



Technical Information

Omnigrad S TR65, TC65

Modular thermometer, optionally with adjustable compression fitting



TR65 with resistance insert (RTD)
TC65 with thermocouple insert (TC)

Applications

- Fine chemicals
- Petrochemicals
- Power stations
- Environmental engineering
- Measuring range:
 - Resistance insert (RTD): -200 to 600 °C (-328 to 1112 °F)
 - Thermocouple (TC): -40 to 1100 °C (-40 to 2012 °F)
- Static pressure range up to 75 bar depending on the process connection used
- Degree of protection up to IP68

Head transmitter

All Endress+Hauser transmitters are available with enhanced accuracy and reliability compared to directly wired sensors. Easy customizing by choosing one of the following outputs and communication protocols:

- Analog output 4 to 20 mA
- HART®
- PROFIBUS® PA
- FOUNDATION Fieldbus™

Your benefits

- For plug-in/screw-in with sliding compression fitting
- High degree of flexibility thanks to modular design with standard terminal heads as per DIN EN 50446 and customer-specific immersion lengths
- High degree of insert compatibility and design as per DIN 43772
- Types of protection for use in hazardous locations:
 - Intrinsic Safety (Ex ia)
 - Flameproof (Ex d)
 - Non-sparking (Ex nA)

Function and system design

Measuring principle

Resistance thermometer (RTD)

These resistance thermometers use a Pt100 temperature sensor according to IEC 60751. The temperature sensor is a temperature-sensitive platinum resistor with a resistance of 100 Ω at 0 °C (32 °F) and a temperature coefficient $\alpha = 0.003851 \text{ } ^\circ\text{C}^{-1}$.

There are generally two different kinds of platinum resistance thermometers:

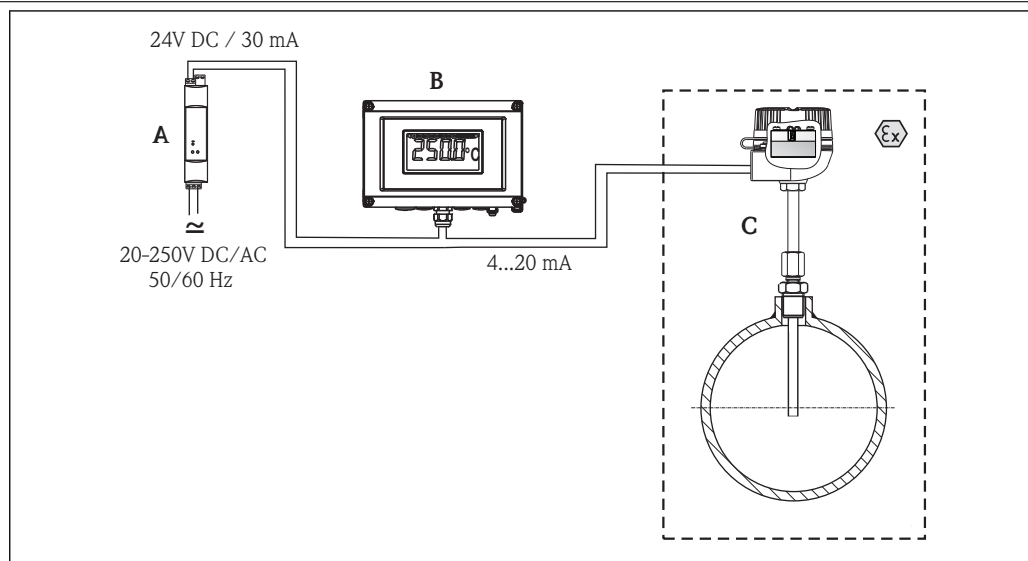
- **Wire wound (WW):** Here, a double coil of fine, high-purity platinum wire is located in a ceramic support. This is then sealed top and bottom with a ceramic protective layer. Such resistance thermometers not only facilitate very reproducible measurements but also offer good long-term stability of the resistance/temperature characteristic within temperature ranges up to 600 °C (1 112 °F). This type of sensor is relatively large in size and it is comparatively sensitive to vibrations.
- **Thin film platinum resistance thermometers (TF):** A very thin, ultrapure platinum layer, approx. 1 μm thick, is vaporized in a vacuum on a ceramic substrate and then structured photolithographically. The platinum conductor paths formed in this way create the measuring resistance. Additional covering and passivation layers are applied and reliably protect the thin platinum layer from contamination and oxidation, even at high temperatures.

The primary advantages of thin film temperature sensors over wire wound versions are their smaller sizes and better vibration resistance. A relatively low principle-based deviation of the resistance/temperature characteristic from the standard characteristic of IEC 60751 can frequently be observed among TF sensors at high temperatures. As a result, the tight limit values of tolerance category A as per IEC 60751 can only be observed with TF sensors at temperatures up to approx. 300 °C (572 °F).

Thermocouples (TC)

Thermocouples are comparatively simple, robust temperature sensors which use the Seebeck effect for temperature measurement: if two electrical conductors made of different materials are connected at a point, a weak electrical voltage can be measured between the two open conductor ends if the conductors are subjected to a thermal gradient. This voltage is called thermoelectric voltage or electromotive force (emf.). Its magnitude depends on the type of conducting materials and the temperature difference between the "measuring point" (the junction of the two conductors) and the "cold junction" (the open conductor ends). Accordingly, thermocouples primarily only measure differences in temperature. The absolute temperature at the measuring point can be determined from these if the associated temperature at the cold junction is known or is measured separately and compensated for. The material combinations and associated thermoelectric voltage/temperature characteristics of the most common types of thermocouple are standardized in the IEC 60584 and ASTM E230/ANSI MC96.1 standards.

