Termotehna Šušlć d.o.o.
32000 Čačak, Potez jezdinsko polje 58
Matični broj: 20184051; PIB: 104544170
Tel/fax: +381 32 5564 044; +381 32 5564 055
e-mail: ttehna@ttermotehna.rs; www.termotehna.rs

T1 - GENUINE THERMOELEMENTS WITH EXTERNAL CERAMIC PROTECTION TUBE

Genuine thermoelements with ceramic tubes are specifically designed for use at extremely high temperatures up to 1800°C.

Protection tube of thermoelement is directly immersed in the medium in which the temperature is measured.

Electrical connection is made via a ceramic block or a transmitter in the connection head.

Basic parts of thermoelements are as follows:

- connection head,
- neck tube,
- external ceramic tube,
- internal ceramic tube,
- thermocouple (Type S, E, B, K),
- process connection.

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

External ceramic 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.

Thermocouple can be of various types and is defined via the configurator.

Process connection is achieved using:
- flange, according to DIN 43734,
- movable connection (compression fitting).

Flange and movable connection (compression fitting) can be moved along the longitudinal axis of thermoelement, which regulates the installation length.

Technical characteristics

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

Use
- blast furnaces,
- annealing and heat treatment furnaces,
- boilers for production of thermal energy, power engineering, reactors,
- industry of glass, porcelain, ceramics, cement, lime.

Field of use

Thermoelements **T1 -** are used for very different temperature measurements and for large measuring ranges.

Thermocouples with one or two ceramic tubes and with a thermocouple type S, R, B are used to measure high temperatures in the production of ceramics, bricks, porcelain, glass, etc., where temperatures are up to 1200°C.

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. The installation of the thermoelements is given in Figure 1.

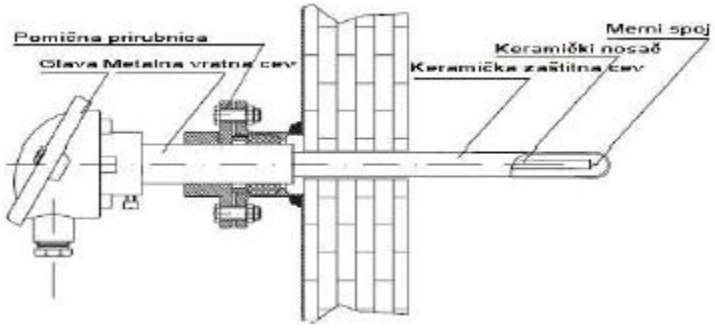


Figure 1. Display of installation of **T1-** thermoelements
(Movable flange / Head / Metal neck tube
Measuring junction / Ceramic support / Ceramic protection tube)

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 S, R and B, are given in Table 5.

Constituent parts
Thermoelements **T1-** are manufactured in line with the provisions of the international standard IEC 584-1.
They consist of a measuring insert (thermocouple in a ceramic support), protection (protective) tube, a neck tube, a connection head in which a transmitter or a ceramic block with terminals for electrical connection can be installed.

Measuring insert
With thermoelements from this group, the thermocouple type S, R, B is placed in a corresponding ceramic support, resistant to high temperatures. Ceramic supports are specified to be stable at operating temperatures and to longitudinally insulate thermoelectrodes of the thermocouple.
Thermocouples type K, N, E, ... are placed inside a metal shell, from which they are insulated by highly compressed magnesium oxide, the so-called mantel structure.

Protection tubes
With thermoelements **T1-**, ceramic protection tubes are used, which are mainly used for high temperatures (above 1200°C) and/or in processes where the presence of gases can cause contamination of the thermocouple.
With thermoelements with labels T1-x36x and T1-x37x, one ceramic tube made of material C610, i.e. C 799(C710), closed at one end and located in the medium in which the temperature is measured, is used as a protection tube. Selection of materials, ie. the type of ceramics, from which the tube is made, depends on the measuring range of the temperature being measured.

With thermoelements marked T1-x35x, two ceramic tubes of different diameters and materials are used, which are resistant to high temperatures and thermal shocks, depending on the conditions of the working environment in which the temperature is measured.

