

OPERATION
MANUAL

**Temperature sensors with flexible
cable**



April 2004 Edition

LIMATHERM SENSOR Sp z o. o.
34-600 Limanowa, Tarnowska 1, tel. +48 18 337 99 00, fax +48 18 337 99 10
www.limatherm.pl, e-mail: sensor@limatherm.com.pl



Temperature sensors with flexible cable

In this Operation Manual, the following series of temperature sensors with flexible cables are presented:

TO...E-1, TOPE-2, T...E-3, T...E-4, TOPE-5, TOPE-113, TT...E-331, T...E-245, T...E-361, T...E-362, T...E-363, T...E-364, T...E-365, T...E-366, T...E-367, TT...E-..., TT...E-1..., T...GE-3, T...GE-4, TTP...-1087, TTJE-1052, TOPMK-..., T...E-6, TO...E-50244, TOPE-116, TT...E-118..., TOPE-408, T...GE-..., PTT...-1047, PTT...-1083, and others.

The temperature sensors presented comply with the following standards:

PN-EN 60751

PN-EN 60584

1. Construction and principle of operation

The basic construction element of this temperature sensor type is either a resistor or a thermocouple. The resistor is extended by a copper wire and the thermocouple is extended by a compensation wire. The measuring unit is placed in a sheath made of acid resistant steel or of one of the following materials as requested and agreed with the end user (purchaser): brass, aluminium, glass, tarflen, etc.). The exposed end of sheath is either tucked around the wire or sealed using a gluing agent. In the case of resistance sensors, the connection with resistor can be made as a 2-, 3- or 4-wire wiring system.

The sensors of this type are fixed using various connectors or cap-screw, either of them is connected with the sheath, is movable (they press down a special ring that is connected to the sheath) or slidable (in the latter case, it is possible to immerse the sensor in a medium at any depth as may be required) and moves along the sheath or the spring that screens the wire. Surface temperature measuring sensors may be fixed using an M4 capscrew or a band clip made of metal.

There are additional accessories provided with those sensors which have to be applied under extremely difficult conditions (aggressive media, vibrations, pressure, etc.); among them, there are: additional screening elements (sheaths) to protect sensors against damage, and, in the case of damage, making it possible to replace a damaged sensor without unsealing the entire measuring system.

Sensors designed for the co-operation with portable temperature gauges can be additionally equipped with a special grip made of plastic or steel, and a special plug.

A wire coming out from the sheath should also be protected against damage. For this purpose, it is either wrapped in plaited, thin steel wires, or protected by a thermally shrinkable lining, or shielded by a special spring.

Measuring element of the sensor responds to a change in temperature of a medium by changing its resistance /thermometric resistor/ or electromotive force EMF /thermocouple/. The changes correspond to their thermometric characteristics as defined in the following standards:

PN-EN 60751 – as for Pt100 thermometric resistors;

PN-EN 60 584 – as for thermocouples.

Specification:

| | |
|---|--|
| Resistor | 1 or 2x Pt 100, 500, 1000 Class A, B, according to PN-EN 60751 |
| Connection line..... | 2-, 3-, or 4-wire as for Pt100 |
| Thermocouple..... | 1 or 2x Fe-CuNi /J/, NiCr-Ni/K/ Class 1, 2 according to PN-EN 60584 |
| Maximum Measurement Range..... | from -200 to +400 °C as for Pt from - 40 to + 400 °C as for J from - 40 to + 400 °C as for K |
| Measuring Junction..... | isolated/separated or earthed |
| Permissible working temperature of wires: | as for silicon: + 180 °C; as for Teflon: 250 °C; and as for glass fibre: 400 °C. |

2. Mounting procedure

In the sites where temperature measurements are taken, sensors are to be mounted strictly according to procedures referring to their special construction. Additionally, sensors should be mounted, if possible, in locations allowing for their easy control and replacement (if damaged) while taking measurements. The temperature measurement accuracy depends, to a high degree, on how the sensor has been mounted. It is important to always bear in mind that sensors transmit signals that depend on the temperature of a place where the measuring element is situated. There occur changes in the temperature distribution in the place of taking temperature measurements because heat is constantly carried away from those places and brought into the surrounding environment. This phenomenon is caused by the fact that one part of the sensor is outside the site the temperature of which is measured, and, furthermore, that the sheath is a good conductor of heat. Such changes in the temperature distribution increase the inaccuracy of measurements; the scale (magnitude) of those changes in temperature distribution depends both on the ratio between the length of the sensor's portion placed at an ambient temperature and the length of the whole sensor (the larger the ratio, the larger the changes), and the difference between ambient temperature and temperature in the place of measuring it (the larger the difference, the larger the changes).

