EPHY MESS

Gesellschaft für Elektro-Physikalische Meßgeräte mbH

Thermocouples

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Content

1. Thermocouples (TC)
acc.DIN IEC 60584 / DIN 43710

1.1 Introduction

Thermocouples are active contact sensors that find wide applications in industrial measuring and control technology because of their almost indefinite small structure forms and a very large temperature range from -200°C to +1700°C (or 2300°C). They are especially useful in the construction of systems, machines and devices. They are also used in molten salt and metal treatment. In many high temperature applications they are a low cost alternative to devices operated by radiation.

1.2 Fundamentals

The temperature to be measured (T_M) is transformed by a thermoelement into an electrical potential (U_T) without the use of any auxiliary voltage source. An electromotive source (EMF) is induced in any metal conductor if the conductor is exposed to a temperature gradient. This force depends on the height of the temperature gradient, on its direction and the combination of thermal materials used. If, for exampple, an increasing gradient induces a positive EMF, then a decreasing gradient induces a negative EMF. The resulting EMF thus depends on the temperature difference between the tip and the end of the wire. The so called thermal energy E, that is, the rate of change

[1] $E = dEMF / dT$

of the EMF with respect to temperature, depends, in general, on the niveau of the temperature. Using two metals with thermal energy as different as possible and joins them into a thermalpair, then a potential arises between the free ends, and this potential depends on the difference between the thermal energies of the two metals.

The norms DIN 43710 and IEC 60584 specify the most important and frequently used combinations of materials with their temperature – potential properties.

1.3 Structure of thermocouple

1.3.1 Measuring point

The measuring point (bead) is the actual temperature sensor and is exposed to the temperature T_M to be measured.

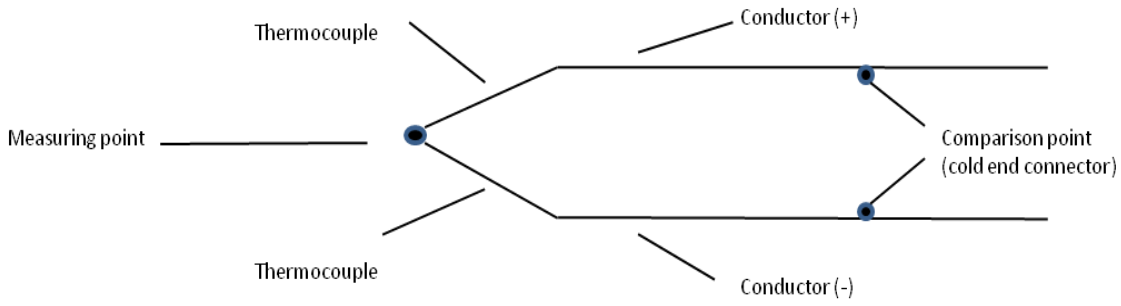


Figure 1: Principle of thermocouple

1.3.2 Thermocouple

A thermocouple consists of two different metal conductors, the so called thermal legs, which are joined with each other at the measuring point. Out of many possibilities for combining materials that are electric conductors, relatively few are suitable for building thermocouples for measurement and control technology. The materials chosen must have a steady temperature potential relationship over a wide temperature range. The mostly used thermocouple types are given in the DIN 43710 and IEC 60584 norms.

Thermo couples	Norm	Alloy short signs	Material names
Type T	IEC 60584	Cu - CuNi	Copper - Constantan
Type E		NiCr - CuNi	Chromel - Constantan
Type J		Fe - CuNi	Iron - Constantan
Type K		Ni - CrNi	Chromel - Alumel
Type S		Pt10%Rh - Pt	Platinum/Rhodium - Platinum
Type R		Pt13%Rh - Pt	Platinum/Rhodium - Platinum
Type B		Pt30%Rh - Pt6%Rh	Platinum/Rhodium - Platinum
Type L	DIN 43710	Fe - CuNi	Iron - Constantan
Type U		Cu - CuNi	Copper - Constantan

1.3.3 Comparison point (cold-end point)

The comparison points (cold-end point) are the second thermoelectric active part of a thermocouple. They are at the free ends of the thermal pair or the extension grade wire and are exposed to the reference temperature T_V. The thermal voltage U_T present at this location depends on the temperature gradient between the measuring point and the comparison location (cold-end point)
(see Figure 1).

[2] $\mathbf{U_T \approx T_M - T_V}$

For measurements to be exact, the temperature at the cold-end must be exactly known and kept as constant as possible.

1.3.4 Extension grade wire

The extension grade wire form an extension of the thermocouple. They join the two thermal legs at the cold-end location. The materials and alloys used must be highly pure and have the same thermal electrical properties as the thermal pair to be extended. One can choose between so called original and substitute materials.
Substitute materials with low resistance (ohm) used to be important for measurement circuits in which the thermal potential and thus temperature were displayed on a moving coil instrument. However, modern technology allows very high input resistances. Noticeable losses do not even arise in extension grade wires with resistances in kΩ range.
Even today, the high cost of some materials (Pt-Rh) justifies the use of significantly less expensive substitute materials. With non noble metals these costs can be neglected.

1.4 Basic values of thermal voltages and tolerances

The temperature – voltage values (basic values) of the shelf thermocouples are quated in the DIN 43710 and IEC 60584 norms. Thermocouples are classified by the maximum permissible deviation from these basic values. A complete table of basic values is in the appendix of this catalogue.

1.5 Fundamental series for thermocouples, abstract

Temp.C	Typ U	Type T	Type L	Type J	Type E	Type K	Type S	Type R	Type B
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	2.05	2.035	2.65	2.585	3.047	2.022	0.299	0.296	0.002
100	4.25	4.277	5.37	5.268	6.317	4.095	0.645	0.647	0.033
150	6.62	6.702	8.15	8.008	9.787	6.137	1.029	1.041	0.092
200	9.2	9.286	10.95	10.777	13.419	8.137	1.44	1.468	0.178
250	11.98	12.011	13.75	13.553	17.178	10.151	1.873	1.932	0.291
300	14.9	18.86	16.56	16.325	21.033	12.207	2.323	2.4	0.431
350	17.92	17.816	19.36	19.089	24.961	14.292	2.786	2.896	0.596
400	21	20.869	22.16	21.846	28.943	16.395	3.26	3.407	0.786
450	24.15		25	24.607	32.96	18.513	3.743	3.933	1.002
500	27.41		27.85	27.388	36.999	20.64	4.234	4.471	1.241
550	30.8		30.75	30.21	41.045	22.772	4.732	5.021	1.505
600	34.31		33.67	33.096	45.085	24.902	5.237	5.582	1.791
all voltages in mV. The full table for range -200°C to +1800°C. is in the appendix									

Table 1: Fundamental series for thermocouples, abstract

1.6 Tolerances

Thermocouples standardized by IEC 60584 are divided in three tolerance classes:

Class		1	2	3[2)]
max. deviations[1)]	(±)	0.5°C or 0.004 |*t*|	1°C or 0.0075 |t|	1°C or 0.015 |t|
applications	Type T	- 40°C to +350°C	- 40°C to +350°C	-200°C to +40°C
max. deviations[1)]	(±)	1.5°C or 0.004 |*t*|	2.5°C or 0.0075 |t|	2,5°C or 0.015 |t|
	Type E	- 40°C to +800°C	- 40°C to +900°C	-200°C to +40°C
applications	Type J	- 40°C or +750°C	- 40°C to +750°C	---
	Type K	- 40°C to +1000°C	- 40°C to +1200°C	-200°C to +40°C
max. deviations[1)]	(±)	1°C or {1+(t-1300) 0.003}°C	1,5°C or 0.0025 |*t*|	4°C or 0.005|*t*|
	Type R/S	0°C to +1600°C	0°C to +1600°C	
applications	Type B	---	+600°C to +1700°C	+600°C to +1700°C

[1)] The permitted deviation is the greater of the following two values: the indicated temperature in °C or the factor multiplied by the actual temperature (positive value)

[2)] Thermocouples and thermo wires are usually delivered in a way that the maximum deviation meets the above table for temperatures >-40°C. The deviation for thermocouples of the same material may be greater below -40°C than quoted for class 3.

Table 2: Tolerance classes

EPHY-MESS normally delivers thermocouples and wires from tolerance class 2. Delivery of goods from classes 1 and 3 is possible on request.
For the tolerances of thermocouples standardized by DIN 43710 please see an appendix of this catalogue.

1.7 Operation conditions

To maintain high measurement accuracy of thermocouples over long periods of time, it is necessary to select them carefully for their intended use. Two factors are very important: maximum temperature and medium to be measured in.

A Ni-CrNi thermocouple (type K) is, for example, highly resistant to oxidizing agents, but if it is heated to over 850°C then its thermal electric properties change in such a way that even at low temperatures (<0°C) there are residual deviations. Thermal pairs of types J and L, which are made Fe-CuNi, are threatened by oxidizing agents at above 550°C, but are highly resistant to reducing agents. The temperature limit is about 700°C. The same is valid for Cu-CuNi thermocouples, which, however, are only suitable for maximum temperatures in the range 400-600°C.

For very high temperatures ranging up to 1700°C, only thermocouples with platinum or its alloys are suitable (types S, R and B). All platinum rhodium thermocouples are sensitive to sulfuric and phosphoric gases.

A general problem with unprotected thermocouples is that at temperatures above 1000°C, foreign materials and metal vapours can diffuse into them and cause their thermal electric properties to change. For these reasons, protective measures must be taken dependent on the atmosphere, the temperature range and the thermal pair (material). For example, the thermocouples could be enclosed in a gas tight ceramic or metallic protective tube or covering, named thermowell.

All versions of assembled thermocouples are available with IECEx, ATEX and TR approval for the use in hazardous areas. The sensors are certified acc. Protection type Ex i (intrinsic safety) and Ex e (increased safety) with the following protection types:

As coil head sensor (WKF):

IECEx: Ex eb IIC, Ex ta IIIC, Ex ia IIC Gb, Ex ia IIIC Gb
ATEX: II 2G Ex e IIC Gb, II 2D Ex ta IIIC Da, II 2G Ex ia IIC Gb, II 2D Ex ia IIIC Db
TR: Ex ia IIC U, Ex e II U, Ex ia IIIC Db U, Ex tb IIIC Db U

As slot resistance thermometer (NWT):

IECEx: Ex eb IIC, Ex ta IIIC, Ex ia IIC Gb, Ex ia IIIC Gb
ATEX: II 2G Ex e IIC Gb, II 2D Ex ta IIIC Da, II 2G Ex ia IIC Gb, II 2D Ex ia IIIC Db
TR: Ex ia IIC U, Ex e II U, Ex ia IIIC Db U, Ex tb IIIC Db U

As screw-in thermometer (LTH):

IECEx: Ex e IIC T6…T3 Gb, Ex ta IIIC T80°C/T95°C/T130°C/T180°C Db
Ex ia IIC T6…T3 Gb, Ex ia IIIC T80°C/T95°C/T130°C/T180°C Db
ATEX: II 2G Exe IIC T6…T3 Gb, II 2D Ex ta IIIC T80°C/T95°C/T130°C/T180°C Da
II2G Ex ia IIC T6…T3 Gb, II 2D Ex ia IIIC T80°C/T95°C/T130°C/T180°C D
TR: 2 Ex e II T6 … T3 Gb, Ex tb IIIC T80°C/T95°C/T130°C/T180°C Db
1 Ex ia IIC T6 … T3 Gb, Ex ia IIIC T80°C/T95°C/T130°C/T180°C Db

