

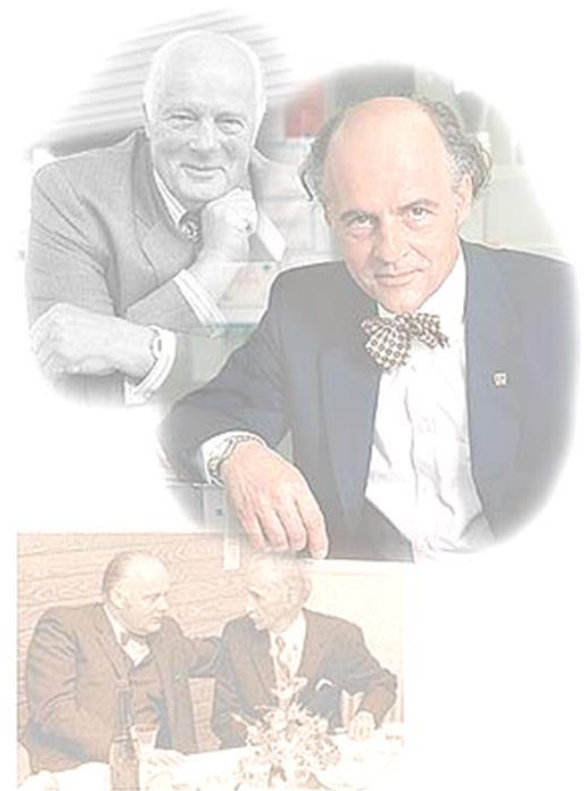
Capacitance Measurement Technology

Basic sales training



60 years of experiences

60 years of experiences in capacitance instrumentation with more than 3.000.000 measuring points world wide.



Capacitance product basket

Nivector



Solicap M



Solicap S



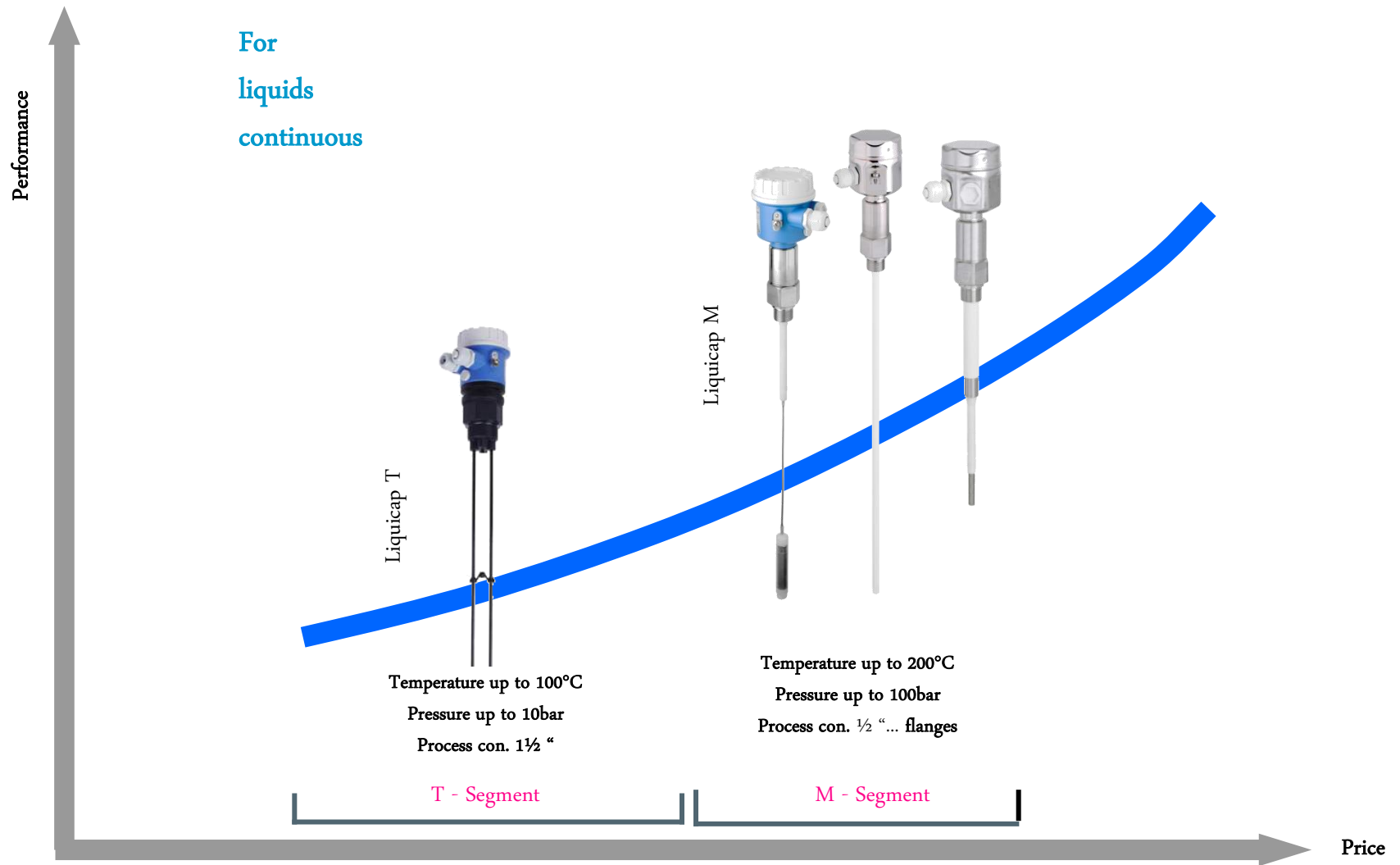
Liquicap T /M



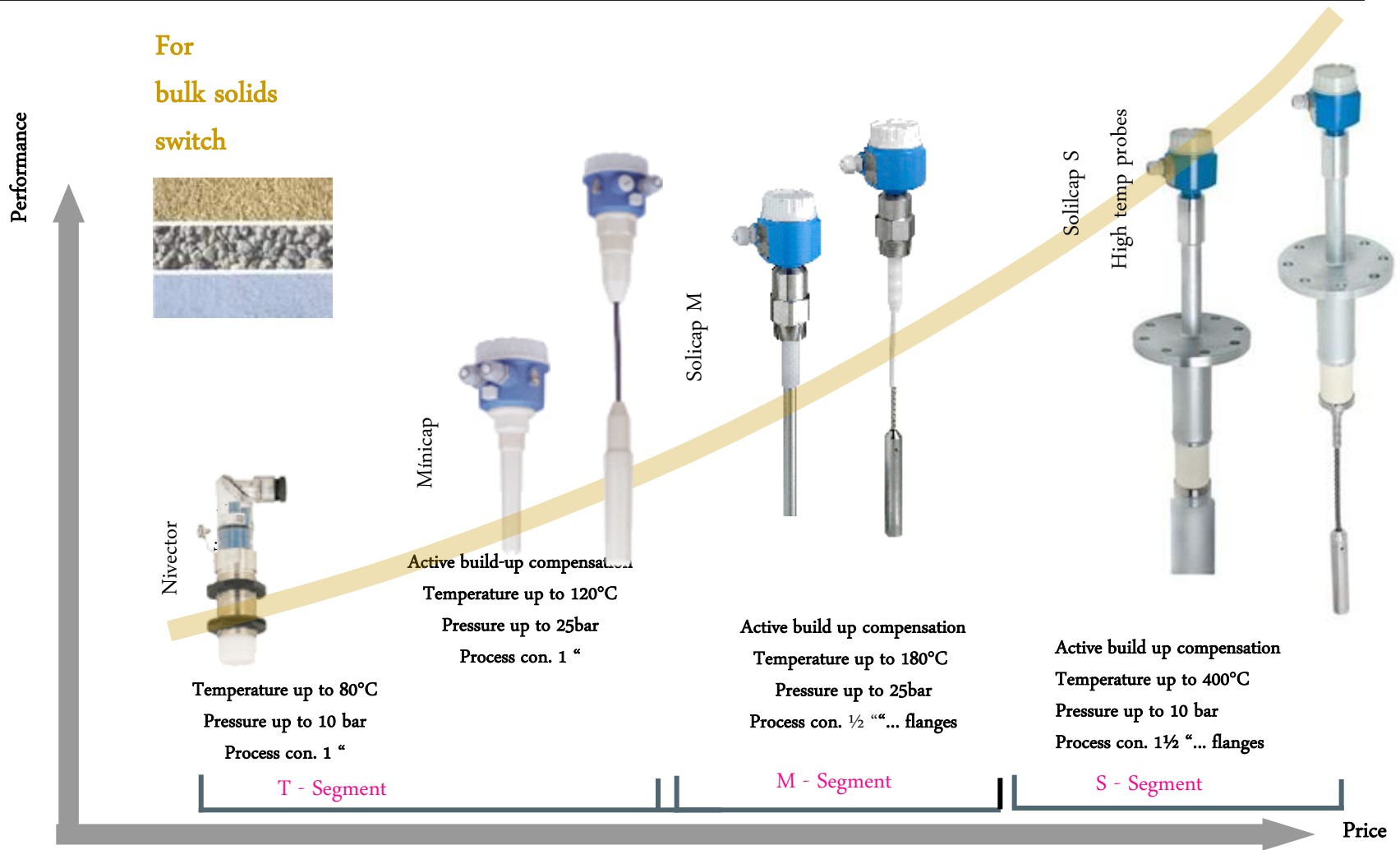
Minicap








Capacitance probes for liquids



Capacitance probes for bulk solids

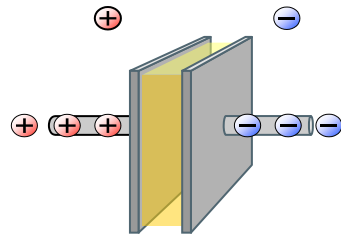


Capacitance Product Portfolio

Continuous liquids		Switch liquids		Switch bulk solids	
<p>Liquicap T FMI21 > FEI20</p> 	<p>Liquicap M FMI51/52 > FEI5x</p> 	<p>Liquicap M FTI51/52 > FEI5x</p> 	<p>Solicap M FTI55/56 > FEI5x</p> 	<p>Solicap S FTI77 > FEI5x</p> 	

Capacitance Basics

Basics – Capacitance measurement



Two metal plates build a capacitor.
Between these plate a electrical field is built!

