

INSTRUCTIONS MANUAL

OMM

Thermocouple and RTD
cable sensors



Thermoelectric and RTD sensors with connecting cable

Sensor series	Cable insulation	Measuring range
TOPE.. TTE..	• JJ (PVC / PVC)	-10 ÷ +105°C
	• SLSL (silicone / silicone)	-50 ÷ +180°C
	• TSL (silicone / silicone)	-50 ÷ +180°C
	• TPSL (teflon® FEP / Cu screen / silicone)	-50 ÷ +180°C
	• TT (teflon® PFA / teflon® PFA)	-50 ÷ +260°C
	• TT (teflon® PFA / steel braid)	-50 ÷ +260°C
	• TCuT (teflon® PFA / Cu screen / teflon® PFA)	-50 ÷ +260°C
	• GLGLP (fibreglass / fibreglass / steel braid)	-50 ÷ +400°C

1. Safety

Information about our products and equipment as well as our installations and technological processes result from extensive research and user experience. We pass these results, however, we do not assume any responsibility which falls outside the scope of the content of each individual contract, in the oral or written form in accordance with our best knowledge. Nevertheless, we reserve the right to introduce technical amendments resulting from the development of our products.

In addition, our Consumer Service Department remains at your disposal to provide further advice, as well as to participate in the search for solutions in the field of production issues and technology of use.

This fact, however, does not relieve the user from the obligation to verify our information and instructions before each application in terms of their usefulness.

It applies in particular to the foreign supplies within the scope of protective rights of third parties, as well as the use and practices that have not been overtly presented by us in writing.

In the case of any damage, our liability is limited to the compensation benefits for quality defects and presented in our General Conditions of Sale and Delivery.

1.1 General safety information

The chapter entitled "Safety" shall entail all the safety aspects that are to be taken into account during the operation of the device.

This device has been designed with regard to the temporary technology principles, and therefore it is reliable in its operation. The device has been tested and left the factory as safe in technical terms. To ensure safety during operation, follow the instructions of this manual.

Ensure the compliance with the general provisions concerning the safety of operating the equipment. In addition to these general information, the individual chapters of this manual also include descriptions and operating instructions along with specific indications regarding safety.

Compliance with all indications and instructions concerning safety allows for protection of the staff and the natural environment against threats and ensures safe and smooth operation of the device.

1.2 Intended use

Temperature sensors are used to measure the temperature in all sorts of process applications. Resistance thermometers or thermocouples can be used with or without a protective tube.

1.3 Technical limits

The device is intended solely for use within the technical limit values specified on the identification plates and technical sheets.

Please observe the following limit values:

- Do not exceed the maximum operating temperature.
- Do not exceed the maximum environment temperature.
- The rules concerning the type of the body protection measures must be observed.

1.4 Warranty provisions

Misuse, not abiding by the instructions of this manual, applying operating staff having no sufficient qualifications as well as arbitrary tampering exclude the manufacturer's liability for the caused damage. Warranty of the manufacturer expires.

1.5 Obligations of the user

- Before using corrosive and abrasive measuring materials, ensure that the relevant structural elements, which are to be in contact with these materials, are sufficiently resistant. TERMOAPARATURA may provide assistance in the matter of selection. It cannot, however, assume any liability whatsoever.
- Above all observe the national laws pertaining to the control of operation, repair, and maintenance of electrical equipment.

1.6 Staff qualifications

Installation, commissioning, and maintenance can be done only by trained personnel, authorised for this purpose by the installation user. The personnel must read and understand this instructions manual and follow its guidelines.

1.7 Guidance on safety in transport

The following points must be observed:

- Do not expose the device to moisture during transport. The device should be properly packaged.
- Package the device in such a way that during the transport it is protected against shocks, for example by means of a package with bubble wrap.

Before installing the device, examine it for possible damages which may have been caused due to unprofessional transport. Damages resulting from transport must be noted in the freight documents. All claims for damages must be immediately asserted against the freight forwarder – even before installation.

