

# Mineral-Insulated Thermocouples

## for Measurements in Industry, Laboratories and Research

Mineral-Insulated Metal-Sheathed (MIMS) thermocouples were successfully introduced many years ago into temperature measurement technology. The standard versions are mainly used in the range between  $-270\text{ °C}$  and  $+1200\text{ °C}$ . They combine the advantages of high flexibility and easy handling in an extremely wide temperature range.

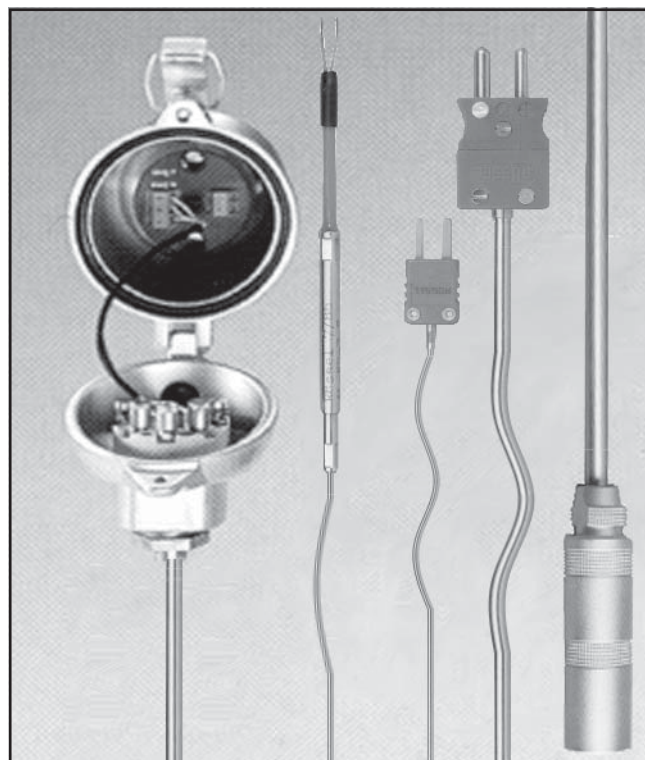
They are supplemented by high-temperature MIMS thermocouples for operating temperatures of  $2000\text{ °C}$  and above.

Inconel 600 is mainly used as sheath material, a nickel-based alloy. This material can easily be welded and soldered, it possesses extremely good resistivity characteristics also at higher temperatures and is resistant against most ambient conditions.

The thermocouple is often the type K (NiCr-Ni) acc. to IEC 60 584-1. Widely in use are also types L resp. J (both Fe-CuNi) and in the higher temperature range the noble metal types S R and B, which are platinum/rhodium alloys.

The thermocouple wires are embedded in a compact insulation of high-purity MgO and enclosed by a metal sheath of a nickel/chromium/iron alloy or of stainless steel. The compact insulation fixes the wires securely so that no damage can occur because of strong vibrations or high bending loads. Also short circuits between the wires or between wire and sheath are virtually impossible.

On pages 4 and 5 of this Product Information only the standard versions are listed. Special designs are of course always available and can be specified as per the ordering code on page 6.



### Special advantages:

- Mechanically resistant
- Short response times
- Easily bendable
- Highly resistant against vibrations
- Numerous different designs for nearly all applications
- Wide temperature range from  $-270\text{ °C}$  to over  $+2000\text{ °C}$

**Mineral-insulated metal-sheath thermocouples:**

MIMS thermocouples are highly versatile due to their special design. They can be mounted in places where conventional temperature sensors cannot be employed.

They are used in the automobile industry, in power plants, refineries, smelting plants, in ship-building, chemical industries, in combustion engines testing plants, turbines, in medicine, on forges and foundries, in missile-building, in vacuum and high-vacuum furnaces etc.

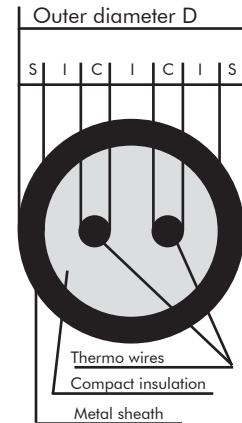
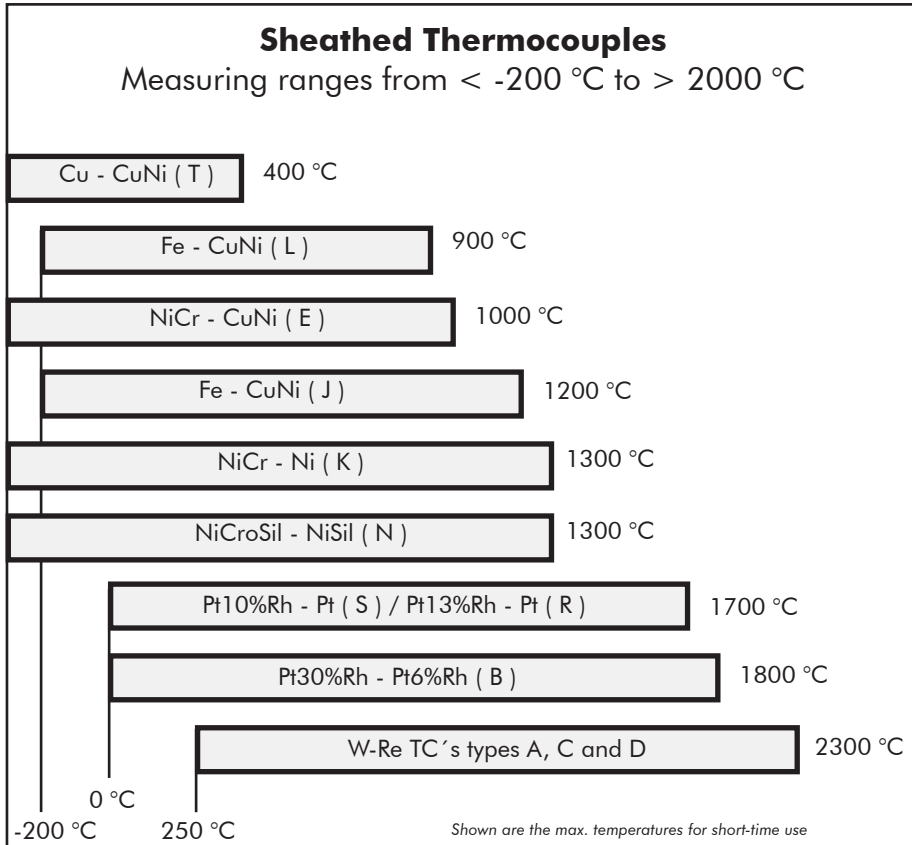
RÖSSEL-Messtechnik manufactures a large variety of designs from 0.25 to 10 mm diameter. The wide temperature range from -270 °C to +1200 °C for the standard thermocouples and up to over 2000 °C for the high-temperature MIMS thermocouples provides them with a wide field of applications.