1.8 Product line overview

Product line overview of EPHY-MESS thermocouples acc. to DIN 43710 and IEC 60584		
Thermowires (TD) and extension grade wires (AL)	bare	uninsulated thermowires of all available types, single (+ or – pole of couple) or paired
	insulated	insulated thermowires of all available types, single or paired (single and common insulated)
Coil head thermocouples (TE-WK)	bare	very simple type, thermocouple with bare bead, max. temperature depending on couple
	SH	thermocouple with shrinkable tube insulated bead (PTFE or PVOF), max. temperature 175°C ... 260°C.
	KH/MH	thermocouple cast in ceramic or metal sleeve, max. temperature approx. 500°C
	ESF	thermocouple, cast in aluminum or brass screw-in housing, max. temperature approx. 500°C
Slot thermocouples (TE-NT)	rigid type	analog to slot resistance thermometers with mica insulation usable sensor for industrial electromotor protection, type T, J, E, K. U and L. max. temperature up to 230°C
Pad thermocouples (TE-FPI)	in Poliymid or in Aluminum/Poliymid film	extremely fast (< 100 m/s) responding, thin thermocouple (type K, T, J and L) for surface measuring up to 200°C
Slide-in thermocouples (TE-EST)	straight type	thermocouple with fixed threaded joint or bajonet cap, bare wire ends or plug – tip plane, semispherical or conical
	angled type	see above, with angle plug connected
Metal sheated thermocouples (TE-MI)	with plug, bare wire ends or head	bendable, fast responding thermocouple, highly resistable to shocks, Ø 0.5 mm ... 8 mm, with or without insulation against case, max. temperature 1300°C.
Thermocouples with thermowell and connection head (TE-SRA)	with or without fitting or flange; with fixed installed measuring sensor	for technical temperature measurement, especially in furnaces of different type, temperature ranges from 200° C up to 1800° C, wells from metal or ceramic. For different op. conditions there are heads acc. DIN 50446 available. They are suitable for ambient temperature up to 200°C
	with replacable sensor	see above, with exchangeable insert, allowing change of thermocouple during operation
Thermocouple-meas. inserts (TE-MES)	with 1,2 oder 3 couples	insert for installation in wells with head, acc. DIN or with sheated cable
Thermocouple plugs	standard types	plug connectors for connection and extension of thermocouples
	miniature type	

Table 3: TC product line

2. Extension grade wires

Extension grade wires (= substitute materials for the thermoelectric wires with equal thermo electric properties) are usually used in the following cases:

- the use of an uninterrupted thermoelectric wire is technically not possible (e.g. thermocouple with connector head or ducts)
- the original thermoelectric wires does not have sufficient mechanical stability
- the resistance of the original thermoelectric wires is too high for the measuring circuit
- significant cost reduction in the case of the thermoelectric wires of noble metals

The following extension grade wires are available for the thermocouples that conform to the DIN 43710 and IEC 60584 norms:

Norm	**Thermocouple**			**Material extension g. wire**			**AL-colour code**		
							Wire insulation		**Sheath (jacket)**
	Type	**+Pole**	**-Pole**	**Code**	**+Pole**	**-Pole**	**+Pole**	**-Pole**	
IEC 60584	T	Cu	CuNi	TX	Cu	CuNi	brown	white	brown
	E	NiCr	CuNi	EX	NiCr	CuNi	violet	white	violet
	J	Fe	CuNi	JX	Fe	CuNi	black	white	black
	K	NiCr	Ni	KX	NiCr	Ni	green	white	green
	K	NiCr	Ni	KC1	Fe	CuNi	green	white	green
	K	NiCr	Ni	KC2	Cu	CuNi	green	white	green
	R/S	Pt13/10Rh	Pt	RC A/SCA	Cu	CuNi	orange	white	orange
	R/S	Pt13/10Rh	Pt	RC B/SCB	Cu	CuNi	orange	white	orange
DIN 43710	U	Cu	CuNi	UX	Cu	CuNi	brown	brown	brown
	L	Fe	CuNi	LX	Fe	CuNi	red	blue	blue

Other types are available on request. The choice of insulation of the above quoted extension grade wires are equal to the thermo electrical wires.

2.1 Thermocouple with welded or hard-soldered measuring point

To establish the correct connection at the measuring point, thermocouple wires for operating temperatures of up to 600°C are hard soldered, and for higher temperatures they are welded to each other. Thermocouples made in this way can be used as it. The extension grade wires are the thermoelectric wires – an additional extension grade wire is not necessary.
This simplest form of thermocouple can be delivered by EPHY-MESS with a wire length of up to 500m.

2.2 Thermocouples with bare (naked) measuring point

This is the simplest version acc. DIN 43732, structure C and D. The extension grade or thermoelectric wire can remain bare or might be insulated over the entire length of the thermocouple, excluding the measuring bead.

Figure 2: Thermocouple with bare measuring bead

2.3 Thermocouple with insulated measuring point i.e. coil head thermocouples (TE-WK)

This type of configuration has its origin and main application range in the electric motors, generators, and transformers industries. Because of its compact form and insulation, these sensors can be installed directly in stator and transformer coils. The measuring bead can be insulated, optionally using shrinkable tubing or by cementing in metal or ceramic sheaths or in screw-in housing.

EPHY-MESS coil head thermocouples can also be used in all areas of industrial measurement and control technology for monitoring temperature processes. The great advantage of this type comes from the small dimensions and the resulting short response times.

2.4 Coil head thermocouples insulated by shrinkable tubing (TE-WK-SH)

Here, the measuring bead and part of the thermoelectric wire are insulated with shrinkable tube.

Figure 3: TE-WK-SH

insulating material / measuring bead protection	PTFE or PVDF shrinkable tubing, other heat shrinkable tubing on request
operating temperature	PTFE: 260° C, PVDF: 175° alt. 190° C
dimensions	depends on the thermoelectrical wire
thermo electrical wire / extension grade wire	all available types (T, E, J, K, S, R, B, L, U)
electric strength at measuring point	≥ 3 kV /1 min

Table 4: Technical data TE-WK-SH

2.5 Coil head thermocouple, cemented in ceramic or metal sheaths (TE-WK-KH / -MH)

This type already has high mechanical resistance, and it is easy to install the sensors. The advantage of small dimensions with fast response time remains. The sheathing materials available include all common metals as well as ceramics.

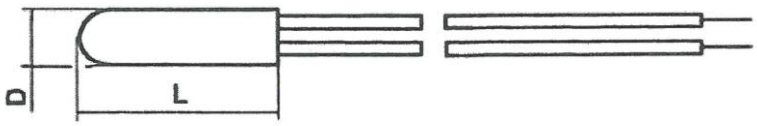


Figure 4: TE-WK-KH / -MH

insulating material / measuring bead protection	ceramic sheath (closed round or flat) Isokeralox 99.7 or Ms-Al-, V2A-or V4A-INOX steel sheath
operating temperature	-50° C... +400° C, with special glass silk up to max. +600°C
dimensions	ø 3 -12, I =10 -40 mm, other dimensions on request
thermo electrical wire / extension grade wire	all available types (E, J, K, S, R, B, L, U)
electric strength at measuring point	≥ 2.5 kV /1 min (metal), ~ 5 kV /1 min (ceramic)

Tabelle 5: Technical data TE-WK-KH / MH

2.6 Coil head thermocouple, cemented in screw-in housing (TE-WK-ESF)

This one is especially suitable for measuring surface temperatures of the housing of electromotor, generators, and transformers and of all other locations accessible by a threaded bore.

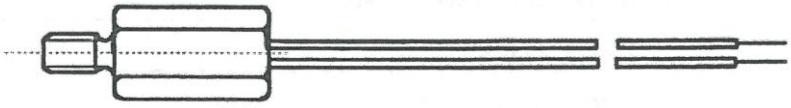


Figure 5: TE-WK-ESF

insulating material / measuring bead protection	aluminum / brass threated joint
operating temperature	-50° C ... +400° C
dimensions	M4 SW8 x 8, Al M5 SW 7 x 10, brass M5 SW8 x 12, Al MG SW 8 x 10, brass M4 SW7 x 10, brass M8 SW 13 x 10, brass further dimensions on request, SW(mm)= metric wrench size
thermoelectrical wire / extension grade wire	all available types (E, J, K, S, R, B, L, U)
electric strength screw-in case	2.5 kV /1 min

Table 6: Technical data TE-WK-ESF

3. Slot thermocouple (TE-NT)

This construction form is equivalent to the rigid Pt100 slot resistance thermometer in regard to insulation, dimensions and ranges of operation (within the coils of electromotors, generators and transformers). While the slot resistance thermometer has greater precision of measurement (+/- 0.3°C), the slot thermocouple has a shorter response time.

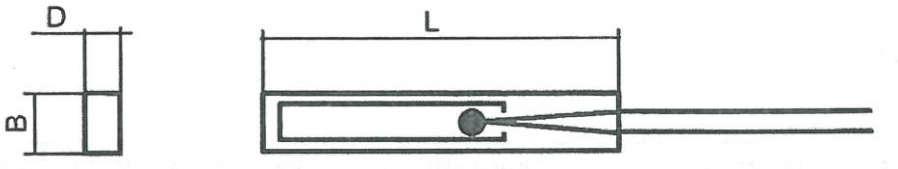


Figure 6: TE-NT

Because of the special inner structure with copper sheet for heat contact between the measuring point and its surroundings, temperature can be measured over a great length (area) than is usual for thermocouples.

The mica insulation ensures sufficient electric strength and stability, as is required for industrial thermometers of this type.

The extension grade wires are separately and entirely insulated with glass silk. To prevent moisture from penetrating into the glass silk insulation, a varnished fiber glass hose (LGLS) can be pulled over the entire length of the extension grade wires right up to the cold point location. This covering also serves very well as mechanical protection.

maximum operating temperature	230°C (incl. LGLS) *
thermocouple type	choice of T, E, J, K,L, U
sensor insulation	fine mica
dimensions in mm	2x8x 200; 2x8x250; 2x10x300
length sensitive to temperature (TEL)	150 mm ; 200mm ; 250mm
bending radius	rigid
extension grade wire	depends on type of thermocouple type; glass silk insulation; length and cross section on customer requests
electric strengt hat sensor	2.5 kV / AC 50 Hz / 1 min
* higher operating temperatures upon request	

Table 7: Technical data TE-NT

4. Pad thermocouples (TE-FPl)

4.1 Application range

Stick-on pad thermocouples have been specially designed for measurements on surfaces. Hence their application ranges lie in research, development and manufacture, where, for example, temperature distribution and gradients in housing, heat utilization must be measured quickly, or where no space is available for larger thermometers.

Pad thermocouples offer the following advantages:

- high flexibility
- small dimensions (7 x 7 x 0.16 mm)
- low response times (as low as 0.06s)
- simple installation (just stick on)

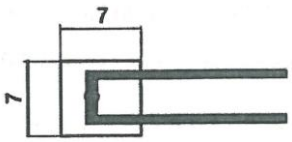


Figure 7: TE-FPI

4.2 Construction

The extremely flat elements are cemented in a foil that is impregnated with cresylic resin and has two metal stripes for connection. These stripes permit easy connection of extension grade wires. The one for the plus pole has a red marking to avoid wrong connection.
Elements of type K (NiCr-Ni) are cemented in an oxidized aluminum foil that is impregnated with phenolic resin. The very high temperature conductivity of aluminum and the good temperature transmission between surface and sensor even permit temperature shock measurements on surfaces. The elements can be attached to a surface with any standard adhesive, as long as a good heat contact at the temperature to be measured is assured. Special adhesives for temperatures up to 200°C can be ordered from EPHY-MESS.

Pad thermocouples are available as types J (Fe-CuNi), T (Cu-CuNi) and K (Ni-CrNi).