Distance between the electrodes (d)

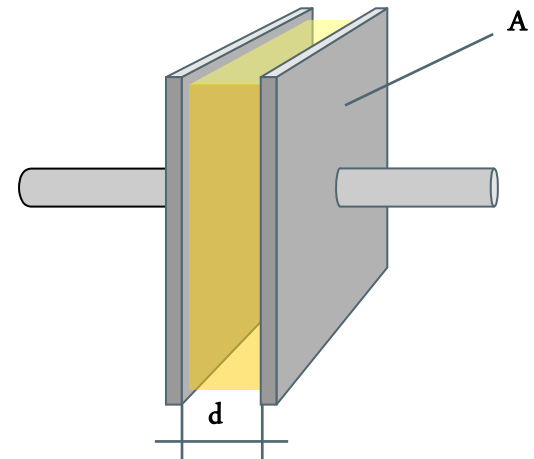
Dimensions of the electrodes (A)

Dielectric between the electrodes (ϵ_r)

$$C = \frac{\epsilon_0 \cdot \epsilon_r \cdot A}{d}$$

ϵ_0 : electrical field constant
: $8,854 \cdot 10^{-12}$ C/(Vm)

ϵ_r : permittivity, dielectric constant



Basic capacitor principle

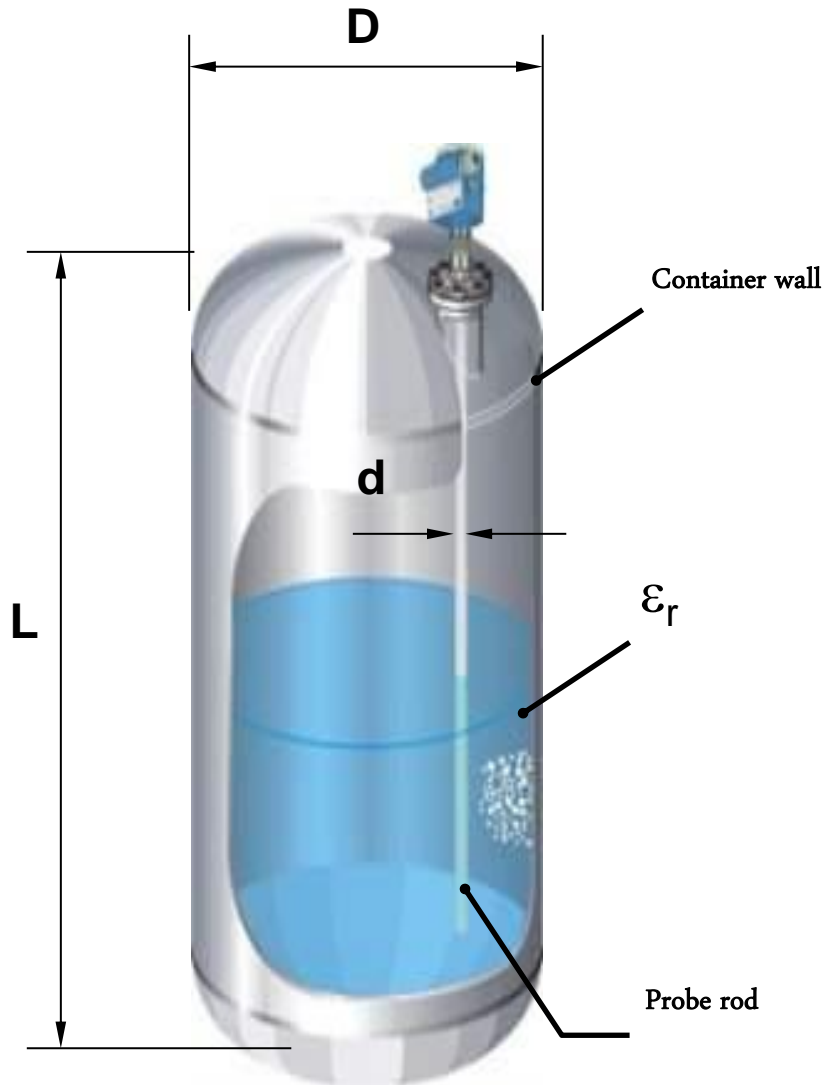
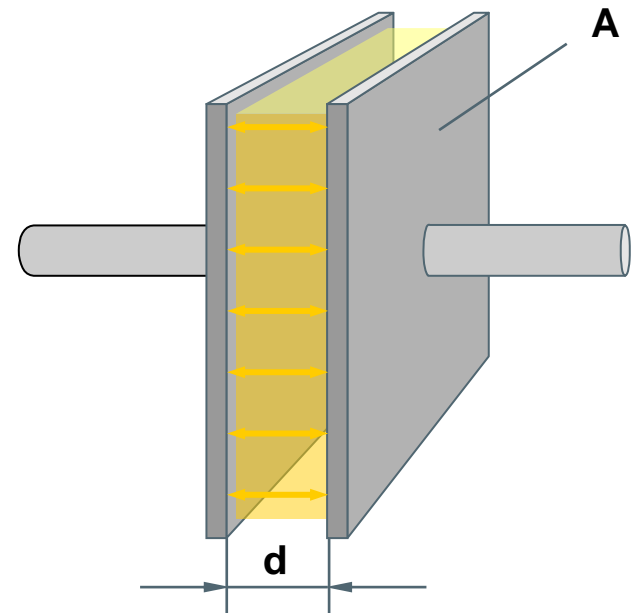
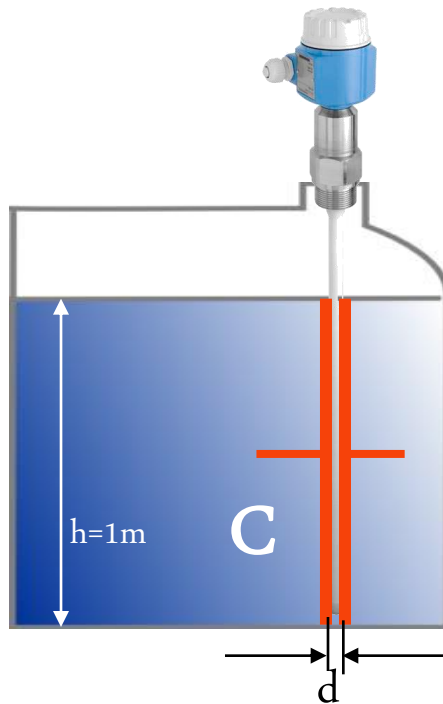


Plate capacitor model



$$C = \frac{2\pi \cdot \epsilon_r \cdot \epsilon_0 \cdot L}{\ln(D/d)}$$

Conductive Liquids > 100 $\mu\text{S}/\text{cm}$



Conductive liquids

- Water base liquids
- Acids and lyes
- Beverage and food
- Water waste-water
- Emulsions
- Dispersions

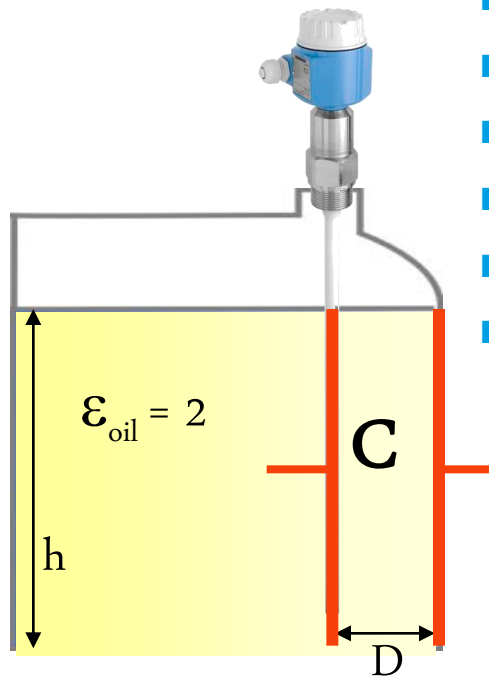
Dielectric constant:
 $\epsilon_{\text{PTFE}} = 2$

Changing of the dielectric constant and conductivity of the Liquid has no influence of the measurement value

Non conductive Liquids

Non conductive liquids ($<1\mu\text{S}/\text{cm}$)

- Petrol
- Oil
- Solvents
- Hydrocarbonat
- Pure alcohol
- Distilled water



Dielectric constant:
 $\epsilon_{oil} = 2$

Changing of the dielectric constant has proportional influence of the measurement value

Continuous level measurement in liquids

Application Strength of Capacitance

- Applications involving continuous level and interface measurement in liquids
- Capacitance continuous level measurement in liquids completing the TOF portfolio
 - Features
 - Very fast measurement time (0,3s)
 - Especial for small tanks (no blocking distance)
 - Unaffected by obstacles
 - Easy commissioning in conductive products (factory calibrated)
 - Interface measurement
 - Price economic solution

Liquicap T FMI21 for continuous measurement in liquids

Technical data FMI21

- Length of probe: 150...2500mm (shortable)
- Probe rods: 316L/1.4404 PP coated
Optional carbon fibre PP coated
- Process pressure: -1...10bar
- Process temperature: -40°C ... 100°C
- Medium conductivity: >30µS/cm (independent of DC)
- Ambient temperature: -40°C ... 70°C
- Accuracy: < 1 %
- Degree of protection: IP66
- Output: 4...20mA
- Supply voltage: 10...30V DC
- Approvals: ATEX Zone 2; General Purpose
USA/Canada;

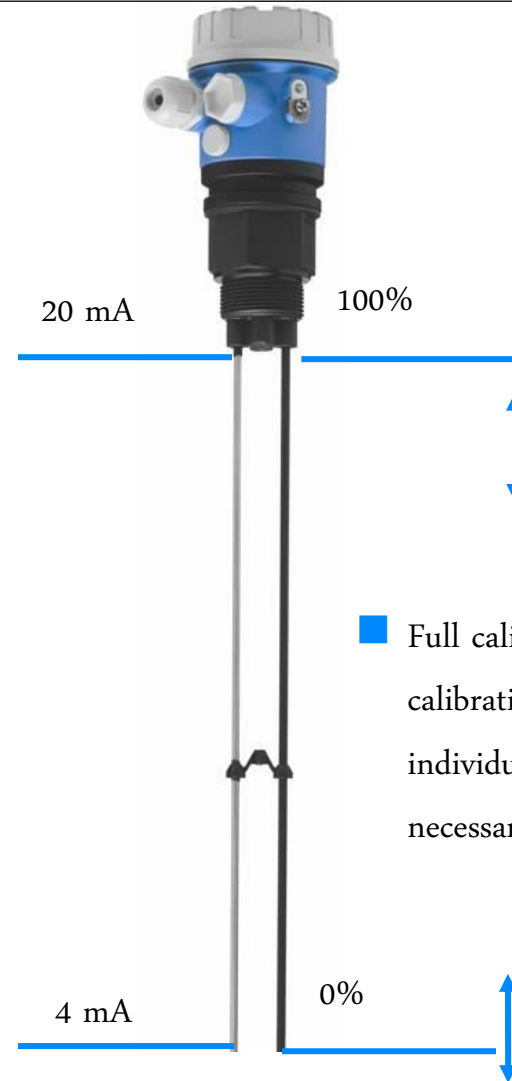


Calibration

no customer calibration required,
pre-calibration on ordered length at
the factory 0%....100%.

