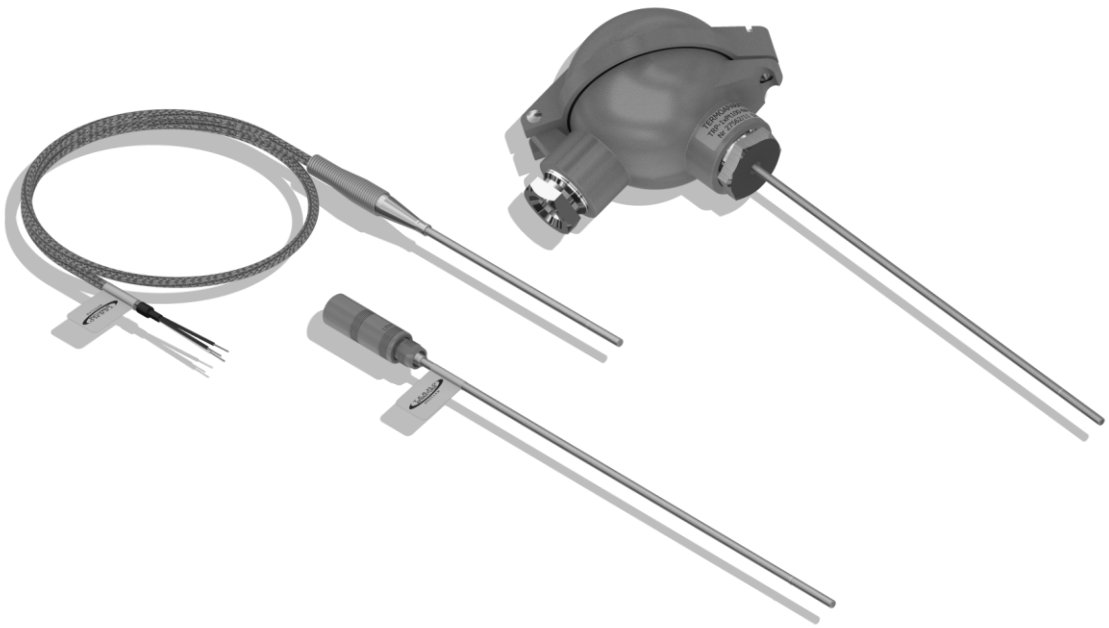
INSTRUCTIONS MANUAL

OMM

Sheathed resistance thermometers and thermocouples

Model: TRP-..., TTP-...



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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 Technical 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 have to 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.

- First of 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.

Sheathed sensors are particularly resistant to vibration and shock, and they can be bent without fear of causing a short circuit. Therefore, they can be widely used in areas with limited access, for installation in small parts, and wherever there is a need for flexible resistance thermometers of small diameter and low thermal inertia. They are used both in industrial and laboratory measurements.

For these reasons, the scope of sheathed sensors is extremely broad. They are used in nuclear technology, chemical and petroleum industry, engineering construction, in construction of machinery and devices, energy industry, metallurgy, plastics processing, etc.

The sheathed cable consists of a thin tube called a sheath, inside which there are two to eight nickel or thermocouple wires surrounded by a highly compacted insulating material (e.g. magnesium oxide). At one end of the cable, the thermocouple wires are connect with a measuring junction and a resistor is connected to the nickel wires.

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

Thermocouples and RTDs, depending on the type of housing on the other end of the sheath, feature the following varieties:

- free ends having 30 mm in length (**BT**)
- sheath terminated in a sleeve with individual Teflon insulated 100 mm wires (**T**)
- sheath terminated in a miniature (**BTW**) or standard plug (**BTWs**)
- sheath terminated in a LEMO® connector (**WL**)
- sheath terminated in a sleeve with a spring and a compensating cable (**TKb**)

- as above, cable terminated in a miniature (**TKbW**) or standard plug (**TKbWs**)
- as above, cable terminated in a LEMO® connector (**TKbWL**)
- BT sensor terminated in a flange with a terminal block – (sheath cartridge, type **W1P..**, **W2..**)
- insert as above, housed in NA type head – (sheathed sensor, type **TRP -...- NA**, **TTP -...- NA**)