In the case it is necessary to accurately measure temperatures, the sensors must be mounted according to the following instructions:

- portions of the sensor's sheath that protrude beyond the site of taking measurements are to be thermally insulated;
- a route of connection line is to be carefully selected in order to avoid this line being exposed to temperature fluctuations, especially when it runs over a long distance; moreover, with regard to the resistance sensors, it is recommended to use a 3-wire connection line;
- longer sensors are to be applied (in order to deeply immerse them) for the purpose of improving the ratio between the length of sensor's sheath situated at an ambient temperature and the total length of a sensor used;
- in the case of pipelines with a low flow rate (in particular in pipelines carrying gaseous media), temperatures should be measured in those segments of the entire pipeline where the pipes cross-sections are reduced/decreased; in such pipes with the reduced cross-sections, the flow velocity is increased, and the rate of heat transfer is higher.

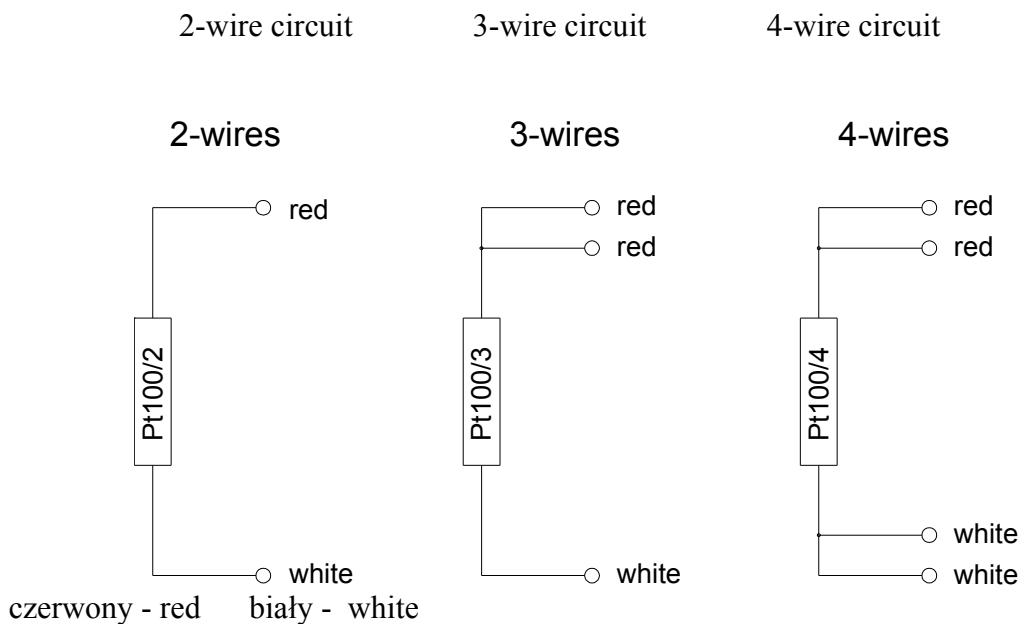
3. Creating a connection line to connect sensors to a measuring gauge

Connection line between sensors and a measuring gauge is to be made of copper wires (resistance wires) or thermoelectric wires (compensation wires); their cross-section areas should not be lower than 1 mm² as required by the relevant regulations referring to electric low voltage wiring systems. While designing a connection line, it should be avoided to couple the wires. However, if it is necessary, soldered joints are recommended. While making a connection line, it is very important to follow all the instructions and recommendations as set forth in a relevant Operation Manual always provided with any gauge the sensor is to be connected to.

