Temperature products, recorders & system components

Quality instruments you can rely on

Endress+Hauser
People for Process Automation

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Endress+Hauser - experts in temperature

With unprecedented experience and extensive manufacturing facilities the world over, Endress+Hauser is recognised as a specialist in temperature measurement technology. We specialise in the design and manufacture of industrial temperature sensors and bespoke engineered solutions tailored to our customers' needs across all industries.

Drawing on considerable international experience and with accredited calibration laboratories (DKD, SIT), our global network of production facilities and representatives support our customers in over 120 countries.

Our production centres manufacture around 7,000 temperature assemblies and transmitters every week to supply Endress+Hauser customers around the globe.

Endress+Hauser's quality management system is accredited to ISO 9001:2008 and the scope of supply covers the design and manufacture of thermowells and industrial temperature sensors. Recognising our customers' requirements for quality, we provide temperature measurement points with individual component parts subject to careful examination in our own test centres. The quality of materials, processes and instruments is fully certified and specific details can be traced back for years!

Our business park in Manchester houses our Centre of Competence for engineered temperature solutions with extensive temperature manufacturing and testing facilities. Within our state-of-the-art Application, Training and Engineering Centre we have calibration and training facilities tailor-made for our customers. Our key personnel have over 80 years of experience and are familiar with all aspects of temperature design and manufacturing techniques to provide an accredited quality service across the UK.

Modular components, modular specification

All our temperature sensors are individually part numbered. This allows you to specify exact lengths, diameters, housings, terminations and many other attributes. Details of products can be found on our technical information sheets available for download at www.uk.endress.com. Furthermore, each component of the modular thermometer can be supplied individually as a spare part.

Ergonomically designed terminal head with clear labelling to identify spare parts and approvals, including serial number for complete traceability.

High purity mineral insulated insert with serial number, temperature range and length clearly labelled.

Termination into terminal block, flying leads or one of our range of electronic temperature transmitters, which again carries its own serial number.

Any testing carried out on the thermowell will be recorded against the assembly's serial number, which is clearly marked on the thermowell.

Traceability The Endress+Hauser modular thermometer is clearly labelled with its own individual serial number. This number is the link to all information regarding the product - simply enter the serial number into our online device viewer and with the click of a mouse you will have detailed information on the part structure along with a list of spare parts and general documentation for the product. Navigate to www.uk.endress.com/device-viewer.

In addition to this, if you have a W@M life cycle management account, you can access the common equipment record and view more detailed information such as individual calibration certificates and test reports delivering total traceability.

General-purpose thermometers

- Economic option
- Separate thermowell
- Thermocouple or RTD
- Configurable options

General-purpose thermometers

	Cable sensor	Sensor with housing	Tube thermowell
RTD T/C	TST310 TSC310	TR24 TEC420	TW251
			
Features	▪ Cost-effective ▪ Selectable dimensions ▪ Optional fitting ▪ Mineral insulated sheath	▪ Cost-effective ▪ Selectable dimensions ▪ Optional fitting ▪ Mineral insulated sheath	▪ Cost-effective ▪ Selectable dimensions ▪ Stainless steel or PTFE olive ▪ Straight, reduced or tapered
Technical data ▪ Temperature ▪ Pressure ▪ Response time ▪ Connection ▪ Sensing element	▪ -200 to 600/1100°C ▪ Up to 40 bar ▪ t90 from ≤2.0s ▪ Optional, compression type ▪ RTD or thermocouple	▪ -200 to 600/1100°C ▪ Up to 50 bar ▪ t90 from ≤2.0s ▪ Optional, compression type ▪ RTD or thermocouple	▪ 600°C ▪ Up to 50 bar ▪ Screwed/weld-in
Typical applications	▪ General light industrial ▪ For extra long lengths ▪ Where space is limited ▪ Thermal profiling	▪ General light industrial ▪ When a thermowell is not needed	▪ General light industrial

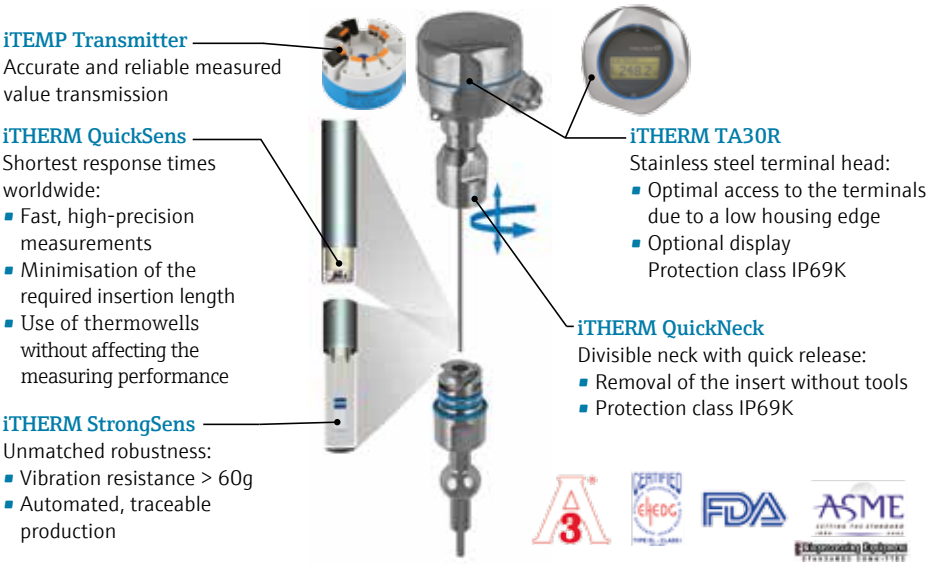
Compact thermometers

- 316 stainless steel housing
- Fast response tip
- Integral electronics
- PC programmable
- Quick response as standard

Compact thermometers

	Compact thermometer		Compact display/switch	
RTD	TMR31	TMR35	TTR31	TTR35
				
Features	▪ Integral transmitter (optional) ▪ Pt100 or 4-20mA output ▪ 3-A compliant (TMR35) ▪ M12 plug connection ▪ Selectable dimensions		▪ Integral display ▪ 2 x PNP or 1 x PNP + 4-20mA output ▪ 3-A compliant (TTR35) ▪ M12 plug connection ▪ Selectable dimensions	
Technical data ▪ Temperature ▪ Pressure ▪ Response time ▪ Connection ▪ Sensing element ▪ Supply voltage	▪ -50 to 200°C with neck ▪ 30 bar (depending on connection) ▪ t90 ≤2.0s ▪ TMR31 screwed/TMR35 hygienic ▪ Pt100, 4-wire, class A ▪ 10 to 35V DC		▪ -50 to 200°C with neck ▪ 30 bar (depending on connection) ▪ t90 ≤2.0s ▪ TTR31 screwed/TTR35 hygienic ▪ Pt100, 4-wire, class A ▪ 12 to 30V DC	
Typical applications	▪ Food and beverage ▪ Energy monitoring ▪ Light chemical/life science ▪ General process		▪ Food and beverage ▪ Energy monitoring ▪ Light chemical/life science ▪ General process	

Approvals/certificates/tests for TM401 and TM411



3-A:	All thermometers fulfil the 3-A hygiene standards for sensors, connections and fittings, no. 74-03.
EHEDG:	TM401 and TM411 have a number of EHEDG approvals.
FDA:	The materials used fulfil the FDA requirements.
ASME-BPE:	Option to fulfil the requirements in the ASME-BPE standard for bioprocessing equipment.
EN 10204-3.1:	Material certificate to EN 10204-3.1 is available for all devices.

