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T6R - THERMOELEMENTS WITH TAPERED TIP

Thermoelements with tapered tip are intended for measuring temperature of liquid and gaseous media, at low and medium pressures, primarily in inaccessible and complicated containers and pipelines.
Thermoelement is installed directly in the medium in which the temperature is measured with or without process connection.

Basic parts of thermoelement are as follows:

- connection head - rotating,
- external protection tube with tapered tip,
- measuring insert,
- process connection.

Connection head (rotating) of thermoelement is defined via the configurator.
External protection tube, flat part tapered tip are made of material W.Nr. 1.4404, (equivalent to W.Nr. 1.4571). Tapered tip is made of solid material.
Measuring insert in mantel structure with different types of thermocouples (J, K, N, T) which are defined via the configurator.
Process connection is achieved by means of connections of different shapes and dimensions.
Advantages of structure with tapered tip of protection tube
Faster response:
Measuring insert is inserted into tapered tip to allow for very fast response without weakening the structure. (Response time is a square function of the measuring insert diameter. Response speed is proportional to the square of diameter of the measuring insert: if diameter is reduced by half, response time is reduced by 4 times, i.e. response speed increases four times. Response time is almost independent of the larger tube diameter, which can be standard: 6, 8, 12 mm).
Choice of diameter of the tip of external protection tube depends on the length of immersion part and total length Ln, and not on response time.
Connection head - rotating:
Rotating head allows the thermoelement to be easily screwed into process, because while screwing, the head does not turn, even though process connection is welded to external protection tube. After finishing the screwing, head can be turned to the desired position and fixed in that position.

From structure point of view:

Mineral-insulated mantel measuring insert guarantees greater resistance to vibrations and is used for higher operating temperatures (Tmax=700°) even with small diameters of measuring insert in order to reduce response time.

Replaceable measuring insert, through connection head, without dismantling the complete thermoelement.

Terminal block of measuring insert, for electrical connection, with metal parts made of stainless steel and blocks made of plastic resistant to high temperature: Unlike ceramics, this solution provides excellent insulation and there is no oxidation even in case of high humidity.

Tapered tip is made of solid material, not welded. This design makes it much stronger and more resistant to pressure, fluid flow and corrosion.

Installation length of thermoelement can be:
constant (achieved by means of process connection which is welded to protection tube),
adjustable (achieved by means of a compression connection, which is movable along protection tube).

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

Use
- chemical industry,
- petroleum industry
- thermal power plants and hydroelectric power plants,
- food industry,
- pharmaceutical industry,
- construction machines, plants, containers...

- More information
- Product selection - configurator

Measurement principle

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

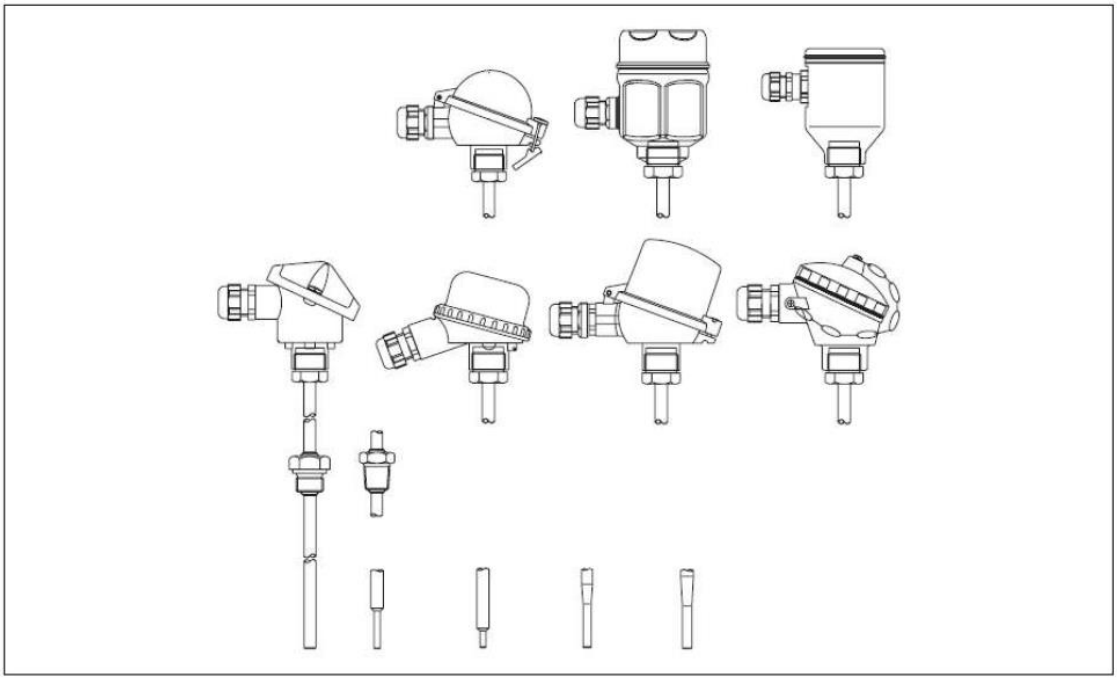
When one junction (hot junction) is at temperature T_1, and the other (cold junction) is at temperature T_2, an electromotive force is generated in the circuit, the value of which depends on the materials used and the values of temperatures T_1 and T_2. This effect, on which thermoelectric temperature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