**Guideline for the response time of mineral-insulated thermocouples**

The response time of a contact thermometer shows how fast the thermometer follows a step in temperature. The response time of a temperature sensor is characterized by an exponential function. The sensor and the surrounding medium is stabilized at a temperature  $T_1$ . This temperature is now altered in one step to an other temperature  $T_2$ , mostly 15 to 25 °C higher than  $T_1$ . The sensor follows this step with a time delay. The lapse of the electrical signal characterizes the transfer function. For technical purposes, two values are selected:  $t_{0,5}$  and  $t_{0,9}$ . This means that the signal has reached 50 %, respectively 90 %, of the final value.

**Response time of MI-thermocouples in seconds (-5 % / +15 %)**

Condi- tions	Time sec.	Measuring junction insulated from sheath Sheath diameter in mm						
		0.5	1.0	1.5	3.0	4.5	6.0	8.0
Water 0.2 m/s	50 %	0.06	0.15	0.21	1.2	2.5	4.0	7
	90 %	0.13	0.5	0.6	2.9	5.9	9.6	17
Air 2 m/s	50 %	1.8	3	8	23	37	60	100
	90 %	5.9	15	25	80	120	200	360



Cross-section of sheathed cable

**Dimensions (EN 61 515)**

Min. wall thickness S	0.10 x D
Min. conductor diameter C	0.15 x D
Min. insulation thickness I	0.08 x D

## Color-Coding of Thermocouples acc. to IEC 60 584-3 (DIN 43 722)

Material	Fe-CuNi	Fe-CuNi	NiCr-Ni	Cu-CuNi	NiCr-CuNi	NiCrSi-NiSi	Pt10Rh-Pt	Pt13Rh-Pt	Pt30Rh-Pt6Rh
Ident. Letter	L *	J	K	T	E	N	S	R	B
Color „+“ Pole	---	black	green	brown	lilac	pink	orange	orange	No color defined
	(red)	(---)	(red)	(red)	(---)	(---)	(red)	(red)	
Color „-“ Pole	---	white	white	white	white	white	white	white	
	(blue)	(---)	(green)	(brown)	(---)	(---)	(white)	(white)	
Color Sheath	---	black	green	brown	lilac	pink	orange	orange	
	(blue)	(---)	(green)	(brown)	(---)	(---)	(white)	(white)	

Identification letters acc. to DIN EN 60 584 (DIN 43 710)

\* Type L acc. to DIN 43 710 (standard withdrawn 07/97)

Identification colors in brackets acc. to withdrawn DIN 43 714

## Thermal EMF Values acc. to DIN EN 60 584-1 (\*DIN 43 710)

Reference junction temperature 0 °C

\* Type L acc. to DIN 43 710 (standard withdrawn 07/97)

Temperature in °C	Type L* μV	Type J μV	Type K μV	Type T μV	Type E μV	Type N μV	Type S μV	Type R μV	Type B μV
-200	-8167	-7890	-5891	-5603	-8825	-3990			
-100	-4747	-4633	-3554	-3379	-5237	-2407			
0	0	0	0	0	0	0	0	0	0
100	5373	5269	4096	4279	6319	2774	646	647	33
200	10953	10779	8138	9288	13421	5913	1441	1469	0178
300	16557	16327	12209	14862	21036	9341	2323	2401	0431
400	22170	21848	16397	20872	28946	12974	3259	3408	0787
500	27862	27393	20644		37005	16748	4233	4471	1242
600	33671	33102	24905		45093	20613	5239	5583	1792
700	39721	39132	29129		53112	24527	6275	6743	2431
800	46219	45494	33275		61017	28455	7345	7950	3154
900	53147	51877	37326		68787	32371	8449	9205	3957
1000		57953	41276		76373	36256	9587	10506	4834
1100		63792	45119			40087	10757	11850	5780
1200		69553	48838			43846	11951	13228	6786
1300			52410			47513	13159	14629	7848
1400							14373	16040	8956
1500							15582	17451	10099
1600							16777	18849	11263
1700							17947	20222	12433
1800									13591

Fat intermediate line = recommended max. permanent operating temperature for MMS thermocouples 3 mm dia.

Dotted line = max. temperature for non-noble metal sheaths

## Permitted Deviations for Thermocouples acc. to DIN EN 60 584-2

Permitted deviation	IEC 60 584-2 Class 1	IEC 60 584-2 Class 2	IEC 60 584-2 Class 3
Permitted deviation +/- ]* Measuring range type T	0.5 °C or 0.004 x (t) °C -40 ... +350 °C	1.0 °C or 0.0075 x (t) °C -40 ... +400 °C	1.0 °C or 0.015 x (t) °C -200 ... +40 °C
Permitted deviation +/- ]* Measuring range type J Measuring range types K & N Measuring range type E	1.5 °C or 0.004 x (t) °C -40 ... +750 °C -40 ... +1000 °C -40 ... +800 °C	2.5 °C or 0.0075 x (t) °C -40 ... +750 °C -40 ... +1200 °C -40 ... +900 °C	2.5 °C or 0.015 x (t) °C --- -200 ... +40 °C -200 ... +40 °C
Permitted deviation +/- ]* Measuring range types S & R Measuring range type B	1.0 °C or (1+(t-1100) x 0.003) °C 0 ... +1600 °C ---	1.5 °C or 0.0025 x (t) °C 0 ... 1600 °C 600 ... 1700 ]**	4.0 °C or 0.005 x (t) °C ---- 600 ... 1700 ]**

] \* The higher value applies

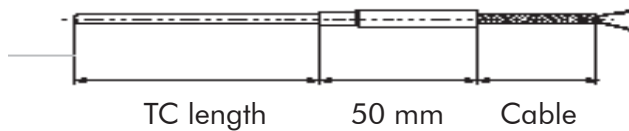
(t) = Numeric value of temperature in °C without algebraic signs

] \*\* Recommended operating temperature range

The normally available material for thermocouples maintain the permitted deviations acc. to a.m. table at temperatures above -40 °C. These materials do not necessarily maintain the permitted deviation of class 3 at temperatures below -40 °C. When thermocouples type E, J, K and N are required, which maintain permitted deviations of class 3 as well as class 1 or 2, the customer has to specify this expressly because a special selection of available material has to be done.

