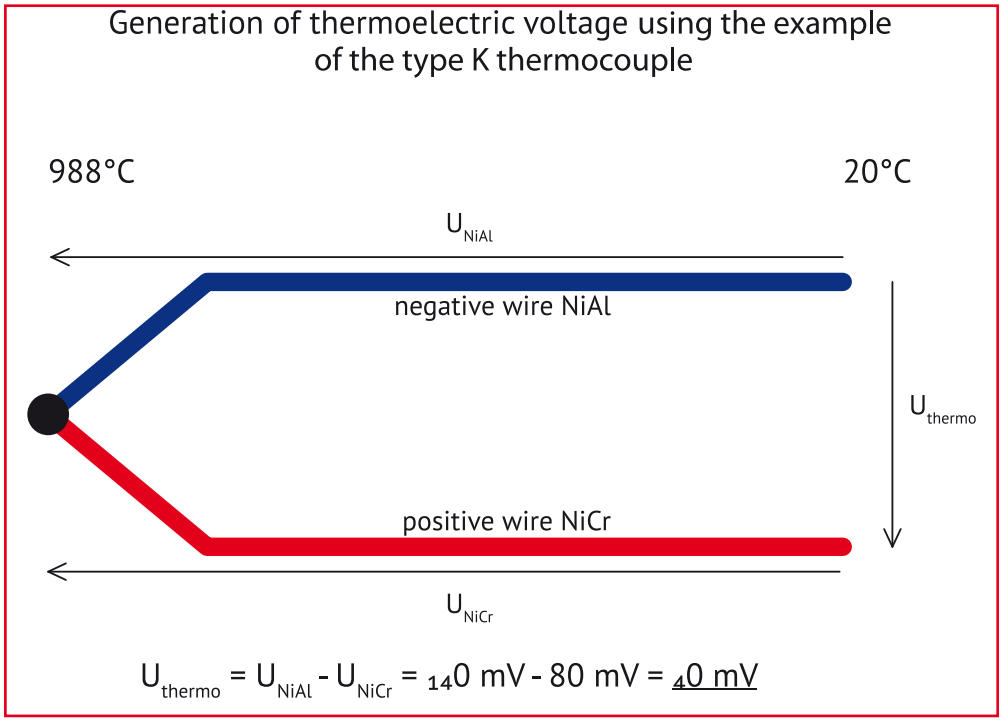
General information about thermocouples

Thermocouple thermometers (also referred to as thermocouples) are used in many areas of temperature measurement. They are characterized by a high flexibility of construction and a fast response.

Especially in areas above 500 ° C thermocouples are the most common.

The thermocouple voltage



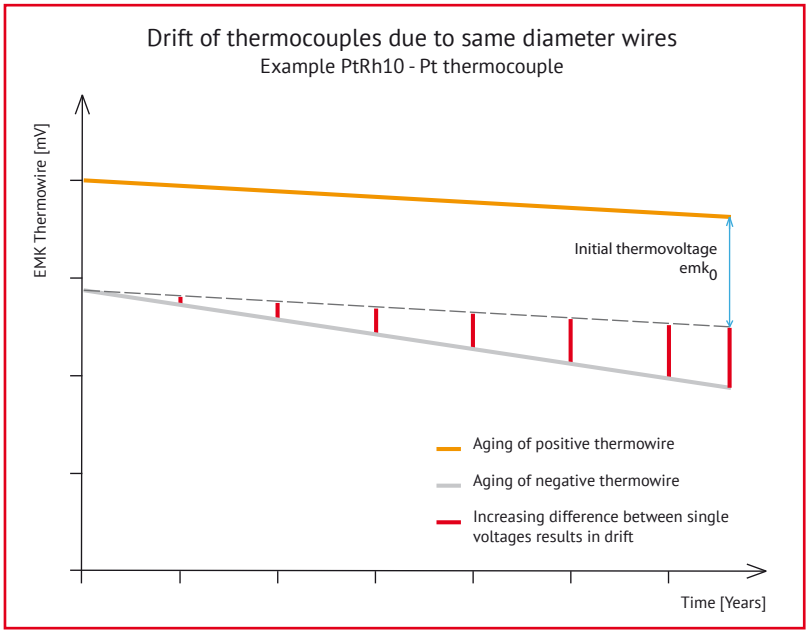
The thermocouple consists of two wires, which consist of different alloys. Each of these wires develops a certain oltage as soon as one end is warmer than the other. If you now connect both wires, then the difference of the respective voltage in the wire can be measured. This difference is referred to as thermoelectric voltage.

