Thermocouples Straight Design per DIN EN 50 446
Model Series TC80, for High Temperature Measurement

Applications

- Blast furnaces, cowper stoves
- Annealing and heat treatment processes
- Refuse, biomass, hazardous waste incineration
- Industrial heating installations, heat generation, power engineering, reactors
- Glass, porcelain, ceramics industry, cement and brick production

Special Features

- Application ranges up to max. +1600 °C (DIN EN 50 446)
- Thermowell made of heat-resistant steel or ceramic, also with ceramic inner tube
- Support tube of carbon steel
- Gastight process connection
- Coating (optional)

Thermocouples Straight Design, Model Series TC80

Description

Model TC80 series thermocouples were developed to measure extremely high temperatures. These high-temperature thermocouples comply with DIN EN 50 446. The thermoelectric wires of the thermocouple fitted within the thermowell are contained either in the capillary holes of a ceramic insulating tube or in the capillary holes of an insulating rod. A thermowell made from high-temperature alloy metal or high-temperature ceramic, with or without an additional inner tube, protects the thermocouple from the process medium as well as mechanical and chemical damage.

A wide selection of process connections, e.g. stop flanges, threaded collars and solid welded flanges, permit direct mounting to the process. For particularly critical applications there are designs with inert gas or compressed air purging or with pressure tight sealing. Of course extremely robust thermowell assemblies can also be used.

Optionally a transmitter can be fitted.
One of the advantages of a built-in transmitter is the increased reliability of the signal transmission. Between the transmitter and the control room, more-economical copper cable can be used rather than specific thermocouple or compensating cable. A cold junction is integrated in all WIKA transmitters.

Data sheets showing similar products:
Thermocouples straight design; Model TC81; see data sheet TE 65.81
Resistance Thermometers straight design; Model TR81; see data sheet TE 60.81

Sensor

Sensor type

Type	Thermocouple	Recommended max. operating temperature	
		DIN EN 60 584-2	ISA (ANSI) MC96.1-1982
K (NiCr-Ni)	non-precious	1200 °C	1200 °C
N (NiCrSi-NiSi)	non-precious	1200 °C	1200 °C
J (Fe-CuNi)	non-precious	750 °C	760 °C
S (Pt10% Rh-Pt)	precious metal	1600 °C	1480 °C
R (Pt13% Rh-Pt)	precious metal	1600 °C	1480 °C
B (Pt30% Rh-Pt6% Rh)	precious metal	1700 °C	1700 °C

The application range of these thermometers is limited by the permissible maximum temperature of the thermocouple as well as the max. permissible temperature of the thermowell material.

Listed thermocouples are available both as single and dual. The measuring point (hot junction) of the probe is supplied ungrounded.

Sensor limiting error

A cold junction temperature of 0 °C is taken as the basis for the definition of the sensor limiting error of thermocouples.

Type K and N

Class	Temperature range	Limiting error
DIN EN 60 584 part 2		
1	-40 °C ... +375 °C	± 1.5 °C
1	+375 °C ... +1000 °C	± 0.0040 · | t | [1]
2	-40 °C ... +333 °C	± 2.5 °C
2	+333 °C ... +1200 °C	± 0.0075 · | t | [1]
ISA (ANSI) MC96.1-1982		
Standard	0 °C ... +1260 °C	± 2.2 °C or [2] ± 0.75 %
Special	0 °C ... +1260 °C	± 1.1 °C or [2] ± 0.4 %

Limiting error with selected temperatures in °C for Type K and Type N thermocouples

Temperature (ITS 90) °C	Limiting error DIN EN 60 584 Part 2 Class 1 °C	Class 2 °C
350	± 1.5	± 2.625
500	± 2.0	± 3.75
600	± 2.4	± 4.50
700	± 2.8	± 5.25
800	± 3.2	± 6.00
900	± 3.6	± 6.75
1000	± 4.0	± 7.50
1100	-	± 8.25
1200	-	± 9.00

Type J

Class	Temperature range	Limiting error
DIN EN 60 584 part 2		
1	-40 °C ... +375 °C	± 1.5 °C
1	+375 °C ... +750 °C	± 0.0040 · | t | [1]
2	-40 °C ... +333 °C	± 2.5 °C
2	+333 °C ... +750 °C	± 0.0075 · | t | [1]
ISA (ANSI) MC96.1-1982		
Standard	0 °C ... +760 °C	± 2.2 °C or [2] ± 0.75 %
Special	0 °C ... +760 °C	± 1.1 °C or [2] ± 0.4 %

Limiting error with selected temperatures in °C for Type J thermocouples

Temperature (ITS 90) °C	Limiting error DIN EN 60 584 Part 2 Class 1 °C	Class 2 °C
350	± 1.5	± 2.625
500	± 2.0	± 3.75
600	± 2.4	± 4.50
700	± 2.8	± 5.25

Type S and R

Class	Temperature range	Limiting error
DIN EN 60 584 part 2		
1	0 °C ... +1100 °C	± 1.0 °C
1	+1100 °C ... +1600 °C	± (1 + 0.003 · (t -1100)) [1]
2	0 °C ... +600 °C	± 1.5 °C
2	+600 °C ... +1600 °C	± 0.0025 · | t | [1]
ISA (ANSI) MC96.1-1982		
Standard	0 °C ... +1480 °C	± 1.5 °C or [2] ± 0.25 %
Special	0 °C ... +1480 °C	± 0.6 °C or [2] ± 0.1 %

1) \| t \| is the value of the temperature in °C without consideration of the sign.
2) Whichever is larger.