Aseptic and hygienic thermometers

- Hygienic process connections
- 316 stainless steel body, insert and head
- Material roughness certification available
- Hygiene fittings compliant with 3-A, EHEDG, ASME-BPE, FDA and TSE certificate of suitability

Hygienic thermometers

	Without thermowell	With thermowell
RTD	TM401 	TM411 
Features	▪ Wide range of process connections	▪ Wide range of process connections ▪ QuickSens- response times t90s: 0.75s ▪ StrongSens- vibration resistance >60g ▪ QuickNeck ▪ TA30R: 316L terminal head, IP69K
Technical data Temperature ranges ▪ QuickSens ▪ StrongSens ▪ Wire wound ▪ Thin film Pressure Response time Process connection Spare insert	▪ -50°C to +200°C ▪ Up to 50 bar ▪ t90 from 9s ▪ See page 31 ▪ Non-replaceable	▪ -50°C to +200°C ▪ -50°C to +500°C ▪ -200°C to +600°C ▪ -50°C to +400°C ▪ Up to 50 bar ▪ t90 from 0.75s ▪ See page 31 ▪ TS111
Typical applications	▪ Food & beverage ▪ Life science	▪ Food & beverage ▪ Life science

General-purpose thermometers

- Insert inside thermowell
- Hazardous area option
- Configurable dimensions
- For spare inserts see page 17

General-purpose thermometers

	With cooling neck	Without cooling neck	Separate fitting
RTD T/C	TR10 TC10	TR11	TR12 TC12
			
Features	▪ Integral thermowell ▪ Mineral insulated sensor ▪ Screw thread ▪ With lagging extension	▪ Integral thermowell ▪ Mineral insulated sensor ▪ Screw thread ▪ Fitting under head	▪ Integral thermowell ▪ Mineral insulated sensor ▪ Optional fittings ▪ Without cooling neck
Technical data ▪ Temperature ▪ Pressure ▪ Response time ▪ Connection ▪ Spare insert	▪ -200 to 600°C/1100°C ▪ Up to 50 bar ▪ t90 from ≤13.0s ▪ Thread ½" to 1" ▪ TPR100/TPC100	▪ -200 to 600°C/1100°C ▪ Up to 50 bar ▪ t90 from ≤13.0s ▪ Thread ½" to ¾" ▪ TPR100/TPC100	▪ -200 to 600°C/1100°C ▪ Up to 50 bar ▪ t90 from ≤13.0s ▪ Supplied separately ▪ TPR100/TPC100
Typical applications	▪ General process ▪ Chemical ▪ Hazardous areas	▪ General process ▪ Chemical ▪ Hazardous areas	▪ General process ▪ Chemical ▪ Hazardous areas

Flanged	DIN form 4 or 4F	Without thermowell
TR13 TC13	TR15 TC15	TR88 TC88
		
▪ Integral thermowell ▪ Mineral insulated sensor ▪ Welded flange ▪ With cooling neck	▪ Integral thermowell ▪ Mineral insulated sensor ▪ Flanged or weld-in ▪ With cooling neck	▪ To fit into existing thermowell ▪ Mineral insulated sensor ▪ Screw thread ▪ With cooling neck
▪ -200 to 600°C/1100°C ▪ Up to 100 bar ▪ t90 from ≤13.0s ▪ Flange up to 2" ▪ TPR100/TPC100	▪ -200 to 600°C/1100°C ▪ Up to 400 bar ▪ t90 from ≤18.0s ▪ Flange or weld-in ▪ TPR100/TPC100	▪ -200 to 600°C/1100°C ▪ Dependent on thermowell ▪ Insert only, t90 from ≤2.0s ▪ Thread ½", M14, M18 ▪ TPR100/TPC100
▪ General process ▪ Chemical ▪ Hazardous areas	▪ General process ▪ Chemical ▪ Hazardous areas	▪ General process ▪ Chemical ▪ Hazardous areas

Heavy duty thermometers

- Hazardous area option
- Optional 316 stainless steel housing
- Configurable dimensions
- For spare insert see page 17

Heavy duty thermometers

	Without thermowell	Tube thermowell screwed or flanged	Solid drilled thermowell screwed or flanged
RTD T/C	TR62 TC62	TR63 TC63	TR66 TC66
			
Features	▪ Replaceable insert ▪ Mineral insulated sensor ▪ Robust design ▪ To fit into existing thermowell	▪ Replaceable insert ▪ Mineral insulated sensor ▪ Robust design ▪ Welded flange or screwed thread	▪ Replaceable insert ▪ Mineral insulated sensor ▪ Robust design ▪ With barstock thermowell
Technical data ▪ Temperature ▪ Pressure ▪ Response time ▪ Fitting ▪ Spare insert	 ▪ -200 to 600°C/1100°C ▪ Dependent on thermowell ▪ Insert only, t90 from ≤2.0s ▪ Screwed to suit thermowell ▪ TPR300/TPC300	 ▪ -200 to 600°C/1100°C ▪ Up to 100 bar ▪ Insert only, t90 from ≤2.0s ▪ Screwed or flanged ▪ TPR300/TPC300	 ▪ -200 to 600°C/1100°C ▪ Up to 500 bar ▪ Insert only, t90 from ≤2.0s ▪ Screwed or flanged ▪ TPR300/TPC300
Typical applications	▪ Oil & gas ▪ Petrochemical ▪ Heavy industry ▪ Hazardous areas	▪ Oil & gas ▪ Petrochemical ▪ Heavy industry ▪ Hazardous areas	▪ Oil & gas ▪ Petrochemical ▪ Heavy industry ▪ Hazardous areas

Heavy duty transmitters

- Insert and display only
- Hazardous area option
- See pages 14 and 15 for thermowells
- For spare insert see page 17
- Optional 316 stainless steel housing

Compact thermometers

	Single chamber	Dual chamber
RTD T/C	TMT142R TMT142C	TMT162R TMT162C
		
Features	▪ Replaceable insert ▪ Mineral insulated sensor ▪ Robust design ▪ 316 stainless steel housing option ▪ Transmitter with single chamber ▪ Optional display	▪ Replaceable insert ▪ Mineral insulated sensor ▪ Robust design ▪ 316 stainless steel housing option ▪ Transmitter with dual chamber display ▪ Optional display
Technical data ▪ Temperature ▪ Pressure ▪ Response time ▪ Fitting ▪ Spare insert ▪ Supply voltage	▪ -200 to 600°C/1100°C ▪ Dependent on thermowell ▪ Insert only from t90 ≤2.0s ▪ Screwed to suit thermowell ▪ TET300/TEC300 ▪ 11 to 40V DC	▪ -200 to 600°C/1100°C ▪ Dependent on thermowell ▪ Insert only from t90 ≤2.0s ▪ Screwed to suit thermowell ▪ TET300/TEC300 ▪ 11 to 40V DC
Typical applications	▪ Oil & gas ▪ Petrochemical ▪ Heavy industry ▪ Hazardous areas	▪ Oil & gas ▪ Petrochemical ▪ Heavy industry ▪ Hazardous areas

Thermowells

- Engineered solutions
- Available in exotic materials
- Wide range of process connections
- Non-destructive testing available

Thermowells

	Tubular up to 100 bar	Barstock up to 500 bar
		
Features	▪ Cost-effective ▪ Reduced tip option for fast response ▪ Greater immersed lengths ▪ Quick turnaround	▪ Drilled and machined from solid bar ▪ Partial or full penetration flange welds ▪ Can be straight, tapered or stepped
Technical data ▪ Temperature ▪ Pressure ▪ Fitting ▪ Flange style	▪ Up to 1100°C ▪ Up to 100 bar ▪ Screwed or flanged ▪ EN, ANSI	▪ Up to 1100°C ▪ Up to 500 bar ▪ Screwed or flanged ▪ EN, ANSI, API
Typical materials	▪ Stainless steel ▪ Alloy C276, C22 ▪ Nickel alloys	▪ Stainless steel ▪ Alloy C276, C22 ▪ Duplex, Super Duplex ▪ 6 Moly ▪ Nickel alloys

Van Stone up to 500 bar	Forged up to 700 bar	Hub up to 700 bar
		
▪ Drilled and machined from solid bar ▪ Can be straight, tapered or stepped ▪ For use with backing flange	▪ High pressure device ▪ Single piece forging ▪ Can be straight, tapered or stepped ▪ Integral flange	▪ High pressure device ▪ Single piece forging ▪ Can be straight, tapered or stepped ▪ Hub and clamp connection
▪ Up to 1100°C ▪ Up to 500 bar ▪ Backing flange type ▪ EN, ANSI	▪ Up to 1100°C ▪ Up to 700 bar ▪ Flanged ▪ EN, ANSI, API	▪ Up to 1100°C ▪ Up to 700 bar ▪ High pressure hub type ▪ Grayloc or equivalent
▪ Stainless steel ▪ Duplex, Super Duplex ▪ 6 Moly ▪ Nickel alloys	▪ Stainless steel ▪ Duplex, Super Duplex ▪ 6 Moly ▪ High tensile carbon steel ▪ Nickel alloys	▪ Stainless steel ▪ Duplex, Super Duplex ▪ 6 Moly ▪ Nickel alloys

