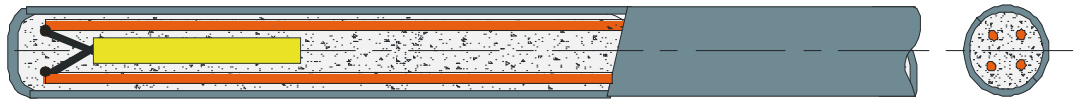
Basic physics

What are the 2 most popular principles to measure temperature?

- **Resistance Temperature Detector (RTD)**



Pt100

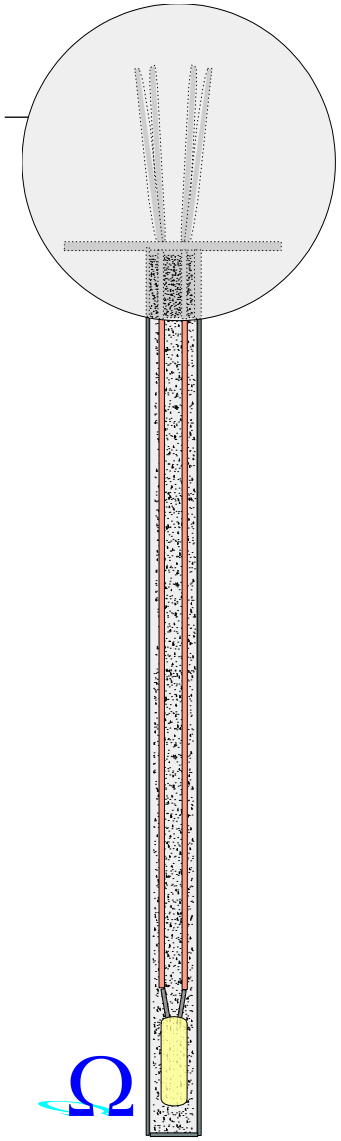
- **Thermocouples (TC)**

RTD - Basic physics

- What does **Pt100** mean

“Pt” means “Platinum”

“100” means “100 Ohm” at “0°C”



ELECTRONIC CARRIER

RTD

PROTECTIVE SHEATH

INTERNAL CONNECTING WIRES

INSULATION

SENSING ELEMENT

CERAMIC BLOCK

TC

PROTECTIVE SHEATH

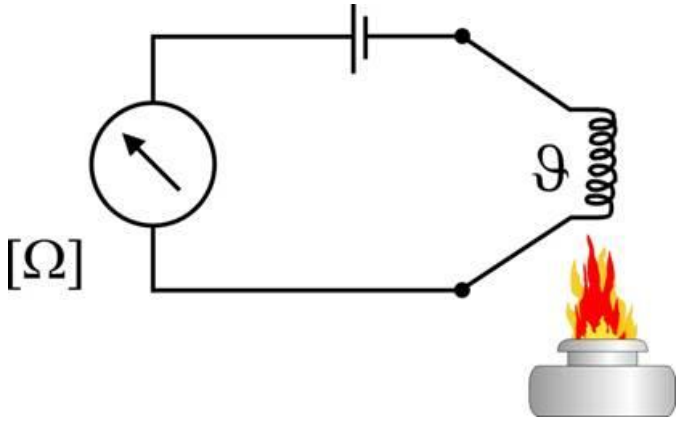
TC METALS

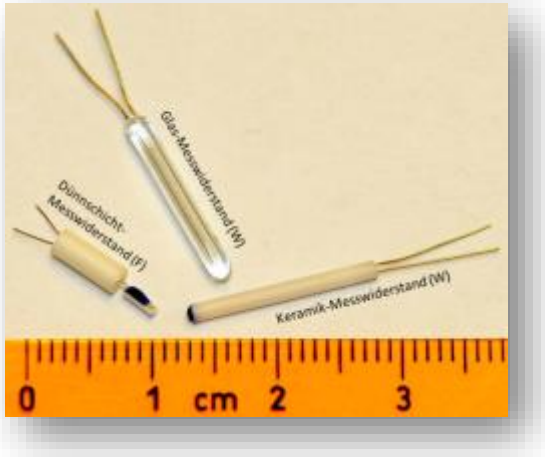
INSULATION

HOT JUNCTION

RTD - Basic physics

- RTD – Resistance Temperature Detector





- An RTD changes its resistance value proportional to the temperature!
- A Pt100 is a “PTC”
  Pt from Platinum, 100 means 100 Ω at 0°C
  Resistance with “Positive Temperature Coefficient”

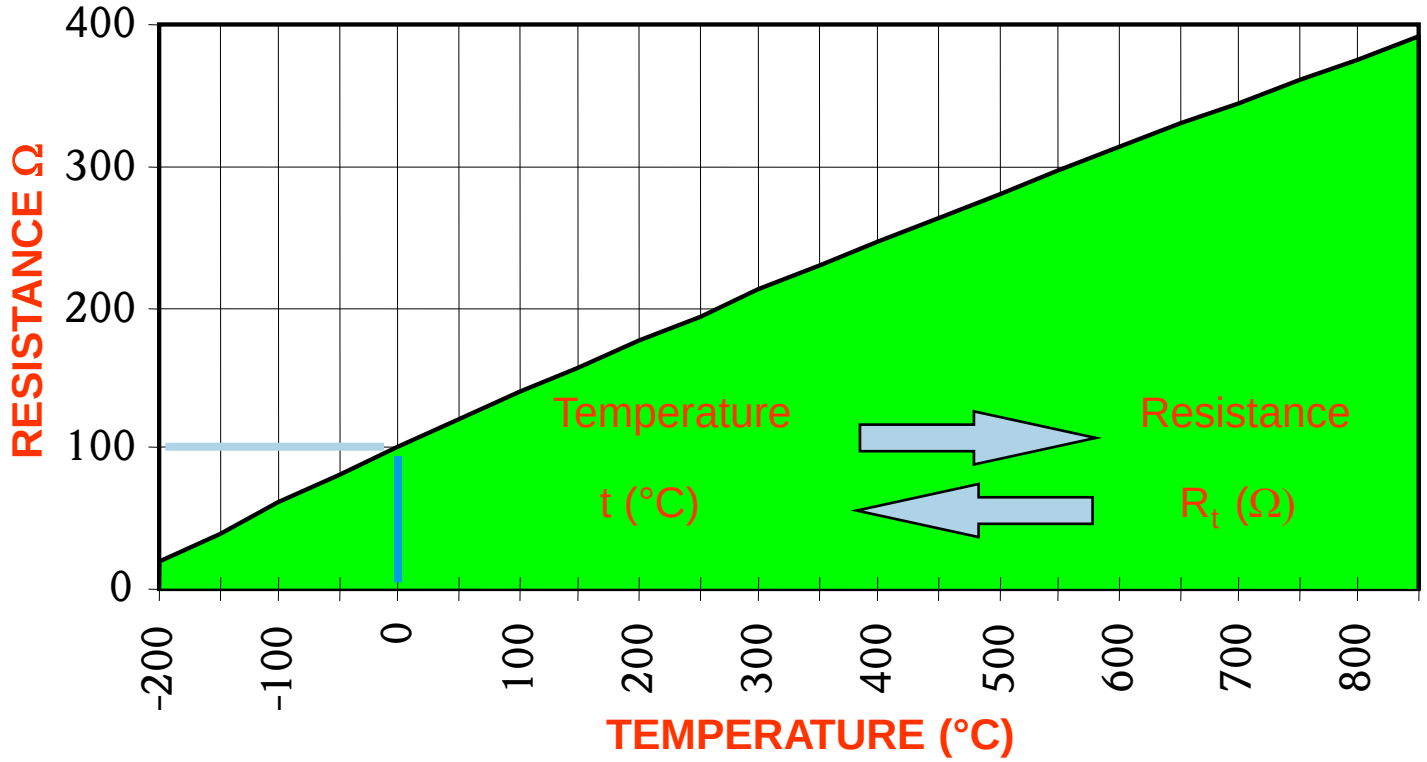
RTD - Basic physics

Reference standard for RTD: EN 60 751

Temperature / Resistance relationship

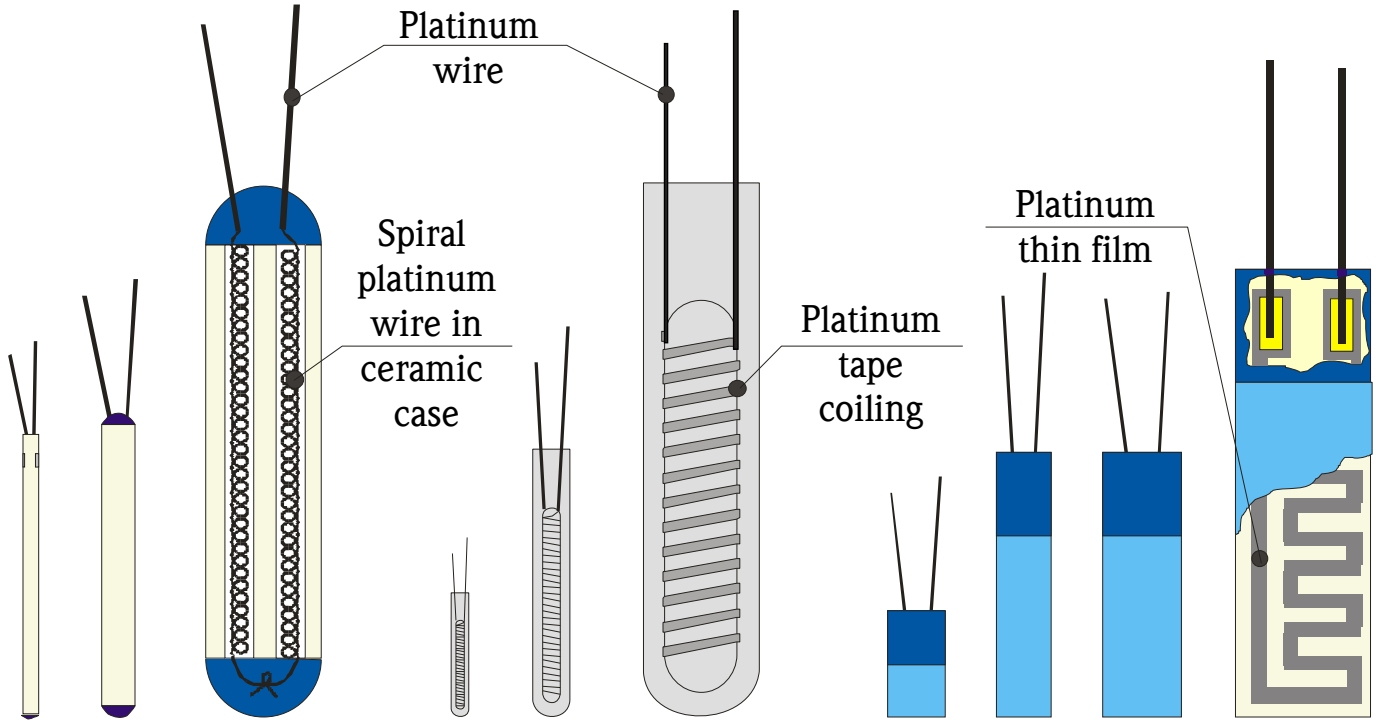
$R_{Pt100} = 100 + (alfa \times T) - (beta \times T^2)$

1°C = 0.385 Ohm



Endress+Hauser

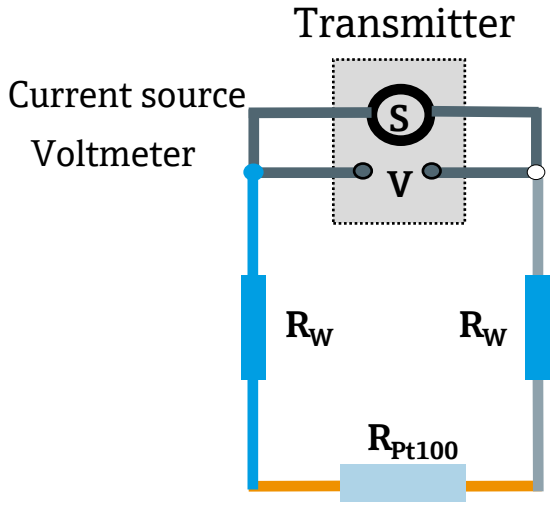
RTD - Basic physics



- Ceramic
  wire wound
- Glass
  wire wound
- Thin film

RTD – 2 wire, 3 wire or 4 wire connection ?

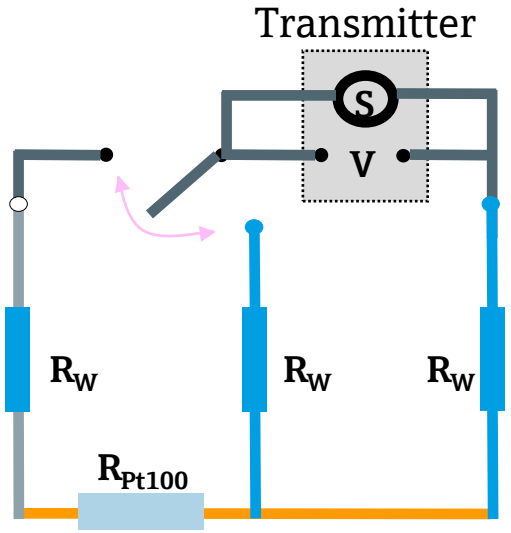
2 wire configuration:



- **Resistances:**
  $R_{Pt100}+2\ R_W$
- **Error:** $2\ R_W$

< 0,5m

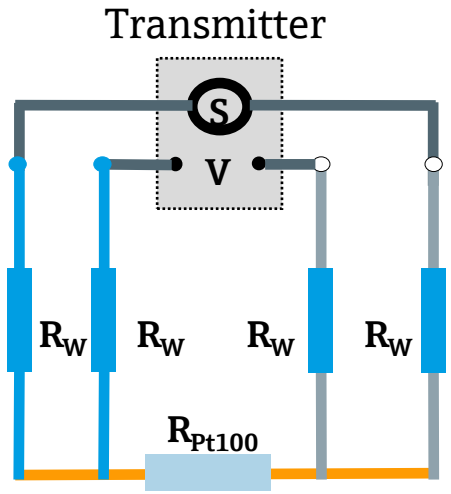
3 wire configuration:



- **Resistances:**
  $(R_{Pt100}+2\ R_W)$
  $-\ (2\ R_W) = R_{Pt100}$
- **Error** if wires and terminals are not 100% identical

< 30m

4 wire configuration:



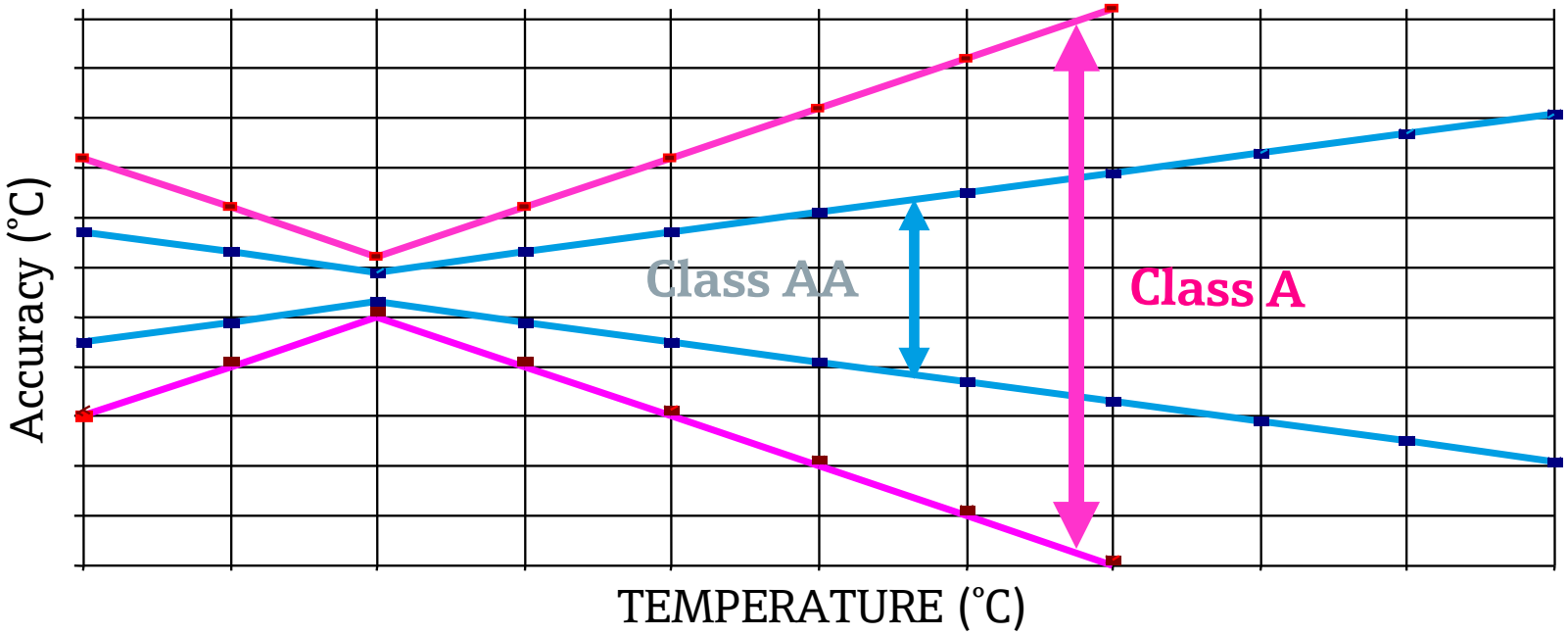
- **Resistances:**
  R_{Pt100}
- **Error:**
  No systematical error

