

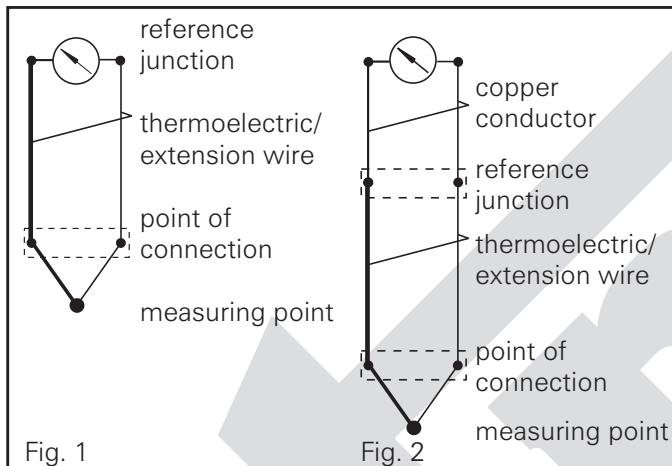
**Measuring principle**

The measuring principle of thermocouples is based on the Seebeck effect. The sensitive part of thermocouples consists of two conductors made of different materials which are connected with each other at one end (measuring point). The other two ends (reference junction), however, are connected with the indicating unit, for example a galvanometer or a high-resistance indicating electronic unit, via connecting wires (see Fig. 1). The amount of the thermoelectric voltage applied at the reference junction depends on the material of the thermowires and on the temperature difference between measuring point and reference junction.

**Note!**

*For absolute measurements the temperature at the reference junction must be known and constant.*

In order to ensure this, the thermocouple is extended by thermoelectric or extension wires up to a point of a defined, constant temperature (see Fig. 2).



**Extension wires**

Extension wires provide the same amount of thermo-electric voltage as the appertaining thermocouples up to 200 °C. They are part of the delivery only in exceptional cases or in case of cable thermocouples.

The extension wires appertaining to the respective thermocouples are marked by a special identifying colour as for each thermocouple only an extension line consisting of a thermoelectrically relevant material may be used.

**Note!**

*For the standardized extension wires the regulations laid down in DIN 43713 and DIN 43714 are valid.*

**Technical parameters**

Besides the special versions of thermocouples whose technical parameters will have to be fixed according to the customer's wishes, the following data are valid for the standard assortment:

- thermocouple: acc. to DIN IEC 584 (type L: DIN 43 710)
- tolerances: acc. to DIN IEC 584, classification 1 and 2 and partly classification 3
- insulation resistance:  $\geq 20 \text{ M}\Omega$  at room temperature and a test voltage of 500 V d.c.
- protection classification: IP 54 acc. to EN 60529 in case of Silicone seals in the heads of higher protection.

**Max. operating temperature of the components**

All types of thermocouples must be protected from inadmissible overheating in any case!

Depending on the materials chosen and under normal operating conditions, the following recommended standard values are valid for the single components in neutral medium:

component	max. temperature
connecting head (B-types only)	
- aluminum casting with rubber gasket	100 °C
- aluminum casting with silicon gasket	150 °C
- "VA"-part with TEFLON gasket	200 °C
connecting head with built-in transmitter	
- standard type	70 °C
- special type	85 °C
connecting cable	
- PVC, normal (PVC, heat-stabilized)	70 °C (105 °C)
- silicone	180 °C
- PTFE	200 °C
- glass-silk insulation	400 °C
If combining different insulation materials: The maximum temperature load of that material with the lowest permissible maximum temperature has to be taken into consideration. Other ranges are possible with special cables. these have to be obtained from the manufacturer.	
protecting tube	see load characteristic diagrams acc. to DIN 43763
-metallic:	
1.1003 pure iron	950 °C
1.4762 X10CrAl24	1150 °C
1.4749 X18CrNi28	1100 °C
1.4841 X15CrNiSi25 20	1150 °C
1.4571 X6CrNiMoTi17 12 2	800 °C
2.4633 NiCr25FeAlY	1200 °C
DVS platinum	1600 °C
-ceramic:	
C 530 Al <sub>2</sub> O <sub>3</sub> -fine-porous	1400 °C
C 610 Al <sub>2</sub> O <sub>3</sub> -gas-proof	1500 °C
C 799 Al <sub>2</sub> O <sub>3</sub> -gas-proof, extremely pure	1600 °C
SiC clay-bound	1350 °C
Si <sub>3</sub> N <sub>4</sub> SYALON	1350 °C
-others:	
graphite	1300 °C
1.4571 coated with Cr <sub>2</sub> O <sub>3</sub> and TiN	400 °C
thermoelectric wires	
-type L Fe-CuNi Ø1/3 mm	600/ 900 °C
-type J Fe-CuNi Ø1/3 mm	600/ 900 °C
-type K NiCr-Ni Ø1/3 mm	900/1200 °C
-type N NiCrSi-NiSi Ø1/3 mm	1000/1150 °C
-type S Pt10Rh-Pt Ø0.35/0.5 mm	1350/1600 °C
-type R Pt13Rh-Pt Ø0.35/0.5 mm	1350/1600 °C
-type B Pt30Rh-Pt6Rh Ø0.35/0.5 mm	1600/1800 °C
MIMS-thermocouples	*
* dependent from the diameter, wire- and MIMS-material as well as the ambient medium	

## Mounting and installation

### -Notice to the mechanical installation

a) The installation has to be carried out in accordance with the relevant regulations and standards being in force for the respective place of measurement (welding regulations, etc.).

In particular, the following guidelines have to be taken into account :

- VDE/VDI 3511

“Temperature measurements in industry”

- VDE/VDI 3512, page 2

“Measuring set-ups for temperature measurements”

b) The installation has to be carried out in consideration of the correspondence between the respective technical parameters of the thermometers and the real field conditions, taking into account in particular:

- measuring range,
- permissible max. pressure, flow rate,
- mounting length, pipe dimensions,
- vibrations, shocks,
- abrasive stresses,
- temperature shock,
- chemical attack of gases,
- density of the medium.

### **Attention!**

*Take the mechanical and thermal stress limits of the protecting tubes as well as the chemical attack of gases on the material of the protecting tube and on the thermoelectric wires into consideration in any case.*

*The chemical influence of gases on the protecting tube and the thermocouple has to be checked in each case of application. In order to ensure that the device is gas-proof, (1 bar at max.!) be careful that the seal fits properly and servicing (i.e. periodical tightening the screw joint).*

c) Notice to the process connection

Try to select the material of the protecting tube in that way that it is identically with the material of the pipe or the tank wall into which the thermometer shall be installed.

•Integral thread:

When mounting the thermometer pay attention to a proper support of the seal! For integral threads the following permissible recommended values for starting torque are valid:

M 18 x 1.5; M 20 x 1.5 G1/2": 50 Nm

M 27 x 2.0 G3/4": 100 Nm

According to DIN 43763, a maximum permissible pressure of 10 MPa is generally fixed.

•Flange mounting:

As laid down by DIN 2527, the flanges have to be selected in consideration of the respective pressure and of the dimensions of the tube. The flange fastening screws have to be tightened evenly crosswise.

Pay attention to a proper fit of the gasket.

•Welding version:

If the thermometer comes into direct contact with any kind of food, particular welding instructions have to be observed. Basically, no uneven patches or similar things are allowed to occur on the welding seams, because these might affect the CIP-capability of the equipment.

In case of high-pressure lines, the relevant acceptance tests will have to be carried out.

•Cap nut fastening:

The permissible starting torques are the same as in case of integral threads!

•Adjustable screw joints:

In this case, attention has to be paid to the choice of the same material as used for the protecting tube with view to a possible contact corrosion. In addition, the “clamping element” has to be chosen in consideration of the tight-ness, e.g.: cutting ring, sealing ring, teflon locking ring.

