Mineral insulated thermocouple sensors

This Operation Manual provides an overview of specific sensors developed for applications in extremely difficult environments owing to their very special construction and operational features.

Mineral insulated thermocouples are highly resistant to vibrations and shock; they may be easily bent in any direction with no risk of short-circuiting their thermoelectrodes. Thus, they can be used in inaccessible sites, in small elements, and, generally in any places where flexible measuring units of small diameters and low thermal inertia are necessary.

Mineral insulated thermocouple sensors are suitable for industrial and laboratory measuring applications. The application range of thermocouples and mineral insulated sensors is exceptional wide. They are applied in nuclear technology, chemical engineering, petroleum chemistry, industrial and civil engineering, machine construction, heavy power engineering, metallurgy, etc.

Thermocouples and sensors with an isolated junction are recommended for measuring temperatures in corrosively aggressive environments in which a measuring thermocouple must be adequately electrically insulated and protected by a special sheath. Sensors having an earthed junction are applied to measure static temperatures or temperatures of flowing gases and corrosively non-aggressive fluids because in such environments it is very important that a measuring device instantly reacts to any change in temperature. Those sensors are manufactured in two versions: either with a voltage output of a thermocouple or with a 4...20 mA current output.

The sensors as represented in this Operation Manual comply with the provisions under the Standard PN-EN 60584.

1. Construction and principle of operation

Mineral insulated thermocouple sensor is manufactured in the form of thin tube/probe called mantle. Inside this tube, there are two (2) or four (4) thermoelectrodes; all the thermoelectrodes’ ends are tightly welded together, thus, forming a measuring junction; the thermoelectrodes inside the tubes are placed in an insulating envelope made of a highly compressed insulating material, for example, magnesium oxide.

The measuring junction may be either isolated/separated from the mineral insulated (SO type) or connected with it, i.e. earthed (SP type); in the case of double, thermocouples, the measuring junctions of the two thermocouples, which are isolated/separated from the mantle, can be either connected with each other (SOA type) or isolated/separated from each other (SOB type).

Depending of the construction form of a cold junction in a thermocouple, there are various construction types of thermocouples, and they decide on the type of sensors:

- with free ends of a 20 mm length (BT)
- with sleeve at its end, 50 mm long free ends are extended by a thermoelectrode wire (T)
- with plug-in socket at its end (BTW)
- with plug “LEMO” type connection (BTL)
- with compensation wire of any length (TKb)
- as above; the compensation wire has a flat, plug-in socket at its end (TKbW)
- as above; the compensation wire has “LEMO” type connection at its end (TKbL)
- a flat thermocouple, BT type, with a flanged end with a terminal block
- insert as above, placed in a connection head, NA type

On the basis of mantle type thermocouples, there are constructed other sensor types; their profiles are described in detail in the Catalogue.
2. Specifications

Diameter of mineral insulated thermocouple $d^*$.............................1.0; 1.5; 2.0; 3.0; 4.5; 6.0 mm
Type of thermocouple ........................................................1; or 2xFe-CuNi(J); or NiCr-NiAl(K)
Temperature Measurement Range.........................from -40 to + 700 °C ( as for J), and
to + 1200 °C ( as for K)
Example of the continuous measurement range (depending on the mantle diameter)...according to
Thermocouple Class..........................................................1 or 2 according  to PN-EN 60584:1997
Measuring junction type.............................. isolated/separated or earthed
Sheath material..........................................................acid-resistant steel (as for J)
                                          Inconel 600 (as for K)
Permissible vibrations...........................................5 to 80 Hz, up to 5g
Permissible working pressure.........................4 MPa
Temperature of air surrounding free ends .................from -40 to + 150°C

<table>
<thead>
<tr>
<th>Time-constant $T$ (water, 0,4 m/s)</th>
<th>Isolated/separated junction</th>
<th>Earthed junction</th>
</tr>
</thead>
<tbody>
<tr>
<td>diameter [mm]</td>
<td>[s]</td>
<td>[s]</td>
</tr>
<tr>
<td>3</td>
<td>1,5</td>
<td>1,2</td>
</tr>
<tr>
<td>6</td>
<td>6,0</td>
<td>2,5</td>
</tr>
</tbody>
</table>