High temperature thermometers

- High resistance to arduous conditions
- Replaceable insert
- Configurable lengths and diameters
- Various sheath combinations
- See page 32 and 33 in the reference section for list of materials

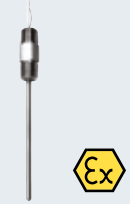
High temperature thermometers

	Refractory sheathed up to 1200°C	Refractory sheathed up to 1700°C	Metallic sheathed up to 1200°C
T/C	TAF11 	TAF12 	TAF16 
Features	▪ Thermocouple types K, J, N, R, S or B ▪ Ceramic insulators ▪ Single sheath ▪ C610(RA), SiC and Sin	▪ Thermocouple types R, S or B ▪ Ceramic insulators ▪ Single, double or triple sheath ▪ C610(RA), C799 (AP)	▪ Thermocouple type K, J, N or S ▪ Ceramic or mineral insulated sheath ▪ Various metallic sheaths available
Technical data ▪ Temperature ▪ Pressure ▪ Fitting ▪ Spare insert	▪ Up to 1200°C defined by T/C type ▪ Up to 1 bar ▪ Optional adjustable flange 70mm ▪ TPC 200	▪ Up to 1700°C defined by T/C type ▪ Up to 1 bar ▪ Optional adjustable flange 70mm ▪ TPC 200	▪ Up to 1200°C ▪ Up to 50 bar ▪ Adjustable flange/ compression fitting ▪ TPC 200
Typical applications	▪ High temperature ovens ▪ Industrial furnaces	▪ High temperature ovens ▪ Industrial furnaces ▪ High temperature kilns ▪ Incinerators	▪ High temperature ovens ▪ Industrial furnaces ▪ Rotary kilns ▪ Incinerators

Sensor inserts

- Spare inserts for modular thermometers
- Thermocouple or RTD versions
- Hazardous area option
- Supplied with terminal block, transmitter or flying leads
- QuickSens, StrongSens

Sensor inserts

	Standard insert	Standard Insert	Standard insert	Spring loaded nipple
RTD T/C	TPR100 TPC100	TS111	TPR300 TPC300	TET300 TEC300
				
Features	▪ Standard replacement sensor ▪ Hazardous area option ▪ Configurable dimensions ▪ With block, transmitter or leads	▪ Hygienic replacement sensor ▪ Hazardous area option ▪ Configurable dimensions ▪ With block, transmitter or leads	▪ For ATEX Ex d units ▪ Integral flame path collar ▪ Configurable dimensions ▪ With block, transmitter or leads	▪ Sprung replacement sensor ▪ Hazardous area option ▪ Configurable dimensions ▪ With leads only
Technical data ▪ Temperature ▪ Pressure ▪ Response time ▪ Fitting ▪ Sensing element ▪ Insert Dia	▪ -200 to 600/ 1100°C ▪ Dependent on thermowell ▪ t90 from ≤2.0s ▪ DIN plate ▪ RTD or thermocouple ▪ 3mm, 6mm	▪ -200 to 600°C ▪ Dependent on thermowell ▪ t90 from 0.75s ▪ DIN plate ▪ RTD, QuickSens, StrongSens. ▪ 3mm, 6mm	▪ -200 to 600/ 1100°C ▪ Dependent on thermowell ▪ t90 from ≤2.0s ▪ DIN plate with flame path collar ▪ RTD or thermocouple ▪ 3mm, 6mm	▪ -200 to 600/ 1100°C ▪ Dependent on thermowell ▪ t90 from ≤2.0s ▪ Spring loaded nipple ▪ RTD or thermocouple ▪ 6mm
Replacement insert for	▪ TR10, 11, 12, 13, 15, 88 ▪ TC10, 12, 13, 15, 88	▪ TM411	▪ TR62, 63, 66 ▪ TC62, 63, 66	▪ TMT142R, 142C ▪ TMT162R, 162C

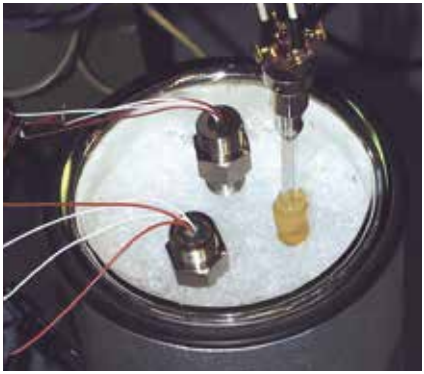
Certification and testing

Individual components of instruments are subject to careful examination in our own test centres. The quality of the materials used in manufacture are fully certified and traceable.

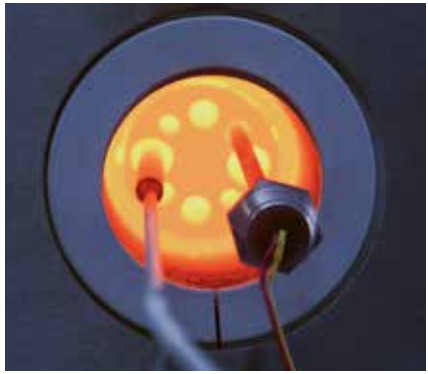
Several methods of non-destructive testing can be performed to guarantee components are free from material joint problems such as cracks, pores and cavities.

Calibrations can be performed in our laboratory and are traceable to national standards to certify the accuracy of our thermometers.

TZC134 Traceable calibration	Calibrated using certified equipment traceable to ISO/IEC 17025, DKD and SIT guidelines for internationally recognised calibration certificates.
TZC133 Primary calibration	Calibrated in our own accredited laboratories to ISO/IEC 17025, DKD and SIT guidelines for internationally recognised calibration certificates.
TZC150 Evaluation report	Issued in lieu of calibration certificate if the immersion length of the sensor is too short for full calibration.
TZC130 Certificate of conformity	Issued by the Endress+Hauser quality department to certify that the goods supplied conform to the customer purchase order.
TZC131 Material certificate 3.1	The inspection certificate EN 10204 3.1 for wetted parts.
TZC138 Hydrostatic test	Using internal or external pressure test the strength and pressure rating of thermowells and process connections can be verified.
TZC125 Dye penetrant	Suitable for checking material surfaces and welded joints for surface breaking defects such as forging defects or cracks.
TZC161 PMI	Positive Material Identification. Non-destructive X-ray fluorescence (XRF) to verify the chemical composition of the materials.
TZCB01 Radiographic test	Hidden faults like inclusions, pores, tears, etc in the base material and/ or in the weld are identified. Furthermore, the exact positioning of the welded components can be checked.
TZC140 Bore concentricity	Thermowell stems are checked for concentricity to guarantee wall thickness.



Ice bath zero point calibration



High temperature calibration

Temperature transmitters

- DIN standard head mount
- DIN rail mount option available (not shown)
- Optional displays
- Variety of interface methods
- Improved accuracy via sensor matching or Calender van Dusen equation

Temperature transmitters

	Economical	Galvanic isolation	HART protocol	HART protocol
	TMT180	TMT181	TMT182	TMT82
				
Features	▪ No ATEX rating ▪ PC programmable	▪ Hazardous area option ▪ PC programmable	▪ Hazardous area option ▪ SIL2 compliant	▪ Hazardous area option ▪ Display interface ▪ Dual input ▪ SIL2/3
Technical data ▪ Input ▪ Accuracy (Pt100) ▪ Interface ▪ Galvanic isolation ▪ Power supply ▪ Display ▪ DIN rail version	▪ RTD ▪ 0.1K/0.08% of span ▪ PC ▪ No ▪ 10 to 35V DC ▪ No ▪ No	▪ RTD, T/C, Ω, mV ▪ 0.2K/0.08% of span ▪ PC ▪ 3.75kV AC ▪ 8 to 35V DC ▪ No ▪ Yes	▪ RTD, T/C, Ω, mV ▪ 0.2K/0.08% of span ▪ HART ▪ 2kV AC ▪ 11 to 35V DC ▪ No ▪ Yes	▪ RTD, T/C, Ω, mV ▪ 0.1K ▪ HART ▪ 2kV AC ▪ 9 to 32V ▪ TID10 (plug on display) ▪ Yes
Interface	ReadWin 2000 ITEMP PCP	ReadWin 2000 ITEMP PCP	HART COMMUNICATION FOUNDATION	HART COMMUNICATION FOUNDATION

