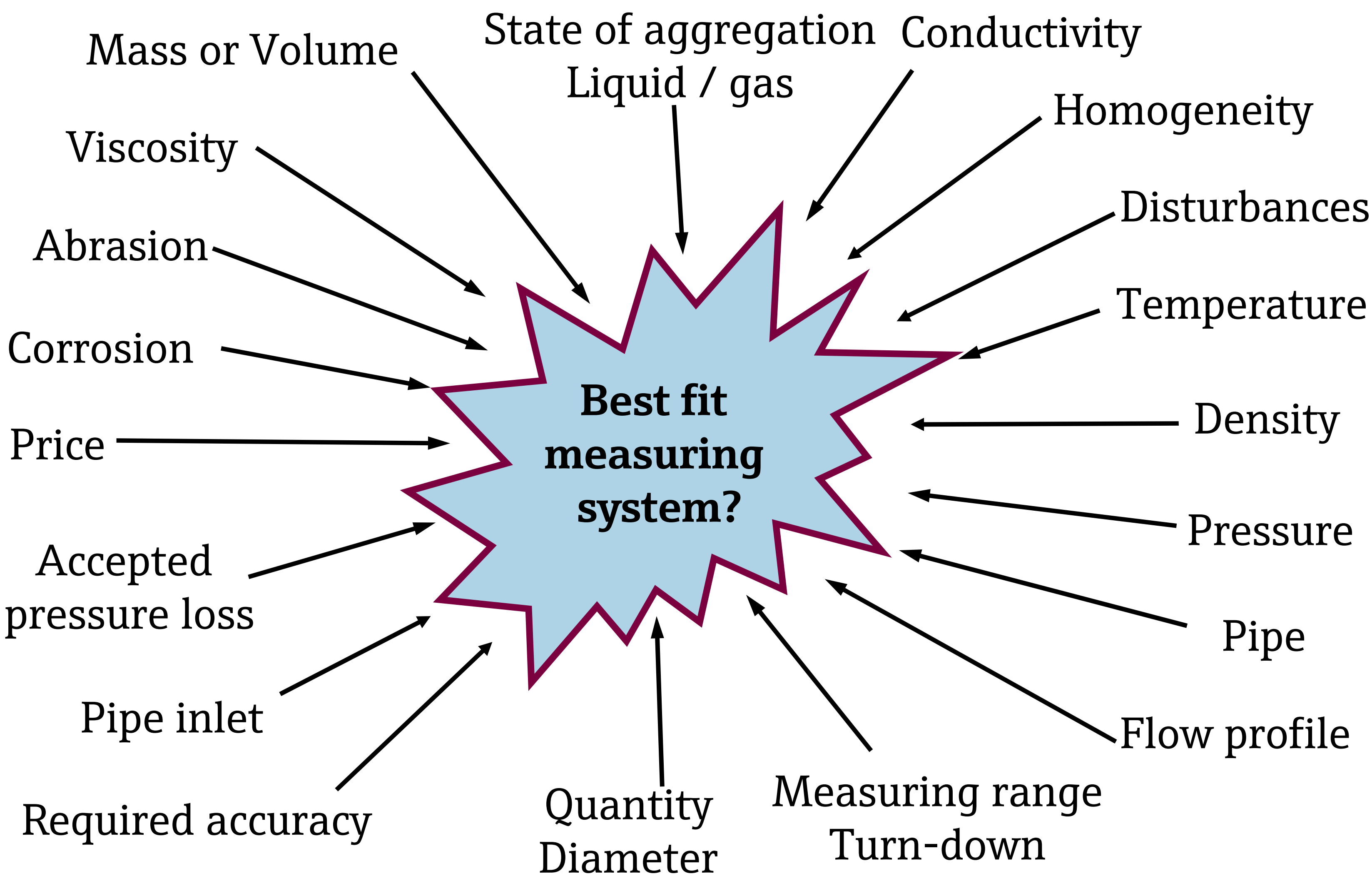
Advantages
- Direct mass flow
- No inlet run
- High accuracy
- Multivariable

Disadvantages
- Pressure loss
- High price

Performance

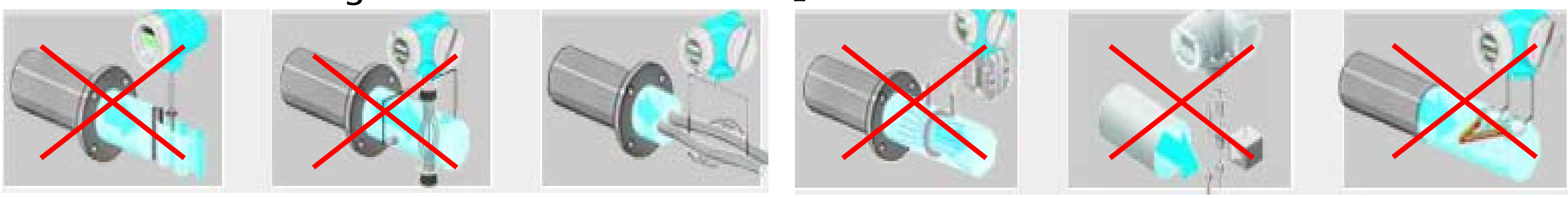
Selection & Sizing

Influences on the selection of the measuring system



Best fit measuring system?

Vortex | Electro-magnetic | Coriolis | Differencial pressure | Thermal | Ultrasonic