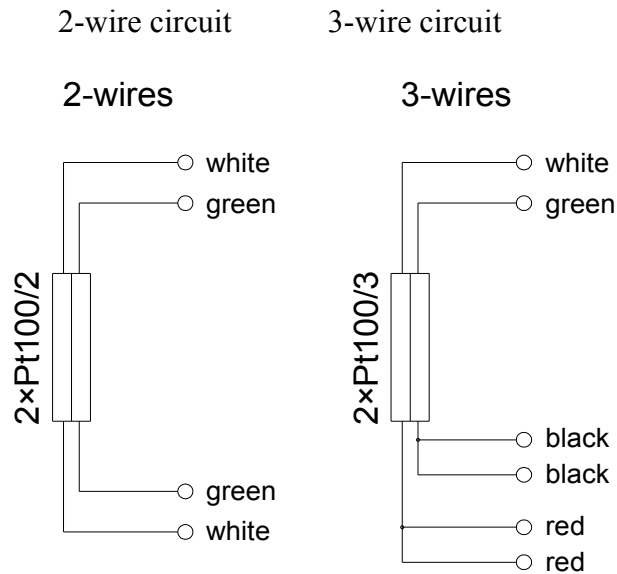
As for resistance sensors with 3- and 4-wire systems, the insulation of wires from one resistor terminal is of the same colour. The method of connecting thermoelectric sensors with external instruments is 'plus to plus' and 'minus to minus'. In the applicable national standards in many countries, there are specified colours of insulations to be applied for wires and for outer insulating sheaths, and the purpose of defining the colour codes is to facilitate mounting and to avoid probable misconnections.

4. Resistance sensors – connection wires marking system

One Measurement Circuit



Two Measurement Circuits

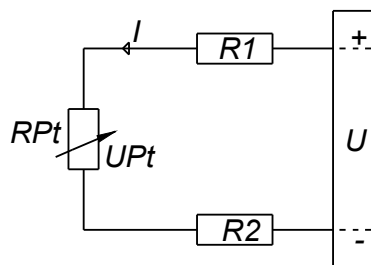


Resistance Sensors – 2-wire connection line
 zielony – green czarny – black

Diameter of the Wire/ Resistance of the Wire

- 2x0.22 mm² - 0.175 Ω/m
- 2x0.25 mm² - 0.165 Ω/m
- 2x0.35 mm² - 0.105 Ω/m
- 2x0.50 mm² - 0.036 Ω/m

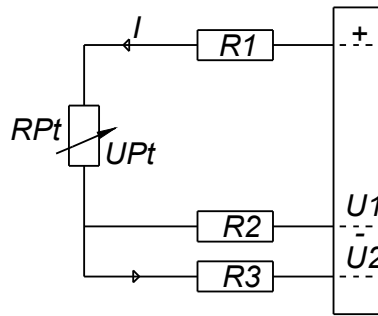
A sensor's 2-wire connection line is applied when it is sufficient to obtain temperature measurements with an average (not high) accuracy. The resistance of R1 + R2 connection line causes the following error in the temperature measurement: as for Pt 100, the error is about 2.6 °C per one Ω (ohm) of the wire resistance, and as for Pt 1000: 0.26°C per one Ω (ohm) of the wire resistance.



Resistance Sensors - 3-wire connection line

OPERATION MANUAL .01

A 3-wire connection line between the resistor and devices is the most commonly used connection line in industrial applications since temperature-depending changes in the resistance are automatically compensated, and the resistance of the connection line is also compensated.

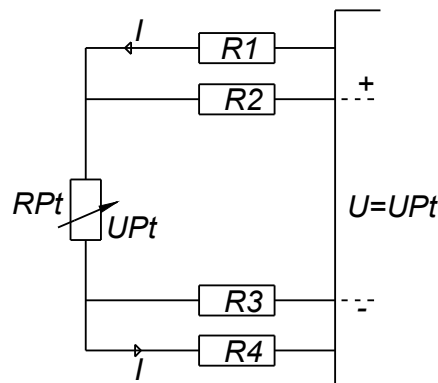


The resistance of all the connection wires must be identical, i.e. $R_1=R_2=R_3$. In the Table below, there are shown examples of errors caused by the resistance difference of 0.1Ω and of 1.0Ω between the wires of a 3-wire connection line for Pt 100 and Pt 1000.