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

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

Constituent parts

The following Figure gives **Group T6R** thermoelements, with different connection heads, process connections and ends of protection tubes.



Group T6R thermoelements consist of a measuring insert, protection tube and connection head in which a plastic block with terminals made of stainless steel for electrical connection can be installed. Structure of the thermoelements is in line with the guidelines of DIN 43729 standard (connection head), DIN 43 772(protection tubes) and DIN 43762 (measuring inserts).

Use of the said standards in the production of thermoelements guarantees a very high degree of durability and stable operation in the most diverse industrial processes. The measuring insert - mantel structure is replaceable and is placed in a protection tube. It can be replaced without stopping the process and dismantling the thermoelements from the process.

Basic design of thermoelements is with a plastic block in the connection head, and upon request, a transmitter programmed in line with the customer's specification can be installed in the connection head.

Thermocouples type J, K, N, T in the measuring insert are placed so that the end of the measuring insert is close to the top of the tapered part of protection tube.

Protection tubes are made of seamless tubes with a diameter of 8, 10 or 12 mm and a tapered part fi 4mm to achieve a faster response. The tapered tip is made of solid material, not welded. This structure makes it much stronger and more resistant to pressure, fluid flow and corrosion.

Thermoelement is installed in the process (pipeline or tank) using a process connection (there is a wide range of connections - see chapter Constituent parts).

Thermocouple is always in line with the requirements of the IEC 60584 standard. Thermocouple in the measuring insert is either insulated or connected to the ground (according to the customer's specification).

Housing of the connection head can be made of different materials: aluminum, stainless steel, polypropylene. The method of installing the connection head on the protection tube and the cable inlet provide a minimum degree of protection IP 65.

Material

Parts which are in contact with the working environment are from W.Nr.1.4404 (equivalent to W.Nr.1.4571).

Weight
From 0.5 to 2.5 kg for standard designs.

Operating characteristics

Working conditions Ambient temperature

Connection head	Temperature in °C
Without transmitter	Metal head from -40 to 100°C
	Polyamide head: -40 to 85°C
With transmitter	-40 to 85°C
With ceramic block	-40 to 85°C

Process temperature

It is limited by the material of the protection tube and is for:

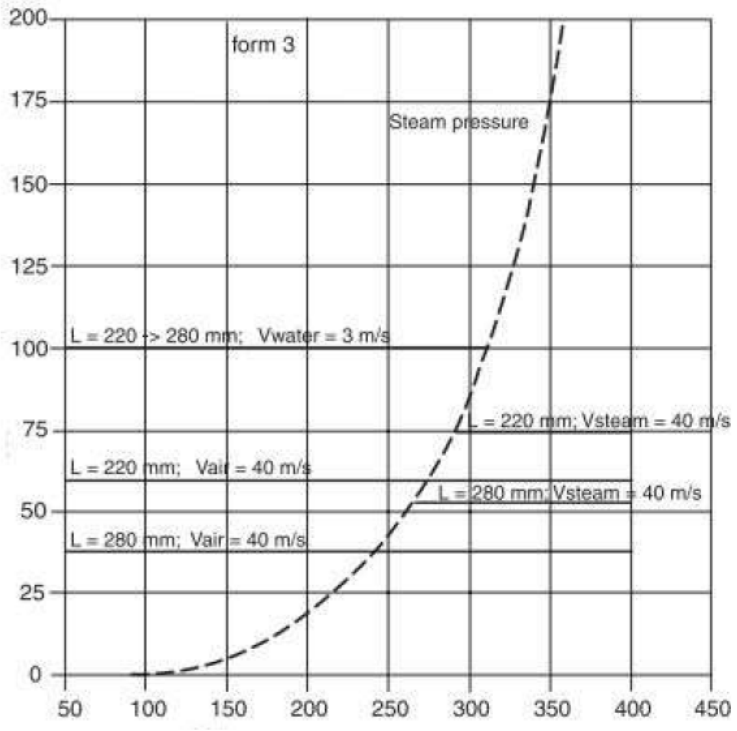
- W.Nr.1.4404 (equiv. W.Nr.1.4571) < 600/ < 800°C