State of aggregation
liquid / gas

Conductivity

Temperature

Density

Mass or Volume

Best fit measuring system

Flow profile

Viscosity

Diameter required

Corrosion

Required accuracy

Price

Accepted pressure loss

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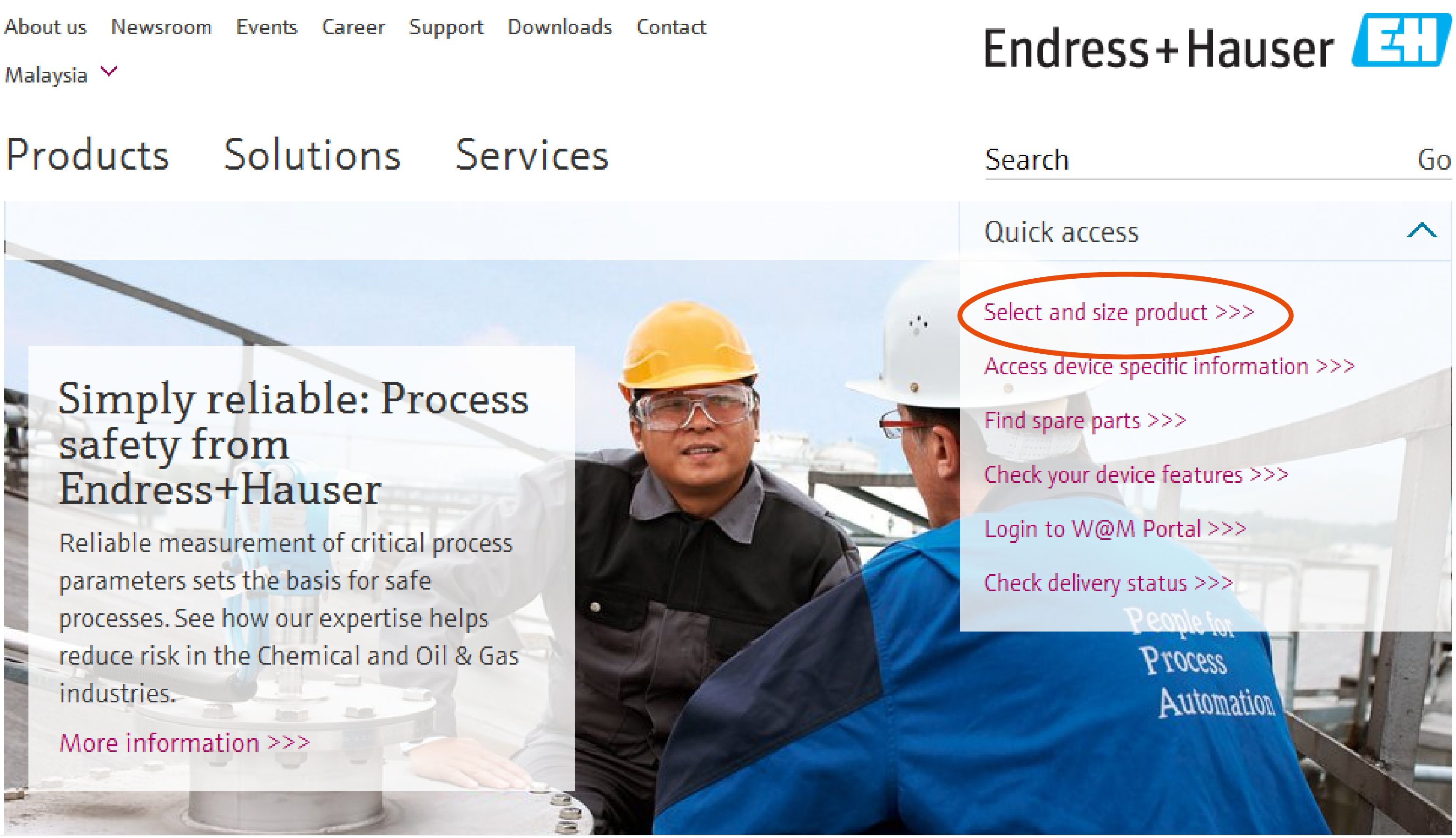
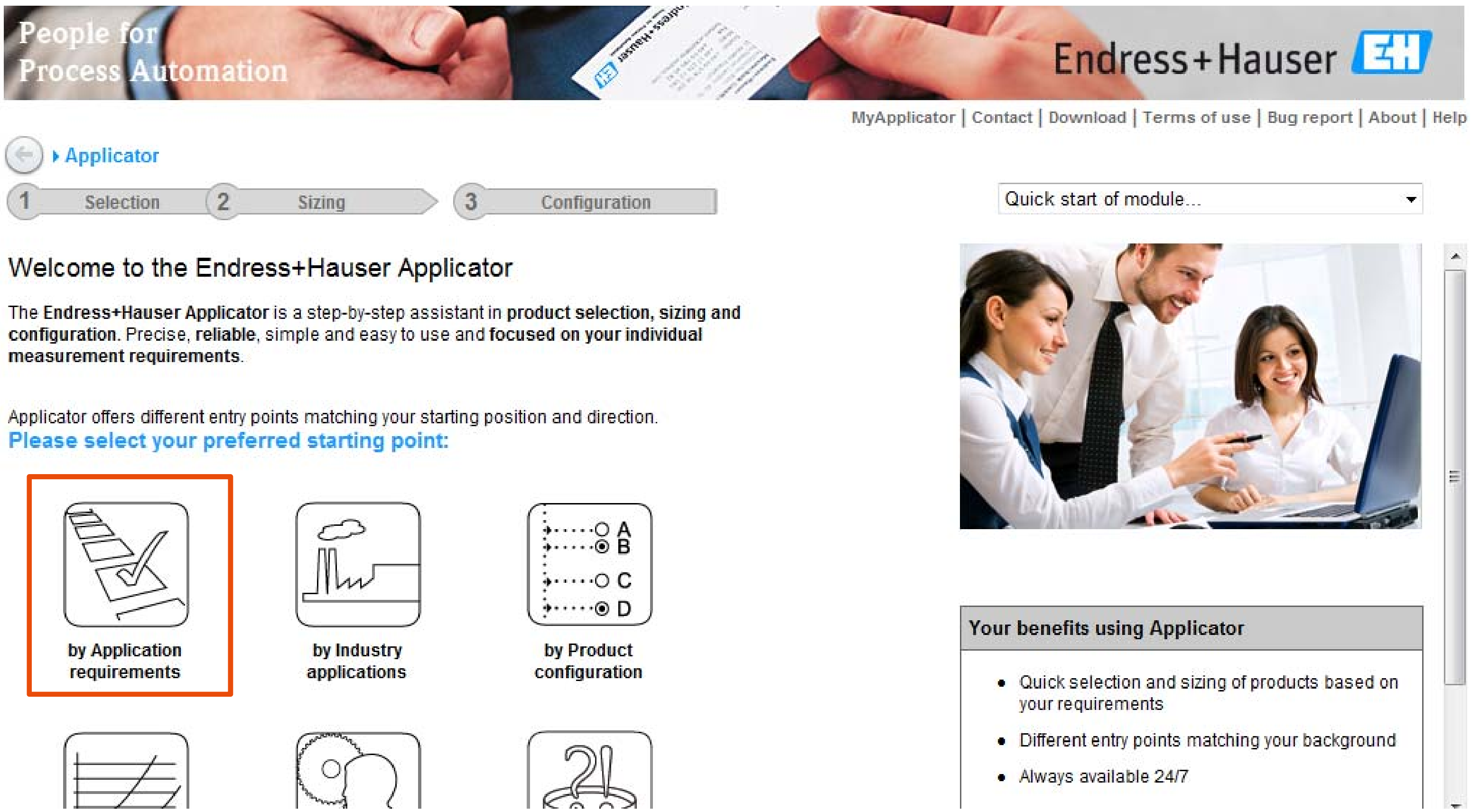
How to select the best fit flowmeter for your process?