< 1000m

RTD - Accuracy

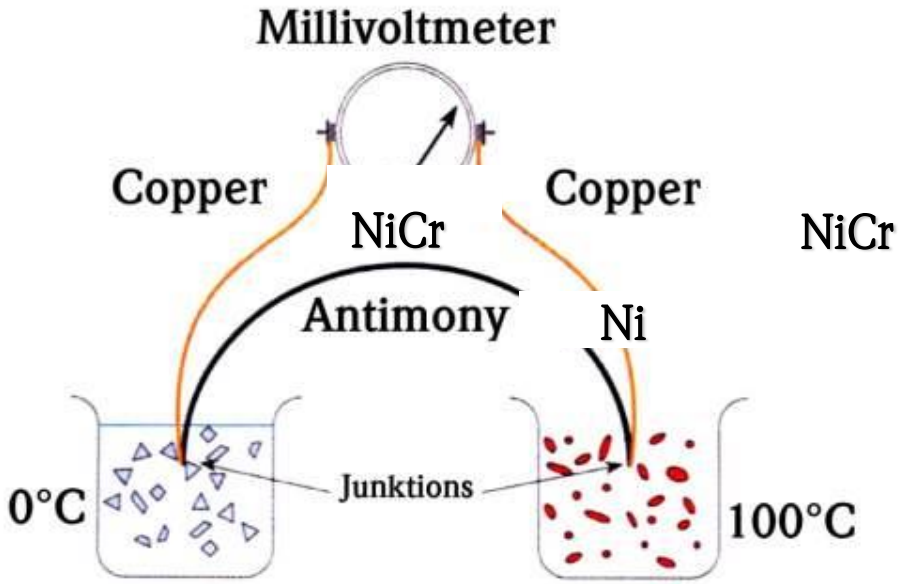
Accuracy according to DIN EN 60751

Class	B	A	AA (1/3B)
Pt100	0.3+0.005*|t|	0.15+0.002*|t|	0.1+0.00167*|t|



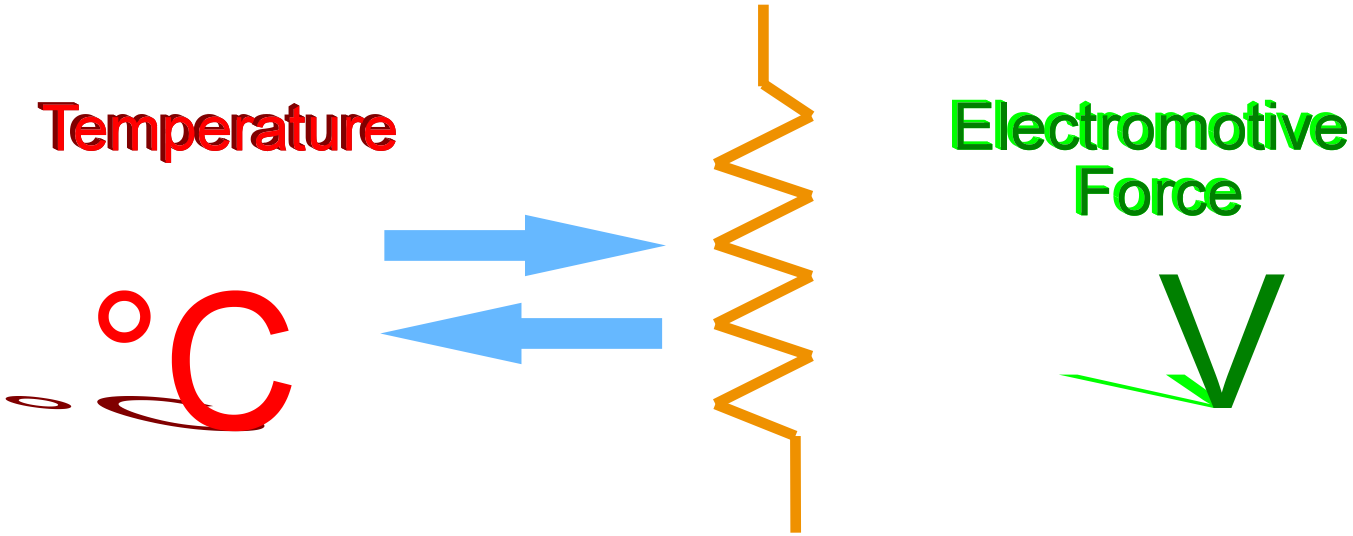
TC - Basic physics

Measurement via Thermocouple



TC – Measuring principle

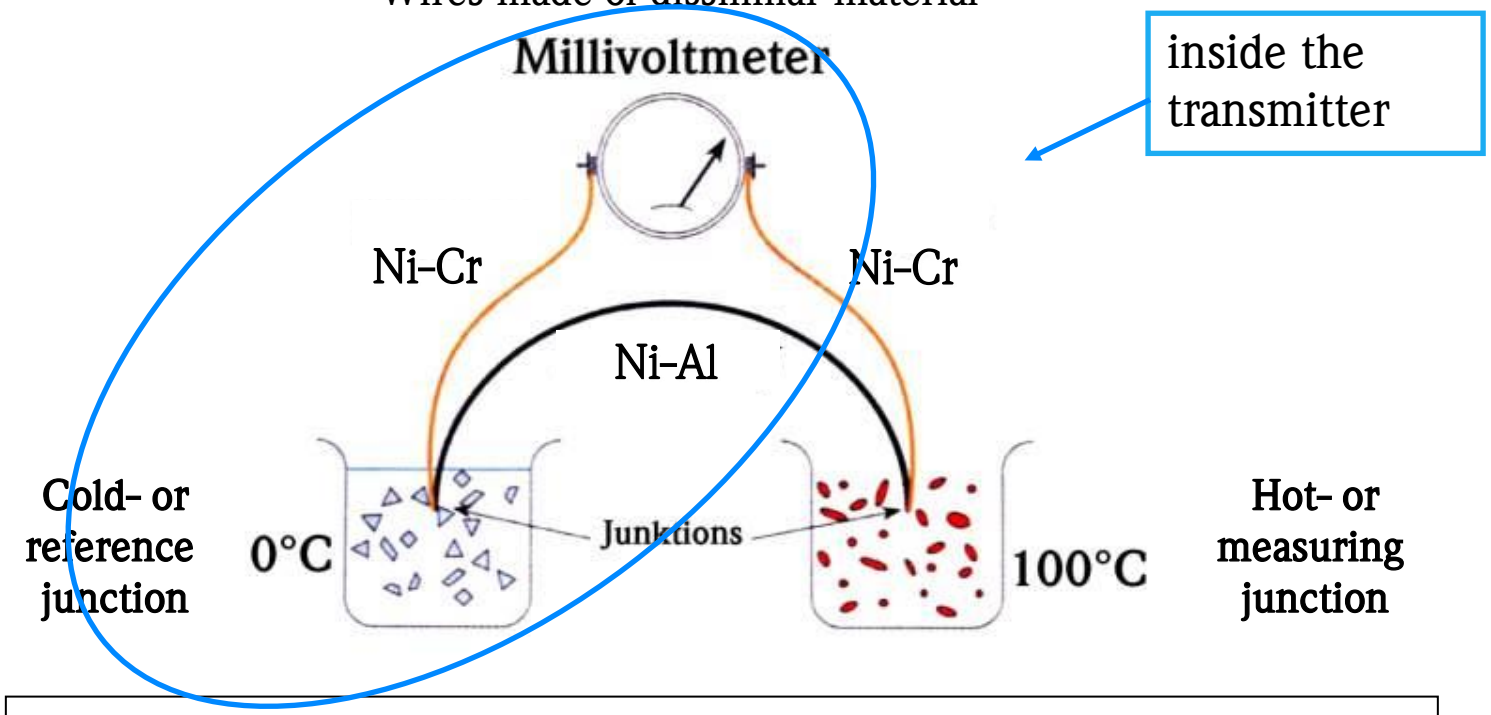
- Indirect measurement of temperature
- The Electromotive Force (EMF) is measured due to a physical effect



TC – Thermocouple - Seebeck Effect

$T_{jct.} \neq T_{ref.}$ ⇒ Electromotive Force (EMF)

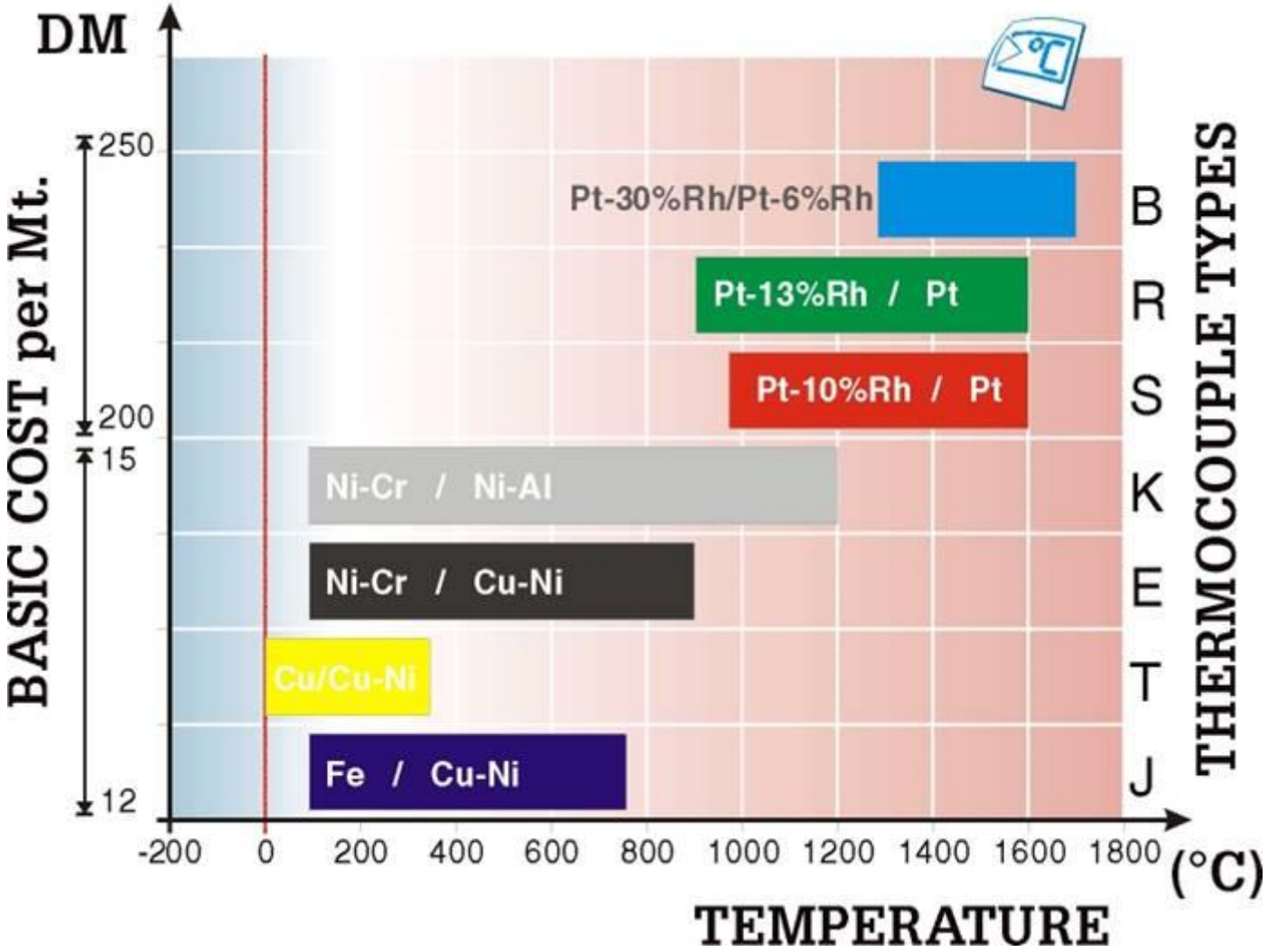
Wires made of dissimilar material



SEEBECK EFFECT

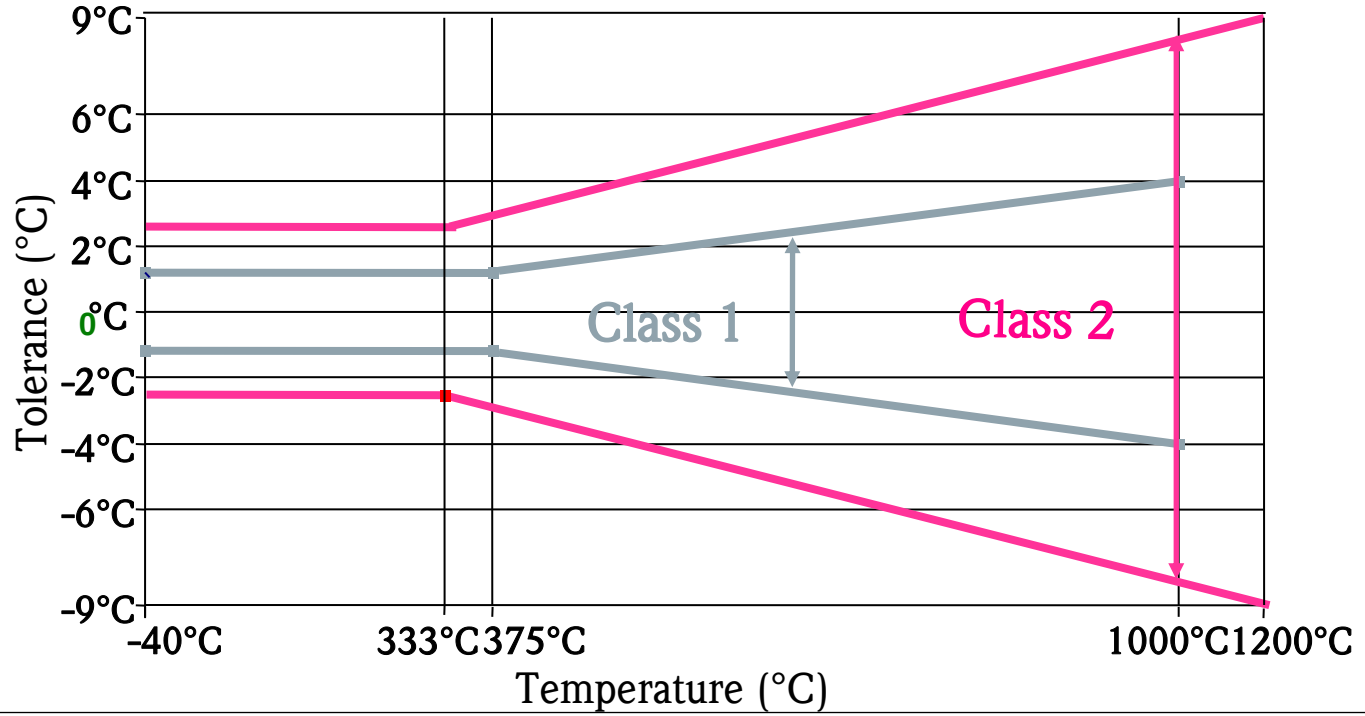
If the conductors' metal is not the same and if the two junctions are at different temperatures, between them a voltage (EMF) is generated, and hence an electric current flows in the circuit.

TC – Useful ranges



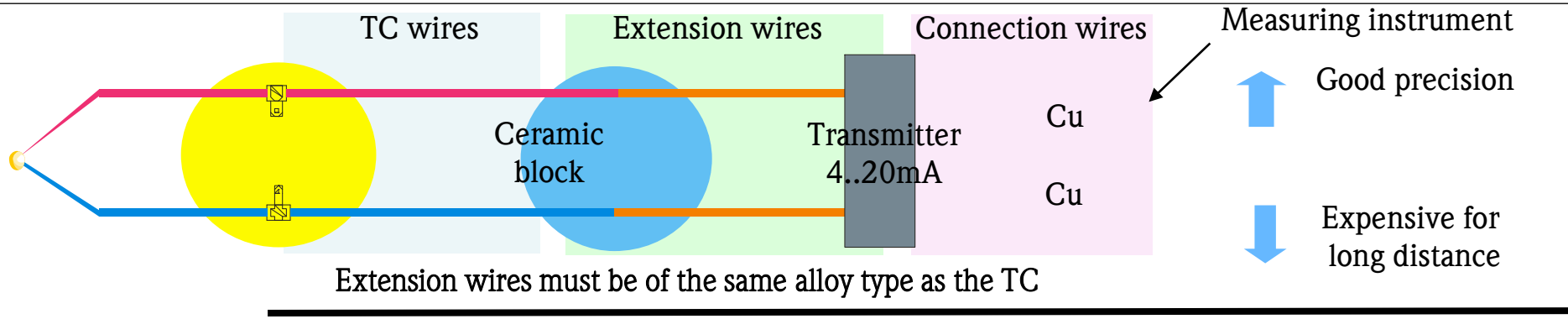
TC - Accuracy

- Tolerance classes according to IEC 584
- Class 1Special
- Class 2 Standard

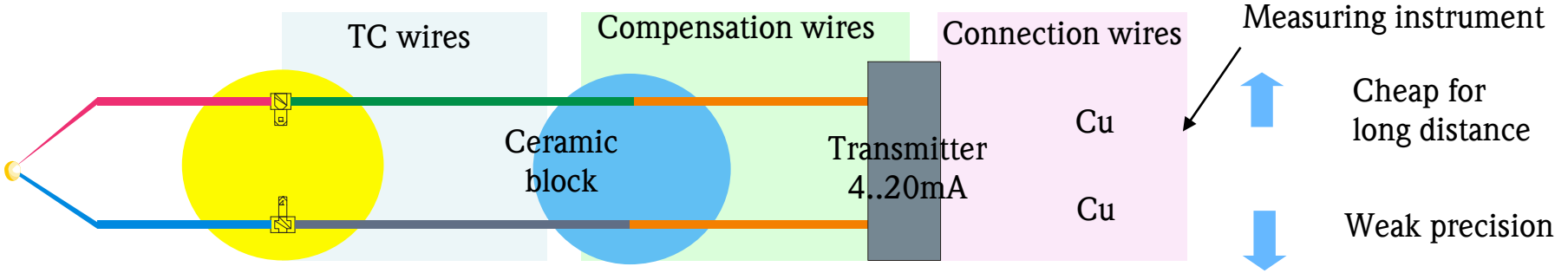


Endress+Hauser

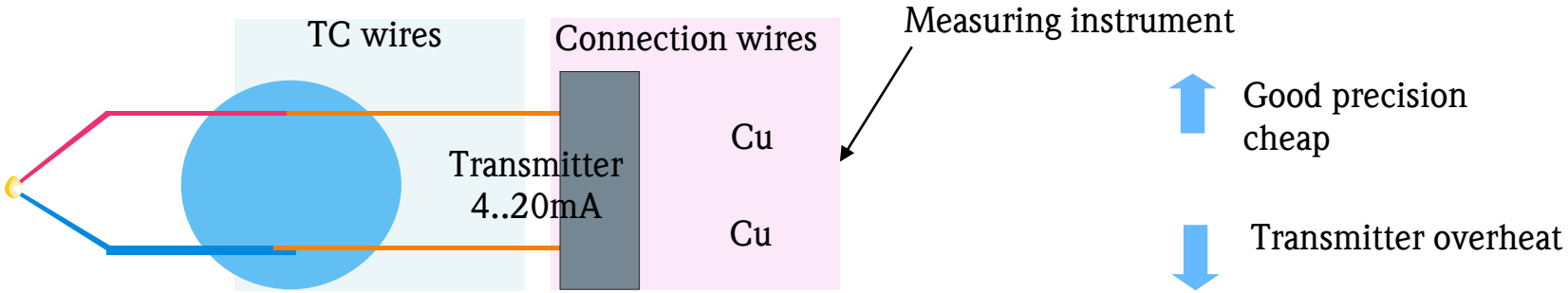
TC - Basic physics



Extension wires must be of the same alloy type as the TC



Compensation wires generate an EMF similar to TC (limited temp. range)



Endress+Hauser

Where to use TC?