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 Class B in accordance with DIN 43760
Type of resistor connecting line	2-, 3-, 4-wire
Thermocouple type	Fe-CuNi (J) NiCr-NiAl (K) NiCrSi-NiSi (N) Cu-CuNi (T) (E) PtRh10% -Pt (S) PtRh13%-Pt (R) PtRh30% -PtRh6% (B) A or B class in accordance with PN-EN 60584-2
Measuring junction type	isolated (SO, SOB), grounded (SP) or exposed (SW)
Acceptable temperature for head operation	+100°C (rubber seal)
Ingress protection rating	IP54 MA head IP55 B head IP65 BEG, NA, DAN, DANW heads
Standard size of the gland	M16x1.5 for MA head M20x1.5 for B, BEG, NA, DAN, DANW heads
Acceptable vibrations	5 to 80 Hz, to 5g
Acceptable operating pressure	4 MPa (40 bar)
The temperature of the air surrounding the sleeve (TKb, TKbW, TKbWs, TKbWL)	-40 .. +150°C (optional execution to +250°C or +400°C)
Minimum sheath bend radius	3 x Diameter

Maximum temperature for sheathed resistance sensors usage

Sheath diameter [mm]	Measuring element	Sheath material	Resistor type	Measuring range
Ø1.5	Ni100..Ni1000	AISI304/AISI316/AISI321	thin-film	-50 .. +180°C
	Pt100..Pt1000			-50 .. +400°C
Ø2.0	Ni100..Ni1000			-50 .. +180°C
	Pt100..Pt1000			-50 .. +400°C
Ø3.0 ÷ Ø8.0	Ni100..Ni1000			-50 .. +180°C
	Pt100..Pt1000			-50 .. +550°C
	Pt100		ceramic	-200 .. +600°C

Maximum temperature for sheathed thermocouples usage

Sheath diameter [mm]	Thermocouple type	Sheath material	Maximum recommended operating temperature
Ø1.0	J, K, N	AISI304/AISI316/AISI321/Inconel® 600	+800°C
	T	AISI304/AISI316/AISI321	+350°C
	E	AISI304/AISI316/AISI321/Inconel® 600	+800°C
Ø1.5	K, N, R, S	Inconel® 600	+1100°C
	J, K, E	AISI304/AISI316/AISI321	+800°C
	T	AISI304/AISI316/AISI321	+350°C
	K, N	XL-SUPERCLAD/Pyrosil® D	+1250°C
Ø3.0	K, N, R, S	Inconel® 600	+1150°C
	J, K, E	AISI304/AISI316/AISI321	+800°C
	T	AISI304/AISI316/AISI321	+350°C
	K, N	XL-SUPERCLAD/Pyrosil® D	+1250°C
Ø6.0	K, N, R, S	Inconel® 600	+1150°C
	J, K, E	AISI304/AISI316/AISI321	+800°C
	T	AISI304/AISI316/AISI321	+350°C
	K, N	XL-SUPERCLAD/Pyrosil® D	+1250°C
	K, N	AISI446	+1200°C

