Technical Information
TI 269T/02/en
60020989

RTD Temperature Sensor
omnigrad T TR 24

Sliding threaded or weld-in process connection
With replaceable insert
PCP (4...20 mA), HART® or PROFIBUS-PA® electronics

Temperature sensors TR 24, series Omnigrad T, are resistance thermometers suitable for almost all industrial processes and generic applications thanks to their modular structure.
They are made up of a measurement probe without a protection well, and a housing, which may contain the transmitter for conversion of the variable measured.

Features and benefits

- SS 316L/1.4404 for probe "wetted" parts
- The most common compression junctions are supplied as standard; others are available upon request
- Customized immersion lenght
- Probe end with reduced diameter for a faster response time
- Surface finishing down to Ra < 0.8 µm
- Stainless steel, aluminium or plastic housing, with protection grade from IP65 to IP67
- Replaceable mineral insulated insert, with diameter 6 or 3 mm
- PCP (4...20 mA, also with enhanced accuracy), HART® and PROFIBUS-PA® 2-wire transmitters
- Pt 100 sensing element with class A accuracy (DIN EN 60751) or 1/3 DIN B
- Pt 100 wire wound (-200...600°C) or thin film (-50...400°C)
- Double Pt 100, for redundancy purposes
- Single Pt 100 with 4 wires connection, double Pt 100 with 3 wires
- ATEX 1 or 1/2 GD EEx ia certification
- EA calibration certificate

50 Years of KnowHow
1953-2003

Endress+Hauser
The Power of Know How

Areas of application

- Fine chemicals industry
- Light energy industry
- Food industry
- General industrial services
- Environmental engineering

Function and system design

Measuring principle

In the RTD (Resistance Temperature Detector) thermometers, the sensing element consists of an electrical resistance with value of 100 Ω at 0°C (called Pt 100, in compliance with standard DIN EN 60751) which increases at higher temperatures according to a coefficient characteristic of the resistor material (platinum). In industrial thermometers that comply with the DIN EN 60751 standard, the value of this coefficient is $\alpha = 3.85*10^{-3}\ °C^{-1}$, calculated between 0 and 100°C.

Equipment architecture

The Omnigrad T TR 24 temperature sensor is made up of a measurement probe and a housing (head), which may contain a transmitter or the terminals on the ceramic block for electrical connection.
The sensor is manufactured according to standards DIN 43729 (housing) and 43735 (probe) and can therefore guarantee a good adaptability to the most common industrial processes.
The measurement probe consists of a (replaceable) insert in mineral oxide with a diameter of 3 or 6 mm.
The TR 24 can be fitted onto the plant (tube or tank) through the use of a compression fitting, which can be chosen from the most common models (see section "Structure of the components"), or it can be inserted into a thermowell (e.g. TW 251, see the TI at the end of this document).

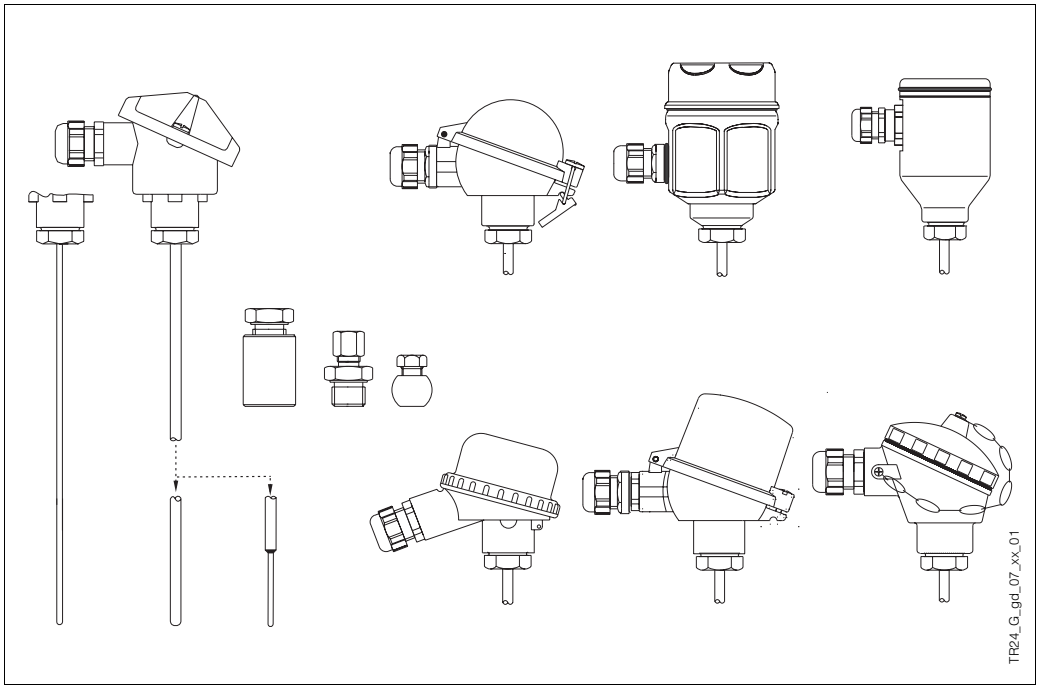


Fig. 1: TR *24 with the various types of heads, process connections and end parts of the probe*

The electrical structure of the thermometer always complies with DIN EN 60751 standard rules. The sensing element is available in two versions with a thin film (TF) or wire wound (WW), the latter with a large measuring and accuracy range.
The housing can be of different types and materials (plastic, painted aluminium alloy, stainless steel). The way in which it fits to probe and the cable gland ensure a minimum grade of IP65 (Ingress Protection).