PROFIBUS PA	FOUNDATION Fieldbus	Single chamber	Dual chamber
TMT84	TMT85	TMT142	TMT162
			
▪ Hazardous area option ▪ Display interface ▪ Dual input	▪ Hazardous area option ▪ Display interface ▪ Dual input	▪ Hazardous area option ▪ Stainless or alloy enclosure ▪ Field or direct mount	▪ Hazardous area option ▪ Stainless or alloy enclosure ▪ Field or direct mount ▪ Dual input
▪ RTD, T/C, Ω, mV ▪ 0.1K ▪ PROFIBUS ▪ 2kV AC ▪ 9 to 32V DC ▪ TID10 (plug on display) ▪ No	▪ RTD, T/C, Ω, mV ▪ 0.1K ▪ FOUNDATION Fieldbus ▪ 2kV AC ▪ 9 to 32V DC ▪ TID10 (plug on display) ▪ No	▪ RTD, T/C, Ω, mV ▪ 0.2K ▪ HART ▪ 2kV AC ▪ 11 to 40V DC ▪ Integral ▪ No	▪ RTD, T/C, Ω, mV ▪ 0.1K ▪ HART, PROFIBUS, FOUNDATION Fieldbus ▪ 2kV AC ▪ 11 to 40V DC ▪ Integral ▪ No

Transmitter accessories, barriers and HART communication device

- Variety of interface methods
- On-site programming of instruments
- Compatible with a wide range of devices
- Easy to use

Transmitter accessories, barriers and HART communication device

	Common Device Interface	Active/passive barrier	Plug-on display	Field Xpert
	TXU10 	RN221/ RB223 	TID10 	SFX370  None EX version SFX350
Features	▪ Communication device for Endress+Hauser transmitters and electronic modules ▪ USB port to standard Endress+Hauser service port connection ▪ Allows users to reconfigure existing devices or keep common stock and configure as needed ▪ Non Ex only	▪ RN221 – Intrinsically safe power supply, galvanic isolation of loop ▪ HART status monitor with alarm relay, set-up using front mounted sockets ▪ RB223 – As above but does not require power supply, bidirectional HART transmission and applications up to SIL 3	▪ Plug-on interface unit with dot-matrix display ▪ 12 DIP switches on underside for configuration of TMT84 ▪ Process display when assembled with suitable terminal head for TMT82, TMT84 & TMT85	▪ Handheld communication device for the configuration of HART protocol electronic modules ▪ Wireless communication via BluetoothTM or WLAN based on an industrial PDA ▪ Device Xpert Configuration software package for field device commissioning, diagnosis and maintenance

Data managers

- Paperless recorders
- Large display of measured values
- Multiple inputs and outputs
- Integrated web server

Data managers

	Ecograph T	Memograph
	RSG35 	RSG40 
Features	▪ 5.5" TFT colour graphics display ▪ 640 x 480 pixels ▪ 128MB internal memory ▪ SD slot & USB port for memory expansion ▪ 24V auxiliary output voltage (200mA)	▪ 7" TFT colour graphics display ▪ 800 x 480 pixels ▪ 128MB internal memory ▪ SD slot & USB port for memory expansion ▪ 24V auxiliary output voltage (200mA)
Technical data ▪ Inputs ▪ Outputs ▪ Alarm setpoints ▪ Mathematics ▪ Power supply ▪ Communication	▪ 4/8/12 analogue, 6 digital ▪ 6 relay ▪ 30 ▪ 4 channels ▪ 90-250V AC or 24V AC/DC, 50/60Hz ▪ Ethernet, USB and serial RS232/485	▪ 4/8/12/16/20 analogue, 6 digital ▪ 6 or 12 relay ▪ 100 ▪ 12 channels ▪ 90-250V AC or 24V AC/DC, 50/60Hz ▪ Ethernet, USB and serial RS232/485
Typical applications	▪ Quality and quantity monitoring ▪ Process monitoring ▪ Display and recording of critical process parameters in production processes ▪ Tank and level monitoring ▪ Temperature profiling ▪ Utilities monitoring	▪ Same as RSG35 with added functionality ▪ Complete information regarding the product and process run ▪ Batch number, batch time, start and stop times for the batch run ▪ Min/max/mean values of all active channels, quantities and operating times. Event log/audit trail entries

Process indicators

- Loop powered process indicators
- Range of housing options
- Display any process variable
- Hazardous area option

Multifunction displays

	Panel indicator	Field indicator	Fieldbus indicator
	RIA15 	RIA14/RIA16 	RID14/RID16 
Features	▪ Loop powered indicator ▪ Panel and field versions ▪ Backlit (optional) 5-digit LCD display & bar graph ▪ Display of HART values	▪ Field display, 5-digit LCD display & bargraph ▪ Illuminated display ▪ Hazardous area option, GRP, aluminium or 316 stainless steel housing ▪ Wall or pipe mounting	▪ 8-channel fieldbus indicator, 5-digit LCD display & bargraph ▪ Illuminated display ▪ Hazardous area option, GRP, aluminium or 316 stainless steel housing ▪ Wall or pipe mounting
Technical data ▪ Temperature ▪ Output ▪ Power supply ▪ Interface ▪ Housing ▪ Protection	▪ 4-20mA ▪ 1 x analogue, 1 x digital(OC) ▪ From loop ▪ Front buttons, HART ▪ Panel 49 x 96 x 41.5mm, Field 131x 81.5 x 55.5mm ▪ Panel IP65 Field IP66 NEMA 4x	▪ 4-20mA ▪ Digital limit switch ▪ From 4-20mA loop ▪ FieldCare via plug ▪ Plastic (GRP), aluminium or 316 stainless steel ▪ IP67	▪ FOUNDATION fieldbus ▪ Device blocks via fieldbus ▪ 9 to 32V DC via fieldbus ▪ FieldCare via plug or fieldbus ▪ Plastic (GRP), aluminium or 316 stainless steel ▪ IP67
Typical applications	▪ Process display monitoring control panels, outdoor localised display and low power consumption	▪ Oil & gas/petrochemical ▪ Outdoor applications ▪ Process display monitoring ▪ Plant and machine construction	▪ Oil & gas/petrochemical ▪ Outdoor applications ▪ 8-channel listener mode ▪ Plant and machine construction

Multifunction displays

- Multiple inputs and outputs
- Coloured, backlit LCD display
- Colour change to indicate alarm
- Intrinsically safe power supply

Multifunction displays

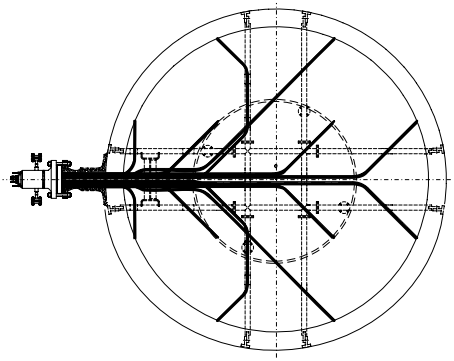
Field/panel meter	DIN rail mounted meter	Bargraph panel meter
RIA45/RIA46	RMA42	RIA452
		
