Cable Resistance Thermometers
Model TR40

Applications

- For direct installation in the process
- Machine building
- Engines
- Storage
- Pipelines and tanks

Special Features

- Application ranges from -200 °C to +600 °C
- For insertion, screw-in with optional process connection
- Cable material PVC, silicon, Teflon® or fibreglass
- Explosion-protected versions Ex-i, Ex-n and NAMUR NE24

Description

Cable resistance thermometers are especially suited for applications where the metal sensor tip is fitted directly into drilled holes, e.g. in machine parts, or directly into the process, i.e. for all applications without chemically-aggressive media and without abrasion.

For mounting into a thermowell, a spring-loaded compression fitting is provided since only this can press the sensor tip to the bottom of the thermowell, without a - potentially critical - application of force onto the sensor tip.

In the standard version the thermocouples are manufactured without process connections. Fastening elements such as threads, union nuts etc. are available as options.
Sensor

The sensor is located in the tip of the sensor.

Sensor method of connection

- 2-wire  The lead resistance compounds the error.
- 3-wire  With a cable length of approx. 30 m or longer measuring deviations can occur.
- 4-wire  The inner lead resistance of the connecting wires is negligible.

Sensor limiting error

- Class B per DIN EN 60 751
- Class A per DIN EN 60 751
- 1/3 DIN B at 0 °C

It makes no sense to combine 2-wire connection with Class A or 2-wire connection with 1/3 DIN B, since the lead resistance of the cable overrides the higher sensor accuracy.

Basic values and limiting errors

Basic values and limiting errors for the platinum measurement resistances are laid down in DIN EN 60 751. The nominal value of Pt100 sensors is 100 Ω at 0 °C. The temperature coefficient α can be stated simply to be between 0 °C and 100 °C with:

\[ \alpha = 3.85 \times 10^{-3} \, ^\circ C^{-1} \]

The relationship between the temperature and the electrical resistance is characterised by polynomials which are defined in DIN EN 60 751. Furthermore, this standard lays down the basic values in °C stages.

<table>
<thead>
<tr>
<th>Class</th>
<th>Limiting error in °C</th>
</tr>
</thead>
</table>
| A     | 0.15 + 0.002 \cdot | |}

<table>
<thead>
<tr>
<th>Class</th>
<th>Limiting error in °C</th>
</tr>
</thead>
</table>
| B     | 0.3 + 0.005 \cdot | |}

1) | t | is the value of the temperature in °C without consideration of the sign

Sensor tip designs

Standard version

In the standard version a sensor is incorporated which is appropriate for the selected measuring range. This sensor can be used for acceleration loads of up to 30 m/s². (Test per DIN EN 60751)

Tip sensitive (thin-film sensor)

A special measurement resistor is connected to the sensor tip. Due to its direct contact to the tip this version cannot be used as an intrinsically-safe thermometer.

Vibrations-resistant sensor tip (max. 10 g)

Special resistors are used for this extremely robust version. In addition a special internal design has been chosen to give long-term resistance to these high loads (100 m/s²). (The test is based on DIN EN 60751)

Metallic sensor

Material: stainless steel

Diameter: 2 mm, 3 mm, 6 mm or 8 mm
Length: selectable

Regardless of the design, the sensor tip must not be bent over the first 60 mm of its length.

For temperature measurement in a solid body, the diameter of the drilling in which the sensor is intended to be inserted, should be a maximum of 1 mm larger than the sensor diameter.

Cable resistance thermometers can be constructed in two different ways:

- Tubular design

The tubular design is characterised by a rigid construction of the metal sensor tip, therefore tubular designs must not be bent.

Inside, the measuring resistor is connected directly to an insulated lead, therefore tubular cable thermocouples can only be used up to the temperatures specified for the cable (see operating temperatures).
Sheathed design
In sheathed resistance thermometers the flexible part of the sensor is a mineral-insulated cable (MI-cable). This consists of a stainless steel outer sheath with a lead forced into it, insulated with a highly-compressed ceramic powder.

The measuring resistor is directly connected to the inner leads of the sheathed cable and is, therefore, suitable for use with higher temperatures. Owing to their flexibility and smaller possible diameters, sheathed resistance thermometers can be used for difficult to access locations. With the exception of the sensor tip and the transition to the connecting cable the sheath can be bent to a radius of 3 times the diameter.

Please note:
The flexibility of the sheathed resistance thermometer must be considered, especially when the flow rates are relatively high.

Transitions
The junction between the metal part of the resistance thermometer and the connecting cable or wire is either crimped, rolled or cast, depending on the design. This area should not be submerged into the process and must not be bent. Compression fittings should not be attached to the transition. The type and dimensions of the transition depend largely on the combination between input leads and metal sensor and the sealing requirements.