1.8 Guidance on safety of electrical installations

Electrical installation of the device can only be made by authorised electricians and in accordance with the electrical plans.

Follow the instructions regarding electrical installation. Otherwise, the type of electrical protection may be affected.

Safe separation of electrical circuits which are dangerous to touch can only be ensured if the connected devices comply with the requirements of VDE 0106 T 101 (basic requirements for safe separation).


In terms of safe separation, lay the power lines separately from the electrical circuits which are dangerous to touch or additionally insulate them.


2. The design and operating method


2.1 General information

The supplied thermometers are ready for operation or possible enclosing.

These thermocouples and resistance thermometers are very accurate, they possibly contain glass or ceramic elements. They should be handled with appropriate care.

-  During the delivery of the thermometer, pay attention if all the loosely packed elements have been unpacked.

-  Long thermometers must be supported in several points, lifted and transported in a proper manner. During the assembly, also apply proper care.

-  Before the assembly, examine the thermometers (see 5.1) in order to exclude damages that may have occurred during shipping.

The basic sensor element is a resistor or a thermocouple, extended by a copper wire (resistor) or a compensating cable (thermocouple). The sensing element is placed in a casing made of acid resistant steel or another agreed material (brass, aluminum, glass, teflon, PVC, etc.). The outlet cover is clamped on the wire or sealed with glue. For resistance sensors connection to the resistor may be formed in a 2-, 3- or 4-wire system.

For mounting of sensors commonly used are various types of connectors or threaded nuts connected to a sheath, movable (pressing the ring connected to the sheath) or sliding (allowing the immersion of the sensor in the medium at any desired depth) or along the sheath or the spring covering the wire. Sensors for measuring the surface temperature can be mounted with a screw, a metal band or a magnet.

Sensors designed to operate in particularly difficult conditions (aggressive medium, vibrations, pressure, etc.) may be equipped with additional sheaths that protect the sensor from damage and in the event of damage allow for quick replacement without unsealing the system.

The wire from the sheath in order to prevent damage may be covered with thin steel wires, heat shrink tube, stainless protective pipe or a spring.

The measuring device responds to changes in temperature of the medium with a change in resistance (thermistor) or electromotive force EMF (thermocouple). These changes are consistent with the thermometric characteristics specified in the following standards:

- for Pt100 thermistors PN EN 60751
- for thermocouples PN EN 60584

Basic technical data:	
Thermistor type	1x or 2xPt100, Pt500, Pt1000 A or B class in accordance with PN-EN 60751 1x or 2xNi100, Ni500, Ni1000 in accordance with DIN 43760
Type of resistor connecting line	2-, 3-, 4-wire
Thermocouple type	1x or 2xFe-CuNi (J) 1x or 2xNiCr-Ni (K) 1x or 2xNiCrSi-NiSi (N) A or B class in accordance with PN-EN 60584-2
Maximum measurement range	-200..+600°C for Pt100 -40..+700°C for J -40..+1200°C for K, N
Measuring junction type	isolated (SO, SOB) or grounded (SP)
Maximum measurement range*	-200 ÷ +400°C -40 ÷ +400°C
Acceptable temperature for wires operation	PVC (+105°C), silicone (+180°C), teflon® FEP (+205°C), teflon® PFA (+260°C), fibreglass (+400°C)

** Maximum measurement RTD range depends on applied thermistor and may be -50..+400°C or -200..+400°C

2.1 Thermocouples

Thermocouples can consist of 1, 2 and sometimes 3 elements. The thermocouple measuring junction is most commonly insulated, but may also be connected to the housing.

The thermocouple and the measuring device are connected by a compensating cable. Be sure to connect the compensating cables suited to the thermocouple of correct polarity. These wires should be placed at a distance of at least 0.5 m from power lines, preferably in their own cable ducts. Twisted and shielded cables reduce the electric and magnetic interference. The principle of connections and insulation colour are shown in the table below.