At the customer's request, a thermoelement with external protection tube can be delivered for temperatures up to 1300°C, but then it corresponds to the T2- structure (See catalog - Thermoelements with metal tubes T2-).

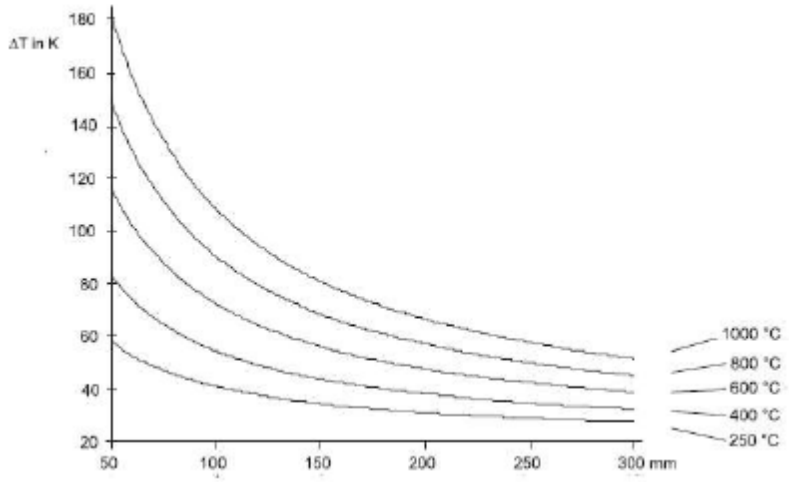
Guidelines for the selection of material and diameter of protection tubes, and guidelines for the use of thermocouples T1- are listed in Tables 1 and 2.

Neck tube and process connection
The ceramic tubes are fixed to a metal neck tube, which is located at the cold end of the thermoelement, just below the connection head.

The neck tube and flange and/or movable connection allow the thermoelement to be incorporated into the process.

The installation length of the thermoelement (L) is adjusted by moving the flange or movable connection along the neck tube. The movable flange is made in the dimensions of DIN 43734, Figure 5, and the movable connection is made according to the user's request.

In order to determine the appropriate installation length of the ceramic tube and the correct distance between the connection head and the heated surface, the metal neck tube dimensions, material and length (Lv) can be selected in the Ordering information form.



Specific lengths and diameters of the neck tube, as well as materials, can be requested by the user based on the technological parameters (specifications) of the process in which the temperature is measured.

Connection head

For thermocouples **T1-**, connection heads, shape A, according to DIN43729 are used. Other connection heads can be ordered according to the Ordering information form.

Connection heads are given in Figure 2.

Length

All thermoelements from **T1-** can be ordered in the lengths specified in the Ordering information.
Lengths 500, 710, 1000 and 1400 are considered standard. Thermoelements of other lengths can be ordered if required by the specification and technical characteristics of the process in which the temperature is measured.

Materials

Table 1: Standard materials and combinations of protection tubes

Metal neck tube (∗)	Diameter	External protection tube	Diameter	Internal protection tube	Diameter	Ceramic support	Diameter	Max temp.
	mm		mm		mm		mm	
W.Nr.1.4301	22	C610	15	/	/	C610	8.5/10	1500
W.Nr.1.4301	22	C799	15	/	/	C799	8.5/10	1800
W.Nr.1.4301	32	C530	26	C610	15	C610	8.5	1500
W.Nr.1.4301	32	C799	26	C799	15	C799	8.5	1800

(∗)Metal neck tube only has the function of a supporting tube.