**With hard-wired cable**

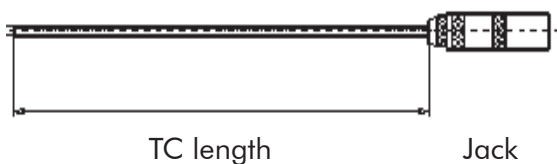
**Form: AL**



In this design the connection cable is hard-wired. The transition sleeve has a diameter of 6 or 8 mm depending on the type of cable. The standard length is 5 mm. The cable type (conductor cross-section, insulation structure, screening) can be chosen from a wide range. Standard is a screened cable with individually Teflon-insulated wires and jointly PVC-insulated with a cross-section of 0.25 mm<sup>2</sup>. The maximum temperature at the sleeve is 85 °C. (When ordering please specify the required cable type.)

**With hard-wired jack**

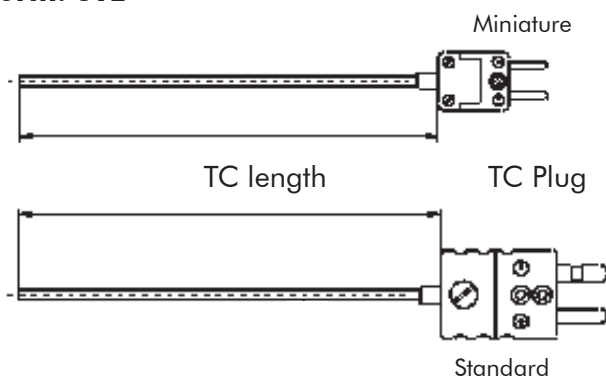
**Form: S**



With type S the connector system is directly connected to the MIMS thermocouple. The standard version is fitted with a jack type RLK size 0 (up to 1.6 mm sheath diameter above that size 1). The positive pole touches the pin. The brass contacts are galvanically gold-plated. The maximum temperature at the jack is 150 °C. Other connector systems are available on request. (When ordering please specify the required type.)

**With hard-wired thermocouple plug miniature or standard**

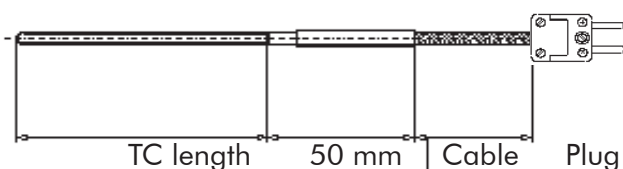
**Form: STE**



With type STE the plug is directly connected to the MIMS thermocouple. The standard version is fitted with a miniature plug (thermocouple dia.  $\leq 1.6$  mm) resp. with a standard plug. The contacts are made of thermocouple material, the outer body of temperature-resistant plastic material. The maximum temperature at the plug is 150 °C. Plug and jack are connected with correct poles and thus provide optimal contact security. Other connector systems are available on request as well as the appropriate jacks. (When ordering please specify the required type)

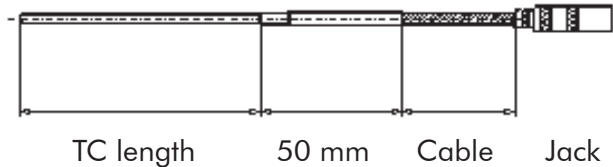
**With hard-wired cable and thermocouple plug**

**Form: ALSTE**



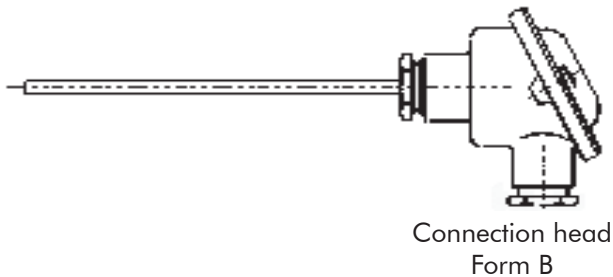
Type ALSTE adds one thermocouple plug to form AL. Depending on customer specification this type is fitted with a miniature resp. standard plug. The contacts are made of thermocouple material, the outer body of temperature-resistant plastic material. The permitted plug and sleeve temperature depends on the type of cable, max. however 150 °C. Other designs e.g. with circular connector systems are available on request.

**With hard-wired cable and LEMO jack**  
**Form: ALS**



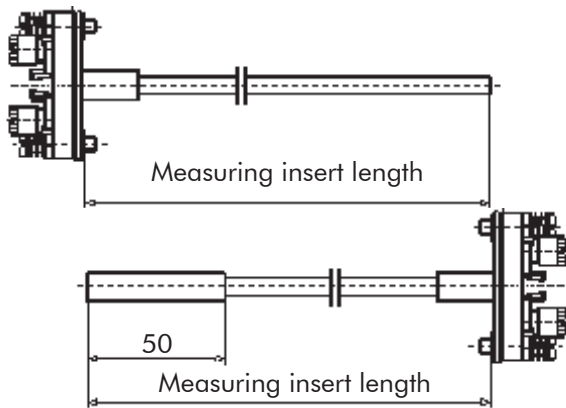
Type ALS adds one circular LEMO jack to form AL. This version is equipped depending on customer specification respectively cable diameter with a round jack size 0 or size 1. Other sizes are available on request. The brass contacts are gold-plated. The brass outer body is matt-chromium-plated. The plug and sleeve temperature depends on the type of cable, max. however 150 °C. Other versions e.g. with circular LEMO plugs are available on request.

**MIMS thermocouple**  
**with connection head form B**



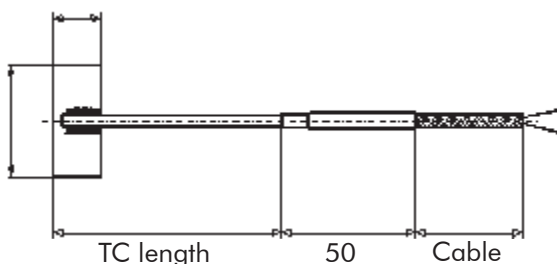
This design consists of a measuring insert with connector socket and cable clips fitted into a connection head form B acc. to EN 50 446. A special pipe screw joint holds the measuring insert firmly in place. The nominal length starts at the bottom edge of the pipe screw joint. Other connection head designs are available on request. Standard versions:  
Sheath diameter see form TMM below.  
Connection head form B acc. to EN 50 446.  
When ordering please specify the required version.