Different alloy pairings have proven to be advantageous because they have an almost linear voltage profile to the temperature. It is important to know that the actual thermoelectric voltage arises in the respective wire and that it can not be measured.

Type	Positive ire [plus]	Negative wire [minus]	Color DIN [plus / minus]	Temperature range [°C]
J	CuNi	Fe	black / white	-200 +750
K	NiCr	NiAl	green / white	-200 +1100
N	NiCrSi	NiSi	pink / white	-200 +1200
S	PtRh10%	Pt	orange / white	0 +1600
R	PtRh13%	Pt	orange / white	0 +1600
B	PtRh30%	PtRh6%	grey / white	+600 +1700
C	WRe25%	WRe5%	red / white	0 +2200

Deviation / Drift

In DIN EN 60584-1, the thermovoltages are given for the respective alloy pairs and temperatures. However, as these are the result of a difference in the true thermoelectric voltage (namely, that which arises in the wire), the values can only be considered approximate.



In addition, manufacturing factors such as the homogeneity and composition of the alloy of the thermo-wire play a decisive role in the development of the thermoelectric voltage. Accordingly, deviations of the thermo-electric voltage are an unavoidable fact. This is taken into account in DIN EN 60584-2, in which the permissible deviations are divided into classes.

Type	Class 1	Class 2	Class 3
Type J			
Temperature range	-40°C to 375°C	-40°C to 333°C	-
Max. error.	± 1,5 °C	± 2,5 °C	-
Temperature range	375°C to 750°C	333°C to 750°C	-
Max. error.	± 0,4% · | *t* |	± 0,75% · | *t* |	-
Type K, Type N			
Temperature range	-40°C to 375°C	-40°C to 333°C	-167°C to +40°C
Max. error.	± 1,5 °C	± 2,5 °C	± 1,5 °C
Temperature range	375°C to 1200°C	333°C to 1200°C	-200°C to -167°C
Max. error.	± 0,4% · | *t* |	± 0,75% · | *t* |	± 1,5% · | *t* |
Type S, Type R			
Temperature range	0°C to 1100°C	0°C to 600°C	-
Max. error.	± 1,0 °C	± 1,5 °C	-
Temperature range	1100°C to 1600°C	600°C to 1600°C	-
Max. error.	± [1 + 0,3% · (*t* - 1100)]°C	± 0,25% · | *t* |	-
Type B			
Temperature range	-	-	600°C to 800°C
Max. error.	-	-	± 4,0 °C
Temperature range	-	600°C - 1700°C	800°C to 1700°C
Max. error.	-	± 0,25% · | *t* |	± 0,5% · | *t* |

Deviation / Drift

The chemical change of the alloys, for example due to thermal aging or chemical contamination, also changes the thermoelectric property. This causes thermal stresses to arise which no longer correspond to the original state assumed in the standard. This is called drift, which, depending on the type of damage, can develop at different rates.Ausführungen

Basically, the thermocouples are divided into three different versions:

- unprotected
- protected by metallic sheath
- protected in ceramic / metallic thermowells

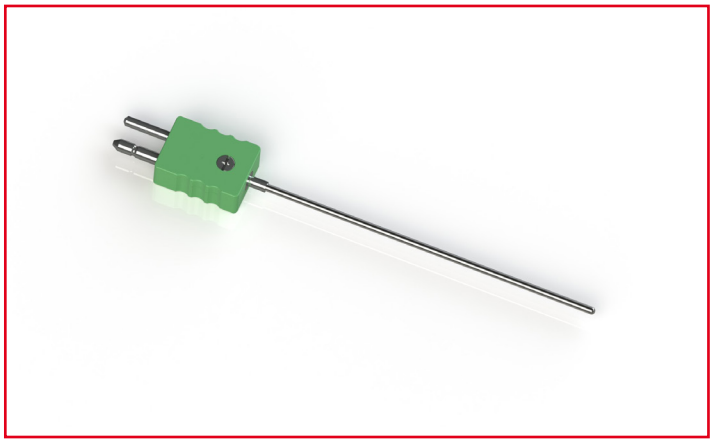
The remarks will briefly be described below.