Table 2: Guidelines for the application of protection tubes

Material	Max temp. in air without pressure(°C)	Advantages	Deficiencies	Field of application
Ceramic C530 (Al_2O_3 > 70%)	1500	Very high resistance to temperature changes	Finely porous, not resistant to gases, sensitive to shocks	Industrial furnaces (delivery with an internal, gas-resistant protection tube is mandatory)
Ceramic C610 (Al_2O_3 > 60%)	1600	Gas resistant, high resistance to high temperatures, medium resistance to temperature changes	Low purity of Al_2O_3, not resistant to alkali vapors, sensitive to shocks	Gas furnaces; Diffusion furnaces; Industrial furnaces (can be used as internal tube in combination with C530)
Ceramic C799 (Al_2O_3 > 99.7%)	1800	Very resistant to gases, high resistance to high temperatures, resistant to acids and alkalis, superheated vapor, very resistant to bending	Low resistance to temperature changes, sensitive to shocks	Industrial furnaces; Protective atmosphere furnaces; Glass and limestone melting furnaces; Cement industry; Desulphurization systems
W.Nr.4762	1150	Fire-resistant, stainless steel, ferroalloy, resistant to sulfur atmosphere (very good for oxidation and good for reduction)	Not resistant in atmospheres containing nitrogen	Preheating and tempering furnaces; Environments in which sulfur-containing gases occur; Exhaust gas ducts, molten zinc up to 480°C
W.Nr.4749	1150	Fire-resistant, stainless steel, ferroalloy, resistant to a reducing atmosphere containing high concentrations of sulfur, to oxidation in the air and gases	Not resistant in atmospheres containing nitrogen	Preheating and tempering furnaces; Environments in which sulfur-containing gases occur; Exhaust gas ducts, molten zinc of 480°C

		generated during oil combustion		
W.Nr.4841	1200	Good thermal, mechanical and corrosion resistance. Resistant to nitrogen atmosphere with low oxygen concentration. It is similar but at the same time better than steel Č.4574.	Not resistant to gases containing sulfur	Industrial furnaces; Combustion chambers; Air circulation furnaces; Petrochemical plants; Cyanogen sauna baths; Molten aluminum up to 700°C; Molten lead up to 700°C; Copper and zinc alloys up to 900°C
W.Nr.2.4816; Inconel 600	1250	Effective resistance to high temperatures, corrosion caused by chloride ions, oxidation resistance at elevated temperatures. Good performance in atmospheres containing nitrogen.	Not recommended for sulfur environments.	Industrial furnaces
Kanthal AF	1300	FeCr alloy. Extremely resistant to oxidation in dry air, up to 1300°C and in humid air up to 1200°C	Low resistance to nitrogen-containing gases	Industrial furnaces; Waste incinerators; Glass, ceramic and cement industry

Weight
The listed weights are determined theoretically.

Thermoelement with protection tube made of ceramics C610, diameter 15mm, length 1000mm, neck tube length 150mm, connection head A……..…**2kg**

Thermoelement with external protection tube made of ceramics C530, diameter 26mm, internal protection tube made of ceramics C610, diameter 15mm, length 1000mm, neck tube length 100mm, connection head A……**3kg**

Electronics
The desired type of output signal, a current signal, can be realized by installing a 2-wire transmitter 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.

Maximum process pressure
Genuine thermoelements are used for processes in which the pressure is up to 1 bar.

Accuracy (certainty)

Maximum errors
Standard IEC 584 defines the standard values and tolerances (permissible errors) of thermocouples.

The standard accuracy classes for thermocouples type S and R are class 2, and for thermocouple type B it is class 3.

Table 3: Permissible measurement errors are given in the following table.

	Standard tolerance (IEC 584)		**Reduced tolerance (IEC 584)**	
Type	**Class**	**Permissible measurement error**	**Class**	**Permissible measurement error**
S PtRh10%-Pt	2	± 1.5°C (0…600) °C ±0.0025|t| (600…1600) °C	1	± 1°C (0…1100) °C ±(1+0.003(t-1100)) (1100…1600) °C
R PtRh13%-Pt	2	± 1.5°C (0…600) °C ±0.0025|t| (600…1600) °C	1	± 1°C (0…1100) °C ±(1+0.003(t-1100)) (1100…1600) °C
B PtRh30%- PtRh6%	3	± 4°C (600…800) °C ±0.005|t| (800…1700) °C	2	±0.0025|t| (600…1700) °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.

Self-heating
Does not occur.

Installation
Group T1- thermoelements are designed for installation in high-temperature industrial furnaces. Thermoelectrodes with a diameter of 0.5 mm are more suitable for application at high temperatures and provide better and longer thermal stability.

In many cases, it is important to check the metrological correctness of the thermocouple through the installation and without removing the thermoelement from the furnace at high temperatures, to avoid thermal shocks and damage to the ceramic tubes.

