1. General

We are capable of supplying complete thermometer assemblies ready for immediate use.

These thermocouples or resistance thermometers are sensitive devices which contain either glass or ceramic parts. They must therefore be handled with due care.

On receiving the thermometer assembly, please make sure to unpack all supplied articles, including those that may be delivered in dismantled form.

Long thermometers must be supported at various points, and lifted up or transported in appropriate manner. The same care must be taken during the actual installation of the device. Prior to installation, please check the thermometers (see 5.1) to ensure that the device has suffered no transportation damages.

2. Thermocouples

Thermocouple assemblies are delivered with 1, 2, or sometimes 3 thermocouple elements. The measuring point is usually insulated but can still be connected to the protecting tube.

The connection of the thermocouple to the measuring instrument is established with a compensation lead (CL). Only the right type of compensation leads suiting the thermocouple and possessing the right polarity should be used for the connection. The leads should be at least 0.5 m away from the power cables, preferably laid in their own cabletrays. Twisted and shielded cables suppress magnetic and electrical parasitical interferences.

3. Resistance Thermometers

Resistance thermometers are supplied with 1, 2, or sometimes with 3 measuring resistors.

The measuring point is isolated. The connection between resistance thermometer and measuring instrument is mostly of the 2-wire type (the sum and compensation of line resistance become part of the measurement). To obtain accurate measurements, the 3-wire technique is used. If highly accurate measurements are desired, the 4-wire technique with constant current and high-resistance voltage pick-up are used.

Conventional copper cables usually found on the market, preferably with 1.5 mm² cross-section should be laid, possibly at about 0.5 m away from the power cables, at best on their own cabletrays.

Twisted and shielded cables suppress magnetic and electrical parasitical interferences.

Depending on the type, care must be taken not to exceed the measuring currents of 0.1 to 10 mA, recommended by the manufacturer (errors may result from inherent heating).
4. Thermometer with head-mounted Transmitter

The afore mentioned problems which could eventually be caused by transfer resistances in the cable and EMC can be prevented by installing a 2-wire transmitter (output signal 4...20 mA) in the sensor head. Required is only a 2-core copper cable. Multiple wire circuits for resistance thermometers and compensation cables for thermocouples are not necessary.

When using the transmitter, please take notice of the following:
- the contents of these instructions or the operating manual provided with the transmitter
- the relevant rules involving the installation and operation of electrical systems, in some cases the regulations and directives for explosion protection.

5. Mounting and Operation

5.1 Installation

The thermometer (thermocouple, resistance thermometer) must be brought into contact with the medium to be measured in the best possible manner.

To avoid thermal conduction errors, the immersion depth should be:
- in fluids 6...8 times greater
- in gases 10...15 times greater

than the protective tube diameter. If only very short insertion lengths are possible, special designs should be applied. It is often helpful to install in a pipe bend, whereby the protective tube must be positioned against the flow of the medium.

5.2 Connecting wires

For all connecting wires it is important to ensure that proper contact has been established and that corrosion, humidity, pollution, electrical parasitic interferences of power cables etc. are avoided.

The cables should be insulated to counter the ambient influences (dry, humid, chemically aggressive, hot), whereby the ambient temperature of both the cable and the connection head may not exceed 100 °C.

Please pay attention to the valid standards and regulations when selecting the types of cables to be used.

If possible, all measuring systems should be operated in ungrounded condition, or only grounded at one point.

When using thermocouples connected to protective tubes, these should be the only ground/mass connection.
5.3 Instructions for explosion prooved Components

1. In accordance with of ElexV, maintenance work (repairs) may be conducted only under the following conditions stated below:

1.1 If a part of an electrical device which is important for explosion protection is repaired, this may be put into operation only after a technical expert has determined that the main explosion protection characteristics still correspond to the required standard and after issuing a certificate or awarding a test mark.

1.2 Item 1.1 shall not be valid if the component has been individually tested by the manufacturer and it is confirmed that the main characteristics for application in hazardous areas comply with the stipulated technical requirements.

2. The ElexV is only valid within the Federal Republic of Germany. In foreign countries, the relevant binding regulation corresponding to ElexV must be adhered to.

3. Repair work may only be carried out using original components of the original manufacturer, otherwise the standards stipulated in the certificate of conformity shall not be fulfilled.

4. When ordering spare parts, exact information on previous delivery such as type of protection (Exd, Exi), No. of the certificate of conformity, serial and item No.s must be supplied.

5. Ex-protected thermometers only fulfill the required safety requirements as a unit component, as determined by the certificate of conformity. Measuring insets or connecting heads alone do not satisfy the explosion-protection requirements.