Maximum process pressure

Pressure values to which protection tubes can be exposed at different temperatures are given in Diagram 1.

Maximum flow

Size of the flow depends on the protection tube and decreases with increasing length of the protection tube/measuring insert. Some informative indicators can be seen in Diagram 1.



Temperature in °C

Diagram 1 – Pressure – temperature for tube with tapered tip ∅12 made of material W.Nr.1.4571

Accuracy (certainty)
Maximum errors

Standard IEC 60584 defines the standard values and tolerances (permissible errors) of thermocouples and they are given in Table 3.
The standard accuracy classes for thermocouples type J, K, N, T.., are class 2.

Table 3: Permissible measurement errors

	Standard tolerance (IEC 60584)		Reduced tolerance (IEC 60584)	
Type	**Class**	**Permissible measurement error**	**Class**	**Permissible measurement error**
J Fe-CuNi	2	± 2.5°C (-40…333) °C ±0.0075|t| (333…750) °C	1	± 1.5°C (-40…375) °C ±(0.004|t| (375…750) °C
K NiCr-Ni	2	± 2.5°C (-40…333) °C ±0.0075|t| (333…1200) °C	1	± 1.5°C (-40…375) °C ±(0.004|t| (375…1200) °C
N		± 2.5°C (-40…333) °C	1	± 1.5°C (-40…375) °C

NiCrSi-NiSi	2	±0.0075|t| (333…1200) °C		±(0.004|t| (375…1200) °C
T Cu-CuNi	2	± 1°C (-40…133) °C ±0.0075|t| (133…350) °C	1	± 0.5°C (-40…125) °C ±(0.004|t| (125…350) °C

|t| = absolute value in °C.

Response time

Tests in water at a flow velocity of 0.4m/s, in line with IEC 751, change of temperature from 23°C to 33°C. The following table gives the response time for measuring inserts with thermocouples, without transmitter.

Tube diameter (mm)	**Thermocouple type**	**Response time**	**Ground connection**			**Isolated junction**		
			Red. tube type	**Conical tube type**	**Straight tube type**	**Red. tube type**	**Conical tube type**	**Straight tube type**
9	J, K, N, T	Ƭ50 Ƭ90	5.5 s 13 s	9 s 31 s	15 s 46 s	6 s 14 s	9.5 s 33 s	16 s 49 s
11		Ƭ50 Ƭ90	5.5 s 13 s	- -	15 s 46 s	6 s 14 s	- -	16 s 49 s

Insulation resistance

Insulation resistance between each terminal and the sheath of the measuring insert (according to IEC 60584) is checked at a test voltage of 100 V DC and is ≤ 100Ω, at ambient temperature.

Installation

Orientation

Not requested.

Installation instructions

For **Group T6R** thermoelements to be installed on the wall of pipelines or containers or other parts of the plant, it must be ensured that the connection on the thermoelement corresponds to the connection in the process.

Depth of immersion can affect the accuracy of the measurement. If the immersion depth is too small, error can be generated during low temperatures in the process fluid, near walls and heat transfer. This error can be avoided if there is a large difference between the process temperature and the ambient temperature. To achieve accuracy, the protection tube should have a diameter, and preferably, immersion depth of at least 80-100mm.