Measuring system

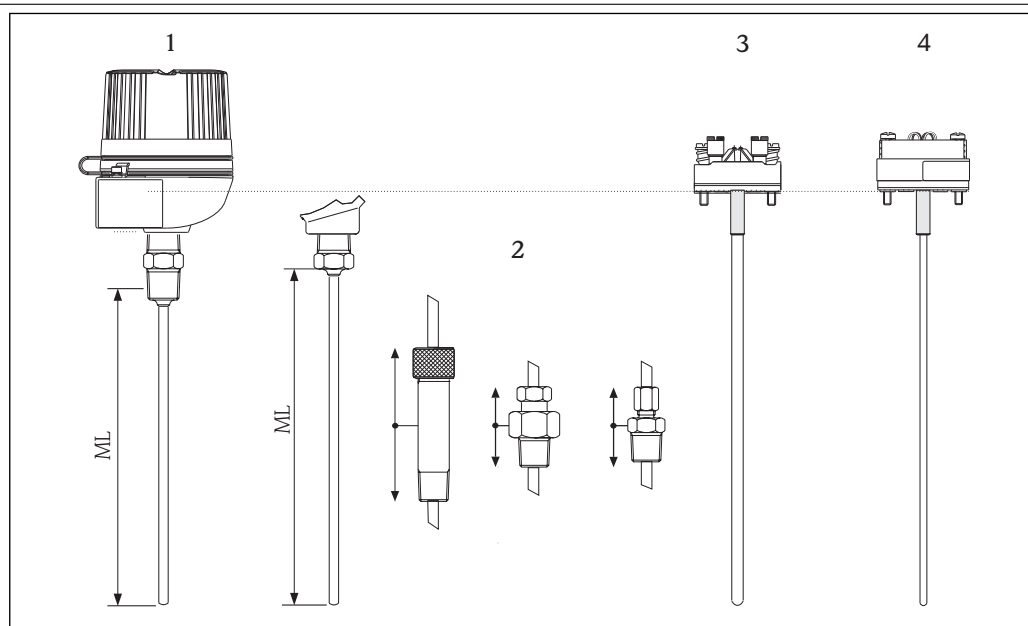


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1 Application example

- A Active barrier RN221N - The RN221N (24 V DC, 30 mA) active barrier has a galvanically isolated output for supplying voltage to loop-powered transmitters. The universal power supply works with an input supply voltage of 20 to 250 V DC/AC, 50/60 Hz, which means that it can be used in all international power grids. More information on this can be found in the Technical Information (see "Documentation").
- B RIA16 field display unit - The display unit records the analog measuring signal from the head transmitter and shows this on the display. The LC display shows the current measured value in digital form and as a bar graph indicating a limit value violation. The display unit is looped into the 4 to 20 mA circuit and gets the required energy from there. More information on this can be found in the Technical Information (see "Documentation").
- C Mounted thermometer with head transmitter installed.

Design



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2 Thermometer design

- 1 Complete thermometer with terminal head and firmly welded thread
- 2 Thermometer with adjustable process connections
- 3 Insert with mounted ceramic terminal block (example)
- 4 Insert with mounted head transmitter (example)
- ML Insertion length

Thermometers from the Omnigrad TR65 and TC65 series have a modular design. The terminal head is used as a connection module for the mechanical and electrical connection of the insert. The position of the actual thermometer sensor in the insert ensures that it is mechanically protected. The insert has flying leads, a ceramic terminal block or mounted temperature transmitter.

Measuring range	■ RTD: -200 to 600 °C (-328 to 1 112 °F) ■ TC: -40 to 1 100 °C (-40 to 2 012 °F)
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Performance characteristics

Operating conditions

Ambient temperature range

Terminal head	Temperature in °C (°F)
Without mounted head transmitter	Depends on the terminal head used and the cable gland or fieldbus connector, see 'Terminal heads' section →  9
With mounted head transmitter	-40 to 85 °C (-40 to 185 °F)
With mounted head transmitter and display	-20 to 70 °C (-4 to 158 °F)

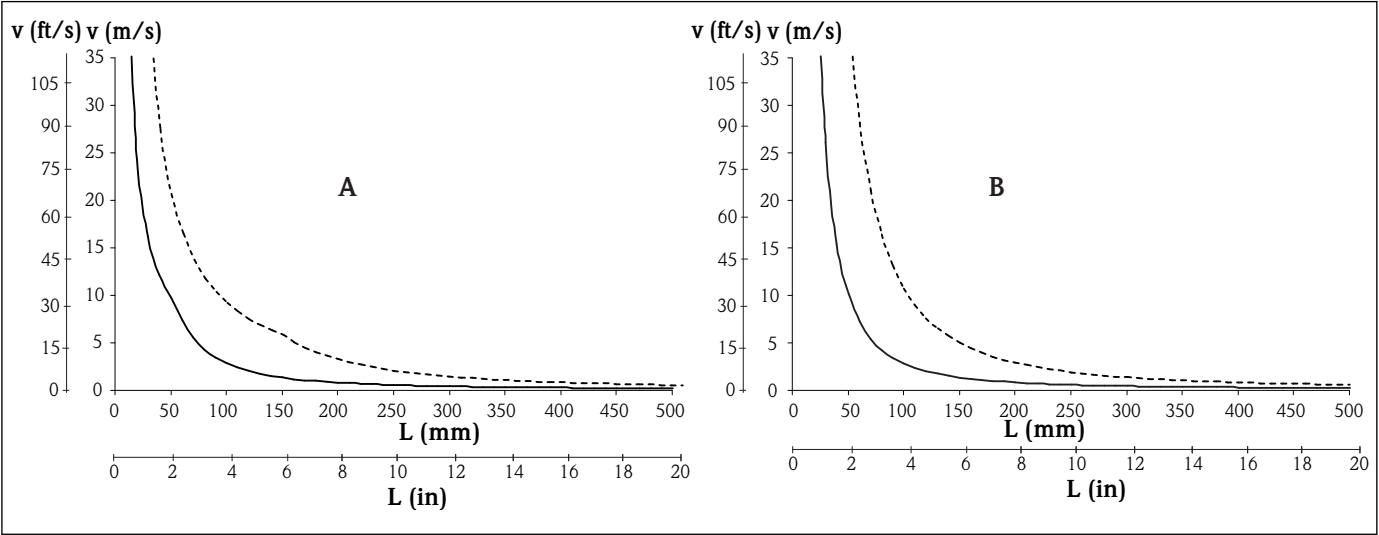
Process pressure

The maximum permitted process pressure depends on the process connection used. For an overview of the possible process connections, see the "Process connection" section →  12.

Process connection	According to standard	Max. Process pressure
Thread NPT ½", NPT ¾"	ANSI B1.20.1	75 bar
Compression fitting		40 bar with metal clamping ring 5 bar with PTFE clamping ring
Spring-loaded compression fitting		Max. atmospheric pressure, not pressure-tight

Permitted flow velocity depending on the immersion length

The highest flow velocity tolerated by the thermometer diminishes with increasing sensor immersion length exposed to the stream of the fluid. In addition it is dependent on the diameter of the thermometer tip, on the kind of measuring medium, on the process temperature and on the process pressure. The following figures exemplify the maximum permitted flow velocities in water and superheated steam at a process pressure of 1 MPa (10 bar).