▪ Bargraph and segment display ▪ Panel or field housing ▪ LEDs for device and relay status ▪ Limit value and alarm output ▪ Mathematic functions ▪ Intrinsically safe loop power supply ▪ Min/max logging function ▪ Set up via PC ▪ 2-channel input	▪ Bargraph and segment display ▪ DIN rail mounting ▪ LEDs for device and relay status ▪ Limit value and alarm output ▪ Mathematic functions ▪ Intrinsically safe loop power supply ▪ Min/max logging function ▪ Set up via PC ▪ 2-channel input	▪ Bargraph and segment display ▪ Digital input for pump control ▪ Preset counter, pulse output ▪ Intrinsically safe loop power supply ▪ Open channel flow calculations ▪ Min/max logging function
▪ 4-20mA, V, Ω , TC or RTD ▪ 4-20mA, V, digital, optional relays ▪ 24-230V AC/DC ▪ Front buttons/FieldCare via plug ▪ Panel - RIA45, Field - RIA46 ▪ IP65 front - RIA45, IP67 - RIA46	▪ 4-20mA, V, Ω , TC or RTD ▪ 2 x 4-20mA, V, digital, optional relays ▪ 24-230V AC/DC ▪ Front buttons/FieldCare via plug ▪ Top hat DIN rail as per IEC 60715 ▪ IP20	▪ 4-20mA, V, Ω , TC, RTD or digital ▪ Up to 8 relays, mA, V, pulse ▪ 90-230V AC or 20-36V DC ▪ Jog wheel/FieldCare via plug ▪ RS232 panel ▪ IP65 front
▪ Process control ▪ Signal conditioning ▪ Process recording and supervision ▪ Process alarm	▪ Process control, signal conditioning, process recording and supervision, control rooms and cabinets, overfill protection, SIL2 compliant process alarm	▪ Process control ▪ Signal conditioning ▪ Process recording and supervision ▪ Pump control ▪ Tank linearisation

Flexible multipoint thermometers

These thermometers offer the possibility of distributing measurement points three-dimensionally within a reactor or vessel. Thermocouples enter the vessel via a common process connection and are routed to achieve the desired positions of the measurement points. This flexibility increases the number of measurements within a vessel from a single or limited number of process connections, thereby giving a better thermal profile of the process.

Connection box (EEx d version) with transmitters for multiple measurements.

Gas tight interchangeable thermocouples.



Measuring point positioning in a process reactor (top view)

Detailed engineering design including material selection, drawing and planning, along with fault-free installation are key factors in the quality and longevity of the measuring system. We tailor our project solutions to meet your needs, offering complete project management.

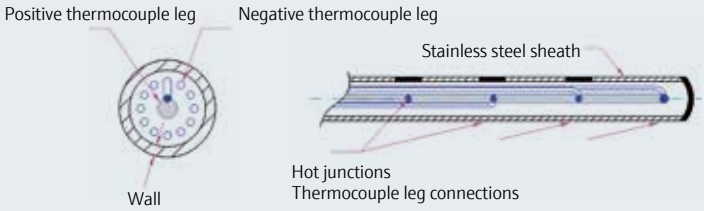
Rigid multipoint thermometers

Rigid straight multipoint thermometers and thermowells are used for measuring temperature profiles. These multipoint thermometers consist of a thermowell with process connection, a number of sensors (usually thermocouples) and a connection box.

Various designs are available including individual interchangeable measurement elements, where each measurement point is in contact with the thermowell wall for faster response to the process temperature. Terminals or transmitters can be fitted in the connection box that is either fitted directly onto the assembly or mounted remotely.

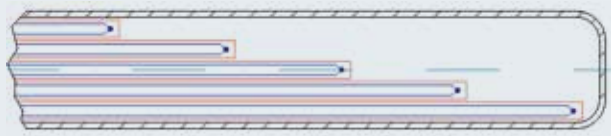
Version 1

Multipoint thermometer with common sheathing
Optimised multipoint (OMP) Constructed from a metallic sheath packed with high purified magnesium oxide powder with a number of conductors around a common central conductor. Thermocouple hot junctions are achieved by joining one of the negative outer conductors to the central positive conductor at different positions along the complete length of the sensor.



Version 2

Multipoint element with individual sheaths
Several mineral insulated thermocouples are placed into a metal tube, the generated multiple sensor is then drawn down in several steps to the required diameter.

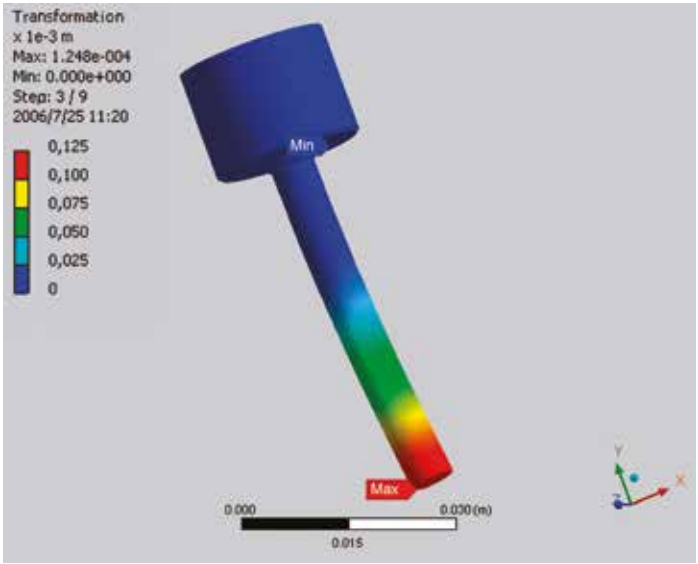


Thermowell design

Thermowells can be divided into two categories:
- Fabricated, constructed from welded tube
- Solid drilled, machined from barstock material

In many cases thermometers cannot be placed directly into the medium and need protection from harsh process conditions. When process conditions do not allow for standard modular style assemblies, a thermowell must be designed to suit the process.

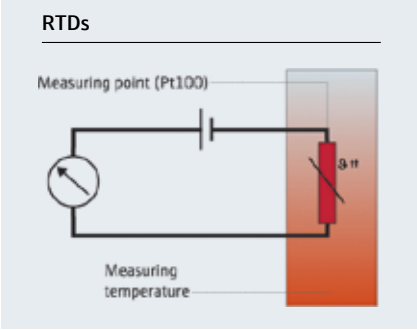
We have a proven track record in the design and manufacture of high quality, specially designed thermowells using exotic materials and ingenious solutions to ensure we present our customers with a product that is optimised for the application.



The correct construction and design of a thermowell requires exact calculations to proven methods. An example of this is the wake frequency calculation that is performed to guarantee process conditions do not induce excessive vortices with the potential to cause the thermowell to fail/shear. Design standards include ASME PTC 19.3TW-2010 and DIN 43772.

Insert technologies

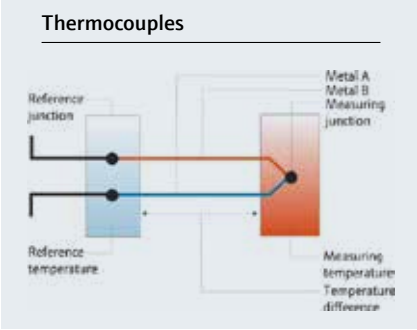
Temperature is the most frequently measured parameter in the process industry. In electrical contact thermometers two measurement principles have asserted themselves as standard: RTDs and thermocouples.



In RTD resistance sensors the electrical resistance changes with a change in temperature. They can measure temperatures typically between -200 and 600°C. They stand out due to their long term stability and high measurement accuracies. The most frequently used resistance sensor element is a Pt100.

There are two main RTD types
Wire wound ceramic sensors:
- Temperatures up to 600°C
- Good long term stability

Thin film sensors:
- Temperatures up to 500°C (QuickSens up to 200°C)
- Smaller than wire wound
- Better vibration resistance (StongSens up to 60g)



A thermocouple is a component made of two different metals connected to each other at one end. An electrical potential (EMF) is caused due to the Seebeck Effect at the open end if the connection and the free ends are exposed to different temperatures. Thermocouples are suitable for temperature measurement in the range of 0°C to 1800°C. They stand out due to the fast response time and high vibration resistance.

There are three hot junction types.
- Ungrounded: slower response time, however the junction is isolated from the loop.
- Grounded: faster response times - however at lower temperatures they can be exposed to ground loop interference.
- Exposed: fastest response times - cannot be used in flowing, pressurised or corrosive applications and also are exposed to ground loop interference.

Process connections (thermowell)

The process connection is the connection between the process and the thermometer. The following are most commonly used in the process industries.

Thread:

The most commonly used thread types are NPT, G and M threads:

- The NPT thread is a US thread norm for self-sealing pipe threads.
- G threads are cylindrical pipe threads and seal using the sealing area above the thread.
- M threads are metric threads which are used at low process pressures.

Welded joint:

The thermowell is directly welded into the vessel or pipe wall.

Compression fitting:

The thermometer is put into a compression fitting and then clamped using either a pipe (reusable) or steel olive. The compression fitting can be screwed or welded into the process.