**MIMS measuring insert**  
**diameter constant or tip reinforced**  
**Form: TMM**



Measuring insert with connector socket, cable clips and spring-loaded pressuring device. Suitable for mounting in connection heads form B acc. to DIN 43 729. Ordering code see page 6. Versions:  
A. Sheath diameter constant 3.0 mm  
B. Sheath diameter constant 6.0 mm  
C. Sheath diameter 6.0 mm, measuring tip 8 mm dia. x 50 mm long  
B. Sheath diameter constant 8.0 mm  
Other versions are available on request.

**MIMS thermocouple**  
**with weld-on plate**  
**Form: AL - RT**

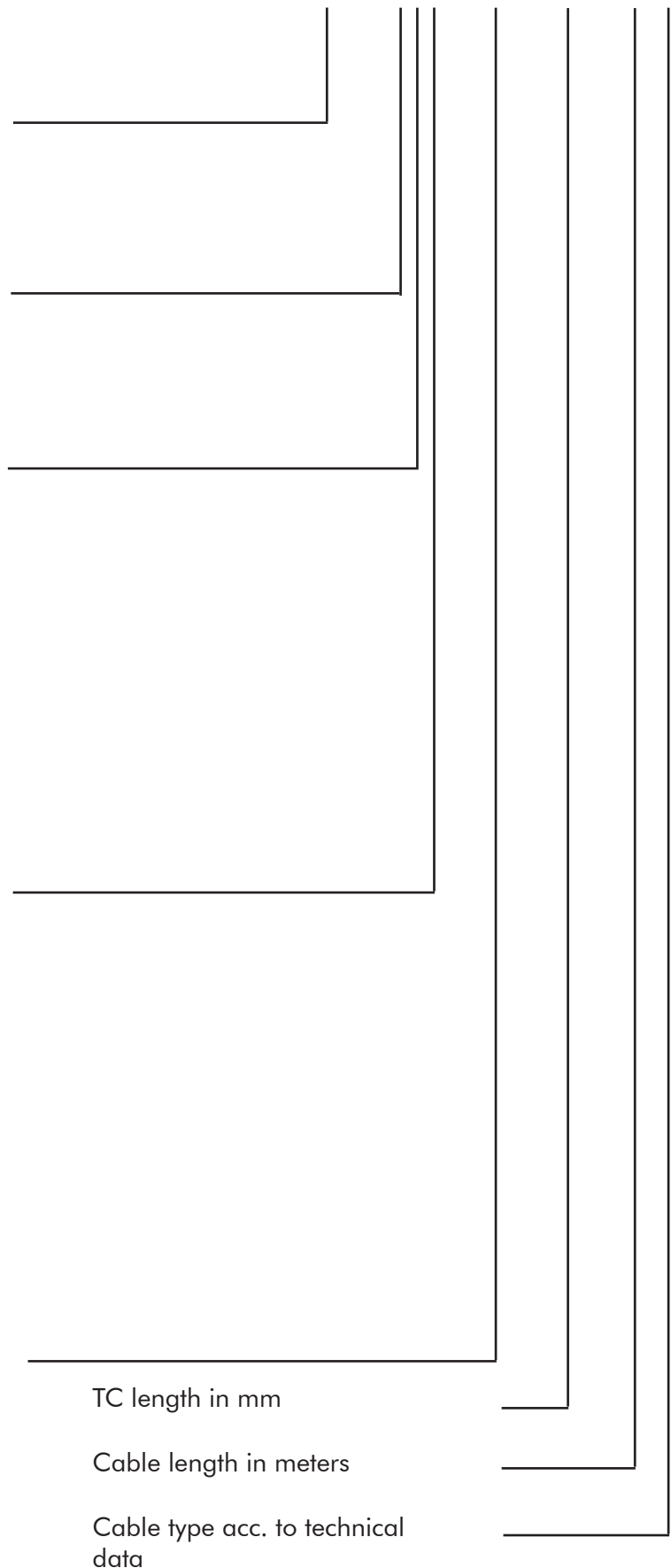


The base version of this MIMS thermocouple can be selected from the data given on pages 4 and 5 of this Product Information except form TMM. Form type design and in particular the material of the plate must be specified in detail. For outer sheath diameters < 1.5 mm please send us an enquiry. Generally excluded are all high-temperature and noble metal thermocouples. The temperature at the transition sleeve depends on the type of cable, max. however 150 °C. Special designs are available on request. When ordering please specify the required type.

