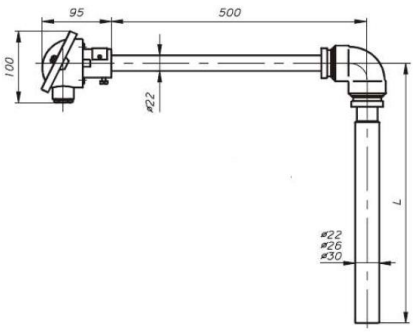
T3 - ANGULAR THERMOELEMENTS

Angle thermoelements are specifically designed for use at increased temperatures, namely in salt baths, molten metals for temperatures up to 1250°C.
Electrical connection is made via a terminal block or a transmitter.
Basic parts of thermoelement are as follows:
- connection head,
- external protection tube,
- measuring insert.

Connection head of thermoelement can be of various dimensions and shapes and is defined via the configurator.



External protection tube of thermoelement is made of material selected to suit the process conditions and is directly immersed in the medium in which the temperature is measured.

Measuring insert can be in classic and mantel design with different types of thermocouples (J, K, N, T, S) that are defined via the configurator.
We recommend the mantel design, which has a number of advantages:

- there is no contamination and oxidation of the hot end of the thermocouple, because it is in highly compressed magnesium oxide, without the presence of oxygen,
- faster response,
- great resistance to vibrations,
- higher reliability in operation,
- longer service life.

The only advantage of the classic measuring insert is the lower price.

Technical characteristics

Basic technical characteristics are specified in the configurator. By filling in the configurator, an order code is generated, which defines the product.

Use

- salt baths,
- molten metals.

Field of use

Group T3- thermoelements are used for measuring temperatures in tempering rooms (salt baths), foundries - for measuring temperatures of molten metals.

The maximum temperature of use is up to 1250°C, thermoelements with type S thermocouple.

The main advantage of these thermoelements is their lifetime, which makes them suitable for use in a wide variety of working conditions where high temperatures are present.

Functionality and structure:

Measurement principle

Thermocouple consists of two thermoelectrodes, made of materials of different conductivity, that are connected to each other with two junctions (hot and cold), so that they form one electrical circuit.

When one junction (hot junction) is at temperature T_1, and the other (cold junction) is at temperature T_2, an electromotive force is generated in the circuit, the value of which depends on the materials used and the values of temperatures T_1 and T_2. This effect, on which thermoelectric temperature measurements are based, is known as the Seebeck effect.

In one industrial thermoelement, one junction of the thermocouple (hot junction) is a measuring junction (exposed to the temperature being measured) and the other junction (cold junction) is a reference junction which is at the known - reference temperature with which the measured temperature is compared to.

Thermovoltage values in mV depending on temperature, for thermocouples Type J, K, N and T,..., are given in Table 5.

Constituent parts

Group T3- thermoelements are manufactured in line with the provisions of the international standard IEC 584-1. They consist of a classic thermocouple or measuring insert - mantel structure, elbow, internal protection tube made of KER 610 ceramics (when type S thermocouple is installed) and external metal protection tube, a neck tube, a connection head in which a transmitter or a ceramic block with terminals for electrical connection can be installed.

Thermocouple - classic structure

In this structure, the corresponding thermoelectrodes of thermocouples J, K, N, T, S previously connected in a thermocouple, are inserted into high temperature resistant ceramic insulators.

Measuring insert – mantel structure

In this structure, the thermocouple is placed inside a metal shell. The thermoelectrodes of the thermocouple are insulated from each other, longitudinally, and from the metal shell with highly compressed magnesium oxide. Materials of the casings of the measuring inserts are: W.Nr.1.4541, W.Nr.2.4816 (Inconel 600), from Nicrobell, all depending on the temperature at which they are used.

Standard materials and dimensions of the thermoelectrodes for thermocouples are listed in Table 1.

External protection tubes

With **Group T3-** thermoelements, metal tubes are used as external protection tubes.

Depending on the temperature and more or less on the severity of the working conditions in which they are used, metal protection tubes are produced from different steels and special alloys, with different diameters and wall thickness.