4.3 Technical data TE-FPI

	TE-FPI-J	**TE-FPI- T**	**TE-FPI-K**
response time	< 100 ms	< 100 ms	< 60 ms
carrier material	kresol resin	kresol resin	aluminum
temperature range	-100° C ... +200° C	·100° C ... +200° C	-100° C ... +200° C
dimensions	7 x 7 x 0.16 mm	7 x 7 x 0.16 mm	7 x 7 x 0.3 mm
type insulation resistivity at100 VDC	10^6 MΩ	10^6 MΩ	10^4 MΩ
voltage strength	>500 VDC	> 500 VDC	>250 VDC
thermopotential	acc. IEC 584/ class 2	acc. IEC 584/ class 2	acc. IEC 584/ class 2

5. Plug-in thermocouple (TE-EST)

5.1 General

Plug-in thermocouples are used to measure or regulate temperatures in ranges up to 400°C, for example, in

- polymer processing machines
- injection moulding machines
- cylinder heads and oil tubs of motors
- bearings
- pipelines and containers
- generators and transformers

They are usually plugged into machine bores parts and are easy to replace.

5.2 Structure

EPHY-MESS plug-in thermocouple, which have good response times, absorb heat via the highly heat conductive base of the protective pipe (stainless steel), which is presented onto the base of the plug-in bore or screw-in sheath with a pressure spring and a bayonet cap. The shape of the base (flat, cone shaped, bore angle 120°) can be adjusted to the geometry of the bore to optimize heat transfer.

There are three types available: **KW1, KW2** and **KW3**.

- KW1: plug-in thermocouple, straight with adjustable bayonet cap
- KW2: plug-in thermocouple, straight with non-adjustable bayonet cap
- KW2: plug-in thermocouple, angled with non-adjustable bayonet cap

Other types are available on request.

5.3 Thermocouple type

The standard thermocouples are of type J (Fe-CuNi) and type K (Ni-CrNi). Custom made units with other thermoelectric wires (types L, S, and R) are possible.
Within one sensor either one or two thermocouples are used. These have reinforced insulated thermal wire ends or directly attached extension grade wires on their connection side.

5.4 Installation

Plug-in thermocouples are mounted spring loaded axially with bayonet caps. The receiving joint (screw-in in bayonet nipple or sheath)n is available as an accessory.

5.2 Plug-in thermal element KW1

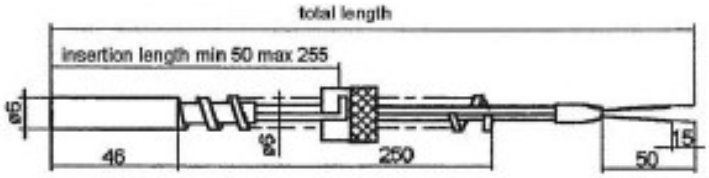


Abbildung 8: TE-EST Type KW1

Models / Type:
- 1 x type J / 2 x type J insulated from protective tube
- 1 x type K / 2 x type K insulated from protective tube

Protective tube:
- stainless steel, ø 6 / 8 mm, straight
- variable insertion length: 50 … 255 mm

Measuring spot:
- flat / semisphere shaped / bore angle 120°

Bayonet cap:
- nickel plated steel, inner dimension 12.5 mm
- adjustable on loaded spring

Extension grade wire:
- PTFE or glass silk insulated
- lengths: 100 / 500 / 1000 … / 3500 mm

Accessories:
- bayonet cap joint (type A) l= 25 mm, ø12 mm with thread R ¼''

5.3 Plug-in thermocouples KW2 / KW3

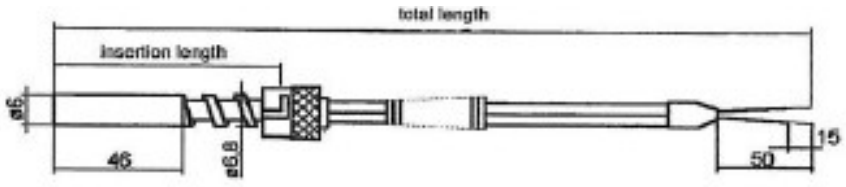


Figure 9: TE-EST type KW2

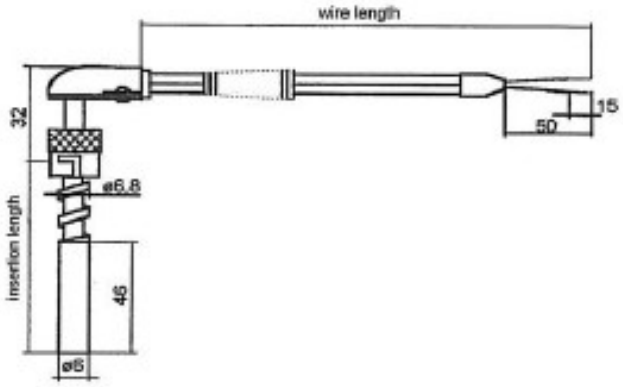


Figure 10: TE-EST type KW3

Models / Type:
- 1 x type J / 2 x type J insulated from protective tube
- 1 x type K / 2 x type K insulated from protective tube

Protective tube:
- stainless steel, ø 6 / 8 mm, straight or angled
- insertion length: 54 or 78 mm fixed

Measuring spot:
- flat / semisphere shaped / bore angle 120°

Bayonet cap:
- nickel plated steel, inner dimension 12.5 mm

Extension grade wire:
- PTFE or glass silk insulated
- lengths: 100 / 500 / 1000 … / 3500 mm

Accessories:
- bayonet joint (type B/C) l= 25 mm, ø12 mm with thread R ¼"
- screw-in sheath, l=58 / 82 (for length 54/78 mm), ø 9 mm with thread R¼"

6. Metal sheathed thermocouples (TE-MI)

6.1.1 General

Metal sheathed thermocouples are generally used where access to the location to be measured is difficult. The mineral insulated jacket of these thermocouples permits a very small bending radius. Especially the construction of reactors, where many long distances from the measuring point to a zone of moderate temperature must be covered, metal sheathed thermocouples provide a number of advantages. The values measured are not influenced by bending or strong vibrations, for the thermal wires, which are cemented in compressed oxide power, are not able to vibrate. Hence the spectrum of uses for these sensors is quite widespread. These sensors are used for temperature measurements

- in and on surfaces of containers, pipelines, devices and machines, in laboratories or in experimental plants
- in gaseous and fluid media such as air, gases, water, oil, etc.
- in low and high pressure environment with low flow speeds

Metal sheathed thermocouples are characterized by their small structure, fast response times, high bending stability and strength in high pressure environment. They are also not sensitive to vibrations. Another advantage of metal sheathed thermocouples lies in their hermetically sealed outer jacket. The thermocouple wires and the measuring point are thus well protected against aggressive gases.

6.1.2 Construction

In the thin walled jacket tube (wall thickness is about 12.15% of jacket diameter) one or two thermal pairs (depending on diameter) are tightly pressed into ceramic powder. In the standard models the thermal wires are insulated from each other and against the jacket. This shortens the response times yet again, especially in gases, but then the jacket is less corrosions proof.

The thermal voltages conform to the norms IEC 60584, class 2, and DIN 43710. Elements that conform to other norms and tolerances are available on request.

For the jacket material of standard models we offer stainless steel M.-No. 1.4541 for temperatures up to 850°C, and Inconel® M.-No. 2.4816 for temperatures up to 1100°C. We also offer the following materials for the jacket: stainless steel M.-No. 1.4571, 1.4841, 1.4845, 1.4749 and the noble metal alloy Pt10%Rh (resist temperatures up to 1300°C). For further information on the stability of these materials against corrosion and heat please look up the tables in the appendix.

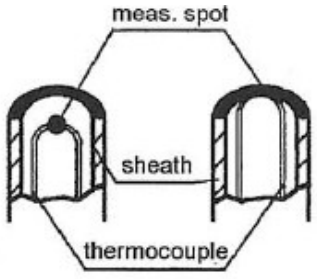


Figure 11: Standard / special type

The dimensions and specifications of the following thermocouples are intended as guides for placing an order. Since we usually deliver custom made models, we have not listed all possible combinations. Just select the model you need to carry out your measurement task.

6.1.3 Overview of types TE-MI

Figure 12: Metal sheathed thermocouple with bare thermal wire ends

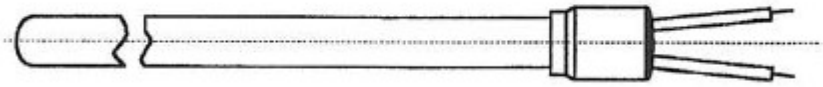


Figure 13: Metal sheathed thermocouple with reinforced and insulated thermal wire ends

Figure 14: Metal sheathed thermocouple, extension grade wires attached (can also be delivered with thermal plugs)

Figure 15: Metal sheathed thermocouple with socket

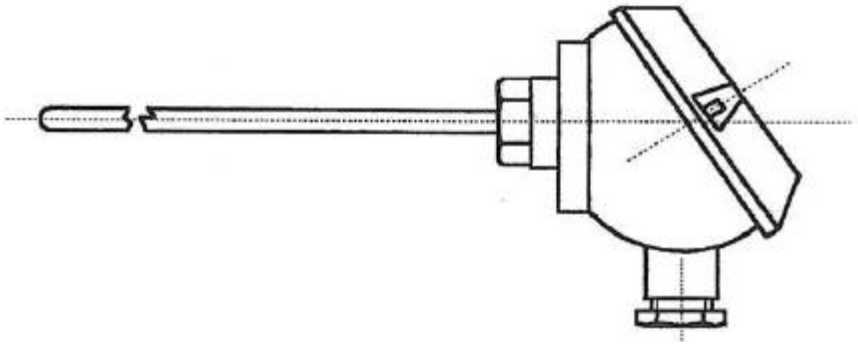


Figure 16: Metal sheathed thermocouple with attached connector head

The metal sheathed thermocouples are available with diameters > 1.5 mm (noble metal thermocouples >3 mm) as double thermocouples.

6.2 Metal sheathed thermocouple with bare thermowire ends

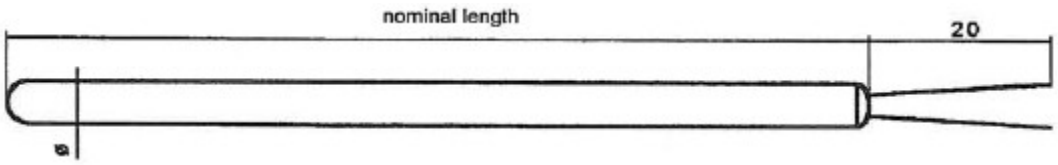


Figure 17: TE-MI

Model with 20 mm long bare connecting wires (original wires). With small jacket diameters <1.5 mm one should select, for stability reasons, a model with transitional wire sheath (with reinforced and insulated thermowires).
The dimensions and materials given here are based on a certain standardization, to cut down costs. However, varying specifications that deviate from these standardization can usually be offered without problems upon request.

