GÜNTHER

General

operating instructions

Installation, maintenance and operation
– thermocouples and resistance thermometers

Temperature Measurement Technology
Reliable . Precise . Certified

General operating instructions

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General operating instructions

1. Introduction

This manual describes the most important points concerning general handling, assembly, operation, possible dangers, as well as possible troubleshooting in case of malfunctions and errors.
The special features when using transmitters are described in chapter 3.8 on page 8.

1.1 Basic principles of temperature measurement with thermocouples and resistance thermometers

Thermocouples and resistance thermometers convert a temperature into an electrical variable (voltage, resistance).
In both cases, these are “contacting thermometers” with a very wide temperature range between -200 °C to +2000 °C.
They represent the beginning of a series of individual components in a measuring chain that are decisive for determining the correct temperature. Therefore, the measuring point in contact with the medium and its protective armature play a very important role in the measurement, control and regulation of thermal processes!

1.2 Structure of thermocouples and resistance thermometers

In the case of both thermocouples and resistance thermometers, the temperature sensor usually consists of the measuring insert, i.e.
- the “internal components” with measuring point and
- the protective fitting, which serves to provide the best possible protection for the measuring insert.

Exceptions to this are, for example, the “mineral-insulated sheathed cables” and various “trailing elements” which are usually supplied without an additional protective fitting.

Thermocouples are usually manufactured with 1, 2 or 3, and for special applications also with several thermocouples. The measuring point is usually insulated, but in exceptional cases it can also be connected to the protection tube (e.g. to achieve fast response times).

Resistance thermometers normally have 1 or 2, occasionally 3, measuring resistors.
The measuring point is always insulated, a possible connection to the protection tube would be an insulation defect in this case.

Ideally, the type and design of the temperature sensor are coordinated with us in advance to suit the measurement task to be fulfilled and the prevailing ambient conditions, so that you receive a product that is best suited to your application.

2. Reception, control and storage of goods

2.1 Inspection of incoming goods

As individual as we produce our products for you, so individual is sometimes the necessary transport packaging.
Often, your sensors are long, very fragile assemblies, which sometimes require complex, often “unconventional” transport securing and packaging.
Therefore, it is essential that you pay attention to possible transport damage already during delivery and unpacking and document this.

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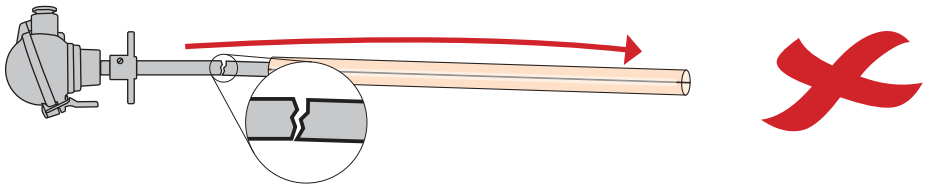
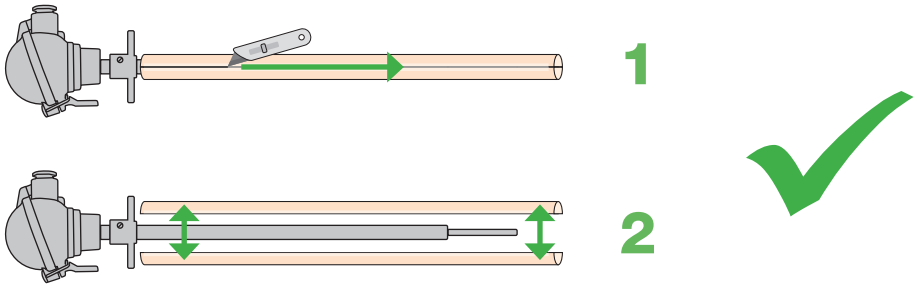
2.2 Removing the transport protection

Be sure to observe our instructions for removing the transport protection materials!
To protect fragile ceramic fittings, we usually use half-shells made of sturdy cardboard. Under no circumstances remove them by simply pulling out the thermocouple - a slight canting can cause the ceramic protection tube to break due to the leverage effect.



To remove the protective jacket, place the sensor on a stable surface and carefully cut open the adhesive strip connecting the two half-shells with a knife. You can then carefully lift out the sensor without risk of breakage.



We usually protect sensitive surfaces with plastic mesh tubes.
These can be easily pulled down for incoming goods inspection and then pulled back again after visual inspection.
Open the connection head and visually check the integrity of the connection wires and small parts.

Later complaints in this regard cannot be accepted!
In principle, make sure that the temperature sensors are handled gently.
Especially long and fragile temperature sensors have to be lifted, transported and mounted with special care.

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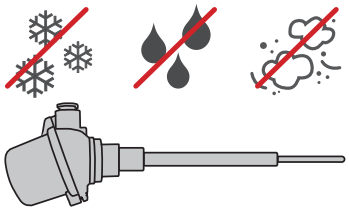
2.3 Storage



Store our products as warm as possible and above all dry and free of dust and dirt! Particularly in the case of ceramic protection tubes, as well as precious metal and molybdenum protection tubes, even small impurities caused by dirt deposits can have a considerable effect on service life.
(Air) moisture penetrating the sensor may have a negative effect on the insulation properties.
Some groups of products may (due to their design) contain components made of untreated steel or cast steel or grey cast iron, which can form "flash rust" in the event of high ambient humidity. In principle, this does not influence the operation of the sensors!
However, sealing surfaces such as connecting flanges or surfaces that come into contact with the medium should be cleaned thoroughly before installation.

If possible, store the sensor to be installed near the furnace before installation. Dry, warm conditions usually prevail there. Re-checking before installation can ensure that no damaged parts are installed in the system. This applies in particular if dry storage could not be guaranteed.

Storage times:

Under optimal conditions, unused temperature sensors can theoretically be stored for several years. However, for temperature sensors made of **mineral insulated** sheathed cables **(sheathed thermocouples, sheathed resistance thermometers, and sheathed measuring inserts),** we strongly recommend **not to exceed a storage time of maximum one year before use.** This is due to the highly hygroscopic properties of the insulation material used in them.

This restriction also applies to **thermocouples with tungsten-rhenium thermocouples.**
In addition, these sensors **should ideally be stored with the measuring point facing downwards.**

3. Installation

3.1 General installation instructions

- To avoid damage, compare the existing (previous) installation or nominal lengths before replacing temperature sensors.
- Especially when installing ceramic protective armatures, there is a risk of material breakage due to "jamming" at or in the process connection point. It is therefore essential to ensure that the temperature sensor is inserted straight!
- With horizontally installed temperature sensors, there is a risk of bending in the heated section. This changes the position of the measuring point in the process over time, which can lead to measurement inaccuracies. In addition, depending on the degree of deformation, it is possible that the sensor will have to be destroyed to be removed.
  In some cases, occasional rotation of the position of the sensor by 180° may counteract the deformation.
- Installation problems can often be solved by installing the temperature sensors at an angle, with special fastening.