Use of protection tubes largely depends on the type of working medium and conditions in it.

The tips of the protection tubes that are in the working medium are welded with special technology and guarantee optimal mechanical resistance and ensure effective temperature measurement, i.e. fast response.

Guidelines for the selection of protection tubes and their use are listed in Table 2.

Connection head

Group T3- thermoelements use connection heads, shape A and B, according to DIN 43729, connection head KNH-L, in which a transmitter and a ceramic block or two transmitters can be installed, and many other connection heads of different shapes and materials. The connection heads are given in Figure.

Length

Lengths 500, 710, 1000 are considered standard.
Thermoelements of other lengths can be ordered depending on the specification and technical characteristics of the process.

Materials

Table 1: Standard materials and dimensions of thermoelectrodes for thermocouples

Thermocouple type	Thermoelectrode material	Thermoelectrode diameter [mm]
J	(+) Fe / (-) CuNi	1.00; 1.38; 2.00; 2.50; 3.00
K	(+) NiCr / (-) Ni	1.00; 1.38; 2.00; 2.50; 3.00
N	(+) NiCrSi / (-) NiSi	1.00; 1.38; 2.00; 2.50; 3.00
T	(+) Cu / (-) CuNi	1.00; 1.38; 2.00; 2.50; 3.00

Table 2: Guidelines for the selection of protection tubes

Work environment	Maximum temperature of use (°C)	Protection tube material
Saltpeter	550	W.Nr.1.1003
Cyan	950	W.Nr.1.1003
	1150	W.Nr.1.4841
Chloride-based salts	600 to 1050	W.Nr.1.4762
Barium salts	1300	W.Nr.2.4867
Sodium salts	1000	W.Nr.1.4541
Aluminum	700	W.Nr.1.1003
	700	Utop MO 1
Magnesium	800	W.Nr.1.1003
Lead	600	St.35.8, enameled
	700	Utop MO 1
	800	W.Nr.1.1003
	900	W.Nr.1.4841
Zinc	480	St.35.8, enameled
	600	W.Nr.1.1003
	700	Utop MO 1
	550	W.Nr.1.1013
	480	W.Nr.1.4762
	480	W.Nr.1.4749
Tin	650	St.35.8, enameled
	600	Utop MO 1
Copper	1250	W.Nr.1.4772

Electronics

If the customer wants a current output signal, a 2-wire transmitter is installed in the connection head.

Transmitters in 2-wire technology and with an output signal of 4-20 mA are very easily programmed with the help of a personal computer, a programming unit and the appropriate software. Transmitters are galvanically isolated.

If the transmitter is intended for installation on a DIN rail, then a ceramic block with terminals for electrical connection is installed in the connection head.

Performances

Working conditions

Working conditions for the connection head
Ambient temperature - the case when the connection head is without transmitter: - 40 to 130°C.
Ambient temperature - the case when the transmitter is installed in the connection head: - 40 to 85°C.

Process temperature
Operating range is defined - determined based on the combination of the type of thermocouple and the material of the protection tube.

Accuracy (certainty)
Maximum errors
Standard IEC 60584 defines the standard values and tolerances (permissible errors) of thermocouples.
The standard accuracy classes for thermocouples type J, K, N, T, S are class 2.

Table 3: Permissible measurement errors

	Standard tolerance (IEC 60584)		**Reduced tolerance (IEC 60584)**	
Type	**Class**	**Permissible measurement error**	**Class**	**Permissible measurement error**
J Fe-CuNi	2	± 2.5°C (-40…333) °C ±0.0075|t| (333…750) °C	1	± 1.5°C (-40…375) °C ±(0.004|t| (375…750) °C
K NiCr-Ni	2	± 2.5°C (-40…333) °C ±0.0075|t| (333…1200) °C	1	± 1.5°C (-40…375) °C ±(0.004|t| (375…1200) °C
N NiCrSi-NiSi	2	± 2.5°C (-40…333) °C ±0.0075|t| (333…1200) °C	1	± 1.5°C (-40…375) °C ±(0.004|t| (375…1200) °C
T Cu-CuNi	2	± 1°C (-40…133) °C ±0.0075|t| (133…350) °C	1	± 0.5°C (-40…125) °C ±(0.004|t| (125…350) °C
S PtRh10%-Pt	2	± 1.5°C (0…600) °C ±0.0025|t| (600…1600) °C		± 1°C (0…1100) °C ±(1+0.003(t-1100)) (1100…1600) °C

Transmitter error must be added to the thermocouple error, including reference junction compensation.

