T6 - SCREW-IN THERMOELEMENTS

Genuine screw-in thermoelements are intended for measuring temperature of liquid and gaseous media, at low and medium pressures, primarily in containers and pipelines.
Electrical connection is made via a terminal block or a transmitter, in the connection head.

Thermoelement is installed directly in the medium in which the temperature is measured.
Basic parts of thermoelement are as follows:

- connection head,
- external protection tube,
- measuring insert,
- process connection.

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

External protection tube of thermoelement is made of material selected to suit the process conditions and is directly immersed in the medium in which the temperature is measured.

Measuring insert can be in classic and mantel design with different types of thermocouples (J, K, N, T) which are defined via the Ordering Information form.
We recommend the mantel design, which has a number of advantages:

- there is no contamination and oxidation of the hot end of the thermocouple, because it is in highly compressed magnesium oxide, without the presence of oxygen,
- faster response,
- great resistance to vibrations,
- higher reliability in operation,
- longer service life.

The only advantage of the classic measuring insert is the lower price.

Process connection is achieved using connections of different shapes and dimensions.

Technical characteristics

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

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

Use

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

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.

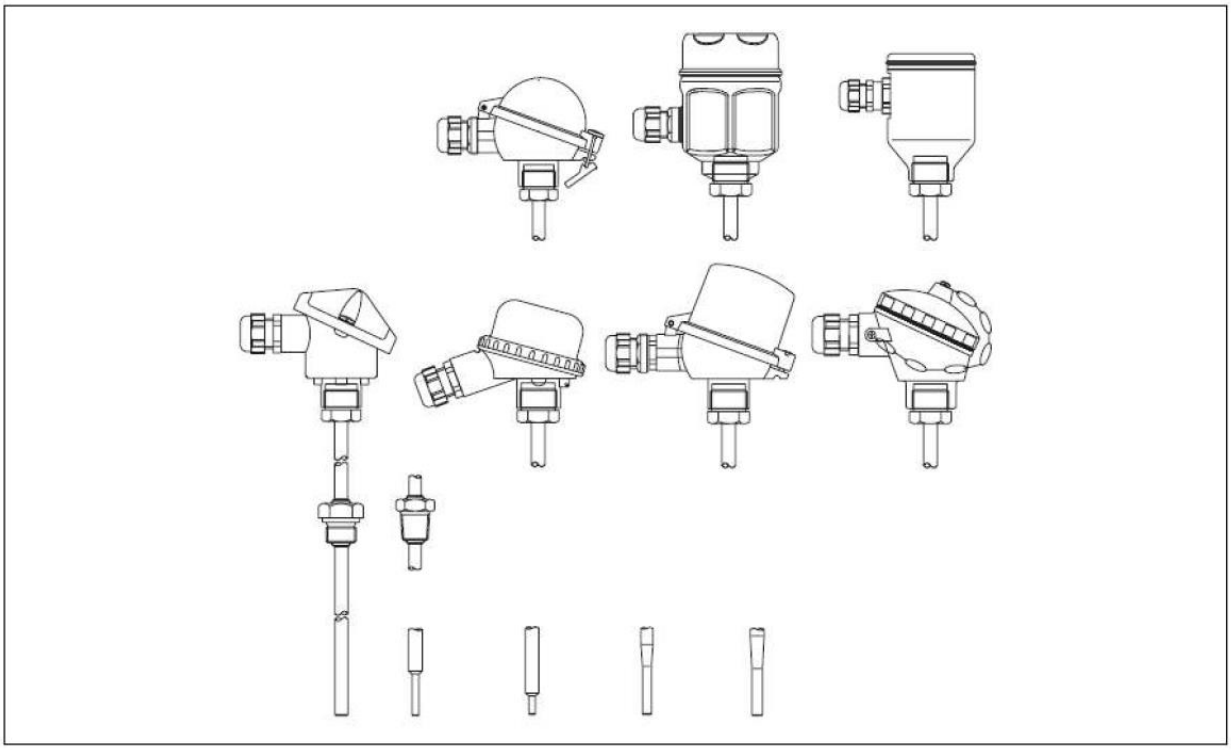
When one junction (hot junction) is at temperature T_1, and the other (cold junction) is at temperature T_2, an electromotive force is generated in the circuit, the value of which depends on the materials used and the values of temperatures T_1 and T_2. This effect, on which thermoelectric temperature 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 T6** thermoelements, with different connection heads, process connections and ends of protection tubes.