Design of measuring spot:
- insulated from jacket
- welded into jacket (not with noble metal thermocouple with Inconel® jacket)

Available types:
- Fe-CuNi, type L, max. operation temperature: 800°C
- Fe-CuNi, type J, max. operation temperature: 800°C
- Ni-CrNi, type K, max. operation temperature: 1100°C
- PtRh-Pt, type S, max. operation temperature: 1300°C
- Pt13Rh-Pt, type R, max. operation temperature: 1300°C

Jacket diameters (0.5 / 1.0 / 1.5 / 3.0 / 4.5 / 6.0 / 8.0 mm):
- range 0.5 … 8 mm for thermocouples of types L, K and J
- range 1.5 … 6 mm for thermocouples of types S and R

Jacket materials (see appendix):
- 1.4541 / 1.4571 / 1.4749, max. op. temperature: 850°C (not for noble thermowires)
- 1.4841 / 1.4845, max. op. temperature: 1050°C (not for noble thermowires)
- Inconel®, max. op. temperature: 1100°C (noble thermowire metals: max. 900°C)
- Pt10Rh, max. op. temperature: 1300°C (only for noble thermowire metals)

Norms / Tolerances:
- DIN 43710 (only Fe-CuNi type L)
- IEC 60584, class 2
- IEC 60584, class 1 (with type S, R, only on request)

Nominal lengths:
- 50 / 100 / 300 / 500 / 2000 mm
- intermediate lengths on request

6.3 Metal sheathed thermocouple with reinforced and insulated wire ends

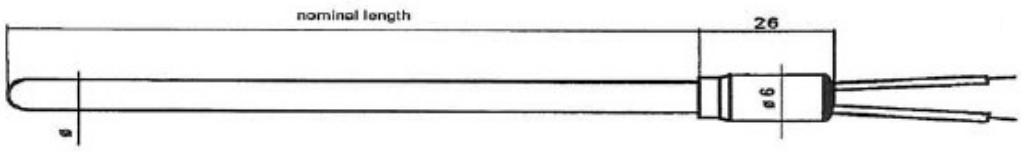


Figure 18: TE-MI

Model with 20 mm / 100 mm long reinforced connecting wires (PTFE or PVC insulated). The TE-MI is sealed off from humidity at the connecting end (final sheath). A final sheath is not necessary above ø6 mm. The maximum temperature permitted near the wire exit is 130°C.

Design of measuring spot:
- insulated from jacket
- welded into jacket (not with noble metal thermocouple with Inconel® jacket)

Available types:
- Fe-CuNi, type L, max. operation temperature: 800°C
- Fe-CuNi, type J, max. operation temperature: 800°C
- Ni-CrNi, type K, max. operation temperature: 1100°C
- PtRh-Pt, type S, max. operation temperature: 1300°C
- Pt13Rh-Pt, type R, max. operation temperature: 1300°C

Jacket diameters (0.5 / 1.0 / 1.5 / 3.0 / 4.5 / 6.0 / 8.0 mm):
- range 0.5 … 8 mm for thermocouples of types L, K and J
- range 1.5 … 6 mm for thermocouples of types S and R

Jacket materials (see appendix):
- 1.4541 / 1.4571 / 1.4749, max. op. temperature: 850°C (not for noble thermowires)
- 1.4841 / 1.4845, max. op. temperature: 1050°C (not for noble thermowires)
- Inconel®, max. op. temperature: 1100°C (noble thermowire metals: max. 900°C)
- Pt10Rh, max. op. temperature: 1300°C (only for noble thermowire metals)

Norms / Tolerances:
- DIN 43710 (only Fe-CuNi type L)
- IEC 60584, class 2
- IEC 60584, class 1 (with type S, R, only on request)

Nominal lengths:
- 50 / 100 / 300 / 500 / 2000 mm
- intermediate lengths on request

Type of installation for ø>0.5 mm:
- with soldered on screw peg M.-No. 1.4541, max. 300°C
- sliding threaded joint M.-No. 1.4541 with PTFE clamping ring, max. 200°C, 10 bar
- sliding threaded joint with cutting ring M.-No. 1.4541, max. 500°C

6.4 Metal sheathed thermocouple with extension grade wires attached

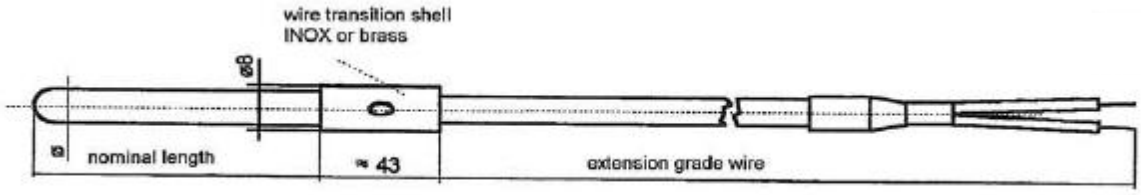


Figure 19: TE-MI

Model with transitional wire shell and attached extension grade wire, individually and joint insulated with PVC or treated glass braid. Also available with standard or miniature plug.

Design of measuring spot:
- insulated from jacket
- welded into jacket (not with noble metal thermocouple with Inconel® jacket)

Available types:
- Fe-CuNi, type L, max. operation temperature: 800°C
- Fe-CuNi, type J, max. operation temperature: 800°C
- Ni-CrNi, type K, max. operation temperature: 1100°C
- PtRh-Pt, type S, max. operation temperature: 1300°C
- Pt13Rh-Pt, type R, max. operation temperature: 1300°C

Jacket diameters (0.5 / 1.0 / 1.5 / 3.0 / 4.5 / 6.0 / 8.0 mm):
- range 0.5 … 8 mm for thermocouples of types L, K and J
- range 1.5 … 6 mm for all other thermocouples

Jacket materials (see appendix):
- 1.4541 / 1.4571 / 1.4749, max. op. temperature: 850°C (not for noble thermowires)
- 1.4841 / 1.4845, max. op. temperature: 1050°C (not for noble thermowires)
- Inconel®, max. op. temperature: 1100°C (noble thermowire metals: max. 900°C)
- Pt10Rh, max. op. temperature: 1300°C (only for noble thermowire metals)

Norms / Tolerances:
- DIN 43710 (only Fe-CuNi type L)
- IEC 60584, class 2
- IEC 60584, class 1 (with type S, R, only on request)

Length of extension grade wire:
- 250 mm and up

Type of installation for ø>0.5 mm:
- with soldered on screw peg M.-No. 1.4541, max. 300°C
- sliding threaded joint M.-No. 1.4541 with PTFE clamping ring, max. 200°C, 10 bar
- sliding threaded joint with cutting ring M.-No. 1.4541, max. 500°C

6.5 Metal sheathed thermocouple with LEMO socket

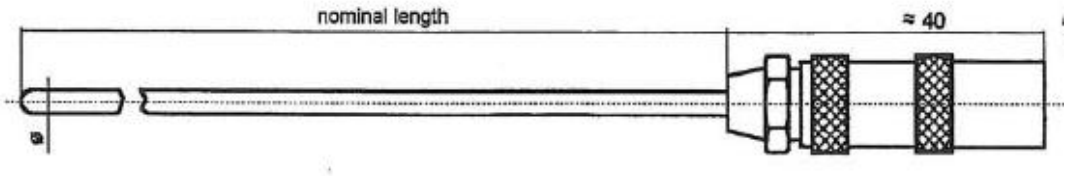


Figure 20: TE-MI

Plug sizes:
0 for ø 0.5 … 1.0 mm
1 for ø >1.0 … 3.0 mm
2 for ø >3.0 … 6.0 mm

Model with LEMO coupling socket, screw-lock or thermocontacts. The sockets are firmly attached to the thermocouple. Maximum temperature at the socket is 130°C.

Design of measuring spot:
- insulated from jacket
- welded into jacket (not with noble metal thermocouple with Inconel® jacket)

Available types:
- Fe-CuNi, type L, max. operation temperature: 800°C
- Fe-CuNi, type J, max. operation temperature: 800°C
- Ni-CrNi, type K, max. operation temperature: 1100°C
- PtRh-Pt, type S, max. operation temperature: 1300°C
- Pt13Rh-Pt, type R, max. operation temperature: 1300°C

Jacket diameters (0.5 / 1.0 / 1.5 / 3.0 / 4.5 / 6.0 / 8.0 mm):
- range 0.5 … 8 mm for thermocouple of type K
- range 1.5 … 6 mm for all other thermocouples

Jacket materials (see appendix):
- 1.4541 / 1.4571 / 1.4749, max. op. temperature: 850°C (not for noble thermowires)
- 1.4841 / 1.4845, max. op. temperature: 1050°C (not for noble thermowires)
- Inconel®, max. op. temperature: 1100°C (noble thermowire metals: max. 900°C)
- Pt10Rh, max. op. temperature: 1300°C (only for noble thermowire metals)

Norms / Tolerances:
- DIN 43710 (only Fe-CuNi type L)
- IEC 60584, class 2
- IEC 60584, class 1 (with type S, R, only on request)

Nominal lengths:
- 100 / 300 / 500 / 1000 mm
- intermediate lengths on request

Type of installation for ø>0.5 mm:
- with soldered on screw peg M.-No. 1.4541, max. 300°C
- sliding threaded joint M.-No. 1.4541 with PTFE clamping ring, max. 200°C, 10 bar
- sliding threaded joint with cutting ring M.-No. 1.4541, max. 500°C

6.6 Metal sheathed thermocouple with attached connector head

Connector head form B

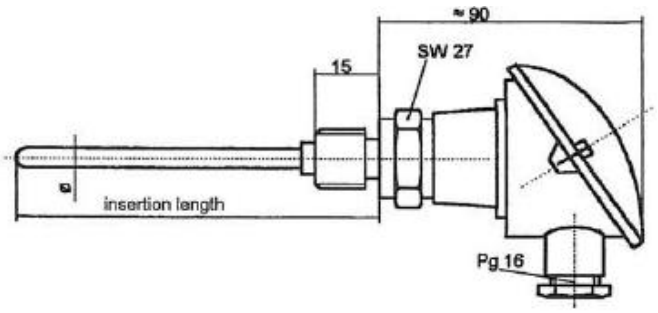


Figure 21: TE-MI

Model with light metal connector head form B, protection type IP 54. Maximum temperature at connector head: 80°C or 130°C with silicone sealing elements.

Design of measuring spot:
- insulated from jacket
- welded into jacket (not with noble metal thermocouple with Inconel® jacket)

Available types:
- Fe-CuNi, type L, max. operation temperature: 800°C
- Fe-CuNi, type J, max. operation temperature: 800°C
- Ni-CrNi, type K, max. operation temperature: 1100°C
- PtRh-Pt, type S, max. operation temperature: 1300°C
- Pt13Rh-Pt, type R, max. operation temperature: 1300°C

Jacket diameters (0.5 / 1.0 / 1.5 / 3.0 / 4.5 / 6.0 / 8.0 mm):
- range 3 … 6 mm for thermocouple of types S and R
- range 3 … 8 mm for thermocouples L, J and K

Jacket materials (see appendix):
- 1.4541 / 1.4571 / 1.4749, max. op. temperature: 850°C (not for noble thermowires)
- 1.4841 / 1.4845, max. op. temperature: 1050°C (not for noble thermowires)
- Inconel®, max. op. temperature: 1100°C (noble thermowire metals: max. 900°C)
- Pt10Rh, max. op. temperature: 1300°C (only for noble thermowire metals)

Norms / Tolerances:
- DIN 43710 (only Fe-CuNi type L)
- IEC 60584, class 2
- IEC 60584, class 1 (with type S, R, only on request)

Nominal lengths:
- 100 / 300 / 500 / 2000 mm
- intermediate lengths on request

Screw-in threading (welded on):
- G1/4'' A, G1/2'' A, G1'' A, M20 x 1.5

Connector head form F

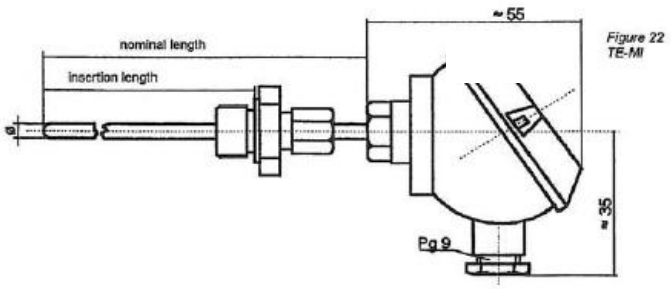


Figure 22: TE-MI

Model with light metal connector head form F, protection type IP 54. Maximum temperature at connector head: 80°C or 130°C with silicone sealing elements.