Response time
Response time for these types of thermocouples is not a circular parameter. If you want that information, contact the Technical Service - TERMOTEHNA.

Insulation
Resistance of the insulation between the electrical terminals on the ceramic block and the external tube is fully guaranteed by the manufacturing procedures. For thermoelements with a measuring insert, according to the IEC 1515 standard, the value of the insulation resistance between the terminal and the protection tube is:

- at 25°C, testing at 500 Vdc $\geq$ 1000 M Ω
- at 500°C, testing at 500 Vdc $\leq$ 5 M Ω

Self-heating
Does not occur.

Installation

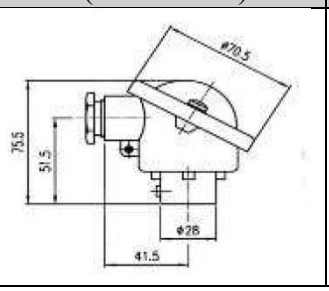
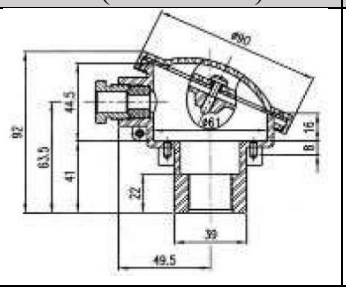
Guidelines for the installation and maintenance of angular T3 thermoelements
In the case of electrode furnaces, the protection tube of the thermoelement should be at least 100mm away from the electrode, if possible. The horizontal part of the thermoelements should be (at the point of fixing) isolated from the housing and ventilation by placing some insulating material, because otherwise the protection tube would act as an electrode and would quickly wear out on the immersed part. Even when this regulation is respected, it is faster to remove the protection tube facing the electrode.
Daily cleaning and regeneration of the salt melt is mandatory according to the manufacturer's recommendations. In order to extend the life of thermocouples and measuring inserts, daily visual inspection of wear of the external protection tube is mandatory. The protection tube should be replaced before total damage, so that the measuring insert or thermocouple can be used again.
Angular thermoelement should be fixed on a suitable support, which is adjusted according to the height of the salt or melt, which varies when the batch is inserted. The thermoelement should be placed on the edge of the ladle, so as not to interfere with the batching, and its immersion in the salt should be from 150 to a maximum of 300mm.
Periodic inspections are recommended because mechanical damage and thermal shocks, aggressive environments, occurrence of abrasion can cause tube damage.

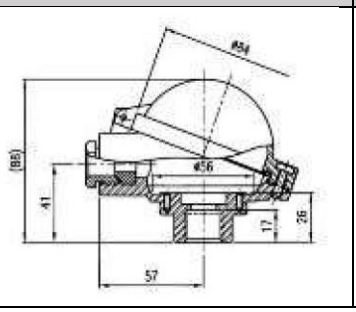
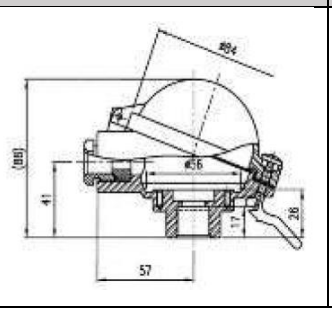
Components

Connection head
Pursuant to the provisions of the DIN 43729 standard, the housing of the connection head, shape B, contains a ceramic block with electrical terminals or a transmitter. It can be of different types and materials (e.g. painted aluminum, crude iron or stainless steel).
It is possible to simultaneously install a ceramic block and a transmitter or two transmitters in the housing of the connection head, shape KNH-L.

Metal neck tubes with a diameter of 22, 26 and 32 mm are installed in the connection head, shape A.
Metal neck tubes with a diameter of 22 mm are installed in the connection head, shape KNH-L.