- High temperatures (300°C – 1700°C)
- High vibration
- Fast response times
- Mechanical stress

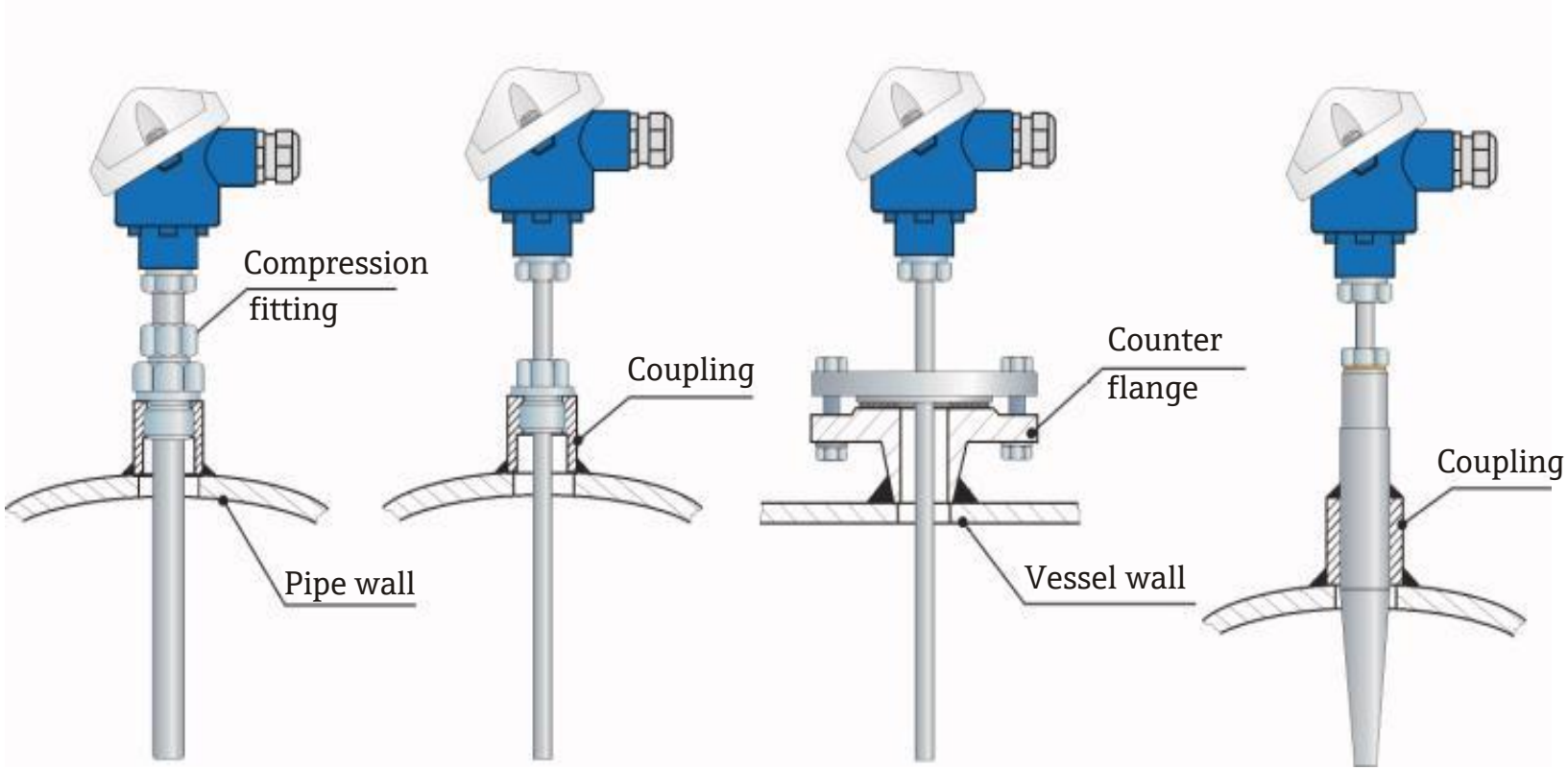
E+H Temperature

The Thermometer

Modular Thermometers for general applications

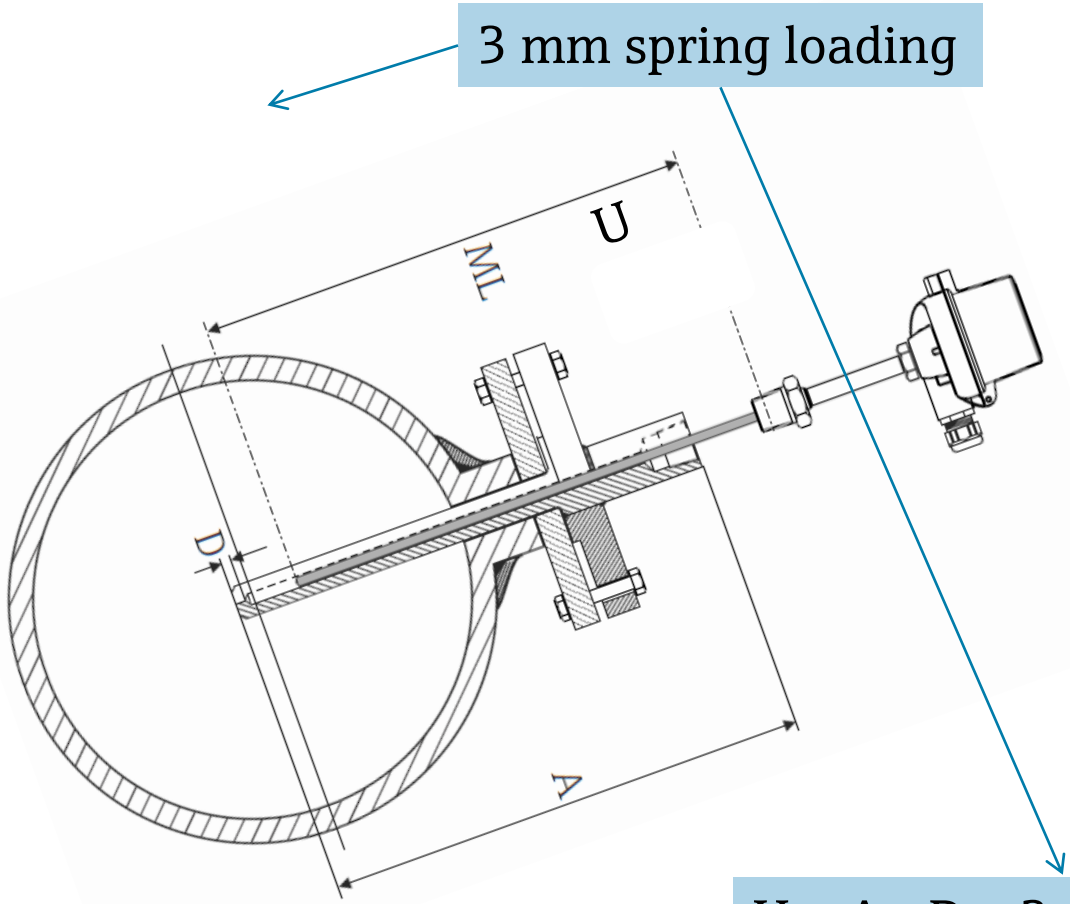
- Solutions for different branches
- Measuring principles: RTDs and TCs
- Replaceable Inserts
- Main applications: Chemical industries …

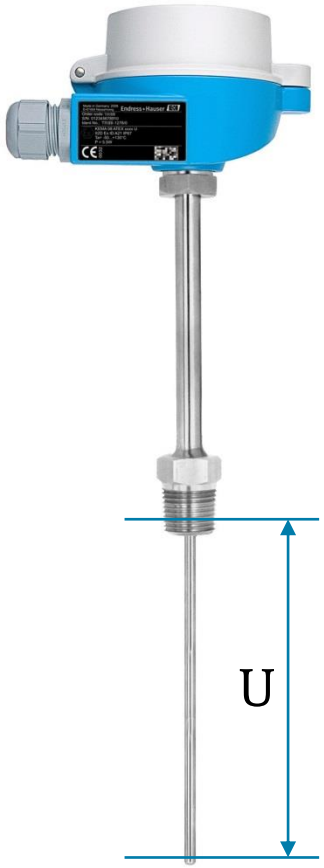
Assembling examples



Installation for general purpose industrial applications

Thermometer for existing TW's





U = A - D + 3 (0.12) in mm (in)

Endress+Hauser

Set-up of the temperature assemblies

Housing

Transmitter

Insert

Thermowell

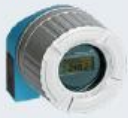
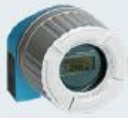
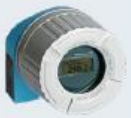
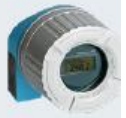
Compact thermometers

Cable probes and compact thermometers overview

Type	Cable sensor, metric and imperial					Compact thermometer, metric and imperial		
Model	TST310	TSC310	TH12	TH52	TH56	TTR31/TTR35 (E-direct)	TMR31/ TM311/ TMR35 (E-direct)	TM371/TM372
Design								
Special feature	Compact thermometers with permanently affixed plug-in or screw-in cable		Compact RTD resistance thermometers with permanently affixed plug-in or screw-in cable	Compact TC thermometers with permanently affixed plug-in or screw-in cable (TH52) or connector (TH56)		Temperature switch with 1/2 PNP switch outputs, 4 to 20 mA	Compact thermometers with integrated transmitter. Short insertion length, extremely fast response times	Compact thermometers for hygienic and aseptic applications, exceptional sensor technology with self-calibration function, HART® protocol
Approval	ATEX Ex ia, ATEX Ex nA, IECEx Ga Ex ia NEPSI Ex ia			-		UL 61010B-1 and CSA C22.2 no. 1010.1-92	UL as per 3111-1, marine approval	EHEDG, ASME BPE, FDA, 3-A, EC 1935/2004, EC 2023/2006, EU 10/2011 - CE/EAC, CRN, CSA universal version
Measuring principle	RTD	TC	RTD	TC			RTD	
Measuring range	-50 to +400 °C	Type J: -40 to +750 °C Type K: -40 to +1100 °C	-50 to +200 °C (-58 to +392 °F)	Type J: -346 to +1330 °F (-210 to +720°C) Type K: -454 to +2100 °F (-270 to +1150 °C)		-50 to +150 °C (-58 to +302 °F)	-50 to +200 °C (-58 to +392 °F)	-40 to +160 °C (-40 to +320 °F)
Process pressure	≤ 100 bar (depending on process connection)							≤ 50 bar (depending on process connection)
Material	1.4404	1.4404, 2.4816	SS316L			1.4404		316L, 1.4435+316L, delta ferrite <1%

Temperature Transmitters

Communication standard	4 to 20 mA				
Field housings	-				
	-				TMT71 
Top hat / DIN rail	TMT127 	TMT128 	-		TMT71 
Head mount	TMT31 	TMT188 	TMT80 	TMT31 	TMT71 
Sensor input(s)	RTD	thermocouple	1-ch universal	RTD	1-ch universal
Approvals	Ex Zone 2	Ex	-	Ex Zone 2	Ex
Additional information	fixed configuration		-		Bluetooth
	-				plug-in display unit (TID10) available for head transmitters

HART		Foundation Fieldbus	ProfiBus	ProfiNet
TMT142B 	TMT162 	TMT162 	TMT162 	-
TMT72 	TMT82 	TMT85 	TMT84 	TMT86 
TMT72 	TMT82 	-	-	-
TMT72 	TMT82 	TMT85 	TMT84 	TMT86 
1-ch universal	2-ch universal	2-ch universal	2-ch universal	2-ch universal
Ex		Ex	Ex	Ex
Bluetooth	SIL 2 SC 3	-	-	Ethernet-APL
plug-in display unit (TID10) available for head transmitters				

Device Features – TMT8x transmitters

- 2 sensor inputs for RTD, TC, mV, Ω
  (2x 3-wire RTD possible)
- Supply voltage: 9 - 32 V DC
- Galvanic isolation: 2 kV (Fieldbus/inputs)
- Measurement accuracy: 0.1 K
- Compatible with the display TID10

iTEMP TMT82 - HART COMMUNICATION PROTOCOL SIL2/SIL3 Transmitter

System integration	
Endress+Hauser	FieldCare (FDT/DTM)
Siemens	SIMATIC PDM (EDD)
Emerson	AMS; FC375/475

TMT82

2 Sensor inputs

High accuracy (0.1 K Pt100)

SIL acc. IEC61508 (SIL2, SW SIL3)

HART6 Protocol

Advanced diagnosis functions

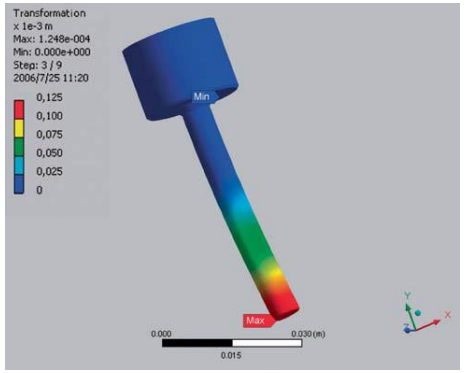
NE107/VDE2650 conformity

Display compatibility (TID10)

International approvals

Design

Thermowells



Thermowell calculation tool

The " Sizing Thermowell Tool" can be found on the Endress+Hauser website for online calculation and engineering of all Endress+Hauser thermometer thermowells.

Endress+Hauser

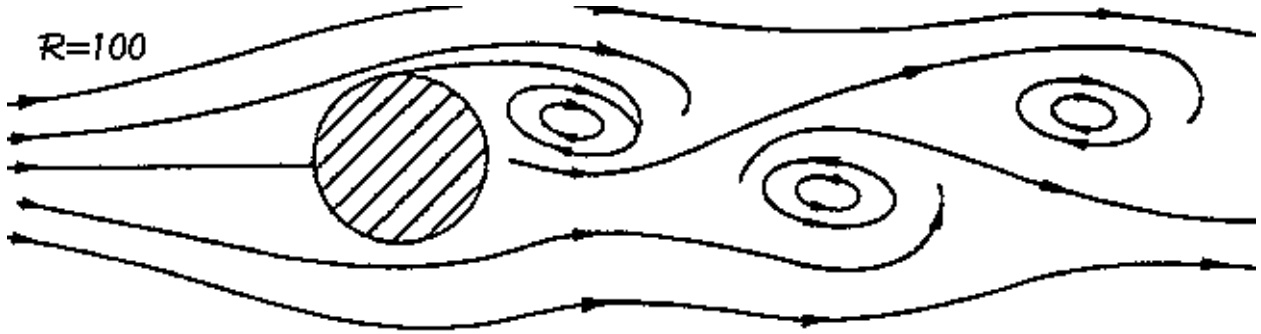
Why Thermowells?

- Advantages
- Sensor can be replaced during operation
  - Calibration
  - Replacement
- Standard Sensor can be adapted to many different applications:
  - Thickness (Pressure attack)
  - Material (Chemicals attack)
  - Shape (Flow attack)
  - Process connection (Flange, thread, weld-in)

- Disadvantages
- Longer response time to temperature changes

Stresses to withstand

- Difference between inner and outer pressure
- Pressure coming from flowing medium
- Stresses due to own weight
- Pressure surges (e.g. water hammer)
- Loading by vibration through periodic vortexes (Kármán-turbulances)
- Material and internal stresses …