Material

• Insert sheath in	SS 316L/1.4404
• Compression fitting in	SS 316/1.4401 or SS 316L/1.4404

Weight

From 0.5 to 2 kg for standard options.

Electronics

The required type of output signal can be obtained by choosing the correct head-mounted transmitter. Endress+Hauser supplies "state-of-the-art" transmitters (the iTEMP® series) built in 2-wire technology and with 4…20 mA output signal, HART® or PROFIBUS-PA®. All of the transmitters can be easily programmed using a personal computer through the ReadWin® 2000 public domain software (for transmitters 4…20 mA and HART®) or the Commuwin II software (for PROFIBUS-PA® transmitters). The HART® transmitters can also be programmed with the hand-held operating module DXR 275 (Universal HART® Communicator).
A PCP (4…20 mA, TMT 180) model with enhanced accuracy is available.
In the case of PROFIBUS-PA® transmitters, E+H recommends the use of PROFIBUS® dedicated connectors. The Weidmüller type (Pg 13.5 - M12) is provided as a standard option.
For detailed information about transmitters, please refer to the relevant documentation (refer to the TI codes at the end of the document).
If a head-mounted transmitter is not employed, the sensor probe can be connected through the terminal block to a remote converter (i.e. DIN rail transmitter).

Performance

Operating conditions

Ambient temperature (housing without head-mounted transmitter)

• metal housings	-40÷130°C
• plastic housings	-40÷85°C

Ambient temperature (housing with head-mounted transmitter)	-40÷85°C
Ambient temperature (housing with display)	-20÷70°C

Process temperature

• Sleeve in SS (TA 50/55 compression fitting)	max 500°C
• Sleeve in PTFE (TA 50/55 compression fitting)	max 200°C
• Sleeve in Viton® (TA70 compression fitting)	max 180°C

Maximum process pressure

• Sleeve in SS (TA 50/55 compression fitting)	4 MPa (40 bar) at 20°C
• Sleeve in PTFE (TA 50/55 compression fitting)	1 MPa (10 bar) at 20°C
• Sleeve in Viton® (TA 70 compression fitting)	2 MPa (20 bar) at 20°C

Maximum flow velocity
The highest flow velocity tolerated by the insert diminishes with increasing lengths of the probe exposed to the stream of the fluid.

Shock and vibration resistance

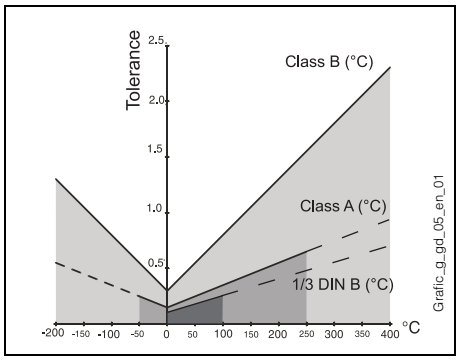
According to DIN EN 60751	3 g peak / 10÷500 Hz

Accuracy

Probe maximum error (type TF)

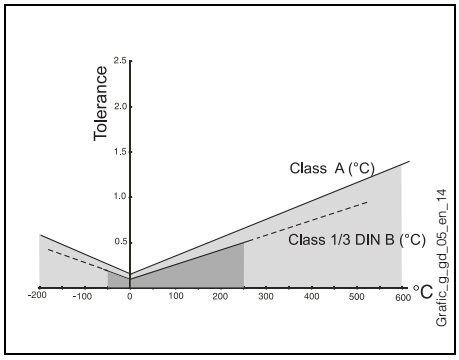
- cl. A
  3σ = 0.15+0.0020|t| -50…250°C
  3σ = 0.30+0.0050|t| 250…400°C
- cl. 1/3 DIN B
  3σ = 0.10+0.0017|t| 0…100°C
  3σ = 0.15+0.0020|t| -50...0 / 100...250°C
  3σ = 0.30+0.0050|t| 250…400°C

(±3σ = range including 99.7% of the readings,
|t| = absolute value of the temperature in °C)



Probe maximum error (type WW)

- cl. A
  3σ = 0.15+0.0020|t| -200…600°C
- cl. 1/3 DIN B
  3σ = 0.10+0.0017|t| -50…250°C
  3σ = 0.15+0.0020|t| -200...-50 / 250…600°C



Transmitter maximum error
See the corresponding documentation
(codes at the end of the document).

Display maximum error
0.1% FSR + 1 digit (FSR = Full Scale Range)

The "4 wires" configuration, provided as a standard connection for the single Pt 100s, excludes additional errors in every condition (e.g. high immersion depths, long connecting cables without head-mounted transmitters, ...). Generally speaking, in the "4 wires" configuration there is a higher guarantee of accuracy.
The "2 wires" connection, used in the version of the ATEX certified insert, may create an additional error due to the resistance of the copper conductors of the mineral insulated cable; such resistance is added to the value of the Pt 100. The incidence of this source of inaccuracy increases with the increase of the insertion length.