Connection heads are given in Figure 1.

head B (DIN 43729)		head A (DIN 43729)	
			

head BA-KL	Ex	head BSS	
			

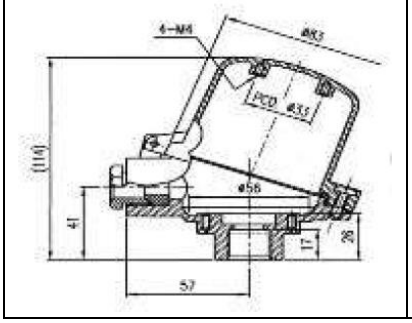
head KNH-L	
	

Figure 1*. Connection heads*

Transmitters

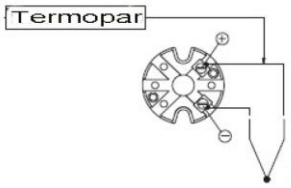
One of the following transmitters can be installed in the connection head:

- PC programmable transmitters 4...20mA (galvanically isolated)
- Transmitters with HART protocol (galvanically isolated), the output contains 4...20mA and HART superimposed signals

Customer can request the desired configuration during the ordering process.

If the transmitters are installed on a DIN rail, ceramic blocks are installed in the connection head.
The standard thermocouple connecting is given in Figure 3.

Classic thermocouple Measuring insert



With **Group T3-** thermoelement

- **classic thermocouple**: one or two thermocouples are installed in suitable high temperature resistant ceramic insulators, which are then inserted into a metal protection tube;
- **measuring insert** – mantel structure, directly placed into the metal protection tube. When replacing the measuring insert, the installation length (Lu) depends on the length (L) of the protection tube.

Figure 3. *Standard connecting*

Certificates

- Calibration certificate for temperature measuring instruments
- Calibration certificate for temperature measuring equipment
- Certificate of calibration laboratory accreditation - accreditation no.: 02-058

Other details
Maintenance

Maintenance guidelines are given in the **Installation** chapter.
Calibration of thermocouples is recommended, once a year, by an authorized laboratory, in line with the Law.

Catalog codes for angular thermoelements

Table 4.1. Angular thermoelements with classic thermocouple

Temperature	Thermocouple	Material of metal protection tube	Nominal length L [mm]	Catalog number	
				thermocouple 1	thermocouple 2
up to 700°C	Fe-CuNI Type J according to IEC 60584-1	Technically pure iron W.Nr.1.1003	500	T3-1111	T3-2111
			710	T3-1112	T3-2112
			1000	T3-1113	T3-2113
up to 950°C	NiCr-NiAl Type K according to IEC 60584-1	Technically pure iron W.Nr.1.1003	500	T3-1211	T3-2211
			710	T3-1212	T3-2212
			1000	T3-1213	T3-2213
up to 950°C	NiCr-NiAl Type K according to IEC 60584-1	Utop MO1	500	T3-1291	T3-2291
			710	T3-1292	T3-2292
			1000	T3-1293	T3-2293
up to 1200°C	NiCr-NiAl Type K according to IEC 60584-1	X10CrSi29 W.Nr.1.4772∅26x4	500	T3-1221	T3-2221
			710	T3-1222	T3-2222
			1000	T3-1223	T3-2223
up to 1250°C	Pt(10%Rh)-Pt Type S according to IEC 60584-1	Č.4586 X20CrNiSi254 SL25	500	T3-1331	T3-2331
			710	T3-1332	T3-2332
			1000	T3-1333	T3-2333