Limiting error with selected temperatures in °C for Type S and Type R thermocouples

Temperature (ITS 90) °C	Limiting error DIN EN 60 584 Part 2 Class 1 °C	Class 2 °C
350	± 1.0	± 1.5
500	± 1.0	± 1.5
600	± 1.0	± 1.5
700	± 1.0	± 1.8
800	± 1.0	± 2.0
900	± 1.0	± 2.3
1000	± 1.0	± 2.5
1100	± 1.0	± 2.8
1200	± 1.3	± 3.0
1300	± 1.6	± 3.3
1400	± 1.9	± 3.5
1500	± 2.2	± 3.8
1600	± 2.5	± 4.0

Type B

Class	Temperature range	Limiting error
DIN EN 60 584 part 2		
2	+600 °C ... +1700 °C	± 0.0025 • | t | [1]
3	+600 °C ... +800 °C	± 4.0 °C
3	+800 °C ... +1700 °C	± 0.005 • | t | [1]
ISA (ANSI) MC96.1-1982		
Standard	+870 °C ... +1700 °C	± 0.5 %

1) | t | is the value of the temperature in °C without consideration of the sign.
2) Whichever is larger.

Limiting error with selected temperatures in °C for Type B thermocouples

Temperature (ITS 90) °C	Limiting error DIN EN 60 584 Part 2 Class 2 °C	Class 3 °C
700	± 1.8	± 4.0
800	± 2.0	± 4.0
900	± 2.3	± 4.5
1000	± 2.5	± 5.0
1100	± 2.8	± 5.5
1200	± 3.0	± 6.0
1300	± 3.3	± 6.5
1400	± 3.5	± 7.0
1500	± 3.8	± 7.5
1600	± 4.8	± 8.0

The long-term stability of precious metal thermocouples rises with an increase in the diameter of the thermoelectric wire. Therefore, the Type S, R and B sensors are available with thermoelectric wire diameters of Ø 0.35 mm or Ø 0.5 mm.

Potential measuring uncertainties due to aging effects

Thermocouples age and change their temperature/thermo-electric voltage curve. Types J (Fe-CuNi) and T (Cu-CuNi) thermocouples age slightly due to oxidation of the pure metal leg. As for Types K and N (NiCrSi-NiSi) thermo-couples, considerable changes in thermoelectric voltage can occur at high temperatures due to chromium depletion in the NiCr leg, which results in a decreasing thermo-electric voltage. This effect is accelerated if there is a shortage of oxygen, since a complete oxide skin is unable to form on the surface of the thermocouple and protect it from further oxidation. The chromium oxidizes in the alloy, giving rise to the **„green rot“** that, eventually destroys the thermocouple. The Ni leg is often damaged by sulphur, which occurs, for example, in flue gases. During the fast cooling of NiCr-Ni thermocouples, that has been operating at temperatures above 700 °C, certain states occur within the crystal structure (**short-range order**), which in Type K elements can result in a change in thermoelectric voltage of up to 0.8 mV (K effect). It has been possible to reduce the **short-range order effect** in Type N (NiCrSi-NiSi) thermocouples by alloying both legs with silicon. The effect is reversible and can be cancelled by annealing above 700 °C with subsequent slow cooling. Thermocouples with smaller diameters react sensitively in this respect . Even cooling in still air can cause deviations greater than 1 K. Types R and S PtRh-Pt thermocouples display practically no aging up to 1400 °C, but they are highly sensitive to impurities. Silicon and phosphorus destroy the platinum very quickly. Silicon, which in the presence of Pt can be released from insulating ceramics even in weakly reducing atmospheres (reduction from SiO_2 to Si), alloys with the Pt limb of the element and causes measuring errors of 10 K and more, even with quantities of only a few ppm.
Production has to proceed, therefore, with very great care.

Design

Based on the connection head-type and the thermowell material, a variety of designs is subdivided into the following main models as per DIN EN 50 446:
AM, AMK, BM, BMK, AK, AKK, BK

1st character
A = Connection head, Form A
B = Connection head, Form B

2nd character
M = Metal thermowell
K = Ceramic thermowell

3rd character
K = Ceramic inner tube
no 3rd character: without inner tube

Designs with metal thermowell
Depending on the material used the upper operating tem-perature limit of metal thermowells can be up to 1200 °C. Generally a non-precious metal thermocouple is used as a sensor (Type K, J and N).

Design with ceramic thermowell
Depending on the ceramics used the upper operating temperature limit of ceramic thermowells can be up to 1600 °C, with higher temperatures on request. Generally a precious metal thermocouple is used as a sensor (Type R, S and B).

For the measurement of temperatures above 1200 °C only precious metal thermocouples can be used.
With precious metal thermocouples, however, there is a risk of 'poisoning' by foreign substances. This risk rises with increasing temperatures. Therefore, at temperatures above 1200 °C gastight ceramics, preferably high-purity C 799, should be used (see "Remarks on the selection and operation of thermowells" on page 11).

The process connection can be gastight up to 1 bar. It is recommended that with toxic or safety-critical process gases, or special installations, further constructive measures be taken in addition to the standard features in order to avoid any leakage of the medium to the outside via the connection head, in the case of a thermowell fracture (e.g. pressure-sealed leadthrough in the connection head).