3.2 Immersion depths

In general, it must be ensured that the temperature sensor (thermocouple, resistance thermometer) is in the best possible contact with the medium to be measured, **as the measuring point communicates only the temperature that it has itself assumed!**
To avoid heat conduction errors as far as possible, the following immersion depths should be observed:

- in liquids → at least 6 - 8 times the diameter of the protection tube
- in gases → at least 10 - 15 times the diameter of the protection tube

If only very short immersion depths are possible, the following apply as the lowest limit values:

- for resistance thermometers → ≥ 1 - 1.5 times the temperature-sensitive length
- for thermocouples → ≥ 30 mm - 50 mm

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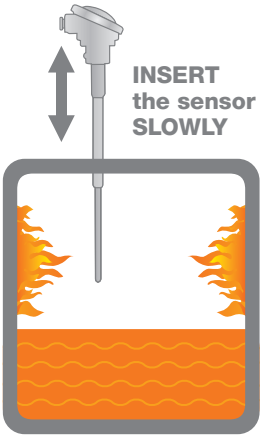
3.3 Insertion rate

Be careful when inserting the new sensor into the hot furnace atmosphere!
Avoid direct contact with flames! Especially when installing ceramic protection fittings, there is a risk of material breakage due to thermal stresses!

Please observe the recommended maximum installation rate:

Ceramic protection tubes with outer diameter up to 15 mm	max. 200 mm / minute
Ceramic protection tubes with outer diameter greater than 15 mm	max. 20 mm / minute
mono- or polycrystalline aluminumoxide	max. 30 mm / minute
Immersion thermocouples for glass or metal melts	Heat for approx. 30 minutes just above the melt surface, then immerse and lower to final position at max. 10 mm / minute.



The same values are also applicable for dismantling!

3.4 Special feature for mineral-insulated metal-sheathed cables (“MIMS”) according to DIN EN 61515

- When installing / transferring **mineral insulated** sheathed thermocouples and resistance thermometers, a minimum bending radius of 5 x outer diameter must be observed.
- Kinks or pinch points must be avoided at all times!
- For guide values for recommended limit temperatures for mineral-insulated thermocouples, please refer to Table C.1 of DIN EN 61515.
- In the case of mineral insulated **sheath resistance thermometers,** the first 50 mm of the sensor (measured from the measuring tip) must not be deformed or mechanically stressed.

3.5 Process connections

- Ensure the correct selection of the process connection in advance with regard to your specific requirements (tightness, temperature resistance, adjustment possibility, corrosion resistance, material compatibility, etc.).
- If very high pressures occur in your application, the temperature sensor may have to be additionally fixed mechanically (e.g. form-fitting) on the system side for safety reasons. Measures in this regard are the responsibility of the operator.
- In the case of process connections for welding (weld-in protective sleeves Form4, etc.), remove the measuring insert before the welding process.
- In the case of welded-on blind flanges, screw-in spigots, etc., corresponding gaskets and connecting elements such as bolts, nuts, etc. are normally not included in the scope of delivery.

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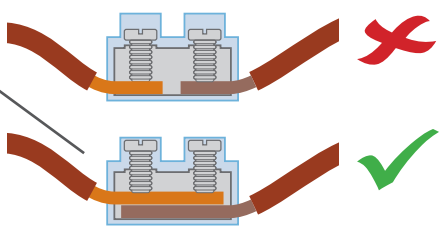
3.6 Electrical connections

The connection of thermocouples and resistance thermometers should generally be carried out by trained specialists!

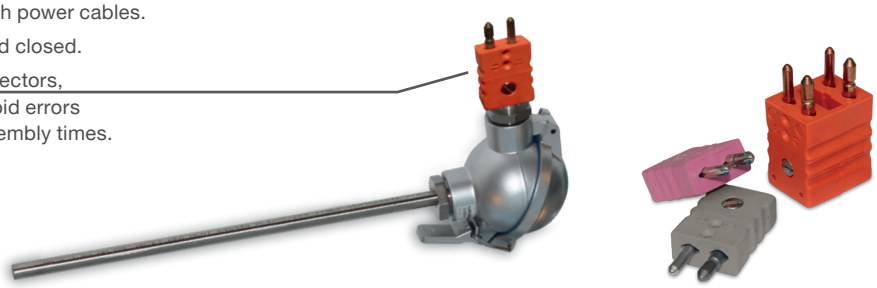
- The connection of the thermocouple and the measuring device is made using a **compensation cable** corresponding to the type of element, observing the correct polarity. Copper wires are not permitted!
- The resistance thermometer and the measuring instrument are connected using a 2-wire connection or, for more accurate measurements, a 3-wire connection or a 4-wire connection. Copper wires are used for this purpose.
  In the case of a 2-wire connection, a circuit compensation must be carried out, since in this case, unlike in the case of a 3-wire and 4-wire connection, the circuit resistance is not compensated.
- When connecting by means of terminal blocks, plug connectors, terminal clamps and luster terminals, make sure that good contact is made when closing the terminal screws! This applies in particular to the connection of very thin individual wires together with larger cable cross-sections in sheath terminals! Errors due to poor execution of these connections / contacts are not always clearly recognizable, and can therefore easily lead to signal interruptions or measurement errors, and thus to defects in your product / process or damage to your equipment!
- The connection of the suitable cable to the terminals of the connection socket is carried out according to the plus / minus or the colour markings.
  Corresponding connection diagrams can be found in the appendix of these operating instructions on pages 15 - 20.
- The markings of the positive and negative conductors on thermocouple compensating cables are internationally standardized.
- For DIN EN (or IEC) 60584, which is valid in Europe and far beyond, the following generally applies:
  The plus-conductor corresponds in colour to the outer colour of the cable, **the minus-conductor is always white!**
  The exact assignment can be found in the colour table in the appendix of this operating manual on page 21.
- For resistance thermometers, the connection or the colour coding results from the standard DIN EN 60751 (see appendix page 22).

3.7 General notes when connecting temperature sensors

- Ensure cleanliness of the connecting parts and the tools!
- Do not reconnect corroded cable ends! Shorten the strands so that only bare metallic wire material is used for the new connection.
- In case of severe corrosion in the connection head, use a suitable, tight cable fitting.
- Temperatures above +150 °C must be avoided at the connection point. When using connection head transmitters, this temperature is significantly lower (see operating instructions / data sheet of the transmitter used).
  The same applies to the use of rubber seals, PVC cables, etc.
- When connecting thermocouples, do not use wire end ferrules and do not apply tinning to the wire ends! If necessary, also observe the standards or guidelines applicable to you (e.g. CQI-9, AMS, etc.), according to which the extension or connection of thermocouples is in part only permissible by means of terminals / contacts made of the respective “compensation materials”!
- Plug connections are normally designed to be protected against polarity reversal. Check in advance whether the connectors used comply with the standards or directives applicable to you. If possible, avoid further clamping or connecting points.
- When using luster terminals, crimp connectors or similar, always connect the cable ends overlapping each other to ensure a direct transition of the thermoelectric voltage (do not use butt connectors or similar).
  In addition, the potential danger from electrical interference must be taken into account.