If there is a possibility that in working conditions, the temperature exceeds the prescribed maximum limit value for the material of the protection tube, vertical installation is recommended, in order to avoid bending of the protection tube due to its own weight, which would lead to damage - breakage of the ceramic support and tearing of the thermocouple.

Components

Connection head

Pursuant to the provisions of the DIN 43729 standard, the housing of the connection head, shape A, 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 tubes with a diameter of 22, 26 and 32 mm are installed in the connection heads, shape A.

Metal neck tubes with a diameter of 22 m are installed in the connection head KNH-L.

Connection heads are given in Figure 2.

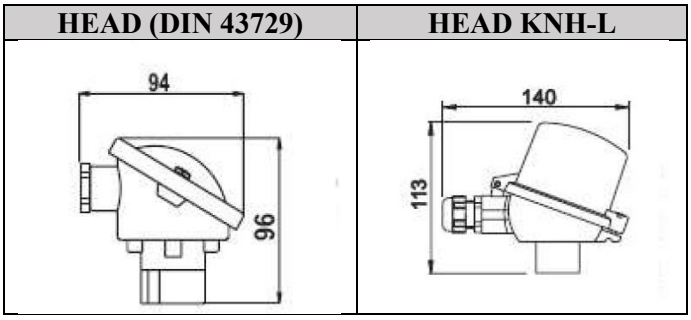


Figure 2. Connection heads

Transmitters

The following transmitters are applicable:

- PC programmable transmitters 4...20mA (galvanically isolated)
- Transmitters with HART protocol (galvanically isolated), the output contains 4...20mA and HART superimposed signals
- Transmitters (galvanically isolated) PROFIBUS PA with output signal, the communication address can be set via the appropriate software or by means of mechanical switches.

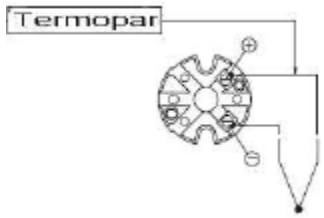
Customer can request the desired configuration during the ordering process.

If the transmitters are installed on a DIN rail, ceramic blocks are installed in the connection head.

Measuring insert – Connecting

With **Group T1-** thermoelements, the measuring insert consists of: one or two thermocouples installed in a suitable ceramic insulator (support) resistant to high temperatures, which is then inserted into a ceramic

protection tube. When replacing the measuring insert, the installation length of the thermocouple depends on the length of the protection tube.



Thermocouple

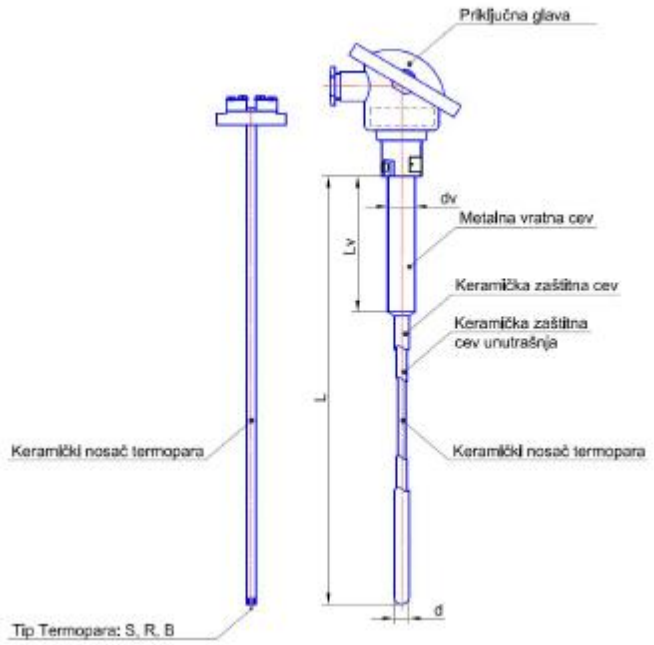


Figure 4. Parts of the thermocouple (Ceramic thermocouple support, Thermocouple type: S, R, B, Connection head, Metal neck tube, Ceramic protection tube, Ceramic protection, Ceramic protection internal tube, Ceramic thermocouple support)