Table 4.2*: Angular thermoelements with measuring inserts – mantel structure*

Temperature	Thermocouple	Material of metal protection tube	Nominal length L [mm]	Catalog number	
				thermocouple 1	thermocouple 2
up to 700°C	Fe-CuNI Type J according to IEC 60584-1	Technically pure iron W.Nr.1.1003	500	T3-1111.1	T3-2111.1
			710	T3-1112.1	T3-2112.1
			1000	T3-1113.1	T3-2113.1
up to 950°C	NiCr-NiAl Type K according to IEC 60584-1	Technically pure iron W.Nr.1.1003	500	T3-1211.1	T3-2211,1
			710	T3-1212.1	T3-2212.1
			1000	T3-1213.1	T3-2213.1
up to 950°C	NiCr-NiAl Type K according to IEC 60584-1	Utop MO1	500	T3-1291.1	T3-2291.1
			710	T3-1292.1	T3-2292.1
			1000	T3-1293.1	T3-2293.1
up to 1150°C	NiCr-NiAl Type K according to IEC 60584-1	X10CrSi29 W.Nr.1.4772∅26x4	500	T3-1221.1	T3-2221.1
			710	T3-1222.1	T3-2222.1
			1000	T3-1223.1	T3-2223.1

***Table 5**: Thermovoltage values in mV depending on temperature*

Thermocouple Fe-CuNi, Type J, according to IEC 60584-1 - Thermovoltage values in mV

°C	0	- 10	- 20	- 30	- 40	- 50	- 60	- 70	- 80	- 90
- 200	- 7,890	- 8,096								
- 100	- 4,632	- 5,036	- 5,426	- 5,801	- 6,159	- 6,499	- 6,821	- 7,122	- 7,402	- 7,659
0	0	- 0,501	- 0,995	- 1,481	- 1,960	- 2,431	- 2,892	- 3,344	- 3,785	- 4,215
°C	0	10	20	30	40	50	60	70	80	90
0	0	0,507	1,019	1,536	2,058	2,585	3,115	3,649	4,186	4,725
100	5,268	5,812	6,359	6,907	7,457	8,008	8,560	9,113	9,667	10,222
200	10,777	11,332	11,887	12,442	12,998	13,553	14,108	14,663	15,217	15,771
300	16,325	16,879	17,432	17,984	18,537	19,089	19,640	20,192	20,743	21,295
400	21,846	22,397	22,949	23,501	24,054	24,607	25,161	25,716	26,272	26,829
500	27,388	27,949	28,511	29,075	29,642	30,210	30,762	31,356	31,933	32,513
600	33,096	33,683	34,273	34,867	35,464	36,066	36,671	37,280	37,893	38,510
700	39,130	39,754	40,382	41,013	41,647	42,283	42,922	43,563	44,207	44,852
800	45,498	46,144	46,790	47,434	48,076	48,716	49,354	49,989	50,621	51,249
900	51,875	52,496	53,115	53,729	54,341	54,948	55,553	56,155	56,753	57,349

Thermocouple NiCr-NiAl, Type K, according to IEC 60584-1 - Thermovoltage values in mV

°C	0	- 10	- 20	- 30	- 40	- 50	- 60	- 70	- 80	- 90
- 100	- 3,553	- 3,852	- 4,138	- 4,410	- 4,669	- 4,912	- 5,141	- 5,354	- 5,550	- 5,730
0	0	- 0,392	- 0,777	- 1,156	- 1,527	- 1,889	- 2,243	- 2,586	- 2,920	- 3,242
°C	0	10	20	30	40	50	60	70	80	90
0	0	0,397	0,798	1,203	1,611	2,022	2,436	2,850	3,266	3,681
100	4,095	4,508	4,919	5,327	5,733	6,137	6,539	6,939	7,338	7,737
200	8,137	8,537	8,938	9,341	9,745	10,151	10,560	10,969	11,381	11,793
300	12,207	12,623	13,039	13,456	13,874	14,292	14,712	15,132	15,552	15,974
400	16,395	16,818	17,241	17,664	18,088	18,513	18,938	19,363	19,788	20,214
500	20,640	21,066	21,493	21,919	22,346	22,772	23,196	23,624	24,050	24,476
600	24,902	25,327	25,751	26,176	26,599	27,022	27,445	27,867	28,288	28,709
700	29,128	29,547	29,965	30,383	30,799	31,214	31,629	32,042	32,455	32,866
800	33,277	33,686	34,095	34,502	34,909	35,314	35,718	36,121	36,524	36,925
900	37,325	37,724	38,122	38,519	38,915	39,310	39,703	40,096	40,488	40,879
1000	41,269	41,657	42,045	42,432	42,817	43,202	43,585	43,968	44,349	44,729
1100	45,108	45,486	45,863	46,238	46,612	46,985	47,356	47,726	48,095	48,462
1200	48,828	49,192	49,555	49,916	50,276	50,633	50,990	51,344	51,697	52,049
1300	52,398	52,747	53,093	53,439	53,782	54,125	54,466	54,807		