- Avoid laying the cables together with power cables.
- Always keep the connection head lid closed.
- Also use our connection head connectors, which are available ex works, to avoid errors during connection or to reduce assembly times.



3.8 Temperature sensors with transmitter

- When installing a transmitter, the installation effort for the connection (cables, etc.) is considerably reduced. In addition, this provides a stable, uniform 4...20 mA signal and no longer requires special compensating cables.
- The transmitter is connected according to the respective connection diagram. This is printed on the built-in transmitter, as well as in the operating manual of the transmitter.
- If the transmitter is installed, make sure that the ambient temperature does not exceed the permissible value (see operating instructions / data sheet of the transmitter used). This is usually around +80 °C.

4. Removal, disposal, recycling of precious metals

4.1 Removal and disposal

- In principle, the sensors are removed in exactly the opposite way to how they are installed.
- Please note, however, that any process connection seals, e.g. made of Viton^{tm} or Teflon® or similar, may be destroyed by contact when the unit is removed while hot.
- Place the removed probe on a fireproof surface to cool down.
- Often, temperature sensors cannot be easily removed from the process connection due to deformation or caking on the protective fitting that may occur during the service life. Therefore, the fitting may have to be cut off from the inside for removal, and thus destroyed.

4.2 Recycling of precious metals

Before disposing of the parts, generally check whether they are thermocouples with precious metal thermocouple (platinum-rhodium alloys)! Do not just throw them away, but talk to us beforehand!
We will offset returned precious metal wire against your next order, issue a credit note, post the value to your precious metal account with us, or purchase these precious metals.
Separate different platinum-rhodium alloys by type if possible.

Please separate and dispose of the remaining components according to the recycling specifications applicable in your company.

General operating instructions

5. Operation of GÜNTHER temperature sensors

5.1 Servicing and maintenance

Temperature sensor and measuring circuit must be checked at regular intervals (depending on absolute temperature and environmental influences) with regard to the following points:

- Protection tube wear / destruction
- Visual inspection for cracks / corrosion
- Drifting of measured values due to aging or chemical attack
- Humidity and contamination (influences insulation resistance)
- Mechanical and chemical damage to the connecting cables (contact points)

In the thermocouple measuring circuit, an mV voltage of known magnitude is connected instead of the thermocouple.
In the resistance thermometer measuring circuit, the measuring resistor is replaced by a known fixed resistor.
In both cases, this makes it possible to determine whether the thermometer or the instrumentation is the cause of a malfunction.
In addition, in many cases there is the possibility of a comparative measurement by a calibrated reference element.

5.2 Quick analysis (for temperature sensors in removed state at room temperature)

Required measurement tools:

- Voltage meter with mV range
- Resistance meter or resistance measuring bridge
- Insulation meter with 60 - 100 V DC voltage

A thermocouple functions properly when

- $R < 20\ \Omega$ (wire $\varnothing > 0.5$ mm), but wire length and wire cross-section must be taken into account
- $R_{iso} \geq 100\ M\Omega$ (insulated thermocouple wire), $R_{iso} \geq 1000\ M\Omega$ (sheathed thermocouple)

A resistance thermometer functions properly when

- $R \approx 110\ \Omega$ (with Pt 100 IEC 751), $R_{iso} \geq 100\ M\Omega$

Use our free app “Thermodragon” to check.
You can find these in the Google PlayStore or the Apple AppStore under the search term “Thermodragon”.
A browser version is available at https://thermodragon.guenther.eu/.

General operating instructions

5.3 Errors and causes (tabular overview)

Table 1 Specific errors

Error	possible cause	possible remedy
Interferences of the measuring signal	■ Electrical/magnetic interference	■ At least 0.5 m distance between measuring and power cable when laid in parallel ■ Shielding by grounded foil/braid ■ Twisting (in pairs) of the connecting cable ■ Crossing (at right angles) of measuring and power lines
	■ Ground loops	■ Only one grounding point in the measuring circuit “floating” (not grounded)
	■ Decrease in insulation resistance	■ Dry out any moisture that may have penetrated the thermometer, if necessary. ■ Replace measuring insert ■ Check whether thermometer is possibly thermally overloaded
Response times too long	■ Incorrect mounting location - in the current shadow - near disturbing heat source	■ Choice of mounting location for optimum heat transfer between medium and measuring point
	■ Incorrect installation method - Immersion depth too shallow - Heat dissipation too large	■ Immersion depth for thermocouple = 5 x d (liquids) to 10 x d (gases); (d = protection tube diameter) ■ Ensure thermal contacts, especially for surface measurements, by means of suitable contact surfaces and/or heat transfer media.
	■ Protection tube too thick ■ Protection tube hole too large	■ Select smallest possible protection tube ■ Fill protection tube hole (if possible) with contact agent (oils, greases, etc.)
	■ Deposits on the protection tube	■ Remove during inspections, possibly change protection tube material or installation location.
Interruptions in the thermometer	■ Vibrations	■ Reinforced springs for measuring insert ■ Shorten installation length ■ Relocate measuring point ■ Special design of measuring insert and protection tube
Heavily corroded or abraded protection tube	■ Protection tube material wrong ■ Medium not as assumed	■ Check the medium, analyse the protection tube and, if necessary, select another material or provide surface protection. ■ Possibly replace the protection tube regularly as a consumable part.

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Table 2 Specific errors - thermocouples

Error	possible cause	possible remedy
Fluctuating temperature display with otherwise perfect measuring circuit design of the thermocouple	▪ Reference junction temperature or voltage is not constant	▪ The temperature of the reference junction or its supply voltage must be kept constant.
Strong deviations of the temperature display from the table values (EN 60584 -1) for thermocouples	▪ Wrong material combination for thermocouple ▪ Bad electrical contacts ▪ External voltage influences (thermoelectric voltage, galvanic voltage) ▪ Wrong compensation cable	▪ Thermocouples, connection point (head, etc.) and connecting leads check for - correct pairing for thermocouple - correct compensating cable - correct polarity of thermocouple and compensating cable - permissible ambient temperature at the connection point and the compensating cable - shorten corroded contacts

Table 3 Specific errors - resistance thermometer

Error	possible cause	possible remedy
Too high or fluctuating temperature display despite known accurate measuring resistor	▪ High cable resistance not balanced ▪ Temperature-related resistance change in resistance of the supply line	▪ If still possible: - Laying of conductors with larger cross-section possibly only from an accessible point in the measuring circuit - Shorten supply line - Cable adjustment - Change to 3- or 4-wire circuit
Fluctuating temperature display with otherwise faultless measuring circuit design	▪ Voltage or power supply not constant	▪ Must be kept constant at < 0.1%

Table 4 Specific errors when installing head transmitters/transducers

Error	possible cause	possible remedy
Signal 0 mA	▪ Supply voltage polarity reversed	▪ Connect supply voltage lines correctly
Signal < 3 or > 22 mA	▪ Sensor breakage, sensor short-circuit	▪ Check temperature sensor and cables
Signal deviations compared against expected measuring signal	▪ Load resistance too high ▪ Supply voltage incorrect ▪ Transmitter with wrong measuring range	▪ Transmitter with wrong measuring range ▪ Check power supply unit and supply voltage ▪ Check whether the measuring range of the indicator and transmitter match

General operating instructions

6. Reference measurements / Hazard sources

Reference measurements are a check of a permanently installed temperature sensor by comparing it with a temporarily inserted reference sensor (= comparison measurement).
Here, subsequent potential hazards are possible, if applicable.