Measurement range

- Type TF -50…400°C
- Type WW -200...600°C

Response time

Tests in water at 0.4 m/s (according to DIN EN 60751; 23 to 33°C step changes):

Diameter of stem	Pt 100 type	Response time
6 mm	TF / WW	t_{50} = 3.5 s
		t_{90} = 8 s
3 mm / 6 mm reduced	TF / WW	t_{50} = 2 s
		t_{90} = 5 s

Insulation

Insulation resistance between terminals and probe sheath (according to DIN EN 60751, test voltage 250 V)
above 100 MΩ at 25°C
above 10 MΩ at 300°C

Self heating

Negligible when the E+H iTEMP® transmitters are employed.

Installation

The Omnigrad T TR 24 thermometers can be mounted on pipes, vessels or other plant parts that may be necessary, by means of compression junctions or thermowells.
The absence of the extension neck (situated between the process connection and the head) may expose the housing to overheating. To ensure that the head temperature does not exceed the limit values defined in paragraph "Operating conditions", refer to figure 3.
In the case of ATEX-certified components (transmitter, insert), please refer to the relevant documentation (refer to the code at the end of this document).
Immersion depth may have an effect on the accuracy of the measurement. If the immersion is too low, an error may be generated in the temperature recorded due to the lower temperature of the process fluid near to the walls and heat transfer, which takes place through the sensor stem. The incidence of such an error can be not negligible if there is a big difference between the process temperature and the ambient temperature. To avoid measurement errors of this kind, it is advisable to set an immersion length (L) of at least 50÷70 mm (without thermowell).
In pipes of a small section the axis line of the duct must be reached and if possible slightly exceeded by the tip of the probe (refer to fig. 2A-2B). Insulation of the outer part of the sensor reduces the effect produced by a low immersion. Another solution may be a tilted installation (see fig. 2C-2D). For use in the food industry, it is best to follow the rule h <= d/2.