Dimension T denominates the length of the transition.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Dimension T in mm</th>
<th>Ø transition in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe Ø = transition Ø</td>
<td>not applicable</td>
<td>identical to probe</td>
</tr>
<tr>
<td>Ø 2 ... 4.5 mm with crimped transition</td>
<td>45</td>
<td>6</td>
</tr>
<tr>
<td>Ø 6 mm with crimped transition</td>
<td>45</td>
<td>7</td>
</tr>
<tr>
<td>Ø 6 mm with crimped transition 1)</td>
<td>45</td>
<td>8</td>
</tr>
<tr>
<td>Ø 8 mm with crimped transition</td>
<td>45</td>
<td>10</td>
</tr>
</tbody>
</table>

1) With a large number of wires (e. g. 2 x 3-wire and shielding)

Connection cable
Numerous insulating materials are available to adapt to different prevailing conditions. The cable end can be supplied ready for connection, fitted with a plug as an option.

Connection cable (standard)
- Wire material: Cu (strands)
- Wire cross-section: approx. 0.22 mm² (standard version)
- Number of wire: according to method of connection
- Insulation material: PVC, silicon, Teflon® or fibreglass
- Shielding (Option)
**Operating Temperatures maximum**

The maximum temperatures of these thermometers are limited by different parameters.

- **Sensor**
  The temperature measuring range is limited by the sensor itself. An optimum choice is made according to the accuracy class and operating conditions.

Outside the defined measuring range the measurement loses its accuracy and the sensor can be damaged.

**Possible measuring ranges are:**
- -50 ... +250 °C
- -50 ... +450 °C
- -200 ... +250 °C
- -50 ... +400 °C (only Class A)
- -200 ... +600 °C (from 450 °C Class B)
- -200 ... +400 °C
- -200 ... +600 °C (only Class B)

- **Connection cable and single lead wires**
  The maximum temperature permissible at each point of the connecting cable is that specified for the connecting cable. The sensor itself could, possibly, be subjected to higher temperatures.

  The following temperature limits apply to conventional connecting cables:
  - PVC  -20 °C ... +100 °C
  - Silicon -50 °C ... +200 °C
  - Teflon® -50 °C ... +250 °C
  - Fibreglass -50 °C ... +400 °C

  Since an isolated cable is also fitted inside the metallic probe of the tubular design, the operating limits of the connection wire apply.

- **Transition**
  The temperature at the transition is further limited by the use of potted sealing compound.

  Maximum temperature of the compound: 150 °C
  Option: 250 °C
  (Other versions available on request).

- **Plugs**
  For optionally-fitted connecting plugs the maximum permissible temperature at the plug is 85 °C.

- **Operating temperature**
  If the temperature to be measured is higher than the permissible temperatures at the cable, plug or transition, the metal part of the sensor must be long enough to protrude from the hot zone. Care must be taken that the lowest of the maximum operating temperatures of cable, transition or plug are not exceeded.

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**Ingress protections**

- **IP protection**
  Cable resistance thermometer can be delivered up to an ingress protection of IP 65 (depending on the cable-sheath material and the number of wires).
  In a special design, IP 67 is also possible on request.
  For connectors with sheated glass fibre the combination with an explosion-protected design is excluded.

- **Explosion protection (option)**
  Cable resistance thermometers of the TR40 product range are available with a type-examination certificate for protection classes Ex-i and Ex-n (Directive 94/9/EG) and NAMUR NE24. The devices comply with the requirements of the directive 94/9/EG (ATEX), EEx-i, for gases and dust.
  The classification or suitability of the device (approved power $P_{\text{max}}$, minimum clearances from hot surfaces as well as the permissible ambient temperature) for the appropriate category should be taken from the type-examination certificate or operating instructions.

**Note:**

When mounting thermometers with flying leads, the personnel fitting them must ensure that the connection is carried out properly and in compliance with the appropriate regulations. When the thermometer cables are terminated within the hazardous area, suitable adapters / connectors should be used. Flying leads must be connected outside of the hazardous area or, when operated in dust explosive atmospheres, within an enclosure which is certified according to the 94/9/EC and EN 50 281-1-1 directives, and provides an ingress protection of at least IP 65. A minimum air and creepage distance of 2 mm must be ensured.
Design

Depending on their electrical connection, cable resistance thermometers are divided into the following designs:

- With single lead wires
- With connecting cables
- With plugs
- With bare connecting wires

Connection with single lead wires
Lead length 150 mm, other length on request
Cu braid 0.22 mm², Teflon® or fibreglass insulated, number of leads dependant on the number of sensors and the method of sensor connection, stripped lead wires, other versions on request

With connection cable
Cable and probe are firmly connected to each other. Cable length and insulating materials to customer specifications. Cu leads 0.22 mm², number of wire according to number of sensor and sensor method of connection, stripped lead wires

With connector fitted on connection cable
The optional connection plug is fitted to the flexible connecting cable.

Designs with bare connecting wires
The inner leads of the mineral-insulated cable protrude. L = 20 mm (standard).