Standard	Type of item			Wire material			Colour marking		
	Type	Pole+	Pole–	Code	Pole+	Pole–	Core insulation		Sheath
							Pole+	Pole–	
IEC 584-3 DIN 43722 JIS C1610	T	Cu	CuNi	TX	Cu	CuNi	brown	white	brown
	E	NiCr	CuNi	EX	NiCr	CuNi	violet	white	violet
	J	Fe	CuNi	JX	Fe	CuNi	black	white	black
	K	NiCr	Ni	KX	NiCr	Ni	green	white	green
	K	NiCr	Ni	KC A	Fe	CuNi	green	white	green
	K	NiCr	Ni	KC B	Cu	CuNi	green	white	green
	N	NiCrSi	NiSi	NX	NiCrSi	NiSi	pink	white	pink
	N	NiCrSi	NiSi	NC	E-Cu	CuNiMn	pink	white	pink
	R/S	Pt13/10Rh	Pt	RCA/SCA	E-Cu	CuNiMn	orange	white	orange
	R/S	Pt13/10Rh	Pt	RCB/SCB	E-Cu	CuNiMn	orange	white	orange
ANSI MC 96.1	B	Pt30Rh	Pt6Rh	BC	CuMn	E-Cu	grey	white	grey
	T	Cu	CuNi	TX	Cu	CuNi	blue	red	blue
	E	NiCr	CuNi	EX	NiCr	CuNi	purple	red	purple
	J	Fe	CuNi	JX	Fe	CuNi	white	red	black
	K	NiCr	Ni	KX	NiCr	Ni	yellow	red	yellow
	R/S	Pt13/10Rh	Pt	RX/SX	E-Cu	CuNiMn	black	red	green
NF C42-324 - 1985	B	Pt30Rh	Pt6Rh	BX	CuMn	E-Cu	grey	red	grey
	T	Cu	CuNi	TX/C	Cu	CuNi	yellow	blue	blue
	E	NiCr	CuNi	EX/C	NiCr	CuNi	yellow	orange	orange
	J	Fe	CuNi	JX/C	Fe	CuNi	yellow	black	black
	K	NiCr	Ni	KX/C	NiCr	Ni	yellow	violet	violet
	K	NiCr	Ni	VC	Cu	CuNi	yellow	brown	brown
	K	NiCr	Ni	WC	Fe	CuNi	yellow	white	white
DIN 43714 - 1979	R/S	Pt13/10Rh	Pt	SC	E-Cu	CuNiMn	yellow	green	green
	B	Pt30Rh	Pt6Rh	BC	CuMn	E-Cu	yellow	grey	grey
	U	Cu	CuNi		Cu	CuNi	red	brown	brown
	L	Fe	CuNi		Fe	CuNi	red	blue	blue
BS 4937	K	NiCr	Ni		Fe	CuNiMn	red	green	green
	R/S	PtRh	Pt		E-Cu	CuNiMn	red	white	white
	T	Cu	CuNi		Cu	CuNi	white	blue	blue
	J	Fe	CuNi		Fe	CuNi	yellow	blue	black
	E	NiCr	CuNi		NiCr	CuNi	brown	blue	brown
	K	NiCr	Ni		NiCr	Ni	brown	blue	red
R/S	NiCr	Ni		E-Cu	CuNiMn	white	blue	red	
	PtRh	Pt		E-Cu	CuNiMn	white	blue	green	

2.2 Resistance thermometers

Resistance thermometers can consist of 1, 2 and sometimes even 3 measuring resistors. The connection between the resistance thermometer and the measuring device is most often created in a 2-wire system (the wire resistance is entered into the measurement after calculation and change). 3-wire systems are used for accurate measurements and 4-wire systems for highly accurate measurements.

Commercially available copper wires with cross section of at least 1.0 mm^2 in accordance with the regulations related to low-voltage electric installations should be laid. The wires should not be connected during carrying out the line. If necessary, it is recommended to use solder connections or plug-socket. Twisted and shielded cables reduce the electric and magnetic interference.

Do not exceed the manufacturer's recommended measuring currents of $0.1 \text{ mA} \dots 5 \text{ mA}$ depending on the design (error resulting from self-heating).