Flange:

Flanges are subject to the DIN, ANSI/ASME or EN standards. They are classified according to material, diameter and pressure rating.

Process connections for hygienic and aseptic applications
For use with - TM401, TM411, TMR35 and TTR35.

Process connections

Design	Connection	Size
	Clamp	DN8-18, DN12-21.3, DN25-38, DN40-51, DN63.5, DN70-76.5 Triclamp ½"- ¾", 1 ½", 2"
	DIN 11851	DN25, DN32, DN40, DN50
	Aseptic screwed pipe connection DIN 11864-1A	DN25, DN40
	SMS 1147	DN25, DN38, DN51
	Weld-in adaptor	Cylindrical or spherical cylinder 30 x 40mm, 12.7mm, 12 x 40mm, 25mm
	Thread (ISO228)	G¾", G1" Liquiphant adaptor
	Varivent	Type B – D31mm Type F – D50mm Type N – D68mm
	Ingold	25 x 30, 25 x 46
	Metallic sealing connection	M12 x 1.5 G½"

Thermowell materials

Common materials used in the construction of thermowells.
This information is to be used only as a guide.

Metal/alloy	Maximum operating temp °C	UNS number	DIN number	Application
Stainless steel AISI304	900	S30400	1.4301	Low cost, resistant to corrosive agents in industrial use.
Stainless steel AISI316	900	S31600	1.4401	Best corrosion resistant austenitic stainless steel.
Stainless steel AISI316Ti	900	S31635	1.4571	As above but titanium stabilised.
Stainless steel AISI316L	900	S31603	1.4404	As above but low carbon version.
Stainless steel AISI310	1100	S31000	1.4841	Good for high temperature, cyclic heating, sulphur bearing atmospheres.
Stainless steel AISI446	1150	S44600	1.4762 1.4749	High temperature, sulphurous atmospheres.
Alloy 600	1100	N06600	2.4816	High temperature, corrosion resistant.
Alloy 800	1100	N08800	1.4876	High temperature, oxidisation and carburisation resistant.
Alloy X	1200	N06002	2.4665	High temperature, resistant to oxidisation and reducing atmospheres.
Alloy C276	1200	N10276	2.4819	Corrosion resistance in many chemical environments.
Alloy 400	538	N04400	2.4360	Excellent corrosion resistance to sea water and chlorinated solvents.
Duplex	300	S31803	1.4462	Excellent corrosion resistance, high strength.
Super Duplex	300	S32750 S32760	1.4410 1.4501	Excellent corrosion resistance to sea water and high strength.
6 Moly	600	S31254	1.4547	Excellent strength and corrosion resistance.

Thermowell materials high temp TAF11, TAF12x & TAF16

Thermowells can be manufactured from AISI316L, AISI310, AISI304, AISI446, Alloy 600 and Alloy 800. Please only use this as a guide and refer to the operating and technical instructions for a more in depth evaluation.

Material name	Maximum operating temp °C	Short form	Application
Kanthal AF	1300	FeCrAl	High resistance to sulphurous, carburising and oxidising environments.
Special nickel/ cobalt alloy	1200	NiCo	Very good resistance to sulfidation and chloride. Excellent resistance to oxidation, hot corrosion, carburisation, metal dusting and nitridation.
C530	1400	Ceramic	Very resistant to temperature shocks.
C610	1500	Ceramic	Highly resistant to hydrogen fluoride, temperature shocks and mechanical influences.
C799	1800	Ceramic	Resistance to hydrogen fluoride gases and alkaline vapours, oxidisation, reducing, neutral atmospheres and temperature shocks.
Sintered silicon carbide	1650	Ceramic SiC	High thermal shock resistance, good thermal conductivity. Furnaces, glass & ceramic industries.
Kanthal Super	1700	MoSi2 with a glass phase	High thermal shock resistance and low porosity, extremely hard.
Special silicon nitride ceramic	1400	Ceramic SiN	Excellent wear and thermal shock resistance. Cement industry and abrasive conditions.

Tolerance classes for RTD thermometers as per IEC 60751 edition 2.0

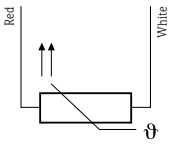
Tolerance class	Temperature range of validity (°C)		Tolerance values (°C)
	Wire wound element	Thin film element	
AA	-50 to +250	0 to +150	± (0.1 + 0.0017 [t])
A	-100 to +450	-30 to +300	± (0.15 + 0.002 [t])
B	-196 to +600	-50 to +500	± (0.3 + 0.005 [t])
C	-196 to +600	-50 to +600	± (0.6 + 0.01 [t])

Approximate tolerance bands of resistance and temperature

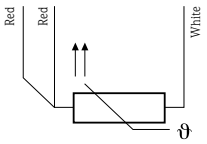
Temp°C	Resistance for Pt100 (Ω)	Class C	Class B	Class A	Class AA	1/5 DIN	1/10 DIN
		± °C	± °C	± °C	± °C	± °C	± °C
-200.00	18.52	2.60	1.30	0.55	0.44	0.26	0.13
-150.00	39.72	2.10	1.05	0.45	0.36	0.21	0.11
-100.00	60.26	1.60	0.80	0.35	0.27	0.16	0.08
-50.00	80.31	1.10	0.55	0.25	0.19	0.11	0.06
0.00	100.00	0.60	0.30	0.15	0.10	0.06	0.03
50.00	119.40	1.10	0.55	0.25	0.19	0.11	0.06
100.00	138.51	1.60	0.80	0.35	0.27	0.16	0.08
150.00	157.33	2.10	1.05	0.45	0.36	0.21	0.11
200.00	175.86	2.60	1.30	0.55	0.44	0.26	0.13
250.00	194.10	3.10	1.55	0.65	0.53	0.31	-
300.00	212.05	3.60	1.80	0.75	0.61	0.36	-
350.00	229.72	4.10	2.05	0.85	0.70	-	-
400.00	247.09	4.60	2.30	0.95	-	-	-
450.00	264.18	5.10	2.55	1.05	-	-	-
500.00	280.98	5.60	2.80	-	-	-	-
550.00	297.49	6.10	3.05	-	-	-	-
600.00	313.71	6.60	3.30	-	-	-	-
650.00	329.64	7.10	3.55	-	-	-	-

Connection modes

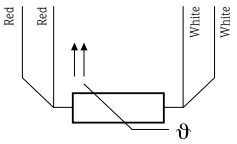
2-wire: Electrical connection of the Pt100 resistance
Features: Additional measurement error due to temperature dependent resistance changes in the cabling.



3-wire: Electrical connection of the Pt100 resistance
Features: Accurate measurement. In the main avoids additional measurement error due to temperature dependent resistance changes in the cabling.



4-wire: Electrical connection of the Pt100 resistance
Features: Highly accurate. No additional measurement error due to temperature dependent resistance changes in the cabling.



International colour codes for thermocouple cable insulation

T/C Type	Conductor +	Conductor -	Temp. range °C	International EN 60584	Former British BS 4937	French to NFC 42-324	German to DIN 43714	Japanese to JIS C 1610-1981	American to ANSI MC 96.1
K	Ni-Cr	Ni-Al	-200 to +1200						
J	Fe	Cu-Ni Constantan	-40 to +750						
T	Cu	Cu-Ni Constantan	-200 to +350						
N	Ni-Cr-Si Nicrosil	Ni-Si-Mg Nisil	-200 to +1200						
E	Ni-Cr	Cu-Ni Constantan	-200 to +900						
B	Pt-30Rh	Pt-6Rh	600 to +1700						
R	Pt-13Rh	Pt	0 to +1600						
S	Pt-10Rh	Pt	0 to +1600						

Temperature range as defined in EN 60584 tolerance classes.