Group T6 thermoelements consist of a measuring insert, protection tube and connection head in which a ceramic block with terminals for electrical connection or a transmitter 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.

Basic design of thermoelements is with a ceramic 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 protection tube.

Protection tubes are made of seamless tubes with a diameter of 9 or 11 mm. The final protection tube can be straight (same diameter along the entire length).

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

Electrical structure of thermoelements is always in line with the requirements of the IEC 60584 standard. Thermocouple in the measuring insert is either isolated 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 SS304/1.4301; SS316Ti/1.4571 or Inconel 600.

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:

- SS16L/1.4404 < 600°C
- SS316Ti/1.4571 < 800°C
- Inconel 600 <1100°C

Maximum process pressure

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

For a tube with a diameter of 9 mm, with a limited flow velocity, the maximum permissible pressures are:

- 50 bar (5 Mpa) at 20°C
- 33 bar (3.3 Mpa) at 250°C
- 24 bar (2.4 Mpa) at 400°C

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.

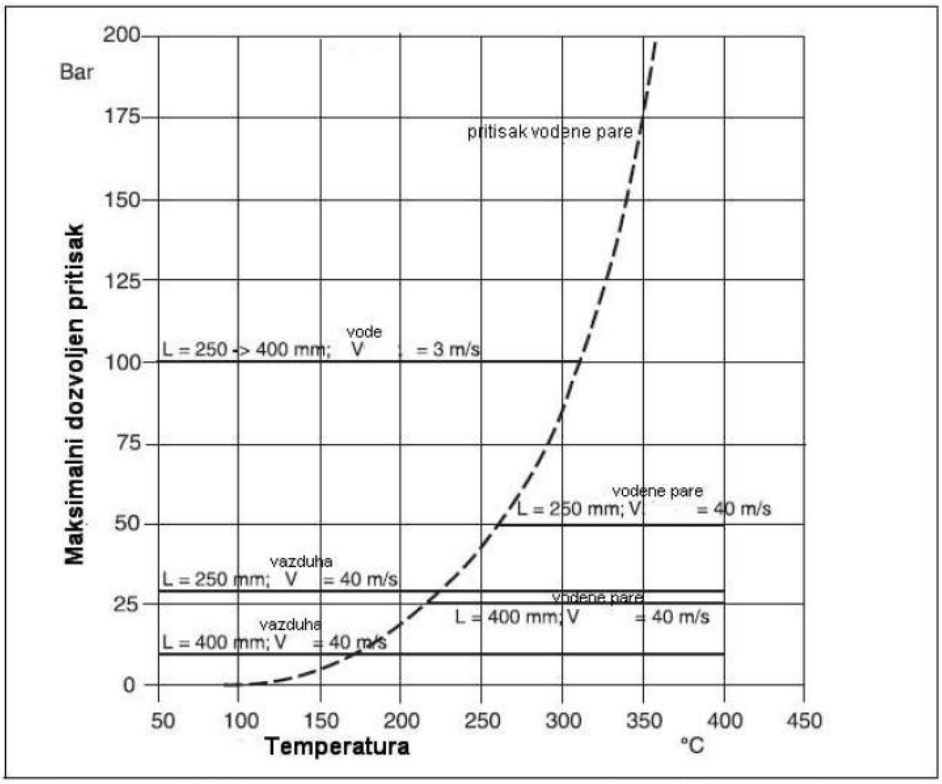


Diagram 1 – Pressure – temperature for straight tube ∅11 made of material SS316Ti/1.4571

*(*Maximum permissible pressure/ Vapor pressure of water/ Water/Water vapor/air/air/ Water vapor/Temperature*)*

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 NiCrSi-NiSi	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
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.
Transmitter error must be added to the thermocouple error, including reference junction compensation.

Response time
Tests in water at a flow velocity of 0.4m/s, 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 values greater than 100Ω, at ambient temperature.

Installation

Orientation
Not requested.

Installation instructions

For **Group T6** 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.