6. If SENSYCON supplies thermometers destined for operation in hazardous areas without protecting tubes, it will be the responsibility of the owner to see to it that:

6.1 these thermometers are deployed only in zones which are permissible in accordance with the certificate of conformity or with the manufacturer’s declaration (e.g. zones 1 or 2).

6.2 a protecting tube is provided for an eventually necessary separation of a zone (e.g. zone 0 from zone 1). Such a tube must correspond fully to the “special conditions” spelled out in the respective certificate of conformity.

7. SENSYCON shall inform the plant owner of the above subject matter in appropriate form, e.g. by drawing attention to this leaflet of instructions.

5.4. Protection Tubes

Thermometers can be installed in any mounting position, preferably hanging vertically, up to temperatures reaching about 500 °C.

Ceramic protection tubes must be protected from mechanical stress (bumps, bends), including temperature shocks e.g. through direct flame contact.

If they are applied to hot processes (e.g. when changing the thermocouple), they must be either prewarmed or inserted very slowly (1...2 cm/min at 1600 °C, 10...20 cm/min at 1200 °C). This also applies when removing the hot protecting tube. Care must be taken to avoid suspending lengths > 500 mm for temperatures > 1200 °C.

6. Maintenance

The thermometer and the entire temperature measuring circuit must be checked at regular intervals for
- wear and tear of protecting tube or chemical activity,
- drifts of the measuring element caused by ageing,
- reduction of insulation resistance through humidity and pollution
- improper contact of the wire connections and
- mechanical and chemical damage of the thermometer and wires.

Resistance thermocouple circuits can be checked by replacing the measuring element with a known defined resistance, thereby simulating a specific temperature.

Thermoelement measuring circuits can be checked by connecting a mV voltage of a known variable to the measuring circuit, instead of the thermocouple.

In both cases, substantial deviations from the set point can be determined, also if the thermometer or the instrumentation is the cause of function errors.

The insulation resistance of the entire ungrounded measuring circuit (wires and thermometer) against ground should be > 1 MΩ (measured with 100 V DC).
7. Troubleshooting

7.1 Quick Check

of thermocouples and resistance thermometers, including their associated measuring circuits in dismantled form.

Required instruments: mV-meter, Ω-meter or resistance bridge, insulation meter with 60...100 V voltage (all measurements at room temperature)

In the case of room temperature the throughput and insulation are checked by “knocking” to see if any wire breaks have occurred.

A thermocouple is regarded as being in order if $R < 20 \, \Omega$ (wire > 0.5 mm diameter); the value depends on the wire cross-section and the length. $R_{\text{aux}} > 100 \, \text{m}\Omega$ (for insulated thermocouples).

A resistance thermometer is considered to be in order if $R$ is about $100 \, \Omega$ (for Pt100), $R_{\text{aux}} > 100 \, \text{M}\Omega$.

A heating up of the thermocouples or resistance thermometers to between 200 and 400 °C (without temperature control) gives further clues to interruptions, polarity errors (for thermocouples), and low insulation resistance etc.

The accuracy of thermometers according to ISO 9000 can only be checked by a reference element.

Therefore in most cases the thermometers has to be removed and checked by a heating device.

7.2 Error Table for Thermocouples and Resistance Thermometers

The entire temperature measuring circuit should be routinely checked.

The following tables contain an illustration of the most important errors and provide suggestions towards their solution.

<table>
<thead>
<tr>
<th>fault</th>
<th>probable cause</th>
<th>remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>errors in the measuring signal</td>
<td>electrical/magnetic pick-up</td>
<td>at least 0.5 m spacing between the measuring cable and power cables supply lines if laid in parallel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>electrostatic shielding caused by a metal foil/braiding grounded at one point</td>
</tr>
<tr>
<td></td>
<td></td>
<td>twist the core wires (in pairs) to combat magnetic pick-up</td>
</tr>
<tr>
<td></td>
<td></td>
<td>right-angled crossing of electrode with interfering power cables</td>
</tr>
<tr>
<td>grounded loops</td>
<td></td>
<td>only one grounding point in circuit or “floating” measuring system (un-grounded)</td>
</tr>
<tr>
<td>drop in insulation resistance</td>
<td></td>
<td>humidity has eventually penetrated the thermometer/inset; in such case dry up and reseal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>replace inset</td>
</tr>
<tr>
<td></td>
<td></td>
<td>check to see if thermometer is thermally overloaded</td>
</tr>
</tbody>
</table>
### Typical Thermocouple Faults