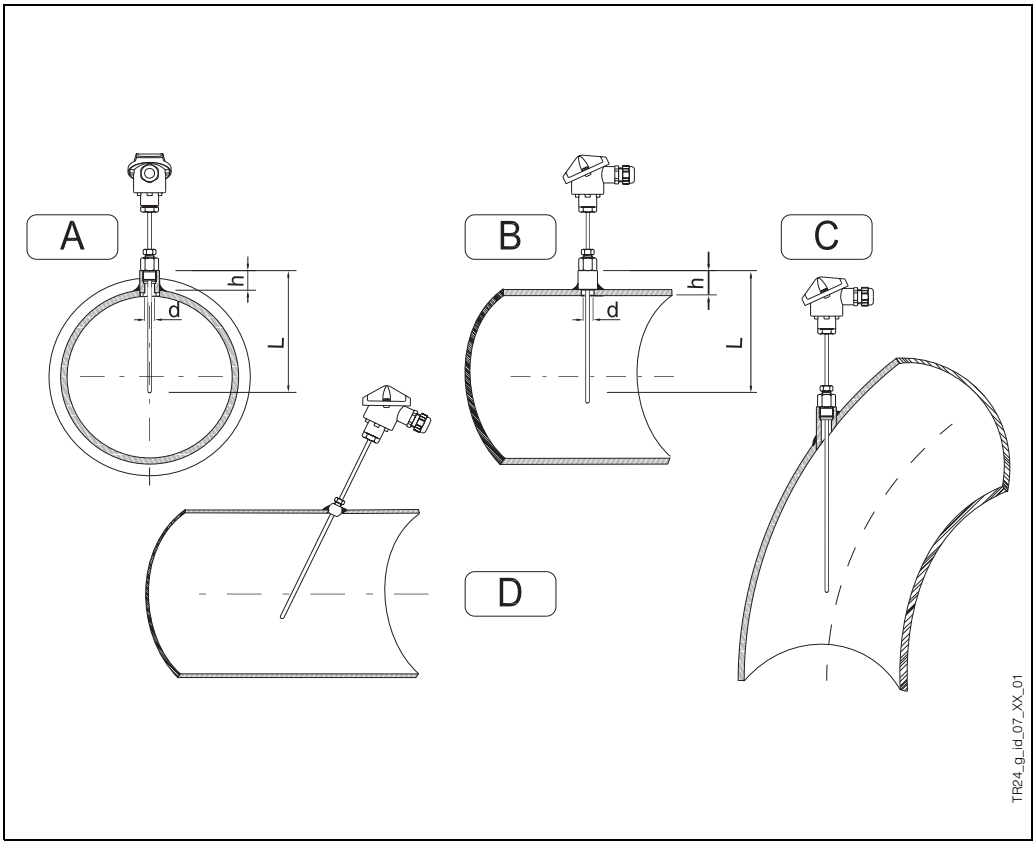


Fig. 2: Installation examples

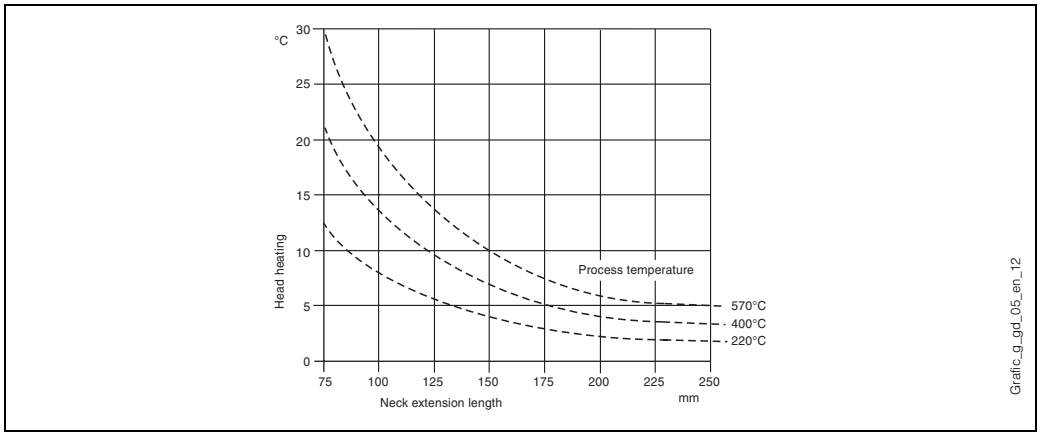


Fig. 3: Heating of the head consequent to the process temperature

In the case of two-phase flows, pay special attention to the choice of measurement point, as there may be fluctuations in the value of the detected temperature.
With regard to corrosion, the base material of the wetted parts in contact with the fluid (SS 316L/1.4404, compression junction in SS 316/1.4401 or SS 316L/1.4404 and several types of sleeves) can tolerate the common corrosive media up to even the highest temperatures. For further information on specific applications, please contact the E+H Customer Service Department.
In the case that the sensor components are disassembled, in the following reassembly procedure the definite torques must be employed. This will assure the housings with the IP grade protection defined.
When the surrounding environment has a high humidity rate and the process is at low temperature, a plastic housing is recommended (e.g. model TA20B) to avoid problems due to condensation.
In the case of vibrations the thin film sensing element (TF) may offer advantages, but the behaviour depends on the intensity, the direction and the dominating frequency in the vibration mode.
The wire wound Pt 100 (WW), besides having a larger measurement and accuracy range, guarantees greater long term stability.

System components

Housing

The housing, which contains the electric terminals or the transmitter, is available in different types and materials, e.g. plastic, painted aluminium alloy and stainless steel. The coupling method with the rest of the probe and the gland for the cable entry ensures a minimum IP65 grade (refer also to fig. 4).
All available heads have internal geometry according to DIN 43729 standard (form B), and thermometer connection M24x1.5.
Head type TA20A is the basic E+H aluminium housing for temperature sensors. It is supplied in the E+H corporate colours, without any extra charge.
Head TA20B is a black polyamide housing, sometimes referred to as the BBK in the “Temperature” market.
A screw cap is employed in TA21E and is joined to the head body by a chain.
The TA20D head (aluminium), also referred to as BUZH, is able to contain a terminal block and a transmitter or two transmitters at the same time. The order of the double transmitter must be carried out by choosing the option "flying wires" in the sales structure, and two transmitters in a separate position (THT1, see the table at the end of the document).
The TA20J head is a stainless steel housing used in other instruments made by E+H and can be provided with a LCD display (4 digits), which operates with 4…20 mA transmitters.
The TA20R is normally recommended by the Temperature division of E+H for hygienic applications.
The TA20W (BUS type) is a round blue/grey coloured head made of aluminium, with a clip for the cap closure.
The cable gland M20x1.5 provided with the housings, is compatible with cables of a diameter between 5 and 9 mm.

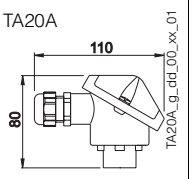
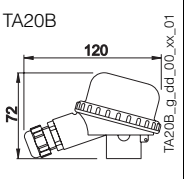
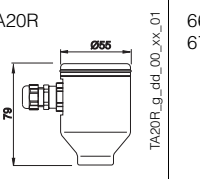
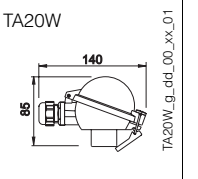
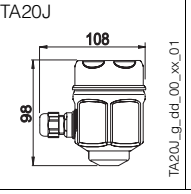
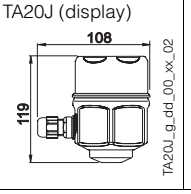
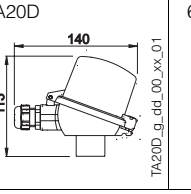
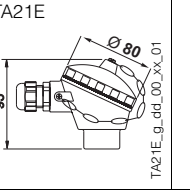
Housing type	IP	Housing type	IP	Housing type	IP	Housing type	IP
TA20A 	66 67	TA20B 	65	TA20R 	66 67	TA20W 	66
TA20J 	66 67	TA20J (display) 	66 67	TA20D 	66	TA21E 	65

Fig. 4: Housings and relative IP grade

Head transmitter

The head-mounted transmitters available are (also refer to the "Electronics" section):

- TMT 180 PCP 4…20 mA
- TMT 181 PCP 4…20 mA
- TMT 182 Smart HART®
- TMT 184 PROFIBUS-PA®.