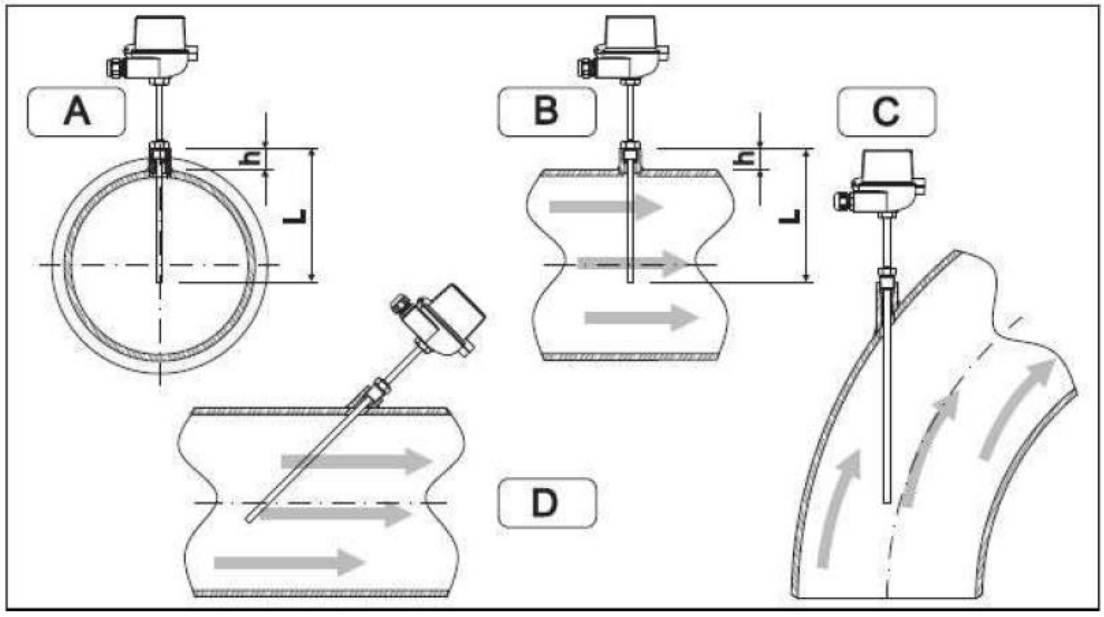
In pipelines of small cross-section, the tip of the thermoelement tube must cross the centerline of the pipeline (example A-B). By insulating the external parts of the thermoelements, the effect caused by the short immersion length is reduced.

Another solution can be the installation of thermoelements at an angle (example C-D). In processes where gases are involved at very high temperatures (from 500 to 600°C), where the effect of radiation is the most important, the immersion length can be a secondary problem. In

the case of two-phase flow, special attention should be paid to the selection of the measuring point to avoid that the measuring point is not in a place where there would be a change (fluctuation) in the detected temperatures.

Regarding corrosion, the base materials for the parts in contact with the process W. Nr 1.4404 (equiv.W.Nr.1.4571) are resistant to pitting corrosion even up to the highest temperatures of use.

For more information on the use of these thermoelements, contact TERMOTEHNA Technical service.



Examples of installation of Group T6 thermoelements

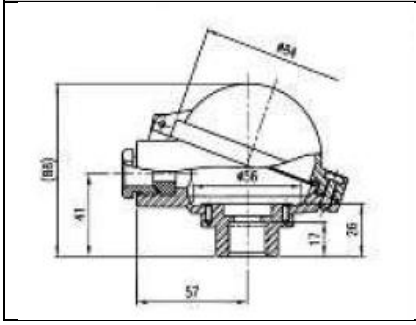
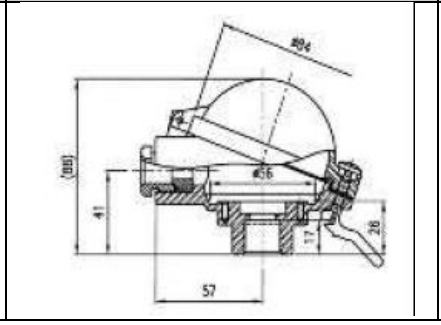
A-B: In pipelines with a small cross-section, the top of the protection tube of the sensor must cross the central line of the pipeline (=L); C-D: Inclined installation.