■ Full calibration or 20mA point at
beginning of the probe

■ Empty calibration or 4mA point at tip
of probe

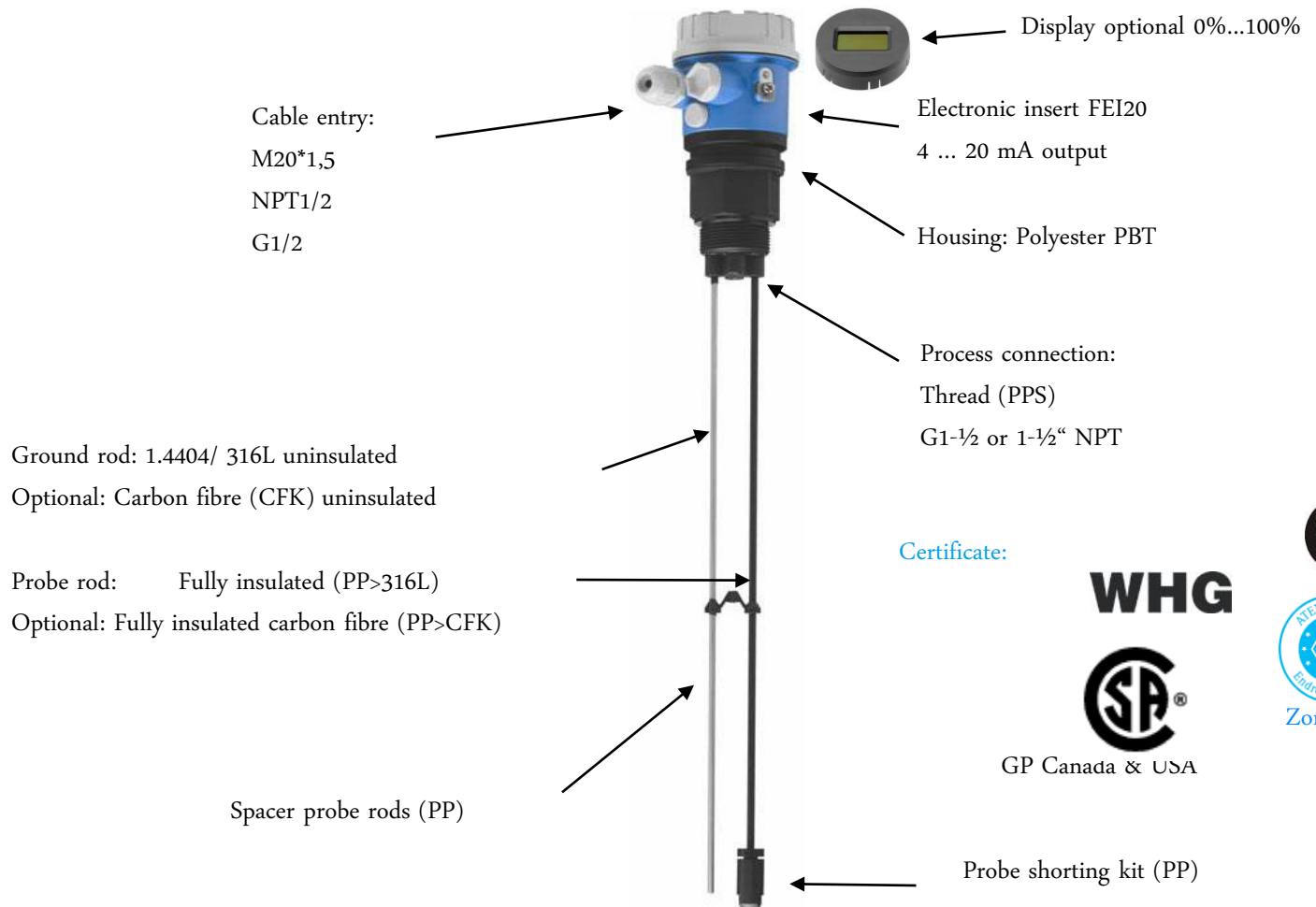


■ Full calibration or empty
calibration point can be
individually shifted by customer, if
necessary.

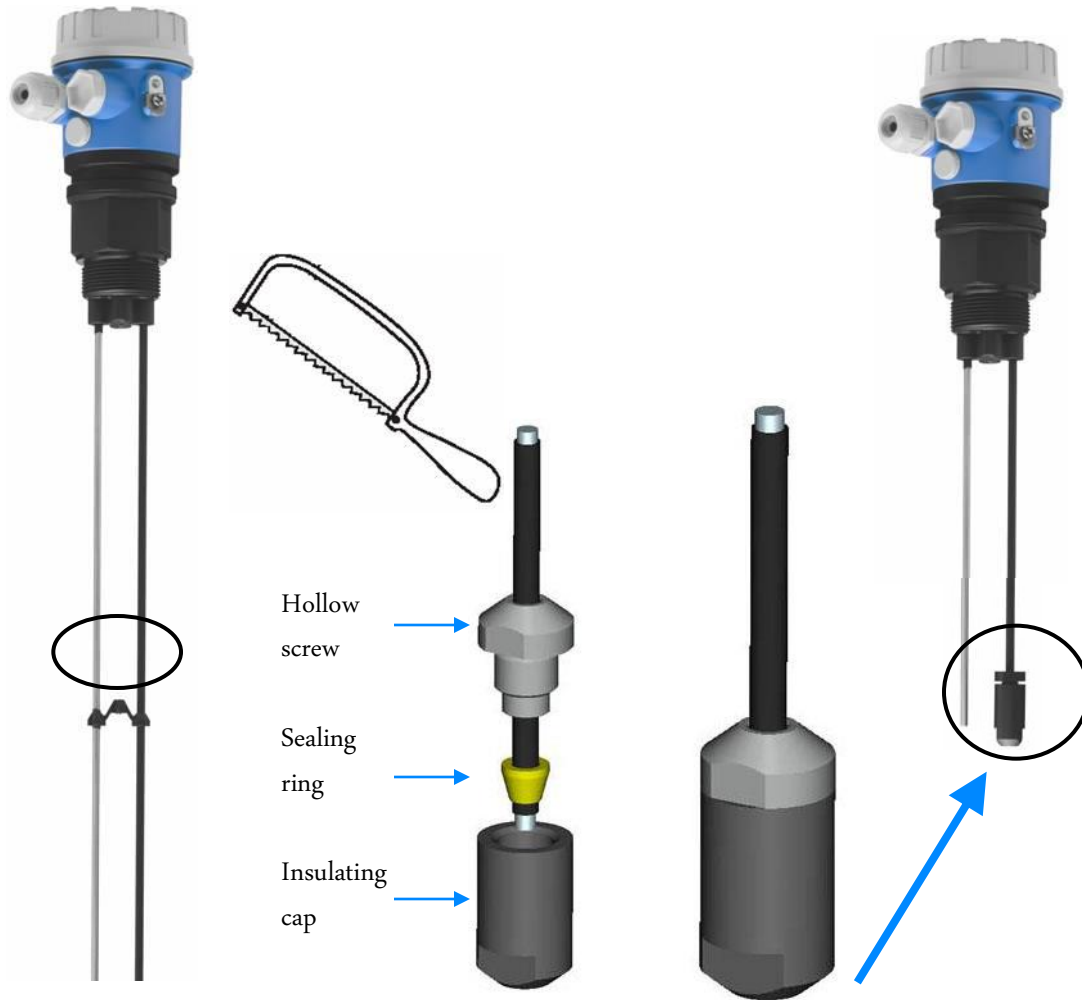
Technology – probe design



Liquicap T – double rod probe L=150...2500mm



Probe shorting kit



Customers can shorten probes as desired.

After probe shorting re-calibration is required.

Application and segmentation

- Application:

- Small storage and buffer vessels.
- Water cisterns
- In acids and caustics



Acids, alkalis

Water



- Application limits:

- Mechanical stability
(e.g. Agitator vessels)
- Non-conductive liquids (solvents...)
- Highly viscous liquids
(built up)