•Fitting flange /mating flange:

In case of ceramic protecting tubes with fitting flange and mating flange, the fixing device is mounted to the carrier tube and the seal to the protecting tube.

d) Adjustment of the PG direction of rotation of the head

In case of thermocouples having standard DIN heads, it is possible to correct the PG direction of rotation whenever a problem is arising, even after the head has been screwed in. For this, loosen the adjusting screw again slightly, rotate the whole connecting head in the desired direction, and tighten the adjusting screw again properly.

**Note!** *If non-standard heads are used, please consult the manufacturer!*

e) Hints for the use at high temperatures

When being used at high temperatures, metallic or ceramic protecting tube materials may become porous. This permits aggressive gases from the environment to penetrate the tubes. In order to avoid this effect, a gas-proof ceramic interior protecting tube can be inserted into the exterior tube.

### **Attention!**

*Harmful gases change the characteristics of the thermocouple (poisoning!).*

Nobel-metal thermocouples (types R/S/B) are “poisoned” with impurities coming from the insulating ceramic material even at high temperatures. Use only absolutely pure gas-proof  $\text{Al}_2\text{O}_3$ - ceramic (C 799) at temperatures of about 1300 °C and above!

At high temperatures, the protecting fitting should be mounted, if possible, vertically pendent into the process. This prevents the fitting from sagging and, thus, the thermocouple from being damaged. If, however, the fitting is mounted horizontally, supporting aids or additional fixing elements should be used.

The insertion of thermocouples in hot processes has to be effected slowly, for example:

at 1200 °C-rate of insertion about 10 to 20 cm/min,

at 1600 °C-rate of insertion about 1 to 2cm/min.

### **Attention!**

*The thermometers may also be preheated. In case of immersion in to warm melting baths, reheating is absolutely necessary!*

When using SiC-tubes, the temperature change should not exceed 100 °C/min.

**-Electric connection**

When using thermometers with built-in transmitter, the parameters and hints for connection contained in the operating instructions for the transmitter have to be observed! Both the type of circuiting and the connecting head show in the next view.

When connecting the wires, take care that the positive pole of the thermocouple is connected with positive terminal of the follow-up electronic unit. Also in case of using intermediate thermoelectric wires or extension wires, the correct polarity has to be ensured. A transposition of the positive and the negative conductor, especially when using intermediate extension wires, leads to faulty indications, which may not always be noticed at once. In general, the positive conductors are marked with red colour in the connecting heads.