Sheath material

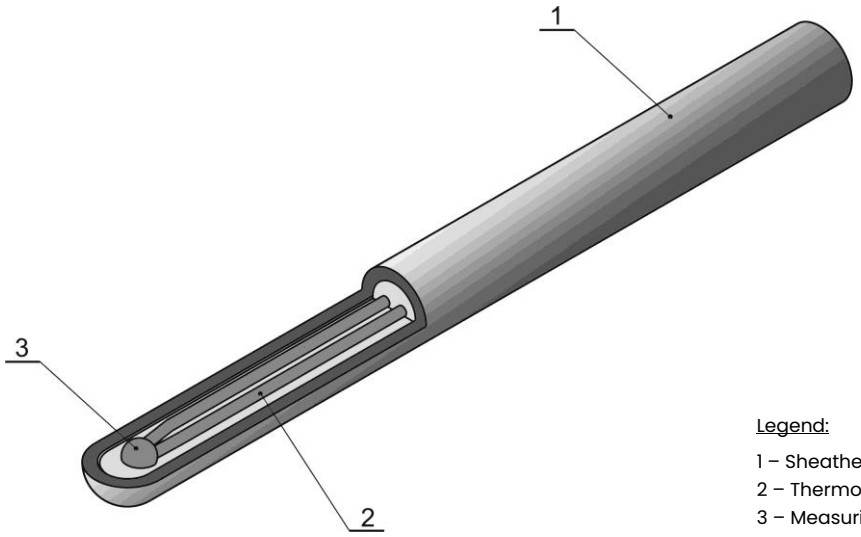
Maximum temperature	Material	Material properties	Application
+800°C	1.4301 (AISI 304) 1.4306 (AISI304L)	1.4301 and 1.4306 materials have different carbon content and different resistance to intergranular corrosion. They have good resistance to organic acids at moderate temperatures and solutions of salts, such as sulphates, sulphides and sulphites as well as alkaline solutions at moderate temperatures. They are also characterised by good weldability. Welding retreatment is usually not necessary, especially for 1.4306.	Chemical and nuclear equipment, textiles, paper, grease and soap, food industries, dairies and breweries, nitric acid production industry.
+800°C	1.4404 (AISI316L)	As a result of the of molybdenum addition, the material is characterised by increased resistance to corrosion in the environment of non-oxidising acids, such as acetic acid, tartaric acid, phosphoric acid, sulphuric acid and others. It is also characterised by increased resistance to pitting corrosion. Good weldability. Welding retreatment is not required.	Sulphur, pulp, textile and dyeing industries, production of fatty acid, soap and pharmaceutical industries.
+800°C	1.4541 (AISI321)	Has a high resistance to intergranular corrosion, even after welding. Good resistance to heavy oils, steam and combustion gases. High resistance to oxidation. Can be used in temperature up to 800°C. Has good weldability in all standard welding processes without the need for welding retreatment. Good ductility.	Structural components for the nuclear industry and reactors, chemical equipment, annealing furnaces, heat exchangers, textile and paper industry, petroleum industry, grease and soap industry, food industry.
+800°C	1.4571 (AISI316Ti)	Steel with the addition of molybdenum is characterised by high resistance to corrosion in acidic environments. Characterised by resistance to pitting corrosion, sea water, and resistance to aggressive environments. Can be used in temperature up to 800°C. Has good weldability in all standard welding	It is suitable for structural components of nuclear devices and reactors, chemical industry apparatus, construction of furnaces, chemical and pharmaceutical industries.

Maximum temperature	Material	Material properties	Application
		processes without the need for welding retreatment. Good ductility.	
+1200°C	1.4749 1.4672 (AISI446)	Very good resistance to reducing atmosphere containing sulphur. Very good resistance to oxidation and air. Good resistance to corrosion caused by ashes after welding, copper, lead and tin. Good weldability with the TIG and arc method. Preheating to a temperature of 200-400°C. It does not require heat treatment after welding.	Petroleum industry, metallurgy, power management technology, recuperators, heat treatment kilns, vortex installations, incinerators.
+1150°C	1.4841 (AISI314)	Excellent corrosion resistance, even at high temperatures. Also suitable in atmospheres containing carbon and sulphur. Resistance to oxidation in air up to 1000°C (interrupted service) or 1150°C (continuous service). Suitable for oscillating thermal annealing. The material is recommended for long-term continuous use; temperature range from 425 to 850°C. Good weldability with the arc method. It does not require heat treatment after welding. Good ductility. After prolonged use, the material becomes brittle.	Boilers and blast furnaces, kilns for kilning clinker and bricks, glass manufacturing, petroleum industry, furnace and power station constructions.
+1150°C	2.4816 (Inconel® 600)	Good general corrosion resistance, resistance to stress corrosion. Very good resistance to oxidation. Not recommended with gases containing CO2 and sulphur above 550°C and sodium above 750°C. For working in the air, resistant to the temperature of 1150°C. Has good weldability in all standard processes. Excellent ductility even after prolonged use.	Reactors with water under pressure, power plants, construction of furnaces, plastics industry, heat treatment, paper and food industry, boilers, aircraft engines.
+1250°C	Pyrosil® D	This material provides superior mechanical strength, good corrosion resistance and low drift for N and K type thermocouples. The temperature recommended for continuous use up to 1250°C, and up to 1300°C for short use, although it may affect its service life. In	Heat treatment, chemical and petrochemical processing, furnaces, steel plants, exhaust gases (especially in the anode furnaces), ceramics, automotive and power industry, as well as in general

Maximum temperature	Material	Material properties	Application
		some cases, the thermocouples in Pyrosil® sheath may replace the R and S type thermocouples, thereby contributing significantly to cost minimisation.	industrial processes.

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.



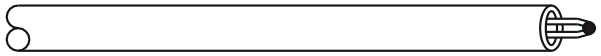
Thermocouples with insulated junction are recommended for temperature measurement in corrosive environments in which the element should be electrically insulated and shielded by the cover. Thermocouples with grounded junction are recommended for measuring static temperatures or flowing gas temperatures and non-corrosive liquids, if fast response to temperature changes is required.