Liquicap M FMI51/52 for continuous measurement in liquids

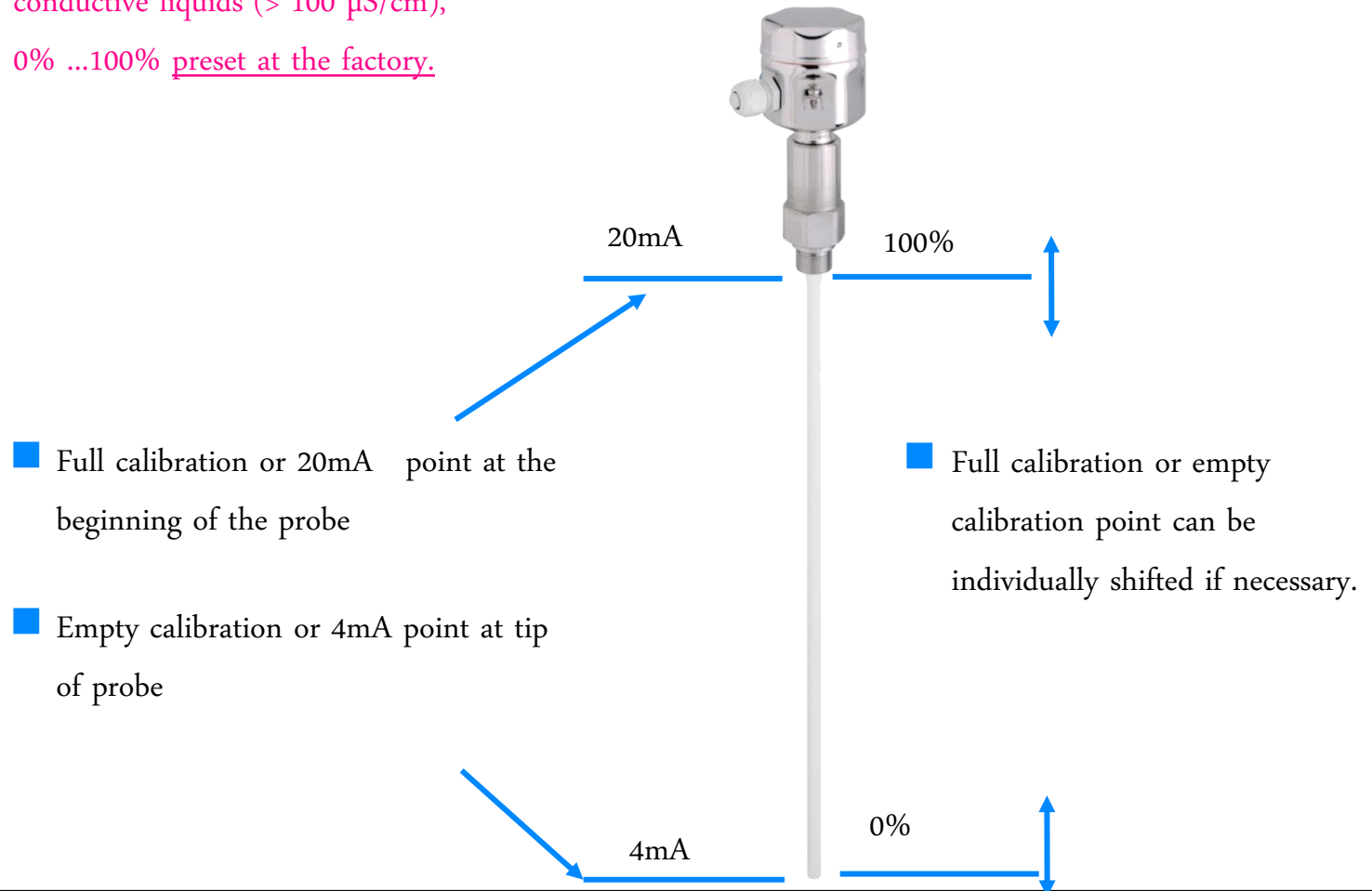
Technical data FMI51 rod probe / FMI52 rope probe



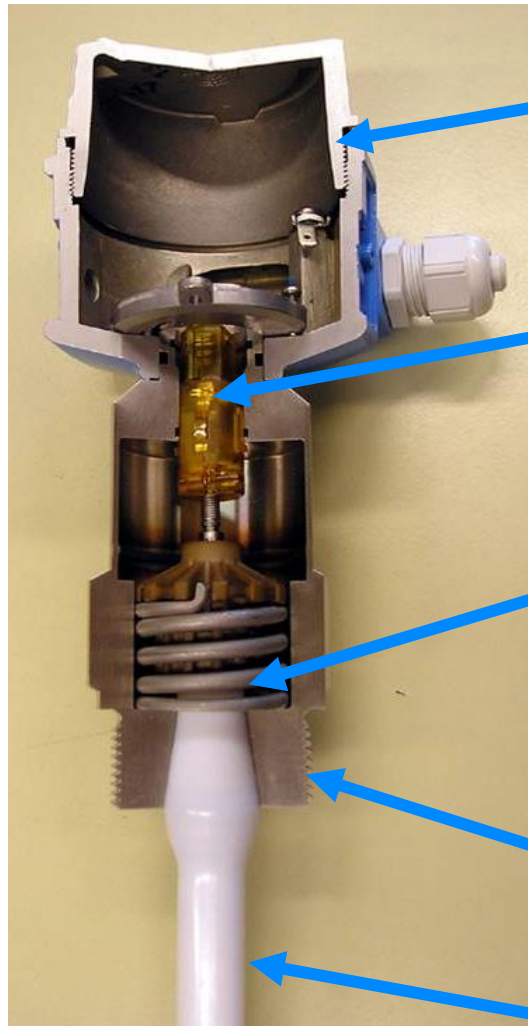
- Active probe length: 0.1...4m rod;
0.4...10m rope
- Probe material: Rod: 316L with PTFE, PFA
insulation
Rope: 316L with FEP, PFA
insulation
- Process pressure: max. 100 bar
- Process temperature: -80...+200°C
- Ambient temperature: -50...+70°C
- Measured value reaction time: 0.3 sec
- Measured value reproducibility: 0.1%
- Output: 2-wire 4...20mA Hart, PFM
- Supply voltage: 12V...36V
- Approvals: ATEX, CSA, FM, WHG, EHEDG

Calibration

No additional calibration required in
conductive liquids ($> 100 \mu\text{S}/\text{cm}$),
0% ...100% preset at the factory.



Probe design



Housing with cable gland to receive the electronic insert

Sensor plug (DAT) with overvoltage protection and configuration memory

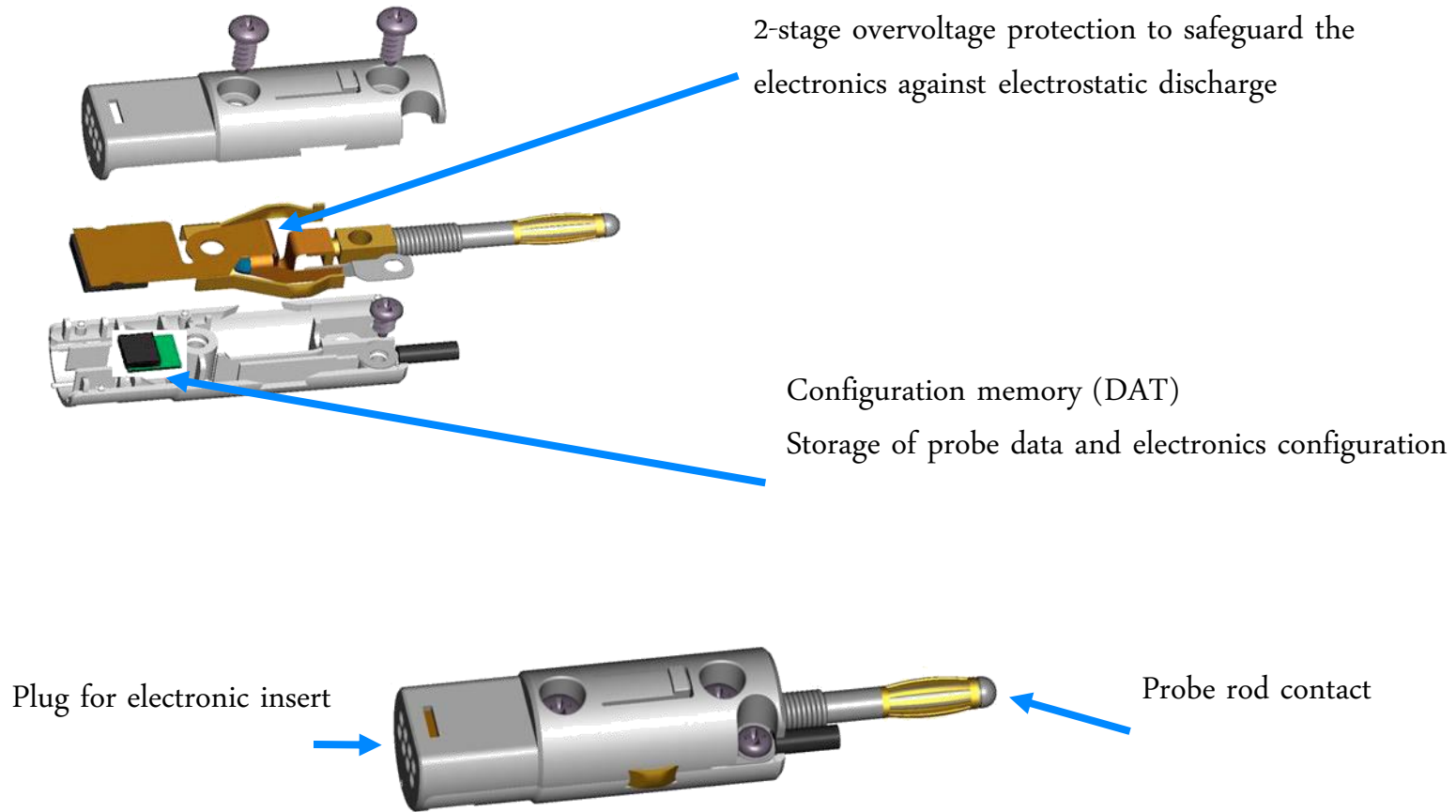
Compression spring safeguards long-term stable tightness

Optional with additional gas-tight feed-through

Process connection with probe rod cone seal

Fully insulated probe rod PFA/PTFE > 316L

Probe design - Connection plug probe electronics



Probe design – gas tight feed trough

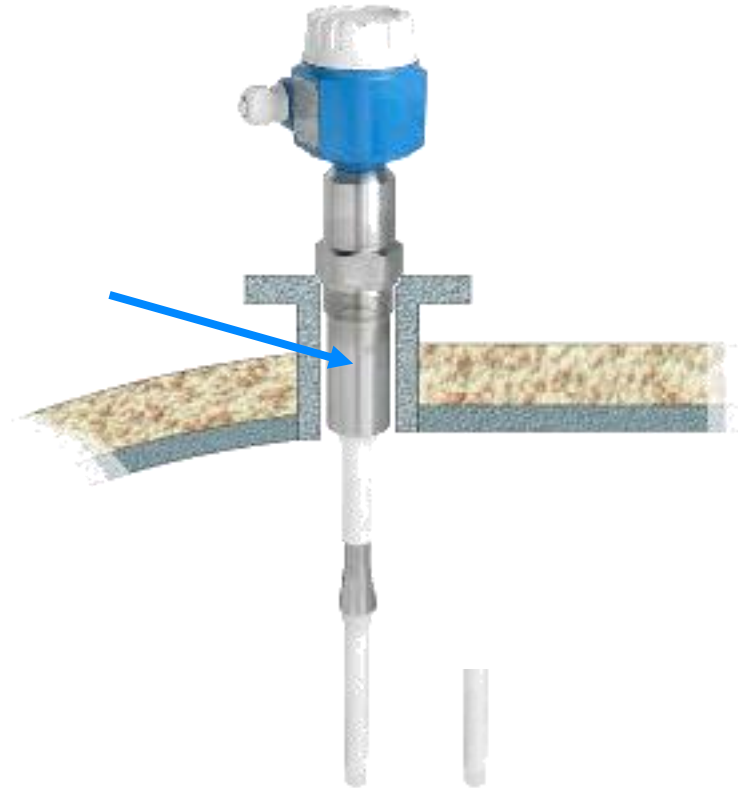
Gastight glass feed through > protection
against aggressive or toxic media (optional)