Auxiliary equipment

Flange DIN 43734

For A= 15mm
B= 55mm; C=75mm

For A= 22mm and 32mm
B= 70mm; C= 90mm

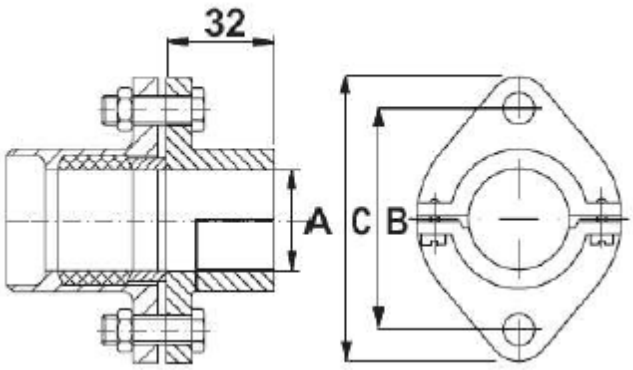


Figure 5. Movable flange DIN 43734

Certificates and solutions

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

Other details

Maintenance

Group T1- thermocouples do not require any special maintenance. Periodic inspections are recommended, as mechanical loads and thermal shocks can cause damage to ceramic tubes. Furthermore, periodic calibration of the temperature measuring instruments in use by an accredited laboratory is recommended.

Service

TERMOTEHNA can service temperature measuring instruments that were in use and bring them to metrologically correct condition.

Table 4: *Catalog codes for standard thermoelements*

Temperature	Material of protection tube	Nominal length L [mm]	Catalog number	
			thermocouple 1	thermocouple 2
up to 1500°C	Ceramic ∅15x2 (KER 610)	500	T1-1361	T2-2361
		710	T1-1362	T2-2362
		1000	T1-1363	T2-2363
		1400	T1-1364	T2-2364
		1600	T1-1364.1	T2-2364.1
		2000	T1-1365	T2-2365
up to 1600°C	Oxide ceramics ∅15x2.5 (KER 710)	500	T1-1371	T2-2371
		710	T1-1372	T2-2372
		1000	T1-1373	T2-2373
		1400	T1-1374	T2-2374
		1600	T1-1374.1	T2-2374.1
		2000	T1-1375	T2-2375
up to 1600°C	Porous ceramics ∅26x4 KER 530 With internal tube ∅15x2 (KER 610)	500	T1-1351	T2-2351
		710	T1-1352	T2-2352
		1000	T1-1353	T2-2353
		1400	T1-1354	T2-2354
		1600	T1-1354.1	T2-2354.1
		2000	T1-1355	T2-2355

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

Thermocouple Pt(10%Rh)-Pt, type S, according to IEC 584-1

°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

Thermocouple Pt(13%Rh)-Pt, Type R, according to IEC 584-1

°C	0	10	20	30	40	50	60	70	80	90
0	0	0,054	0,111	0,171	0,232	0,296	0,363	0,431	0,501	0,573
100	0,647	0,723	0,800	0,879	0,959	1,041	1,124	1,208	1,294	1,380
200	1,468	1,557	1,647	1,738	1,830	1,923	2,017	2,111	2,207	2,303
300	2,400	2,498	2,596	2,695	2,795	2,896	2,997	3,099	3,201	3,304
400	3,407	3,551	3,616	3,721	3,826	3,933	4,039	4,146	4,254	4,362
500	4,471	4,580	4,689	4,799	4,910	5,021	5,132	5,244	5,356	5,469
600	5,582	5,696	5,810	5,925	6,040	6,155	6,272	6,388	6,505	6, 623
700	6,741	6,860	6,979	7,098	7,218	7,339	7,460	7,582	7,703	7,826
800	7,949	8,072	8,196	8,320	8,445	8,570	8,696	8,822	8,949	9,076
900	9,203	9,331	9,460	9,589	9,718	9,848	9,978	10,109	10,240	10,371
1000	10,503	10,636	10,768	10,902	11,035	11,170	11,304	11,439	11,574	11,710
1100	11,846	11,983	12,119	12,257	12,394	12,532	12,669	12,808	12,946	13,085
1200	13,224	13,363	13,502	13,642	13,782	13,922	14,062	14,202	14,343	14,483
1300	14,624	14,785	14,906	15,047	15,188	15,329	15,470	15,611	15,752	15,893
1400	16,036	16,176	16,317	16,458	16,599	16,741	16,882	17,022	17,163	17,304
1500	17,445	17,585	17,726	17,866	18,006	18,146	18,286	18,425	18,564	18,703
1600	18,842	18,981	19,119	19,257	19,395	19,533	19,670	19,807	19,944	20,080
1700	20,215	20,350	20,483	20,616	20,748	20,878	21,006			