2.1.1 Types of measuring junctions

JUNCTION ISOLATED FROM SHEATH

Thermocouple junction is fully isolated from the sheath which is tightly welded. It is a standard type of junction due to the possibility of using thermocouples in the vicinity of equipment that may produce an electromagnetic field that causes interference to other types of measuring junctions.

EXPOSED JUNCTION



The thermocouple junction is fully exposed which provides a very fast response time to temperature changes. Wires of the thermocouple are not protected against liquids and gases.

GROUNDED JUNCTION

Thermocouple junction is connected to a lid, which is tightly welded with the sheath. This provides fast response to changes in temperature, while protecting the junction against external environmental factors (liquids, gases).

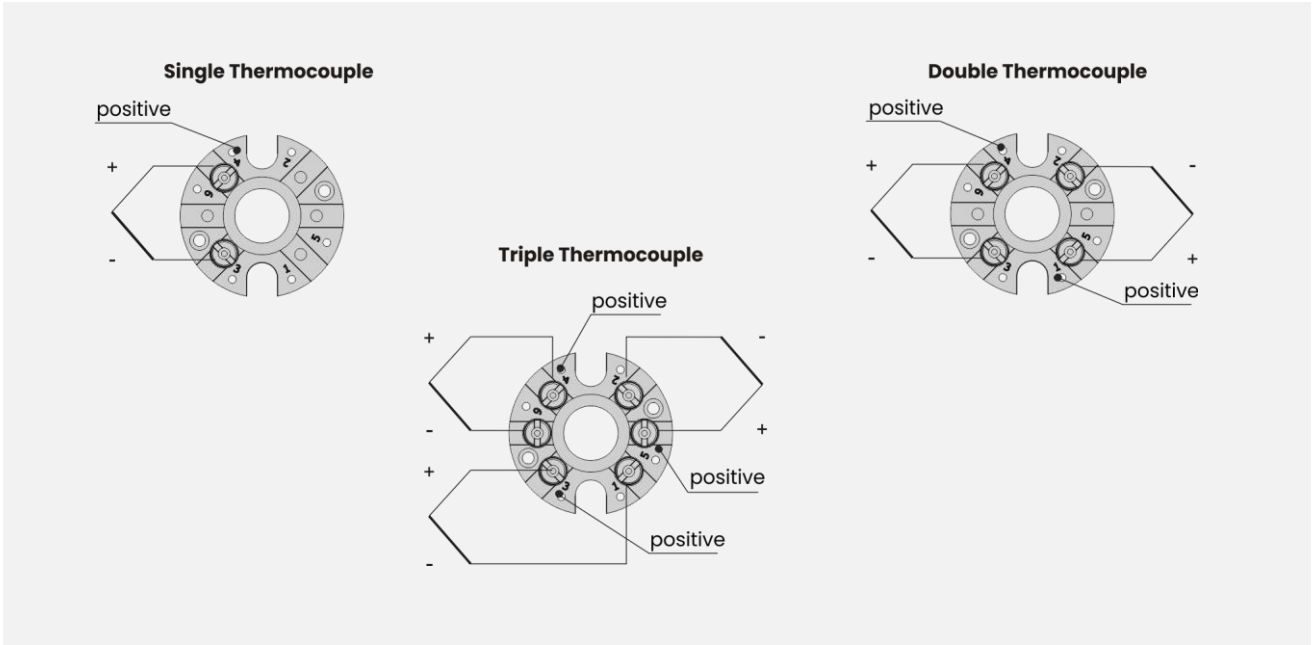
2.1.2 Compensating cables

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 positive pole on the terminal block is marked with a red dot.