6.1 Electric shock hazard

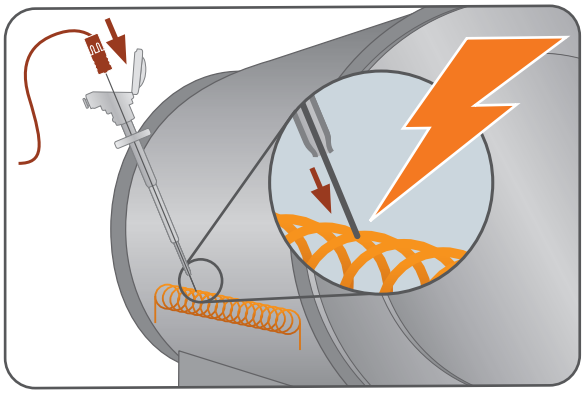
The following danger warnings apply to the testing of thermocouples in electrically heated furnaces by using the test port integrated in the connection head provided for this purpose!

In the event of a defective or pre-damaged protective fitting, there are potential hazards associated with temperature reference measurements by manually inserted temporary measuring equipment in test openings of thermocouples / resistance thermometers.

Caution! You are inserting a possibly electrically conductive object (reference thermocouple / reference resistance thermometer) into a system in operation in which possibly uninsulated electrical heating elements are active.

The thermocouples and resistance thermometers to be tested usually have suitable closed protection fittings adapted to the application. Normally, the reference test medium is introduced and used within this protective fitting.
If the connection is made in accordance with the instructions and the protective fitting is intact, the use of a suitable reference sensor is harmless in terms of occupational safety.
In addition, there are designs / applications in which the reference sensor is specifically inserted outside the thermocouple protection fitting (in parallel) into the furnace chamber, or the protection fitting is already open to the furnace interior due to its design. In the first case, the natural stop that normally limits the insertion of a reference probe through the bottom of the protection tube can be omitted (for example, due to age-related damage such as mechanical or corrosive influences at the end of the protection tube).

If such pre-damage is not noticed, or if this damage is caused by the reference sensor itself when it is inserted (protective tube base is destroyed), and at the same time a reference sensor that is not adapted to the installation length (= too long) is used, then depending on the installation position and installation direction of the test equipment, this can theoretically lead to contact between an active heating element and the test equipment by projecting too far beyond the original length!



In the event of such contact,
there is a danger to life due to electric shock!

GÜNTHER GmbH Temperaturmesstechnik assumes no liability for these potential hazards, as all these conditions are beyond our control!

We therefore recommend taking the following measures before or during the measurement:

- Have such measurements performed only by instructed qualified personnel.
- Before measuring, make sure that the protective fitting, especially its base, is intact and undamaged.
- Use reference sensors whose installation length is adapted to the length of the sensor to be checked (= natural stop).
- If you use universal reference sensors which are not length-adapted, i.e. longer, then ensure at least by means of a marking or an adjustable stop or similar that its measuring point does not project beyond the end of the sensor to be checked in the event of a fault.
- Use suitable, electrically insulating tools / gloves with VDE labeling to insert the reference sensor.

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6.2 Hazards relating to the escape of hot gases

In the event of damage to a protective fitting or an unsealed test port, uncontrolled escape of hot gases may occur under certain circumstances when opening the connection head cover / test port!
(Especially with system overpressure / chimney effect with vertical installation,...)

This also applies to gas-fired furnace systems!

We therefore recommend taking the following measures before or during the measurement:

- Have such measurements performed only by instructed qualified personnel.
- Before measuring, make sure that the protective fitting, especially its base, is intact and undamaged.
- Do not position yourself directly in front of the test port.
- Use protective gloves and goggles and close the test port immediately.

6.3 Hazard due to leaks

In vacuum processes, a defective protective fitting can cause oxygen to flow into the chamber unintentionally during heat treatment, causing considerable damage to the product and the heatsealing bands.

We therefore recommend taking the following measures before or during the measurement:

- Have such measurements performed only by instructed qualified personnel.
- Before measuring, make sure that the protective fitting, especially its base, is intact and undamaged.
- Check the sensor in advance by performing a leak test.
- Open the closed test bores slowly and carefully.
- Insert the reference sensor particularly carefully, especially towards the end, if the protective fitting is made of thin-walled ceramic material.

6.4 GÜNTHER Service

You cannot or do not want to check your thermal processes or temperature sensors yourself? Contact us! Our trained and experienced technicians will be happy to answer your questions or provide you with a non-binding service offer.

For further information please visit our homepage www.guenther.eu or contact our sales department – they will then forward you to the service employee suitable for your request.

7. Legal remarks

7.1 General remarks

“Simple” thermocouples and resistance thermometers are **passive components** which cannot be operated alone or independently, i.e. without a connecting cable and measuring device.
They are intended for installation in machines as well as partly completed machines, and are not subject to any currently valid EU directive. (Exceptions to this are sensors for so-called controlled areas, such as potentially explosive atmospheres, as well as sensors with built-in electronics, such as transmitters).
Please refer to our “Manufacturer‘s Declaration of Conformity”.

This operating manual contains **important information** for your personal safety and for avoiding damage to the system. Warning and hazard information as well as contents with high relevance are highlighted in the text.

The **intended use** of the respective sensor type requires the recommendation or approval of the system manufacturer or consultation of the user with us, and furthermore the observance of all chapters listed in this manual, such as proper transport, storage, installation, maintenance, the suitability of connections, lines, measuring devices, etc.

7.2 Exclusion of liability

Our technical application advice is always based on our best knowledge and many years of experience, or on our own tests and feedback from our customers. Nevertheless, it can only serve as a non-binding reference and does not exempt the user from carrying out his own tests or evaluations regarding the suitability for a specific application.
Frequently, we are not aware of all relevant process parameters, or these change due to repairs, maintenance or modifications to the facility.
Especially for customized special solutions, it is usually not possible to make a statement in advance about service life, drift behavior, malfunctions and the like.
The use of our products is beyond our influence and control and is therefore fundamentally the responsibility of the user.

In individual cases, it may be necessary to deviate from the common connection and assignment diagrams and standard designs listed in these operating instructions or in the applicable standards and directives for design reasons.
Changes in this regard are usually requested by or agreed with the user in advance.

GÜNTHER GmbH Temperaturmesstechnik cannot accept any liability for damage resulting from the above.