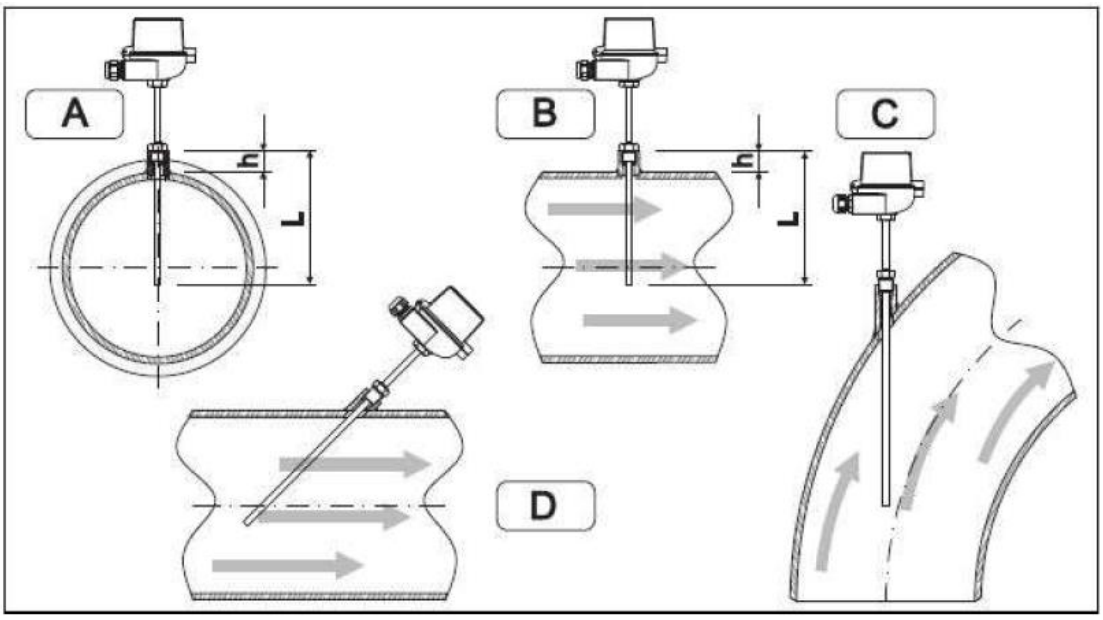
Depth of immersion can affect the accuracy of the measurement. If the immersion depth is too small, error can be generated during low temperatures in the process fluid, near walls and heat transfer. This error can be avoided if there is a large difference between the process temperature and the ambient 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 in order 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 (SS316L/1.4404; SS316Ti/1.4571 and Inconel 600/2.4816) 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

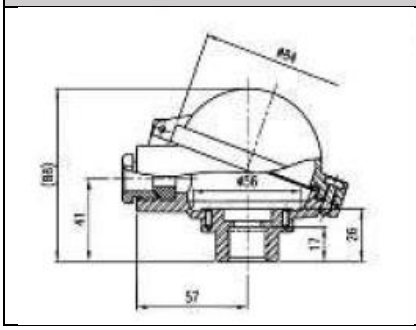
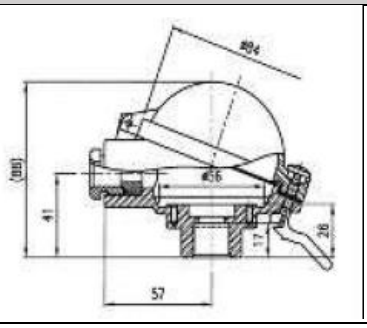
A-B: In pipelines with a small cross-section, the top of the protection tube of the sensor must cross the central line of the pipeline (=L); C-D: Inclined installation.