Design of measuring spot:
- insulated from jacket
- welded into jacket (not with noble metal thermocouple with Inconel® jacket)

Available types:
- Fe-CuNi, type L, max. operation temperature: 800°C
- Fe-CuNi, type J, max. operation temperature: 800°C
- Ni-CrNi, type K, max. operation temperature: 1100°C
- PtRh-Pt, type S, max. operation temperature: 1300°C
- Pt13Rh-Pt, type R, max. operation temperature: 1300°C

Jacket diameters (3.0 / 4.5 / 6.0 / 8.0 mm):
- range 3 … 6 mm for thermocouple of types S and R
- range 3 … 8 mm for thermocouples L, J and K

Jacket materials (see appendix):
- 1.4541 / 1.4571 / 1.4749, max. op. temperature: 850°C (not for noble thermowires)
- 1.4841 / 1.4845, max. op. temperature: 1050°C (not for noble thermowires)
- Inconel®, max. op. temperature: 1100°C (noble thermowire metals: max. 900°C)
- Pt10Rh, max. op. temperature: 1300°C (only for noble thermowire metals)

Norms / Tolerances:
- DIN 43710 (only Fe-CuNi type L)
- IEC 60584, class 2
- IEC 60584, class 1 (with type S, R, only on request)

Nominal lengths:
- 100 / 300 / 500 / 1000 mm, intermediate lengths on request

Type of installation for ø>0.5 mm:
- with soldered on screw peg M.-No. 1.4541, max. 300°C
- sliding threaded joint M.-No. 1.4541 with PTFE clamping ring, max. 200°C, 10 bar
- sliding threaded joint with cutting ring M.-No. 1.4541, max. 500°C
- sliding threaded joint with cutting ring phosphate treated steel, max. 300°C

7. Straight thermocouple with thermowell and connection head (TE-SRA)

Straight thermocouple with metallic or ceramic thermowell and connection head are used primarily in industrial measurement technology with temperatures to be measured from 200°C to 1800°C at pressures up to 1 bar.

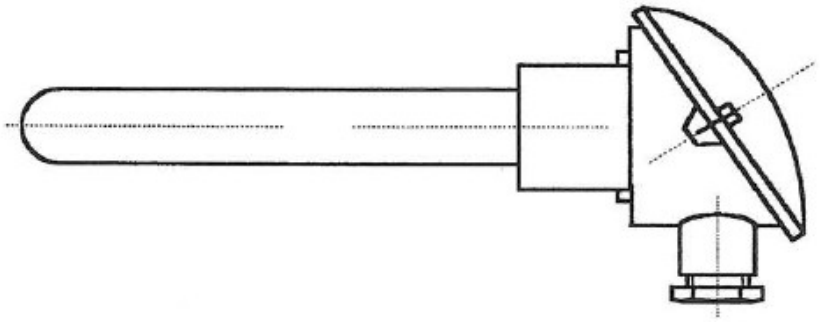


Figure 23: Thermocouple in thermowell

7.1.1 Thermowells (protective tubes)

For the functionality and quality of a thermocouple to be maintained over a sufficiently long period of time, one must select materials for thermowire, insulation, thermowell and connector head from the viewpoint of stability under the given operating conditions. General information about thermowires and materials for thermowells can be found in the following DIN norms:

- DIN 50446 metall thermowell for thermocouples
- DIN 43732 thermopairs (wires) and thermocouples (element)
- DIN 50446 electric temperature measuring devices, overview of straight thermocouples

The most common materials for thermowells and their stability are listed in the appendix of this catalogue.

Please mention in selecting a thermocouple or material for a protective tube, that the partner with the lower operation temperature sets the maximum temperature for the whole combination.

Thermocouple Type	Wire-ø, mm		
	2.5	1 / 1.38	0.35 / 0.5
J, L	800°C	600°C	--
K	1200°C	900°C	--
S, R	--	--	1600°C
B	--	--	1800°C

Table 8: Operation temperature with several wire diameters

7.1.2 Connection heads

For thermocouples there are five different choices of connector heads, depending on your application, in acc. with DIN 50446. All models are tight to splashing waters to conform IP 53 (for an overview of the IP protection types see the appendix). Other and higher water proof classes are available upon request, as special versions for a number of models. The maximum environmental temperature is 200°C for light metal models and 120°C for plastic.

7.1.3 Attachment

The attachment of thermocouple, that is, the installation of them in protective tubes, is normally carried out with a stop flange that is gas proof to about 1 bar, or a sliding pipe coupling that is gas proof to about 1 bar. These are not part of the thermocouple, but can be ordered as accessories.

7.1.4 Hints of installation

The fitting length of the thermocouple should be as large as possible so that errors of measurement due to the conduction of heat via the protective tube or the thermal wires are kept as small as possible. Vertical installation is preferable to horizontal installation so that deflection, especially of longer protective tubes, is avoided. If this is not possible, an appropriate support should be added.
For the connecting line between connector head and the measurement or display device the proper extension grade wire must be used (same type or substitute material). Also, the polarity of the thermocouple must be checked and may not be changed, because that would case errors of measurement.

7.1.5 Selection of type

The diagrams and tables that follow, show the possibilities that exist for the delivery of straight thermocouple in protective tubes. All types can, with few exceptions, be combined with one other. There will certainly be an appropriate model for your special application.

7.2 Thermocouple with metallic thermowell (and ceramic inner tube) type A

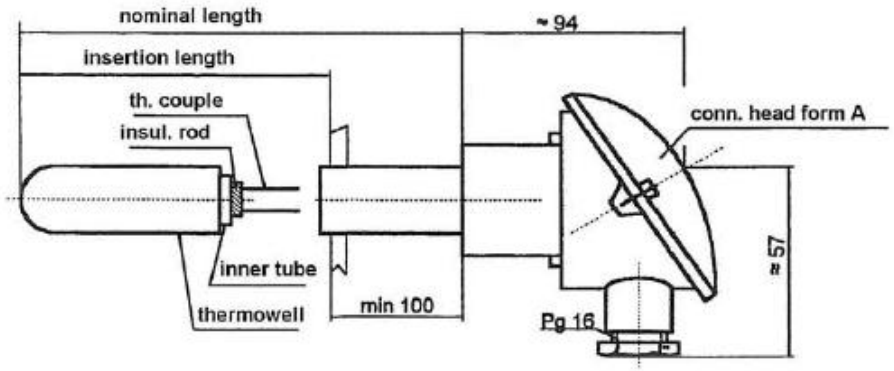


Figure 24: TE-MH

thermocouple (TP)		inner tube	protection tube		nominal length	connection head	fastening
amount	type, wire diameter	material KER 610	material max. operating temperature	dimensions mm	mm	form	welded on flange [2]
1 TP	FE-CuNi Type L ø 2.5mm	without	St. 35.8 M-No. 1.0305 550°C	ø 22 x 2	500	A	without
2 TP	NiCr-Ni Type K ø 2.5mm	with	St. 35.8 enamelled M-No. 1.0305 en. 550°C	ø 26 x 4	710	AUZ	with [1][3]
	Pt10 Rh-Pt[7] Type S ø 0.5mm		X10Cr AL 24 M-No. 1.4762 1200°C		1000	AUS	
	Pt10 Rh-Pt[7] Type S ø 0.35mm		X15CrNi Si25 20 M-No.1.4841 1150°C		1400	AUG	
	FE-CuNi Type J ø 2.5mm		X18Cr N 28 M-No. 1.4749 1100°C		2000	ABK	
					3000[6]		
					intermediate length [5][6]		

[1] welded on flange not available on enameled thermowell
[2] flange C 32 ND6 DIN 2527 from not alloyed steel
[3] please quote insertion length
[4] only with M.-No. 1.4749.
[5] please quote nominal length
[6] nominal length over 2000 mm only with TP NiCr-Ni without inner tube with thermowell ø 26 x 4 mm M.-No. 1.4749
[7] only available with ceramic inner tube

7.3 Thermal elements with ceramic protective tube and ceramic inner tube type A

thermocouple (TP)			protective and und inner tubes		nominal length	connector head	fastening
amount	type	wire ø	material protection tube dimension max. operating temperature		mm	Form	welded flange[2)] flush with stay tube
1 TP	Pt10Rh-Pt Type S	0.35	KER 610 ø 16 x 2 1500°C	without	500	A	without
2 TP	Pt13Rh-Pt Type R	0.5	KER 610 ø 24 x 2.5 1500°C	without	710	AUZ	with
	PtRh 18 TypeB		KER 710 ø 15 x 2.5 1800°C	without	1000	AUS	
			KER 710 ø 24 x 3 1800°C		1400	AUG	
			KER 530 ø 26 x 4 1600°C	KER 610 ø 16 x 2	intermediate lengths[4)]	ABK	
			KER 610[1)] ø 16 x 2 1500°C	KER 610 ø 10 x 1.5			
			KER 610 ø 24 x 2.5 1500°C	KER 610 ø 16 x 2			
			KER 710 ø 24 x 3 1800°C	KER 710 ø 15 x 2.5			

[1)] combination protective tube KER 610 with inner tube KER 610 ø 10 x 1.5 only with nominal lengths up to 1000 mm
[2)] flange C32 ND 6 DIN 2527 of unalloyed steel
[3)] stay tube dimensions: ø 22 x 2 150 mm for protective tube with outer-ø up to 16 mm; else ø 32 x 1.5 x 200 mm. Material St. 35.8. With more than 500°C fire danger for St35.8, material X10Cr Al 24 only deliverable as special model.
[4)] indicate nominal length desired

7.4 Thermal elements with metallic protective tube and ceramic inner tube type B

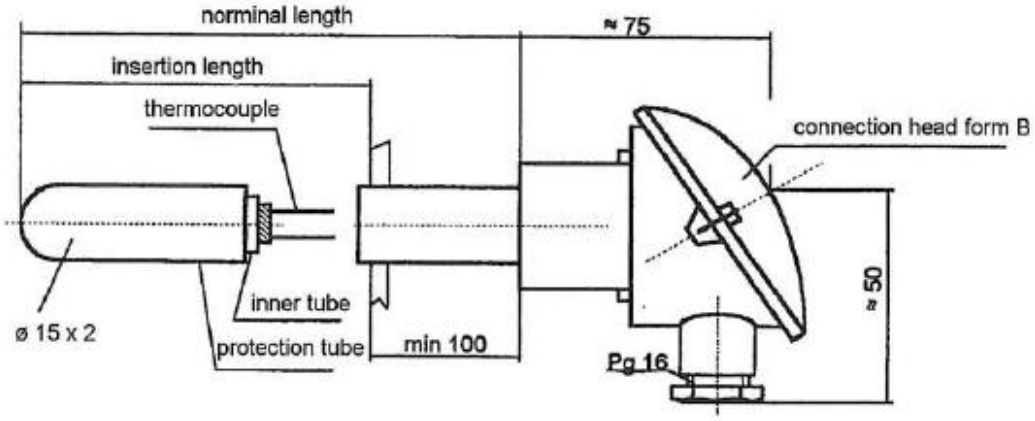


Figure 25: TE-MH

thermocouple (TP)		inner tube	protective tube		nominal length	connector head	fastening
amount	type, wire ø	material KER 610	material max. operating temperature	dimensions mm	mm	form	welded on flange [1]
1 TP	FE-CuNI Type L ø 1.0 mm	without	St. 35.8 M.-No. 1.0305 550°C	ø 15 x 2	180	A	without
2 TP	NiCr-Ni Type K ø 1.38 mm	with	St. 35.8 enamel. M.-No. 1.0305 en. 700°C		250	BUZ	with [2] [3]
	Pt10 Rh-Pt[5] Type S ø 0.5 mm		X10Cr AL 24 M.-No. 1.4762 1250°C		355	BUS	
	Pt10 Rh-Pt[5] Type S ø 0.35mm		X15CrNi Si25 20 M.-No.1.4841 1250°C		500	BUG	
	FE-CuNi Type J ø 1.0mm				intermediate lengths [4]	BBK	