Minimum bend radius.................................3d
Mounting length L.............................................any length; thermocouples, inserts and
sensors having L >1500 mm are supplied in coils
Length of compensation cable Lk..............................any length

<table>
<thead>
<tr>
<th>Table 1</th>
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<tbody>
<tr>
<td>Type</td>
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<td></td>
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</tbody>
</table>

Types of Transmitters........................................APAQ-HCF; LTT-01; FLEX TOP 2211; TxBlock
Plugs and sockets of thermocouples are SMP or OST type according to catalogues Omega and
Heraeus (as indicated below).
Plugs material ..................................................Nylon filled with glass fibre
Working temperature........................................max 200°C

The minimum mineral insulated diameter of double thermocouples is 2 mm.

Thermocouple Material Profile:

Acid resistant steel - max working temperature in the air environment.............850°C
resistance in carbon dioxide............................................650°C
resistance to intercrystalline corrosion in an oxidizing environment
proper resistance in an oxidizing environment
proper resistance to alkaline organic acids and to the majority of inorganic acids except for HCl and H₂SO₄

Inconel 600 - resistance in an oxidizing environment 1150°C
resistance in carbon dioxide 500°C
resistance in an atmosphere containing sulphur or water vapour to 500°C
corrosion resistance and low electrochemical corrosion resistance in high temperatures – hydrogen permeable

3. Connecting sensors to thermocouples

◆ Using a terminal block

In the case of thermoelectric sensors, polarity must carefully be observed; thus, on a terminal block, the positive pole of thermocouple is marked as + in order to allow the end user to properly connect the thermoelectric sensor.

When the thermoelectric sensor is connected with external devices, then, the corresponding pole on the terminal block must be connected with the corresponding pole of the wire (which has a polarity-specific colour). In the Table below, there are shown: thermoelectric sensor types, the respective rule to connect a specific sensor type, and corresponding colour codes.

<table>
<thead>
<tr>
<th>Thermocouple type</th>
<th>Wire Type</th>
<th>Metal composition</th>
<th>Colour Code</th>
<th>Tolerances</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Compens.</td>
<td>Thermoel. Wire +</td>
<td>Wire - IEC 584 PN-89/M</td>
<td>Class 1</td>
<td>Class 2</td>
</tr>
<tr>
<td>J</td>
<td>-</td>
<td>JX Fe CuNi black</td>
<td>blue</td>
<td>±1.5</td>
<td>±2.5</td>
</tr>
<tr>
<td>K</td>
<td>-</td>
<td>KX NiCr NiAl green</td>
<td>yellow</td>
<td>±1.5</td>
<td>±2.5</td>
</tr>
<tr>
<td>K</td>
<td>KCA</td>
<td>Fe 410 Alloy green</td>
<td>-</td>
<td>-</td>
<td>±2.5</td>
</tr>
<tr>
<td>K</td>
<td>KCB</td>
<td>Cu CuNi green</td>
<td>-</td>
<td>-</td>
<td>±2.5</td>
</tr>
<tr>
<td>N</td>
<td>-</td>
<td>NX Nicrosil pink</td>
<td>-</td>
<td>±1.5</td>
<td>±2.5</td>
</tr>
<tr>
<td>N</td>
<td>NC</td>
<td>Cu 278 Alloy pink</td>
<td>-</td>
<td>-</td>
<td>±2.5</td>
</tr>
</tbody>
</table>

◆ to a TC/4-20 mA Transmitter – Diagram of Wiring
The recommended cross-section areas of compensation and extension wires used to connect sensors and external devices are either 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**.

4. **Recommended outer diameters of cables for cable glands**

   Cable gland: Pg 9   cable diameter /Ø4 – 6.0 mm/
   Cable gland: Pg 16  cable diameter /Ø4 -12.5 mm/

5. **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.

6. **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 bad handling or misuse which does not comply with the provisions as set forth in this Operation Manual.

7. Recommended methods of assembling the sensors

![Diagram](Fig. 1. Examples of assembling sensors with sheaths using UZ and UG fitting devices.)

![Diagram](Fig. 2. Examples of assembling sensors with threaded connectors.)