Unprotected

Here, the bare thermo wire is used, which is only protected by insulators from a short circuit. These insulators are often ceramic sleeves which are threaded onto the wire. This is true in areas where the thermowire is not chemically affected and requires a very fast response time. For example, tungsten / rhenium thermocouples are used in hydrogen stoves in this embodiment.

Protected by metallic coat

Often referred to as coat or towed thermocouple execution is most commonly used. Here, the thermocouple wires are electrically insulated by an oxide powder (usually magnesium oxide) and fixed in a continuous tube made of stainless steel. This is rolled on coils and is available from very small diameters of 0.1 mm for medical applications to several millimeters Ø.



As sheath different types of stainless steel can be found according to the chemical requirements. In the area of heat treatment, versions in W.14841 or W2.4816 (Inconel 600) can often be found. But exotic designs, such as platinum / rhodium alloys, are sometimes found.

In addition to the very inexpensive production of the endless tube, the flexibility of the jacket thermocouples is another advantage.

Protected in metallic / ceramic thermowells

Particularly in areas with high thermal / mechanical requirements, additional protection mechanisms had to be developed to allow correct measurement.

thermo-control thermocouples

For example, in the field of heat treatment systems, high thermal loads often lead to mechanical deformations of the sheath thermocouples described above. To prevent this, the jacket thermocouples were placed in an additional metallic protective tube, so that the measurement always takes place in the same place.

thermo-control Körtvélyessy GmbH was one of the first manufacturers to produce thermocouples with thin-walled ceramic thermowells at the end of the 1980s.

These have the great advantage that virtually no deformation takes place at 1800°C. Due to the thin-walled design also very good properties against thermal shock are given, as well as an improved reaction time to temperature fluctuations.

The figure above shows a thermo-control Körtvélyessy GmbH shielding gas thermocouple, in which two single crystal Al_2O_3 thermowells have been used.

thermo-control thermocouples

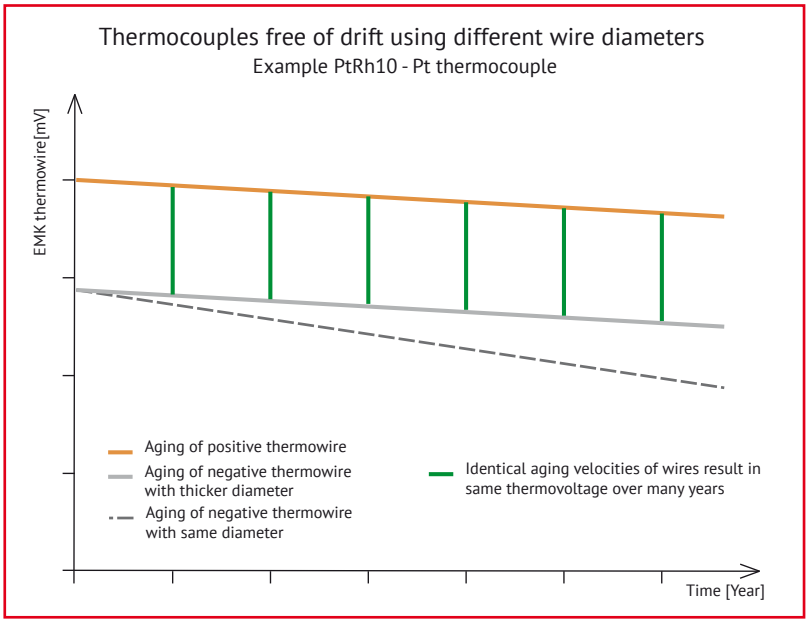
thermo-control Körtvélyessy GmbH specializes in the construction of high-precision and durable platinum / rhodium thermocouples.