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



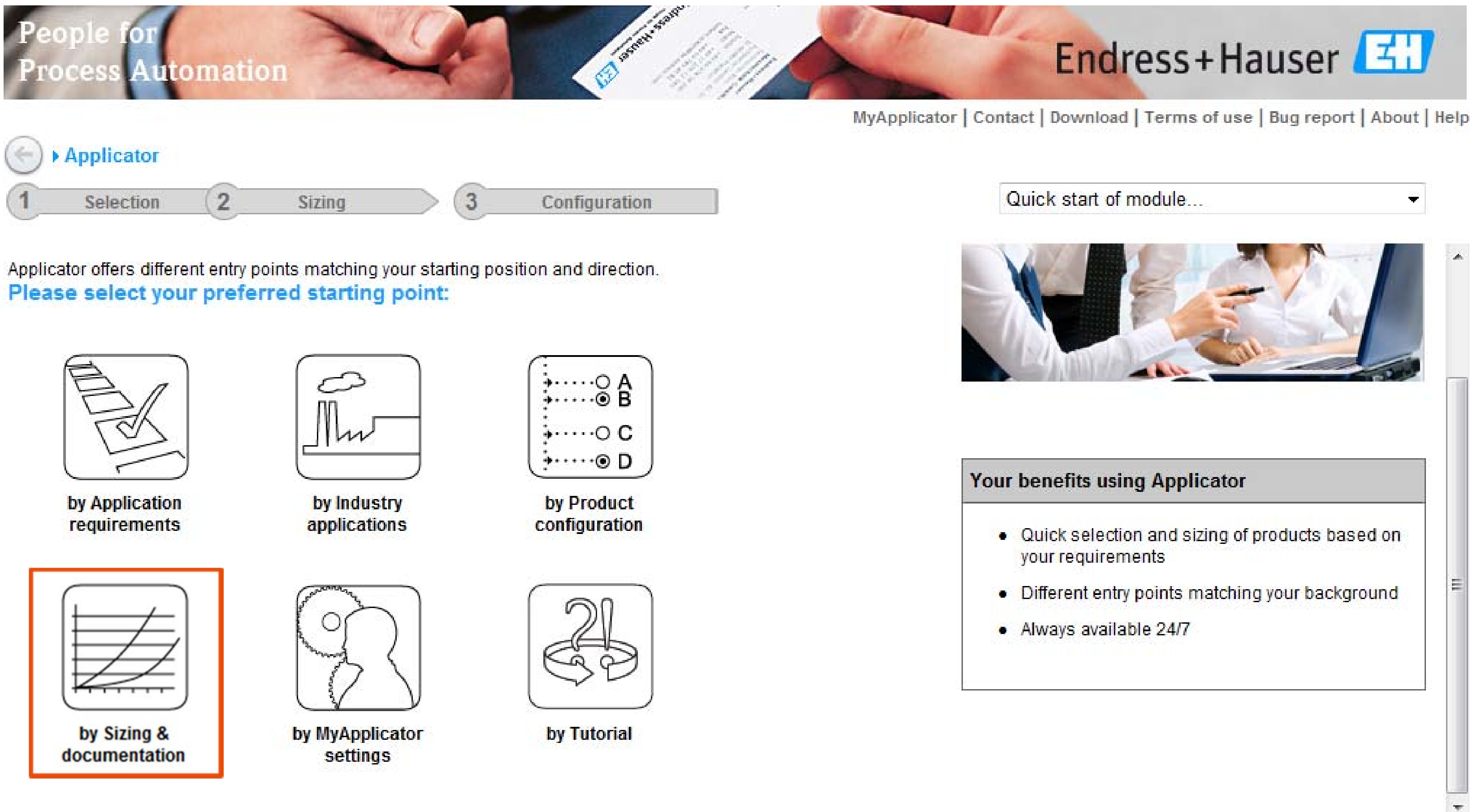
Applicator Selection

- Product selection by filling up the Application requirements



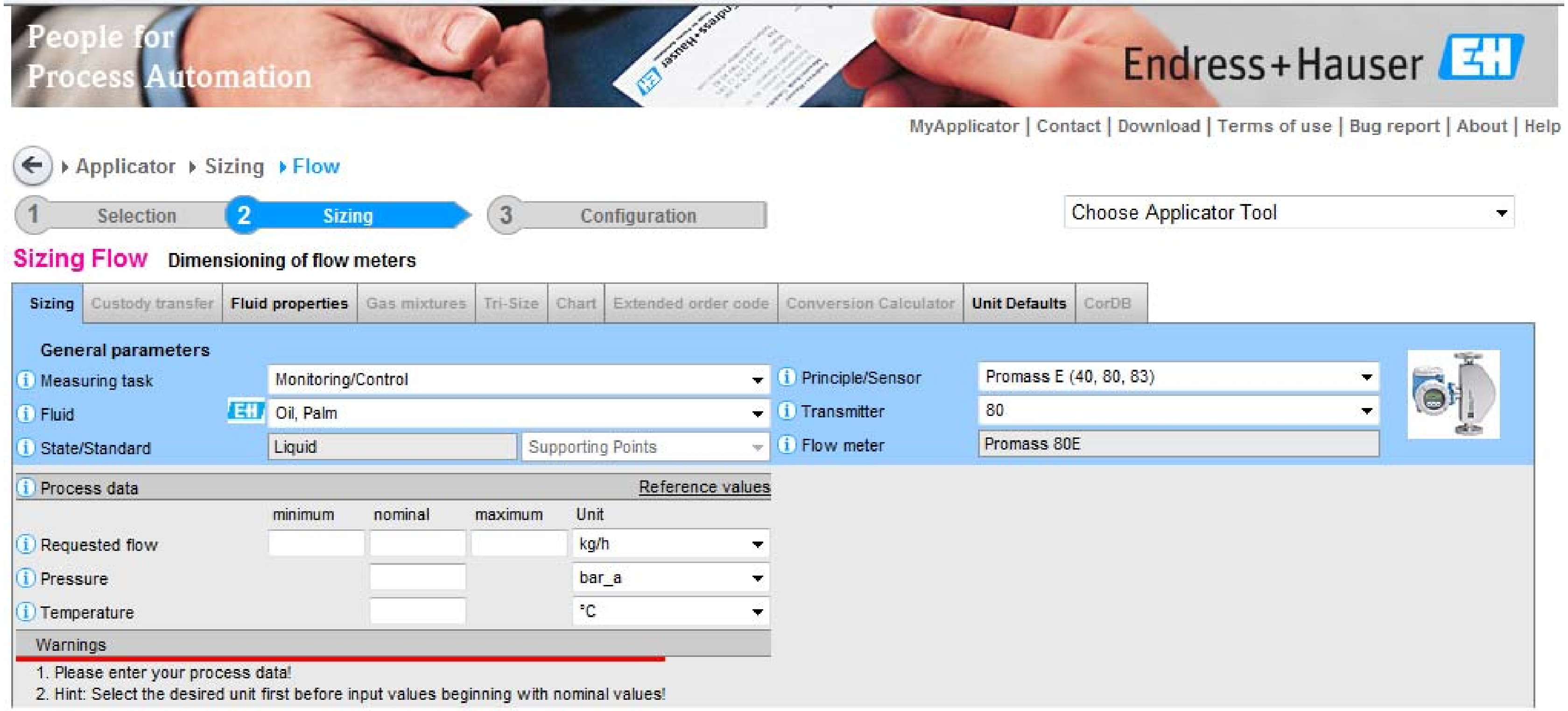
Applicator Sizing

- Product sizing by input of process conditions



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



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

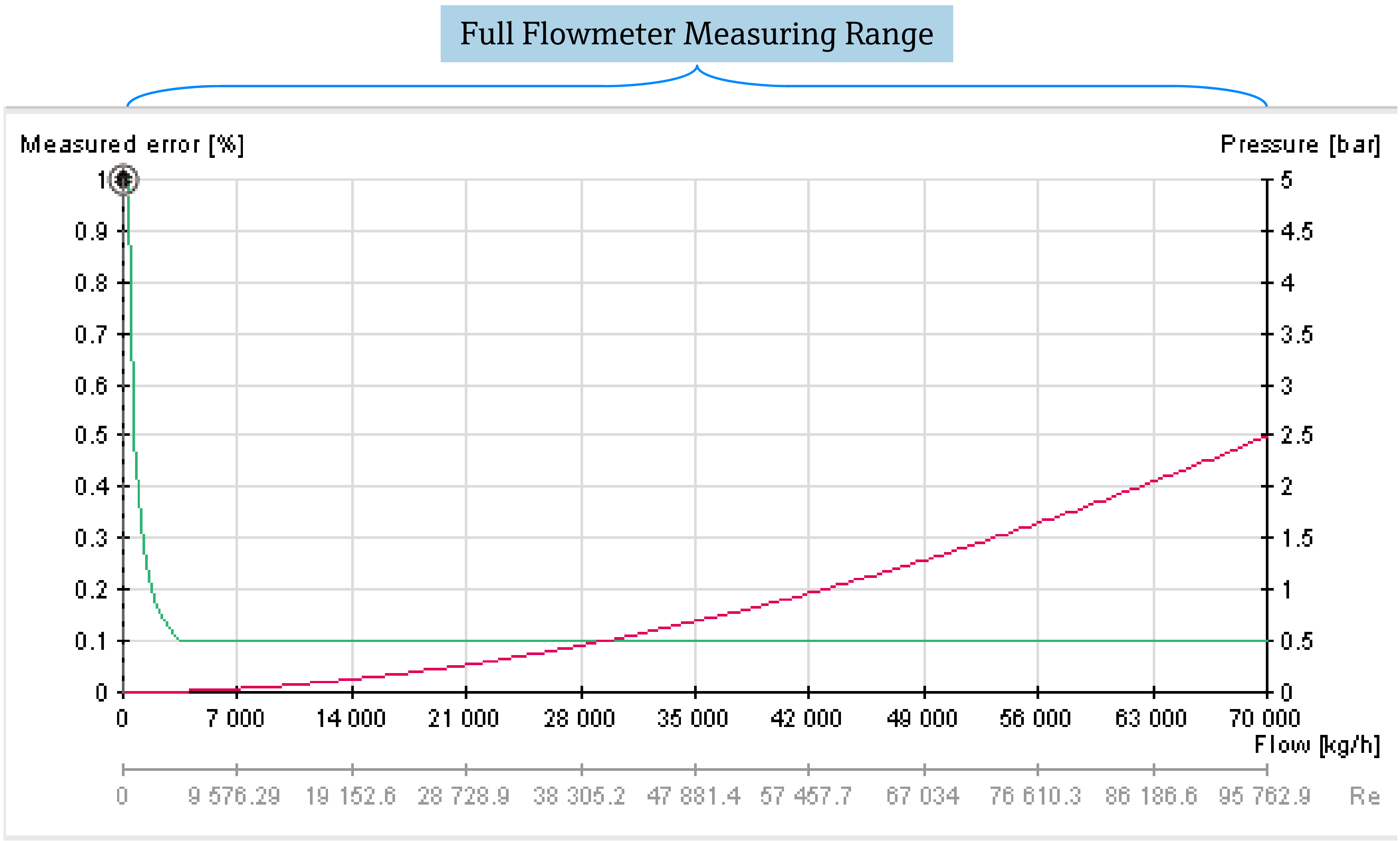
Procedure of the sizing process

Sizing is the compromise of:

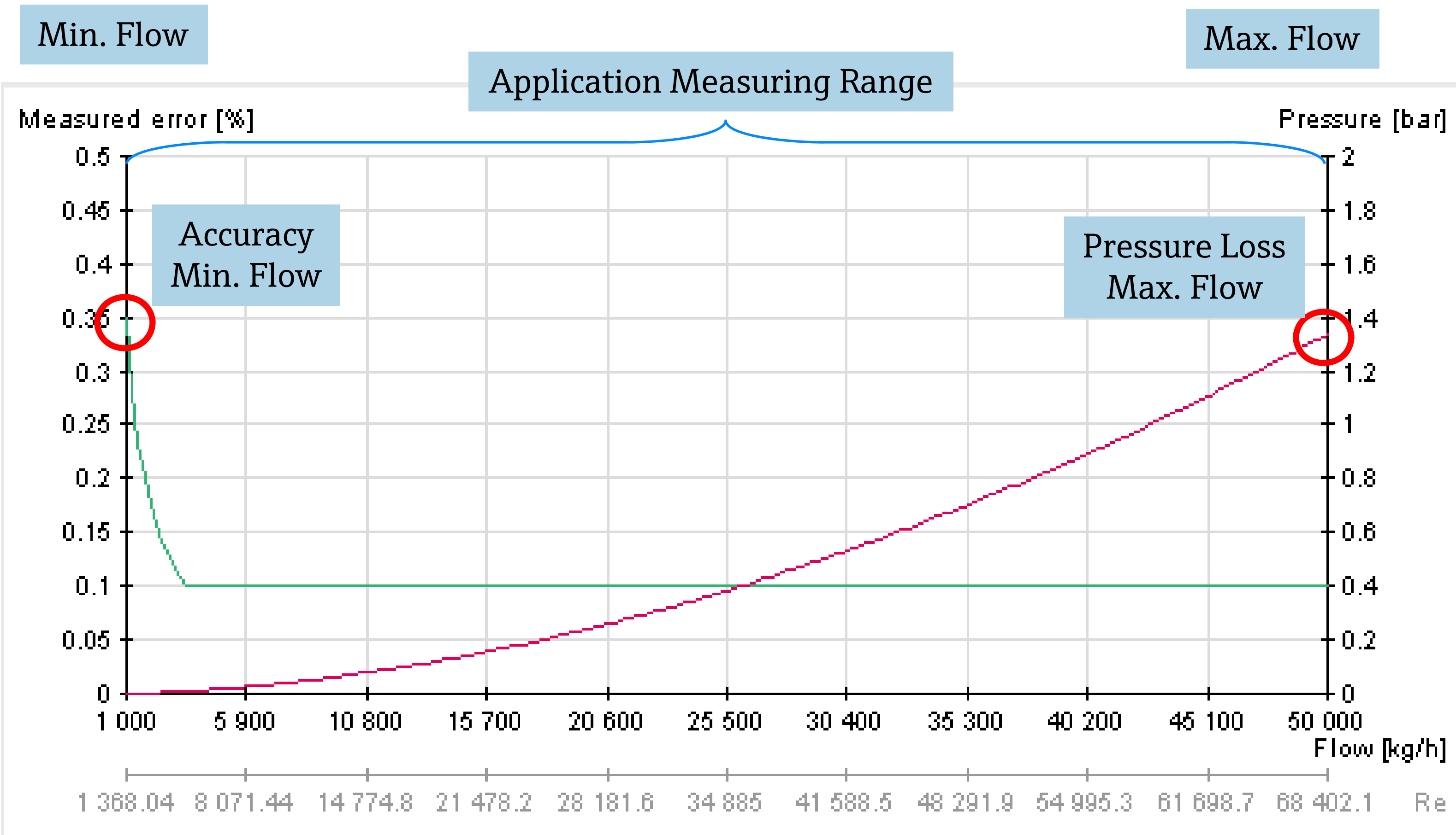
Accuracy at minimum flow rate
vs.
Pressure loss at maximum flow rate