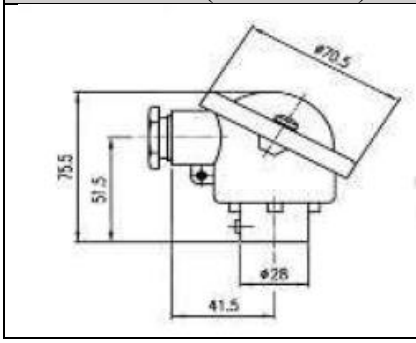
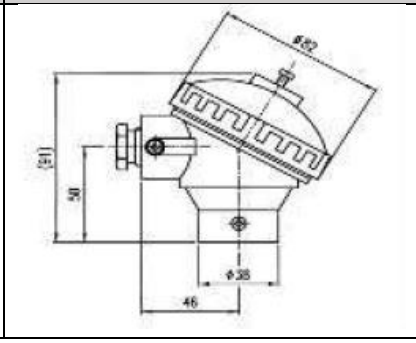
The installation length of the thermoelement affects the accuracy. If the installation length is short, the measurement error is caused by the heat transferred through the process connection and the pipeline walls.
When installing in pipelines, it is ideal that the installation length must be greater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

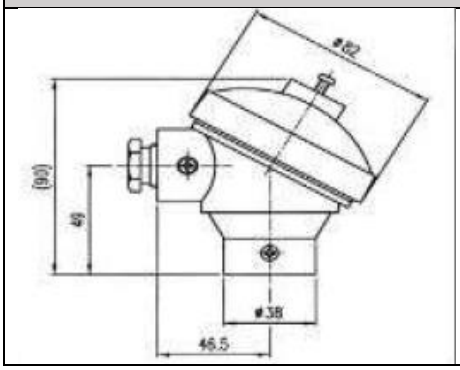
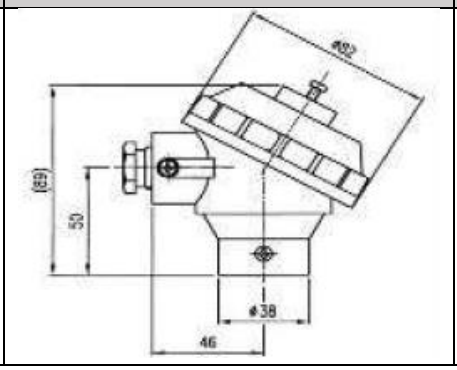
Note: When during installation it is not possible to achieve the installation length to be greater than half the diameter of the pipeline, then go for installation at an angle (examples C-D).

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 KPP	
			

Shapes and dimensions of connection heads

Transmitters

The following transmitters are applicable:

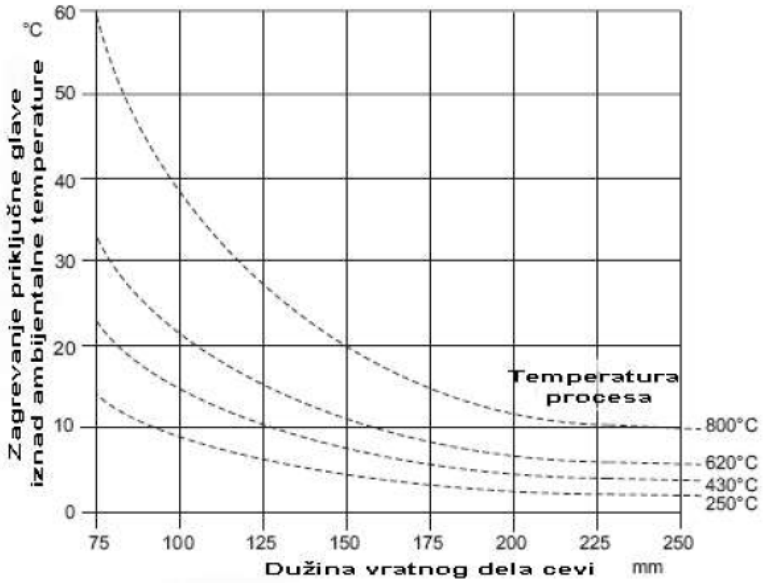
- PC programmable transmitters 4...20mA (galvanically isolated)
- Transmitters with HART protocol (galvanically isolated), the output contains 4...20mA and HART superimposed signals

- 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.

Neck tube

Neck part of the tube is the part between the connection and the connection head. It is common for the diameter of the neck tube to be the same as the diameter of the tube below the connection port. As shown in the following figure, the length of the neck part of the tube has an effect on the temperature in the connection head. It is necessary that this temperature be within the limits specified in the Working conditions chapter.