The same applies to the completeness / correctness of the information in these operating instructions.
These are regularly reviewed and corrected, and the issue is updated accordingly.
For further information in this regard, please refer to our Terms and Conditions under www.guenther.eu/gtc

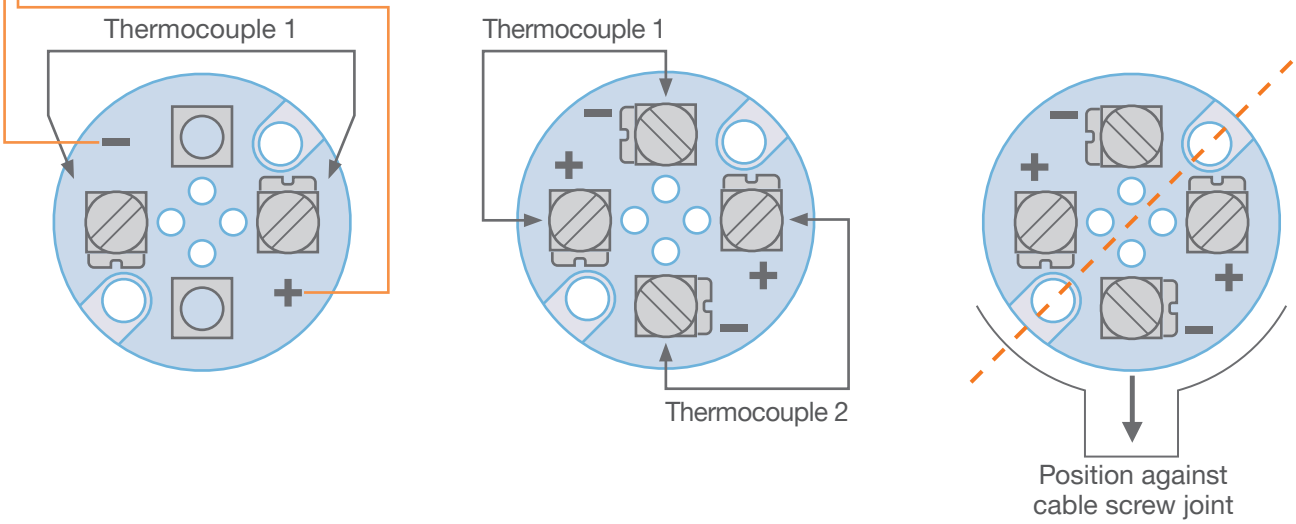
Assignment and marking of connection sockets

Designation / marking of sockets – Form L

Minus pole marking
Marking by inscription of the “minus” sign and/or wide line in thermocouple identification colours on the socket plate.

Plus pole marking
Marking by inscription of the “plus” sign and/or wide line in thermocouple identification colours on the socket plate.

Connection socket – Form L



All special cases not defined here, such as multiple thermocouples or special connection sockets, must also always be clearly and unambiguously marked so that the risk of incorrect connection is also minimized when mounting and wiring in poorly accessible places or in less than optimal lighting conditions.

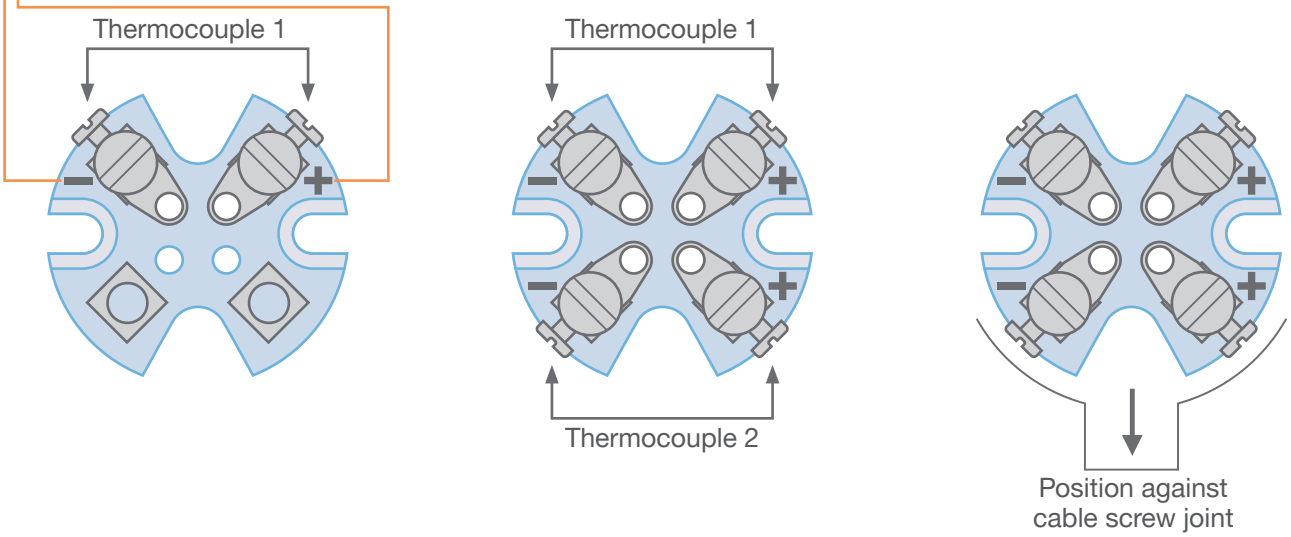
Assignment and marking of connection sockets

Designation / marking of sockets – Form B

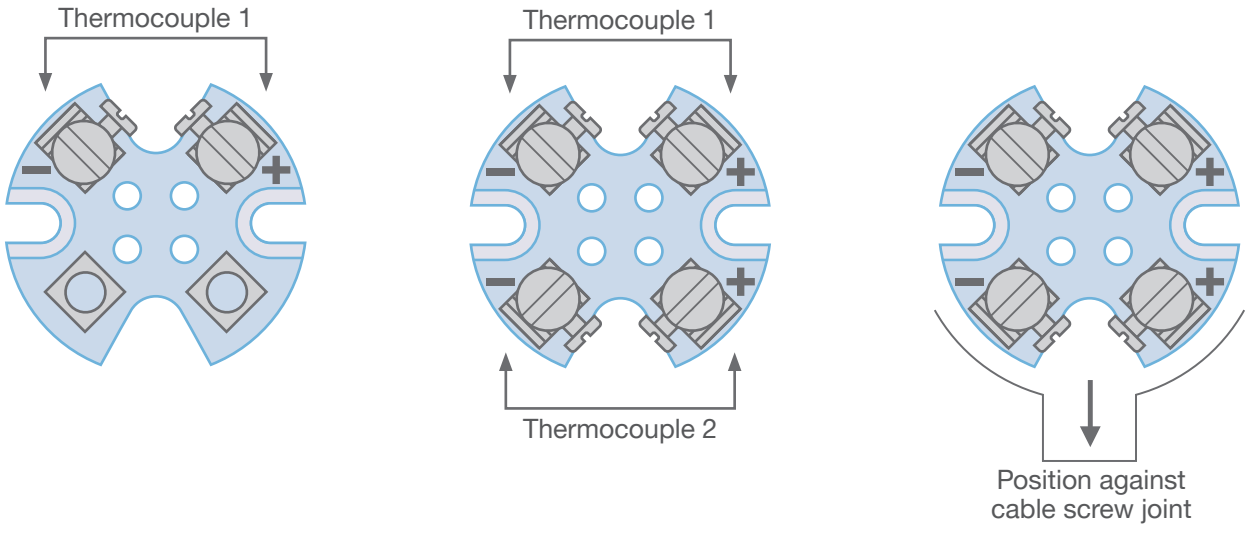
Minus pole marking
Marking by inscription of the “minus” sign and/or wide line in thermocouple identification colours on the socket plate.