The TMT 180 and the TMT 181 (see fig. 5) are PC programmable transmitters.
The TMT 180 is also available in a version with enhanced accuracy (0.1°C vs. 0.2°C) in the temperature range -50…250°C and in a version with a fixed measurement range (specified by the customer in the order phase).
The TMT 182 output consists of 4…20 mA and HART® superimposed signals.
For the TMT 184 (see fig. 6), with PROFIBUS-PA® output signal, the communication address may be set via software or via mechanical dip-switch. The customer may specify the configuration desired during the order phase.

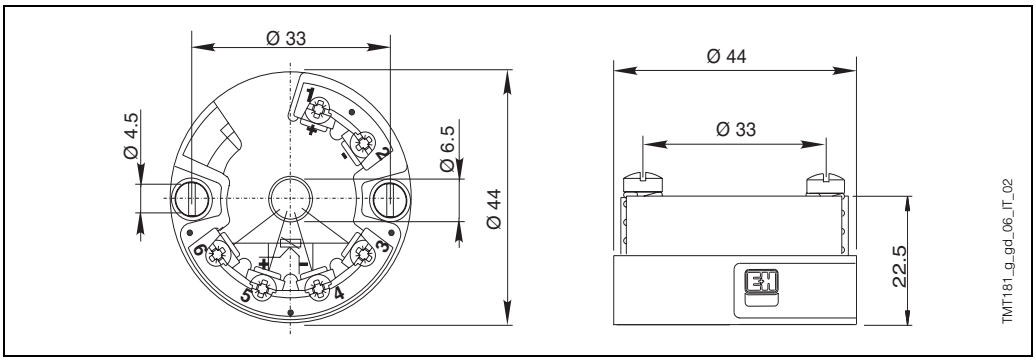


Fig. 5: TMT 180-181-182

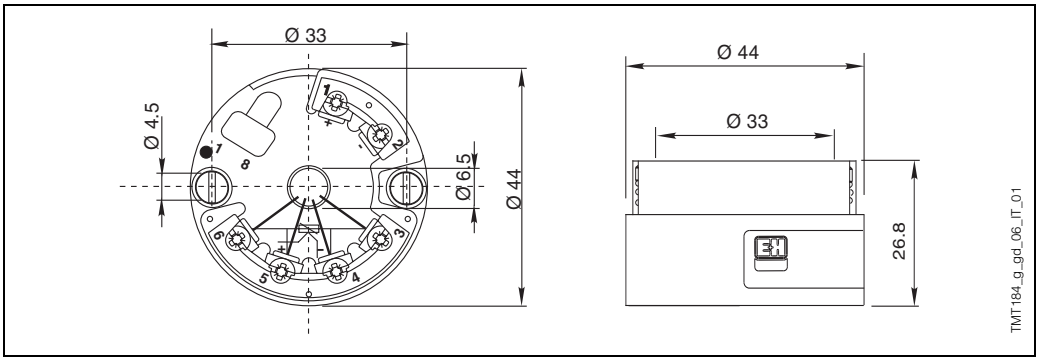
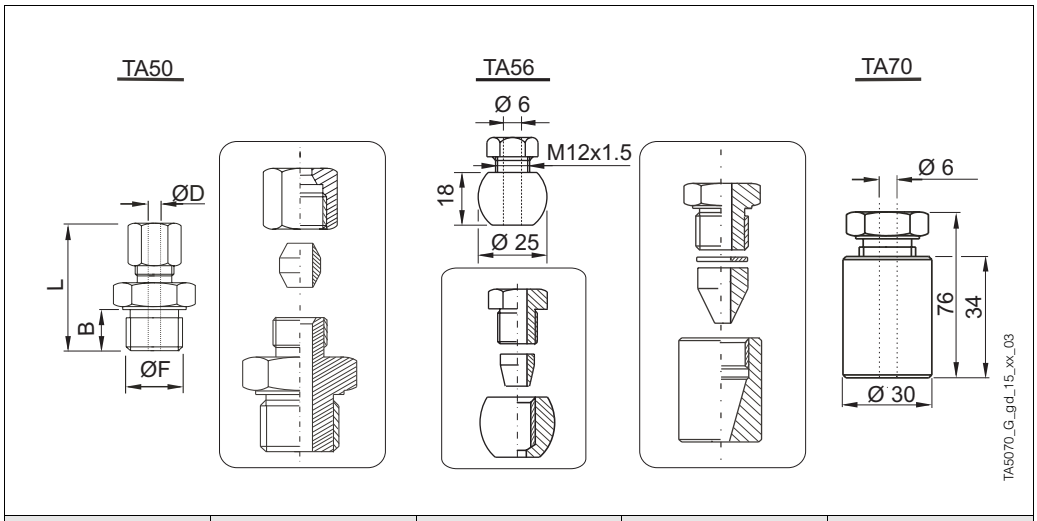


Fig. 6: TMT 184

Process connection

Standard compression fittings are available in the following types:
- threaded G 1/2" and G 1" in SS316/1.4401, with sleeve in SS or PTFE (TA 50)
- welded spherical in SS316L/1.4435, with sleeve in Peek (TA 56), for 6 mm probes only
- welded cylindrical in SS316L/1.4404, with sleeve in Viton® (TA 70), for 6 mm probes only.