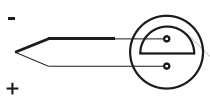
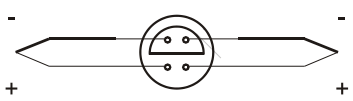
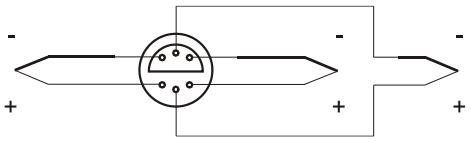
Standard	Type of item			Material of the compensating cable			Colour marking		
							Core insulation		Sheath
	Type	Pole+	Pole–	Code	Pole+	Pole–	Pole+	Pole–	
IEC 584-3 DIN 43722 JIS C1610	T	Cu	CuNi	TX	Cu	CuNi	brown	white	brown
	E	NiCr	CuNi	EX	NiCr	CuNi	violet	white	violet
	J	Fe	CuNi	JX	Fe	CuNi	black	white	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
	B	Pt30Rh	Pt6Rh	BC	CuMn	E-Cu	grey	white	grey
ANSI MC 96.1	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
	B	Pt30Rh	Pt6Rh	BX	CuMn	E-Cu	grey	red	grey
NF C42-324 - 1985	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
	R/S	Pt13/10Rh	Pt	SC	E-Cu	CuNiMn	yellow	green	green
	B	Pt30Rh	Pt6Rh	BC	CuMn	E-Cu	yellow	grey	grey
DIN 43714	U	Cu	CuNi		Cu	CuNi	red	brown	brown
	L	Fe	CuNi		Fe	CuNi	red	blue	blue

- 1979	K	NiCr	Ni		Fe	CuNiMn	red	green	green
	R/S	PtRh	Pt		E-Cu	CuNiMn	red	white	white
BS 4937	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
	K	NiCr	Ni		E-Cu	CuNiMn	white	blue	red
	R/S	PtRh	Pt		E-Cu	CuNiMn	white	blue	green

2.1.3 Connection of the thermocouples on the terminal block diagram

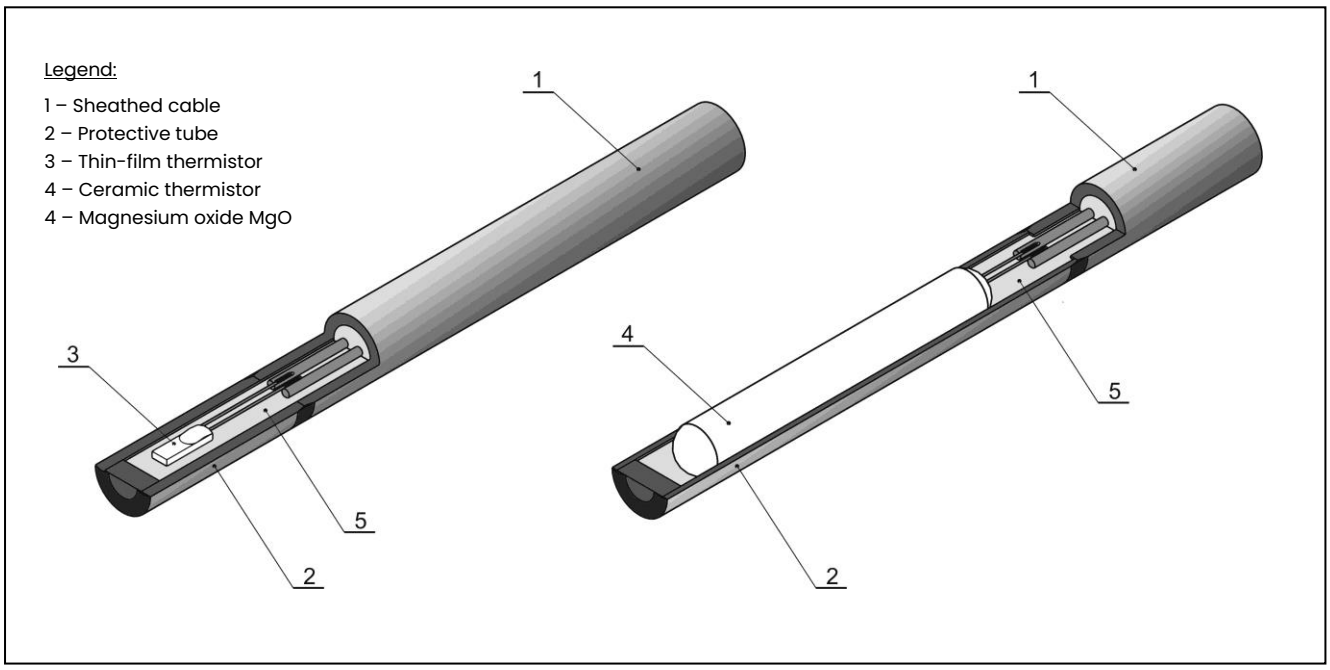


2.1.4 Connection of LEMO® connectors diagram

Single thermocouple (1xP)	Double thermocouple (2xP)	Triple thermocouple (3xP)
		

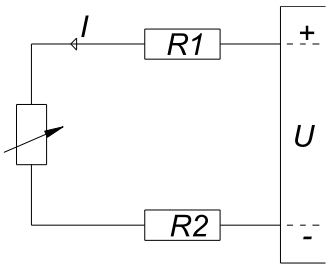
2.2 Resistance thermometers

RTDs are used when highly accurate measurements are necessary. RTDs 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.