Plus pole marking
Marking by inscription of the “plus” sign and/or wide line in thermocouple identification colours on the socket plate.

Connection socket – Form B non-precious



Connection socket – Form B precious metal

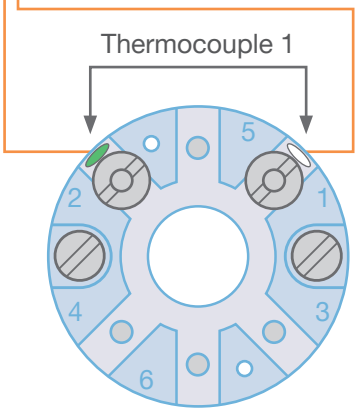


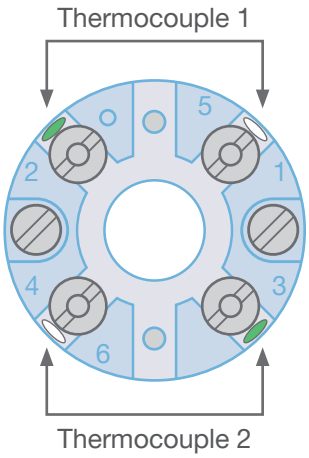
Assignment and marking of connection sockets

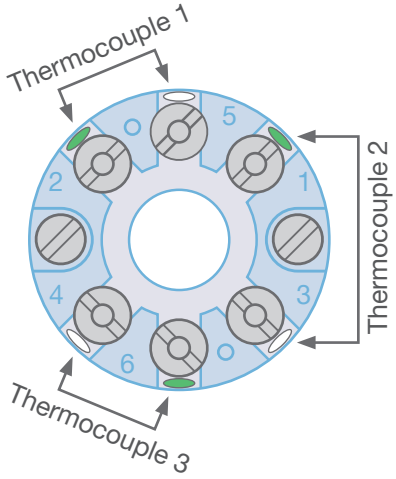
Designation / marking of sheathing sockets

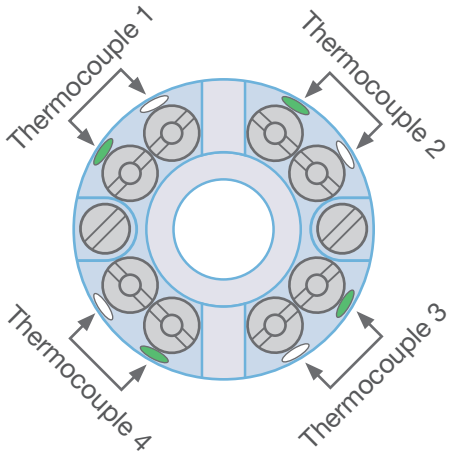
Minus pole marking
Marking by inscription of the “minus” sign and/or wide line in thermocouple identification colours on the socket plate.

Plus pole marking
Marking by inscription of the “plus” sign and/or wide line in thermocouple identification colours on the socket plate.







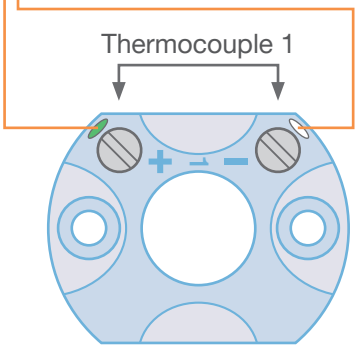


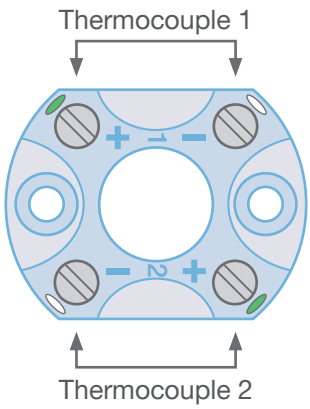
Assignment and marking of connection sockets

Designation / marking of ring sockets

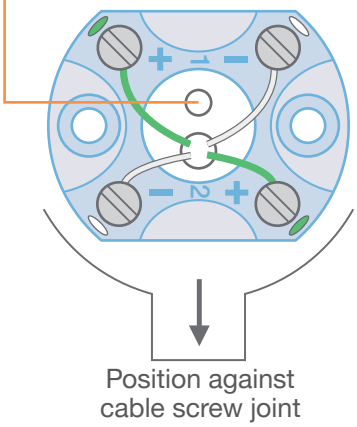
Minus pole marking
Marking by inscription of the “minus” sign and/or wide line in thermocouple identification colours on the socket plate.

Plus pole marking
Marking by inscription of the “plus” sign and/or wide line in thermocouple identification colours on the socket plate.





Testable elements with test opening
The position of the test opening is always opposite the cable connection



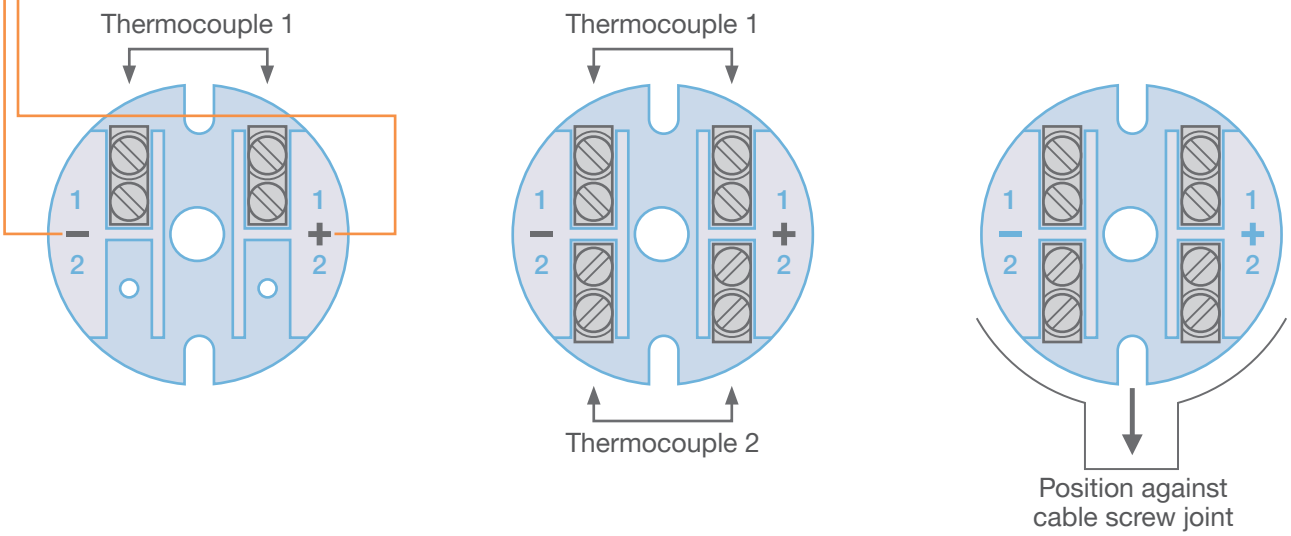
Assignment and marking of connection sockets