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

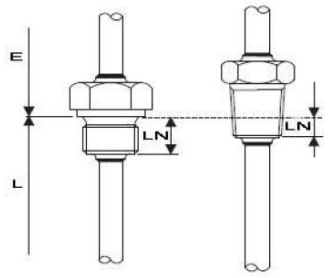
Process connection

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		Thread 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

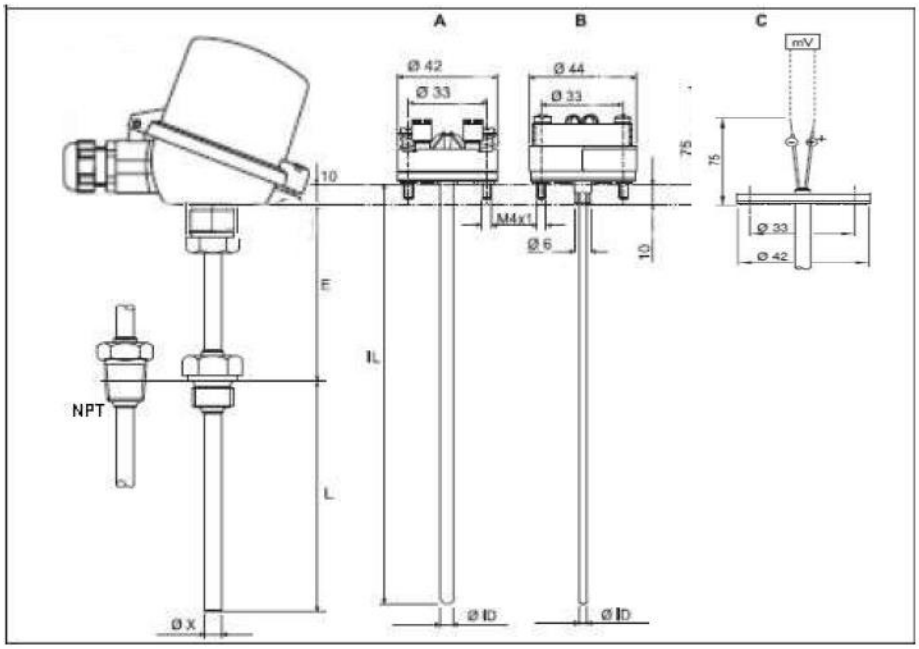
Measuring inserts

Measuring inserts - mantle structures are installed in **Group T6** screw-in thermoelements.

The insertion length of the measuring inserts depends on the nominal length (L) of the thermoelement. Standard nominal lengths are 160 and 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 nominal thermoelement length(L).

Layout of constituent parts - functional components of Group T6 thermoelements



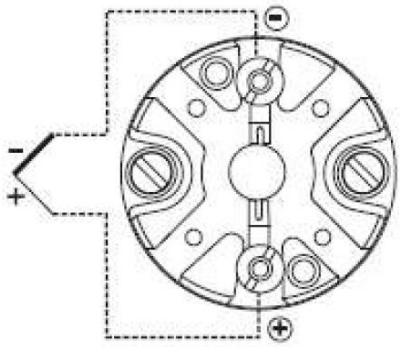
A – Model with ceramic block installed
B – Model with transmitter for connection head
C – Model with free ends
Lv – Neck part of the tube
du – Measuring insert diameter
Lu – Insert length = L + Lv + 10mm
L – Nominal length
D – Protection tube diameter

Wiring

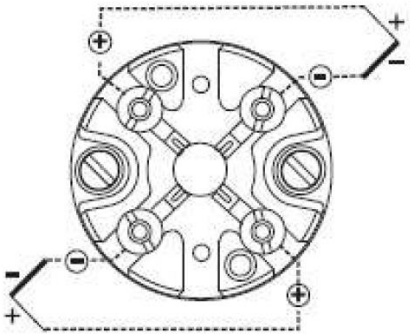
Wiring diagrams

The method of connecting the thermocouple to the ceramic block in the connection head is given.

1 x Thermocouple



2 x Thermocouple



Transmitters

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If the transmitters are installed on a DIN rail, ceramic 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 T6 thermoelements do not require any special maintenance.