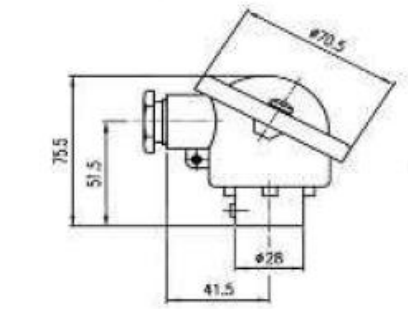
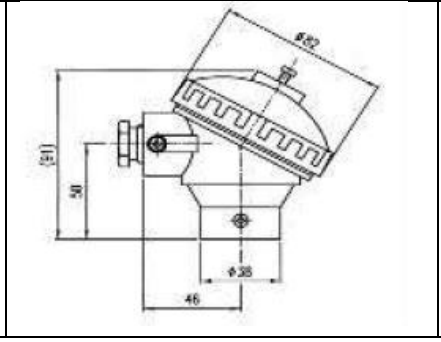
The installation length of the thermoelement affects accuracy. If the installation length is short, the measurement error is caused by the heat transferred through the process connection and the pipeline walls.
When installing pipelines, it is ideal that the installation length must be greater than half the diameter of the pipeline.
Minimum installation length = 80 to 100mm, i.e. 8 x sensor tube diameter.

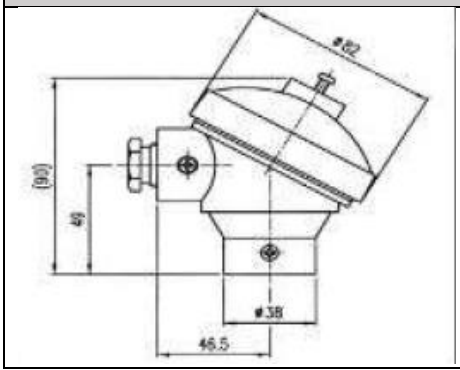
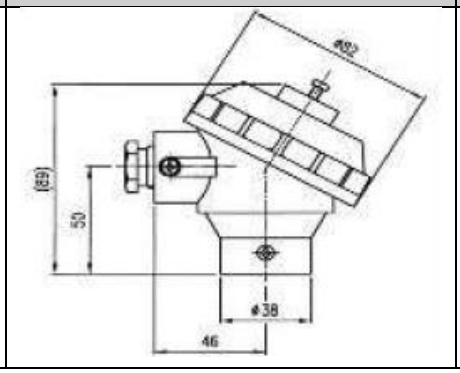
Note:
When during installation it is not possible to achieve the installation length to be greater than half the diameter of the pipeline, then go for installation at an angle (examples C-D).

Constituent parts

All connection heads have an internal shape and size in line with DIN 43729. The connection with the thermocouple can be a connection M24x1.5", 1/2", 1/2" NPT. The following figures show the shapes of the connection heads. All measurements are in mm. Cable inlets are M20x1.5 or ½ NPT.

head BA-KL	Ex	head BSS	
			

head B (DIN 43729)	Ex	head KPP	
			

head LS	Ex	head KNC	
			

Shapes and dimensions of connection heads

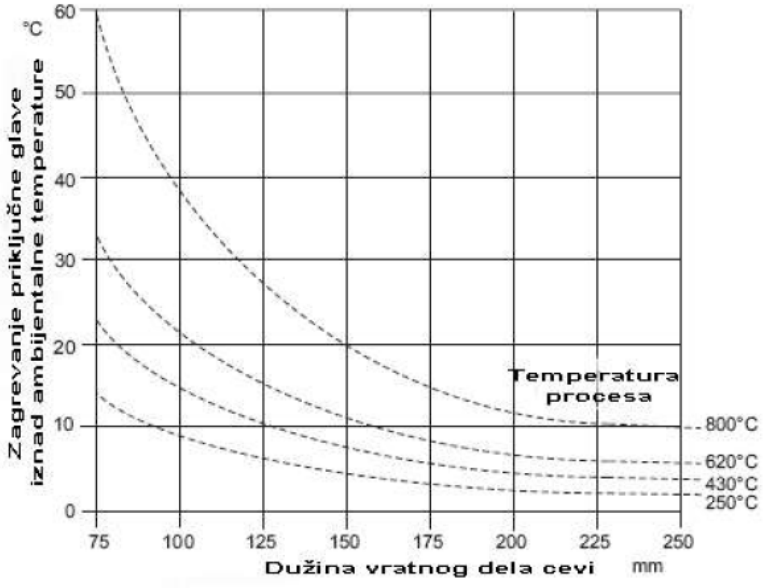
Transmitters

The following transmitters are applicable:

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

- Transmitters (galvanically isolated) PROFIBUS PA with output signal, the communication address can be set via the appropriate software or by means of mechanical switches. Customer can request the desired configuration during the ordering process.