Designation / marking of sockets – Form A, precious metal

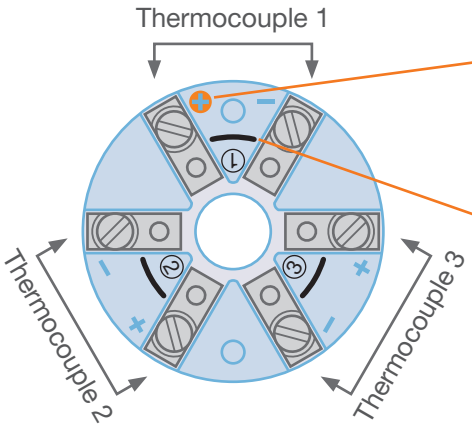
Minus pole marking
Marking by inscription of the “minus” sign and/or wide line in thermocouple identification colours on the socket plate.

Plus pole marking
Marking by inscription of the “plus” sign and/or wide line in thermocouple identification colours on the socket plate.

Connection socket – Form A precious metal



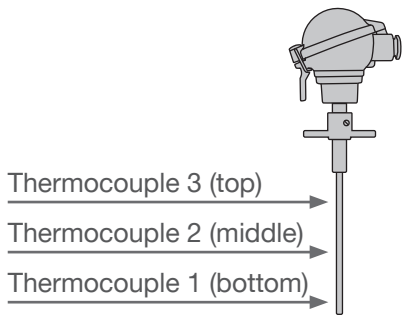
Special case 6-pole



Plus pole marking
Marking with waterproof felt-tip pen in the existing “plus recess” directly next to the terminal block in thermocouple identification colour e.g. PtRh-Pt (type S = orange)

In addition, in the case of a 6-pole socket,
the connection line should be marked with a waterproof black felt-tip pen in such a way that the connection between the terminal blocks can be recognized.

Markings for multi-point thermocouples



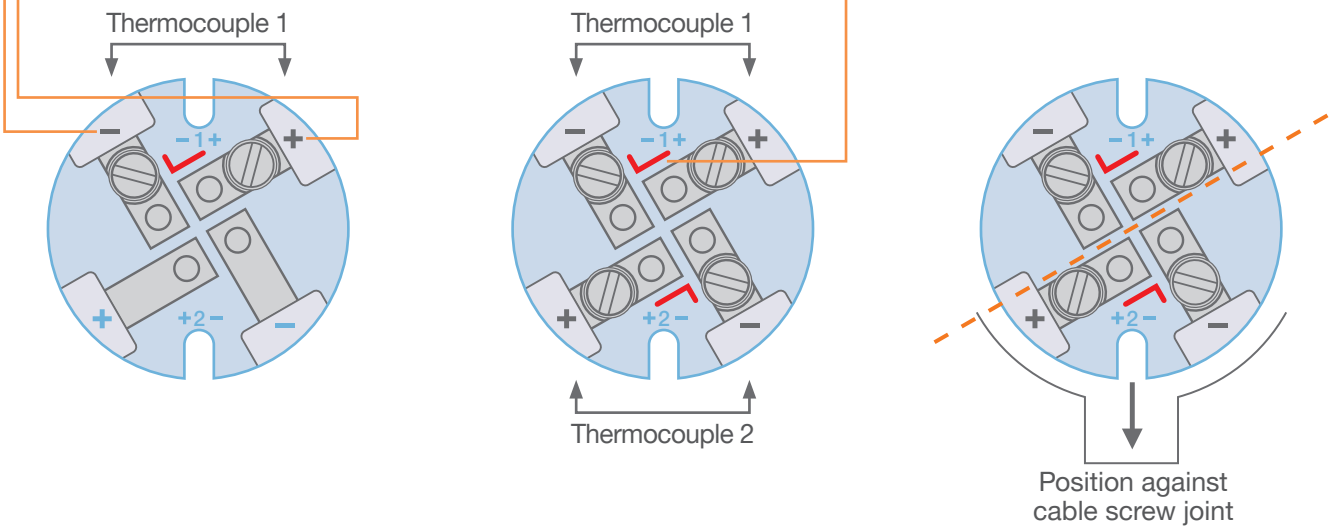
Assignment and marking of connection sockets

Designation / marking of sockets – Form A, non-precious metal

Minus pole marking
Marking by inscription of the “minus” sign and/or wide line in thermocouple identification colours on the socket plate.

Plus pole marking
Marking by inscription of the “plus” sign and/or wide line in thermocouple identification colours on the socket plate.

Additional markings
Element-specific colour marking with waterproof, coloured felt-tip pen so that the affiliation of the clamping blocks is recognizable.



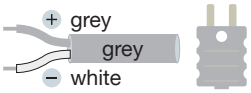
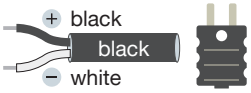
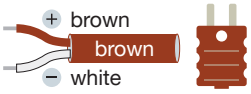
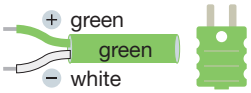
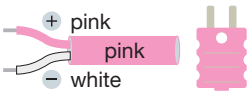
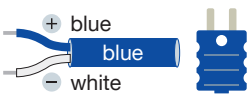
Farbkennzeichnungen und Grenzabweichungen

Colour-markings

of compensation and thermocouple cables,
as well as thermocouple plugs according to DIN EN 60584

Limit deviations

according to DIN EN 60584-2
(Reference point 0 °C)