- 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

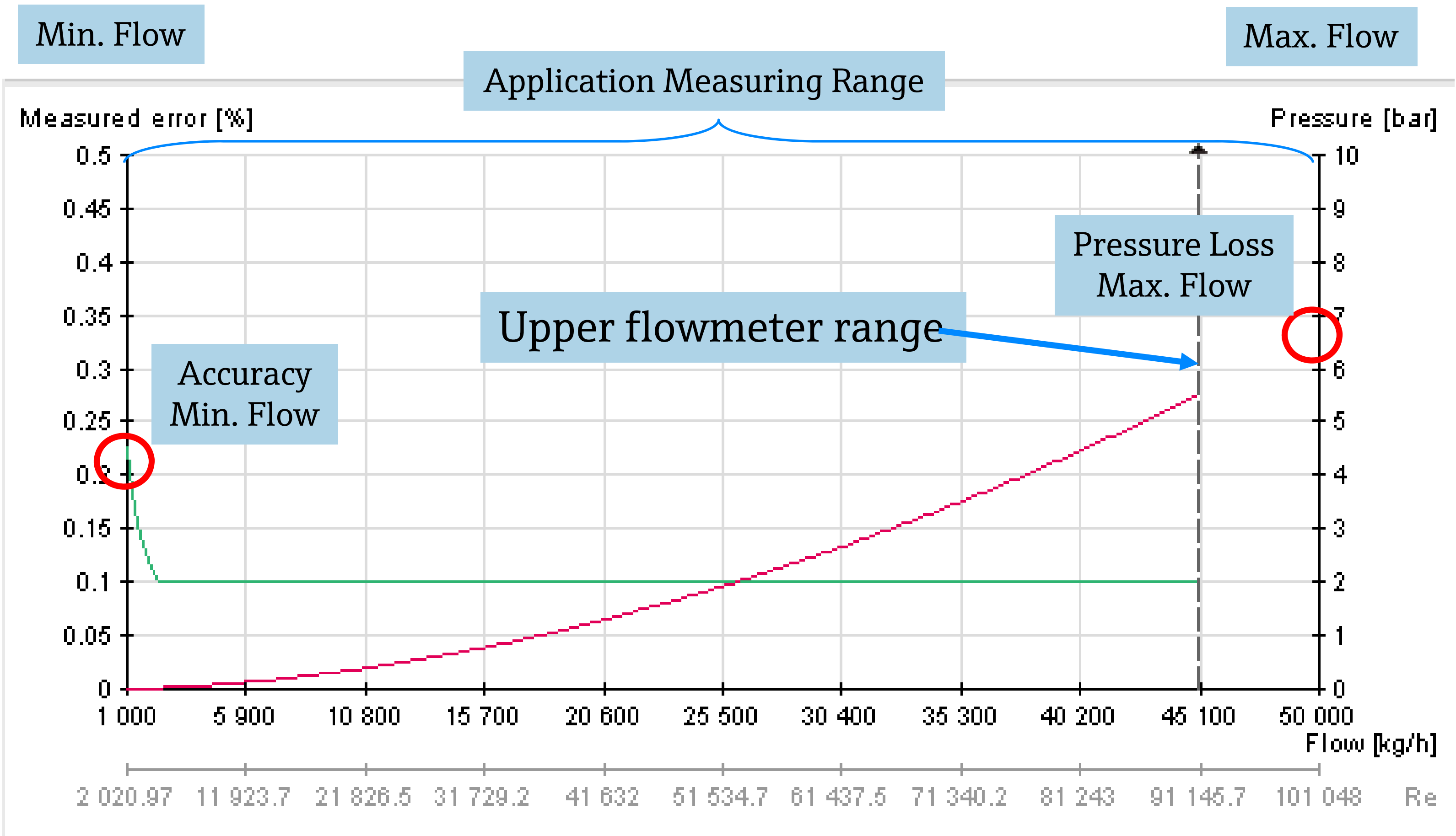


Accuracy vs. Pressure Loss for Ideal DN



Best compromise solution

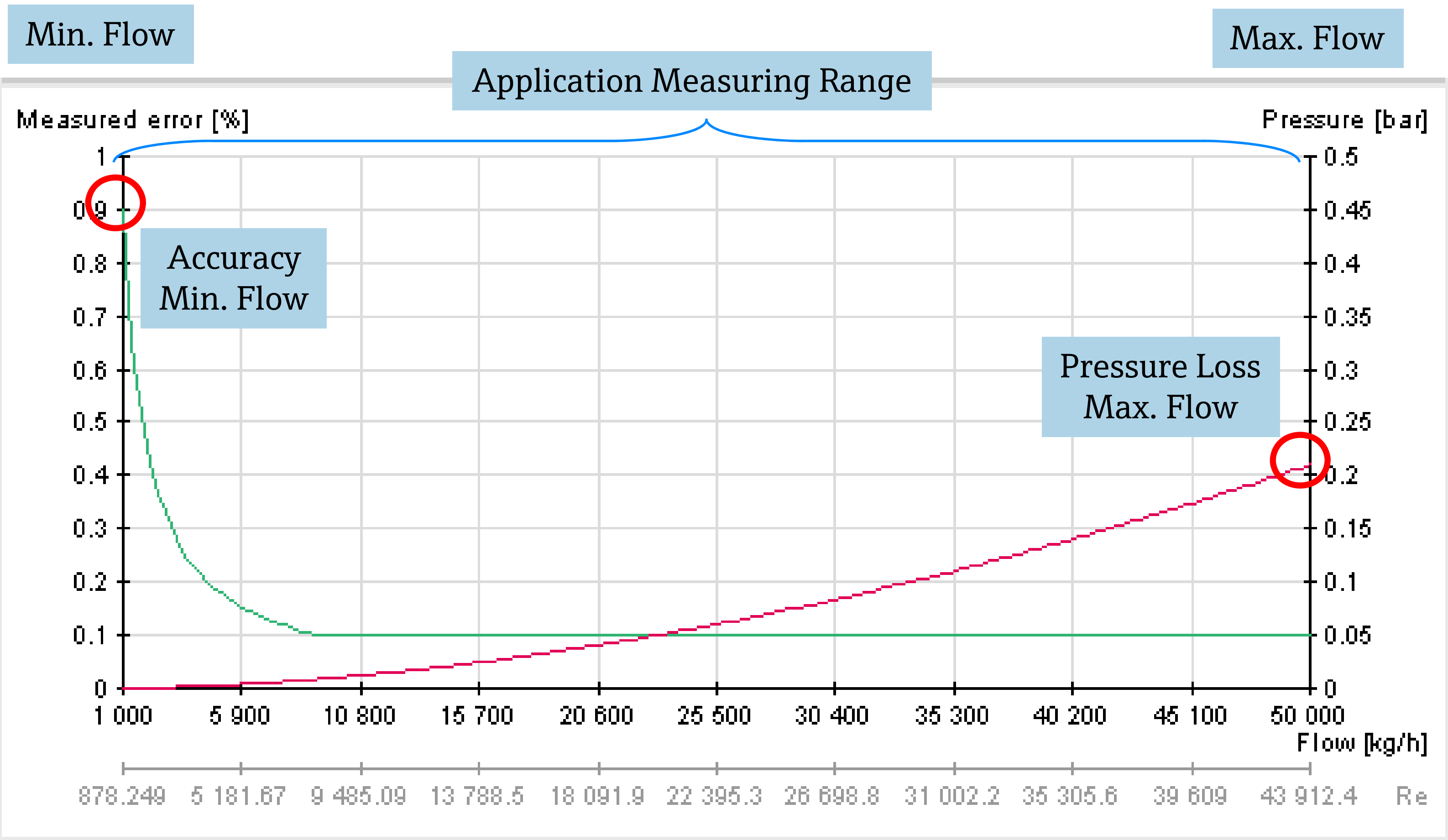
Accuracy vs. Pressure Loss for DN 40



Optimized solution for high accuracy

FG050BPEC

Accuracy vs. Pressure Loss for DN 80



Optimized solution for low pressure loss

Endress+Hauser

TriSize Function for Comparison of DN

Pressure Loss

vs.