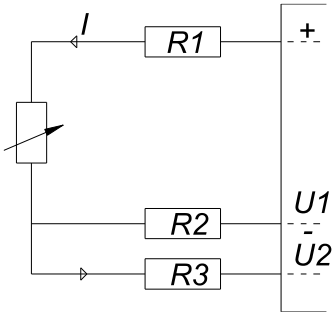


2.2.1 Methods of connecting with peripherals

- 2-wire line.
  2-wire sensor connection is used in cases where high accuracy of measurement is not required. R1 + R2 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

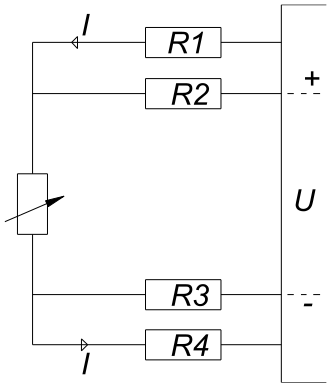


Interconnect wires must have the same resistance R1=R2=R3. The following table gives an example of errors in 3-wire connection for Pt100 and Pt1000 for the difference in wire resistance 0.1Ω and 1Ω.

	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.

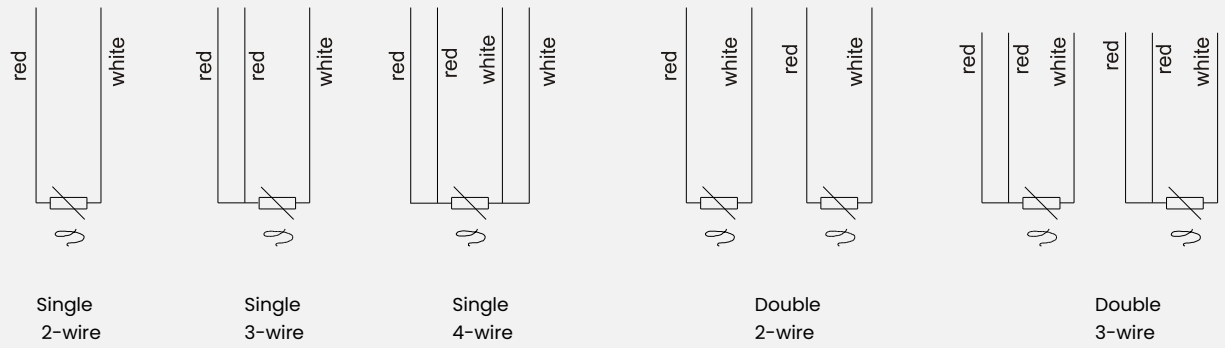
- 4-wire line.
  This connection is used if high accuracy of measurement is necessary. In the case of 4-wire connection, influence of the resistor wires resistance is completely eliminated.



R1=R2=R3=R4

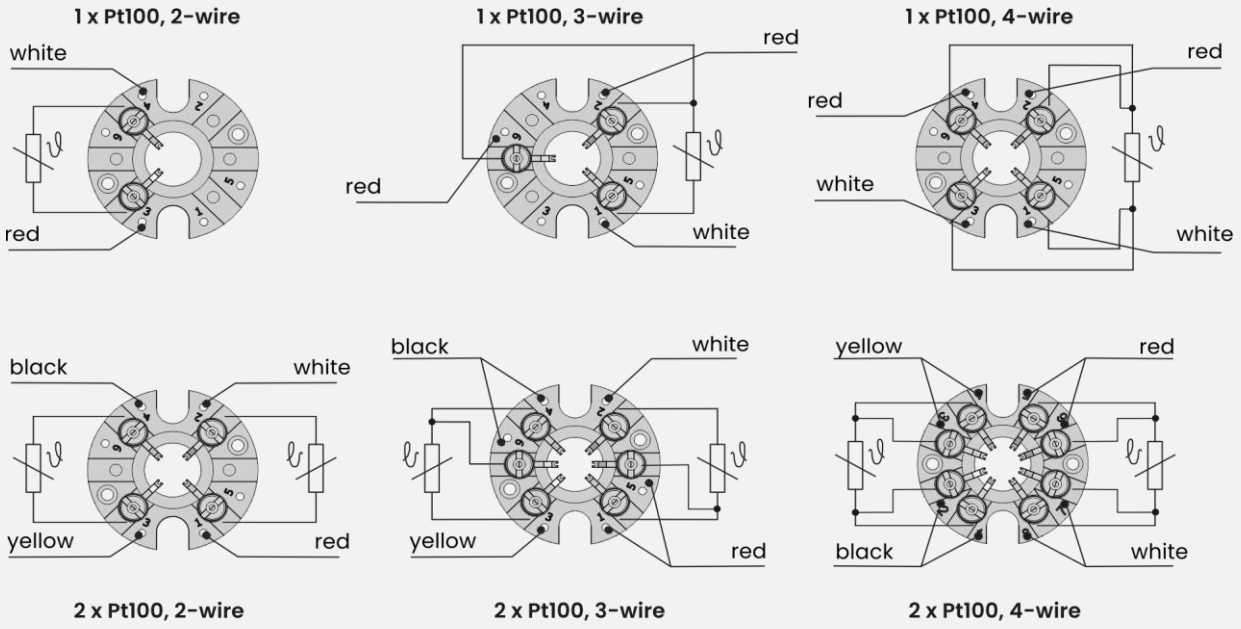
For practical reasons, a single line resistance of the RTD input circuit should not be greater than 11Ω.