Other versions may be supplied upon request. Figure 7 illustrates the basic dimensions.



Model	F	L (mm)	D (mm)	B (mm)
TA 50	G1"	70	3/6	25
TA 50	G1/2"	47	3/6	15

Fig. 7: Basic dimensions of process connections

Probe

On TR 24 the measurement probe is constituted by a replaceable mineral insulated insert (MgO) . The insert length is available in the most commonly used dimensions or can be personalized by the customer within a range of values (refer to "Sales Structure" at the end of the document).
For replacement, the length of the insert (IL) must be chosen in compliance with the immersion length (ML) of the process. If spare parts are required, refer to the following table:

Tip of the sensor	Insert	Insert diameter	Insert length (mm)
Straight/reduced	TPR 100	3/6 mm	IL = L + 35

Although the wiring diagram of single Pt 100 is always supplied with 4 wires configuration, the connection of a trasmitter can be executed with 3 wires as well, by avoiding to connect whichever of the terminals. The configuration Pt 100 double with 2 wires (class B) is only available for the ATEX certified inserts.
The use of a TR 24 with standard lengths ensures fast delivery times; this allows our customers to reduce the amount of spare parts to be kept on stock.

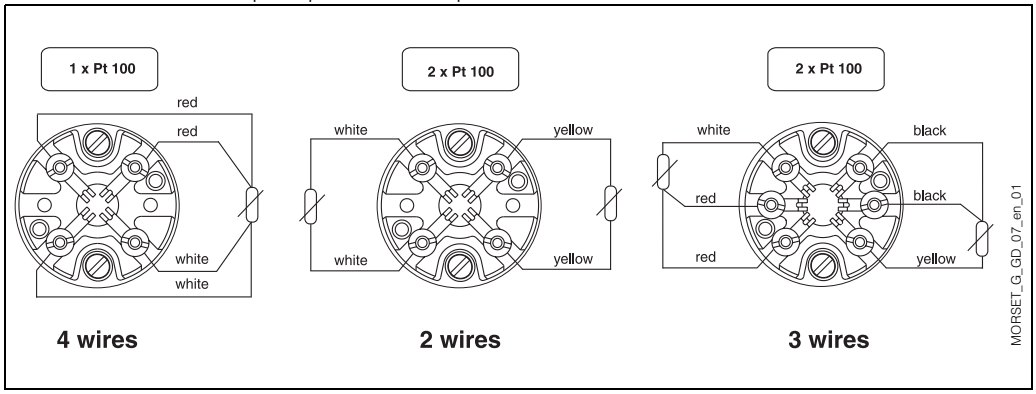


Fig. 8: Standard electrical diagrams (ceramic terminal block)