These are characterized by the following properties:

- Drift-free measurement over many years (4 years under warranty)
- Separate guidance of the installed thermocouples in ceramic thermowells
- Arrangement of an additional empty tube for the in-situ inspection of the built-in thermocouples by a calibrated test thermocouple
- Contacting the measuring tip to the inside of the ceramic protective tube to increase the reaction time to temperature changes

Non drifting PtRh-Pt Thermocouples

Due to the aging of the thermo wires, the thermoelectric property is changed. Since the two alloys must be different so that a thermoelectric voltage can be measured, the rate at which aging occurs is also different in speed. This changes the difference in the voltage; The result is the so-called drift.



After much research, thermo-control Körtvélyessy GmbH has succeeded in adjusting the diameters of the individual thermo wires so that the speed of aging is equally fast. The patented result is that the difference between the two thermo-wire voltages always remains the same. The thermocouple is therefore free from drift, even after 5 years of continuous load at 1200 ° C.

However, this mechanism is lost when the thermowells are mechanically or chemically damaged and the thermocouple wires are exposed to the atmosphere / vacuum contaminants. Therefore, damaged thermocouples should not continue to be operated if possible, but should be sent in immediately for repair.Verwendung separater Schutzrohre

The use of separate thermowells offers many advantages that greatly increase the process reliability of the thermocouple.

Damage to the thermowells is usually not all broken. The unprotected thermocouple develops a drift, as the thermo-wire is chemically altered by diffusion of foreign substances. This usually leaves a thermocouple protected from the atmosphere and retains its freedom from drift. A constant comparison of the displays can be realized by any control and so early a drift development can be detected.

At the latest during the routine inspection of the thermocouple by a test thermocouple, the difference in the display of the installed thermocouples is determined and the replacement of the thermocouple can be initiated.

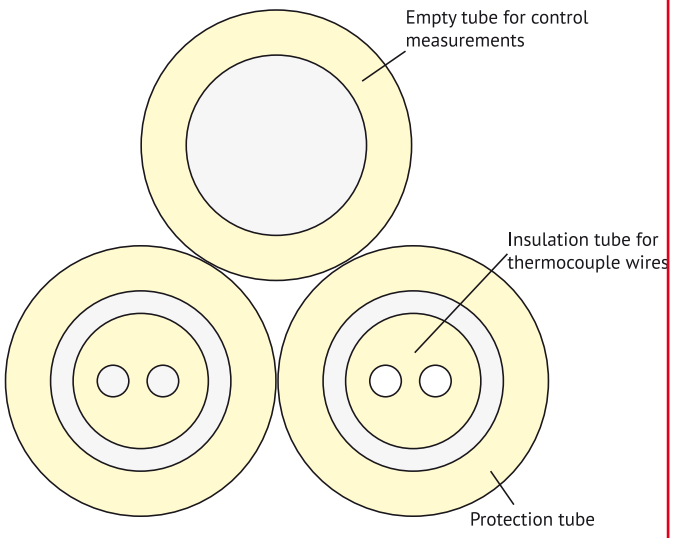
If all thermocouples are installed in a thermowell, they will all be chemically altered if damaged. A drift may be detected too late.

Additional empty tube for test measurements

For a long time, the review of the thermocouples was very cumbersome. Either they had to be removed and recalibrated in an external laboratory or compared by installing a second calibrated thermocouple in a neighboring bushing. Both procedures are very costly and unnecessarily tie up capital and working hours.

Separate protection tubes

Cross secton of a thermo-control thermocouple with 2 thermocouples and one empty tube



Due to the patented arrangement of an additional empty pipe, the thermo-control Körtvélyessy GmbH can make the inspection in the installed state, without affecting the current production.

The additional empty pipe is located directly next to the equipped protective pipes. Now, if a corresponding test thermocouple is inserted into the empty tube, you get a very accurate comparison measurement.

It is recommended that when purchasing new thermocouples you also purchase a test thermocouple from the same wire batch. Thus, the conversion of the measured values is avoided, since all thermocouples have the same original deviation and in this case corresponds to the relative deviation of the actual.