Accuracy

Trisize Display

Update current size from 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.	5.7[illegible] m/s	**2.61[illegible] m/s**	1.078 [illegible]/s
Velocity (meas. tube) at req. Flow max.	28.5[illegible] m/s	**13.0[illegible] m/s**	5.391 [illegible]/s
Measured error Vol. at req. Flow min.	0.26[illegible] %	**0.41[illegible]**	1.05 %
Measured error Vol. at req. Flow nom.	0.1[illegible]	**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 erro	0.1 % / 0.05 %	**0.1 % / 0.05 %**	0.1 % / 0.05 %
Reynolds No. a	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.		

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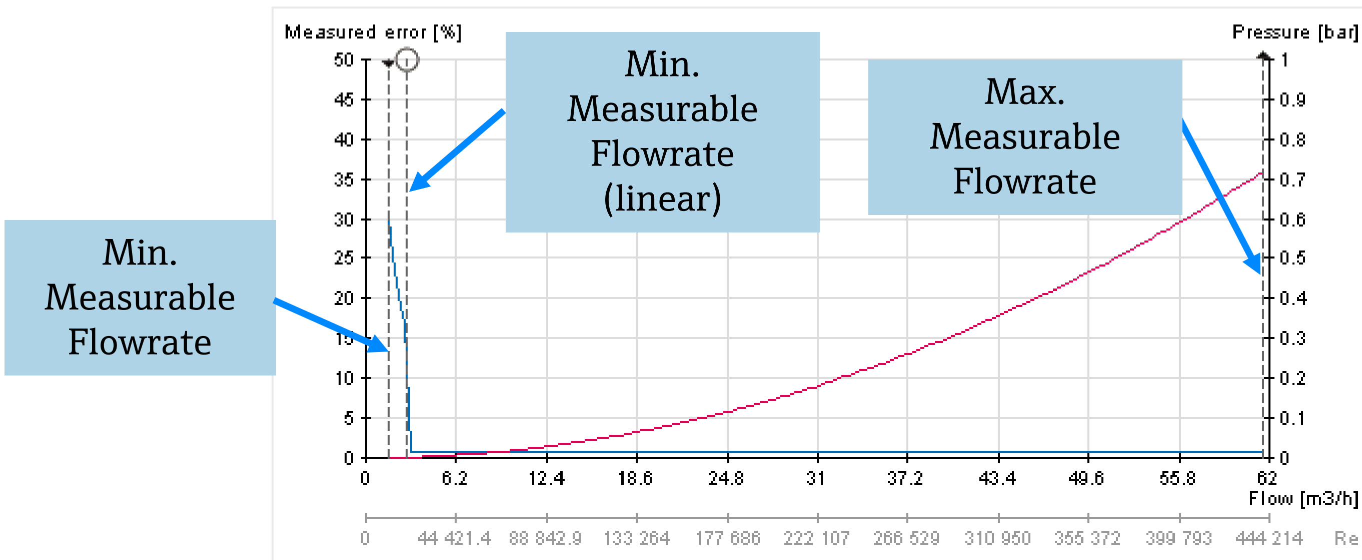
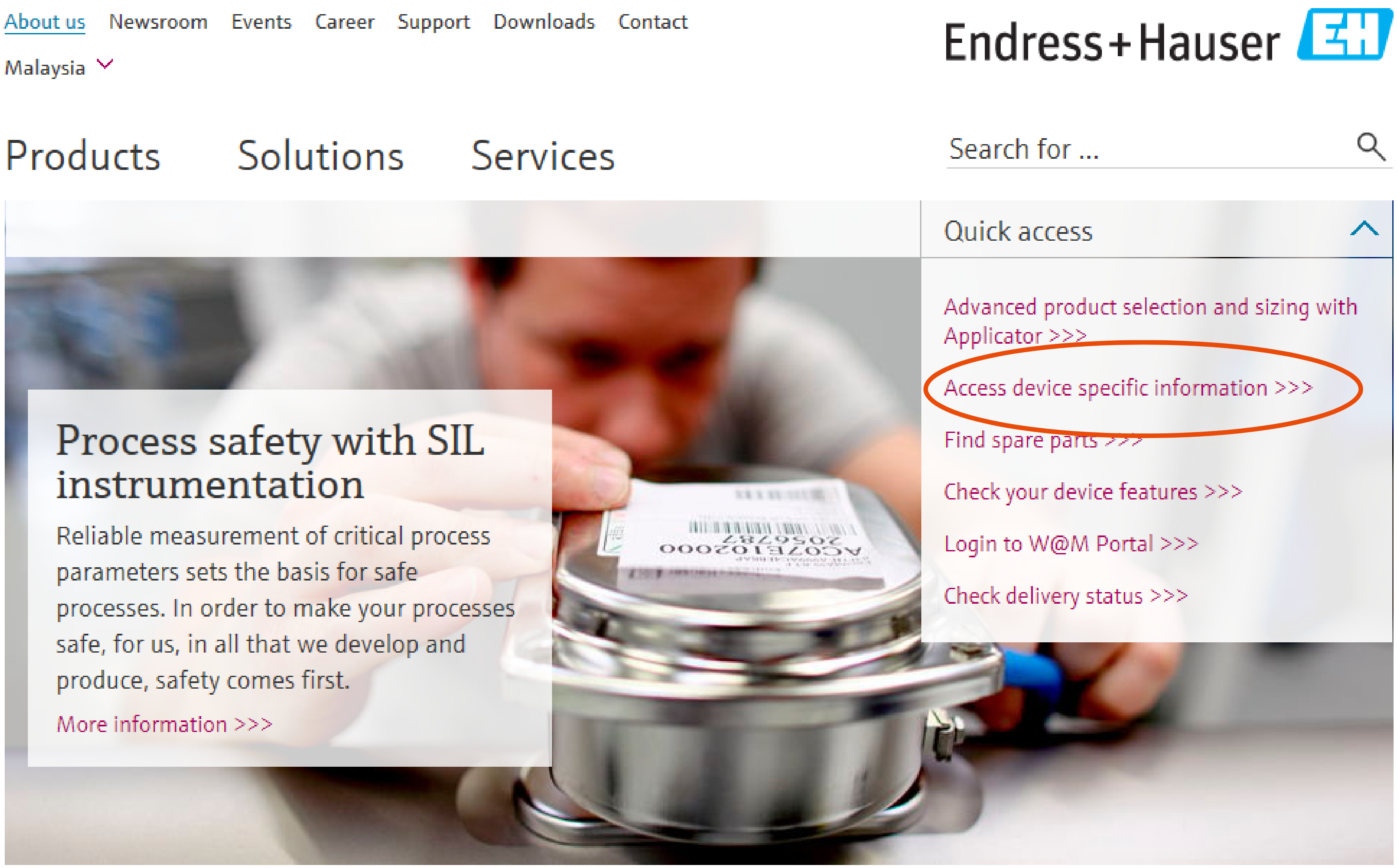
Special Case: Vortex Flowmeter