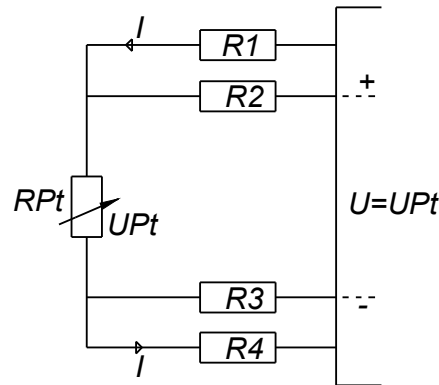
| | <i>Difference in the resistance of wires</i> | |
|--------|--|-----------------------------|
| | <i>0.1Ω</i> | <i>1Ω</i> |
| Pt100 | 0.26°C | 2.6°C |
| Pt1000 | 0.03°C | 0.26°C |

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

Resistance Sensors – 4-wire connection line



This connection line is used when a very high accuracy of temperature measurements is required. In the case of a 4-wire connection line, the impact of resistor's wires resistance is totally eliminated.



$$R_1=R_2=R_3=R_4$$

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

5. Thermoelectric Sensors - connection wires marking system

When the thermoelectric sensor is connected with external devices, then, the corresponding pole on a device must be connected with the corresponding pole of the sensor's wire (which has a polarity-specific colour). In the Table below, there are represented respective rules of connecting the instruments and the corresponding colour codes.

| Type of thermoelectric sensor | Type of wire | | Metal Composition | | Colour Code | | Tolerances | | Temperature Range |
|-------------------------------|--------------|----------------|-------------------|-----------|-------------|---------|------------|-----------|------------------------------|
| | Compensation | Thermoelectric | Wire + | Wire - | IEC 584 | PN-89/M | Class 1 | Class 2 | |
| J | - | JX | Fe | CuNi | black | blue | ± 1.5 | ± 2.5 | $-25 \div 200^\circ\text{C}$ |
| K | - | KX | NiCr | NiAl | green | yellow | ± 1.5 | ± 2.5 | $-25 \div 200^\circ\text{C}$ |
| K | KCA | - | Fe | 410 Alloy | green | - | - | ± 2.5 | $0 \div 150^\circ\text{C}$ |
| K | KCB | - | Cu | CuNi | green | - | - | ± 2.5 | $0 \div 100^\circ\text{C}$ |
| T | - | TX | Cu | CuNi | khaki | brown | ± 0.5 | ± 1.0 | $-25 \div 200^\circ\text{C}$ |
| E | - | EX | NiCr | CuNi | violet | - | ± 1.5 | ± 2.5 | $-25 \div 200^\circ\text{C}$ |
| N | - | NX | Nicrosil | Nisil | pink | - | ± 1.5 | ± 2.5 | $-25 \div 200^\circ\text{C}$ |
| N | NC | - | Cu | 278 Alloy | pink | - | - | ± 2.5 | $0 \div 150^\circ\text{C}$ |

Cross-section Areas of Compensation and Extension Wires

0.22 mm²; 0.5 mm²; 0.75 mm²; 1.0 mm²; 1.5 mm²

And the recommended cross-section areas of compensation and extension wires to be applied to connect sensors with external instruments are: 1.0 mm² or 1.5 mm² according to PN-89/M-53859.

General rules on applying respective colours for compensation wires:

- according to the German Standard DIN IEC 584, **the colour** of an outer insulating sheath, an outer insulation, and a positive wire assigned to the positive thermoelectrode in the sensor is **the same**, and the colour of negative thermoelectrode is **white**;
- according to the Polish Standard PN-89/M-53859, **the colours** of an outer insulating sheath, and an outer insulation are different, **the colour of insulation** of the wire assigned to the positive thermoelectrode is **red**, whereas the insulation of the wire assigned to the negative thermoelectrode may be of any other colour **except for red, purple, and pink**.

| <i>Type of Sensor</i> | <i>Sheath Material</i> | <i>Measurement Range</i> | <i>Method of Fixing</i> | <i>Diameter of Sheath</i> |
|-----------------------|------------------------|--------------------------|-------------------------|---------------------------|
| TO..E-1 | Brass | -50÷180°C | Smooth Connector | Ø4,8 |
| TOPE-2 | 1.4541 | 0÷400°C | Thread /Bayonet | Ø4, Ø5, Ø6 |
| T..E-3 | 1.4541 | -40÷250°C -40÷400°C * | Thread /Bayonet | Ø10 |
| T..E-4 | Brass | -40÷250°C -40÷400°C * | Thread /Bayonet | Ø7 |
| TOPE-5 | Nickel Plated Brass | -40÷250°C -40÷400°C * | Thread /Bayonet | Ø4,2 |
| TOPE-113 | Nickel Plated Brass | 0÷400°C | Thread /Bayonet | Ø6/8 |
| TT..E-331 | Nickel Plated Brass | 0÷400°C | Thread /Bayonet | Ø6/8 |
| T..E-245 | 1.4541 | -40÷250°C -40÷400°C * | Thread /Bayonet | Ø5, Ø6 |
| T..E-361 | 1.4541 | -40÷180°C | UG-3 | Ø4, Ø5, Ø6, Ø8 |
| T..E-362 | 1.4541 | -40÷400°C * | UG-4 | |
| T..E-363 | 1.4541 | -40÷180°C | Threaded Connector | Ø4, Ø5, Ø6, Ø8 |
| T..E-364 | | -40÷400°C * | | |
| T..E-365 | | | | |
| T..E-366 | | | | |