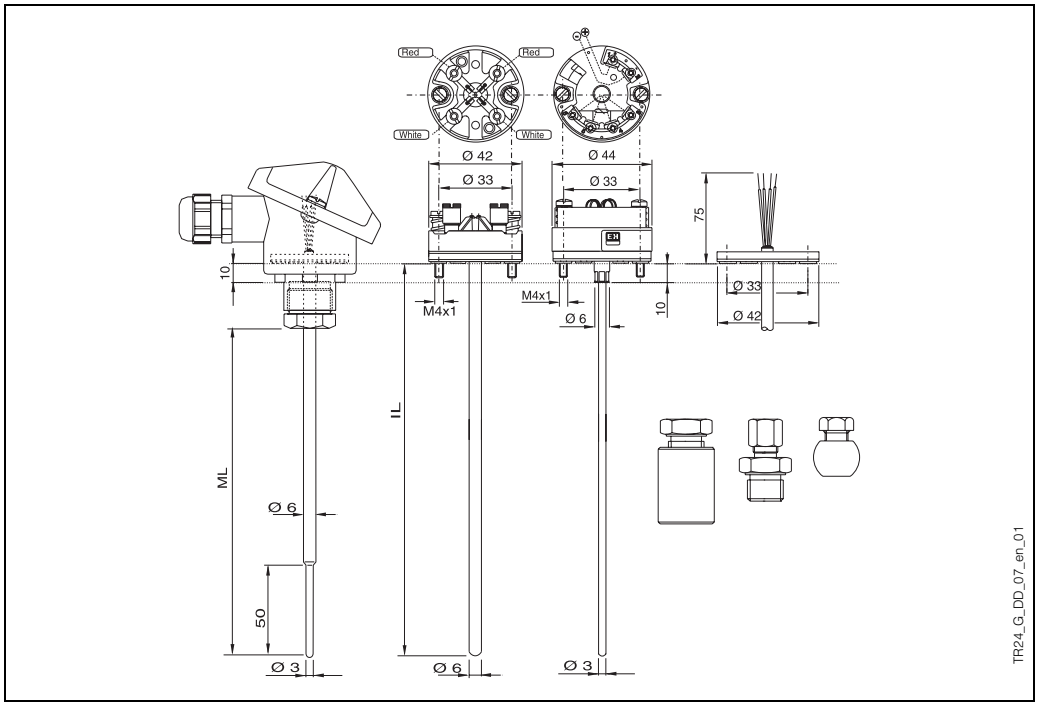


Fig. 9: Functional components

Certificates & approvals

Ex approval	ATEX Certificate KEMA 01 ATEX1169 X (1 GD or 1/2 GD IIC EEx ia T6...T1 T85...450°C).
PED approval	The Pressure Equipment Directive (97/23/CE) is respected. As paragraph 2.1 of article 1 is not applicable to these types of instruments, the CE mark is not requested for the TR 24 destined for general use.
Material certification	Material certifications can be requested separately.
Test report and calibration	With regards to the tests and calibration, the "Inspection Report" consists of a compliance declaration for the essential points of the standard DIN EN 60751. The "Factory calibration" is carried out in an authorised laboratory EA (European Accreditation) of E+H according to an internal procedure. The “Evaluation Report” is a calibration that can be applied to sensors with a low immersion length (see the table below). In this case the procedure accuracy cannot be evaluated because of the low immersion. A calibration may be requested separately according to an accredited procedure EA (SIT calibration).

	Temperature range	**Minimum immersion length (ML)**
Factory calibration	-80...-40°C	260 mm
	-40...0°C	160 mm
	0...250°C	80 mm (3 mm insert) 120 mm (6 mm insert)
	250...550°C	300 mm
Evaluation test report	0...140°C	50 mm

Further details

Maintenance

The Omnigrad T thermometers do not require any specific maintenance.
In the case of ATEX certified components (transmitter and insert) please refer to the corresponding specific relevant documentation (refer to the code at the end of the document).

Delivery time

For small quantities (approximately 10 units) and standard options, between 5 and 15 days depending on the configuration required.

Ordering information

Sales structure

TR24-	Safety (Ex) certification
	A Ex certification not required
	B ATEX II 1 GD EEx ia IIC certified
	E ATEX II 1/2 GD EEx ia IIC certified

	Head material, conduit, IP grade
	A TA20A Aluminium, conduit M20x1.5, IP66/IP67
	4 TA20A Aluminium,PROFIBUS® connector, IP66
	2 TA20A Aluminium, conduit 1/2" NPT, IP66/IP67
	7 TA20B Polyamide, black, conduit M20x1.5, IP65
	E TA21E Aluminium, screw cap, M20x1.5, IP65
	6 TA20D Aluminium, high cap, conduit M20x1.5, IP66
	5 TA20D Aluminium, high cap, PROFIBUS® connector, IP66
	8 TA20D Aluminium, high cap, conduit 1/2" NPT, IP66
	J TA20J SS316L, conduit M20x1.5, IP66/IP67
	K TA20J SS316L, with display, conduit M20x1.5, IP66/IP67
	M TA20J SS316L, PROFIBUS® connector, IP66
	R TA20R SS316L, screw cap, conduit M20x1.5, IP66/IP67
	S TA20R SS316L, screw cap, PROFIBUS® connector, IP66
	W TA20W Aluminium, round cap, clip, conduit M20x1.5, IP66
	Y Special version

	Pipe diameter, type of material
	1 Diameter 3 mm, SS 316L/1.4404
	2 Diameter 6 mm, SS 316L/1.4404
	5 Diameter 6 mm, reduced 3x50mm, SS 316L/1.4404

	Process connection
	A Without process connection
	B Compression fitting TA50 in SS 316/1.4401, G1/2", sleeve in SS
	C Compression fitting TA50 in SS 316/1.4401, G1/2", sleeve in PTFE
	D Compression fitting TA50 in SS 316/1.4401, 1/2" NPT, sleeve in SS
	E Compression fitting TA50 in SS 316/1.4401, 1/2" NPT, sleeve in PTFE
	F Weld-in spherical compression fitting TA56 in SS 316L/1.4435, d.25, sleeve in Peek
	G Weld-in cylindrical compression fitting TA70 in SS 316L/1.4404, d.30x34, sleeve in Viton
	Y Special version

	Immersion length ML (50-3700 mm)
	B 80 mm, immersion length ML
	D 120 mm, immersion length ML
	F 175 mm, immersion length ML
	H 235 mm, immersion length ML
	K 275 mm, immersion length ML
	L 335 mm, immersion length ML
	M 365 mm, immersion length ML
	N 425 mm, immersion length ML
	X ... mm immersion length ML to specify
	Y ... mm special immersion length ML

	Terminal type or built-in transmitter
	F Flying leads
	C Ceramic terminal block
	2 TMT180-A21AD fixed range, from...to...°C, accuracy 0.2 K span, -50...650°C
	3 TMT180-A21AD fixed range, from...to...°C, accuracy 0.1 K span, -50...250°C
	4 TMT180-A11 configurable, from...to...°C, accuracy 0.2 K span, -200...650°C
	5 TMT180-A11 configurable, from...to...°C, accuracy 0.1 K span, -50...250°C
	P TMT181-A isolated, 2-wire PCP transmitter, configured from ...to ...°C
	Q TMT181-B isolated, 2 wire PCP ATEX transmitter, configured from ...to ...°C
	R HART® transmitter 2-wire TMT182-A, isolated, configured from ...to ...°C
	T HART® ATEX transmitter 2-wires TMT182-B, isolated, configured from ...to ...°C
	S TMT184-A 2-wire PROFIBUS-PA® transmitter, isolated, configured from ...to ...°C
	V TMT184-B 2-wire PROFIBUS®-PA ATEX transmitter, isolated, configured from ...to ...°C