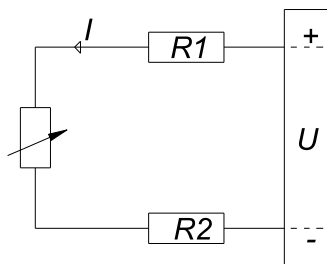
Approximate resistance of RTD power cords:

- $2 \times 0.22 \text{ mm}^2 - 0.175 \text{ } \Omega/\text{m}$
- $2 \times 0.35 \text{ mm}^2 - 0.105 \text{ } \Omega/\text{m}$
- $2 \times 0.50 \text{ mm}^2 - 0.036 \text{ } \Omega/\text{m}$

Methods of connecting with peripherals

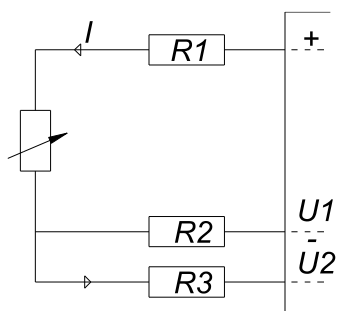
- 2-wire line.

2-wire sensor connection is used in cases where high accuracy of measurement is not required. $R_1 + R_2$ line resistance applies the measurement error ratio for Pt100 of approx. 2.6°C per one Ω of wire resistance, for Pt1000 of approx. 0.26°C per one Ω of wire resistance.



- 3-wire line.

Connecting a resistor with the devices using a three-wire line is mostly used in industry due to the automatic compensation of resistance changes depending on the temperature, as well as the compensation of the line resistance



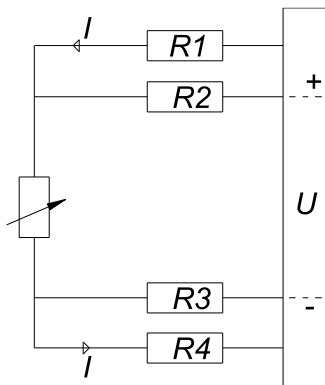
Interconnect wires must have the same resistance $R_1=R_2=R_3$. The following table gives an example of errors in 3-wire connection for Pt100 and Pt1000 for the difference in wire resistance 0.1Ω and 1Ω .

	Wires resistance difference	
	0.1Ω	1Ω
Pt100	0.26°C	2.6°C
Pt1000	0.03°C	0.26°C

For practical reasons, a single line resistance of the RTD input circuit should not be greater than 11Ω .

- 4-wire line.

This connection is used if high accuracy of measurement is necessary. In the case of 4-wire connection, influence of the resistor wires resistance is completely eliminated.



$$R_1=R_2=R_3=R_4$$

For practical reasons, a single line resistance of the RTD input circuit should not be greater than 11Ω .

3. Installation

The sensors must be mounted in the measuring places in accordance with the designed mounting way, if possible, in places that help you control the operation and exchange in case of damage. Temperature measurement accuracy depends largely on the method of installing the sensor.

It should be remembered that the sensor transmits signals depending on the temperature in which the measuring element is placed. As a part of the sensor is placed beyond the measuring place, at the environment temperature, and the sheath is good heat conductor, it results in the change of temperature distribution in the measurement place by constant heat dissipation to the environment. The changes increasing measurement inaccuracy are the bigger the bigger is the ratio of the sensor in the environment temperature to the length of the whole sensor and the bigger is the difference between the environment temperature and the temperature at the measurement place.

If it is required to measure the temperature accurately the following recommendations should be applied at the installation of sensors:

- insulate parts of the sensor sheath that exceed the measurement place
- carry out the connection line, especially at the greater lengths, so that it is not exposed at temperature differences and for the resistance thermometers it is recommended to use 3-wire line
- apply longer sensors (deeply immersed) in order to obtain favourable ratio of the sheath length in the environment temperature to the total length
- apply at the place of measurement parts of pipeline with smaller cross section and in order to increase the flow speed and intensity of receiving heat in pipelines (particularly in gas pipelines) of little flow intensity.