Thermowell – Important differences

Bar stock thermowell

Pipe thermowell

Bar stock thermowells - versions

Weld in

Threaded

Flanged

Pipe thermowells - versions

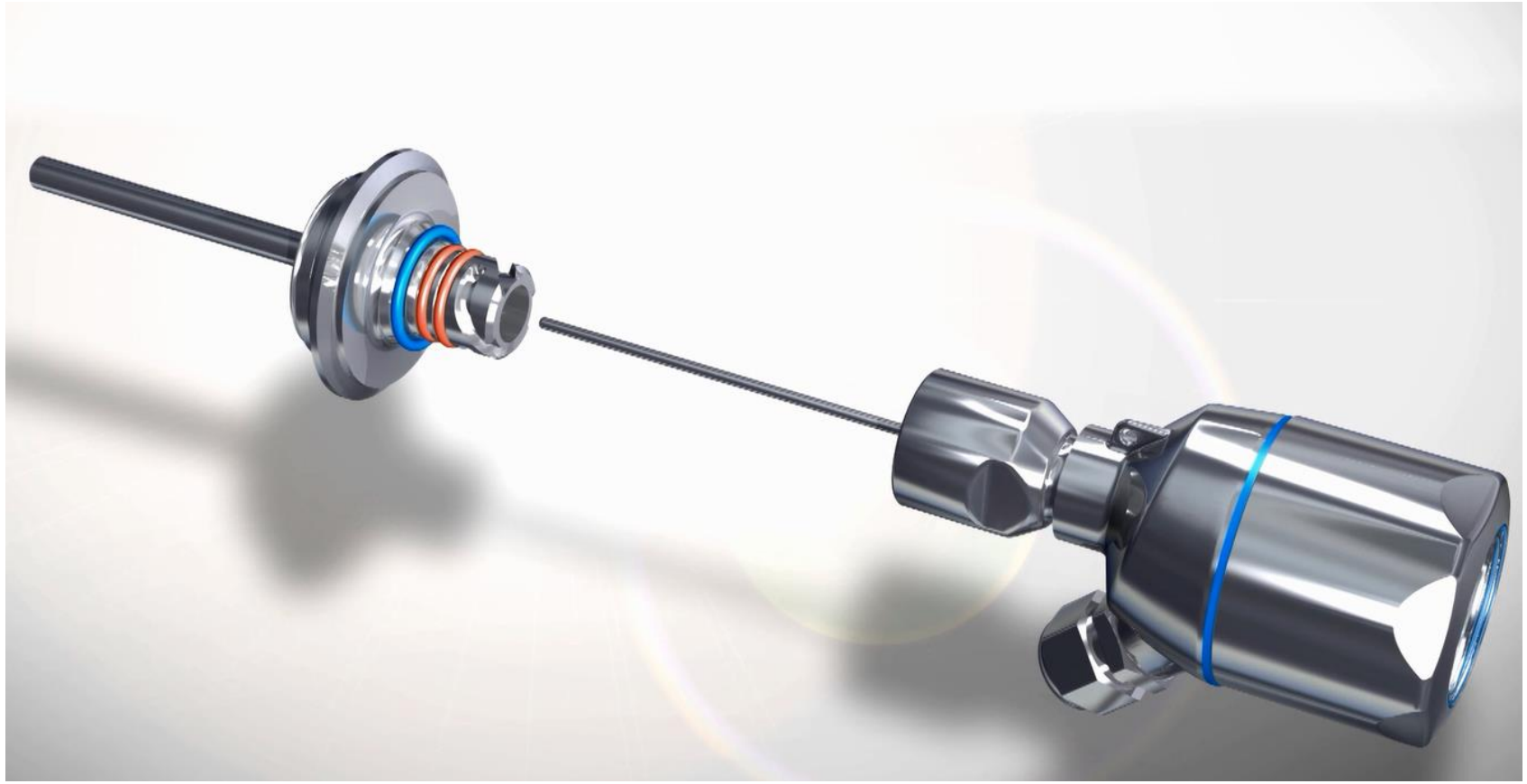
Flanged with neck

Threaded with neck

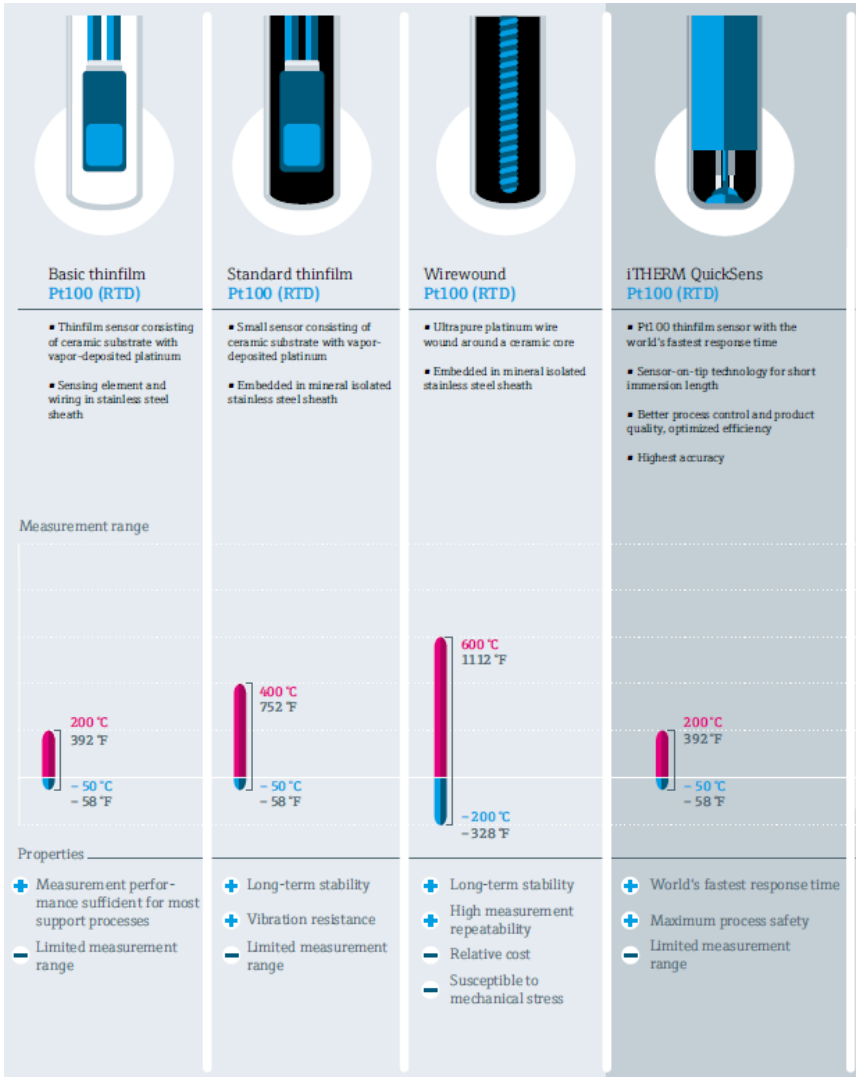
Threaded w/o neck

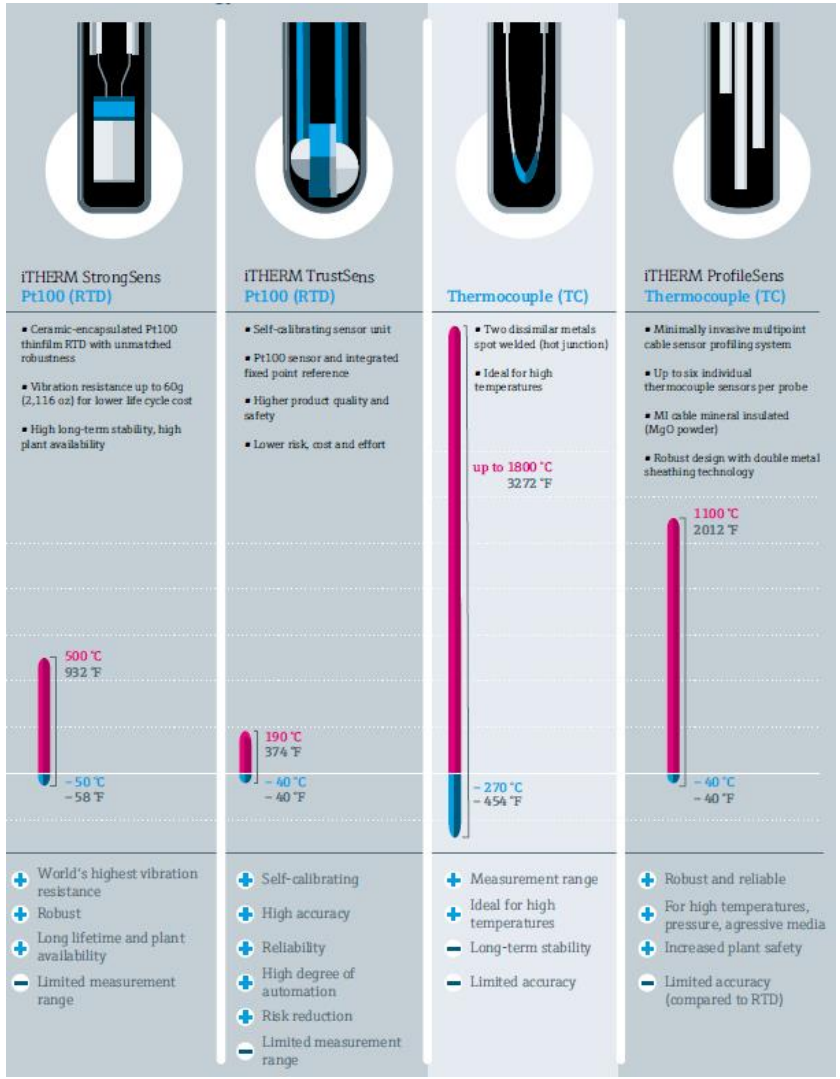
With compression fitting

Cost reduction with Quickneck® – Quicksens® - Strongsens®



Sensor technology

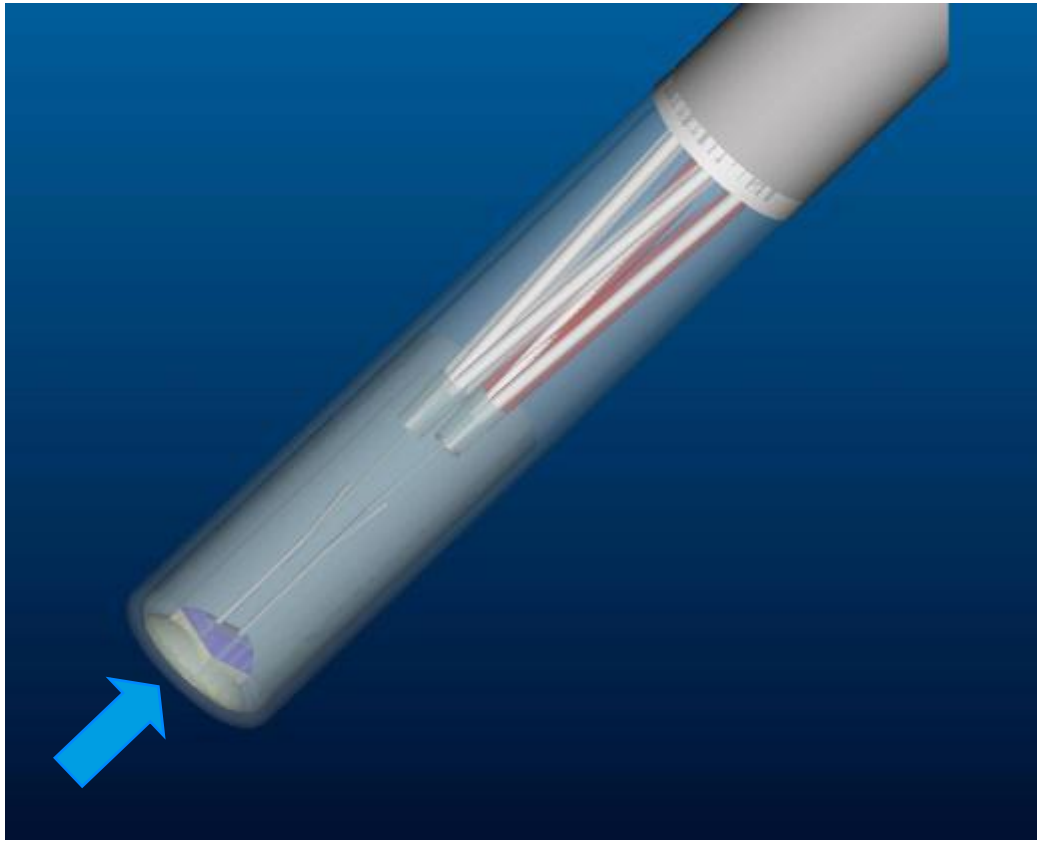




Endress+Hauser

Cost reduction by Quicksens®

- Thin film element with optimized thermal contact
- New production method granting for highest quality



Cost reduction by Strongsens®

– novel inserts with unmatched robustness

Vibration resistance higher than 60g

→ Greater system safety due to lower risk of failure

→ Reduction of life cycle costs due to longer life-time

Automated production

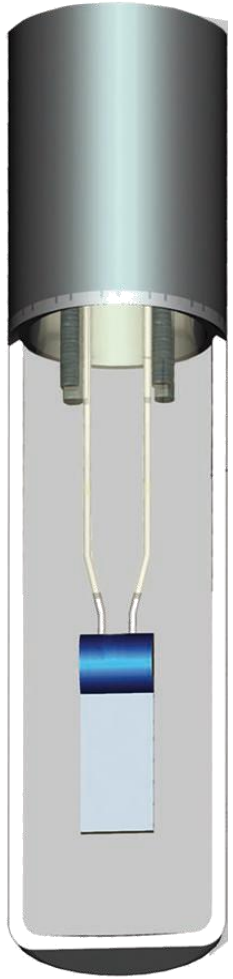
→ Full traceability and best quality

→ Highest process safety

High long-term stability

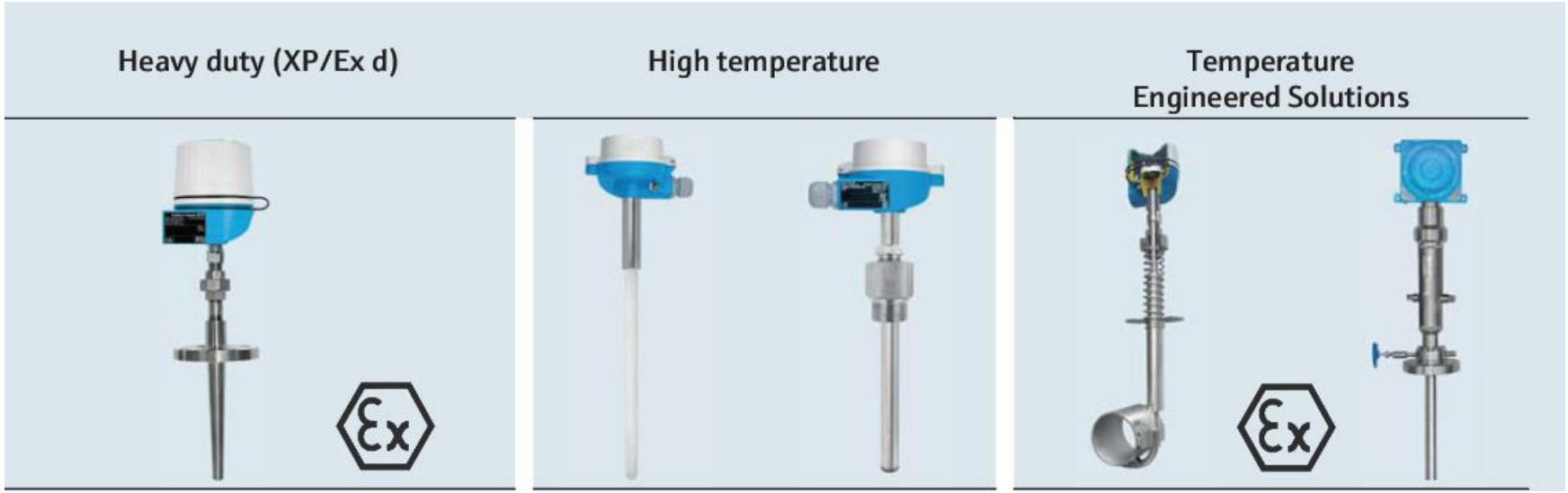
→ Reliable measurement values

→ High system safety



Thermometer product overview (1)

Thermometer product overview (2)



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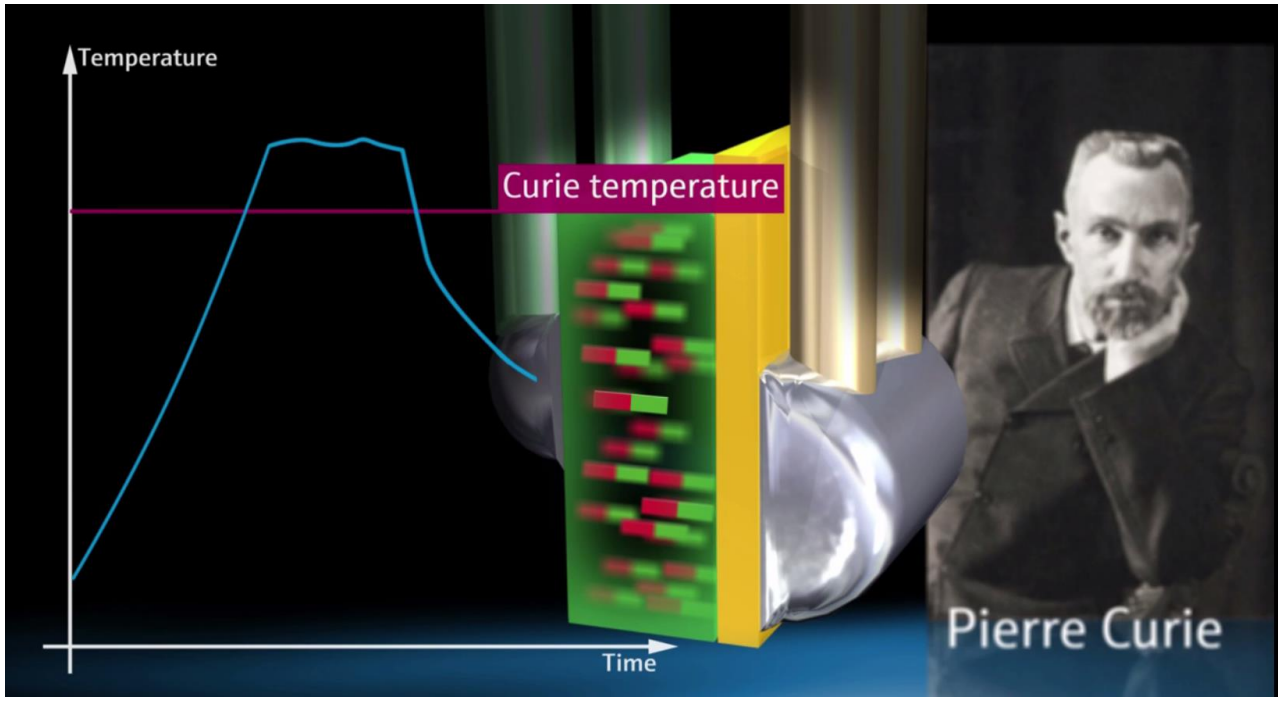
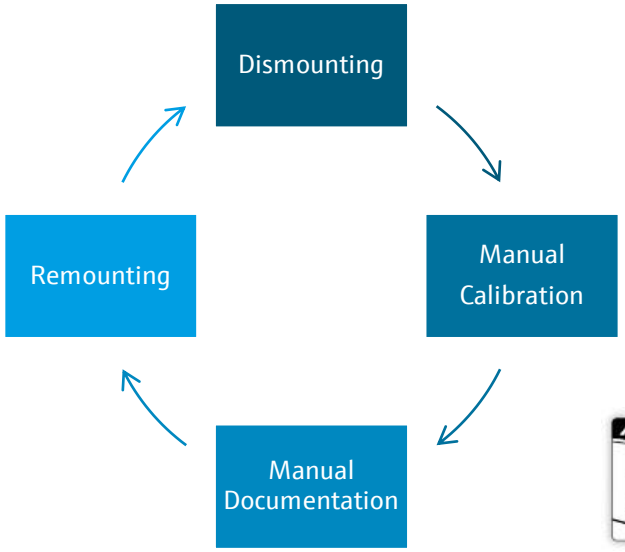
iTherm TrustSens TM371



