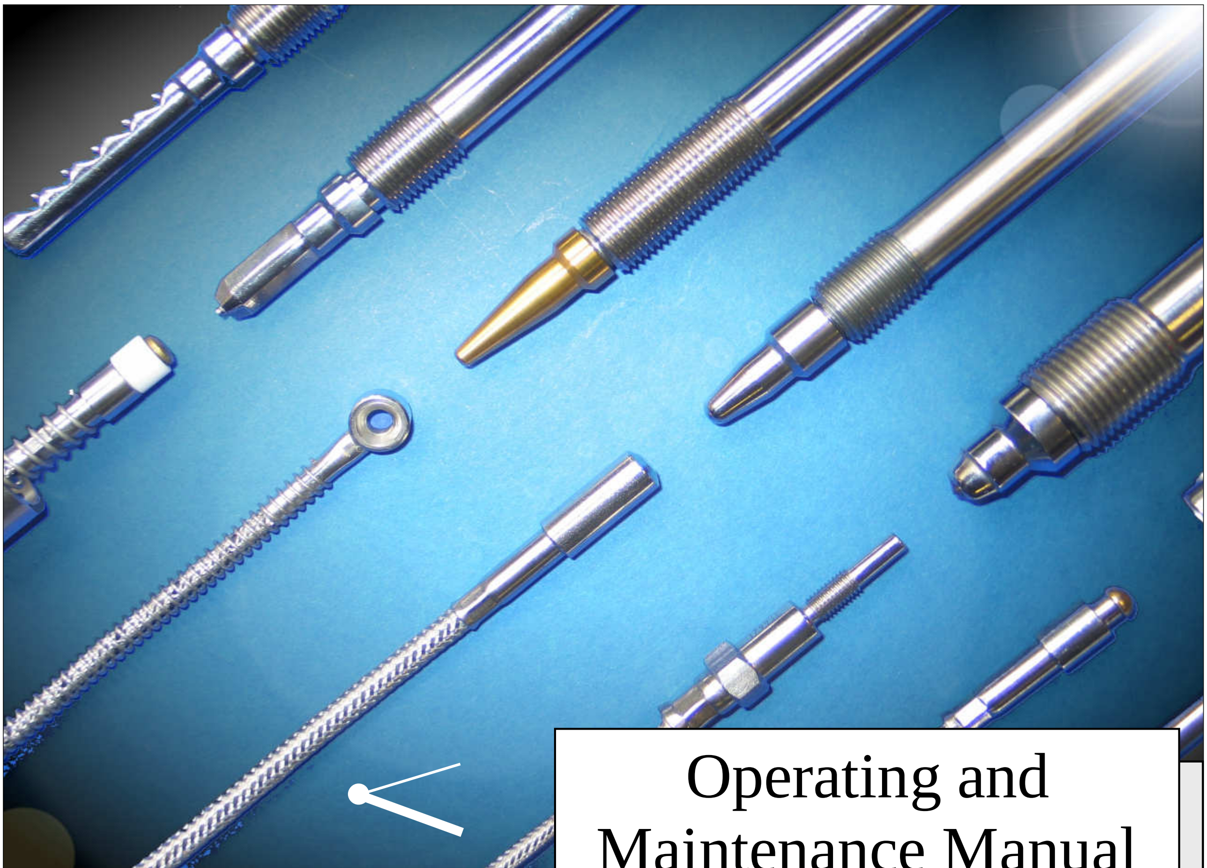
Thermocouples



Operating and
Maintenance Manual
English

Operating and Maintenance Manual Thermocouples

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Subject to alterations

1 General Information

Please read these operating instructions carefully and in full before assembling and connecting the sensor! If damage occurs through non-compliance with the operating manual, the warranty claim will expire. We do not assume liability for consequential damages.

Warranty:

We grant a warranty of 24 months from purchase date for the sensor.

The warranty covers the free-of-charge rectification of defects which are evidentially due to the use of faulty materials or imperfect execution. The damaged device must be sent in immediately to the manufacturer after the defect becomes known and must be accompanied by the purchase docket and an error description.

Further going claims shall be excluded.

The liability for defects does not refer to natural wear, transport damages as well as damage as a result of non-compliance with the installation instructions, installation provisions customary in a country or due to incorrect installation.