3 Permitted flow velocity

- A Medium water at $T = 50\text{ }^{\circ}\text{C}$ ($122\text{ }^{\circ}\text{F}$)
- B Medium superheated steam at $T = 400\text{ }^{\circ}\text{C}$ ($752\text{ }^{\circ}\text{F}$)
- L Immersion length
- v Flow velocity
- Insert diameter 3 mm (0.12 in)
- - - Insert diameter 6 mm (0.24 in)

Shock and vibration resistance

RTD:

The Endress+Hauser inserts exceed the requirements of IEC 60751 which specify shock and vibration resistance of 3 g in the range from 10 to 500 Hz.

The vibration resistance at the measuring point depends on the sensor type and design, see the following table:

Sensor type	Vibration resistance for the sensor tip ¹⁾
iTHERM StrongSens Pt100 (TF, vibration-resistant)	600 m/s ² (60 g)
Thin-film sensor (TF)	>4 g
Wire wound sensor (WW)	>3 g

1) (measured according to IEC 60751 at varying frequencies in the 10 to 500 Hz range)

Thermocouple TC:

4G / 2 to 150 Hz as per IEC 60068-2-6

Accuracy

Permissible deviation limits of thermoelectric voltages from the standard characteristic for thermocouples as per IEC 60584 or ASTM E230/ANSI MC96.1:

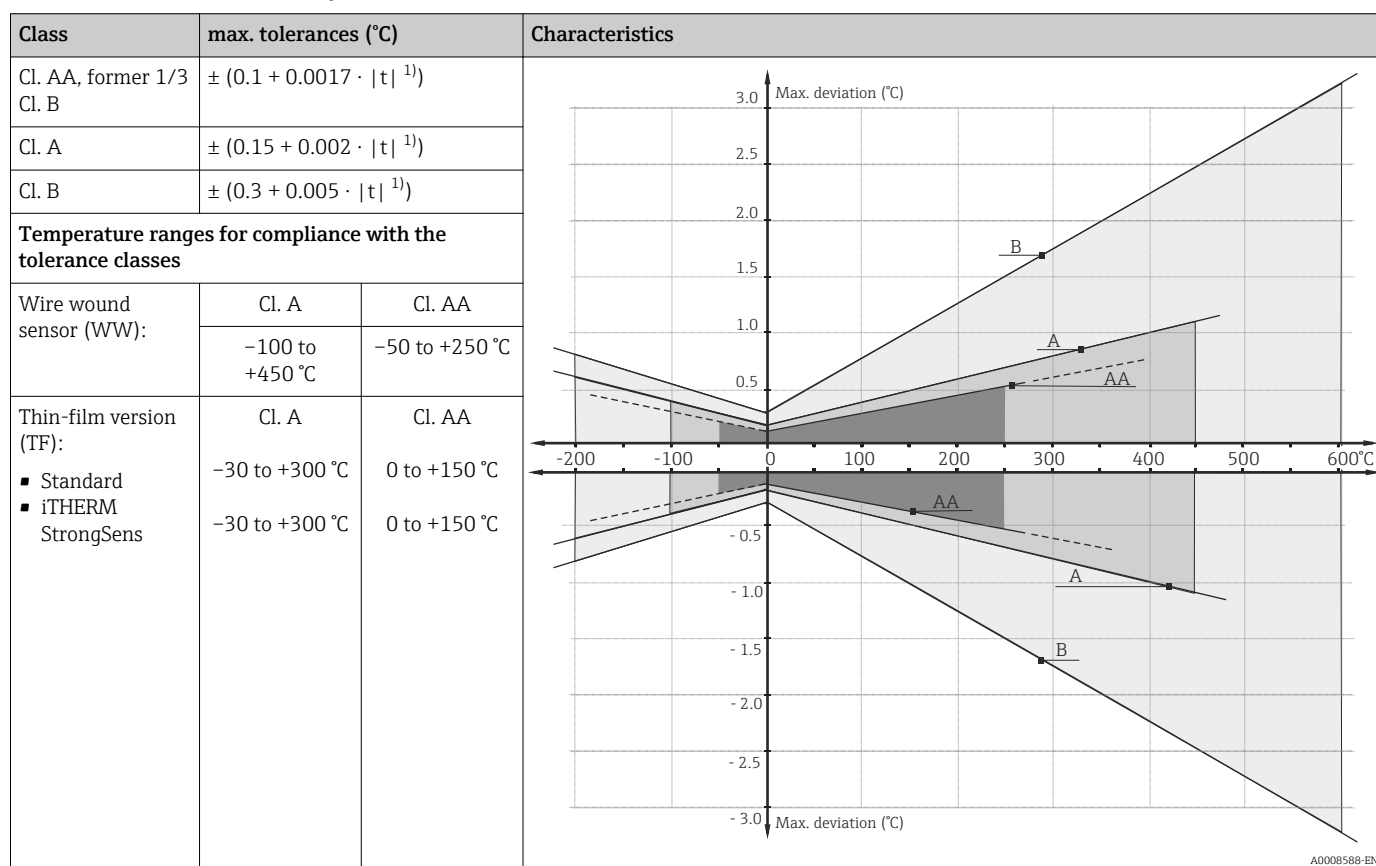
Standard	Type	Standard tolerance		Special tolerance	
IEC 60584		Class	Deviation	Class	Deviation
	J (Fe-CuNi)	2	$\pm 2.5\text{ °C}$ (-40 to 333 °C) $\pm 0.0075 t ^{1)}$ (333 to 750 °C)	1	$\pm 1.5\text{ °C}$ (-40 to 375 °C) $\pm 0.004 t ^{1)}$ (375 to 750 °C)
	K (NiCr-NiAl)	2	$\pm 2.5\text{ °C}$ (-40 to 333 °C) $\pm 0.0075 t ^{1)}$ (333 to 1200 °C)	1	$\pm 1.5\text{ °C}$ (-40 to 375 °C) $\pm 0.004 t ^{1)}$ (375 to 1000 °C)

1) $|t|$ = absolute value in °C

Standard	Type	Standard tolerance	Special tolerance
ASTM E230/ANSI MC96.1		Deviation, the larger respective value applies	
	J (Fe-CuNi)	$\pm 2.2\text{ K}$ or $\pm 0.0075 t ^{1)}$ (0 to 760 °C)	$\pm 1.1\text{ K}$ or $\pm 0.004 t ^{1)}$ (0 to 760 °C)
	K (NiCr-NiAl)	$\pm 2.2\text{ K}$ or $\pm 0.02 t ^{1)}$ (-200 to 0 °C) $\pm 2.2\text{ K}$ or $\pm 0.0075 t ^{1)}$ (0 to 1260 °C)	$\pm 1.1\text{ K}$ or $\pm 0.004 t ^{1)}$ (0 to 1260 °C)

1) $|t|$ = absolute value in °C

RTD resistance thermometer as per IEC 60751



1) $|t|$ = absolute value °C



In order to obtain the maximum tolerances in °F, the results in °C must be multiplied by a factor of 1.8.