Inactive length

- Bridging of mounting nozzles
 - Safe switching even with condensate in the area of the nozzle
- Condensate at the tank ceiling

Inactive length

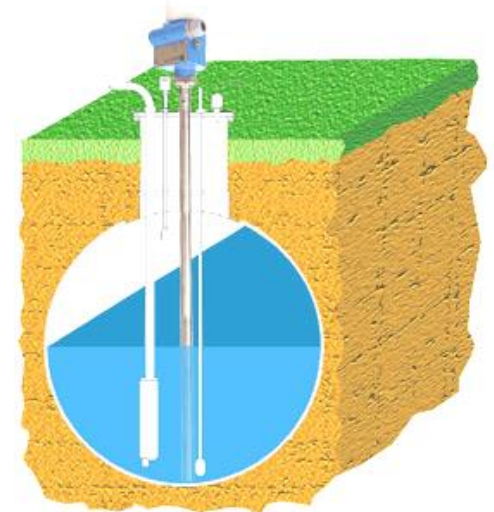
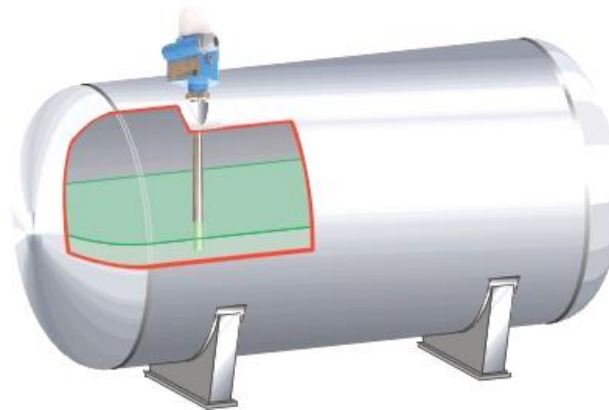


Probe design – Ground Tube



Applications:

- to increase sensitivity in media with low dielectric constant (factor 5)
- As reference potential in non-metallic containers
- To increase lateral stability in tanks with agitators
- For continuous level measurement in horizontal, cylindrical and spherical tanks



Level measurement commissioning via FieldCare

The capacitance level calculation program “CapCalc” integrated into Fieldcare calculates customized calibration values.

Endress+Hauser GmbH+Co. KG
 Hauptstraße 1
 79689 Maulburg
 Germany



19.07.2005

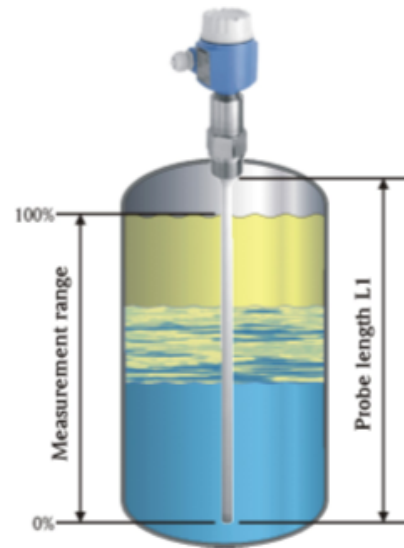
Customer: Muster GmbH+Co. KG
 Customer-No.: X0815
 Street: Musterstraße 5
 ZIP-Code/Town: 12345 Musterstadt

Attention: Hans Mustermann
 Phone: 0815 - 12345
 Fax: 0815 - 6789
 Reference: Trennschichtmessung
 Tag: 1122334455

Probe type FMI51, rod 10mm, PTFE or PFA
 Probe diameter: 8 mm
 Probe diameter with isolation: 10 mm
 DC-value of isolation: 1,9
 Base capacity: 25 pF
 Auxiliary capacities: 0 pF
 Probe length L1: 1000 mm
 inactive length L3: 0 mm
 Measurement range: 1000 mm
 Wall distance: 250 mm

Medium top
 Name: Trafo Öl
 Conductivity: 0,01 µS/cm
 Dielectric constant: 2,1

Medium bottom
 Name: Wasser
 Conductivity: 180 µS/cm
 Dielectric constant: 80,3



Empty calibration with medium top		
0%	53,13 pF	Copy
Full calibration with medium bottom		
100%	498,10 pF	Copy



Liquid continuous measurement applications

Creme fraîche



Medium: Creme fraîche (yoghurt, quark, milk, ...)
• Very sticky

Tank: Recipient tank
Height: 700mm
Diameter: 400mm

Probe: FMI51
Probe Ø: 8mm
Length: 660mm



Previous measuring method:

DC11TEN with FEC12

→ Problems caused by build-up
(Creme fraîche)!



Sludge



Medium:

Surplus sludge

- 4-5% solids
- Conductivity 1mS/cm
- Very sticky

Tank:

Height: 2.50m

Diameter: 1.20m

Probe:

Liquicap M – FMI51

fully insulated, PTFE

Probe Ø: 8mm

Length: 1800mm

Electronics:

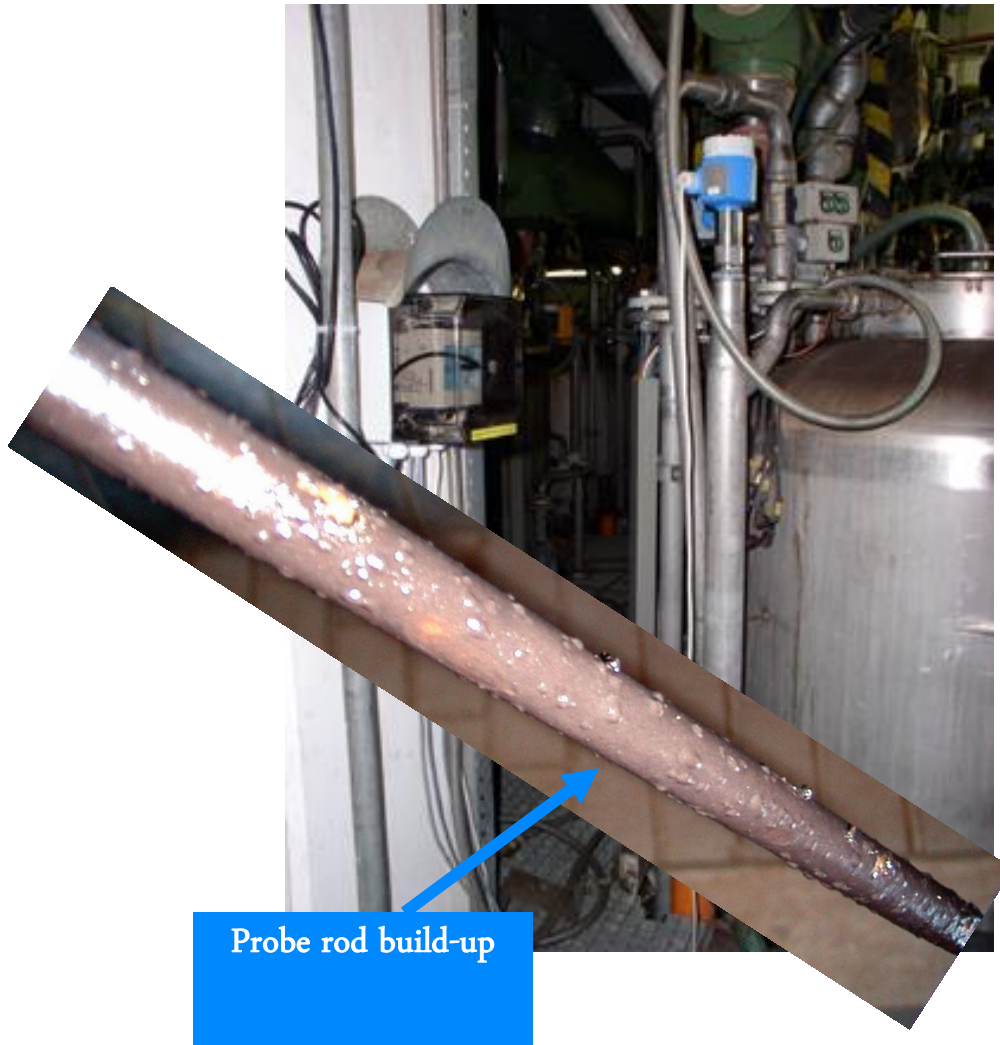
FEI50H

Alternative:

Prosonic FMU40/FMU30



Solid-Liquid Mixture



Medium: Seeds-water mixture

- DK \approx 80
- Sludge \rightarrow sticky
- Temperature approx. 30°C

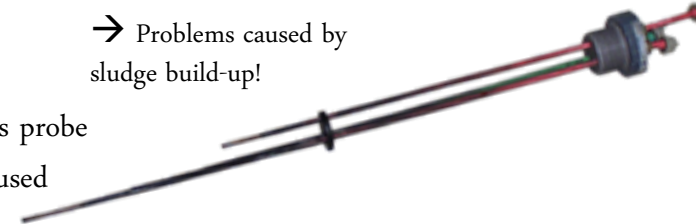
Test object: Bypass
Height: ca. 800mm
Diameter: 60.3mm

Probe: FMI51
Fully insulated, PTFE
Probe \varnothing : 8mm
Length: 730mm
Inactive length: 130mm

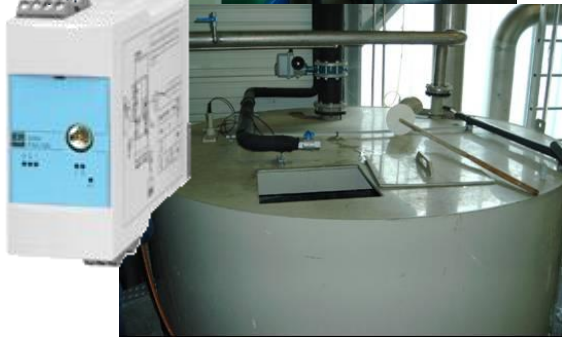
Electronics: In “build-up mode”

Previous measuring method:
Conductive limit switch
 \rightarrow Problems caused by
sludge build-up!