	RTD type, temperature range, wiring diagram				
	3	1 Pt 100, TF	Class A,	- 50/400°C	4 wires
	7	1 Pt 100, TF	Class 1/3 DIN B,	- 50/400°C	4 wires
	C	1 Pt 100, WW	Class A,	-200/600°C	4 wires
	G	1 Pt 100, WW	Class 1/3 DIN B,	-200/600°C	4 wires
	B	2 Pt 100, WW	Class A,	-200/600°C	3 wires
	D	2 Pt 100, WW	Class B,	-200/600°C	2 wires

	F	2 Pt 100, WW Class 1/3 DIN B, -200/600°C 3 wires
	Y	Special version
Material certification		
	0	Material certification not requested
	9	Special version
Test and calibration on the insert		
	0	Test and calibration not requested
	1	Inspection report on sensor
	2	Inspection report on loop
	A	Factory calibration, single RTD, 0-100°C
	B	Factory calibration, single RTD, loop 0-100°C
	C	Factory calibration, double RTD, 0-100°C
	E	Factory calibration, single RTD, 0-100-150°C
	F	Factory calibration, single RTD, loop, 0-100-150°C
	G	Factory calibration, double RTD, 0-100-150°C
	H	Evaluation report, single RTD, 0-100°C
	Y	Special version
Additional options		
	0	Additional options not required
	9	Special version
Marking		
		Tagging according to customer specifications
TR24-		Complete order code

Sales structure

THT1	**Model and version of the head transmitter**	
	A11	TMT180-A11 programmable from...to...°C, accuracy 0.2 K, span limit -200...650°C
	A12	TMT180-A12 programmable from...to...°C, accuracy 0.1 K, span limit -50...250°C
	A13	TMT180-A21AA fixed range, accuracy 0.2 K, span 0...50°C
	A14	TMT180-A21AB fixed range, accuracy 0.2 K, span 0...100°C
	A15	TMT180-A21AC fixed range, accuracy 0.2 K, span 0...150°C
	A16	TMT180-A21AD fixed range, accuracy 0.2 K, span 0...250°C
	A17	TMT180-A22AA fixed range, accuracy 0.1 K, span 0...50°C
	A18	TMT180-A22AB fixed range, accuracy 0.1 K, span 0...100°C
	A19	TMT180-A22AC fixed range, accuracy 0.1 K, span 0...150°C
	A20	TMT180-A22AD fixed range, accuracy 0.1 K, span 0...250°C
	F11	TMT181-A PCP, 2-wire, isolated, programmable from...to...°C
	F21	TMT181-B PCP ATEX, 2-wire, isolated, programmable from...to...°C
	F22	TMT181-C PCP FM IS, 2-wire, isolated, programmable from...to...°C
	F23	TMT181-D PCP CSA, 2-wire, isolated, programmable from...to...°C
	L11	TMT182-A HART®, 2-wire, isolated, programmable from...to...°C
	L21	TMT182-B HART® ATEX, 2-wire, isolated, programmable from...to...°C
	L22	TMT182-C HART® FM IS, 2-wire, isolated, programmable from...to...°C
	L23	TMT182-D HART® CSA, 2-wire, isolated, programmable from...to...°C
	K11	TMT184-A PROFIBUS-PA®, 2-wire, programmable from...to...°C
	K21	TMT184-B PROFIBUS-PA® ATEX, 2-wire, programmable from...to...°C
	K23	TMT184-C PROFIBUS-PA® FM IS, 2-wire, programmable from...to...°C
	K24	TMT184-D PROFIBUS-PA® CSA, 2-wire, programmable from...to...°C
	YYY	Special transmitter
Application and services		
	1	Assembled into position
	9	Special version
THT1-		Complete order code

Supplementary documentation

❑ RTD thermometers Omnigrad TST - General information	TI 088T/02/en
❑ Terminal housings - Omnigrad TA 20	TI 072T/02/en
❑ Temperature head transmitter iTEMP® Pt TMT 180	TI 088R/09/en
❑ Temperature head transmitter iTEMP® PCP TMT 181	TI 070R/09/en
❑ Temperature head transmitter iTEMP® HART® TMT 182	TI 078R/09/en
❑ Temperature head transmitter iTEMP® PA TMT 184	TI 079R/09/en
❑ RTD insert for temperature sensors - Omniset TPR 100	TI 268T/02/en
❑ TA fittings & sockets Omnigrad TA50, TA55, TA60, TA70, TA75	TI 091T/02/en
❑ Thermowell for temperature sensors - Omnigrad TW 251	TI 245T/02/en
❑ Safety instructions for use in hazardous areas	XA 003T/02/z1
❑ E+H Thermolab - Calibration certificates for industrial thermometers. *RTD and thermocouples*	TI 236T/02/en

Subject to modification

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