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



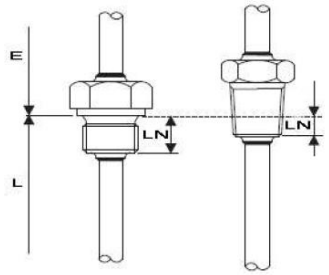
*(*Heating of the connection head above the ambient temperature/ Process temperature/ Length of the neck part of the tube*)*

Process connection

Standard process connections are:

- M20 x 1.5
- R1/2" and R1"
- 1/2" and 3/4" NPT
- Other variants upon request.

The following figure gives the standard connections.

Process connection		Design		Wound length LN in mm
Cylindrical	Conical	M	20 x 1.5	14
		R	1/2"	15
			1"	18
			3/4"	15
		NPT	1/2"	8
			3/4"	8.5

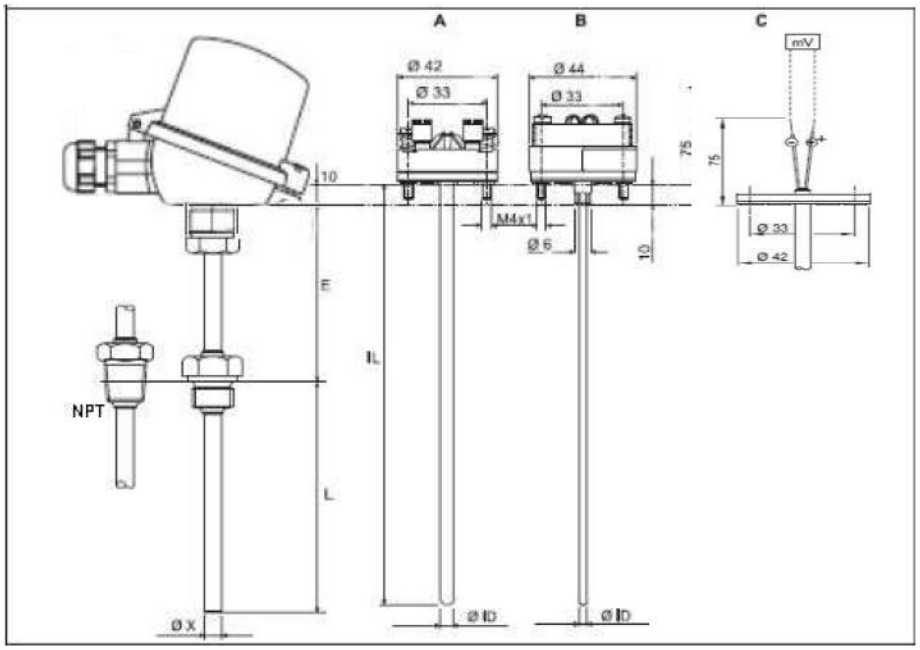
Measuring inserts

Measuring inserts - mantle structures are installed in **Group T6R** screw-in thermoelements.

The insertion length of the measuring inserts depends on the nominal length (L) of the thermoelement. Standard nominal lengths are 100; 150; 200; 250 mm. Thermoelements of non-standard, nominal lengths can also be supplied, if the user requests it.

When replacing the measuring insert, the insert length (Lu) must correspond to the thermoelement length (Ln).

Layout of constituent parts - functional components of Group T6R thermoelements



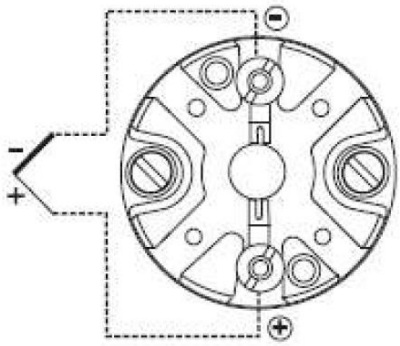
A – Model with plastic block installed
B – Model with transmitter for connection head
C – Model with free ends
Lv – Neck part of the tube
du – Measuring insert diameter
Lu – Insert length = L + Lv + 10mm
L – Nominal length
D – Protection tube diameter

Wiring

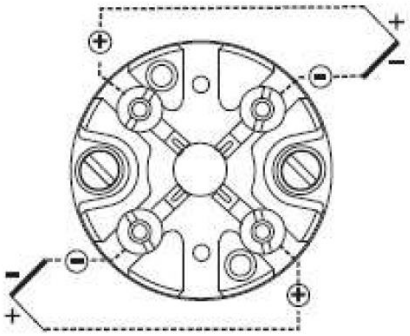
Wiring diagrams

Method of connecting the thermocouple to the plastic block in the connection head is given.