Competitors probe
Previously used



Process water



Medium: Process water for microfiber production

- Circulating flow

Tank: PVC tank

Height: 3200mm

Diameter: 2450mm

Probe: FMI51 with ground tube

Probe Ø: 12mm

Length: 2000mm

Reference measurement:

Deltapilot S (pressure)

Start of test: 17.03.2005 (week 11)

Bitumen



IXA320



- Medium: Bitumen
- $DK \approx 2 \dots 3$
 - Not conductive
 - Very sticky
 - Temperature 180 ... 190°C

Tank: Cylindrical horizontal
Width: 7750mm
Diameter: 2400mm

Probe: DC16
Probe Ø: 12mm
Length: 2050mm
Inactive length: 750mm

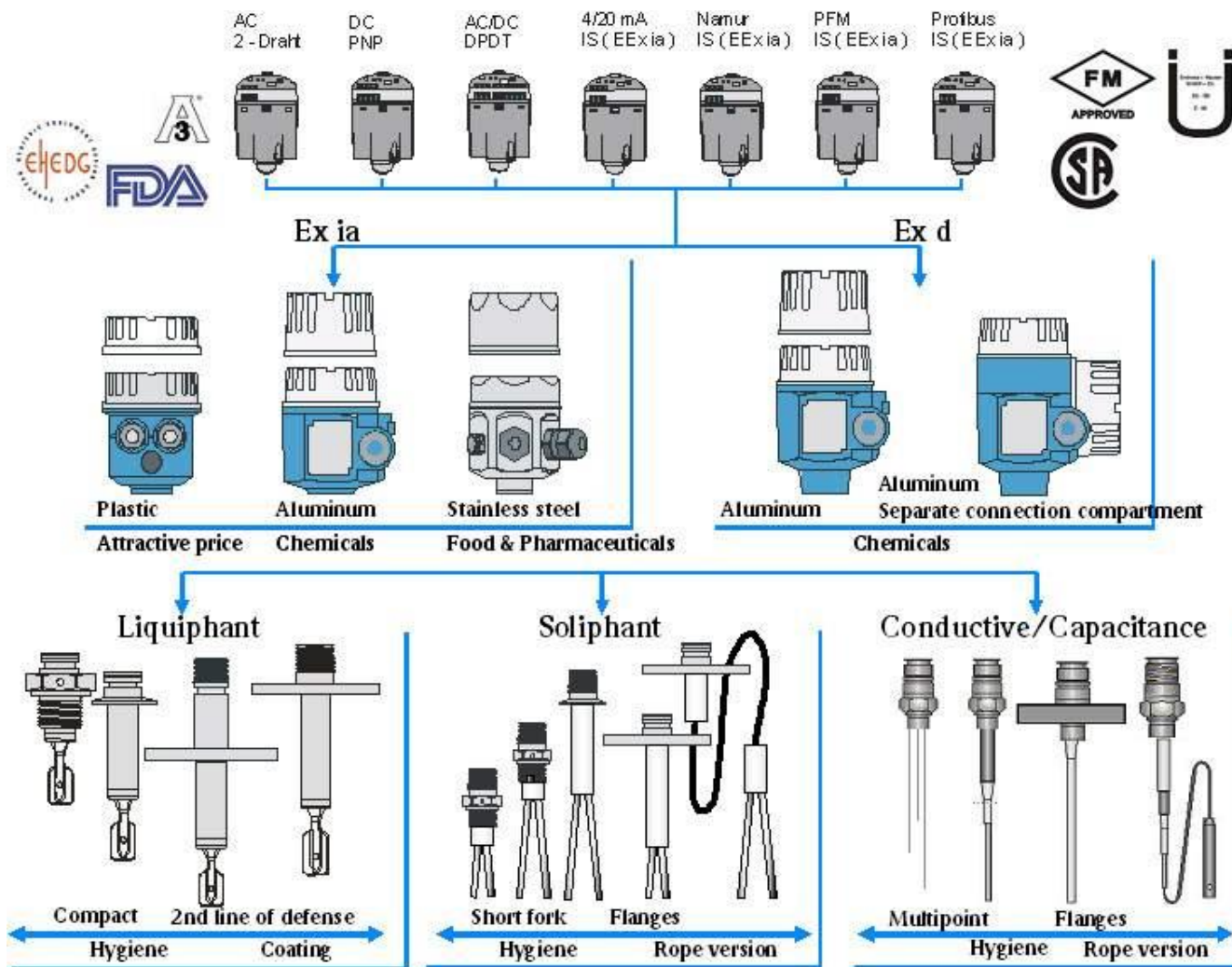
Previous measuring method:
Capacitive rope probe of VEGA
→ Problems occurred!

Point level switch in liquids with Liquicap M FTI51/52

Application strength of Capacitance

- Applications involving limit detection and interface detection in liquids
- Level limit switch for liquids completing Vibronic-/Conductive portfolio
- Features
 - two-point control (pump control)
 - highly viscous and build-up forming media
 - interface detection (e. g. oil – water)
 - foam detection in conductive liquids

Based on the uniform switch platform



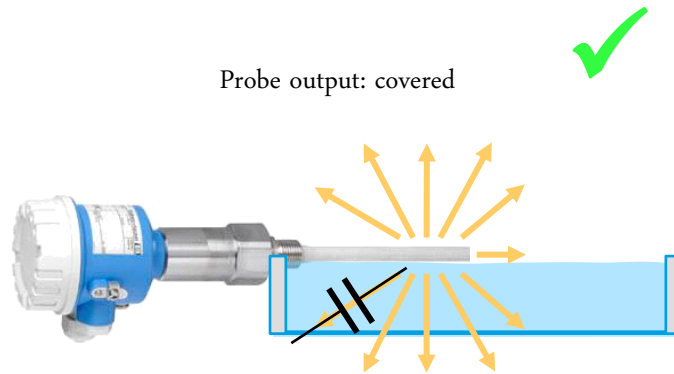
Technical data FTI51 rod probe and FTI52 rope probe

- Active probe length: 0.1...4 m rod; 0.4...10 m rope
- Active build up compensation: optional
- Probe material:
 - Rod: 316L with PTFE, PFA insulation
 - Rope: 316L with FEP, PFA insulation
- Process pressure: Max. 100 bar
- Process temperature: -80 °C ... +200 °C
- Ambient temperature: -50 °C ... +70 °C
- Switch reaction time: 0.3...10 sec adjustable
- Switch point reproducibility: 0.1%
- Output: Relay, PFM, DC-PNP, 8/16mA, 3-wire
- Approvals:
 - ATEX, CSA, FM, WHG, EHEDG
 - 3A, TIIS, NEPSI in preparation



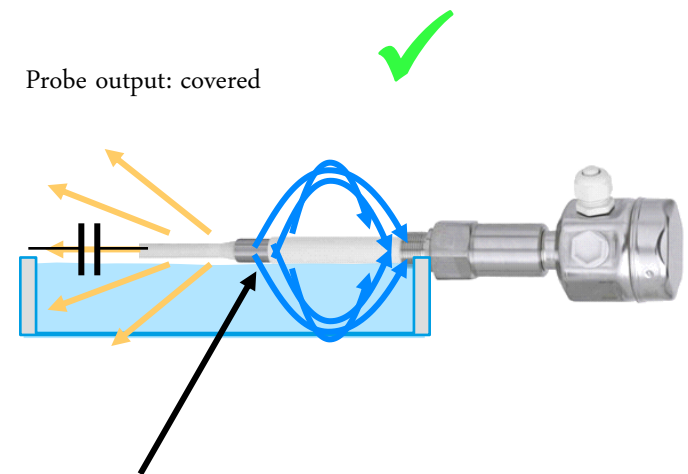
Active build-up compensation for adhesive media (1)

Standard probe generates a homogeneous electric field in all directions for capacity measurement



- The standard probe measures the capacity homogeneously around the probe rod. In this case, the capacity between the probe rod and the process connection is also measured

Probe with active build-up compensation generates an electric field directed into the tank for capacity measurement



- The active build-up compensation shields the probe rod in relation to the process connection. Only the capacity between the probe and the opposite tank wall is measured

Liquid point level switch applications

Classification:
INTERNAL

Tooth paste production



Medium: tooth paste (sticky)

Sensor: FTI51 with active build-up compensation and FEI52 (DC PNP)

Application: Maximum switch

Targets: build-up performance
comparison to “old” Multicap T

Previous measurement:
DC16TES-ABA1B1BN31

Customer feedback: „No problems occurred!“

Biogas plant



Medium: liquid manure (extremely sticky)

Tank: steel tank

Probe: FTI51 with FEI52

Previous measurement:

Liquicap M - FMI51 (faulty operation because of build-up)

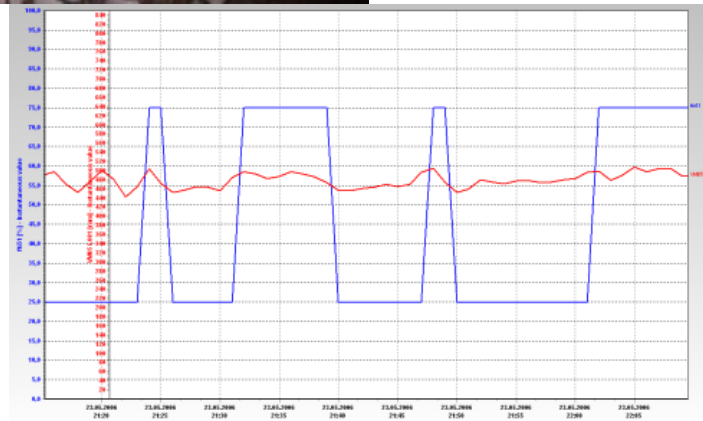
Targets: build-up performance



Pump control with FEI55



- Medium: water
- Tank: steel tank
- Probe: FTI51 with FEI55
- Reference: Liquicap M - FMI51
- Targets: test of pump control function