IEC tolerance class EN 60584-2

IEC code		Class 1	Class 2
J	Temp range Tolerance value Temp range Tolerance value	-40 to 375°C ±1.5°C 375 to 750°C ±0.4% reading	-40 to 333°C ±2.5°C 333 to 750°C ±0.75% reading
K/N	Temp range Tolerance value Temp range Tolerance value	-40 to 375°C ±1.5°C 375 to 1000°C ±0.4%	-40 to 333°C ±2.5°C 333 to 1200°C ±0.75% reading
T	Temp range Tolerance value Temp range Tolerance value	-40 to 125°C ±0.5°C 125 to 350°C ±0.4% reading	-40 to 133°C ±1°C 133 to 350°C ±0.75% reading
E	Temp range Tolerance value Temp range Tolerance value	-40 to 375°C ±1.5°C 375 to 800°C ±0.4% reading	-40 to 333°C ±2.5°C 333 to 900°C ±0.75% reading
R/S	Temp range Tolerance value Temp range Tolerance value	0 to 1100°C ±1°C 1100 to 1600°C ±[1 +0.3% x (Rdg-1100)]°C	0 to 600°C ±1.5°C 600 to 1600°C ±0.25% reading
B	Temp range Tolerance value Temp range Tolerance value	Not established	600 to 1700°C ±0.25% reading

Terminal heads

The terminal heads, in which the terminal block or transmitter is installed, differ in shape and material depending on the application. Materials used are plastic, varnished aluminium or 316 stainless steel. All terminal heads have an internal form according to DIN 43729 (form B) as well as a thermometer connection of M24. The cable glands supplied with the terminal heads are suitable for cables with a diameter of 5-9mm.

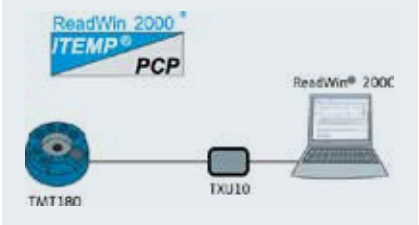
Process connections

TA30A	IP	TA30A Double cable entry	IP	TA30H	IP
 Form B Standard (also with display)	66/ 67	 (Also with display)	66/ 67		66/ 67
TA30H Double cable entry	IP	TA30D	IP	TA21E	IP
	66/ 67	 Form BUZH	66		65
TA20B	IP	TA30R	IP	TA30R (also with display)	IP
	65		69K		69K
TA30P	IP	TA30S	IP	TA21H	IP
	65		66		66/ 68

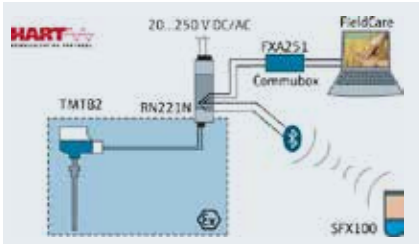
Temperature transmitter configuration

TMT181/182 can only be configured whilst powered.
TXU10 for use in safe area only.
Use FAX251 for Ex areas.

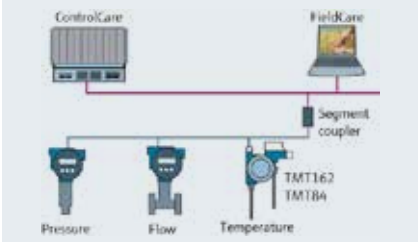
Online configuration with SETUP connector, socket and ReadWin 2000 operating software.



HART signal for on-site or centralised device set-up using a hand-held terminal or PC. Operation, visualisation and maintenance at the PC using FieldCare, AMS, PDM or ReadWin 2000 software.



Temperature transmitter for PROFIBUS PA and FOUNDATION Fieldbus enables data exchange and operation using standardised fieldbus protocols.



Endress+Hauser is one of the pioneers in fieldbus technology and plays a worldwide leading role in the application of the HART, PROFIBUS DP/PA and FOUNDATION Fieldbus technology.

- Accredited PROFIBUS competence centre
- Engineering of fieldbus networks
- System integration checks
- Training courses, seminars
- Endress+Hauser's own fieldbus laboratory

Pipe dimensions in accordance with ANSI B36.10

Nominal bore		Outside diameter	Pipe schedule – inside diameter (all dimensions in mm)							
Inches	mm		5S	10S	10	20	30	40S	Std Wt	
½	15	21.34	18.04	17.12				15.80	15.80	
¾	20	26.67	23.37	22.45				20.93	20.93	
1	25	33.40	30.10	27.86				26.64	26.64	
1 ½	40	48.26	44.96	42.72				40.90	40.90	
2	50	60.32	57.02	54.76				52.50	52.50	
3	80	88.90	84.68	82.80				77.92	77.92	
4	100	114.30	110.08	108.20				102.26	102.26	
5	125	141.30	135.76	134.50				128.20	128.20	
6	150	168.27	162.73	161.47				154.05	154.05	
8	200	219.07	213.53	211.55		206.37	204.99	202.71	202.71	
10	250	273.05	266.25	264.67		260.35	257.45	254.51	254.51	
12	300	323.85	315.93	314.71		311.15	307.09	304.79	304.79	
14	350	355.60	347.68	346.04	342.90	339.76	336.54		336.54	
16	400	406.40	398.02	398.02	393.70	390.56	387.34		387.34	
18	450	457.20	448.82	447.64	444.50	441.36	434.94		438.14	
20	500	508.00	498.44	496.92	495.30	488.94	482.60		488.94	
22	550	558.00	548.44	546.92	545.30	538.94	532.60		538.94	
24	600	609.60	598.52	596.90	596.90	590.54	581.06		590.54	
26	650	660.40			644.56	635.00			641.34	
28	700	711.20			695.36	685.80	679.44		692.14	
30	750	762.00	749.30	746.16	746.16	736.60	730.24		742.94	
32	800	812.80			796.96	787.40	781.04		793.74	
34	850	863.60			847.76	838.20	831.84		844.54	
36	900	914.40			898.56	889.00	882.64		895.34	

Pipe schedule – inside diameter (all dimensions in mm)										
	40	60	80S	XS	80	100	120	140	160	XXS
	15.80		13.88	13.88	13.88				11.78	6.40
	20.93		18.85	18.85	18.85				15.55	11.03
	26.64		24.30	24.30	24.30				20.70	15.22
	40.90		38.10	38.10	38.10				33.98	27.96
	52.50		49.24	49.24	49.24				42.84	38.18
	77.92		73.66	73.66	73.66				66.64	58.42
	102.26		97.18	97.18	97.18		92.06		87.32	80.06
	128.20		122.24	122.24	122.24		115.90		109.54	103.20
	154.05		146.33	146.33	146.33		139.73		131.75	124.37
	202.71	198.45	193.67	193.67	193.67	188.89	182.55	177.83	173.05	174.61
	254.51	247.65	247.65	247.65	242.87	236.53	230.17	222.25	215.89	222.25
	303.23	295.31	298.45	298.45	288.89	280.97	273.05	266.69	257.21	273.05
	333.34	325.42		330.20	317.50	307.94	300.02	292.10	284.18	
	381.00	373.08		381.00	363.52	354.02	344.48	333.34	325.42	
	428.66	419.10		431.80	409.54	398.48	387.34	377.86	366.72	
	477.82	466.76		482.60	455.62	442.92	431.80	419.10	407.98	
		513.54		532.60	510.84	488.14	475.44	462.74	450.04	
	574.64	560.38		584.20	547.68	531.82	517.56	504.86	490.52	
				635.00						
				685.80						
				736.60						
	777.84			787.40						
	828.64			838.20						
	876.30			889.00						

Conversion factors

Commonly used units of pressure

Bar	Millibar	Pa	Kpa	PSI	in H_2O	mm H_2O	in Hg
1	1000	100,000	100	14.50	401.46	10197.16	29.53
0.001	1	100	0.1	0.0145	0.402	10.197	0.0295
0.00001	0.01	1	0.001	0.000145	0.00402	0.102	0.000295
0.01	10	1000	1	0.145	4.015	101.971	0.295
0.0689	68.948	6894.757	6.895	1	27.68	703.07	2.036
0.00249	2.491	249.0889	0.249	0.0361	1	25.4	0.0736
0.000098	0.0981	9.807	0.0098	0.00142	0.0393	1	0.0029
0.0339	33.863	3386.389	3.386	0.491	13.595	345.316	1

Thread dimensions

Size (G = BSP)	Major Dia. (mm)	Pitch (mm)
G 1/8"	9.7	0.91
G 1/4"	13.2	1.34
G 3/8"	16.7	1.34
G 1/2"	21.0	1.81
G 5/8"	22.9	1.81
G 3/4"	26.4	1.81
G 1"	33.2	2.31
1/8" NPT	10.3	0.94
1/4" NPT	13.7	1.41
3/8" NPT	17.1	1.41
1/2" NPT	21.3	1.81
3/4" NPT	26.7	1.81
1" NPT	33.4	2.21