2.2.2 Designation of the power cords



Approximate resistance of RTD power cords:
2x0,22 mm² - 0,175 Ω/m
2x0,35 mm² - 0,105 Ω/m
2x0,50 mm² - 0,036 Ω/m

2.2.3 Connection of the resistance thermometers on the terminal block diagram



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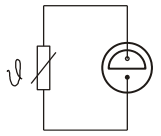
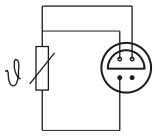
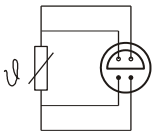
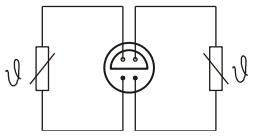
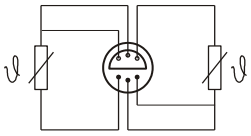
2.2.4 Connection of LEMO® connectors diagram

1 x Pt100			2 x Pt100	
2-wire	3-wire	4-wire	2-wire	3-wire
				

2.3 Thermometers with transducers

You can avoid potential problems arising from the transitional resistance of the wires and electromagnetic compatibility by installing 2-conductor transducers (output 4 ... 20 mA) on the connection head. Only the twisted-pair copper cable is necessary. Using multi-wire systems in resistance thermometers and compensation cables in thermocouples is then unnecessary.

In the case of using the transducers, consider:

- The instruction manual of the transducer;
- The relevant provisions concerning the performance and operation of electrical systems, as well as regulations and guidelines for explosion protection.

3. Usage in potentially explosive atmospheres

1. According to the provisions concerning electrical installations in potentially explosive atmospheres, repairs can be carried out only if:

1.1 If repairs have been made on a part of the electrical system responsible for explosion protection, the installation may then be activated if the system has a relevant validation character or after an expert verifies if it meets the requirements for explosion protection properties, and issues a relevant certificate.

1.2 The provisions of clause 1.1. do not apply if the manufacturer has conducted the unit test and confirms that the installation meets the requirements for explosion protection properties.

2. The Regulation on electrical installations in potentially explosive areas is valid in Poland only. Wherever it is not applicable, acts equivalent to this regulation have to be observed.

3. Repairs may only be performed using original spare parts from the original supplier. Otherwise, the requirements of the certificate of compliance with EU laws are not met.

4. In the case of ordering spare parts, information on the previous deliveries have to be given, for example, the type of protection (Exd, Exi) according to the certificate of compliance with EU laws, the order number, production number, the order item.

5. Thermometers as explosion-proof installations meet the safety technology requirements only as a structural unit, which has been established in a certificate of compliance with EU laws. Measuring inserts or connecting heads do not meet the requirements for explosion protection by themselves.

6. If TERMOAPARATURA provides thermometers without the protective tube to be used in potentially explosive areas, then you are responsible for the fact that:

   - the thermometers will be used only in areas for which they have the appropriate authorisation according to the manufacturer's declaration (e.g. zone 1, zone 2).