Limit detection in solids

Application strength of Capacitance

- Applications for point level switch in solids
- Point level switch for bulk solids for rough process conditions complementing Vibronic switches
- Features
 - Up to 400°C Process temperatures (e.g. Power plant fly ash control)
 - Unaffected by build-up (active build-up compensation)
 - Robust design (grain size up to 100mm, tensile loads up to 60KN)
 - Easy commissioning

Solicap M FTI 55 / 56 for limit detection in solids

Classification:
INTERNAL

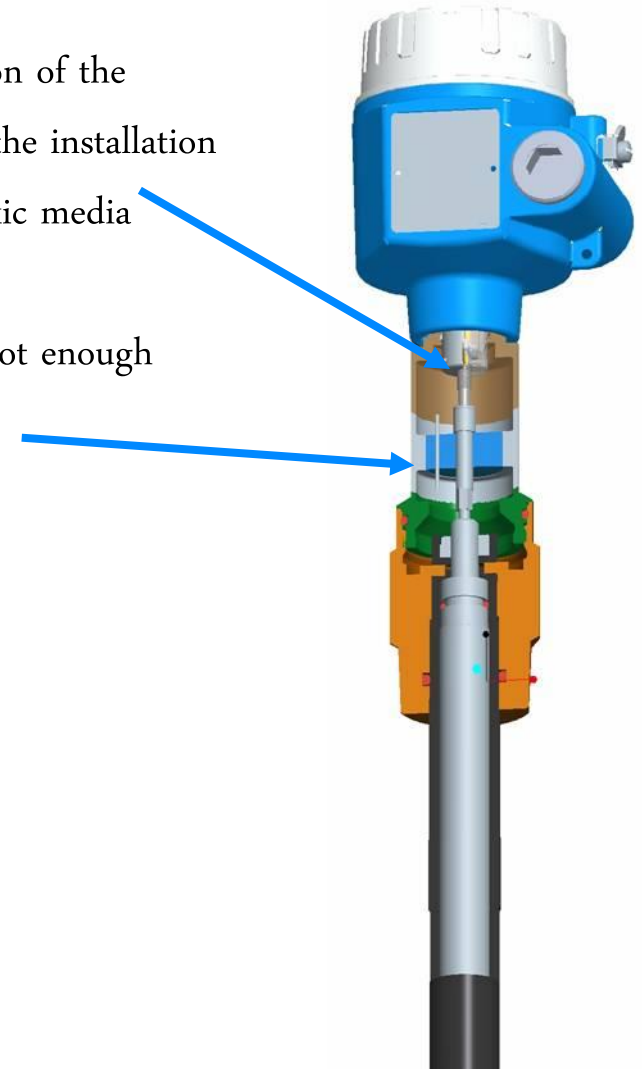
Technical data FTI55 rod probe and FTI56 rope probe

- Active probe length: 0.1...4 m rod; 0.5...22 m rope
- Rod lateral loading: up to 300Nm (robust)
- Rope tensile loading: up to 60.000N (indestructible)
- Probe material:
 - Rod: 316L/steel insulation PPS/PE
 - Rope: 316L/steel insulation PTFE/PA
- Process pressure: Max. 25 bar
- Process temperature: -50 °C ... +80°C/120°C/180 °C
- Ambient temperature: -50 °C ... +70 °C
- Switch reaction time: 0.3...10 sec adjustable
- Output: Relay, PFM, DC-PNP, 8/16mA, 3-wire
- Approvals: ATEX, CSA, FM,
TIIS, NEPSI (pending)



Probe features

- Two-stage overvoltage protection directly at the probe > protection of the electronics against electrostatic discharge – reliable operation of the installation
- Gastight glass feed through > protection against aggressive or toxic media
- Separate housing for high ambient temperatures and if there is not enough space at the mounting location



Probe design

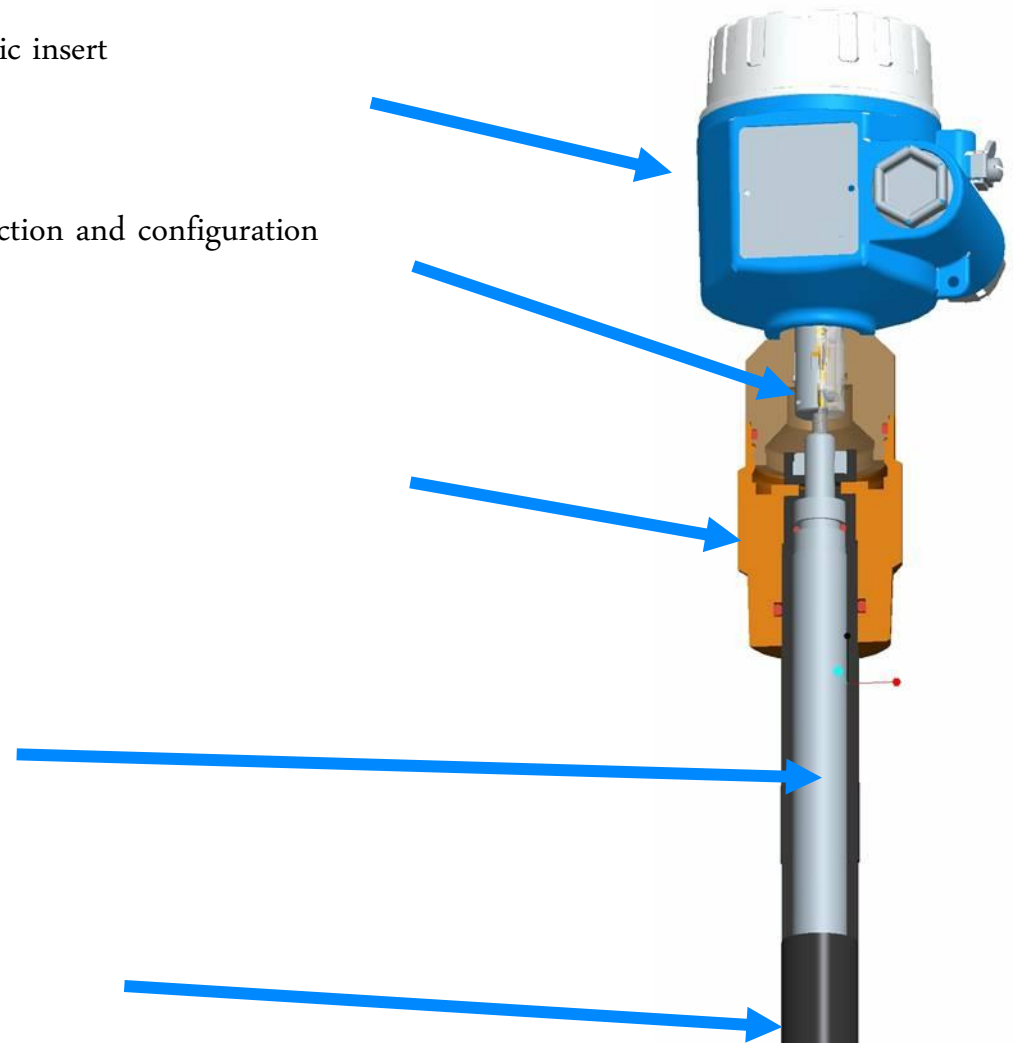
Housing with cable gland, electronic insert

Sensor plug with overvoltage protection and configuration memory (DAT)

Process connection with probe rod

Probe rod 316L/steel

Probe rod insulation PPS /PE



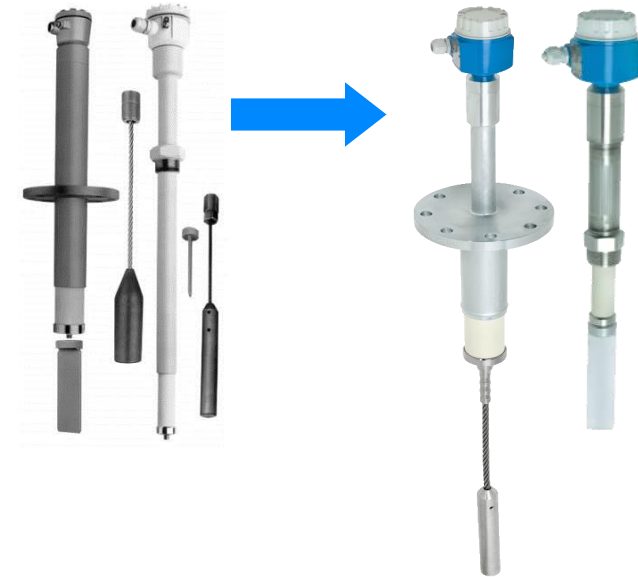
Technical data Solicap S FTI77



Active probe length:	sword 0.2 ... 1m; rope 0.5 ... 20m
Sword lateral loading:	up to 250Nm (fine-grained) up to 800Nm (coarse solids)
Rope tensile loading:	6mm up to 7,500N 12mm up to 20,000N
Probe material:	sword: 316L/steel rope: 316L/steel
Process pressure:	max. 10bar
Process temperature:	-50°C ... +400°C
Ambient temperature:	-50°C ... +70°C/ -50°C ... +120°C (separate version)
Switch reaction time:	0.3...10 sec adjustable
Output:	Relay, PFM, DC-PNP, 8/16mA, 3-wire, 2-wire
Approvals:	ATEX, CSA, FM, IEC, TIIS, NEPSI

Solicap S newly added features

- Active build-up compensation
- Worldwide explosion-proof approvals
- Compact electronics
 - Cyclical checking from the switching unit
- Gastight glass feed through
- Two-stage overvoltage protection
- Functional safety SIL 2/SIL 3
- EN10204-3.1 Material inspection certificate
- Separate housing included in FTI77 structure



Solicap S FTI77 for limit detection in solids high temperature

Classification:
INTERNAL

Application with Multicap

Multicap - DC11ES

Capacitive level measurement in a latex tank.

The DC11ES is used for a reliable level measurement of latex. Due to the steam for separating the impurities there is a lot of foam.

We delivered four capacitive probes DC11ES-1A5CQ2KM1.

The customer need a capacitive fully insulated rod probes for this application. Inactive part of the probe is 150mm and active part 2050mm with FEC12 , 4-20 mA output.