- 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

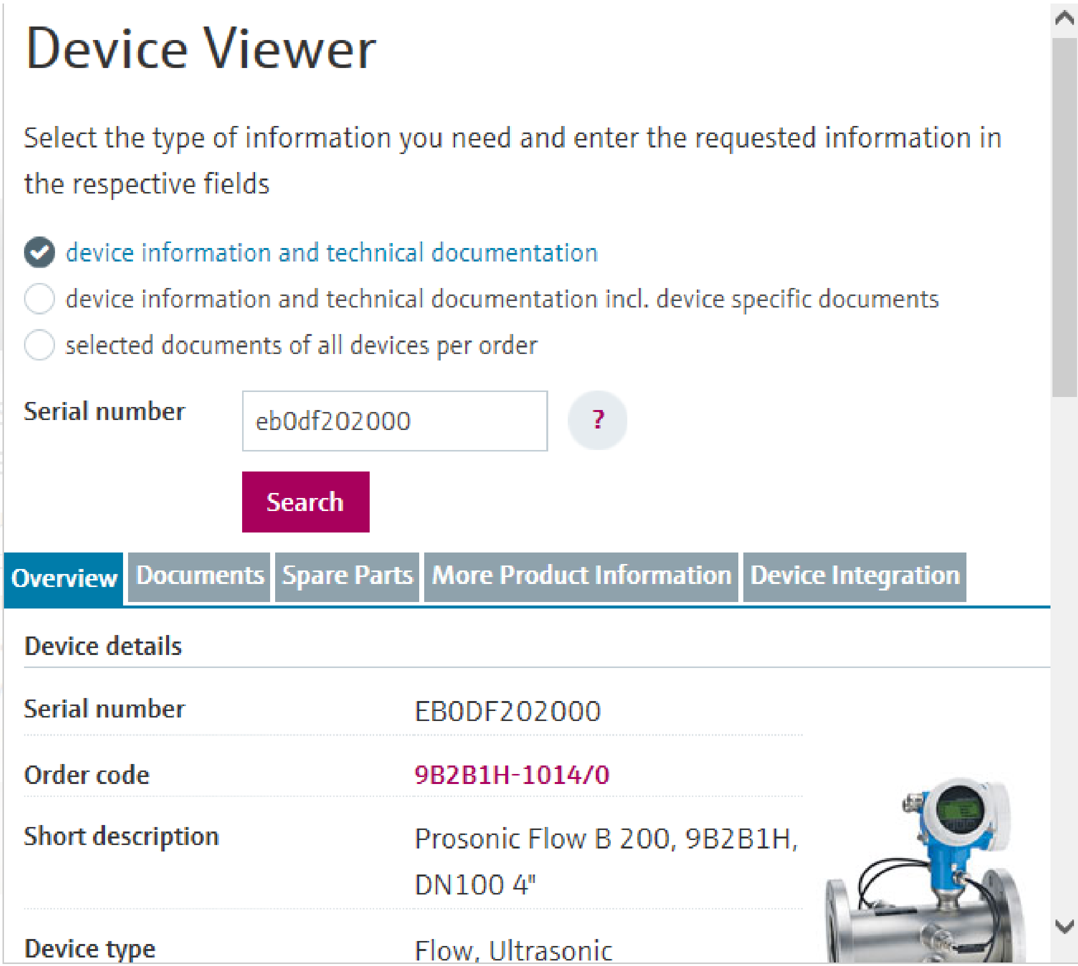


Measuring Range Prowirl 72F DN50 for Water

Device Specific Information



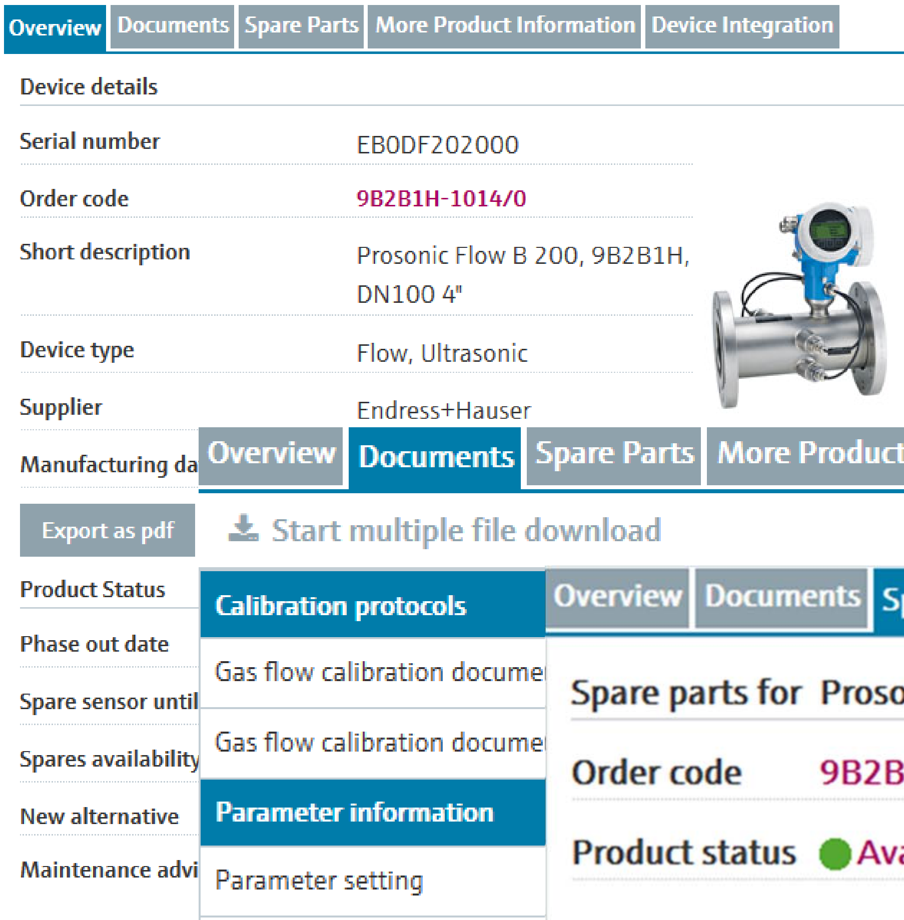
Device Specific Information

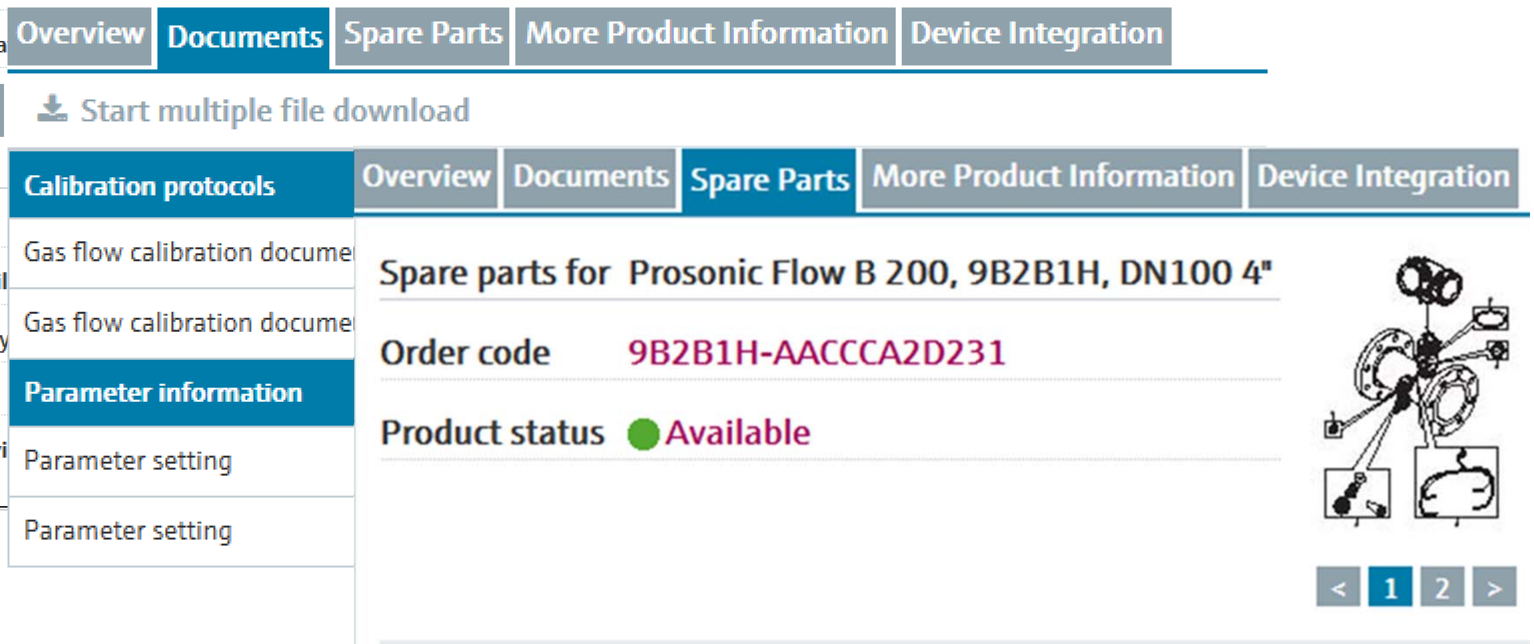


- Obtain device information by entering serial number or order number

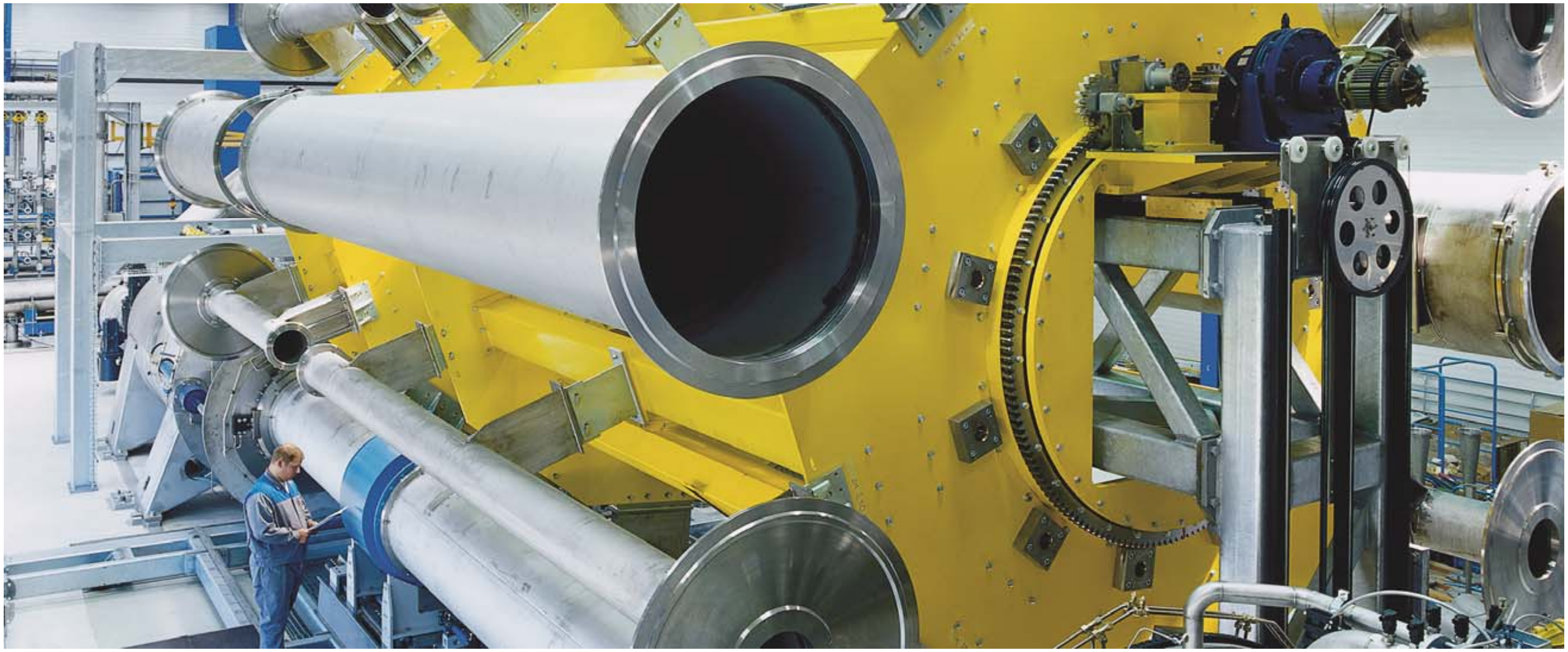
What's in Device Specific Information?