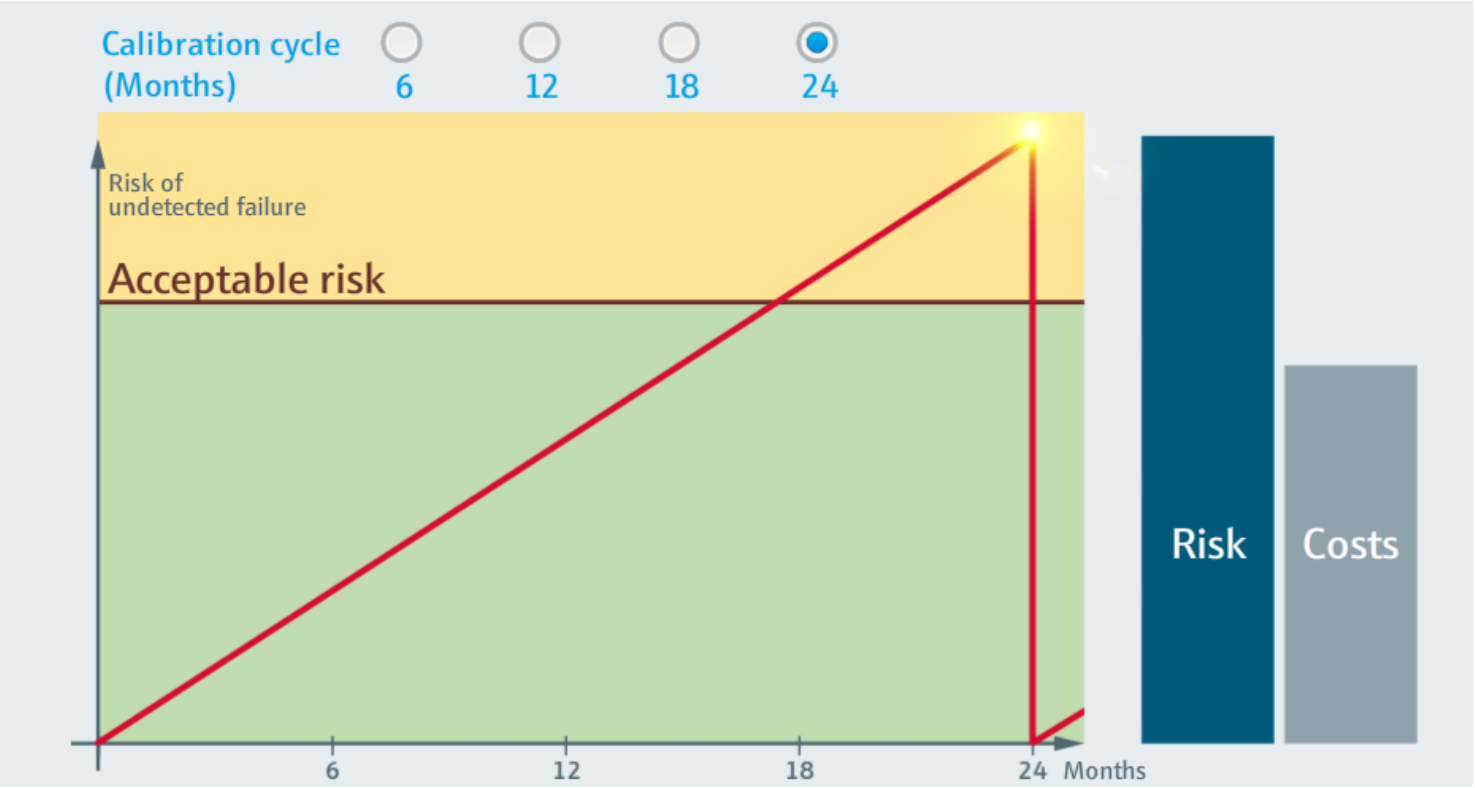
YouTube BE

https://www.youtube.com/watch?v=zKxuQNABWQI&t=26s

Manual calibration of thermometers in retrospect

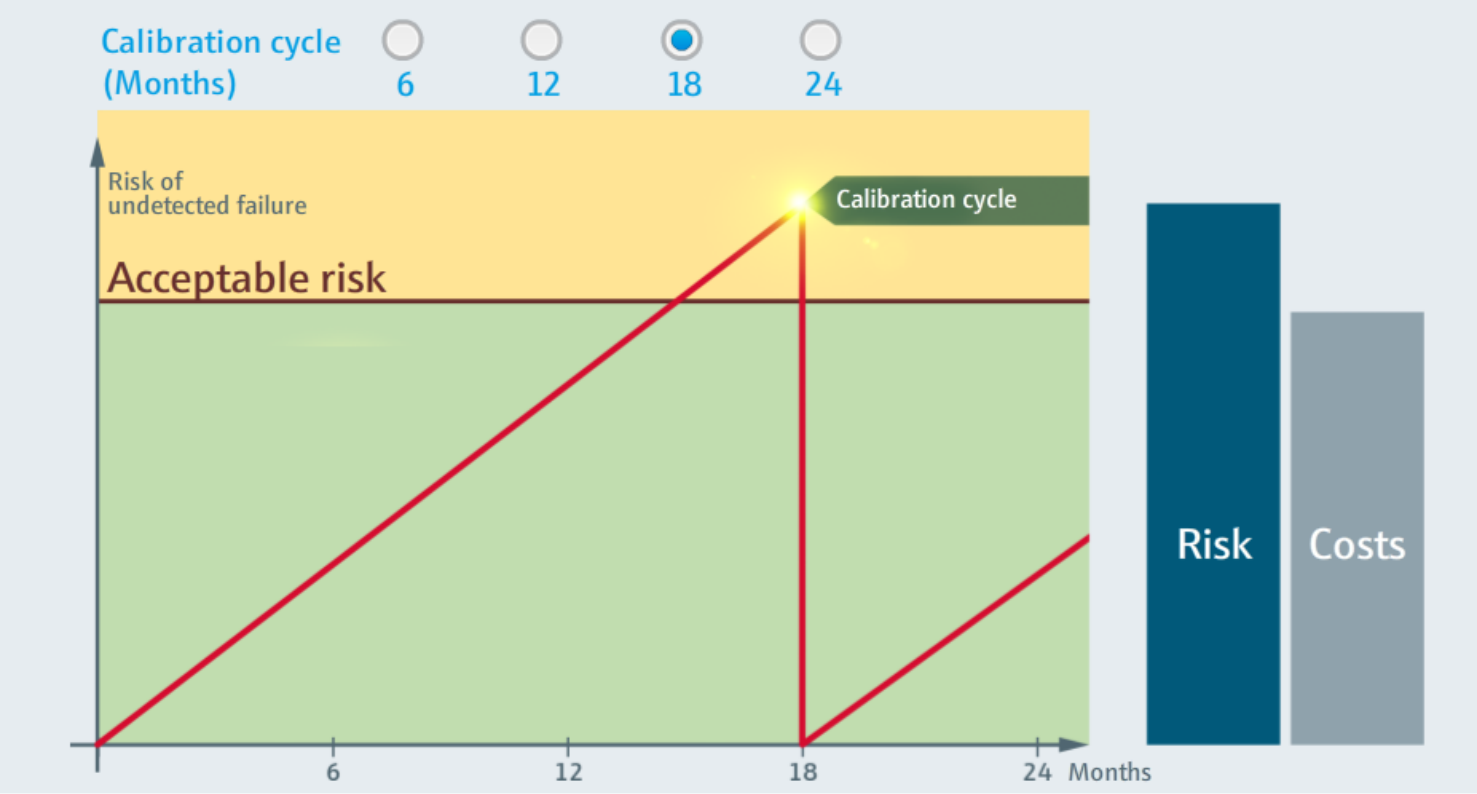


Instead: Risk based approach



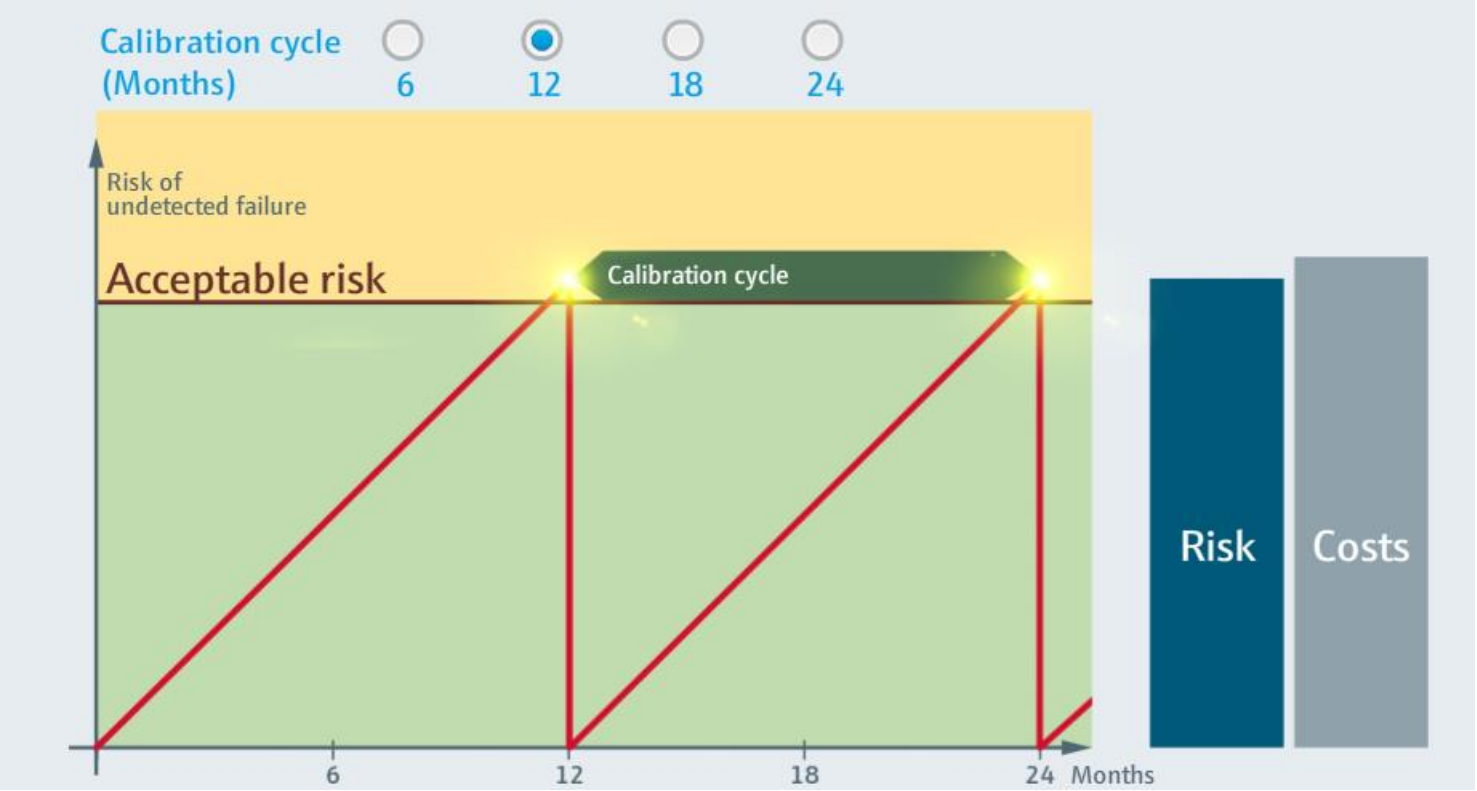
Endress+Hauser

Instead: Risk based approach



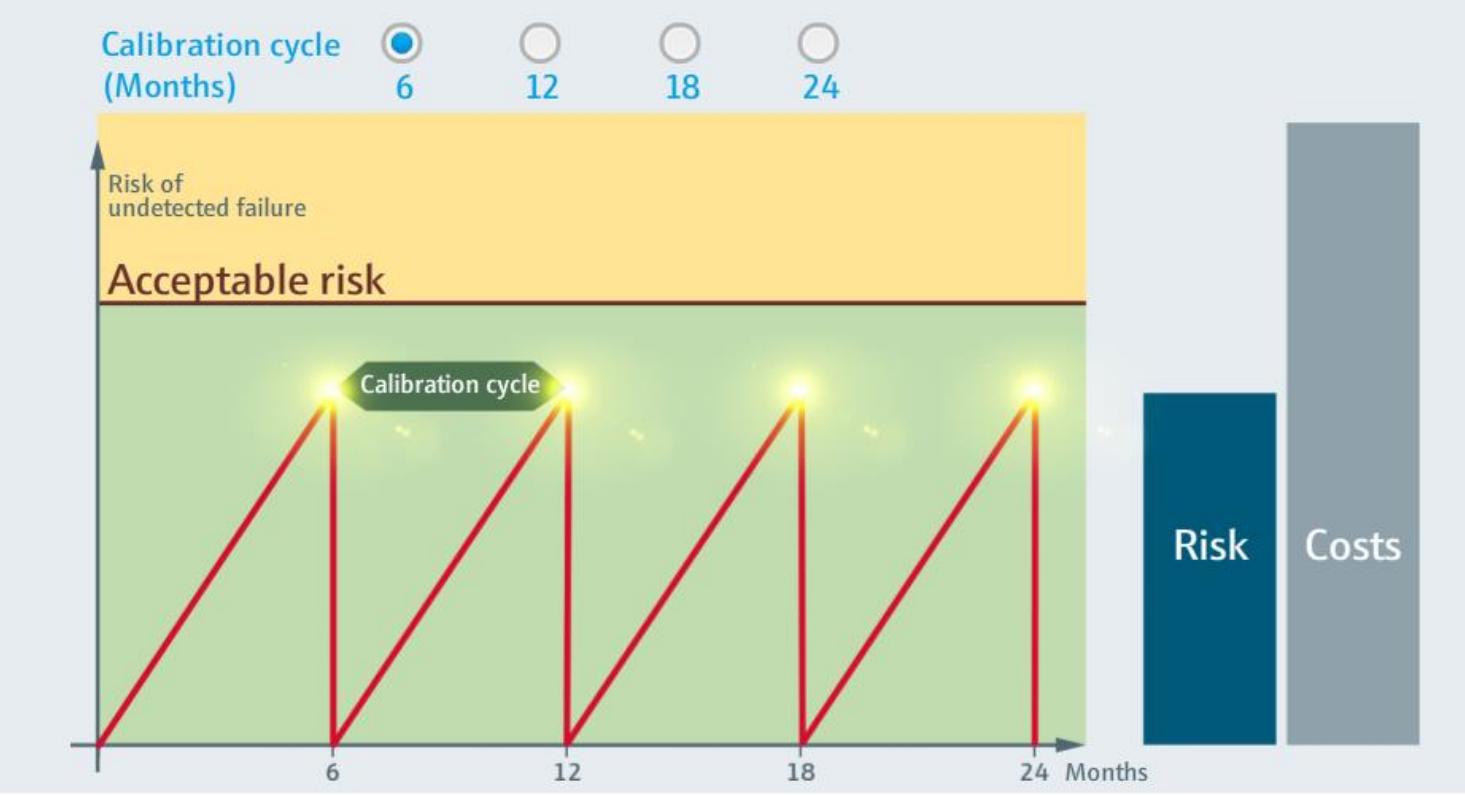
Endress+Hauser

Instead: Risk based approach



Endress+Hauser

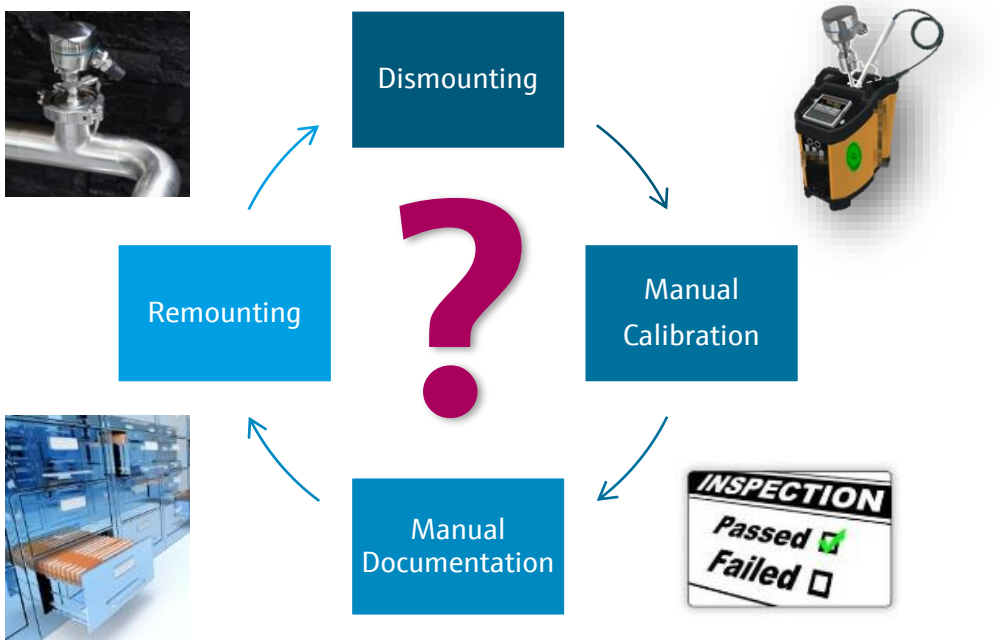
Instead: Risk based approach



Endress+Hauser

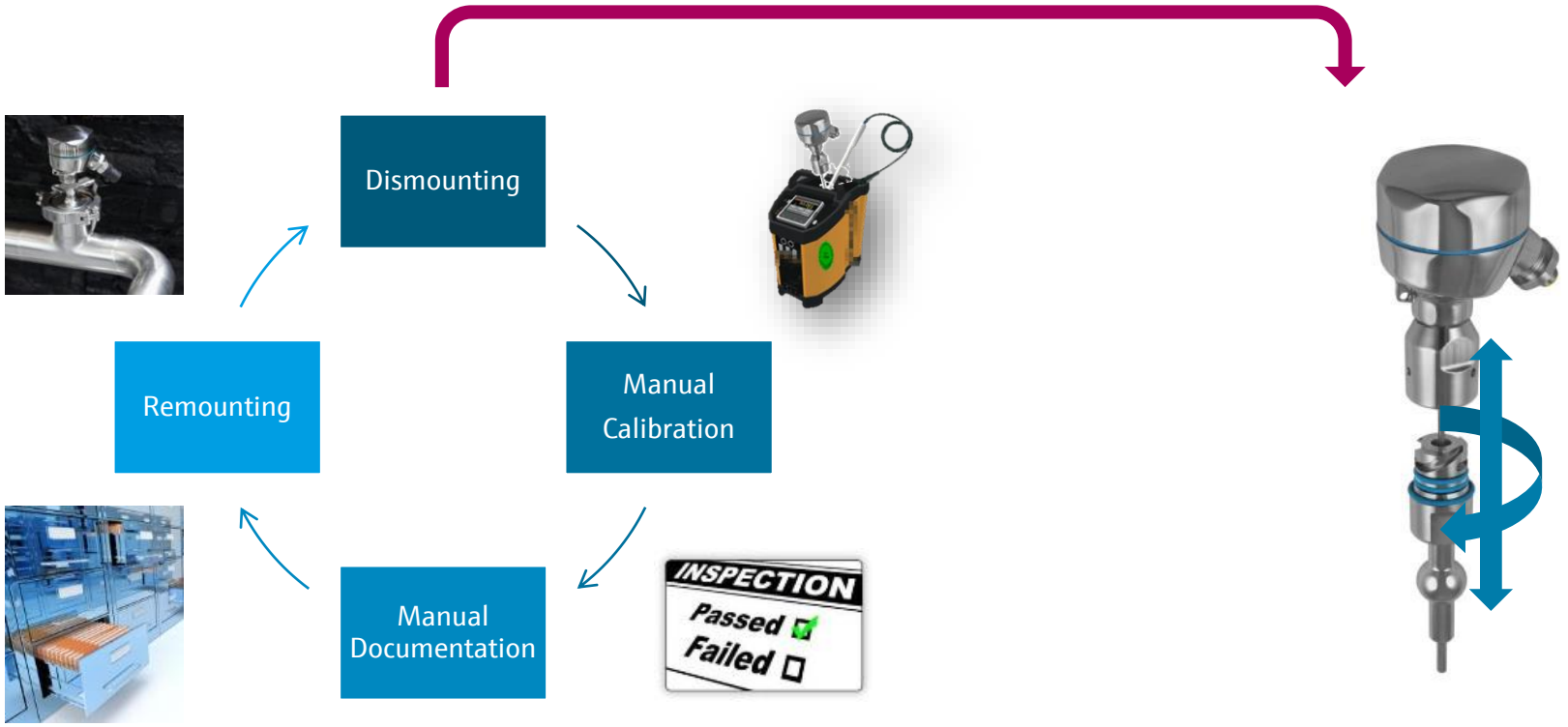
People for Process Automation!