[1] flange C 25 ND6 DIN 2527 of unalloyed steel
[2] welded flange not possible on enamelled protective tube
[3] indicate fitting length desired
[4] indicate nominal length desired
[5] deliverable only with ceramic inner tube

7.5 Thermal elements with ceramic protective tube type B

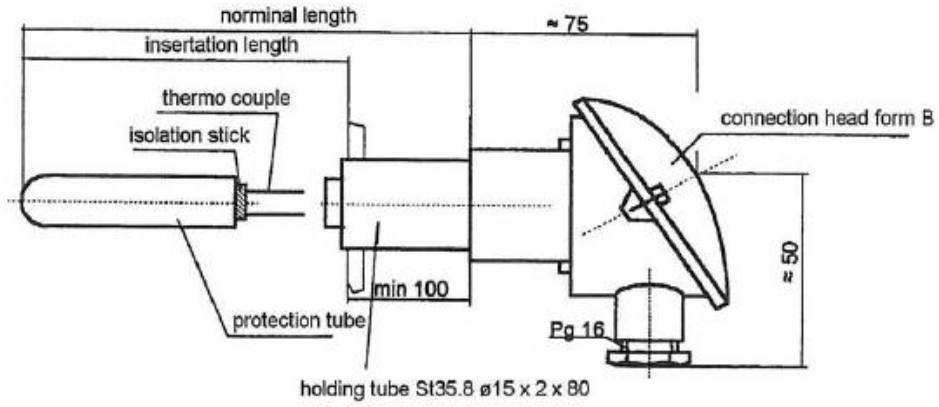


Figure 26: TE-KH

thermocouple (TP)			protective tube	nominal length	connector head	fastening
amount	type	wire ø	material protective tube dimensions max. operating temperature	mm	form	welded flange flush[2] with stay tube
1 TP	Pt10Rh-Pt Type S	0.35	KER 610 ø 10 x 1.5 1500°C	180	B	without
2 TP	Pt13Rh-Pt Type R	0.5	KER 610 ø 10 x 2 1800°C	250	BUZ	with
	PtRh 18 Type B			355	BUS	
				500	BUG	
				intermediate lengths [4]	BBK	

[1] flange C32 ND 6 DIN 2527 of unalloyed steel
[2] with more than 500°C fire danger for material St 35.8
material X10Cr Al 24 only deliverable as special model

[3] indicate nominal length desired

8. Measuring inserts for thermal elements (TE-MES)

8.1 General

Measuring inserts for thermal elements are intended for installation in protective armatures (protective tube with connector head). They can also be easily exchanged during operations. Because of the open connector socket, measuring inserts are not suitable for direct use as temperature sensors.

Measuring inserts can be installed in

- all thermal elements with forms in DIN 43764
- connector heads with dimensions as in DIN 50446 (form B)
- protective tubes with bore diameters 3.5 - 7 - 9 – 11

8.2 Construction

Measuring inserts are available in two forms, depending on their use. Either with an insert tube (ø 6 mm), or correspondingly with jacket lead (ø 3 or 6 mm) with the thermal wires installed therein and a connector base that is secured by a flange.

Attachment is achieved by two bolts in the connector head. Two contact springs ensure that the tip of the measuring insert is pressed against the base of the protective tube so that heat is transferred well from the protective tube to the thermal pair. Vibrations of the measuring insert are prevented and compensation is made for various expansions of the length of the protective tube and measuring insert.

In the case of protective tubes with diameter greater than 7 mm, the thickness of the tip of the measuring insert is strengthened from 6 mm to 8 mm or 10 mm. This reduces the air gap and minimizes resistances to heat transfer. Measuring inserts with 3 mm diameter are intended for installation in armatures with especially low response times.

EPHY-MESS measuring inserts with insert tube in conformance to DIN 43735 (type TE-MS) contain 1 or 2 thermal pairs. These are insulated with ceramic multiholed capillaries against each other and against the high-grade steel insert tube. With types K and J a special model with 3 thermal pairs can be delivered. In models with jacket lead (type TE-MI) the thermal wires are cemented in highly compressed ceramic powder so as to render these measuring inserts especially invulnerable to vibrations.

The measuring points of the thermal pairs are electrically insulated from the insert tube or the jacket. The measuring point, which is a few mm away from the base, can be welded into the base upon request. This reduces the response time to some extent.

The insulation resistance between the thermal elements is, for all types, 1000 M-Ohm at 250V, T=25°C +/- 10°C and relative humidity < 80%.

8.3 Measuring inserts with insert tube by DIN 43735 (TE-MES-MS)

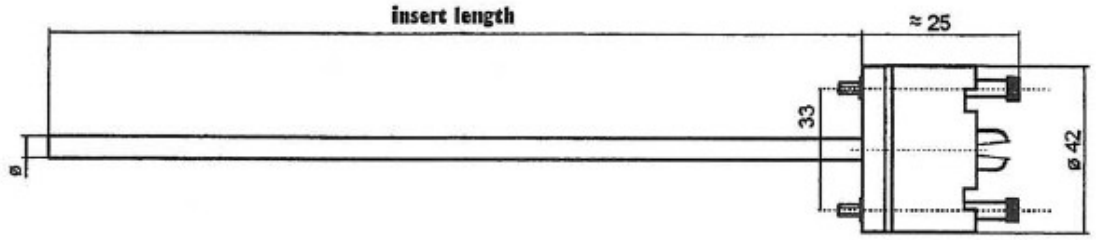


Figure 27: TE-MES-MS

measuring insert	thermal pair (TP)				fitting length
diameter mm	amount	short name operating temperature	norms tolerance	model	mm
6	1TP	Fe-CuNi Type L max. 600°C	DIN 43710[1)]	insulated from base	275
8	2TP[2)]	Fe-CuNi Type J max. 600°C	1/2 DIN, 43710[1)]	welded into base	315
10		NiCr-Ni Type K max. 850°C	ANSI standard		375
			ANSI special		405
			DIN IEC 584 class 1		435
			DIN IEC 584 class 2		525
					555
					655
		other types	special tolerance		as required
[1)] only for Fe-CuNi type L		[2)] not for thermal pairs types Typ S, R and B			

8.4 Measuring inserts in model with jacket lead (TE-MES-MI)

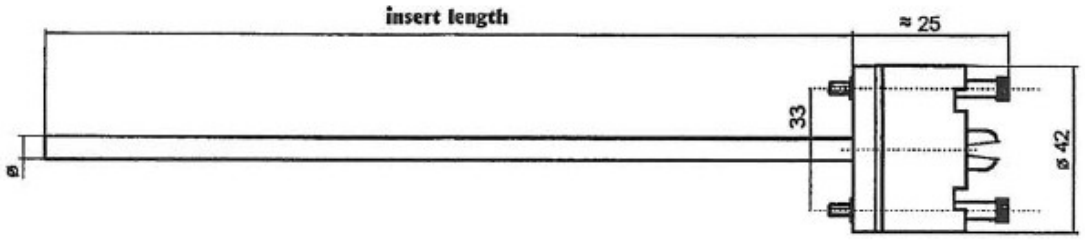


Figure 28: TE-MES-MI

measuring insert	**thermal pair (TP)**				**material of jacket**	**fitting length mm for insert diameter**	
diameter mm	amount	short name operation temperature	norms tolerance	model	max. operation temperature	3 mm	6 /8 / 10 mm
3	1TP	FeCu-Ni Type L max. 800°C	DIN 43710[2)]	insulated from base	not rusting steel[1)], 850°C	290	275
6	2TP	FeCu-Ni Type J max. 800°C	1/2 DIN 43710[1)2)]	welded into base[2)]	Inconel®[3)] 1100°C	315	315
8		Ni-CrNi Type K max. 1100°C	ANSI standard			405	375
10		Pt10 Rh-Pt Type S max. 1100°C	ANSI special			555	405
		Pt13 Rh-Pt Type R max. 1100°C	DIN IEC 584 Class 1[1)]				435
		PtRh 18 Type B max. 1100°C	DIN IEC 584 Class 2				525
							555
							655
			other types	special tolerance		as required	

[1)] not for thermal pairs types S, R and B
[2)] only for Fe-CuNi type L
[3)] with types S, R and B recommended operation temperature is 900°C, above which there is danger of stability loss through contamination of the thermal pair by Inconel precipitation

9. Plugs and couplings for thermal elements

Plugs and couplings for thermal elements are useful for attaching thermal elements to measuring and evaluation units and for extending leads. Please observe that only thermal plugs of the same type as a thermal element may be connected to that element. Otherwise thermal potentials could induce errors of measurement.

The plug contacts are made of massive thermal element material so as to permit high mechanical stress. These contacts cannot be lost. Thermal wires of ø 2.8 ø6 mm (standard models) or ø0.5 ø4 mm (miniature models) can be attached to them. With double plug connections various pairings are possible.

Housing is obtainable in temperature resistant plastic (-100°C … +200°C) and radiation resistant ceramics (-100°C … +900°C). For certain types a model in brown high temperature plastic (up to 220°C) is deliverable. Please look up for details in the appropriate order summary.

Higher temperatures are available on request.

There are three kinds of connectors for thermal elements:

- standard connectors
  - simple model (plastic)
  - double model (plastic)
  - ceramic model

- miniature connectors (plastic)
  - simple model
  - 3 poled model
  - double model

- connectors for mounting printed boards
  - simple model (plastic)

In our catalogue you will also find numerous accessories and mounting materials for connectors for thermal elements such as for strain relief, holding angles, crush screw fittings and spacer and crush bushings.