Response time

Calculated at an ambient temperature of approx. 23 °C by immersing in running water (0.4 m/s flow rate, 10 K excess temperature):

Thermometer type	Diameter	t _(x)	Conical tip (120°)	Straight tip
Resistance thermometer (measuring probe Pt100, TF/WW)	6 mm	t ₅₀		3.5 s
		t ₉₀		8 s
	3 mm	t ₅₀		2 s
		t ₉₀		5 s
Thermocouple (not grounded)	6 mm	t ₅₀		2.5 s
		t ₉₀		7 s
	3 mm	t ₅₀		1 s
		t ₉₀		2.5 s
Thermocouple (grounded)	6 mm	t ₅₀		2 s
		t ₉₀		5 s
	3 mm	t ₅₀		0.8 s
		t ₉₀		2 s



Response time for insert without transmitter.

Insulation resistance

Insulation resistance ≥ 100 MΩ at ambient temperature.

Insulation resistance between the terminals and the outer jacket is measured with a minimum voltage of 100 V DC.

Self heating

RTD elements are passive resistances that are measured using an external current. This measurement current causes a self-heating effect in the RTD element itself which in turn creates an additional measurement error. In addition to the measurement current, the size of the measurement error is also affected by the temperature conductivity and flow velocity of the process. This self-heating error is negligible when an Endress+Hauser iTEMP temperature transmitter (very small measurement current) is connected.

Calibration

Endress+Hauser provides comparison temperature calibration from –80 to +1 400 °C (–110 to +2 552 °F) based on the International Temperature Scale (ITS90). Calibrations are traceable to national and international standards. The calibration certificate is referenced to the serial number of the thermometer. Only the insert is calibrated.

Insert: Ø6 mm (0.24 in) and 3 mm (0.12 in)	Minimum insertion length of insert in mm (in)	
Temperature range	without head transmitter	with head transmitter
–80 to 250 °C (–110 to 480 °F)	No minimum immersion length required	
250 to 550 °C (480 to 1 020 °F)	300 (11.81)	
550 to 1 400 °C (1 020 to 2 552 °F)	450 (17.72)	

Material

Process connection, insert

The temperatures for continuous operation specified in the following table are only intended as reference values for use of the various materials in air and without any significant compressive load. The maximum operating temperatures are reduced considerably in some cases where abnormal conditions such as high mechanical load occur or in aggressive media.

Description	Short form	Recommended max. temperature for continuous use in air	Properties
AISI 316/1.4401	X5CrNiMo 17-12-2	650 °C (1 202 °F) ¹⁾	■ Austenitic, stainless steel ■ High corrosion resistance in general ■ Particularly high corrosion-resistance in chlorine-based and acidic, non-oxidizing atmospheres through the addition of molybdenum (e.g. phosphoric and sulfuric acids, acetic and tartaric acids with a low concentration)
AISI 316L/ 1.4404 1.4435	X2CrNiMo17-12-2 X2CrNiMo18-14-3	650 °C (1 202 °F) ¹⁾	■ Austenitic, stainless steel ■ High corrosion resistance in general ■ Particularly high corrosion-resistance in chlorine-based and acidic, non-oxidizing atmospheres through the addition of molybdenum (e.g. phosphoric and sulfuric acids, acetic and tartaric acids with a low concentration) ■ Increased resistance to intergranular corrosion and pitting ■ Compared to 1.4404, 1.4435 has even higher corrosion resistance and a lower delta ferrite content
Alloy600/ 2.4816	NiCr15Fe	1 100 °C (2 012 °F)	■ A nickel/chromium alloy with very good resistance to aggressive, oxidizing and reducing atmospheres, even at high temperatures ■ Resistance to corrosion caused by chlorine gases and chlorinated media as well as many oxidizing mineral and organic acids, sea water etc. ■ Corrosion from ultrapure water ■ Not to be used in sulfur-containing atmospheres

- 1) Can be used to a limited extent up to 800 °C (1472 °F) for low compressive loads and in non-corrosive media. Please contact your Endress+Hauser sales team for further information.

Components

Family of temperature transmitters

Thermometers fitted with iTEMP transmitters are an installation-ready complete solution to improve temperature measurement by significantly increasing accuracy and reliability, when compared to direct wired sensors, as well as reducing both wiring and maintenance costs.

PC programmable head transmitters

They offer a high degree of flexibility, thereby supporting universal application with low inventory storage. The iTEMP transmitters can be configured quickly and easily at a PC. Endress+Hauser offers free configuration software which can be downloaded from the Endress+Hauser Website. More information can be found in the Technical Information.

HART® programmable head transmitters

The transmitter is a 2-wire device with one or two measuring inputs and one analog output. The device not only transfers converted signals from resistance thermometers and thermocouples, it also transfers resistance and voltage signals using HART® communication. It can be installed as an intrinsically safe apparatus in Zone 1 hazardous areas and is used for instrumentation in the terminal head (flat face) as per DIN EN 50446. Swift and easy operation, visualization and maintenance by PC using operating software, Simatic PDM or AMS. For more information, see the Technical Information.