<table>
<thead>
<tr>
<th>fault</th>
<th>probable cause</th>
<th>remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>response times too long, incorrect readouts</td>
<td>wrong location for installation; there is a heat source within the flow path</td>
<td>change the point of installation so that the medium can transmit its temperature to the thermometer without interference</td>
</tr>
<tr>
<td></td>
<td>wrong installation:</td>
<td>immersion depth approximately temperature sensitive length + 6 × (fluids) up to 10 × (gases) d (d = external protecting tube diameter) &lt;br&gt;− insufficient installation depth &lt;br&gt;− excessive loss of warmth</td>
</tr>
<tr>
<td></td>
<td>protecting tube too thick, drilled hole for protecting tube too big</td>
<td>select the smallest possible protecting tube for the process; response time at first exposure should be proportional to the cross-section or the volume of the thermometer, depending on the tentative thermal figures and air gaps within the assembly. Fill any such gaps with contact agent (oil, grease) if possible.</td>
</tr>
<tr>
<td></td>
<td>deposits on the protecting tube</td>
<td>remove during inspections &lt;br&gt;− if possible, select another protecting tube, another installation point</td>
</tr>
<tr>
<td>thermometer interruptions</td>
<td>vibrations</td>
<td>reenforced springs on inset &lt;br&gt;− shorten inset insertion length &lt;br&gt;− change the measuring point (if possible) &lt;br&gt;− special construction of inset and protecting tube</td>
</tr>
<tr>
<td>highly corroded protecting tube</td>
<td>− composition of the medium is not as assumed, or has changed &lt;br&gt;− unsuitable material chosen for protecting tube</td>
<td>check the medium, eventually analyze the defective protecting tube and select a more suitable material, whilst providing additional surface protection &lt;br&gt;− in certain circumstances the protecting tube must be replaced from time to time, since it is subject to wear</td>
</tr>
</tbody>
</table>

### Typical Thermocouple Faults

<table>
<thead>
<tr>
<th>fault</th>
<th>probable cause</th>
<th>remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>fluctuating temperature readout even though thermocouple circuit is faultless</td>
<td>reference junction temperature or voltage is not constant</td>
<td>temperature or supply voltage must be kept constant at &lt; 0.1 %; check instruments &lt;br&gt;− for non-precious metal-thermocouples use the full value for measurement; use only about half the value of thermocouples made of precious metals</td>
</tr>
<tr>
<td>temperature display highly deviates from the table values for thermocouples</td>
<td>improper material combinations, bad electrical contacts, parasitic voltages (thermostatic voltages, galvanic voltage), wrong compensation cable</td>
<td>check thermocouples and wires for &lt;br&gt;− correct pairing &lt;br&gt;− correct compensation lead &lt;br&gt;− correct pinup &lt;br&gt;− permitted ambient temperature at connection head</td>
</tr>
</tbody>
</table>
Typical Resistance Thermometer Faults

<table>
<thead>
<tr>
<th>fault</th>
<th>probable cause</th>
<th>remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>too high or fluctuating temperature readout despite known cross-section, accurate sensor of the resistance thermometer</td>
<td>wire resistance too high, uncompensated</td>
<td>if still possible:</td>
</tr>
<tr>
<td></td>
<td>supply lead resistance altered by high temperature</td>
<td>− select 2-wire leads with bigger cross-sections eventually move to a more accessible point</td>
</tr>
<tr>
<td></td>
<td></td>
<td>− shorten wire</td>
</tr>
<tr>
<td></td>
<td></td>
<td>− lead adjustment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>− change to 3 or 4 wire system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>− use the head transmitter</td>
</tr>
</tbody>
</table>
| fluctuating temperature readout even though measuring circuit of the resistance thermometer | voltage or power supply is not constant                  | Must be kept constant at < 0.1 %. Fully affects the measurement when tuned off bridge and current/voltage measurements (4-wire).

8. Wiring diagram and color coding

![Wiring diagram and color coding](image)

*Fig. 1* upper half: resistance thermometer according to DIN EN 60 751 Z-18845 lower half: thermocouple according to DIN EN 60 584
Our information regarding our products, equipment, plants and processes is based on extensive research and experience in the field of applied engineering. We are making such information available, to the best of our knowledge and in written form, without assuming any liability over and above the terms of this contract but reserving the right to make technical changes of our products at any time without prior notification. In addition, our applications engineers are available on request to provide further consultation and cooperation in solving production and application-related problems.

This however does not relieve the user from the obligation to verify the suitability of our information and recommendations before putting our products to use.

This applies particularly to deliveries destined for customers in foreign countries, especially in their obligation to ensure that no patent rights of third parties are infringed upon, including applications and processing methods which we have not expressly spelled out in writing. In case of damage or quality deficiencies, our liabilities and indemnities are limited to the same volumes as stipulated in our General Terms of Supply and Delivery.