9.1 Plug connectors for thermal elements, standard models

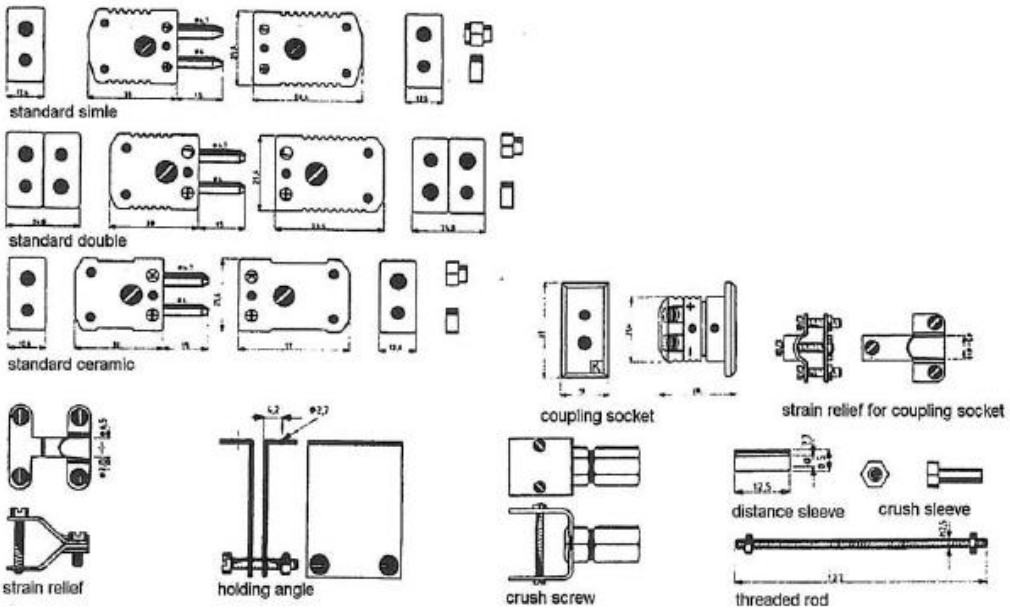


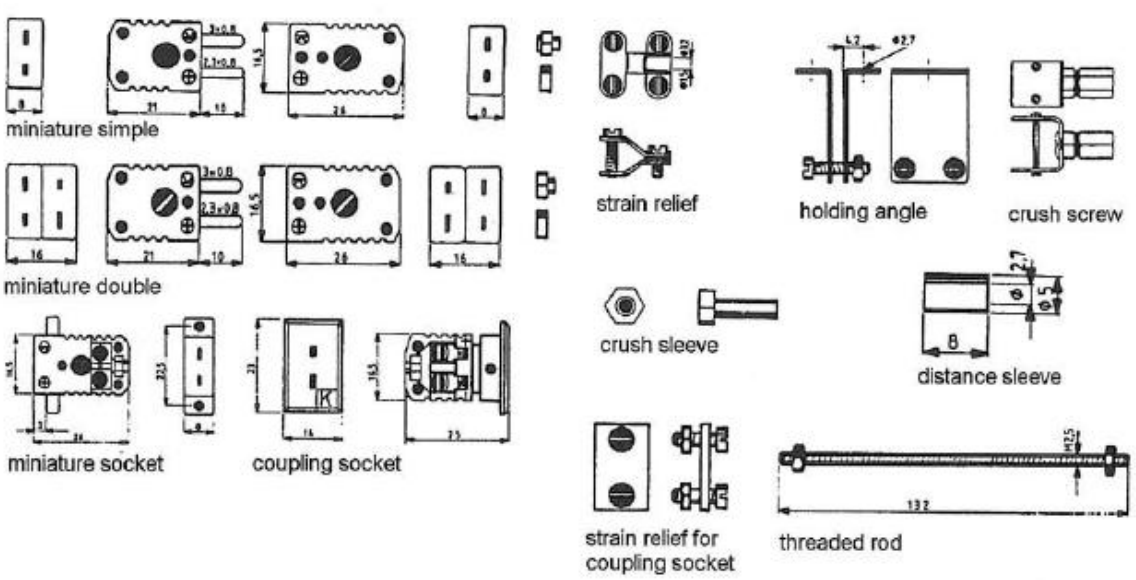
Figure 29: Plug connectors

Order numbers standard plug connectors														
	contact material			simple			ceramic		double		HTK-ST-[1]			
IEC	+small	-large	Farbe	plug	coupling	socket	plug	coupling	plug	coupling	plug	coupling	ceramic-socket	
K	NiCr	Ni	yellow	0220	0220	0220	0220	0220	0220	0220	0220	0220	0220	
J	Fe	CuNi	black	0220	0220	0220	0220	0220	0220	0220	0220	0220	0220	
T	Cu	CuNi	blue	0220	0220	0220	0220	0220	0220	0220				
E	NiCr	CuNi	violet	0220	0220	0220	0220	0220	0220	0220				
R	*Pt13R	Pt	green	0220	0220	0220	0220	0220	0220	0220				
S	Pt10Rh	Pt	green	0220	0220	0220	0220	0220	0220	0220				
B	Pt13Rh	Pt6Rh	white	0220	0220	0220	0220	0220	0220	0220				
U	Cu	Cu	white	0220	0220	0220	0220	0220	0220	0220				
C	*W Re5	W	red	0220	0220	0220	0220	0220	0220	0220				
D	*W Re3	W	red	0220	0220	0220	0220	0220	0220	0220				
N	Nicrosil	Nisil	orange	0220	0220	0220	0220	0220	0220	0220	0220	0220	0220	
DIN														
K	NiCr	Ni	green	0220	0220	0220			0220	0220				
J	Fe	CuNi	blue	0220	0220	0220			0220	0220				
T	Cu	CuNi	brown	0220	0220	0222			0220	0220				
S	*Pt10R	Pt	white	0220	0220	0220			0220	0220				
S	*Pt30R	Pt6Rh	white	0220	0220	0220			0220	0220				
U	Cu	Cu	white	0220	0220	0220			0220	0220				

* copper – copper alloy

[1] HTK = high temperature plastic, colour brown, continual use 220°C

9.2 Plug connectors for thermal elements, miniature models

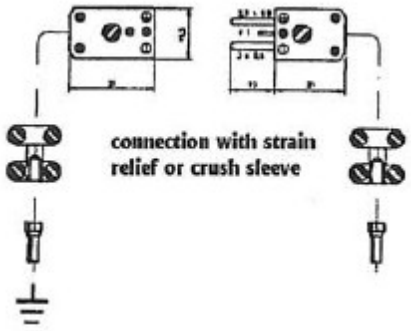


Order numbers miniature plug connectors													
	contact material			simple			double			HTK-M-[1]			
IEC	+small	-large	colour	plug	coupling	socket	coupling socket	plug	coupling	plug	coupling	min.-socket	
K	NiCr	Ni	yellow	0220	0220	0220	0220	0220 0146	0220 0158	0220	0220	0220	
J	Fe	CuNi	black	0220	0220	0220	0220	0220 0147	0220 0159	0220	0220	0220	
T	Cu	CuNi	blue	0220	0220	0220	0220	0220 0148	0220 0160				
E	NiCr	CuNi	violet	0220	0220	0220	0220	0220 0149	0220 0161				
R	*Pt13R	Pt	green	0220	0220	0220	0220	0220 0150	0220 0162				
S	Pt10Rh	Pt	green	0220	0220	0220	0220	0220 0151	0220 0163				
B	Pt13Rh	Pt6Rh	white	0220	0220	0220	0220	0220 0152	0220 0164				
U	Cu	Cu	white	0220	0220	0220	0220	0220 0153	0220 1656				
C	*W Re5	W	red	0220	0220	0220	0220	0220 0189	0220 0191				
D	*W Re3	W	red	0220	0220	0220	0220	0220 0190	0220 0192				
N	Nicrosil	Nisil	orange	0220	0220	0220	0220	0220 0210	0220 0211	0220	0220	0220	
DIN													
K	NiCr	Ni	green	0220	0220	0220	0220	0220	0220 0122				
J	Fe	CuNi	blue	0220	0220	0220	0220	0220	0220 0123				
T	Cu	CuNi	brown	0220	0220	0220	0220	0220	0220 0124				
S	*Pt10R	Pt	white	0220	0220	0220	0220	0220	0220 0125				
S	*Pt30R	Pt6Rh	white	0220	0220	0220	0220014	0220	0220 0106				
U	Cu	Cu	white	0220	0220	0220	0220	0220	0220 0107				

* copper – copper alloy

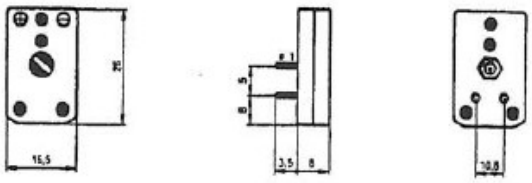
[1] HTK = high temperature plastic, colour brown, continual use 220°C

9.3 Plug connectors for thermal elements, 3-poled miniature models



Order numbers miniature plug connector 3-poled						
IEC	contact material +small	-large	colour	order number miniature plug	order number miniature coupling	order number miniature socket
K	NiCr	Ni	yellow	0220	0220	0220 1005
J	Fe	CuNi	black	0220	0220	0220 1010
DIN						
K	NiCr	Ni	green	0220	0220	0220 1033
J	Fe	CuNi	blue	0220	0220	0220 1038

9.4 Miniature couplings for mounting printed boards



Miniature couplings for mounting printed boards				
IEC	contact material +small	-large	colour	order number miniature coupling
K	NiCr	Ni	yellow	0220 2002
J	Fe	CuNi	black	0220 2007
DIN				
K	NiCr	Ni	green	0220 2032
J	Fe	CuNi	blue	0220 2037

9.5 Accessories for thermal plug connectors

article	order number standard coupling	order number miniature coupling
strain relief for simple plug connector	0241 0001	0241 0004
strain relief for double plug connector	0241 0007	0241 0008
holding angle for simple plug connector 1 pair	0241 0002	0241 0005
holding angle for double plug connector 1 pair	0241 0010	0241 0020
threaded rod 1 pair	0241 0003	0241 0003
spacer bushing 12.5 package of 10	0190 0001	0190 0001
spacer bushing 8.0 package of 10	0190 0002	0190 0002
crush bushing ø 1.6	0180 0014	---
crush bushing ø 2.2	---	0180 0011
crush bushing ø 3.1	0180 0012	---
crush bushing ø 4.6	0180 0013	---
crush bushing ø 6.4	0180 0015	---
strain relief for coupling socket	0241 0018	0241 0021
crush screw for simple plug connector ø 0.7	---	0241 0022
crush screw for simple plug connector ø 1	---	0241 0023
crush screw for simple plug connector ø 1.5	---	0241 0024
crush screw for simple plug connector ø 2	0241 0011	---
crush screw for simple plug connector ø 3	0241 0012	0241 0025
crush screw for simple plug connector ø 4.5	0241 0013	---
crush screw for simple plug connector ø 6	0241 0014	---
crush screw for double plug connector ø 2	0241 0009	0241 0026
crush screw for double plug connector ø 3	0241 0015	0241 0027
crush screw for double plug connector ø 4.5	0241 0016	---
crush screw for double plug connector ø 6	0241 0017	---

EPHY MESS
Gesellschaft für Elektro-Physikalische Meßgeräte mbH

Check list for orders

To process your order quickly and correctly, we need sufficient information from you about the products you would like to have. The following check list should help you to avoid inquiries from us or even misunderstandings, which would lead to a delay in filling your order.

In the case of thermal elements products and custom orders that deviate greatly from our standard product line, we would appreciate receipt of a drawing or sketch with your order.

- **Thermal wires and equalizer leads (TD/AL)**
  - thermal element type, norm (DIN, IEC, ANSI etc.) and tolerance
  - type of line (complete or only + pole / -pole
  - wire lead diameter or cross section
  - insulation material(s)
  - length

- **Thermal elements for armature heads (TE-WK)**
  - thermal element type, norm (DIN, IEC, ANSI etc.) and tolerance
  - type of construction (bare, SH, KH etc.)
  - dimensions of sheaths / bolt housing and material
  - length, cross section and insulation of equalizing lead
  - operation temperature

- **Slot thermal elements (TE-NT)**
  - thermal element type, norm (DIN, IEC, ANSI etc.) and tolerance
  - dimensions
  - lengths, cross section and insulation of equalizing lead

- **Foil thermal elements**
  - thermal element type (only J, T and K)

- **Plug-in thermal elements**
  - construction form (KW1, KW2, KW)
  - thermal element type and number of thermal pairs
  - diameter of protective tube
  - fitting length
  - type of measuring point (flat, cone shaped, 120°)
  - length and insulation of equalizing lead

- **Jacket thermal elements (TE-MI)**
    - thermal element type and norm (DIN, IEC, ANSI etc.)
    - type of measuring point (insulated, not insulated)
    - material and diameter of jacket
    - nominal length
    - operation temperature
    - construction
        - with bare thermal wire ends
        - with reinforced and insulated thermal wire ends (insulation and length)
        - with equalizer lead attached (insulation and length)
        - with Lemosa plug connector
        - with connector head (form B / F, IP protection type, type of screw-in thread)

- **Straight thermal elements with protective tube and connector head (TE-SRA)**
    - thermal element type and number of thermal pairs
    - norm (DIN, IEC, ANSI etc.) and tolerance
    - model (metallic protective tube, with/without inner tube)
        - material(s) for protective tube / inner tube
    - dimensions
    - nominal length and fitting length
    - connector head
        - construction form
        - IP protection type
    - means of attachment

- **Measuring inserts for thermal elements (TE-MES)**
    - thermal element type and number of thermal pairs
    - norm (DIN, IEC, ANSI etc.) and tolerance
    - type of measuring point (insulated, not insulated)
    - construction type (DIN 43735 / jacket lead)
    - diameter
    - insert length

I Appendix thermocouples (TE)

I.I Suitability of materials for outer jacket

1.4541

Resistance to corrosion and heat:
Especially resistant to aggressive media, steam, combustion gases in chemical media. Resistant to oxidation in air for constant temperatures up to 850°C, or in air for non constant temperatures up to 800°C, or in carbon dioxide up to 650°C. Viscous to -250°C.