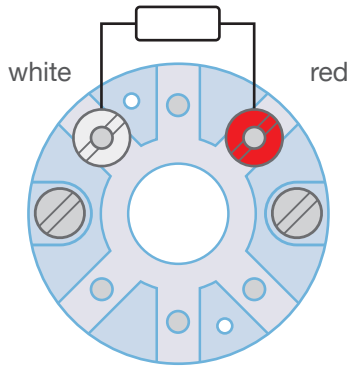
Type	Thermocouple	Colour-marking	Tolerance Class 1	Tolerance Class 2
Type R	Pt13Rh-Pt		0 °C to 1100 °C (±) 1,0 °C 1100 °C to 1600 °C (±) [1+0,003(t-1100)] °C	0 °C to 600 °C (±) 1,5 °C 600 °C to 1600 °C (±) 0,0025 x [t]
Type S	Pt10Rh-Pt		0 °C to 1100 °C (±) 1,0 °C 1100 °C to 1600 °C (±) [1+0,003(t-1100)] °C	0 °C to 600 °C (±) 1,5 °C 600 °C to 1600 °C (±) 0,0025 x [t]
Type B	Pt30Rh-Pt6Rh		- - - -	- - 600 °C to 1700 °C (±) 0,0025 x [t]
Type J	Fe-CuNi		-40 °C to 375 °C (±) 1,5 °C 375 °C to 750 °C (±) 0,004 x [t]	-40 °C to 333 °C (±) 2,5 °C 333 °C to 750 °C (±) 0,0075 x [t]
Type T	Cu-CuNi		-40 °C to 125 °C (±) 0,5 °C 125 °C to 350 °C (±) 0,004 x [t]	-40 °C to 133 °C (±) 1,0 °C 133 °C to 350 °C (±) 0,0075 x [t]
Type E	NiCr-CuNi		-40 °C to 375 °C (±) 1,5 °C 375 °C to 800 °C (±) 0,004 x [t]	-40 °C to 333 °C (±) 2,5 °C 333 °C to 900 °C (±) 0,0075 x [t]
Type K	NiCr-Ni		-40 °C to 375 °C (±) 1,5 °C 375 °C to 1000 °C (±) 0,004 x [t]	-40 °C to 333 °C (±) 2,5 °C 333 °C to 1200 °C (±) 0,0075 x [t]
Type N	NiCrSi-NiSi		-40 °C to 375 °C (±) 1,5 °C 375 °C to 1000 °C (±) 0,004 x [t]	-40 °C to 333 °C (±) 2,5 °C 333 °C to 1200 °C (±) 0,0075 x [t]
Type C	W5Re-W26Re		- - - -	- - 426 °C to 2315 °C (±) 0,01 x [t]
Type A	W5Re-W20Re		- - - -	- - 1000 °C to 2500 °C (±) 0,01 x [t]

The higher value applies in each case (t = numerical value of the temperature in °C)

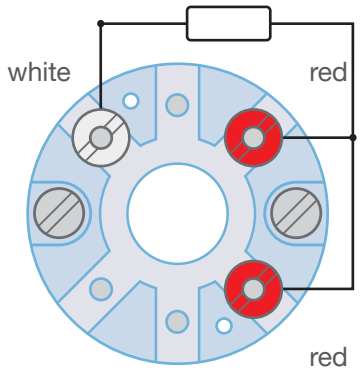
Color coding when connecting resistance thermometers

Marking of resistance thermometer measuring inserts

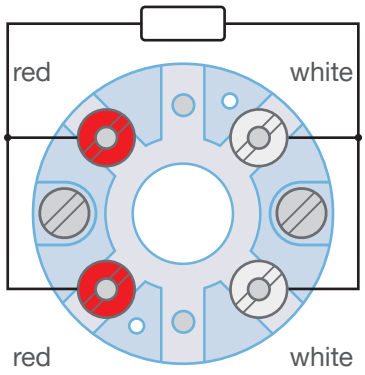
1xPt100 2-wire-connection



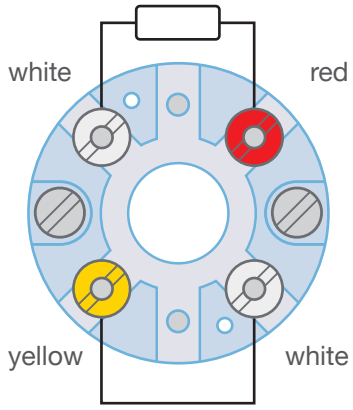
1xPt100 3-wire-connection



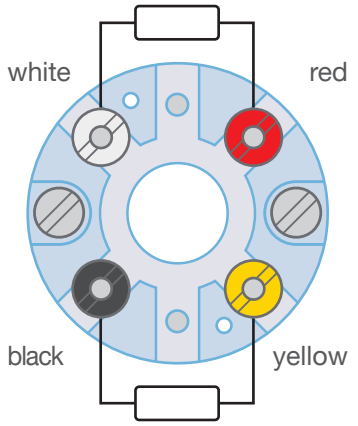
1xPt100 4-wire-connection



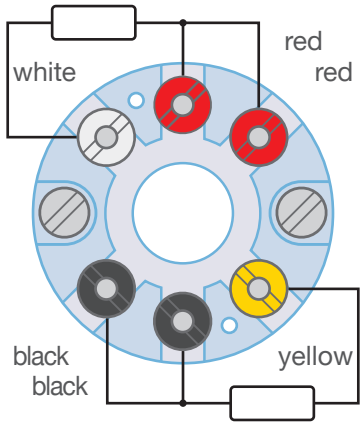
1xPt100 with loop



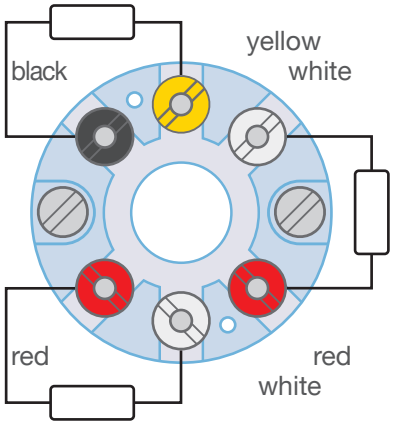
2xPt100 2-wire-connection



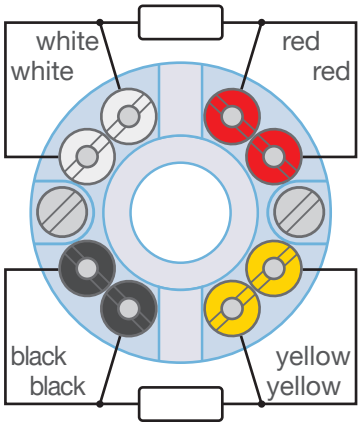
2xPt100 3-wire-connection



3xPt100 2-wire-connection



2xPt100 4-wire-connection

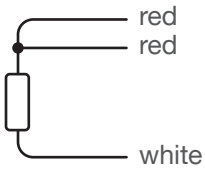


Color coding when connecting resistance thermometers

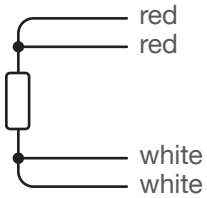
Connection types for resistance thermometers according to DIN EN 60751

1xPt100 2-wire connection

1xPt100 3-wire connection

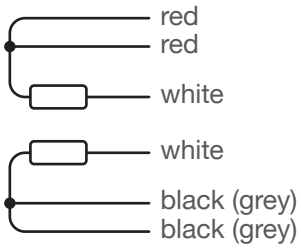


1xPt100 4-wire connection

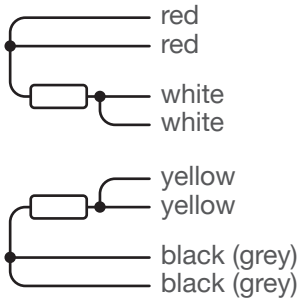


2xPt100 2-wire connection

2xPt100 3-wire connection



2xPt100 4-wire connection



Depending on the connecting cable used, deviations in the conductor colours are possible, if the measuring circuits remain clearly assignable.

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