Thermocouple Pt(10%Rh), Type S, according to IEC 60584-1 - Thermovoltage values in Mv

°C	0	10	20	30	40	50	60	70	80	90
0	0	0,055	0,113	0,173	0,235	0,299	0,365	0,432	0,502	0,573
100	0,645	0,719	0,795	0,872	0,950	1,029	1,109	1,190	1,273	1,356
200	1,440	1,525	1,611	1,698	1,785	1,873	1,962	2,051	2,141	2,232
300	2,323	2,414	2,506	2,599	2,692	2,786	2,880	2,974	3,069	3,164
400	3,260	3,356	3,452	3,549	3,645	3,743	3,840	3,938	4,036	4,135
500	4,234	4,333	4,432	4,532	4,632	4,732	4,832	4,933	5,034	5,136
600	5,237	5,339	5,442	5,544	5,648	5,751	5,855	5,960	6,064	6,169
700	6,274	6,380	6,486	6,592	6,699	6,805	6,913	7,020	7,128	7,236
800	7,345	7,454	7,563	7,672	7,782	7,892	8,003	8,114	8,225	8,336
900	8,448	8,560	8,673	8,786	8,899	9,012	9,126	9,240	9,355	9,470
1000	9,585	9,700	9,816	9,932	10,048	10,165	10,282	10,400	10,517	10,635
1100	10,754	10,872	10,991	11,110	11,229	11,348	11,467	11,587	11,707	11,827
1200	11,947	12,067	12,188	12,308	12,429	12,550	12,671	12,792	12,913	13,034
1300	13,155	13,276	13,397	13,519	13,640	13,761	13,883	14,004	14,125	14,247
1400	14,368	14,489	14,610	14,731	14,852	14,973	15,094	15,215	15,336	15,456
1500	15,576	15,697	15,817	15,937	16,057	16,176	16,296	16,415	16,534	16,653
1600	16,771	16,890	17,008	17,125	17,243	17,360	17,477	17,594	17,711	17,826
1700	17,942	18,056	18,170	18,282	18,394	18,504	18,612			

Thermocouple Cu-CuNi, Type T, according to IEC 60584-1 - Thermovoltage values in mV

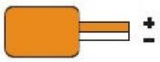
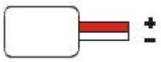
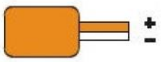
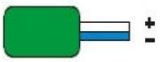
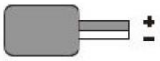
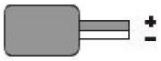
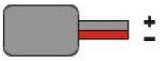
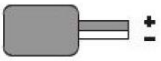
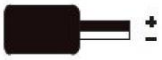
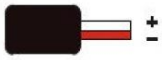
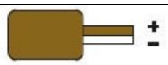
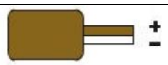
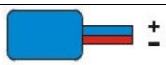
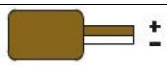
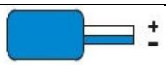
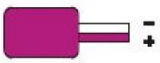
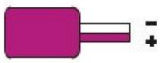
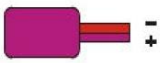
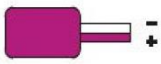
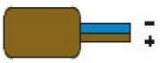
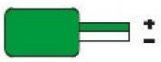
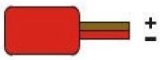
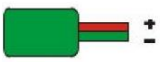
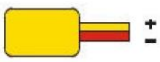
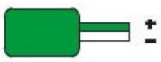
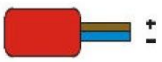
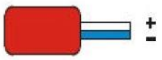
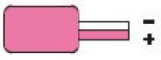
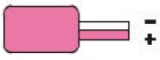
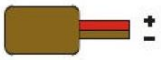
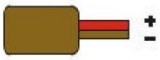
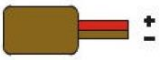
°C	0	- 10	- 20	- 30	- 40	- 50	- 60	- 70	- 80	- 90
- 100	- 3,37	- 3,65	- 3,92	- 4,17	- 4,41	- 4,64	- 4,86	- 5,06	- 5,26	- 5,43
0	0	- 0,38	- 0,75	- 1,12	- 1,47	- 1,81	- 2,15	- 2,47	- 7,78	- 3,08
°C	0	10	20	30	40	50	60	70	80	90
0	0	0,39	0,78	1,19	1,61	2,03	2,46	2,90	3,35	3,81
100	4,27	4,74	5,22	5,71	6,20	6,70	7,20	7,71	8,23	8,75
200	9,28	9,82	10,36	10,90	11,45	12,01	12,57	13,13	13,70	14,28
300	14,86	15,44	16,03	16,62	17,21	17,81	18,42	19,027	19,63	20,25
400	20,86									