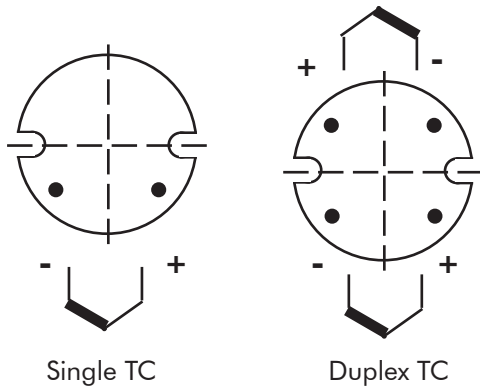
**Ordering code:**

**Example: ALSTE - 1KB - 3.0 - 600 - 3 - A**

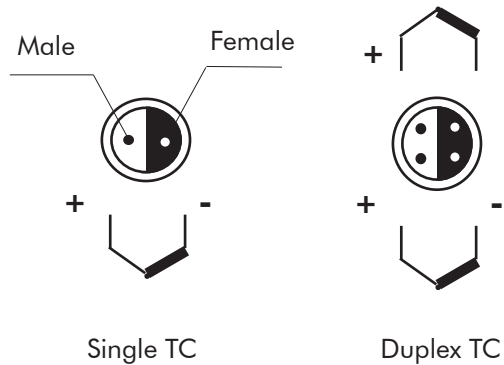
- Form
- AL = with connection cable
  - ALS = with cable and LEMO jack
  - ALSTE = with cable and TC plug
  - S = with LEMO plug
  - STE = with TC plug
  - TMM = sheathed measuring insert
  - B-KB = with connection head form B
  - AL-RT = with weld-on plate
- Number of thermocouples (1 or 2)  
No figure = single thermocouple
- Thermocouple types acc. to EN 60 584
- E = NiCr - CuNi
  - J = Fe - CuNi
  - K = NiCr - Ni
  - T = Cu - CuNi
  - N = NiCrSi - NiSi
  - S = Pt10%Rh - Pt
  - R = Pt13%Rh - Pt
  - B = Pt30%Rh - Pt6%Rh
- Thermocouple type acc. to DIN 43 710
- L = Fe - CuNi
- Thermocouple types acc. to ASTM 988
- AA = W - W26%Re
  - AE = W3%Re - W26%Re
  - AO = W5%Re - W25%Re
- Sheath material identification letter
- B = Inconel mat. no.: 2.4816
  - D = Stainless steel mat. no.: 1.4841
  - E = Stainless steel mat. no.: 1.4541
  - AW = Nimonic 75
  - AH = Platinum 10% rhodium
  - AA = Platinum 6% rhodium
  - N = Tantalum
  - O = Molybdenum
- Sheath diameter
- 0.25 = Ø 0.25 mm
  - 0.5 = Ø 0.5 mm
  - 1.0 = Ø 1.0 mm
  - 1.5 = Ø 1.5 mm
  - 1.6 = Ø 1.6 mm
  - 3.0 = Ø 3.0 mm
  - 3.2 = Ø 3.2 mm
  - 4.5 = Ø 4.5 mm
  - 4.8 = Ø 4.8 mm
  - 6.0 = Ø 6.0 mm
  - 6.4 = Ø 6.4 mm
  - 6.0/8.0 = Ø 6.0 mm reinforced to 8.00 mm
  - 8.0 = Ø 8.0 mm



**Wiring diagram form TMM resp. B-KB**



**Wiring diagram form S resp. ALS**



**Wiring diagram thermocouple plug**

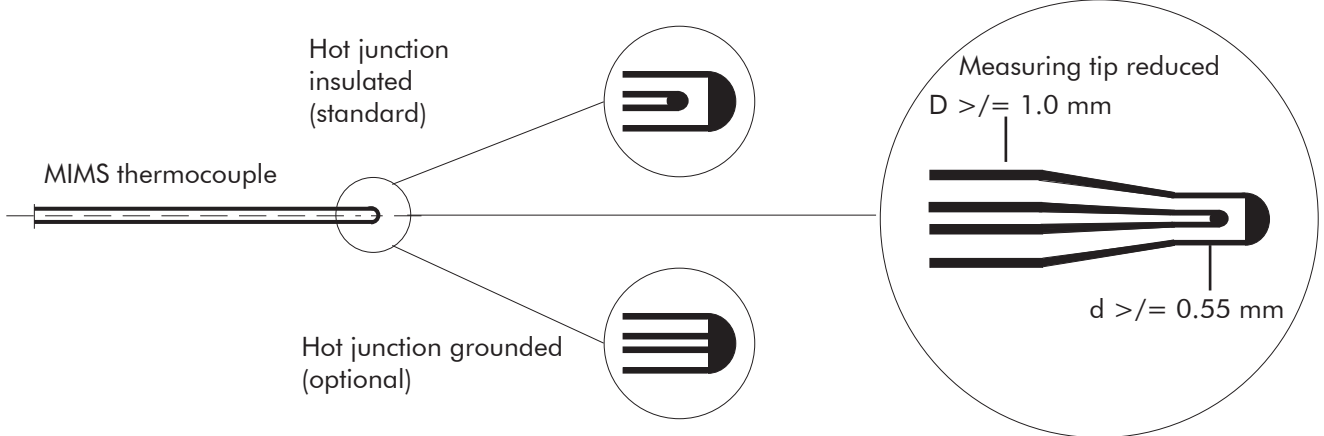


Miniature plug type: TS - \* M(ini)

Standard plug type: TS - \* S(standard)

\* = Identification letter of the TC acc. to EN 60 584-1

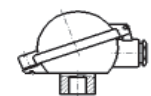
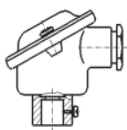
**Measuring tip type**



**With duplex thermocouples the hot junctions are galvanically insulated from each other and from the sheath!**

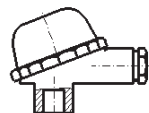
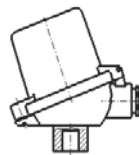
**Connection head designs: Form B**

Form B



Form BKD-RP

Form BKD-RPH  
Form BKK-RPH



Form BKK

**Connection heads:**

The connection head form B acc. to EN 50 446 made from cast aluminium as well as form BKD.

Connection heads with high covers e.g. for mounting one or two transmitters are also available (forms BKD-SPH resp. BKD-RPH).

Available are also designs made from moulded plastic material with screw cover form BKK and hinged cover form BKK-RPH. The standard cable thread for all connection heads is M 20 x 1 (PG 16).

The standard protection classification is IP 43.

Other protection classifications (e.g. IP 65) as well as connection heads made from other materials are available on request.



## Nominal Values of Thermocouples Types J, K, N acc. to IEC 60 584 - 1

Shown is the thermoelectric voltage in  $\mu\text{V}$  versus the temperature in  $^{\circ}\text{C}$  based on a cold junction temperature of  $0^{\circ}\text{C}$ . Intermediate values can be interpolated linearly. The error is less than  $0.1^{\circ}\text{C}$ .