1 x Thermocouple



2 x Thermocouple



Transmitters

The following transmitters are applicable:

- PC programmable transmitters 4...20mA (galvanically isolated)
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- Transmitters (galvanically isolated) PROFIBUS PA with output signal, the communication address can be set via the appropriate software or by means of mechanical switches. Customer can request the desired configuration during the ordering process.

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

Certificates

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

Certificates

- Certificate for resistance thermometers and thermoelements for explosive atmospheres

- Ex label: Ex e II T4…T6 (Zone 1 and 2)
- Ex label: Ex e ia II CT4…6 (Zone 0, 1 and 2)

Other details

Maintenance

Group T6R thermoelements do not require any special maintenance.
Periodic inspections are recommended because mechanical damage and thermal shocks, aggressive environments, occurrence of abrasion can cause protection tube damage.
Furthermore, calibration of thermocouples is recommended, once a year, by an authorized laboratory, in line with the Law.

Table: *Catalog codes for standard* ***Group T6*** *thermoelements*

Temperature	Thermocouple	Material of metal protection tube	Nominal length L [mm]	Measuring insert ∅6 Length Lu [mm]	Catalog number	
					thermocouple 1xPt 100	thermocouple 2xPt 100
up to 400°C	Fe-CuNi Type J, according to IEC 60584-1 in mantel measuring insert	∅9x1.5 Č.4574 W.Nr. 1.4571	160	315	T6- 1111	T4- 2111
			250	405	T6-1112	T4-2112
up to 400°C	NiCr-NiAl Type K, according to IEC 60584-1 in mantel measuring insert	∅9x1.5 Č.4574 W.Nr. 1.4571	160	315	T6-1211	T6-2211
			250	405	T6-1212	T6-2212
up to 500°C	Fe-CuNi Type J, according to IEC 60584-1 in mantel measuring insert	∅11x2 Č.7400 W.Nr.1.7335	160	315	T6-1121	T6-2121
			250	405	T6-1122	T6-2122
up to 500°C	NiCr-NiAl Type K, according to IEC 60584-1 in mantel measuring insert	∅11x2 Č.7400 W.Nr.1.7335	160	315	T6-1221	T6-2221
			250	405	T6-1222	T6-2222

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

Thermocouple Fe-CuNi, Type J, according to IEC 584-1 - Thermovoltage values in mV

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

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Thermocouple NiCr-NiAl, Type K, according to IEC 584-1 - Thermovoltage values in mV

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

Thermocouple NiCrSi-NiSi, Type N, according to IEC 584-1 - Thermovoltage values in mV

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

Thermocouple Cu-CuNi, Type T, according to IEC 584-1 - Thermovoltage values in mV

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

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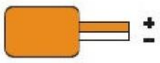
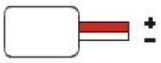
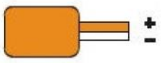
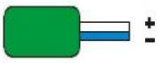
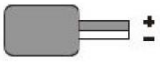
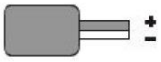
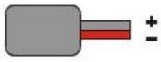
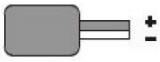
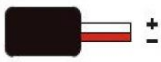
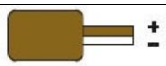
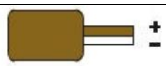
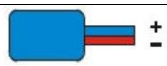
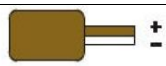
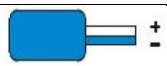
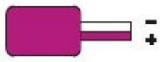
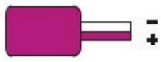
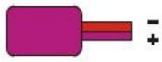
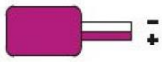
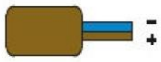
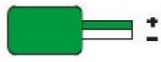
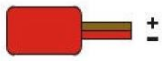
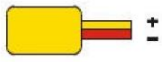
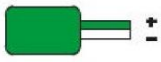
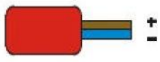
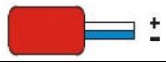
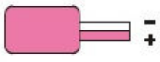
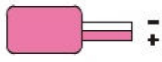
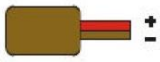
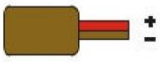
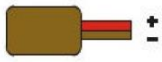
TERMOTEHNA

International Colour Codes applied to temperature engineering

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