Innovative solutions for higher productivity, safety and plant availability



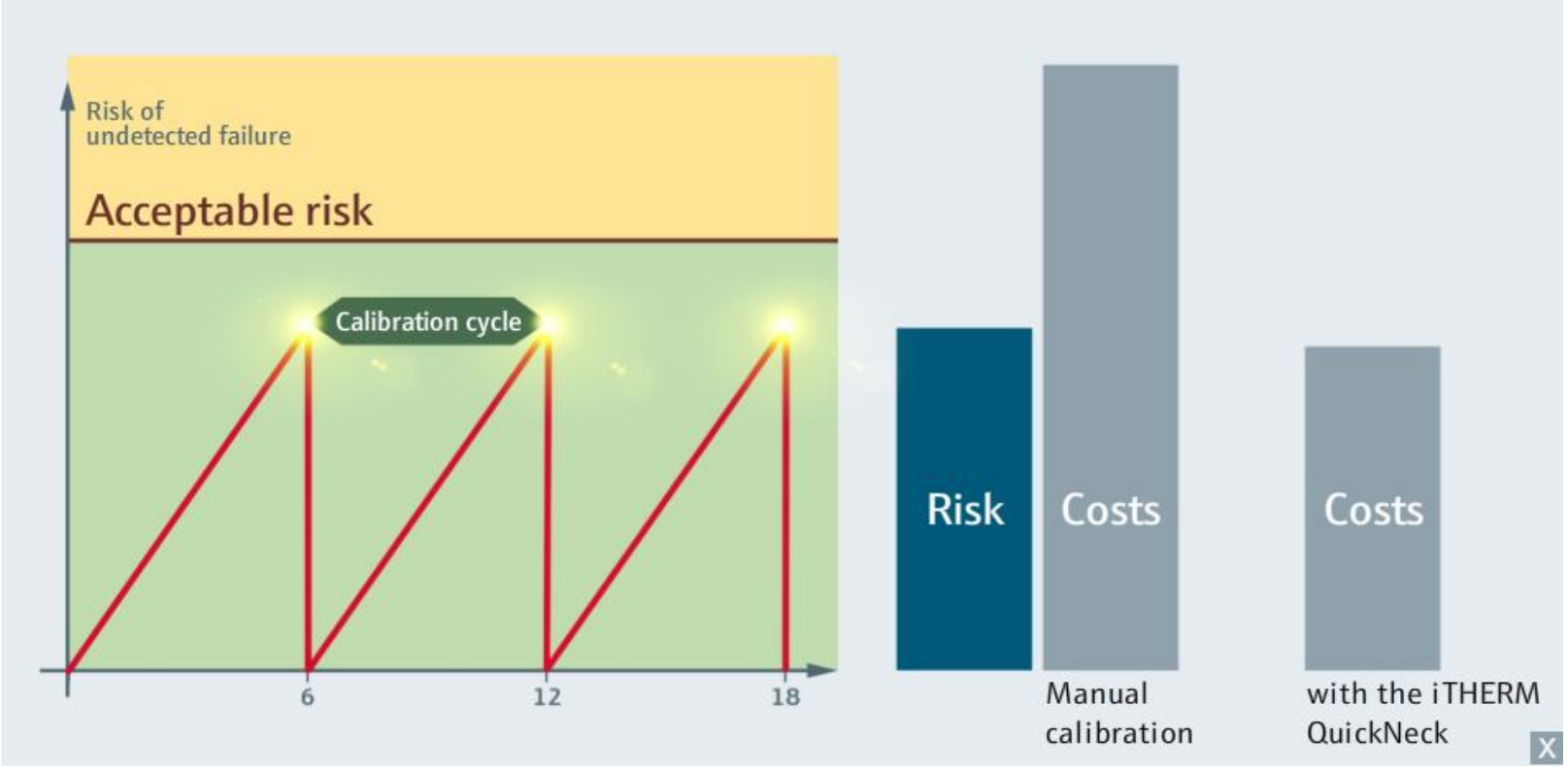
Endress+Hauser

First Step – Evolution with iTHERM QuickNeck



Endress+Hauser

First Step – Evolution with iTHERM QuickNeck



Endress+Hauser

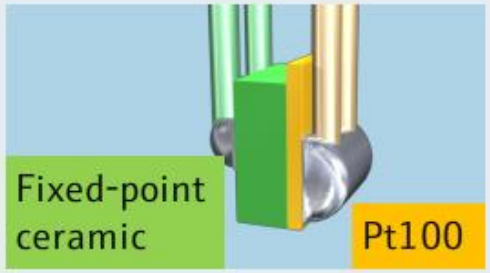
Inline calibration with iTHERM TrustSens

Reference thermometer

Block or oil calibrator

Homogeneity
repeatability

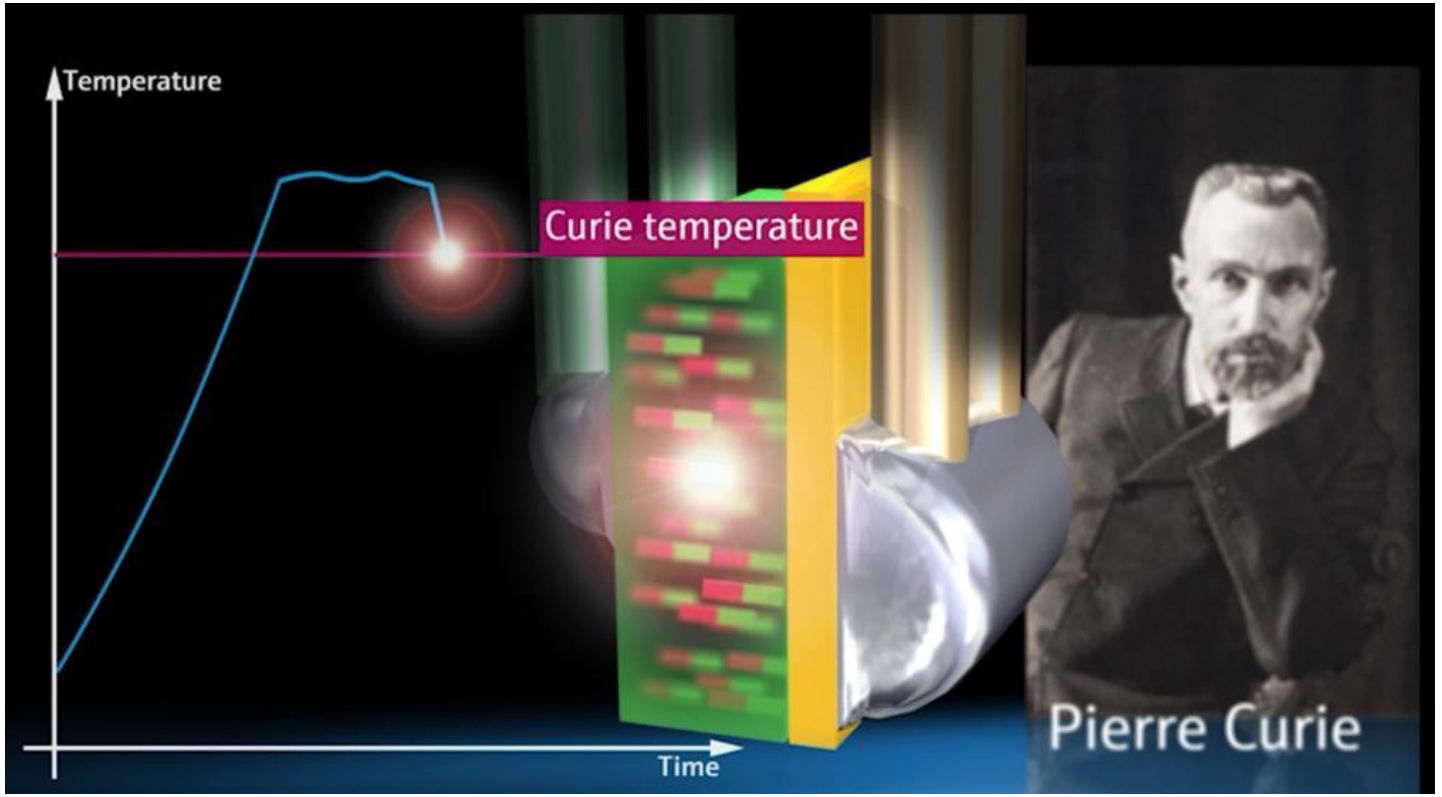
Sensor



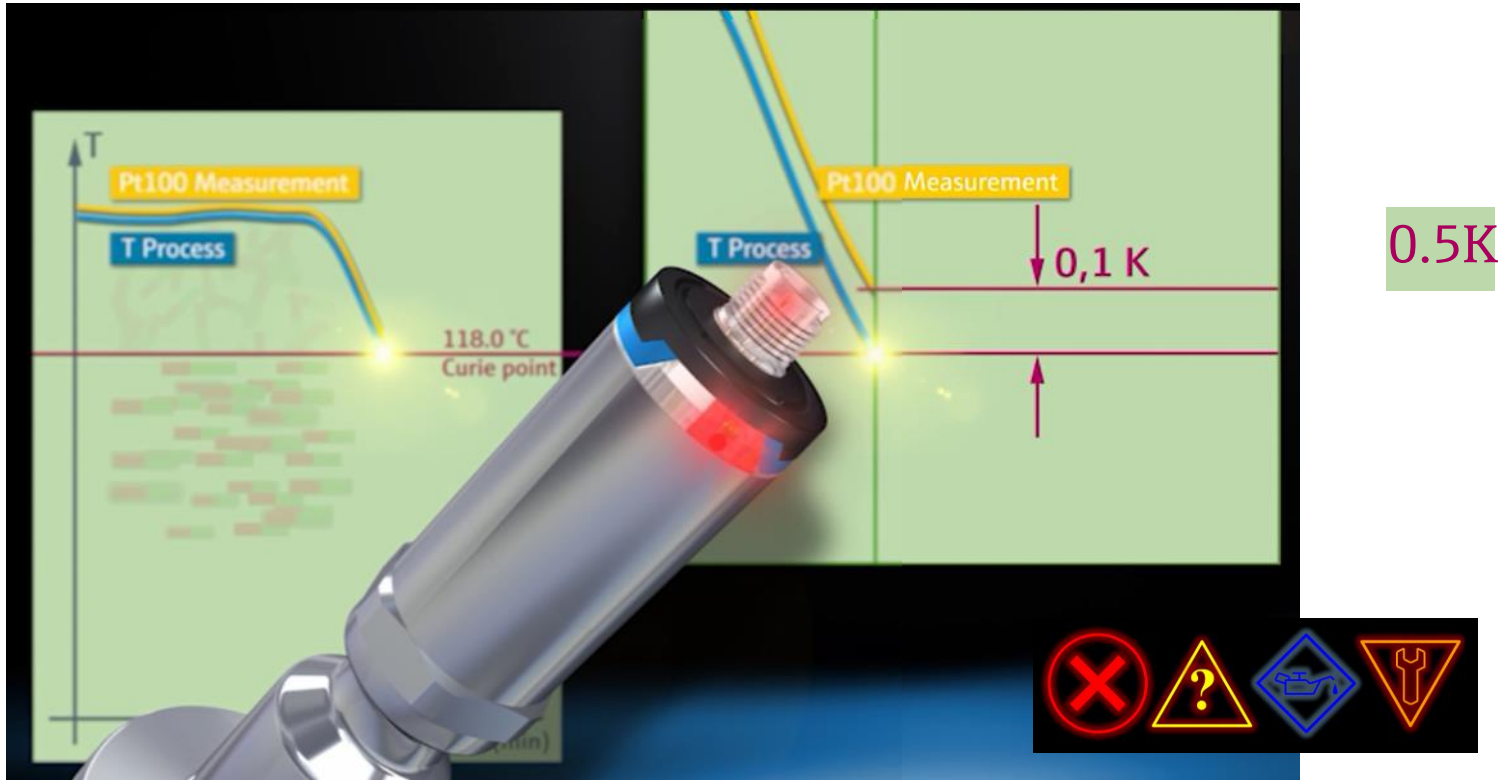
Process

Endress+Hauser

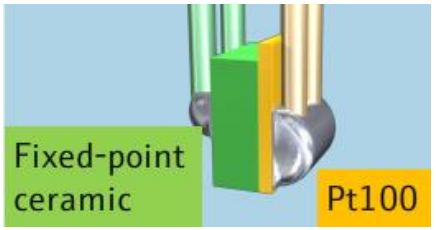
Curie Temperature as calibration reference



Curie Temperature as calibration reference



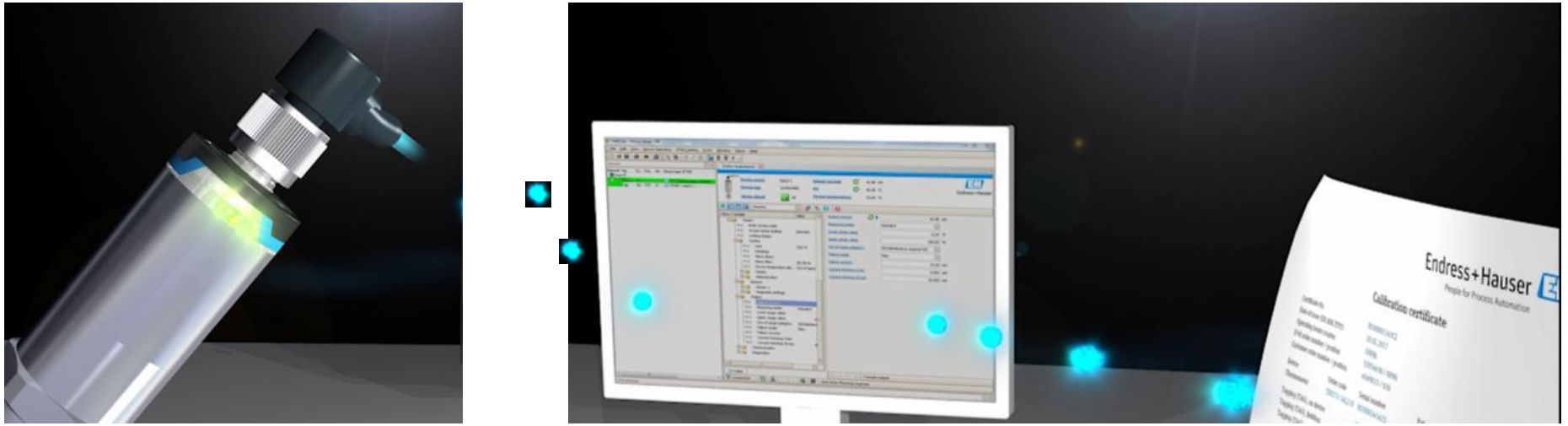
0.5K



Endress+Hauser

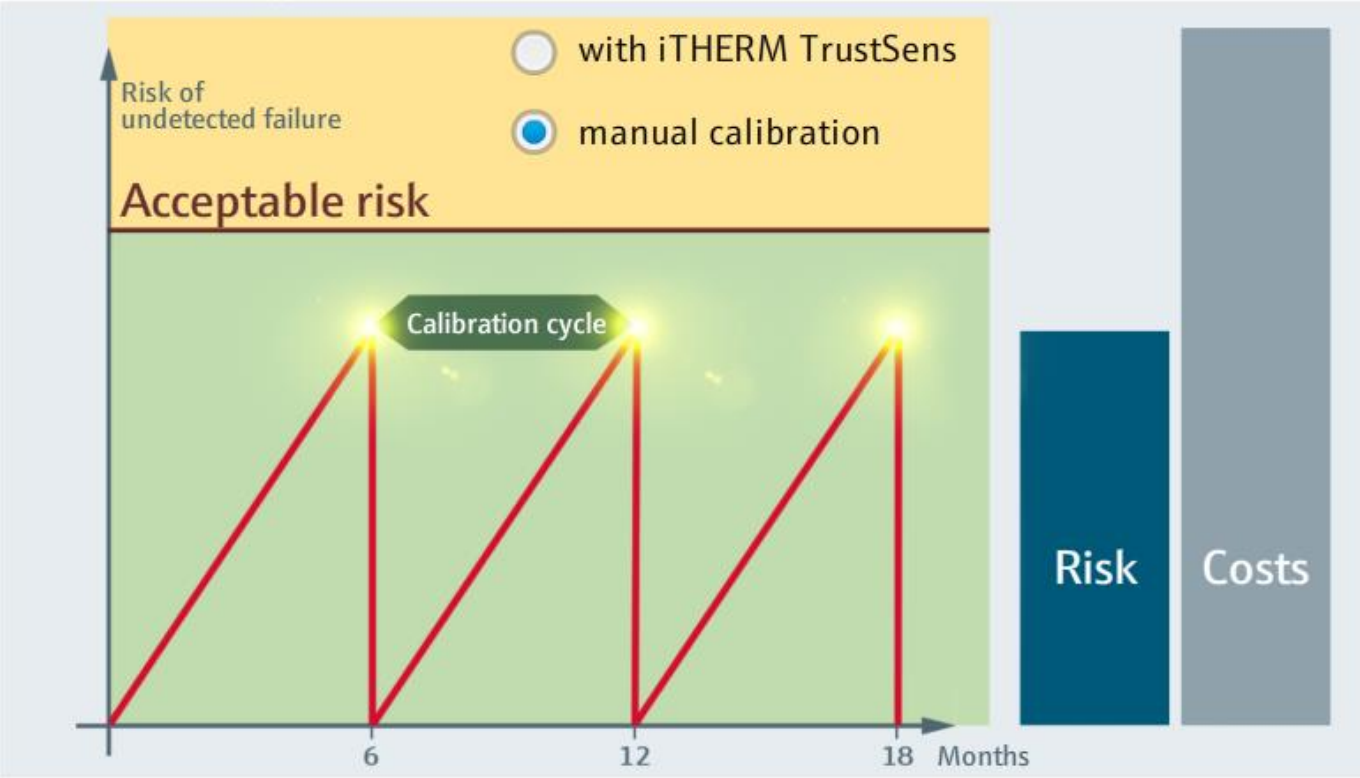
Automatic calibration certificate

Endress+Hauser FieldCare software



Endress+Hauser

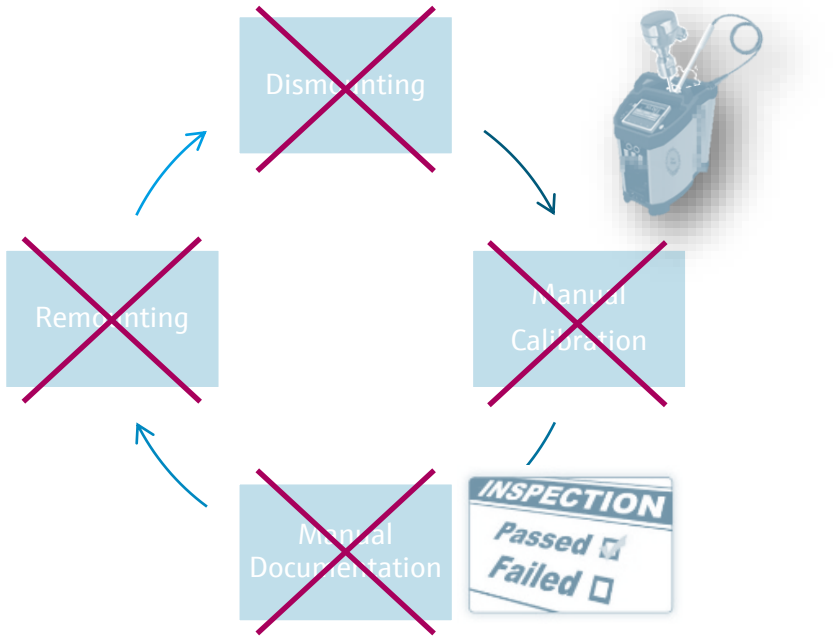
The revolution of calibrations – iTHERM TrustSens