Thermocouple NiCrSi-NiSi, Type N, according to IEC 60584-1 - Thermovoltage values in mV

°C	0	- 10	- 20	- 30	- 40	- 50	- 60	- 70	- 80	- 90
- 200	- 3,99	- 4,08	- 4,16	- 4,22	- 4,27					
- 100	- 2,40	- 2,61	- 2,80	- 2,99	- 3,17	- 3,33	- 3,49	- 3,63	- 3,76	- 3,88
0	0	-0,26	- 0,51	- 0,77	- 1,02	- 1,26	- 1,50	- 1,74	- 1,97	- 2,19
°C	0	10	20	30	40	50	60	70	80	90
0	0	0,26	0,52	0,79	1,06	1,33	1,61	1,90	2,18	2,47
100	2,77	3,07	3,37	3,67	3,98	4,30	4,61	4,93	5,25	5,58
200	5,91	6,24	6,57	6,91	7,25	7,59	7,94	8,28	8,63	8,98
300	9,34	9,69	10,05	10,41	10,77	11,13	11,50	11,86	12,23	12,60
400	12,97	13,34	13,71	14,09	14,46	14,84	15,22	15,60	15,98	16,36
500	16,74	17,12	17,51	17,89	18,28	18,66	19,05	19,44	19,83	20,22
600	20,60	20,99	21,39	21,78	22,17	22,56	22,95	23,34	23,74	24,13
700	24,52	24,91	25,31	25,70	26,09	26,49	26,88	27,27	27,67	28,06
800	28,45	28,84	29,24	29,63	30,02	3041	30,80	31,19	31,58	31,98
900	32,37	32,75	33,14	33,53	33,92	34,31	34,70	35,08	35,47	35,86
1000	36,24	36,63	37,01	37,40	37,78	38,16	38,55	38,93	39,31	39,69
1100	40,07	40,45	40,83	41,21	41,59	41,96	42,34	42,71	43,09	43,46
1200	43,83	44,20	44,57	44,94	45,31	45,68	46,04	46,41	46,77	47,14
1300	47,50									

TERMOTEHNA

International Colour Codes applied to temperature engineering

Thermocouple type		Europe	Germany	USA	Serbia	Great Britain
		DIN43722(IEC 584-3)	DIN 43714	ANSI MC 96.1	IEC 584-3	BS 4937 / 1843
R **S**	⊕ Platinum-13% Rhodium ⊖ Platinum ⊕ Platinum-10% Rhodium ⊖ Platinum					
B	⊕ Platinum-30% Rhodium ⊖ Platinum-6% Rhodium					
J	⊕ Iron ⊖ Copper-Nickel					
T	⊕ Copper ⊖ Copper-Nickel					
E	⊕ Nickel- Chromium ⊖ Copper-Nickel					
K	⊕ Nickel- Chromium ⊖ Nickel	 				 
N	⊕ Nickel- Chromium-Silicon ⊖ Nickel- Silicon					
U	⊕ Copper ⊖ Copper-Nickel					
L	⊕ Iron ⊖ Copper-Nickel