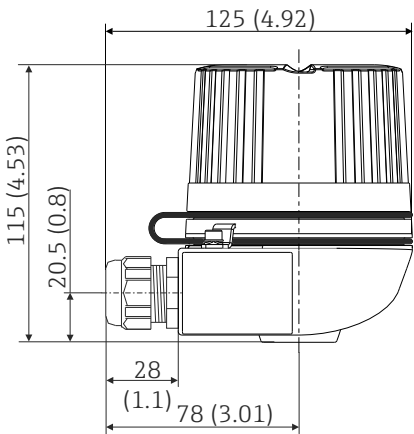
Advantages of the iTEMP transmitters:

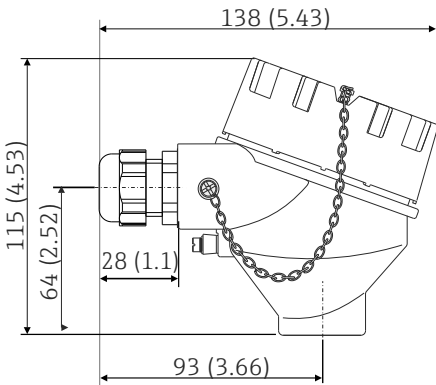
- Dual or single sensor input (optionally for certain transmitters)
- Unsurpassed reliability, accuracy and long-term stability in critical processes
- Mathematical functions
- Monitoring of the thermometer drift, sensor backup functionality, sensor diagnostic functions
- Sensor-transmitter matching for dual sensor input transmitter, based on Callendar/Van Dusen coefficients

Terminal heads

All terminal heads have an internal shape and size in accordance with DIN EN 50446, flat face and a thermometer connection of M24x1.5, G½" or ½" NPT thread. All dimensions in mm (in). The cable glands in the diagrams correspond to M20x1.5 connections. Specifications without head transmitter installed. For ambient temperatures with head transmitter installed, see "Operating conditions" section.

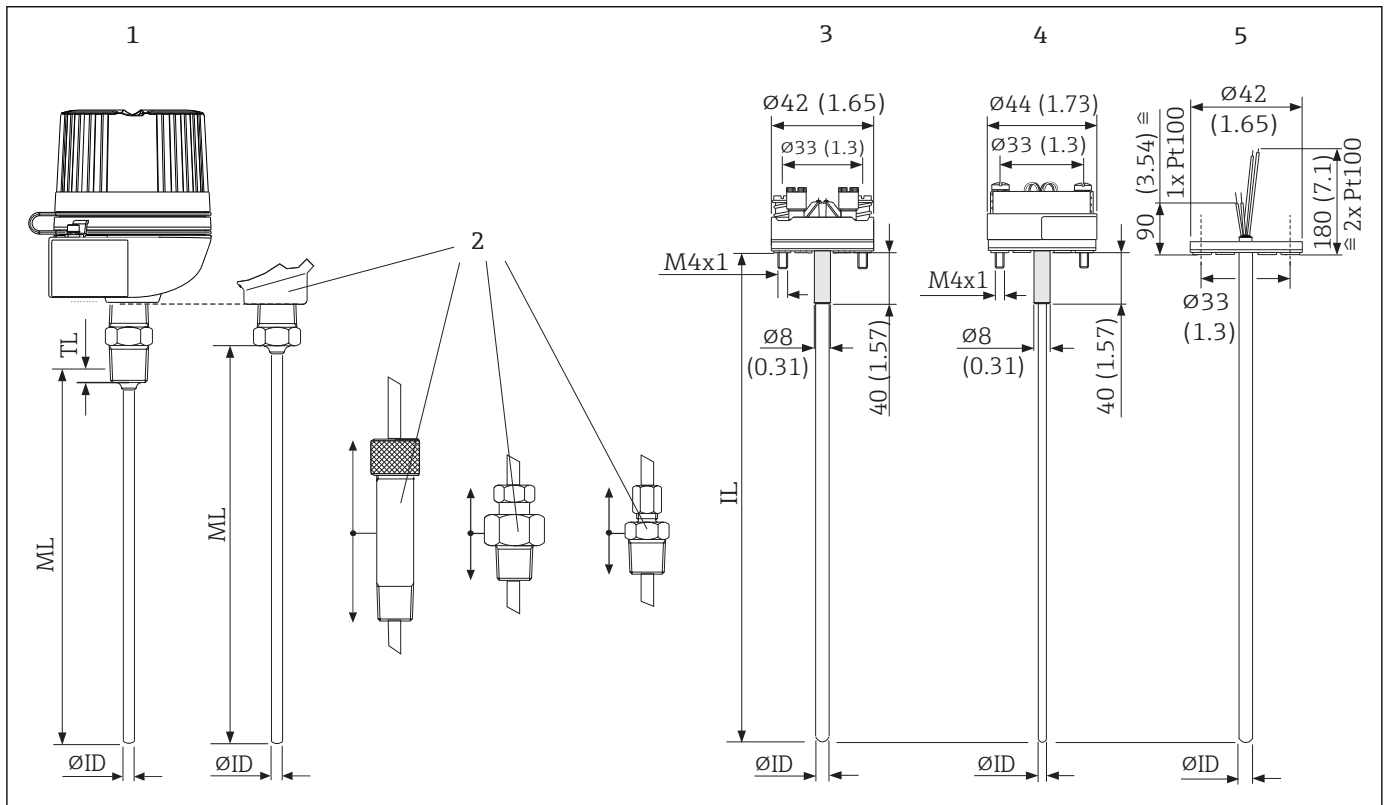
TA30H	Specification
A0009832	■ Flameproof (XP) version, explosion-protected, captive screw cap, available with one or two cable entries ■ Degree of protection: IP 66/68, NEMA Type 4x Encl. Ex-version: IP 66/67 ■ Temperature: -50 to +150 °C (-58 to +302 °F) for rubber seal without cable gland (observe max. permitted temperature of cable gland!) ■ Material: aluminum; polyester powder coated ■ Thread: ½" NPT, ¾" NPT, M20x1.5, G½" ■ Extension neck/thermowell connection: ½" NPT ■ Color of head: blue, RAL 5012 ■ Color of cap: gray, RAL 7035 ■ Weight: approx. 640 g (22.6 oz)

TA30H with display window in cover	Specification
 A0009831	- Flameproof (XP) version, explosion-protected, captive screw cap, available with one or two cable entries - Degree of protection: IP 66/68, NEMA Type 4x Encl. Ex-version: IP 66/67 - Temperature: -50 to +150 °C (-58 to +302 °F) for rubber seal without cable gland (observe max. permitted temperature of cable gland!) - Material: aluminum; polyester powder coated - Thread: ½" NPT, ¾" NPT, M20x1.5, G½" - Extension neck/thermowell connection: ½" NPT - Color of head: blue, RAL 5012 - Color of cap: gray, RAL 7035 - Weight: approx. 860 g (30.33 oz) - Head transmitter optionally available with TID10 display

TA21H, DIN B	Specification
 A0010194	- Head with captive screw cap and safety chain - Protection class: IP66/68 (NEMA Type 4x encl.) - Max. temperature: 100 °C (212 °F) for rubber seal without cable gland - Material: aluminum alloy, stainless steel; rubber seal under the cover - Double threaded cable entry: ½" NPT, ¾" NPT, M20 oder G½" - Head color: blue - Cap color: gray - Weight: approx. 600 g (21.2 oz)

Design

All dimensions in mm (in).