The past

Endress+Hauser

The revolution of calibrations – iTHERM TrustSens

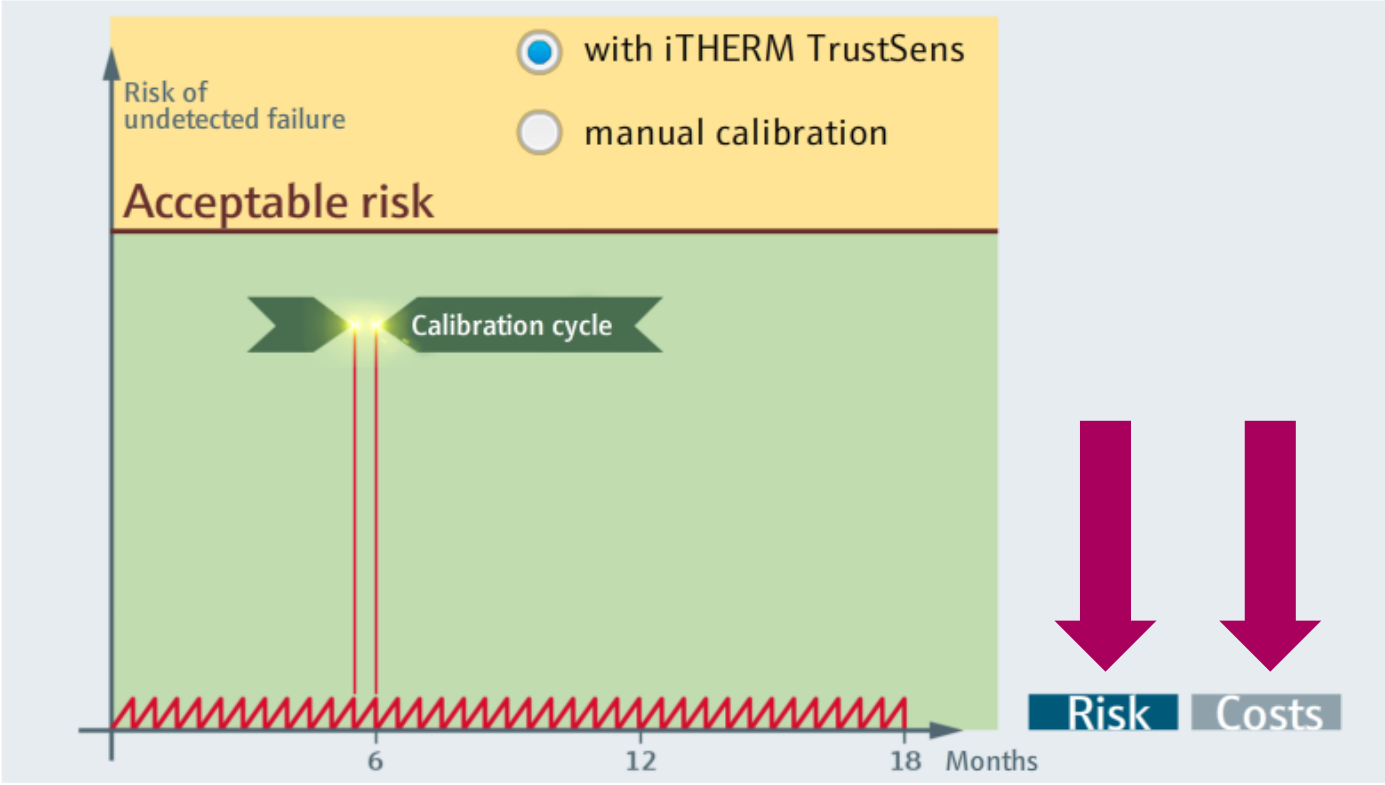


Shutdowns

Risk of non-conformity

Endress+Hauser

The revolution of calibrations – iTHERM TrustSens



The future!

Endress+Hauser

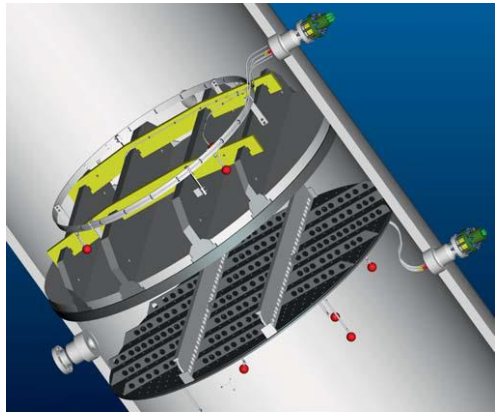
The Revolution – iTHERM TrustSens

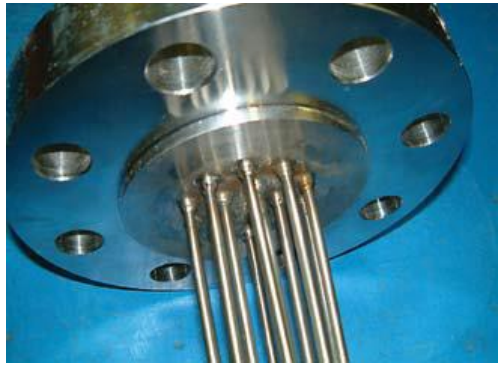
100% Compliance – 0% Effort

Endress+Hauser

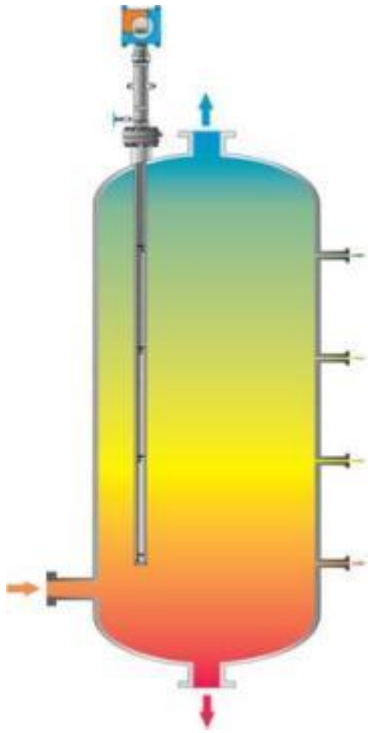
Special Application examples

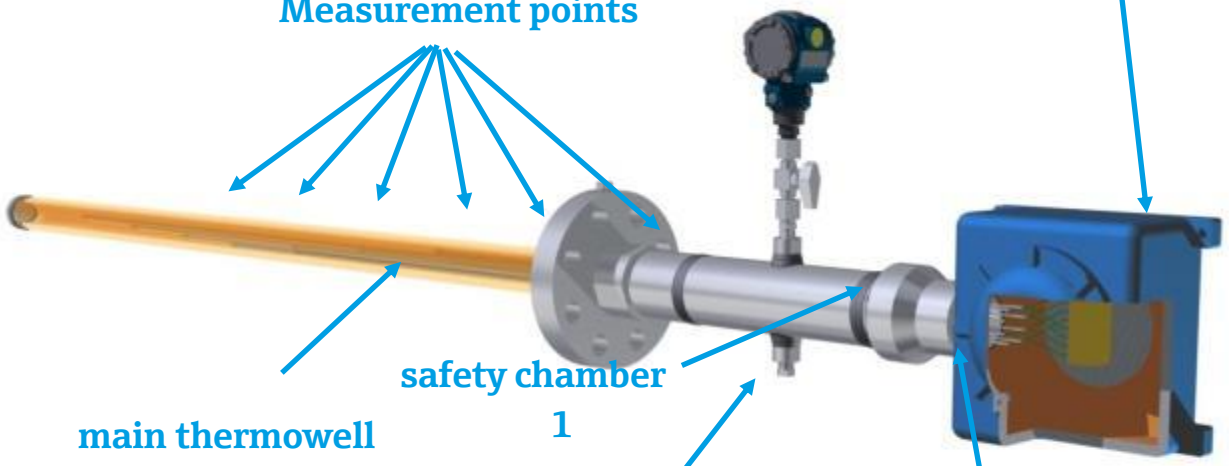
Temperature Engineered Solutions (TES)





Engineered solutions – Example: Straight Multipoint





Flame lamination joint for unloosing compression fittings to replace the inserts

Measurement points

main thermowell

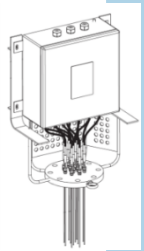
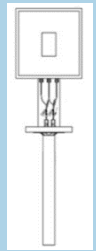
safety chamber 1

safety chamber 2

standard flanged process connection

junction box

Product offering / Segmentation– Multipoints

	MultiSens Flex	MultiSens Linear	MultiSens Slim	MultiSens Bundle
				
Without diagnostic chamber	TMS 0 1	TMS 1 1	TMS 2 1	TMS 3 1
With diagnostic chamber	TMS 0 2	TMS 1 2		

Product features and the values for the customer

iTHERM TMS01 MultiSens Flex Multipoint
Modular direct contact TC and RTD multipoint thermometer for Oil&Gas and Petrochemical applications

MultiSens Flex benefits

- *Infinite 3D sensors distribution layouts for any process monitoring configuration*
- *High degree of customization thanks to a modular product design for easy installation, process integration and maintenance*
- *High degree of insert process compatibility as per standard IEC 60584, ASTM E230 and IEC 60751*
- *On board electronic heat protection for long product lifetime*
- *Compliance to different types of protection for use in hazardous locations for a wide and easy process integration*

By complying with the highest safety standards, it provides a complete temperature profile just by using one nozzle. The TMS01 is configurable with or w/o thermowells for an optimal response times or mechanical strength/sensors replacement.

Product offering – iTHERM MultiSens Flex – TMS01

Frame/neck

- Modular support system, adjustable for all available junction boxes
- Support frame: Material: 316/316L
- Tube neck: 304

Process connection

- Flanges according to ASME and EN standards available
- Other connections on requests
- Material: 316/L ; 304/L; 316Ti; 321; 347

Thermowells (optional)

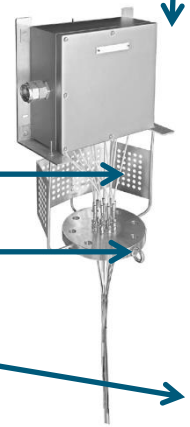
- Tube according to EN/ASME standards
- Material: 316/L ; 321; 347

Junction Box

Marking:

- Atex II 2 GD Ex e IIC Gb
- Atex Ex ia Ga IIC T
- Atex tb IIIC

Material: AISI 316, Aluminum (on request)



Electronics

- TMT 8x, 18x, 125
- Terminal blocks

Inserts

- Thermocouple (type J,K,N,T) grounded and ungrounded execution
- RTD Pt100 Wire Wound, Thin film or StrongSens
- Insert sheath material: Alloy600, 316/L, Pyrosil or special on request
- Ø range = from 2 mm (0.08 in) to 6 mm (0,23 in)
- Single or duplex thermocouples

Product features and the values for the customer

iTHERM TMS02 MultiSens Flex Multipoint
Modular direct contact TC and RTD multipoint thermometer for Oil&Gas and Petrochemical applications

MultiSens Flex benefits

- *Same as TMS01*
- *Increased safety thanks to a diagnostic chamber able to contain the process in the event of leakages through the primary seals*

Product offering – iTHERM MultiSens Flex – TMS02

Frame/neck

- Modular support system, adjustable for all available junction boxes
- Material: 316/316L

Process connection

- Flanges according to ASME and EN standards available
- Other connections on requests
- Material: 316/L ; 304/L; 316Ti; 321; 347

Thermowells (optional)

- Tube according to EN/ASME standards
- Material: 316/L ; 321; 347

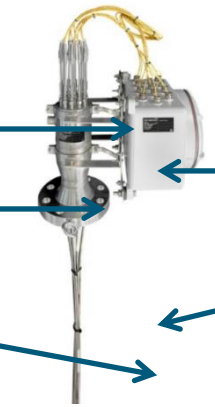
Junction Box

Marking:

- Atex II 2 GD Ex e IIC Gb
- Atex II 2 GD Exd IIC Gb
- Atex Ex ia Ga IIC T
- Atex tb IIIC

Material: AISI 316

Aluminum (on request)



Electronics

- TMT 8x, 18x, 125
- Terminal blocks

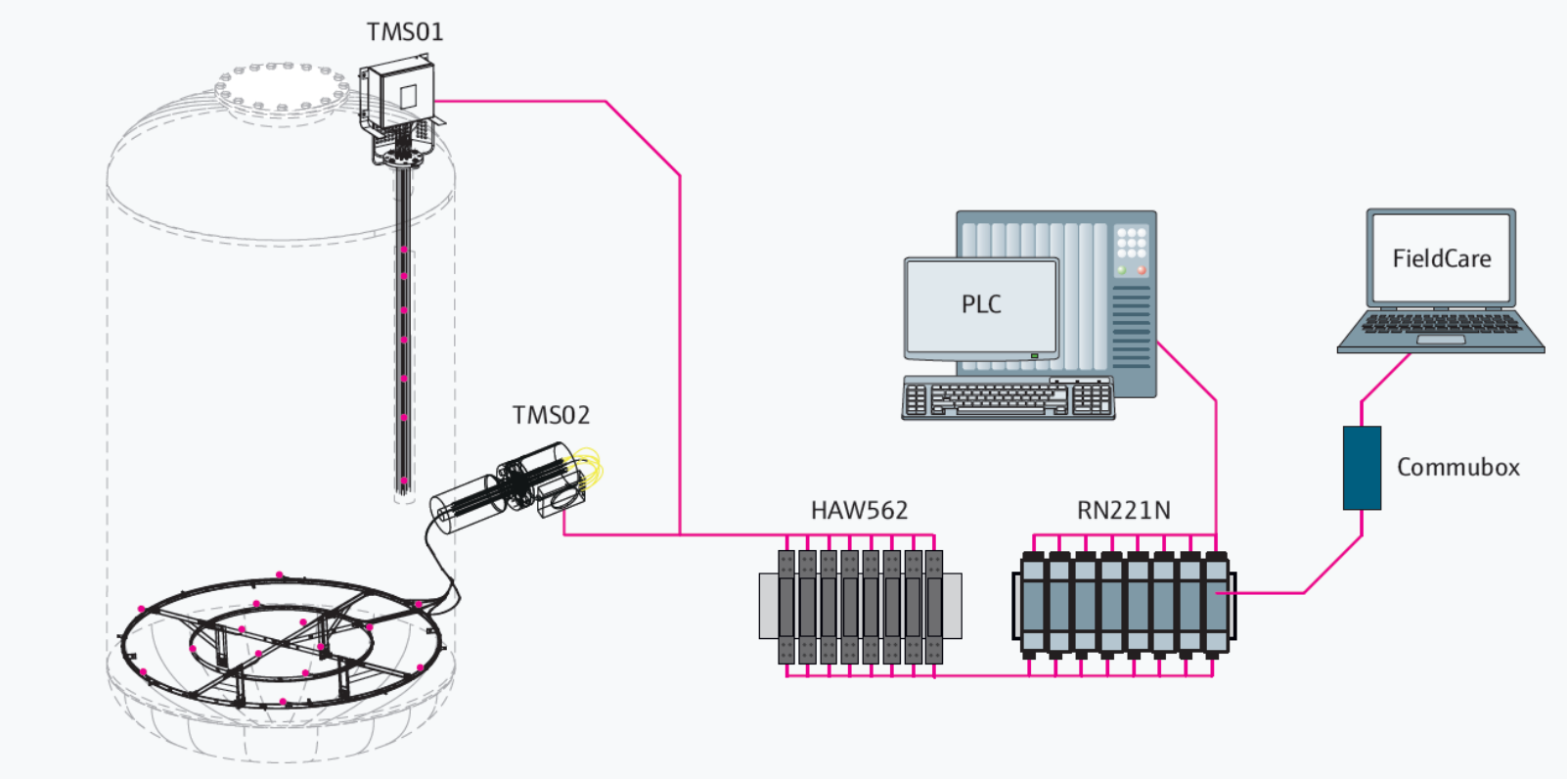
Diagnostic Chamber

- Integrated on board
- Materials as for the Process connection

Inserts

- Thermocouple (type J,K,N,T) grounded and ungrounded execution
- RTD Pt100 Wire Wound, Thin film or StrongSens
- Insert sheath material: Alloy600, 316/L, Pyrosil or special on request
- Ø range = from 2 mm (0.08 in) to 6 mm (0,23 in)
- Single or duplex thermocouples

Product offering – iTHERM MultiSens Flex – TMS0x



Endress+Hauser

Product features and the values for the customer

iTHERM TMS21 MultiSens Slim Multipoint
Minimally invasive bendable TC multipoint thermometer for Petrochemical and Chemical applications

It is composed of several low diameters thermocouples protected by one overall primary tube thermowell. Two different product configurations are available, with or without flexible upper thermowell-hose (for axial centering).