The manufacturer is not liable for damages which have not affected the item of delivery itself, in particular not for indirect or consequential damages or financial losses in connection with this product.

We retain the right to repair, rework, spare parts delivery or reimbursement of the purchase price.

If our identification (serial number) is removed, a warranty claim cannot be made.

The product is manufactured by:

Gräff GmbH
Temperatur-, Mess- und Regeltechnik
Bonner Strasse 54
D-53842 Troisdorf

2 Functionality

A thermocouple sensor is a conductor pair made of different materials, which is connected at one end and is part of a device which uses the thermo-electric effect for temperature measurement. When heating up a metal, the electrons start to move more and more, dependent on the temperature. This creates a certain voltage which also increases in relation to the temperature increase. When using two different metals, the electrons move at different speed in each material. In the course of this, one receives two different voltages. In the case of temperature measuring technology the differential voltage of the two materials is measured and put in relation to the temperature. This relation does not run precisely linear, and must be calculated mathematically differently according to each thermocouple.
The reference junction is the connection point of the thermocouple which lies at a known (reference point) temperature and which is compared with the measuring temperature.

2.1 Thermo Lines and Compensating Lines

Thermo lines and compensating lines are used for the electrical connection between the open ends of a thermocouple and the reference junction in cases where the sides of the thermocouple are not directly connected to the reference junction.

Thermo lines are produced with conductors, which have the same rated nominal composition as that of the corresponding thermocouple.

Compensating lines are made of conductors which have a different rated nominal composition as the corresponding thermocouple.

2.2 Type “J” Fe-CuNi

The Fe-CuNi element is the most commonly used thermocouple of all and must not be confused with the “old Type L” which is laid down in DIN 43710. In addition to traditional reasons, the causes for this are based on its low price and the comparatively high thermoelectric voltage. This thermocouple is one of the few which can be used in aggressive environments. It is used in the lower to medium temperature range. However, at temperatures from 550℃ the danger of oxidation is very high. Th e maximum temperature for permanent applications is rated at 700℃; short-term measurem ents can be carried out up to 750℃. At 769℃ the iron leg undergoes a magnetic conversion and at 910℃ a change of the crystalline structure. Both effects affect a lasting change of the output signal. If the thermocouple is used in a moist environment, the unprotected iron leg will rust. In the presence of sulphurous gases above 500℃ there will be a light embrittlement of the iron. The Fe-CuNi element is also widely used as sheath thermocouple.

2.3 Type “K” Ni-CrNi

The Ni-CrNi element was mainly developed for oxidising environments, it is mainly used in temperatures above 500℃. At temperatures above 750 ℃ unprotected use should be avoided as the oxidation rate rises strongly. The same applies for the use in sulphurous, oxidising or reducing atmosphere. The damage incurred thereby leads to irreversible changes of the thermo-electrical properties which lead to permanent measuring deviations. When used in a vacuum and at high temperatures the vacuum sensitivity must be observed, as the chrome diffuses slowly from the positive leg. When oxygen or water vapour can act directly on the element, so-called “green rot” can occur. This results in a very large measurement error. In the temperature range of 400℃ to 600℃, the positive l eg undergoes reversible structural change which amounts up to 5K change of the output signal. One can counteract this effect with artificial pre-aging of the element.

2.4 Sheath Elements

Sheath thermocouples are thermocouples which are manufactured from sheath thermocouple cables. Sheath thermocouple cables are f***lexible*** metal-sheathed cables with conductors which are isolated from one another by compacted metal oxide.

2.5 Sealed Thermocouple

A measuring point which is electrically connected with the outer sheath. This results in improved properties for the sensor response time.

2.6 Insulated Thermocouple

A measuring point which is arranged insulated from the outer sheath.

A poor insulation resistance causes moisture which penetrates into the insulation and which can result in distinct measuring faults. The sensors are therefore generally hermetically sealed. The measuring insert itself is also sealed to avoid penetration of moisture into the probe tube. Measuring inserts can be exchanged safely as they represent a closed unit.