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





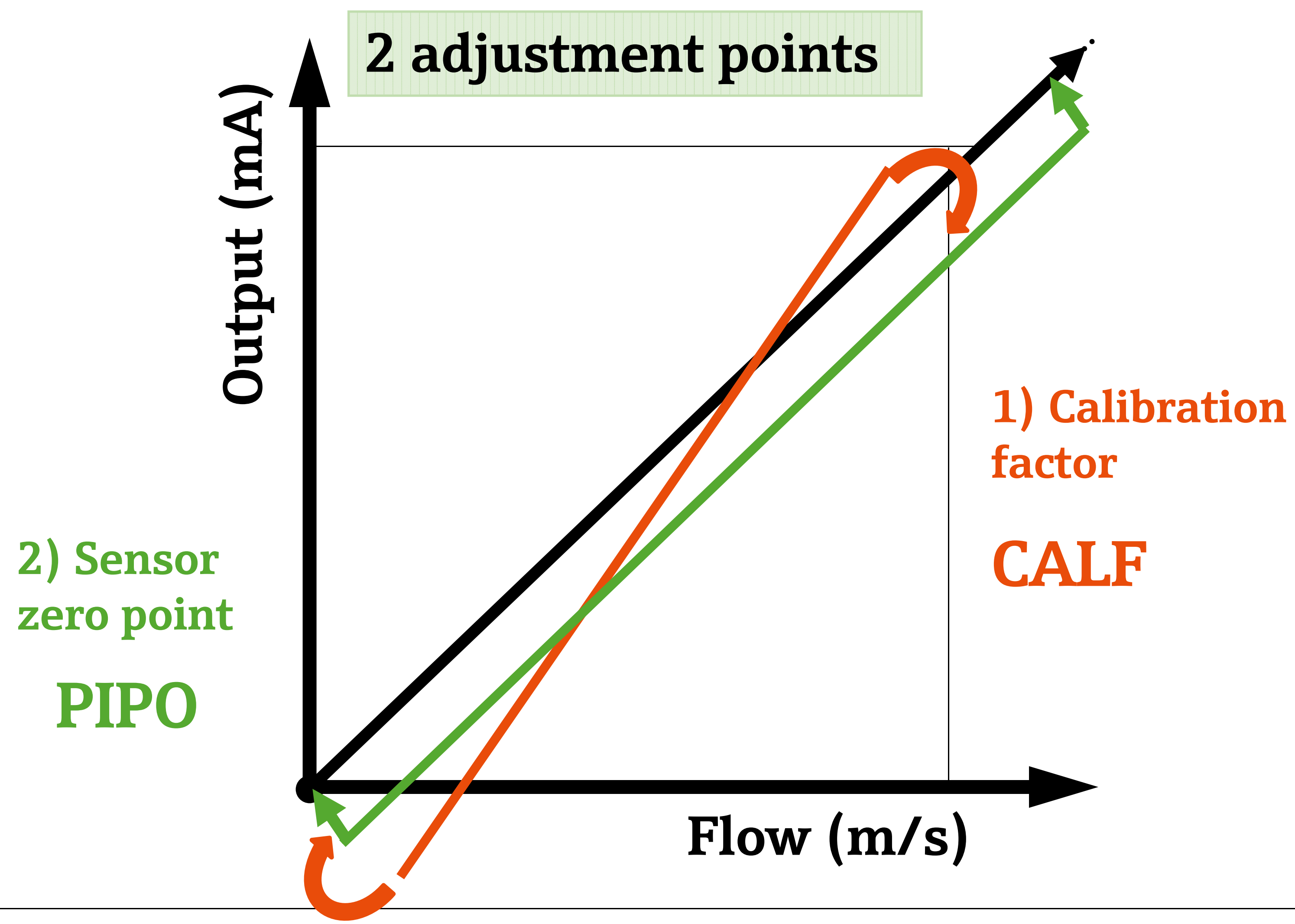
Calibration



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



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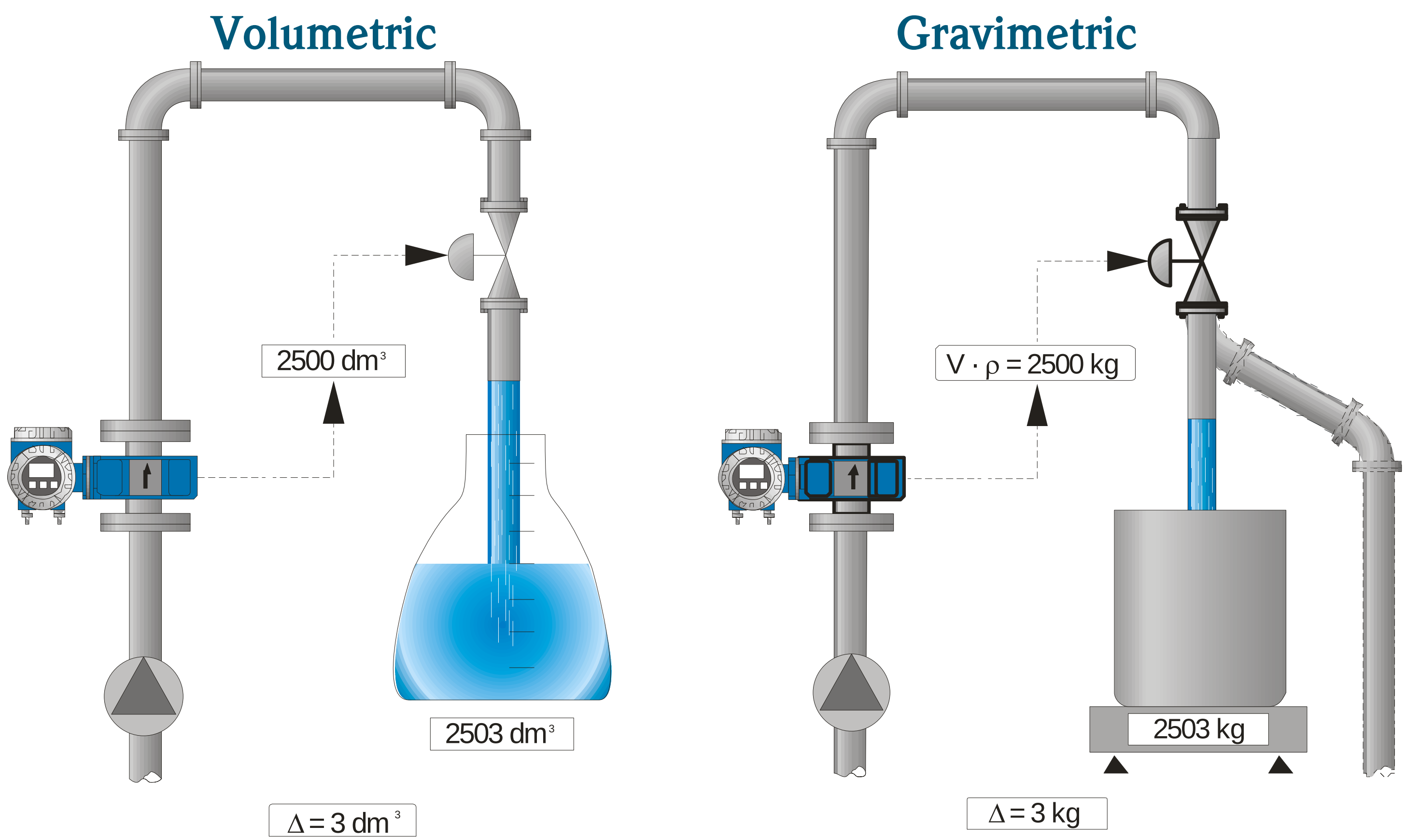
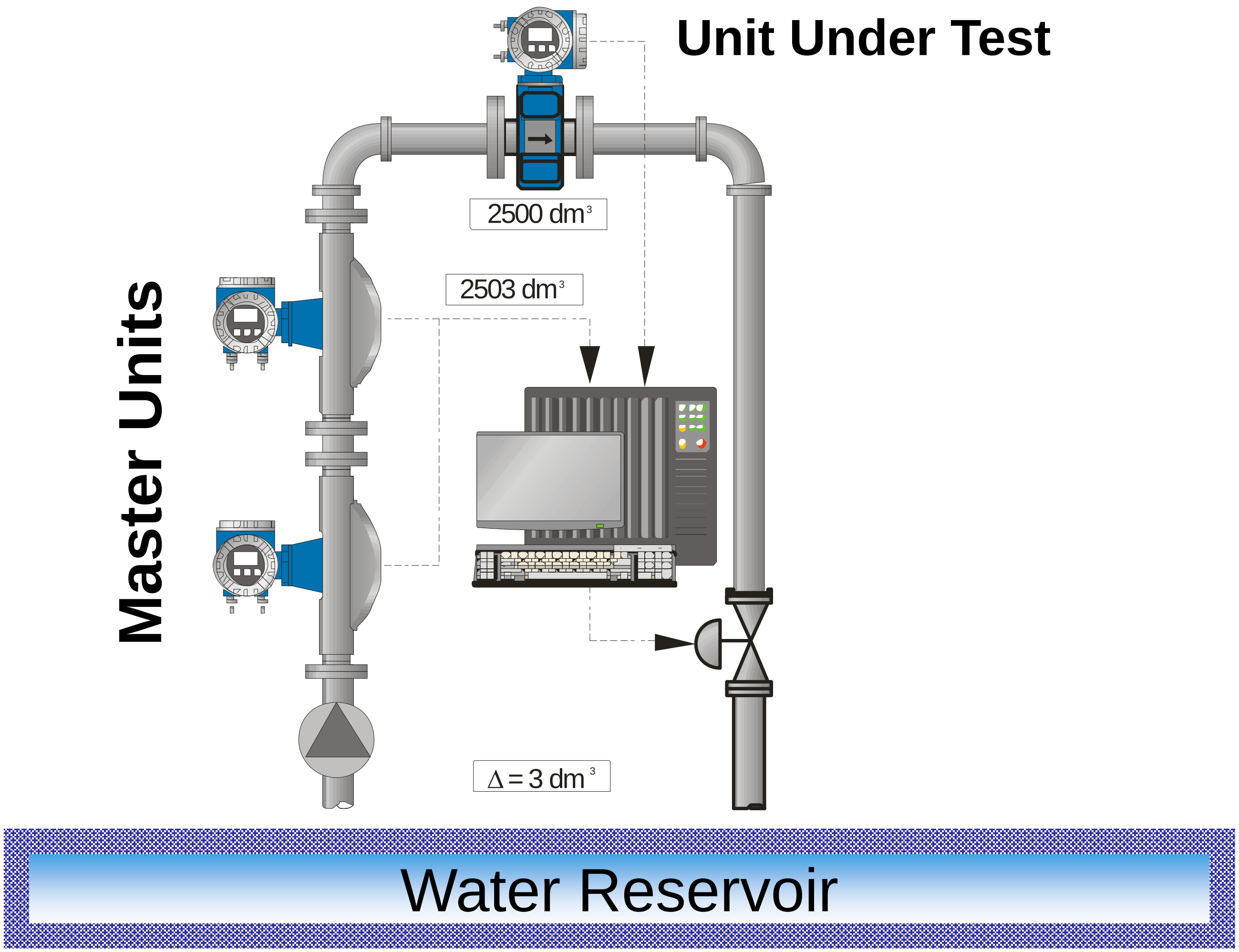
Calibration methods – primary calibration method