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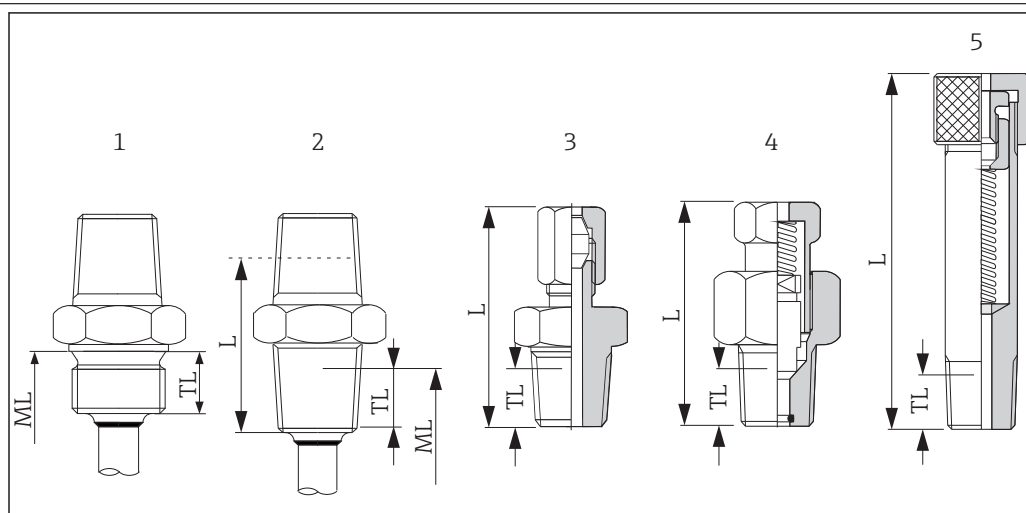
4 Dimensions of Omnigrad S TR65 and TC65

- 1 Complete thermometer with terminal head and firmly welded thread
- 2 Thermometer with adjustable process connections
- 3 Insert with terminal block mounted
- 4 Insert with head transmitter mounted
- 5 Insert with flying leads
- TL Screw-in length
- ML Insertion length
- IL Installation length of insert
- ØID Insert diameter

Weight

0.5 to 2.5 kg (1 to 5.5 lbs) for standard options.

Process connection



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5 Available process connections

Item No.	Model		L in mm (in)	TL in mm (in)
1	Thread, fix-weld	M20	-	14 mm (0.55 in)
2		NPT 1/2" NPT 3/4"	42 mm (1.65 in)	8 mm (0.31 in) 15 mm (0.59 in)
3	Compression fitting	NPT 1/2" NPT 3/4"	55 mm (2.16 in)	8 mm (0.31 in)
4	Spring-loaded compression fitting	NPT 1/2"	60 mm (2.36 in)	8 mm (0.31 in)
5	Spring-loaded compression fitting	NPT 1/2" NPT 3/4"	105 mm (4.13 in) 120 mm (4.72 in)	8 mm (0.31 in)

Spare parts

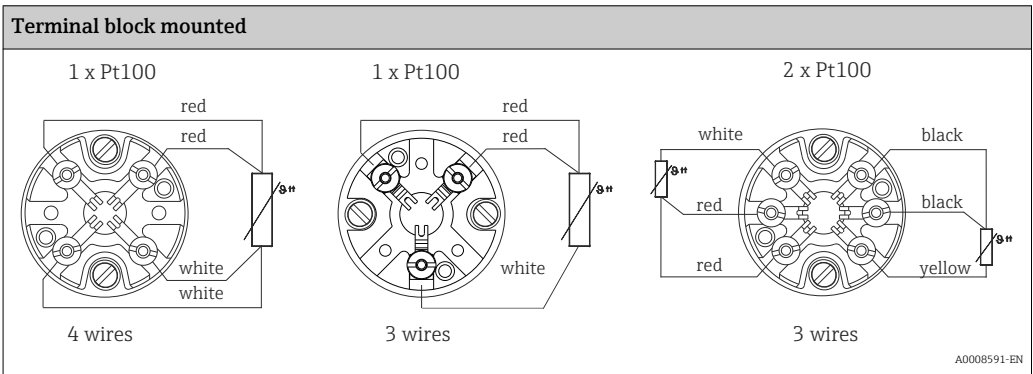
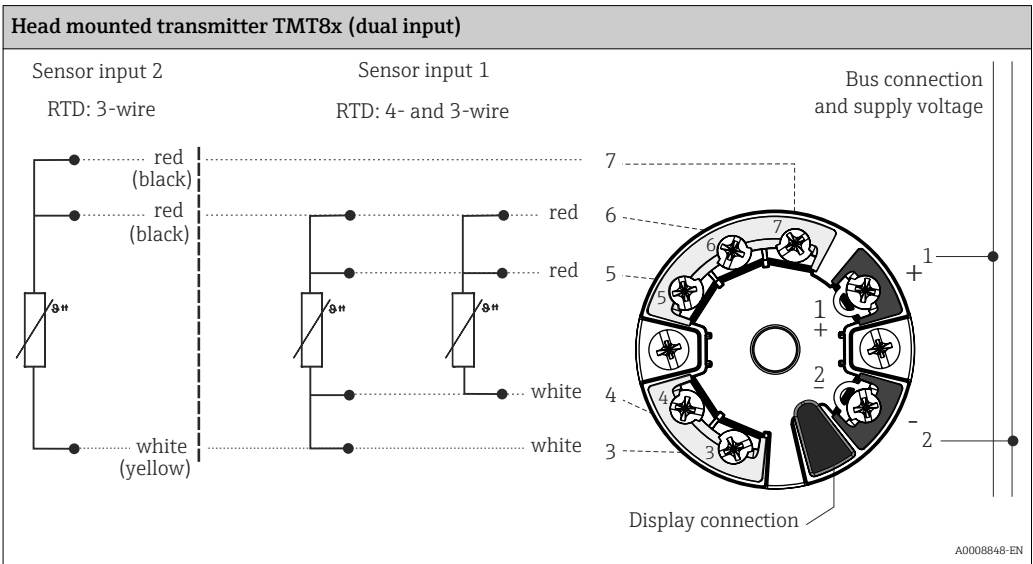
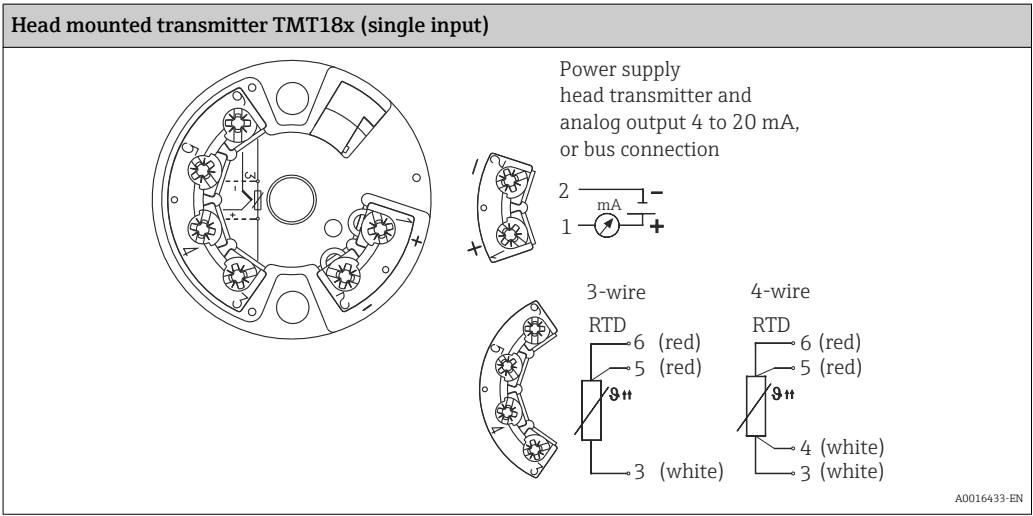
The following adjustable compression fittings (see figure above, item 2) are available as spare parts:

Spare part	Diameter	Connection	Material
Process connection TA50-CB	6 mm	NPT 1/2"	1.4401 (316)
Process connection TA50-DB		NPT 3/4"	1.4401 (316)
Spare parts kit TA50-xx, content: 10 pcs, Order No.: 60011599	6.1 mm	-	1.4401 (316)

Wiring

Wiring diagrams for RTD

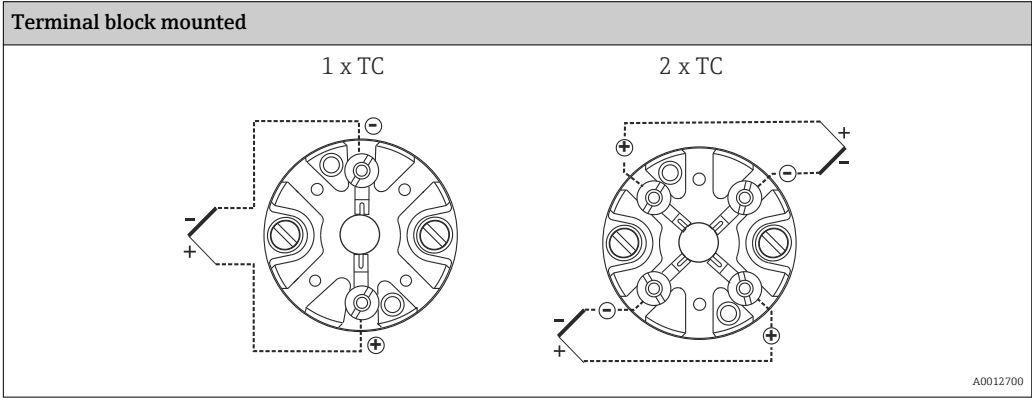
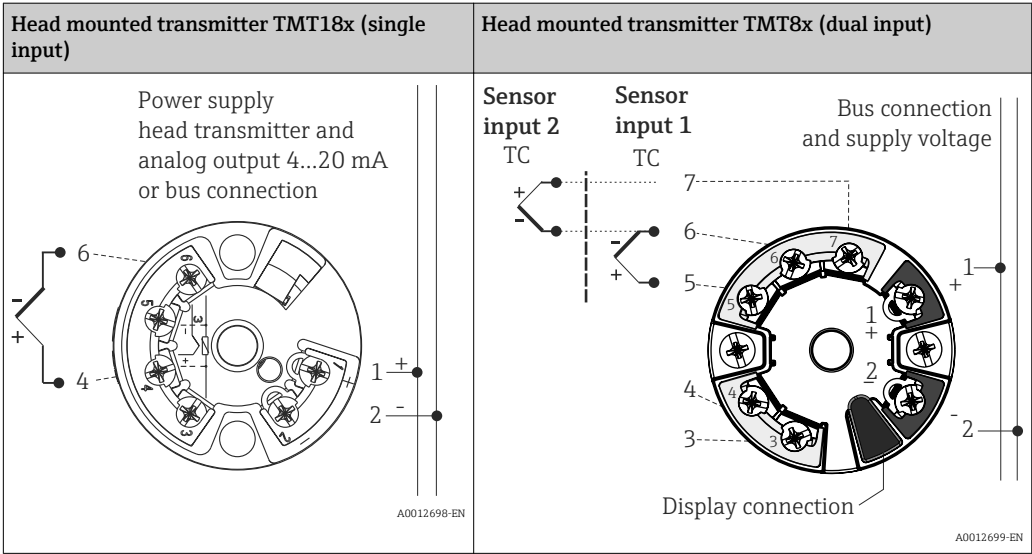
Type of sensor connection