Type J	0	10	20	30	40	50	60	70	80	90
<b>-200</b>	-7890									
<b>-100</b>	-4633	-5037	-5426	-5801	-6159	-6500	-6821	-7123	-7403	-7659
<b>0</b>	0	-501	-995	-1482	-1961	-2431	-2893	-3344	-3786	-4215
<b>0</b>	0	507	1019	1537	2059	2585	3116	3650	4187	4726
<b>100</b>	5269	5814	6360	6909	7459	8010	8562	9115	9669	10224
<b>200</b>	10779	11334	11889	12445	13000	13555	14110	14665	15219	15773
<b>300</b>	16327	16881	17434	17986	18538	19090	19642	20194	20745	21297
<b>400</b>	21848	22400	22952	23504	24057	24610	25164	25720	26276	26834
<b>500</b>	27393	27953	28516	29080	29647	30216	30788	31362	31939	32519
<b>600</b>	33102	33689	34279	34873	35470	36071	36675	37284	37896	38512
<b>700</b>	39132	39755	40382	41012	41645	42281	42919	43559	44203	44848
<b>800</b>	45494	46141	46786	47431	48074	48715	49353	49989	50622	51251
<b>900</b>	51877	52500	53119	53735	54347	54956	55561	56164	56763	57360
<b>1000</b>	57953	58545	59134	59721	60307	60890	61473	62054	62634	63214
<b>1100</b>	63792	64370	64948	65525	66102	66679	67255	67831	68406	68980
<b>1200</b>	69553									

TypeK	0	10	20	30	40	50	60	70	80	90
<b>-200</b>	-5891									
<b>-100</b>	-3554	-3852	-4138	-4411	-4669	-4913	-5141	-5354	-5550	-5730
<b>0</b>	0	-392	-778	-1156	-1527	-1889	-2243	-2587	-2920	-3243
<b>0</b>	0	397	798	1203	1612	2023	2436	2851	3267	3682
<b>100</b>	4096	4509	4920	5328	5735	6138	6540	6941	7340	7739
<b>200</b>	8138	8539	8940	9343	9747	10153	10561	10971	11382	11795
<b>300</b>	12209	12624	13040	13457	13874	14293	14713	15133	15554	15975
<b>400</b>	16397	16820	17243	17667	18091	18516	18941	19366	19792	20218
<b>500</b>	20644	21071	21497	21924	22350	22776	23203	23629	24055	24480
<b>600</b>	24905	25330	25755	26179	26602	27025	27447	27869	28289	28710
<b>700</b>	29129	29548	29965	30382	30798	31213	31628	32041	32453	32865
<b>800</b>	33275	33685	34093	34501	34908	35313	35718	36121	36524	3692
<b>900</b>	37326	37725	38124	38522	38918	39314	39708	40101	40494	40885
<b>1000</b>	41276	41665	42053	42440	42826	43211	43595	43978	44359	44740
<b>1100</b>	45119	45497	45873	46249	46623	46995	47367	47737	48105	48473
<b>1200</b>	48838	49202	49565	49926	50286	50644	51000	51355	51708	52060
<b>1300</b>	52410	52759	53106	53451	53795	54138	54479	54819		

Type N	0	10	20	30	40	50	60	70	80	90
<b>-200</b>	-3990									
<b>-100</b>	-2407	-2612	-2808	-2994	-3171	-3336	-3491	-3634	-3766	-3884
<b>0</b>	0	-260	-518	-772	-1023	-1269	-1509	-1744	-1972	-2193
<b>0</b>	0	261	525	793	1065	1340	1619	1902	2189	2480
<b>100</b>	2774	3072	3374	3680	3989	4302	4618	4937	5259	5585
<b>200</b>	5913	6245	6579	6916	7255	7597	7941	8288	8637	8988
<b>300</b>	9341	9696	10054	10413	10774	11136	11501	11867	12234	12603
<b>400</b>	12974	13346	13719	14094	14469	14846	15225	15604	15984	16366
<b>500</b>	16748	17131	17515	17900	18286	18672	19059	19447	19835	20224
<b>600</b>	20613	21003	21393	21784	22175	22566	22958	23350	23742	24134
<b>700</b>	24527	24919	25312	25705	26098	26491	26883	27276	27669	28062
<b>800</b>	28455	28847	29239	29632	30024	30416	30807	31199	31590	31981
<b>900</b>	32371	32761	33151	33541	33930	34319	34707	35095	35482	35869
<b>1000</b>	36256	36641	37027	37411	37795	38179	38562	38944	39326	39706
<b>1100</b>	40087	40466	40845	41223	41600	41976	42352	42727	43101	43474
<b>1200</b>	43846	44218	44588	44958	45326	45694	46060	46425	46789	47152
<b>1300</b>	47513									



## Nominal Values of Thermocouples Types L (DIN 43 710) and S, R (IEC 60 584-1)

Shown is the thermoelectric voltage in  $\mu\text{V}$  versus the temperature in  $^{\circ}\text{C}$  based on a cold junction temperature of  $0^{\circ}\text{C}$ . Intermediate values can be interpolated linearly. The error is less than  $0.1^{\circ}\text{C}$ .

Type L	0	10	20	30	40	50	60	70	80	90
<b>-200</b>	-8167									
<b>-100</b>	-4747	-5154	-5543	-5915	-6269	-6607	-6929	-7240	-7545	-7850
<b>0</b>	0	-514	-1022	-1523	-2016	-2500	-2974	-3438	-3888	-4325
<b>0</b>	0	520	1045	1574	2107	2644	3184	3728	4274	4822
<b>100</b>	5373	5926	6480	7036	7593	8152	8711	9271	9831	10392
<b>200</b>	10953	11514	12075	12636	13197	13757	14318	14878	15438	15998
<b>300</b>	16557	17117	17677	18237	18797	19358	19919	20480	21043	21606
<b>400</b>	22170	22734	23300	23867	24434	25003	25573	26144	26715	27288
<b>500</b>	27862	28437	29013	29591	30169	30749	31330	31913	32497	33083
<b>600</b>	33671	34262	34855	35451	36049	36651	37257	37867	38480	39099
<b>700</b>	39721	40349	40982	41619	42262	42910	43562	44220	44882	45548
<b>800</b>	46219	46893	47572	48253	48938	49627	50320	51017	51720	52429
<b>900</b>	53147									

Type S	0	10	20	30	40	50	60	70	80	90
<b>0</b>	0	55	113	173	235	299	365	433	502	573
<b>100</b>	646	720	795	872	950	1029	1110	1191	1273	1357
<b>200</b>	1441	1526	1612	1698	1786	1874	1962	2052	2141	2232
<b>300</b>	2323	2415	2507	2599	2692	2786	2880	2974	3069	3164
<b>400</b>	3259	3355	3451	3548	3645	3742	3840	3938	4036	4134
<b>500</b>	4233	4332	4432	4532	4632	4732	4833	4934	5035	5137
<b>600</b>	5239	5341	5443	5546	5649	5753	5857	5961	6065	6170
<b>700</b>	6275	6381	6486	6593	6699	6806	6913	7020	7128	7236
<b>800</b>	7345	7454	7563	7673	7783	7893	8003	8114	8226	8337
<b>900</b>	8449	8562	8674	8787	8900	9014	9128	9242	9357	9472
<b>1000</b>	9587	9703	9819	9935	10051	10168	10285	10403	10520	10638
<b>1100</b>	10757	10875	10994	11113	11232	11351	11471	11590	11710	11830
<b>1200</b>	11951	12071	12191	12312	12433	12554	12675	12796	12917	13038
<b>1300</b>	13159	13280	13402	13523	13644	13766	13887	14009	14130	14251
<b>1400</b>	14373	14494	14615	14736	14857	14978	15099	15220	15341	15461
<b>1500</b>	15582	15702	15822	15942	16062	16182	16301	16420	16539	16658
<b>1600</b>	16777	16895	17013	17131	17249	17366	17483	17600	17717	17832
<b>1700</b>	17947	18061	18174	18285	18395	18503	18609			