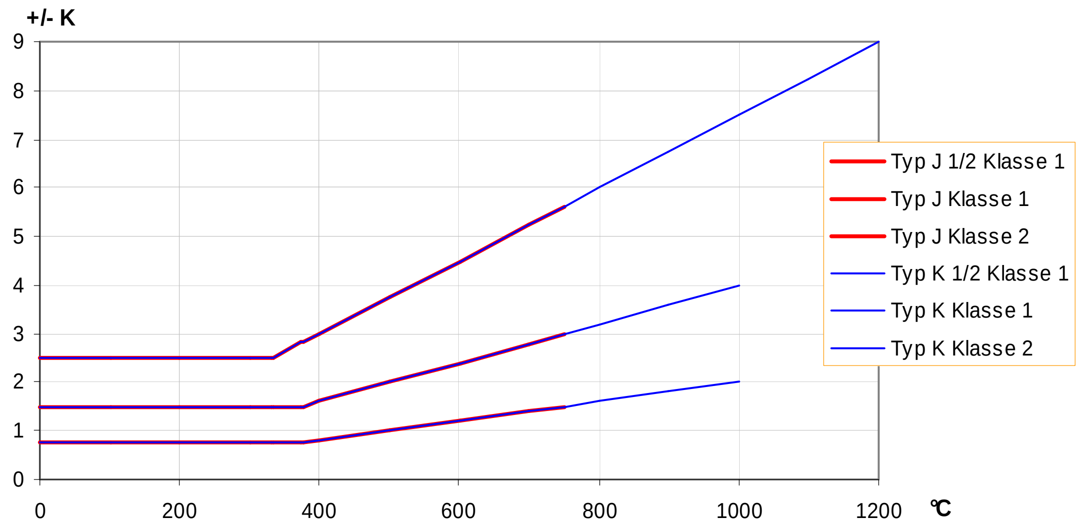
2.7 Standardization and Tolerances

Please note that these tolerance data only refer to the temperature sensor and any errors in the complete measuring system must be added to this.

Thermocouple Type	Standard	Measuring range	Colour Codes		
				Internat. IEC 584	Germany DIN 43714
J (Fe-CuNi)	DIN EN 60584	-40 to +750℃	Sheath Positive terminal Negative terminal	Black Black White	
L (Fe-CuNi)	DIN EN 43710 *Old standard was withdrawn in 1994*	-100 to +900℃	Sheath Positive terminal Negative terminal		Blue Re Blue
K (NiCr-Ni)	DIN EN 60584	-40 to +1200℃	Sheath Positive terminal Negative terminal	Green Green White	Green Red Green

Tolerance Classes for Thermocouples

Type	*Class*	*Temperature range*	*Tolerance*
J	**1/2 Class 1**	**-40℃ to 375℃**	**+/- 0.75 K**
		+375℃ to 750℃	**+/- 0.002 * T**
	Class 1	-40℃ to 375℃	+/- 1.5 K
		+375℃ to 750℃	+/- 0.004 * T
	Class 2	**-40℃ to 375℃**	**+/- 2.5 K**
		+375℃ to 750℃	**+/- 0.0075 * T**
K	1/2 Class 1	-40℃ to 375℃	+/- 0.75 K
		+375℃ to 1000℃	+/- 0.002 * T
	Class 1	**-40℃ to 375℃**	**+/- 1.5 K**
		+375℃ to 1000℃	**+/- 0.004 * T**
	Class 2	-40℃ to 333℃	+/- 2.5 K
		+333℃ to 1200℃	+/- 0.0075 * T



2.8 Response Time

Due to the thermal resistance in the sensor, this will never react immediately, instead always with a delay. This causes a short-time measuring error owing to a rapid temperature change of the measuring medium and the lag of the quantity to be measured. How fast the thermometer responds depends, first of all on the ratio of the thermal resistance to the heat storage capacity of the thermometer. This means that the greater the heat resistance is, the slower the temperature sensor will heat up, which means that the measuring error exists for a longer period. For short response times, small sensors and thin materials with good heat conducting properties should be used, provided mechanical load will permit this. Air gaps represent a very large heat resistance. Heat conducting paste, resp. metal oxide in which the sensor is imbedded, are a remedy here. (The choice of the correct thermal transfer medium is dependent on the operating temperature). Thermocouples, due to their lower thermal mass, have a lower response time on principle than resistance thermometers. This mainly applies to sheath thermocouples. As most thermocouples are, however, also inserted in a protective pipe, this effect relativises itself. In general, the response time increases with increasing protective pipe diameter.