Wiring diagrams for TC

Thermocouple wire colors

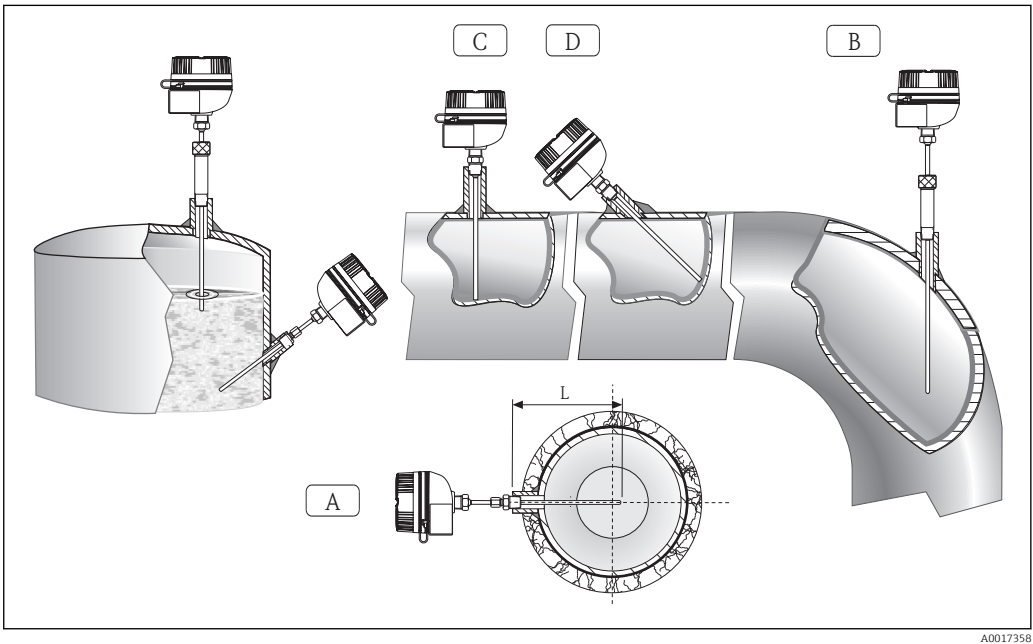
As per IEC 60584	As per ASTM E230
- Type J: black (+), white (-) - Type K: green (+), white (-)	- Type J: white (+), red (-) - Type K: yellow (+), red (-)



Installation conditions

Orientation No restrictions.

Installation instructions



6 Thermometer installation

A, C In pipes with a small cross-section, the sensor tip should reach or extend slightly past the center axis of the pipe (= *L*).

B, D Slanted orientation.

The immersion length of the thermometer influences the accuracy. If the immersion length is too small, errors in the measurement are caused by heat conduction via the process connection and the container wall. For installation in a pipe, therefore, the recommended installation depth ideally corresponds to half of the pipe diameter. Installation at an angle (see B and D) could be another solution. When determining the immersion length or installation depth all the parameters of the thermometer and of the process to be measured must be taken into account (e.g. flow velocity, process pressure).

- Installation possibilities: Pipes, tanks or other plant components
- ATEX certification: Observe the installation instructions in the Ex documentation!

Minimum immersion depth

Error caused by heat conduction ≤0.1 K; measured according to IEC 60751 at 100 °C in liquid medium

Sensor type	Diameter ID	Immersion depth
Thin-film sensor (TF), iTHERM StrongSens, vibration-resistant	6 mm (¼ in)	≥ 40 mm (1.57 in)
Thin-film sensor (TF)	3 mm (⅛ in)	≥ 30 mm (1.18 in)
	6 mm (¼ in)	≥ 50 mm (1.97 in)
Wire wound sensor (WW)	3 mm (⅛ in)	≥ 30 mm (1.18 in)
	6 mm (¼ in)	≥ 60 mm (2.36 in)

Certificates and approvals

CE mark	The measuring system meets the legal requirements of the applicable EC guidelines. These are listed in the corresponding EC Declaration of Conformity together with the standards applied. Endress+Hauser confirms successful testing of the device by affixing to it the CE mark.
Hazardous area approvals	For further details on the available Ex versions (ATEX, CSA, FM etc.), please contact your nearest Endress+Hauser sales organization. All relevant data for hazardous areas can be found in separate Ex documentation.
Other standards and guidelines	■ IEC 60529: Degrees of protection provided by enclosures (IP code) ■ IEC/EN 61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use ■ IEC 60751: Industrial platinum resistance thermometers ■ IEC 60584 and ASTM E230/ANSI MC96.1: Thermocouples ■ DIN EN 50446: Terminal heads
Test report and calibration	The "Factory calibration" is carried out according to an internal procedure in a laboratory of Endress+Hauser accredited by the European Accreditation Organization (EA) to ISO/IEC 17025. A calibration which is performed according to EA guidelines (SIT/Accredia) or (DKD/DAkkS) may be requested separately. The calibration is performed on the replaceable insert of the thermometer. In the case of thermometers without a replaceable insert, the entire thermometer - from the process connection to the tip of the thermometer - is calibrated.
Calibration according to GOST	Russian Metrology Test, +100/+300/+500/+700 °C + transmitter factory calibration, 6 points (fixed)

Ordering information

Detailed ordering information is available from the following sources:

- In the Product Configurator on the Endress+Hauser website: www.endress.com → Select your country → Products → Select measuring technology, software or components → Select the product (picklists: measurement method, product family etc.) → Device support (right-hand column): Configure the selected product → The Product Configurator for the selected product opens.
- From your Endress+Hauser Sales Center: www.addresses.endress.com



Product Configurator - the tool for individual product configuration

- Up-to-the-minute configuration data
- Depending on the device: Direct input of measuring point-specific information such as measuring range or operating language
- Automatic verification of exclusion criteria
- Automatic creation of the order code and its breakdown in PDF or Excel output format
- Ability to order directly in the Endress+Hauser Online Shop

Supplementary documentation

Technical Information:

- iTEMP temperature head transmitter:
 - TMT180, PC-programmable, single-channel, Pt100 (TI00088R/09/en)
 - PCP TMT181, PC-programmable, single-channel, RTD, TC, Ω, mV (TI00070R/09/en)
 - HART® TMT182, single-channel, RTD, TC, Ω, mV (TI00078R/09/en)
 - HART® TMT82, two-channel, RTD, TC, Ω, mV (TI01010T/09/en)
 - PROFIBUS® PA TMT84, two-channel, RTD, TC, Ω, mV (TI00138R/09/en)
 - FOUNDATION Fieldbus™ TMT85, two-channel, RTD, TC, Ω, mV (TI00134R/09/en)
- Application example:
 - RN221N Active barrier, for supplying loop-powered transmitters (TI073R/09/en)
 - RIA16 Field display unit, loop-powered (TI00144R/09/en)

Supplementary ATEX documentation:

- RTD/TC Thermometer Omnigrad TRxx, TCxx, TxCxxx, ATEX II 1GD or II 1/2GD Ex ia IIC T6...T1 (XA00072R/09/a3)
- RTD/TC Thermometer Omnigrad S TR/TC6x, ATEX II1/2, 2GD or II2G (XA014T/02/a3)
- RTD/TC Thermometer Omnigrad S TR/TC6x, ATEX II 1/2 or 2G; II 1/2 or 2D; II 2G (XA00084R/09/a3)



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