MultiSens Slim benefits

- *High number of measuring points in a small diameter*
- *Low invasiveness temperature profiling probe*
- *Easy mounting and cabling*

It can monitor the temperature on a very high number of points along a line just by using one process connection.

Endress+Hauser

Product offering – iTHERM MultiSens Slim – TMS21

Frame/neck

- As accessory
- Material: 316/316L

Process connection

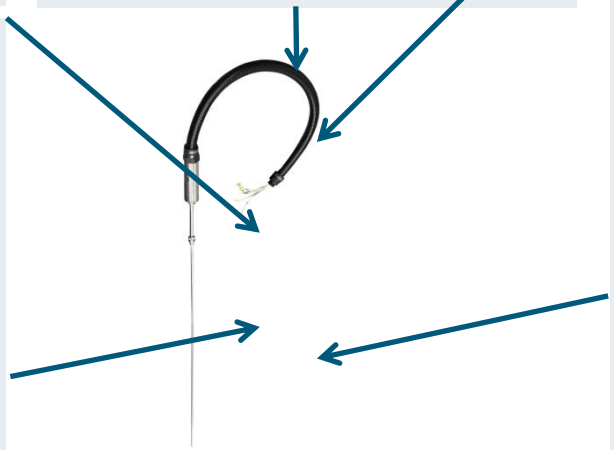
- Compression fitting (SS 316L)
- Other connection types on requests

Thermowells

- Tube according to EN/ASME standards
- Material: 316/L ; 321; 347
- 3.2 mm (0.13 in); 6 mm (0.24 in)
- 6.35 mm (0.25 in); 8 mm (0.31 in)
- 9.5 mm (0.37 in); special on request

Extension Conduit

- Used to protect the extension cables from environmental agents
- Mat.: Polyamide; other materials on request
- IP66/67 degree by using E+H suggested adapters.



Electronics

- As accessories
  - TMT 8x, 18x, 12x 125

Inserts

Not replaceable grounded or ungrounded thermocouple inserts

- Thermocouple (type J,K,E,N)
- Insert sheath material: Alloy600, 316/L, or special on request
- Ø range = from 0,5 mm (0.019 in) to 1,5 mm (0,06 in)

Product features and the values for the customer

iTHERM TMS11 MultiSens Linear Multipoint
Modular straight TC and RTD multipoint thermometer for Oil&Gas and Petrochemical applications

MultiSens Linear benefits

- *High degree of insert process compatibility as per standard IEC 60584, ASTM E230 and IEC 60751*
- *Several safety standard compliances (such as but not limited to ATEX, PED) for easy process integration*
- *High degree of customization thanks to a modular product design for easy installation, process integration and maintenance*
- *On board electronic heat protection for long product lifetime*
- *Superior mechanical strength and sensors replacement thanks to a primary thermowell*

The TMS11 is available with a primary thermowell for superior mechanical strength/sensors replacement.

Product offering – iTHERM MultiSens Linear – TMS11

Frame/neck

- Modular support system, adjustable for all available junction boxes
- Support frame: Material: 316/316L
- Tube neck: 304

Process connection

- Flanges according to ASME and EN standards available
- Other connections on requests

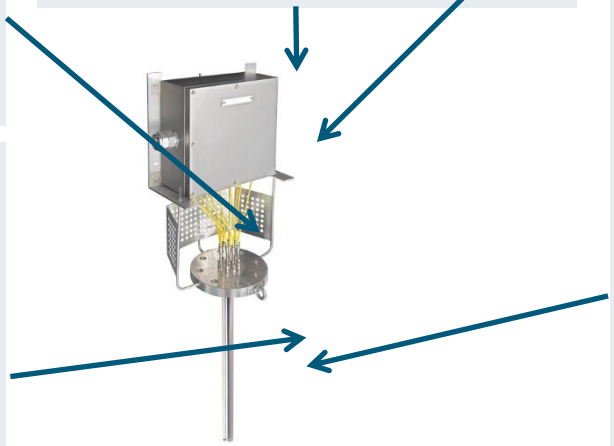
Thermowell

- Tube according to EN/ASME standards
- Material: 316/L ; 321; 310S
- Sizes:
- 1/2; 3/4; 1; 1 1/4; 1 ½; 2; 2 ½; 3 Inches
- 21.3; 26,7; 33,4; 42,2; 48,3; 60,3; 73; 88,9 mm

Junction box

Marking:

- Atex II 2 GD Ex e IIC Gb
- Atex Ex ia Ga IIC T / Atex tb IIIC
- Material: AISI 316, Aluminum (on request)

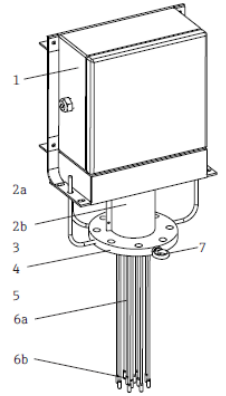


Electronics

- TMT 8x, 18x, 125
- Terminal blocks

Inserts

- Thermocouple (type J,K,N,T) grounded and ungrounded execution
- RTD Pt100 Wire Wound, Thin film or StrongSens
- Insert sheath material: Alloy600, 316/L, Pyrosil or special on request
- Ø = 3 mm (0,12 in)
- Single or duplex thermocouples



Endress+Hauser

Product features and the values for the customer

iTHERM TMS12 MultiSens Linear Multipoint
Modular straight TC and RTD multipoint thermometer for Oil&Gas and Petrochemical applications

MultiSens Linear benefits

- *Same as TMS11*
- *Increased safety thanks to a diagnostic chamber able to contain the process in the event of leakages through the primary seals*

Product offering – iTHERM MultiSens Linear – TMS12

Frame/neck

- Mat: 316L
- Size compatible with diagnostic chamber

Process connection

- Flanges (Welding neck) according to ASME and EN standards available
- Other connections on requests

Thermowell

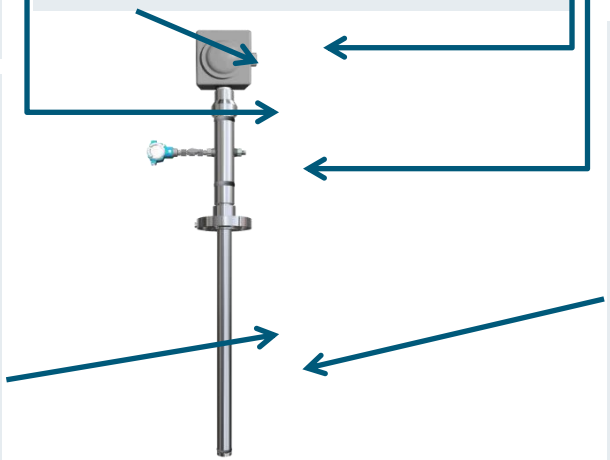
- Tube according to EN/ASME standards
- Material: SS 316/L ; 321;
- 1/2;3/4;1;1 1/4;1 1/2,2,2 1/2,3 Inches
- 21.3;26,7;33,4;42,2;48,3,60,3;73;88,9 mm

Junction box

Marking:

- Atex II 2 GD Ex e IIC Gb
- Atex II 2 GD Exd IIC Gb
- Atex Ex ia Ga IIC T
- Atex tb IIIC

Material: AISI 316; Aluminum (on request)



Electronics

- tbd

Diagnostic Chamber

- Mat: 316L; 321
- Size:

- 1 ¼; 11/2, 2, 2 1/2, 3 inches
- 42,2; 48,3, 60,3; 73; 88,9 mm

Inserts

- Thermocouple (type J,K,N,T) grounded and ungrounded execution
- RTD Pt100 Wire Wound, Thin film or StrongSens
- Insert sheath material: Alloy600, 316/L, Pyrosil or special on request
- Ø = 3 mm (0,12 in)
- Single or duplex thermocouples

Product features and the values for the customer

iTHERM TMS31 MultiSens Bundle Multipoint
High precision multipoint thermometer for average and local temperature measurement in silos and storage applications

It can monitor the temperature on a high number of points along a line just by using one entry. This TMS31 is composed of several TCs or RTDs fixed to a primary metal rope or inside a customized polymeric conduit.

MultiSens Bundle benefits

- *Mechanically flexible and high number of measuring points probe, mounted on rope/rod;*
- *Not affected by pressure conditions*
- *Easy mounting and cabling, installation versatility*

Specially designed for temperature average detection and temperature profiling in silos and storage applications.

Product offering – iTHERM MultiSens Bundle – TMS31

Frame/neck

- Tube neck

Process connection

- Flanges according to ASME and EN standards available
- Other connections on requests

Reinforcement system

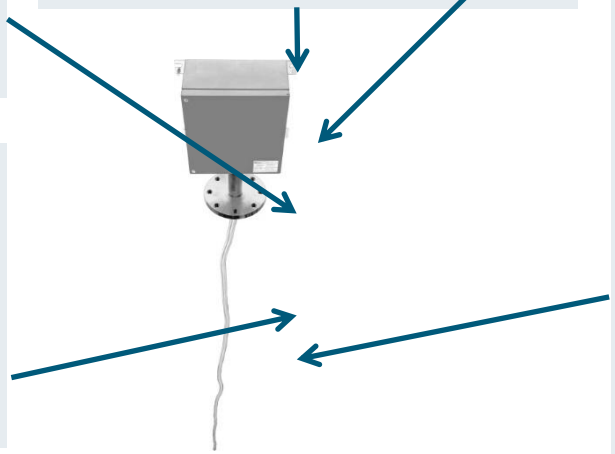
- Metallic Rope + balance weight
- Polymeric flexible hose

Junction box

Marking:

- Atex II 2 GD Ex e IIC Gb
- Atex Ex ia Ga IIC T / Atex tb IIIC

Material: AISI 316, Aluminum (on request)



Electronics

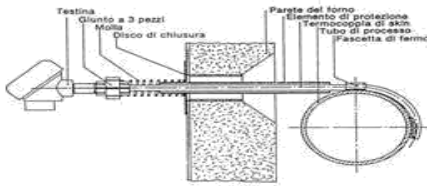
- tbd

Inserts

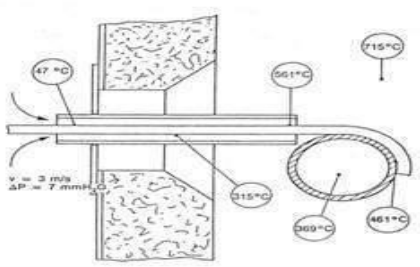
- Thermocouple (type J,K,N,T) grounded and ungrounded execution
- RTD Pt100 Wire Wound, Thin film or StrongSens
- Insert sheath material: Alloy600, 316/L, Pyrosil or special on request
- Ø = from 1,5 to 3 mm (0,12 in)
- Single or duplex thermocouples

Surface temperature measurement

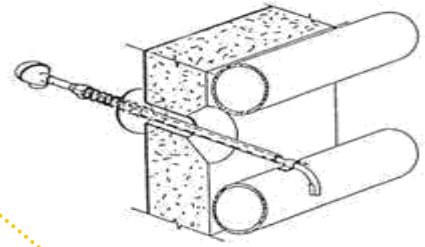
- Design



- Solution



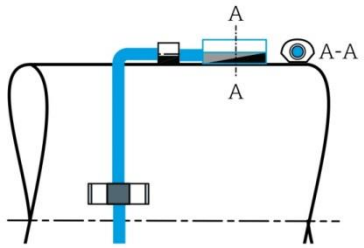
- Application



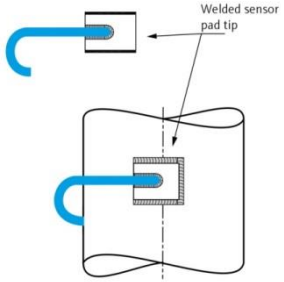
Endress+Hauser

Surface temperature measurement

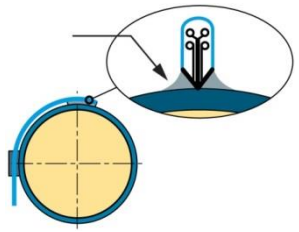
Fixed style connection



Fan Tip

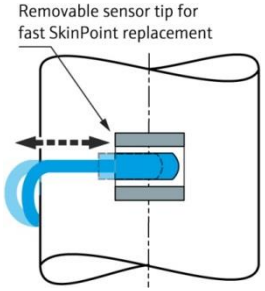


Pad Tip

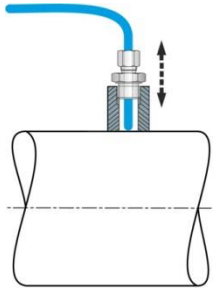


Knife-edge Tip

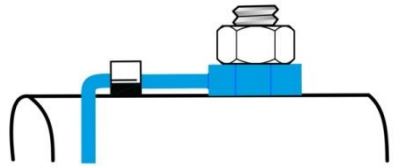
Removable connection



Sliding pad



Compression fitting



Washer Pad

High Temperature with leak detection

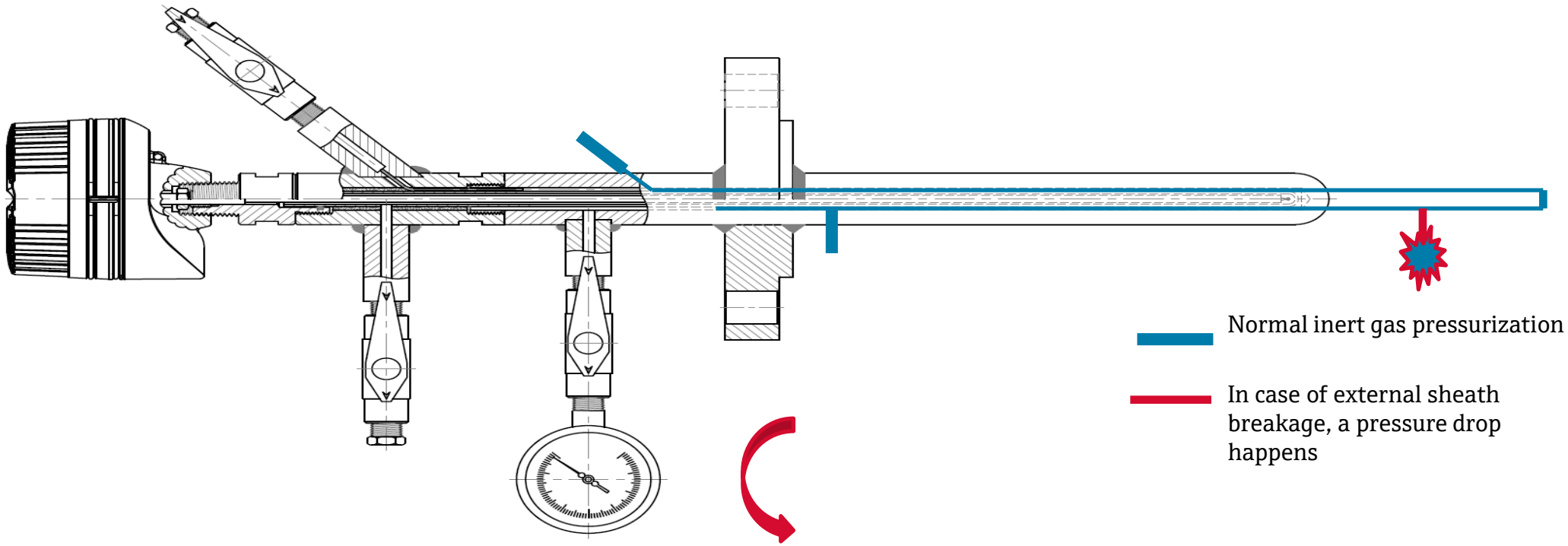
Definition:

- Customized products for harsh applications, e.g. gasifiers, able to withstand at very high temperatures, sometimes in combination with pressure, and very aggressive environments.

Features:

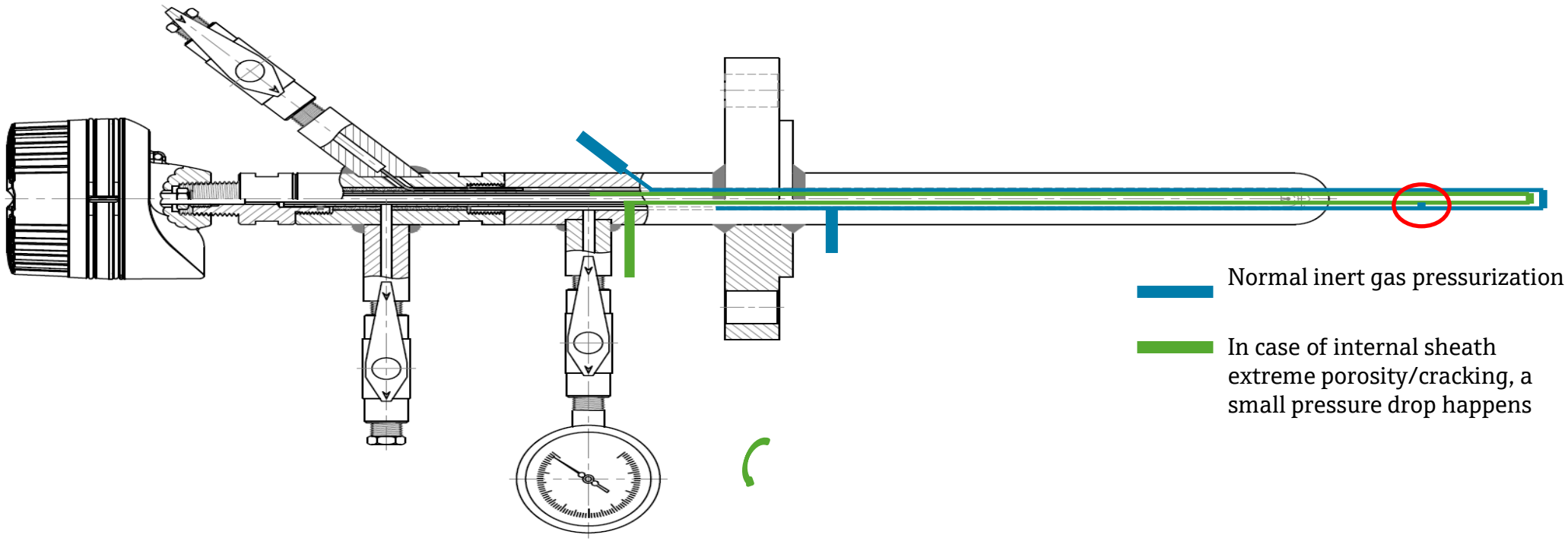
- Increased safety – Purging system
- Special process connections are available
- Special thermowell materials are needed

High Temperature with leak detection



Endress+Hauser

High Temperature with leak detection



Questions?