4. Maintenance / repair

Thermometers and temperature measuring circuits should be regularly checked in terms of:

- wear of the protective tube or influence of chemicals,
- a change in the output rate of measuring devices over time due to the ageing process,
- insulation resistance drop due to moisture or soiling,
- a wrong contact of wire connections,
- mechanical and chemical damage to thermometers and wires.

Cabling of measuring circuits of resistance thermometers are checked by replacing measuring device with a known non-adjustable resistor and this way simulating the temperature.

Thermocouple measuring circuits are checked by replacing the thermocouples through connecting voltage on a known level of MV series to the measuring circuit.

In both cases you can check if there are large deviations from the setpoints and if the thermometer or instruments are the reason for functional errors.

The insulation resistance of the entire measuring circuit without earthing (power lines and thermometer) in relation to the ground should be $> 1 \text{ M}\Omega$ (as measured with a voltage of 100 VDC).

5. Error messages

5.1 Quick supervision method

Instant supervision of thermocouples and resistance thermometers as well as its measuring circuits while disassembled.

Required instruments:

- millivoltmeter
- ohmmeter or resistance bridge
- insulation resistance meter with voltage 60 ... 100 V (all measurements in room temperature)

You can perform the following tests:

- Check penetration and insulation at room temperature.
- By "tapping", check if the wires are broken.

Thermocouple must be classified as correct if $R < 20 \Omega$ (wire $> 0.5 \text{ mm } \emptyset$). This value is dependent on the length and section of a wire. Risol (insulation resistance) = 100 M Ω (insulated thermocouple).

Resistance thermometer must be classified as correct if $R > 110 \Omega$ (with Pt100), Risol $> 100 \text{ M}\Omega$.

- As a result of heating the thermocouples or resistance thermometers up to the temperature of approx. 200°C to 400°C (without temperature control), you can find out if the wires are broken, if the polarity of the thermocouples is wrong, and if the insulation resistance is too low, etc.

Tip!

The accuracy of the temperature sensors can be checked in accordance with the requirements of ISO 9001 only by using comparable reference elements. In this respect, disassembly and supervision in the fire-chamber is necessary.

5.2 Error table

You should regularly check the entire temperature measuring circuit. The following table shows the most common errors and their possible causes, as well as suggested solutions.

Error	Cause of the error	Solution
Distortion of the measuring signal	<ul style="list-style-type: none"> • Electric/magnetic influence 	<ul style="list-style-type: none"> • The distance between the measuring cables of at least 0.5 m in the case of parallel arrangement. • Electrostatic shielding with foil/coil grounded at one point. • Twisting pairs as a protection against magnetic influences. • Crossing measurement leads with confounding power cords at right angle. • Usage of transducers.
	<ul style="list-style-type: none"> • Ground fault 	<ul style="list-style-type: none"> • Only one earthing point in the circuit or measuring system in a "suspended state" (without earthing)
	<ul style="list-style-type: none"> • Insulation resistance drop 	<ul style="list-style-type: none"> • The thermometer or the measuring insert is moist or wet; if necessary, dry up and seal it tightly. • Check to make sure if the thermometer is not thermally overloaded.
Response times are too long, Wrong measurement results	<ul style="list-style-type: none"> • Wrong enclosure place: <ul style="list-style-type: none"> - In a shadowed place - Within the scope of operation 	<ul style="list-style-type: none"> • Select the mounting location in such a way that the agent can transmit temperature to the thermometer without interference.
	<ul style="list-style-type: none"> • Wrong enclosure method: <ul style="list-style-type: none"> - Immersion too shallow. - Heat dissipation too large. 	<ul style="list-style-type: none"> • The depth of immersion being approx. the length sensitive to the temperature of $+ 6 \times$ (liquids) to $10 \times$ (gases) d (d = outer diameter of pipe protection). • Ensure thermal contacts, especially in the case of surface measurements, through appropriate contact surfaces and/or heat transmitting substances.
	<ul style="list-style-type: none"> • Protective tube too thick. • The opening of the protective tube too large. 	<ul style="list-style-type: none"> • Use a protective tube that is as small as possible, depending on the process technology. • The response time during the first approach proportional to the section or volume of the thermometer, depending on the coefficient of heat absorption and air gaps in the body.
	<ul style="list-style-type: none"> • Deposits on the protective tube. 	<ul style="list-style-type: none"> • Remove during inspections. • If possible, use another protective tube or select a different installation location.