Certified volume **Certified scale**

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 — Coriolis	Secondary Calibration Method
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!

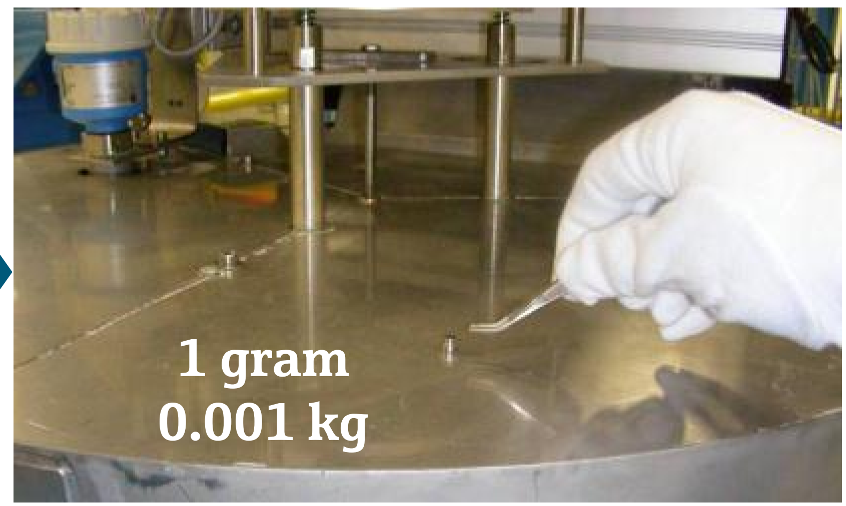
- Improved accuracy from ±0.05% to the new level of ±0.015%
- Through the advancement and progression of two existing rigs each in Reinach and Greenwood
- Accredited to ISO/IEC 17025 by the Swiss accreditation body (SAS) in Bern (August 2007)
- March 2009: A2LA accreditation for second, identical PremiumCal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

- Electro polished certified weights accuracy class F2 with 0.8 g/50 kg ➡ ±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

Standard Kilo at (BIPM) Paris

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

National Standard Kilo of METAS

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

Gravimetric scale of E+H Flowtec

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

PremiumCal rigs in Reinach and Greenwood

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

Meter accuracy

Promass 83/84F DN 08 – 400

Premium Calibration +/-0.05%

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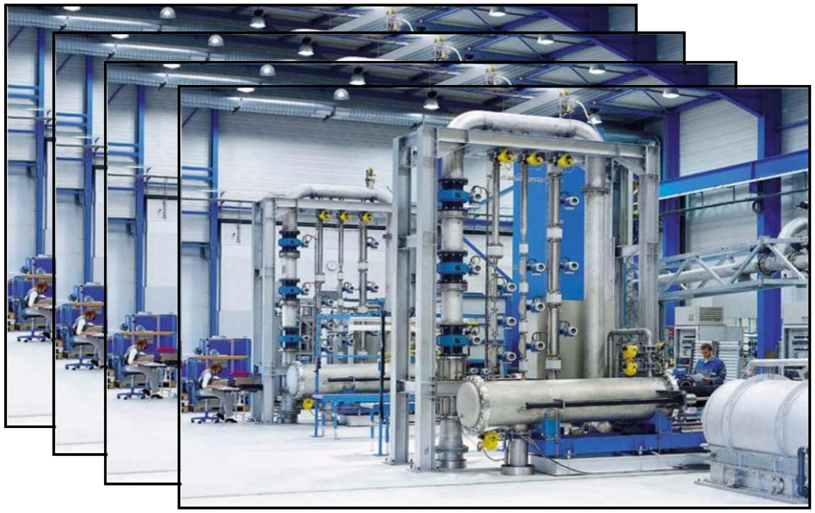
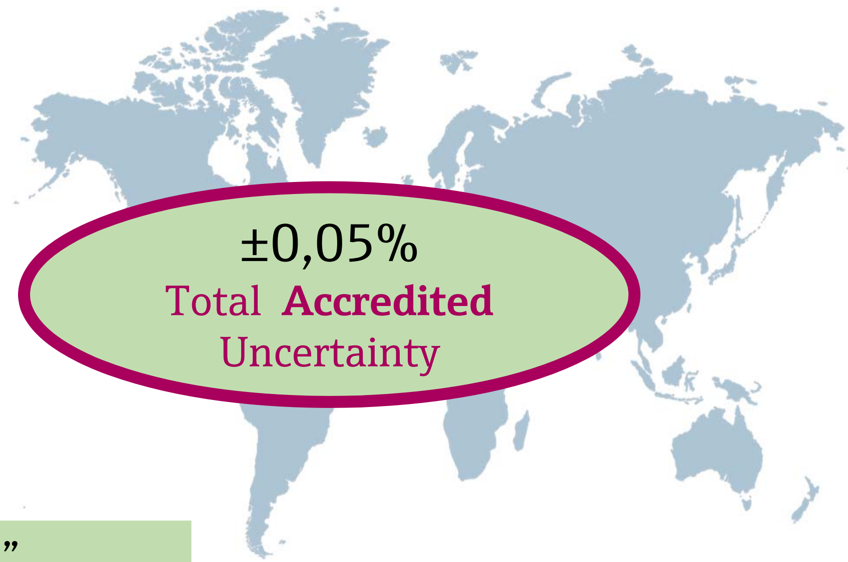
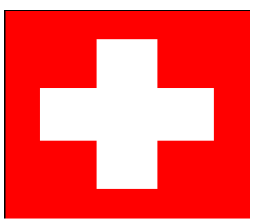
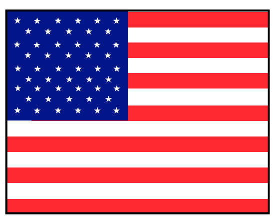
Endress+Hauser: World wide use of primary calibrations





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

SAS		A2LA		SAS		CNAS
	≡		≡		≡	
Reinach/Cernay		Greenwood		Aurangabad		Suzhou

Any Questions?

Thank you very much for your attention