Periodic inspections are recommended because mechanical damage and thermal shocks, aggressive environments, and the occurrence of abrasion can cause sleeve 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 60584-1 - 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

Thermocouple NiCr-NiAl, Type K, according to IEC 60584-1 - Thermovoltage values in mV

°C	0	- 10	- 20	- 30	- 40	- 50	- 60	- 70	- 80	- 90
- 100	- 3,553	- 3,852	- 4,138	- 4,410	- 4,669	- 4,912	- 5,141	- 5,354	- 5,550	- 5,730
0	0	- 0,392	- 0,777	- 1,156	- 1,527	- 1,889	- 2,243	- 2,586	- 2,920	- 3,242
°C	0	10	20	30	40	50	60	70	80	90
0	0	0,397	0,798	1,203	1,611	2,022	2,436	2,850	3,266	3,681
100	4,095	4,508	4,919	5,327	5,733	6,137	6,539	6,939	7,338	7,737
200	8,137	8,537	8,938	9,341	9,745	10,151	10,560	10,969	11,381	11,793
300	12,207	12,623	13,039	13,456	13,874	14,292	14,712	15,132	15,552	15,974
400	16,395	16,818	17,241	17,664	18,088	18,513	18,938	19,363	19,788	20,214
500	20,640	21,066	21,493	21,919	22,346	22,772	23,196	23,624	24,050	24,476
600	24,902	25,327	25,751	26,176	26,599	27,022	27,445	27,867	28,288	28,709
700	29,128	29,547	29,965	30,383	30,799	31,214	31,629	32,042	32,455	32,866
800	33,277	33,686	34,095	34,502	34,909	35,314	35,718	36,121	36,524	36,925
900	37,325	37,724	38,122	38,519	38,915	39,310	39,703	40,096	40,488	40,879
1000	41,269	41,657	42,045	42,432	42,817	43,202	43,585	43,968	44,349	44,729
1100	45,108	45,486	45,863	46,238	46,612	46,985	47,356	47,726	48,095	48,462
1200	48,828	49,192	49,555	49,916	50,276	50,633	50,990	51,344	51,697	52,049
1300	52,398	52,747	53,093	53,439	53,782	54,125	54,466	54,807		

Thermocouple NiCrSi-NiSi, Type N, according to IEC 60584-1 - Thermovoltage values in mV

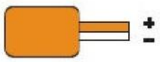
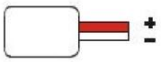
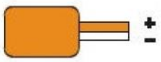
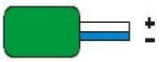
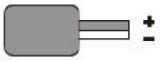
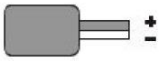
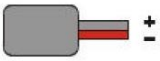
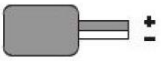
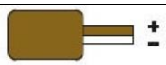
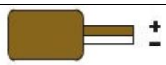
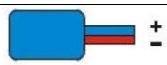
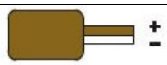
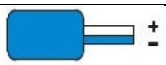
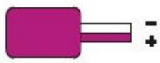
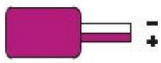
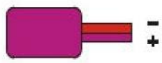
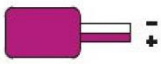
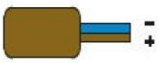
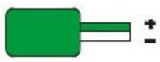
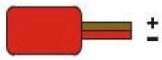
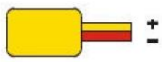
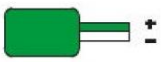
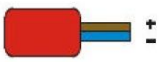
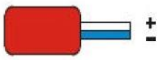
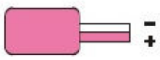
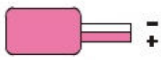
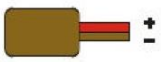
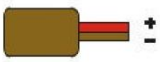
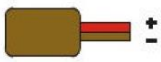
°C	0	- 10	- 20	- 30	- 40	- 50	- 60	- 70	- 80	- 90
- 200	- 3,99	- 4,08	- 4,16	- 4,22	- 4,27					
- 100	- 2,40	- 2,61	- 2,80	- 2,99	- 3,17	- 3,33	- 3,49	- 3,63	- 3,76	- 3,88
0	0	-0,26	- 0,51	- 0,77	- 1,02	- 1,26	- 1,50	- 1,74	- 1,97	- 2,19
°C	0	10	20	30	40	50	60	70	80	90
0	0	0,26	0,52	0,79	1,06	1,33	1,61	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 60584-1 - 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									

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