The length of the flying leads can be adapted to customer requirements. These blank internal leads are made of solid wire and thus are not suitable for longer distances.

Version with plug fitted directly to the sensor
These versions are based on the design with bare connecting wires. The plug is fitted directly to the metal sensor.
Process connections for straight probes

The cable resistance thermometers can be fitted with optional process connections. Dimension A denominates the insertion length into the process.

To minimise heat dissipation errors through the thread the insertion length A should be at least 25 mm long. The position of the thread is specified by dimension X, regardless of the type of connection.

Please note:
- For parallel threads (i.e G 1/2) the dimensioning always refers to the sealing collar of the thread on the process-side.
- In the case of tapered threads (i.e. NPT) the measurement plane is located approx. in the centre of the thread.

Fixed screw connections/threads

are used to fit the probe into a threaded connection with an female thread.

Insertion length A, to customer specification
Material: stainless steel, others on request

The sensor must be rotated in order to the screw-fitted into the process. Therefore, this assembly first needs to be mechanically assembled and after that it can then be electrically connected.

Compression fitting

allows simple adjustment to the required insertion length at the installation point.

As the compression fitting can be moved along the sensor, the dimensions A and N define the ex works condition. The length of the compression fitting defines the smallest possible length X of approx. 40 mm.

Material: stainless steel
Ferrule material: stainless steel or Teflon®

Stainless steel ferrules can only be set once, once they have been loosened, they can no longer be slid along the sheath.
- Max. temperature at process connection 500 °C
- Max. pressure load 40 bar

Ferrules of Teflon® can be adjusted several times, once they have been loosened, they can be slid along the sheath repeatedly.
- Max. temperature at process connection 150 °C
- For pressure-less operation

For sheathed thermocouples with Ø 2 mm only Teflon® ferrules are permissible.
Spring-loaded compression fitting
allows simple adjustment to the required insertion length at
the installation point and retains the spring pre-load at the
same time.

As the compression fitting can be moved along the sensor,
the dimensions A and X define the ex-works condition. The
length of the compression fitting defines the smallest possi-
ble length X of approx. 80 mm.

Material: stainless steel
Ferrule material: stainless steel

Stainless steel ferrules can only be set once, once they
have been loosened, they can no longer be slid along the
sheath.

- Max. temperature at process connection 500 °C

The spring-loaded compression fitting is not intended to be
pressure loaded.

Union nut
serves to fit the sensor to threaded connections with
male threads.

The sensor and thread can be rotated against each other,
therefore the order in which the mechanical and electrical
installation occurs is not important.

This option is not sensible for NPT threads.

Insertion length A: to customer specification
Material: stainless steel, others on request

Male nut
serves to fit the sensor to threaded connections with
female threads.

The sensor and thread can be rotated against each other,
therefore the order in which the mechanical and electrical
installation occurs is not important.

This option is not sensible for NPT threads.

Insertion length A: to customer specification
Material: stainless steel, others on request
**Angled probes**

Sheathed cable thermometers can be supplied in pre-bent shapes. In this case the position of the bend is indicated by a further dimension.

Dimension X denominates the distance of the bend from the lower edge of the transition.

Dimension A always indicates the insertion length of the sensor, the area which is built into the process.

If a screw connection is used on the bent probe, then dimension Y denominates the distance from the centre of the bend to the measurement plane of the screw connection.

A fixed fitting connection is not sensible, as the bent sensor would have to be screwed into the process with a wide sweeping movement.
Plug (option)

Cable thermocouples can be supplied with plugs fitted.

The following options are available:

- **Spade lugs**
  (not suitable for versions with bare connecting wires)

- **Lemosa plug size 1 S (male)**
- **Lemosa plug size 2 S (male)**

- **Lemosa plug size 1 S (female)**
- **Lemosa plug size 2 S (female)**

Further options

**Bend protection**
Bend protection (strain relief spring or shrink tubing) serves to protect the transition where the rigid probe and the flexible connection cable join. This should always be used when any movement of the connection cable relative to the thermometer mounting point is expected.

For installation in accordance with Ex-n, bend protection is obligatory.

The standard length of the strain relief spring is 60 mm.

**Transition (inline transition) with same diameter as sensor**
As an option a transition can be selected which has the same diameter as the metal sensor. In this way it is possible to slide the cable clamps and compression fittings together from both ends of the sensor. The transition is hardly visible. However, the operating limits of the transition do not change, which means it must remain outside the process and may not be stressed with a compression fitting.
Electrical connection

Without plug

1 x Pt100
2-wire

- red
- white

1 x Pt100
3-wire

- red
- red
- white

1 x Pt100
4-wire

- red
- red
- white

2 x Pt100
2-wire

- red
- white

2 x Pt100
3-wire

- red
- red
- black
- black
- yellow

Lemosa plug

Plug (male)

Plugs (female)

front view

view of plug contacts

Screw-in-plug, Binder

Plug (male)

Plug (female)

view of plug contacts

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