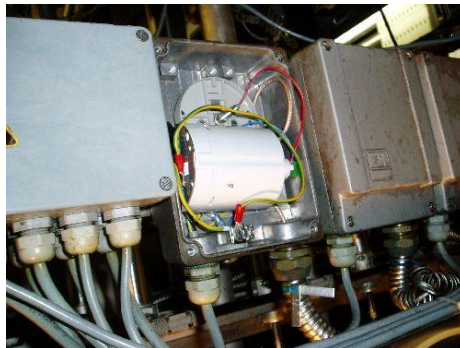
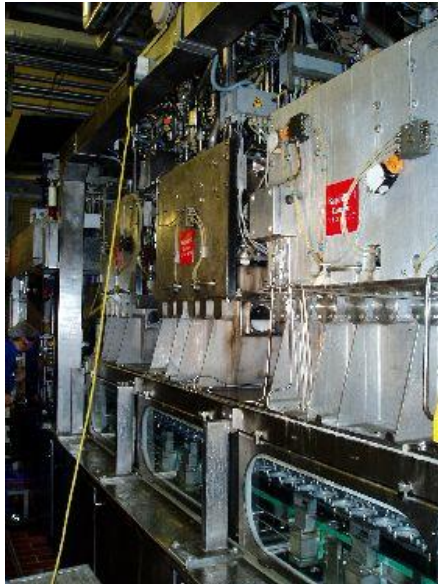
As shown in enclosed pictures, the medium is very sticky and build-up is remarkable high on the surface of the probe.

The probe has been in operation about half a year

Main purpose of these stripper tanks is to separate all impurities from basic latex. This is done by feeding steam through the latex liquid from the bottom of the tank upwards. Because of the steam, there is a lot of foam in the surface of liquid.



Yoghurt



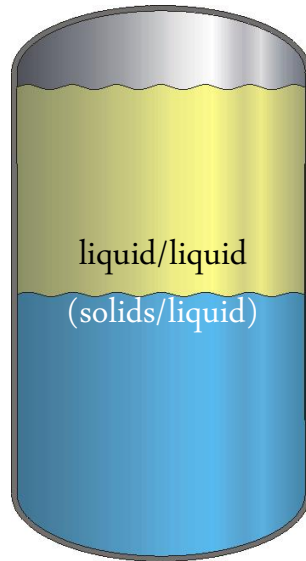
- Medium: Yoghurt (liquid)
- Foam formation
 - Foam should not be recognized
 - Highly conductive
- Tank: GASTI recipient tank
- Probe: 11375
Length: 385mm
- Electronics: FEI57C (build-up mode)
Transmitter power supply unit FMC671Z
- Previous measuring method:
EC47 TSP 4.3MHz
Transmitter power supply unit FMC671Z
- Start of test: 22.02.2005 (week 8/05)

Customer is very satisfied with the new electronic insert FEI57C!

Interface measurement

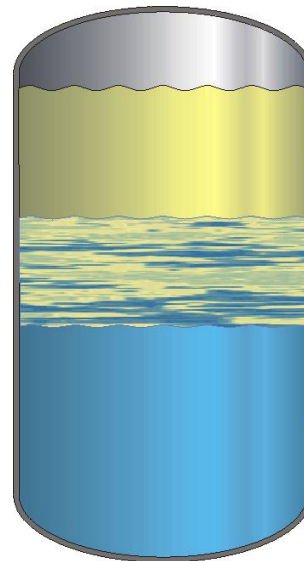
What is an interface layer?

Clear interface layer

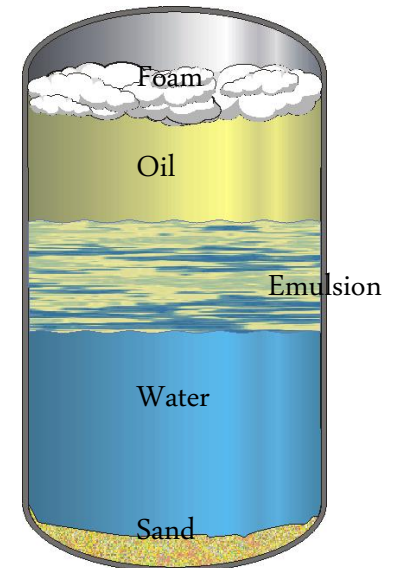


High precision

Emulsion



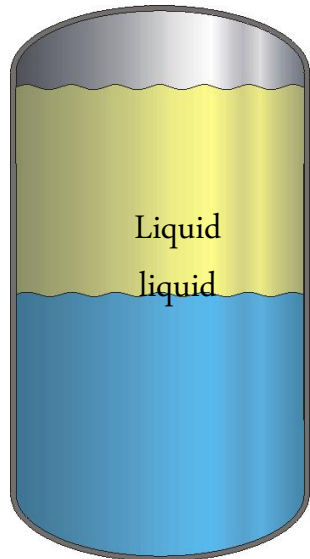
Several interface layers



E.g. separator

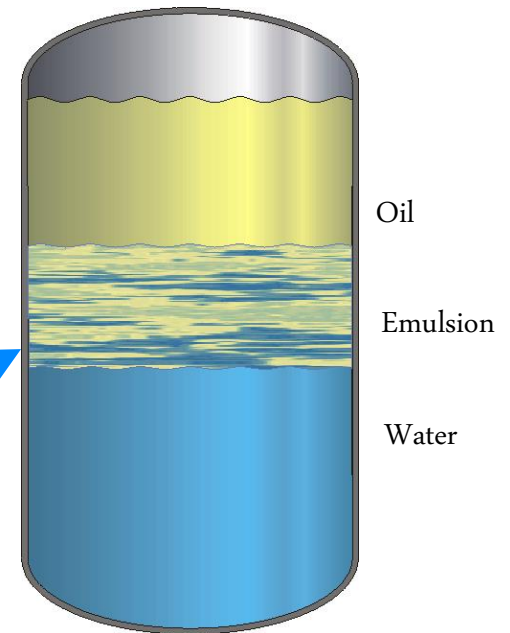
Segmentation interface measurement

Clear interface layer



- In a clear interface layer Levelflex M and Liquicap M can be used.
- In an expected emulsion layer the signal reflection is not sufficient for a standard Levelflex. In this case, Liquicap M provides a safe average value measurement. Recommendation: Always use **Liquicap M** or the new **Levelflex FMP55** in emulsions.

Interface layer with emulsion



Highest precision with Levelflex

Industry:
Chemical industry

Average value measurement, safe measured value with Liquicap M

Industry:
Chemical industry
Oil + gas

Interface measurement commissioning via FieldCare

The interface layer and Level calculation program integrated into the Fieldcare calculates customized calibration values.

Endress+Hauser GmbH+Co. KG
 Hauptstraße 1
 79689 Maulburg
 Germany



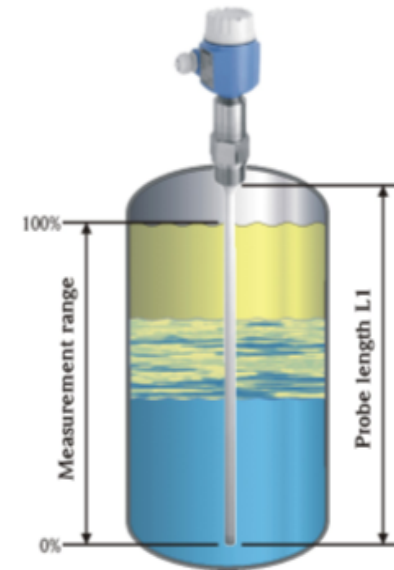
19.07.2005

Customer	Muster GmbH+Co. KG	Attention	Hans Mustermann
Customer-No.	X0815	Phone	0815 - 12345
Street	Musterstraße 5	Fax	0815 - 6789
ZIP-Code/Town	12345 Musterstadt	Reference	Trennschichtmessung
		Tag	1122334455

Probe type	FMI51, rod 10mm, PTFE or PFA
Probe diameter	8 mm
Probe diameter with isolation	10 mm
DC-value of isolation	1,9
Base capacity	25 pF
Auxiliary capacities	0 pF
Probe length L1	1000 mm
inactive length L3	0 mm
Measurement range	1000 mm
Wall distance	250 mm

Medium top	
Name	Trafo Öl
Conductivity	0,01 µS/cm
Dielectric constant	2,1

Medium bottom	
Name	Wasser
Conductivity	180 µS/cm
Dielectric constant	80,3



Empty calibration with medium top	0%	53,13 pF	Copy
Full calibration with medium bottom	100%	498,10 pF	Copy



Interface measurement

With capacitive probes – no problem



Advantages of capacitive probes

- No problem with emulsion layers because the “average value“ is measured
- Independent of the emulsion layer thickness
- Not affected by density changes
- Easy to install and simple commissioning
- Known price-effective technology

Limitations of capacitive probes

- Conductive and non-conductive medium required (in case of two non-conductive media:
 $\Delta DK > 25$)
- Build-up formation

Solid applications

Classification:
INTERNAL

Capacitance instrumentation for solids

Markets – today and in future

- Primary industry
 - Cement, concrete, glass, sand, salt...
 - Mining
- Food industry
 - Animal feed
 - Grain
 - Flour
- Energy
 - Coal
 - Fly ash



Coal bunker

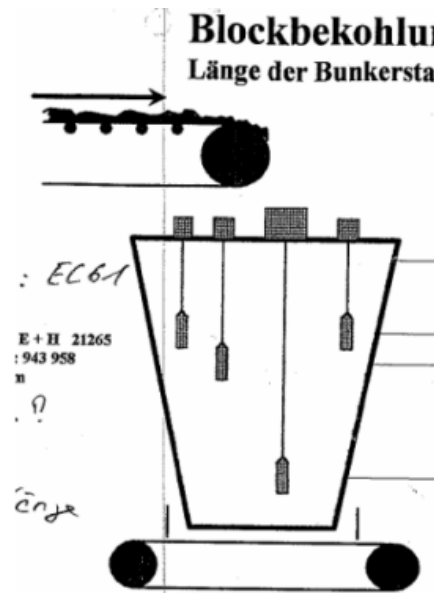


Customer ordered 20 Solicap M FTI56 and FTC325PFM

Medium: coal
Tank: steel tank
Height: approx. 5m

Probe: FTI56 with FEI57S

Targets: rough process conditions
Level limit: LL, L, H and HH detection



Minicap FTC260

FTC260 with active build-up compensation as a
Max. switch in a filter dust vessel



Thank you for your attention

Any questions?