The ninety percent time T09 provides information about the period in which 90% of the measured value is reached. With the help of this time, one can compare the response time of different sensors.

2.9 The correct choice

The sensor type and the conductor must be chosen very carefully to comply with the requirements. The main focus is on the temperature range and the impact of the medium to be measured (corroding or conducting). Normal soldered connections of the connecting cables with the measuring resistance cannot be used at more than 170℃. That is why nearly all (except in the case of special requirements) connections are carried out with the laser. When using this method, there are no thermo voltages which can falsify the measuring result.

2.10 Temperature Sensor with Connection Head

Such sensors have a modular design. They are composed of the measuring insert, the protective pipe, the connection head and the therein contained terminal base as well as possibly flanges or clamp screw connections. Measuring inserts are ready-made units consisting of temperature sensor and terminal base. These are inserted in the protective pipe, which is frequently made of stainless steel. The base plate of the insert tube fits flush with the base plate of the protective pipe to guarantee good thermal transition. The fastening screws of the measuring insert lie on springs, so that contact flush with the base is guaranteed even in the case of different longitudinal expansion of insert tube and protective pipe. This way, the measuring insert can be exchanged more easily later on.
There is also the possibility of manufacturing measuring inserts with integrated two-wire measuring transducer.
If a measuring insert is not used the temperature sensor is located directly in the protective pipe, imbedded in aluminium oxide or heat conducting medium. This has the advantage that better heat transfer of the sensor is guaranteed. However, the disadvantage is that later exchange of the sensor is not possible.
If a thermowell is used, a thermometer can be removed without having to depressurize the system or emptying it. This is a type of protective pipe, which is firmly installed at the measuring site into which the thermometer is slid and affixed. As the thermowell comes into direct contact with the measuring medium, it has the same requirements with regard to chemical and mechanical resistance as are otherwise placed on the protective pipe.
Materials used for the connection heads are cast iron, aluminium or plastic.

3 Operating the Sensor

1. Remove thermometer from packaging and check for transport damage.
2. Check construction dimensions: Diameter, measuring surface, cable length, screw-in thread resp. mounting parts must correspond to the ordered design.
3. Using a suitable seal, screw the temperature sensor into the provided sensor bore with a suitably sized spanner, so that the sensor tip has heat-conducting contact with the medium to be measured.
4. Connect measuring lead according to the wiring diagram.
5. The maximum operating temperature may not be exceeded.
6. A special maintenance is not necessary.

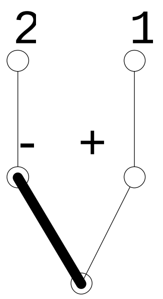
3.1 Please observe the warnings listed below!

- **Avoid twisting the connecting cables**
- **There must be no mechanical tensile load on the cable**
- **The temperature range of the expansion / measuring tip / cable must be heeded**
- **In the case of non-moisture-proof design, moisture may not act on the cable / measuring bush**
- **Vibrations and oscillations must be avoided in the case of standard designs. Articles specially provided for this are excepted (see Q-characteristics).**
- **Only use suitable tools for installation**
- **Structural changes to the sensors, resp. other applications are not permitted**
- **Mechanical loads can destroy the temperature sensor**

If it must be assumed that a hazard-free operation is no longer possible for man and machine, the sensor must be taken out of operation and secured against unintentional operation. It must be assumed that hazard-free operation is no longer possible when:

- **the sensor or the connecting cable show visible damage**
- **the sensor no longer works according to its specifications**
- **after serious transport stress**

3.2 Connection



Fe-CuNi “L“ : + = rot / red
- = blau / blue

Fe-CuNi “J“ : + = schwarz / black
- = weiß / white

NiCr-Ni “K“ + = grün/ green
- = weiß / white

Connector pin assignment

Please see our quality characteristics for connector pin assignment.

4 Possible Error Sources

- Humidity
- Connection terminals (terminal material not made of thermal material)
- Electromagnetic disturbance variables

Literature: Matthias Nau; Elektrische Temperaturmessung (*Electrical Temperature Measurement*); Fulda 2003