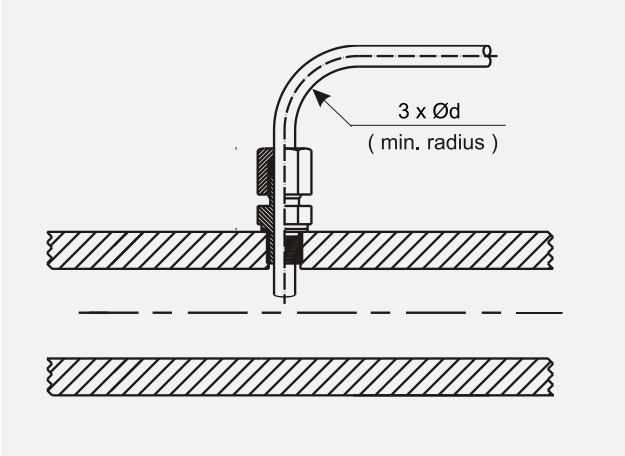
   - In terms of the necessary division of zones (e.g. zone 0 and zone 1) a protective tube which meets the requirements of “Specific conditions” according to the certificate of compliance with EU laws appropriate to the application is to be used.

   - TERMOAPARATURA informs the user of the above fact in an appropriate manner, for example in the form of a reference to the manual.

4. Assembly examples

Sensors without additional outer sheath can be freely bend if you observe the following constraints:

- It is forbidden to bend 50 mm tips of the resistance sensors due to the possibility of damaging the resistor.
- Acceptable minimum inner bend radius of the sheath is equal to three times the diameter of the sheath.



5. Packaging, storage and transport

The sensors should be packed in a way that secures them against damage during transport in collective and/or unit packaging. The sensors should be stored in packages, indoors and in rooms where there is no steam and aggressive substances, in which the air temperature is from +5°C to 50°C, and relative humidity does not exceed 85%.

They should be transported in packages secured against sensor displacement. They may be transported by land, sea or air, provided that the direct influence of weather conditions is eliminated.

6. Error messages

6.1 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 Ω (wire > 0.5 mm Ø). This value is dependent on the length and section of a wire. Risol (insulation resistance) = 100 MΩ (insulated thermocouple).

Resistance thermometer must be classified as correct if R > 110 Ω (with Pt100), Risol > 100 MΩ.

- 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.

6.2 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	• Electric/magnetic influence	• The distance between the measuring cable 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. • Using transducers.
	• Ground fault	• Only one earthing point in the circuit or measuring system in a "suspended state" (without earthing)
	• Insulation resistance drop	• The thermometer or the measuring insert is moist or wet; if necessary, dry up and seal it tightly. • Replace the measuring insert. • Check to make sure if the thermometer is not thermally overloaded.
Response times are too long, Wrong measurement results	• Wrong enclosure place: – In a shadowed place – Within the scope of operation	• Select the mounting location in such a way that the agent can transmit temperature to the thermometer without interference.
	• Wrong enclosure method: – Immersion too shallow. – Heat dissipation too large.	• The depth of immersion being approx. the length sensitive to the temperature of + 6 × (liquids) to 10 × (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.
Interruptions in the thermometer	• Vibration.	• Reinforcing the springs by the measuring insert. • Shortening the housing.

Error	Cause of the error	Solution
		• Displacement of thermocouple measurement junction (if possible) • Special design of the protective tube measuring insert.
Sheath strongly subject to corrosion	• The composition of the environment different from assumptions or changed. • You have selected incorrect material of the sheath.	• Check the environment. • Possibly analyse the damaged sheath and then apply better suited material. • Provide extra surface protection. • Protective tube should be replaced on a regular basis as a wearing part.

6.3 Characteristic errors in thermocouples

Error	Cause of the error	Solution
The temperature display is deviating, while the remaining structure of the thermocouple measuring circuit is faultless.	• Reference junction temperature not constant.	• Reference junction temperature has to be maintained at a constant level. – (<0.1%) (check instruments).
Temperature display with strong deviations in relation to the thermocouples tables.	• Incorrect material combinations. • Wrong sockets. – Interference voltages (thermovoltages, galvanic voltages). • Incorrect compensating cable.	• Check thermocouples and wires in terms of: – the right selection. – unbroken compensating cable. – correct polarity. • Permissible environment temperature at the connection head.

6.4 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.	• Line resistance too high, not compensated. • Cable resistance changing due to temperature change	• If still possible: – 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.
The temperature display is deviating, while the remaining structure of the resistance thermometer measuring circuit is faultless.	• Unstable power supply or voltage.	• 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.