Thermocouple Pt(30%Rh)-Pt(6%Rh), Type B, according to IEC 584-1

°C	0	10	20	30	40	50	60	70	80	90
0	0	0,054	0,111	0,171	0,232	0,296	0,363	0,431	0,501	0,573
100	0,647	0,723	0,800	0,879	0,959	1,041	1,124	1,208	1,294	1,380
200	1,468	1,557	1,647	1,738	1,830	1,923	2,017	2,111	2,207	2,303
300	2,400	2,498	2,596	2,695	2,795	2,896	2,997	3,099	3,201	3,304
400	3,407	3,551	3,616	3,721	3,826	3,933	4,039	4,146	4,254	4,362
500	4,471	4,580	4,689	4,799	4,910	5,021	5,132	5,244	5,356	5,469
600	5,582	5,696	5,810	5,925	6,040	6,155	6,272	6,388	6,505	6, 623
700	6,741	6,860	6,979	7,098	7,218	7,339	7,460	7,582	7,703	7,826
800	7,949	8,072	8,196	8,320	8,445	8,570	8,696	8,822	8,949	9,076
900	9,203	9,331	9,460	9,589	9,718	9,848	9,978	10,109	10,240	10,371
1000	10,503	10,636	10,768	10,902	11,035	11,170	11,304	11,439	11,574	11,710
1100	11,846	11,983	12,119	12,257	12,394	12,532	12,669	12,808	12,946	13,085
1200	13,224	13,363	13,502	13,642	13,782	13,922	14,062	14,202	14,343	14,483
1300	14,624	14,785	14,906	15,047	15,188	15,329	15,470	15,611	15,752	15,893
1400	16,036	16,176	16,317	16,458	16,599	16,741	16,882	17,022	17,163	17,304
1500	17,445	17,585	17,726	17,866	18,006	18,146	18,286	18,425	18,564	18,703
1600	18,842	18,981	19,119	19,257	19,395	19,533	19,670	19,807	19,944	20,080
1700	20,215	20,350	20,483	20,616	20,748	20,878	21,006			

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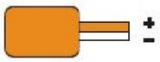
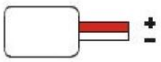
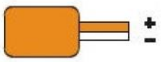
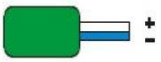
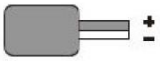
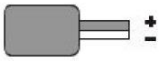
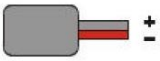
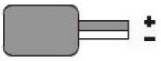
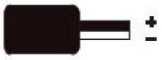
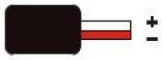
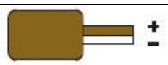
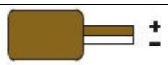
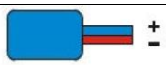
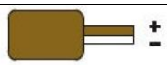
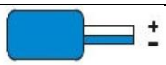
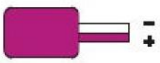
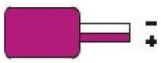
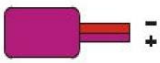
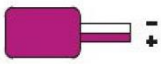
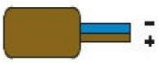
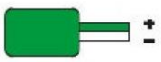
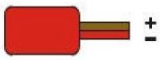
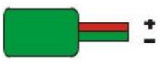
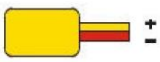
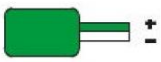
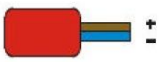
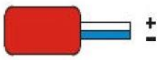
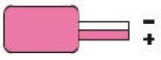
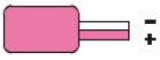
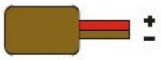
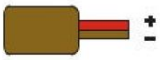
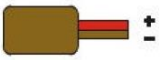
International Colour Codes applied to temperature engineering

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					
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