After having removed the connecting cover, the

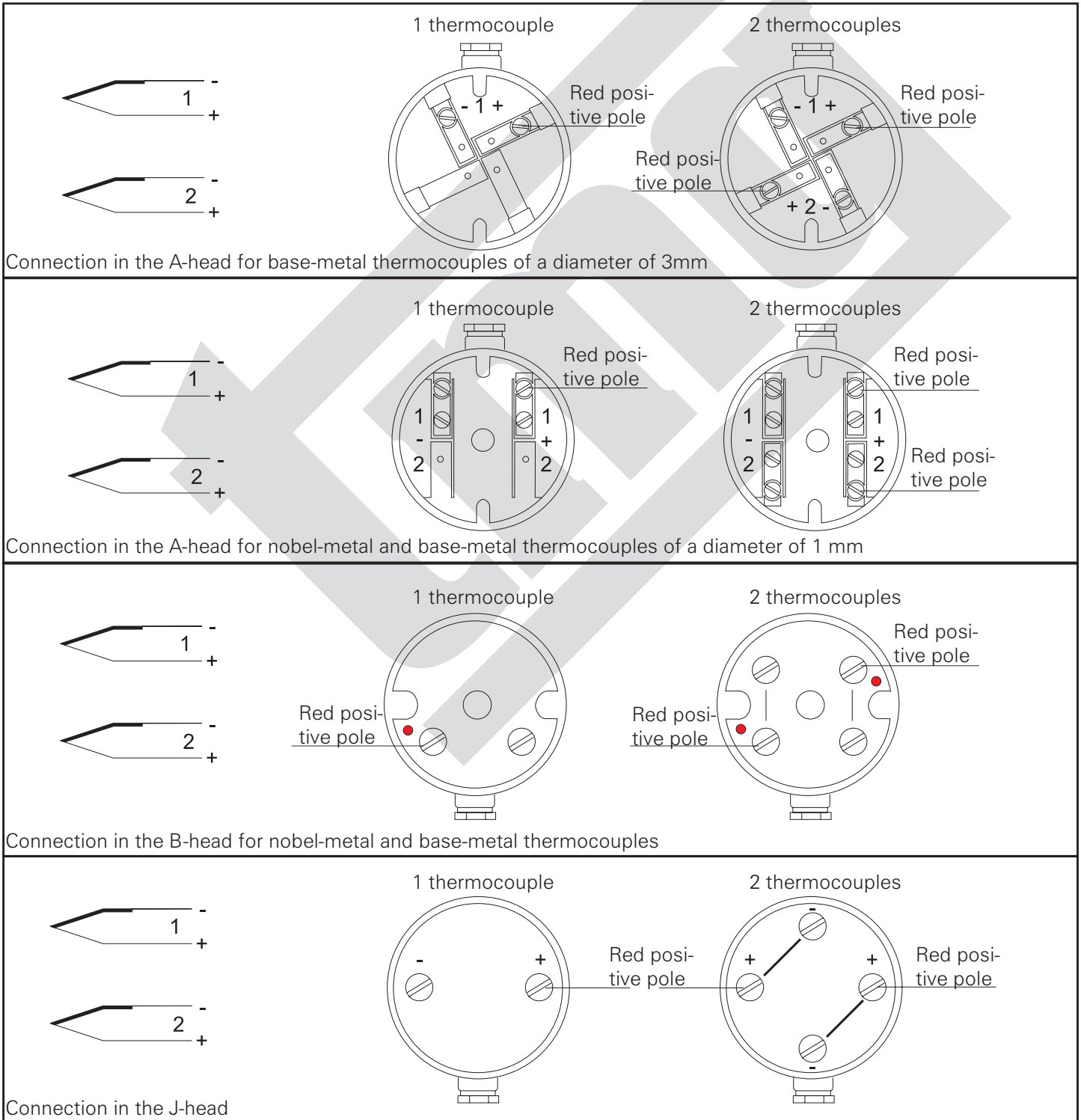
thermocouple can be connected. For this, the connecting wire which is to be led through the PG-screw joint into the interior space of the connecting head is connected with the ends of the conductors by means of the connecting terminal.

**Hint!**

*All clipped connections have to be absolutely clean and tightened fast. Contact resistances at the connecting points lead to measuring errors!*

The wires connecting the thermocouple and the indicating unit have to be in conformity with the regulations being effective for insulated electric lines in power installations (see VDE No. 0250) or, in exceptional cases, in telecommunication installations (see VDE No. 0810).