Error	Cause of the error	Solution
Interruptions in the thermometer	<ul style="list-style-type: none"> • Vibration. 	<ul style="list-style-type: none"> • Shortening the housing. • Displacement of thermocouple measurement junction (if possible)
Protective tube strongly subject to corrosion	<ul style="list-style-type: none"> • The composition of the environment different from assumptions or changed. • You have selected incorrect material of the sheath. 	<ul style="list-style-type: none"> • Check the environment. • Possibly analyse the damaged protective tube and then apply better suited material. • Provide extra surface protection. • Protective tube should be replaced on a regular basis as a wearing part.

5.3 Characteristic errors in thermocouples

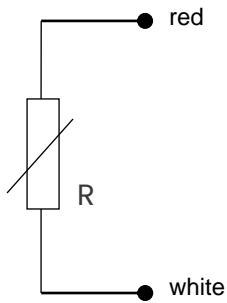
Error	Cause of the error	Solution
Temperature indicator is deviating, while the remaining structure of the thermocouple measuring circuit is faultless.	<ul style="list-style-type: none"> • Temperature or power supply of thermocouple reference junction at a constant level 	<ul style="list-style-type: none"> • Temperature or power supply has to be maintained at a constant level. – (<0.1%) (check instruments).
Temperature indicator with strong deviations in relation to the thermocouples tables.	<ul style="list-style-type: none"> • Incorrect material combinations. • Wrong sockets. – Interference voltages (thermovoltages, galvanic voltages). • Incorrect compensating cable. 	<ul style="list-style-type: none"> • Check thermocouples and wires in terms of: <ul style="list-style-type: none"> – the right selection. – unbroken compensating cable. – correct polarity.

5.4 Characteristic errors in resistance thermometers

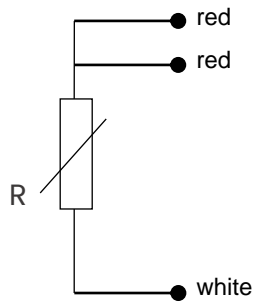
Error	Cause of the error	Solution
Temperature indicator too high or deviating in comparison with the known range and despite the accuracy of resistance thermometer measuring resistor.	<p>Line resistance too high, not compensated.</p> <ul style="list-style-type: none"> • Cable resistance changing due to temperature change. 	<ul style="list-style-type: none"> • If still possible: <ul style="list-style-type: none"> – lay two new cables with greater range depending on the space available. – shorten the power line. – wires compensation. – use 3- or 4-wire systems – the use of transducers with sensor heads.
Temperature indicator is deviating, while the remaining structure of the thermocouple of the resistance thermometer measuring circuit is faultless.	<ul style="list-style-type: none"> • Unstable power supply or voltage. 	<ul style="list-style-type: none"> • Has to be maintained at a constant level of < 0.1%. It is included in full in the measurement in the case of the bridge being out of adjustment while the current/voltage (4-wire system) is being measured.

6. Electrical connections

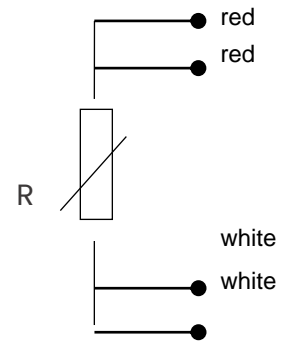
Resistance thermometers



Pt100 / 2-wire



Pt100 / 3-wire



Pt100 / 4-wire

Thermocouples