Type R	0	10	20	30	40	50	60	70	80	90
<b>0</b>	0	54	111	171	232	296	363	431	501	573
<b>100</b>	647	723	800	879	959	1041	1124	1208	1294	1381
<b>200</b>	1469	1558	1648	1739	1831	1923	2017	2112	2207	2304
<b>300</b>	2401	2498	2597	2696	2796	2896	2997	3099	3201	3304
<b>400</b>	3408	3512	3616	3721	3827	3933	4040	4147	4255	4363
<b>500</b>	4471	4580	4690	4800	4910	5021	5133	5245	5357	5470
<b>600</b>	5583	5697	5812	5926	6041	6157	6273	6390	6507	6625
<b>700</b>	6743	6861	6980	7100	7220	7340	7461	7583	7705	7827
<b>800</b>	7950	8073	8197	8321	8446	8571	8697	8823	8950	9077
<b>900</b>	9205	9333	9462	9591	9720	9850	9980	10111	10242	10374
<b>1000</b>	10506	10639	10771	10905	11039	11173	11307	11442	11578	11714
<b>1100</b>	11850	11986	12123	12260	12397	12535	12673	12812	12950	13089
<b>1200</b>	13228	13367	13507	13646	13786	13926	14066	14207	14347	14488
<b>1300</b>	14629	14770	14911	15052	15193	15334	15475	15616	15758	15899
<b>1400</b>	16040	16181	16323	16464	16605	16746	16887	17028	17169	17310
<b>1500</b>	17451	17591	17732	17872	18012	18152	18292	18431	18571	18710
<b>1600</b>	18849	18988	19126	19264	19402	19540	19677	19814	19951	20087
<b>1700</b>	20222	20356	20488	20620	20749	20877	21003			

## High-Temperature MIMS Thermocouples

Sheath material	Type
Pt 6 % Rh - Pt	AA
Pt 10 % Rh - Pt	AH
Tantal	N
Molybdenum	O
Titan	Q
Nickel	W
Niob 1 % Zirconium	AV
Molybdenum 50 % Rhenium	BE
Incoloy	X

Wire material	Type
Pt 10 % Rh - Pt	S
Pt 13 % Rh - Pt	R
Pt 30 % Rh - Pt 6 % Rh	B
Ir 60 % Rh - Ir	V
W 5% Re - W 20 % Re	A
W3 % Re - W 25 % Re	D (AO)
W5 % Re - W 26 % Re	C (AE)

Insulation material	Type
Magnesium-oxide	M
Aluminium-oxide	A
(Beryllium-oxide) <sup>1)</sup>	(B)
Hafnium-oxide	H

<sup>1)</sup> Should not longer be used because of hazard to your health

For high temperatures of 2000 °C and above or for highly corrosive environments we supply specially designed thermocouples.

To a large degree these thermocouples are being used in space technology, in research laboratories and in all industries.

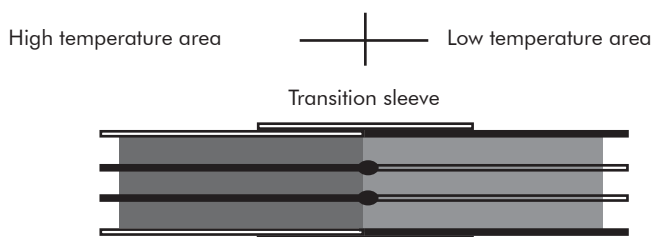
For the various applications suitable sheath materials, thermocouple combinations and insulation materials are used by us.

For the production of the hot junctions new technologies had to be developed as the load on the hot junctions at high temperatures is very high due to various factors. Only materials specially suited and tested are used for these applications. The insulation materials are of high purity. The possible applications of the various materials depend to a large degree on the ambient conditions.

The operation in air (oxidizing atmosphere) is possible only up to certain - normally considerably lower - temperatures except for platinum alloys. The sheath materials shown in the tables are only an excerpt from all the materials available. Other materials are available on request.

For long thermocouples it is recommended for cost reasons to make a transition to a different material. The insertion length of the part exposed to the high temperature can be manufactured as per customer specification.

### Transition thermocouple



### Transition thermocouple

Standard transition sleeve  
Sheath: AA AH N O BE AV on Inconel  
Insulation: HfO, MgO or Al<sub>2</sub>O<sub>3</sub>

### The following tests can be made and certified on request:

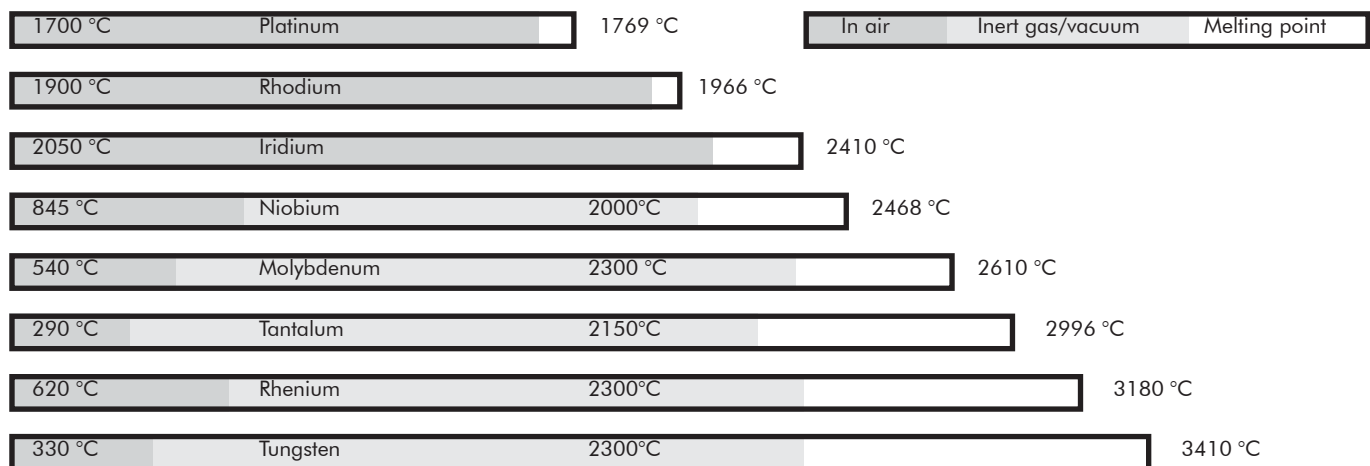
Thermoelectric voltage temperature  
X-ray photos of hot junction and transition  
Helium leakage  
Oscillation