Very good stability in:
Benzine, benzole, boric acid, buthyl alcohol, iron sulfate, acetic anhydride, formaldehyde, tannic acid, potassium carbonate and sulfate, carbolic acid, copper nitrate and sulfate, sodium phosphate and sulfide, phosphoric acid up to 50% concentration, cleaning fluids, nitric acid up to 100°C.

Areas of use
Construction of reactor and chemical devices, atomic energy and similar systems, heat exchangers, industrial ovens, petroleum processing, and food, dairy, brewery and chemical industries.

1.4571

Resistance to corrosion and heat:
Resistance as above for 1.4541 but with increased resistance to certain acids e.g. phosphoric, sulfuric, formic and acetic acid. At constant temperatures resistant up to approx. 900°C, at non constant temperatures approx. 800°C. Good welding properties.

Areas of use
as under 1.4541, but with increased resistance to corrosion and pitting. Main uses: chemical, rubber and paint industries, atomic energy systems, laboratories, reactor construction, up to 400°C in construction of pressured containers.

1.4841 / 1.4845

Resistance to corrosion and heat:
Highly refractory steel can be used in air up to 1200°C (1.4845 up to 1050°C), up to 1000°C at non constant temperatures, little carbonization, maintains mechanical strength properties at high temperatures, especially resistant to corrosion in atmosphere with nitrogen, carbon dioxide and little oxygen. Little resistance in oxidizing and reducing atmospheres.

Areas of use
Furnace construction; furnace with nitrogenous, oxygen poor gases; nitriding furnaces with ammonia; heat exchangers; cement, enamelling and glass industries; whenever resistance to scaling and the effects of heat is necessary.

Inconel®

Resistance to corrosion and heat:
Resistant to corrosion at high temperatures; resistant to stress cracks and pitting corrosion induced in chlorous media. Not attacked by ammonia in aqueous solutions at any temperature or concentration; very resistant to halogens, chlorine, and hydrogen chloride.

Areas of use:
Standard material for corrosion requirements at high temperatures, good pliability, mechanically resistant at high steam pressures; can be used in furnaces and facilities for heat processing, chemical processes, research and development.

1.4749

Resistance to corrosion and heat:
Good resistance in oxidizing, sulfuric atmosphere up to 1025°C. Good oxidation resistance bot hat constant and at cyclical temperatures, in air up to 1100°C, or in reducing sulfuric atmosphere (with hydrogen sulfide) up to 950°C.

Areas of use:
Temperatures above 700°C, industrial furnaces such as baking ovens, annealing furnaces, and through type furnaces; in steel processing; for all sulfuric atmospheres; for quick measurements in molten masses of zinc under 600°C, of lead, of copper and copper alloys, and of light metal alloys.

Pt10%Rh

Corrosion, heat resistance, stability:
High heat resistance up to 1300°C in the absence of oxygen, sulfur and silicon; else high heat resistance up to 1200°C.

Especially resistant to following reagents:
Halogens Cl_2, hydrogen sulfide HF_4 40%, HCl 36%, H_2SO_4 96%, acetic acids, NaOCl-solutions. Under K_2SO_4 at 1150°C no weight change, no external attack.

Harmful:
Reducing hydrogen gases with sulfuric components, which can lead to brittleness by absorption of silicon from reinforcement ceramics or, over 1000°C, to sulfuric eutectic mixtures. Sensitive to phosphorus, danger of phosphoric brittleness.

Area of use:
Glass, electrochemical and catalytic technology; laboratory operations; smelting furnaces; ultimate waste disposal of products of nuclear technology.

I.II Stability of ceramic and metallic materials for protection tubes

KER 530
fine porous, not gas proof, resistant to changing temperatures, high aluminum oxide constant >80%, max. temp. 1650°C.

KER 610
gas proof, high resistance to fire, high aluminum oxide content >60%, max.temp. 1600°C.

KER 710
gas proof, greatest resistance to fire, pure aluminum oxide >99,7%, max. temp. 1900°C.

St. 35.8 M.-No. 1.0305
for temperatures up to 550°C in air. Low resistance to sulfuric gases; medium resistance to nitrogenous gases.

St. 35.8 M.- No. 1.0305-fire enamelled
for temperatures up to 550°C, at most 1 bar excess pressure fort the low pressure area in furnaces, flue gas canals and containers.

X10Cr Al M.- No. 1.4762
for temperatures up to 1200°C in air. High resistance to sulfuric gases; low resistance to nitrogenous gases.

X18Cr Ni28 M.- No. 1.4749
for temperatures up to 1100°C in air. Extremely high resistance to sulfuric gases; low resistance to nitrogenous gases; good resistance to lead and zinc molten masses.

X15CrNi Si 2520 M.- No. 1.4841
for temperatures up to 1100°C in air. Low resistance to sulfuric gases. High resistance to nitrogenous, oxygen poor gases. High resistance to long period creeps.

I.III Basic thermal voltages and tolerances

The temperature – voltage values (basic voltage values) of standard thermal pairs. Values according to norms DIN 43710 and IEC 60584.

Basic voltage values for thermal pairs

Tempera-ture / °C	Type U	Type T	Type L	Type J	Type E	Type K	Type S	Type R	Type B
-200	-5.70	-5.603	-8.15	-7.890	-8.824	-5.891			
-150	-4.69	-4.648	-6.60	-6.499	-7.279	-4.912			
-100	-3.40	-3.378	-4.75	-4.632	-5.237	-3.553			
-50	-1.85	-1.819	-2.51	-2.431	-2.787	-1.889	-0.236	-0.226	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	2.05	2.035	2.65	2.585	3.047	2.022	0.299	0.296	0.002
100	4.25	4.277	5.37	5.268	6.317	4.095	0.645	0.647	0.033
150	6.62	6.702	8.15	8.008	9.787	6.137	1.029	1.041	0.092
200	9.20	9.286	10.95	10.777	13.419	8.137	1.440	1.468	0.178
250	11.98	12.011	13.75	13.553	17.178	10.151	1.873	1.923	0.291
300	14.90	18.860	16.56	16.325	21.033	12.207	2.323	2.400	0.431
350	17.92	17.816	19.36	19.089	24.961	14.292	2.786	2.896	0.596
400	21.00	20.869	22.16	21.846	28.943	16.395	3.260	3.407	0.786
450	24.15		25.00	24.607	32.960	18.513	3.743	3.933	1.002
500	27.41		27.85	27.388	36.999	20.640	4.234	4.471	1.241
550	30.80		30.75	30.210	41.045	22.772	4.732	5.021	1.505
600	34.31		33.67	33.096	45.085	24.902	5.237	5.582	1.791
650			36.64	36.066	49.109	27.022	5.751	6.155	2.100
700			39.72	39.130	55.110	29.128	6.274	6.741	2.430
750			42.92	42.283	57.083	31.214	6.805	7.339	2.782
800			46.22	45.498	61.022	33.277	7.345	7.949	3.154
850			49.63	48.716	64.924	35.314	7.892	8.570	3.546
900			53.14	51.875	68.783	37.325	8.448	9.203	3.957
950				54.948	72.593	39.310	9.012	9.848	4.386
1000				57.942	76.358	41.269	9.585	10.503	4.833
1050				60.876		43.202	10.165	11.170	5.297
1100				63.777		45.108	10.754	11.846	5.777
1150				66.664		46.985	11.348	12.532	6.237
1200				69.536		48.828	11.947	13.224	6.783
1250						50.633	12.550	13.922	7.308
1300						52.398	13.155	14.624	7.845
1350						54.125	13.761	15.329	8.393
1400							14.368	16.035	8.952
1450							14.973	16.741	9.519
1500							15.576	17.445	10.094
1550							16.176	18.146	10.674
1600							16.771	18.842	11.257
1650							17.360	19.533	11.842
1700							17.942	20.215	12.426
1750							18.504	20.878	13.008
1800									13.585
all voltage values in mV									

I.IV Tolerances of thermal pairs as normed by IEC 60584

Thermocouples standardized by IEC 60584 are divided in three tolerance classes:

Class		1	2	3[2)]
max. deviations [1)] (±)		0.5°C or 0.004 |*t*|	0.5°C or 0.0075 |*t*|	1°C or 0.0015 |*t*|
applications Type T		-40°C to +350°C	-40°C to +350°C	-200°C to +40°C
max. deviations [1)](±)		1.5°C or 0.004 |*t*|	2,5°C or 0.0075 |*t*|	1.5°C or 0.0075 |*t*|
	Type E	-40°C to +800°C	-40°C to +900°C	-200°C to +40°C
applications	Type J	-40°C to +750°C	-40°C to +750°C	---
	Type K	-40°C to +1000°C	-40°C to +1200°C	-200°C to +40°C
max. deviations [1)](±)		1°C or {1+(t-1300)0.003}°C	1.5°C or 0.0075 |*t*|	4°C or 0.0015 |*t*|
applications	Type R and S	0°C to +1600°C	0°C to +1600°C	---
	Type B	---	+600°C to 1700°C	-600°C to +1700°C

[1)] The permitted deviation ist he greater oft the following two values: the indicated temperature in °C for the factor multiplied by the actual temperature (positive value)

[2)] Thermocouples and thermowires are usually delivered so that the maximum deviation meets the above table for temperatures above -40°C. The deviation for thermocouples of the same material may be greater below -40°C than quated for class 3.

I.V Tolerances of thermal pairs as normed by DIN 43710

For thermal element types U and L, norm DIN 43710 does not set up tolerance classes but simply lays down maximum tolerances as follows:

short name of the thermal pair	Cu - CuNi Type U			Fe- CuNi Type L		
plus legg	copper			iron		
minus legg	copper-nickel					
temperature	base voltage	max. tolerance		base voltage	max. tolerance	
°C	mV	°C	%	mV	°C	%
-200	-5.7			-8.15		
-100	-3.40			-4.75		
0	0	-		0	-	
100	4.25	± 3	-	5.37	± 3	-
200	9.20			10.95		
300	14.90			16.56		
400	21.00			22.16		
500	27.41	-	± 0.75	27.85	-	± 0.75
600	34.31			33.67		
700				39.72		
800				46.22	-	± 0.75
900				53.14		
DIN 43710 does not specify tolerances for temperatures under 0°C.						

I.VI IP protection types

Extract from DIN 40050, part 3:

Format of the short name

Initial „IP“	Protection against being touched and against foreign objects or water penetrating into
Digit 1: 0, 1, …, 6	Level of protection against being touched and against foreign objects penetrating into
Digit 2: 0,1, …, 8	Level of protection against water penetrating into

Definition of levels of protection

Digit 1	Definition		Digit 2	Definition
0	No protection		0	No special protection
1	Protection against large foreign objects		1	Protection against water falling perpendicularly
2	Protection against foreign objects of medium size		2	Protection against water falling from an angle
3	Protection against small foreign objects		3	Protection against water spray
4	Protection against grained foreign objects		4	Protection against splashed water
5	Protection against dust deposits		5	Protection against hosed water or water jets
6	Protection against penetration of dust		6	Protection in casse of flooding
			7	Protection if dipped
			8	Protection if submerged

Main protection types listed

IP	Digit 2								
Digit 1	0	1	2	3	4	5	6	7	8
	IP 00								
1	IP 01		IP 12						
2	IP 02			IP 23					
3	IP 03	IP 31	IP 32						
4	IP 04		IP 42	IP 43					
5	IP 05			IP 53	IP54	IP 55	IP 56		
6						IP 65		IP 67	

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