OPERATION MANUAL .01

| <i>Type of Sensor</i> | <i>Sheath Material</i> | <i>Measurement Range</i> | <i>Method of Fixing</i> | <i>Diameter of Sheath</i> |
|------------------------|------------------------|--------------------------------|--------------------------|---|
| T..E-367 | 1.4541 | -40÷180°C -40÷400°C * | Outer, Threaded Sheath | Ø5/6, Ø5/7, Ø6/8 |
| TT..E-.. | 1.4541 | 0÷400°C | Thread /Bayonet | Ø4/6, Ø6 |
| TT..E-1.. | 1.4541 | 0÷300°C (J) 0÷400°C (K) | Thread /Bayonet | Ø6/8 |
| T..GE-3 | 1.4541 | -40÷400°C | Thread | M6, M8x1, M10x1, M12, M14x1.5, M20x1.5 |
| T..GE-4 | 1.4541 | -40÷400°C | Thread | Ø6/M10x1 |
| TTP..-1087 | 1.4541 | -40÷600°C | Thread | M8x1 |
| TTJE-1052 | 1.4541 | -40÷250°C | M4 Capscrew | Ø3,5 |
| TOPMK-.. | 1.4541 | -30÷150°C | - | Ø5 |
| TOPE-6 | 1.4541 | -40÷180°C -40÷400°C * | M4 Capscrew | - |
| TOPE-50244 | Brass | -50÷150°C | Band Clip | Ø5,8 |
| TOPE-116 | 1.4541 | -50÷200°C | Band Clip | - |
| TOPE-1186 TOPE-1187 | mosiądz | -40÷400°C | M3, M4 Capscrews | - |
| TOPE-408 | 1.4541 | -50÷200°C | Male (External) Thread | Ø3 |
| TOPGE-5 TOPGE-6 | 1.4541 | -40÷400°C | Thread | Ø6/Ø8,5 |
| PTT..-1047 | 1.4541 | -40÷800°C (K) -40÷700°C (J) | Thread | Ø4/Ø5/Ø7 |
| PTT..-1083 | Inconel 600 | -40÷400°C | Female (Internal) Thread | Ø4,5/Ø6 |

6. Packing and storing instructions, transportation

The sensors to be transported must always be properly packed in order to avoid any damage during the transportation. It is recommended to place the sensors to be transported either in one general, shared package or in individual unit packages. The sensors should be stored in their packages in indoor storage spaces: the indoor air must contain **no traces of vapours and/or aggressive substances**, the indoor air temperatures must range from +5 °C to 50 °C, and the relative humidity **must not exceed 85%**. Whilst being transported, the sensors must be protected against shifting inside the packagings. The sensors manufactured by 'Limatherm Sensor' can be transported using maritime, rail, road, or air modes of transport, in all cases provided that the direct impact of atmospheric factors on the sensors during the

transportation it totally eliminated. The detailed transportation conditions are specified in the Polish Standard PN-81/M-42009.

7. Warranty

- The Manufacturer provides the original purchaser of the sensor (sensors) with a twelve (12) month warranty and necessary service; for this period, the Manufacturer guarantees the uninterrupted and error free functioning of sensors;
- The twelve (12) month warranty begins on the day of purchase;
- Also, the Manufacturer provides the original purchaser of the sensors with a post-warranty service;
- The warranty voids in the case of any changes in and repairs of the instrument performed by the user;
- This warranty does not cover damages resulting from improper transportation, nor defects and errors caused by improper handling or misuse which does not comply with the provisions as set forth in this Operation Manual.