**Circuiting of thermocouples and MIMS-thermocouples in the connecting head**



Connection in the J-head

Reference tables of thermoelectric voltage [mV] acc. to ITS 90 (type L acc. to IPTS 68)							
[°C]	Typ K	Typ N	Typ J	Typ L	Typ S	Typ R	Typ B
-200	-5.891	-3.990	-7.890	-8.15			
-150	-4.913	-3.336	-6.500	-6.60			
-100	-3.554	-2.407	-4.633	-4.75			
-50	-1.889	-1.269	-2.431	-2.51			
0	0.000	0.000	0.000	0.00	0.000	0.000	0.000
50	2.023	1.340	2.585	2.65	0.299	0.296	0.002
100	4.096	2.774	5.269	5.37	0.645	0.647	0.033
150	6.138	4.302	8.010	8.15	1.029	1.041	0.092
200	8.138	5.913	10.779	10.95	1.440	1.468	0.178
250	10.153	7.597	13.555	13.75	1.873	1.923	0.291
300	12.209	9.341	16.327	16.56	2.323	2.401	0.431
350	14.293	11.136	19.090	19.36	2.786	2.896	0.596
400	16.397	12.974	21.848	22.16	3.259	3.408	0.787
450	18.516	14.846	24.610	25.00	3.742	3.933	1.002
500	20.644	16.748	27.393	27.85	4.233	4.471	1.242
550	22.776	18.672	30.216	30.75	4.732	5.021	1.505
600	24.905	20.613	33.102	33.67	5.239	5.583	1.792
650	27.025	22.566	36.071	36.64	5.753	6.157	2.101
700	29.129	24.527	39.132	39.72	6.275	6.743	2.431
750	31.213	26.491	42.281	42.92	6.806	7.340	2.782
800	33.275	28.455	45.494	46.22	7.345	7.950	3.154
850	35.313	30.416	48.715	49.63	7.893	8.571	3.546
900	37.326	32.371	51.877	53.14	8.449	9.205	3.957
950	39.314	34.319	54.956		9.014	9.850	4.387
1000	41.276	36.256	57.953		9.587	10.506	4.834
1050	43.211	38.179	60.890		10.168	11.173	5.299
1100	45.119	40.087	63.792		10.757	11.850	5.780
1150	46.995	41.976	66.679		11.351	12.535	6.276
1200	48.838	43.846	69.553		11.951	13.228	6.786
1250	50.644	45.694			12.554	13.926	7.311
1300	52.410	47.513			13.159	14.629	7.848
1350	54.138				13.766	15.334	8.397
1400					14.373	16.040	8.956
1450					14.978	16.746	9.524
1500					15.582	17.451	10.099
1550					16.182	18.152	10.679
1600					16.777	18.849	11.263
1650					17.366	19.540	11.848
1700					17.949	20.223	12.426

### DIN IEC 584 accuracy classes and types of thermocouples

In the DIN IEC 584 standard being in force there are laid down the basic values and tolerances of the thermocouple combinations to be used. At the older Fe-CuNi-thermocouples (Fe-Const) application the DIN 43 710, type L, especially for secure the alternativ requirements to old-plants.

Classes of the limit deviations for thermocouples acc. to DIN 584-2						
Type	class 1		class 2		class 3	
	deviation	temp. area	deviation	temp. area	deviation	temp. area
base - metal - thermocouples						
K	1.5 °C or 0.004 lt l	-40...1000 °C	2.5 °C or 0.0075 lt l	-40...1200 °C	2.5 °C or 0.015 lt l	-200... 40 °C
N	1.5 °C or 0.004 lt l	-40...1000 °C	2.5 °C or 0.0075 lt l	-40...1200 °C	2.5 °C or 0.015 lt l	-200... 40 °C
J	1.5 °C or 0.004 lt l	-40... 750 °C	2.5 °C or 0.0075 lt l	-40... 750 °C	-	-
L	-	-	3.0 °C or 0.0075 lt l	-40... 750 °C	-	-
nobel - metal - thermocouples						
S	1.0 °C or 1+0.003(t-1100 °C)	0...1600 °C	1.5 °C or 0.0025 lt l	0...1600 °C	-	-
R	1.0 °C or 1+0.003(t-1100 °C)	0...1600 °C	1.5 °C or 0.0025 lt l	0...1600 °C	-	-
B	-	-	0.0025 lt l	600...1700 °C	4.0 °C or 0.0005 lt l	600...1700 °C

The limit deviations are ± tolerances. They be declare in °C or % from the measuring value. It be valid the always greatest value. These table is a abridged version acc. to DIN 584, part 2, page 3 (type L acc. to DIN 43710).

### Inadmissible operations

- exceeding the permissible maximum temperature or also
- falling below the permissible minimum temperature,
- exceeding the permissible pressure values (acc. to DIN-43763 temperature-pressure-load diagrams),
- high mechanical stresses, particularly such, which lead to deformations of the protecting-tube zone
- high chemical stresses, e.g. aggressive gases and

- vapours, leading to the destruction of the protecting tubes or to the poisoning of the interior thermoelectric wires
- exceeding the electrical connected loads,
- exceeding the degree of moistening and termical stress of the connecting head according to the respective protecting system.

The instructions are guide lines without obligations!