Resistance  
Sealing (on bare wire ends or transition to compensating cable)  
Material (sheath, thermo-wires, insulation)

## Guidelines for the use of high-temperature thermocouples

Sheath Material	Type	Thermo wire type	Insulation	Atmosphere	Rec. oper. temp.
Pt 6% Rh	AA	S; R; B; V	MgO	oxidizing	1400 °C
Pt 10% Rh	AH	S; R; B; V	MgO	oxidizing	1400 °C
Pt 6% Rh	AA	V; A; C; D	MgO / HfO	oxidizing	1700 °C
Pt 10% Rh	AH	V; A; C; D	MgO / HfO	oxidizing	1700 °C
Tantalum	N	A; C; D	Al <sub>2</sub> O <sub>3</sub> / HfO	inert / vacuum	1700 °C
Tantalum	N	A; C; D	HfO	inert / vacuum	2200 °C
Molybdenum	O	A; C; D	HfO	inert/vacuum/reducing	2200 °C
Mo 50% Re	BE	A; C; D	HfO	inert/vacuum/reducing	2200 °C

## Melting points and maximum operating temperatures



## Thermoelectric voltages of high-temperature thermocouples

Temperature in °C	W5%Re-W20%Re	W3%Re-W25%Re	W5%Re-W26%Re	Ir40%Rh-Ir
	Type A	Type D (AE)	Type C (AO)	Type V
100	1337	1144	1451	371
200	2872	2601	3090	841
300	4513	4284	4865	1380
400	6204	6126	6732	1961
500	7908	8073	8657	2562
600	9606	10082	10609	3172
700	11284	12118	12559	3861
800	12934	14170	14494	4448
900	14550	16212	16398	5021
1000	16128	18230	18260	5576
1100	17662	20211	20071	6116
1200	19150	22149	21825	6643
1300	20589	24040	23520	7159
1400	21976	25882	25155	7669
1500	23311	27673	26729	8177
1600	24593	29412	28243	8687
1700	25822	31093	29696	9205
1800	26998	32712	31087	9732
1900	28120	34257	32413	10272
2000	29186	35717	33669	10826
2100	30194	37073	34849	11395
2200	31142	38299	35940	---
2300	32028	39365	36931	---

Thermoelectric voltages in  $\mu\text{V}$ , reference temperature 0 °C

## Technical Data:

### MIMS thermocouple:

Standard: thermocouples acc. to IEC 60 584-1  
Other types available on request

### Permitted deviation:

Class 1 or 2 acc. to IEC 60 584-2  
Narrower permitted deviations are available on request.

### Insulation resistance:

Typically  $\geq 5000 \text{ MOhm} \cdot \text{m}$  at 23 °C  
Min.  $1000 \text{ MOhm} \cdot \text{m}$  (EN 61 515)

### Insulation material:

High-purity magnesium-oxide (MgO)

### Sheath material:

Inconel 600	mat. no: 2.4816
Temperature-resistant steel	mat. no.: 1.4841
Stainless steel	mat. no.: 1.4541

### Sheath diameters (in mm) :

Standard: 0.25; 0.5; 1.0; 1.5; 3.0; 6.0; 8.0  
Special: 0.35; 1.6; 2.0; 3.2; 4.5; 4.8; 10.0

### Remark:

From 1.5 mm sheath diameter upwards duplex designs (2 thermocouples in joint sheath) are available.

### Round jacks and plugs:

For forms S resp. ALS round jacks type RLK size 0 or 1 are used. Depending on the type of wiring the jacks have 2 or 4 poles.  
The brass precision contacts are gold-plated the brass outer body is matt-chromium-plated.  
Contacts made of thermocouple material are available on request.

Other connector systems and sizes are also available on request as well as the appropriate counter plugs.

### Conductor types:

A ) TT - 465 - 2K - 0.25 L (stranded):  
High-quality thermo wire class 1  
Individually and jointly Teflon-insulated  
Screen braiding Cu, tin-plated  
2 x stranded wire  $0.25 \text{ mm}^2$  cross-section  
Max. ambient temperature 220 °C

B ) GG - 220 - 2K - 0.5 M (solid):  
High-temperature thermo wire class 1  
Individually and jointly insulated with special glass silk, 2 x solid wire 0.5 mm dia., max. ambient temperature 400 °C

C ) TP - 440 - 2KC - 0.25 L:  
Compensating cable  
Individually Teflon- and jointly PVC-insulated, screen braiding Cu  
2 x stranded wire  $0.25 \text{ mm}^2$  cross-section  
Max. ambient temperature 85 °C

D ) TG - 412 - 2KC - 0.25 L:  
Compensating cable  
Individual wires Teflon-insulated  
jointly braided with glass silk  
braided with stainless-steel wires  
2 x stranded wire  $0.25 \text{ mm}^2$  cross-section  
Max. ambient temperature 240 °C

### Thermocouple jacks and plugs:

Thermocouple plugs and jacks (EN 61 515) are available in two sizes: miniature and standard. In both the contacts are made of thermocouple material.  
The design of the plugs is such that wrong poling is not possible. Plug systems are available for all types acc. to IEC 60 584 and for some special designs (W-Re thermocouples).  
The max. ambient temperature is 200 °C. High-temperature designs for up to 285 °C respectively 425 °C are available on request.

All data given in this data sheet are typical but do not constitute binding and/or guaranteed characteristics. Any data needs to be verified in detail by the customer in relation to any specific application. We reserve the right to change any specification without prior notice in line with our policy of continuous technical improvement.

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