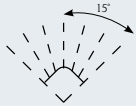
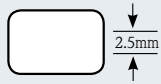
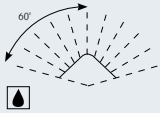
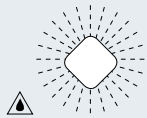
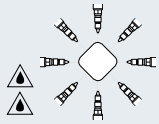
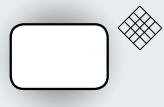
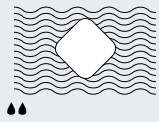
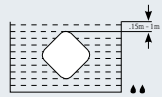
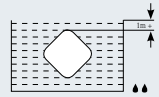
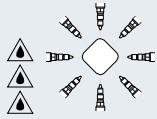
Length	Volume
1 in = 25.4 mm	1 in^3 = 16.39 cm^3
1 ft = 0.3048 m	1 ft^3 = 0.02832 m^3
1 yd = 0.914 m	1 gal (imp) = 4546.09 cm^3
1 mile = 1.609 km	1 litre = 1000 cm^3

Mass	Density & Flow
1 lb = 0.4536 kg	1 lb/in^3 = 27.68 g/cm^3
1 ton = 1016 kg	1 lb/ft^3 = 16.018 kg/m^3
1 tonne = 1000 kg	1 ft^3/s = 0.02831 m^3/s

Abbreviation	Prefix	Factor	Value
k	kilo	10^3	1,000
h	hecto	10^2	100
da	deca	10	10
d	deci	10^{-1}	0.1
c	centi	10^{-2}	0.01
m	milli	10^{-3}	0.001
µ	micro	10^{-6}	0.000001

Temperature conversion	
℃ = ℉ -32 x 5/9	℉ = ℃ x 9/5 + 32

The IP rating system as set out in BS EN 60529:1992

1st digit	Protection against solid objects	2nd digit	Protection against liquids
0	Not protected	0	Not protected
1	 Protected against solid objects over 50mm e.g. accidental touch by hands	1	 Protected against vertically falling drops of water
2	 Protected against solid objects over 12mm e.g. fingers	2	 Protected against direct sprays of water up to 15° from the vertical
3	 Protected against solid objects over 2.5mm (tools and wires)	3	 Protected against sprays up to 60° from the vertical
4	 Protected against solid objects over 1mm (tools, wires and small wires)	4	 Protected against water sprayed from all directions – limited ingress permitted
5	 Protected against dust – limited ingress (no harmful deposit)	5	 Protected against low pressure jets of water from all directions – limited ingress permitted
6	 Totally protected against dust	6	 Protected against strong jets of water E.g. for use on ship decks – limited ingress protected
		7	 Protected against the effects of temporary immersion between 15cm and 1m. Duration of test 30 min
		8	 Protected against long periods of immersion under pressure
		9K	 Protected against close-range high pressure, high temperature spray downs.

Classification of divisions and zones

Type of area	ATEX and IEC	Definitions
Continuous hazard	Zone 0 / Zone 20 Cat 1	A place in which an explosive atmosphere is continuously present
Intermittent hazard	Zone 1 / Zone 21 Cat 2	A place in which an explosive atmosphere is likely to occur in normal operation
Hazard under abnormal conditions	Zone 2 / Zone 22 Cat 3	A place in which an explosive atmosphere is not likely to occur in normal operation but may occur for short periods

On occasion the ATEX and IEC zones may be used in the corresponding NEC and CEC system

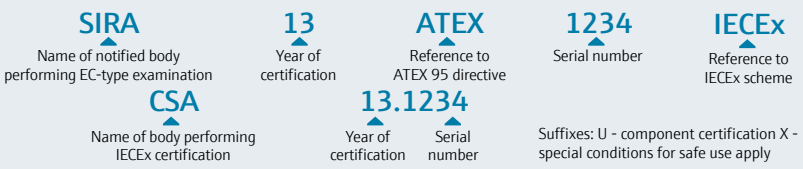
Equipment groups (ATEX and IECEx)

Equipment group	Equipment category	Equipment protection level	Atmosphere	Protection level	Required protection performance & operation
II (all other areas)	1	Ga / Da	Gas, vapour, mist, dust	Very High	Two faults
II (all other areas)	2	Gb / Db	Gas, vapour, mist, dust	High	One fault
II (all other areas)	3	Gc / Dc	Gas, vapour, mist, dust	Low	Normal operation

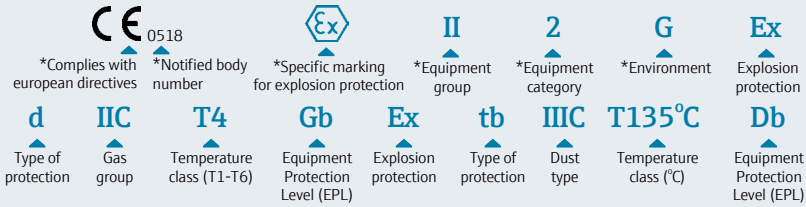
Apparatus groups (ATEX and IECEx)

Group	Environment	Location	Typical substance
I	Gases, vapours	Coal mining	Methane (Fire damp)
IIA		Surface and other locations	Acetic acid, Acetone, Ammonia, Butane, Cyclohexane, Gasoline (petrol), Kerosene, Methane (natural gas) (non-mining), Methanol (methyl alcohol), Propane, Propan-2-ol (iso-propyl alcohol), Toluene, Xylene
IIB			Di-ethyl ether, Ethylene, Methyl ethyl ketone (MEK), Propan-1-ol (n-propyl alcohol), Ethanol (ethyl alcohol)
IIC			Acetylene, Hydrogen, Carbon disulphide
IIIA	Combustible dusts	Surface and other locations	Combustible flyings
IIIB			Non-conductive
IIIC			Conductive

ATEX & IECEx certificate number



Typical ATEX & IECEx marketing (*ATEX only)



Protection Concepts (ATEX and IECEx)

Type of protection	Symbol	Typical IEC EPL	Typical zone(s)	IEC standard	Basic concept of protection
Electrical equipment for gases, vapours and mists (G)					
General requirements	-	-	-	IEC 60079-0	-
Optical radiation	Op pr Op sh Op is	Gb Ga Ga	1,2 0,1,2 0,1,2	IEC 60079-28	Protection against ignitions from optical radiation
Increased safety Type 'n' (non-sparking)	e nA	Gb Gc	1,2 2	IEC 60079-7 IEC 60079-15	No arcs, sparks or hot surfaces Enclosure IP54 or better
Flameproof	d	Gb	1,2	IEC 60079-1	Contain the explosion, quench the flame
Type 'n' (enclosed break)	nC	Gc	2	IEC 60079-15	
Quartz / SandFilled	q	Gb	1,2	IEC 60079-5	Quench the flame
Intrinsic safety	ia ib ic	Ga Gb Gc	0,1,2 1,2 2	IEC 60079-11	Limit the energy of sparks and surface temperatures
Pressurised	px py pz	Gb Gb Gc	1,2 1,2 2	IEC 60079-2	Keep the flammable gas out
Type 'n' (sealing & hermetic sealing) Type 'n' (restricted breathing)	nC nR	Gc Gc	2 2	IEC 60079-15	
Encapsulation	ma mb mc	Ga Gb Gc	0,1,2 1,2 2	IEC 60079-18	
Oil immersion	o	Gb	1,2	IEC 60079-6	
Electrical equipment for combustible dusts (D)					
General requirements	-	-	-	IEC 60079-0	-
Enclosure	ta tb tc	Da Db Dc	20 21 22	IEC 60079-31	Standard protection for dusts, rugged tight enclosure
Intrinsic safety	ia ib ic	Da Db Dc	20 21 22	IEC 60079-11	Limit the energy of sparks and surface temperatures
Encapsulation	ma mb mc	Da Db Dc	20 21 22	IEC 60079-18	Protection by encapsulation of incendive parts
Pressurised	pD	Db Dc	21,22 22	IEC 61241-4	Protection by pressurisation of enclosure

UK

Endress+Hauser Ltd
Floats Road
Manchester
M23 9NF
Tel: 0161 286 5000
Fax: 0161 998 1841
info@uk.endress.com
www.uk.endress.com

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Endress+Hauser

People for Process Automation