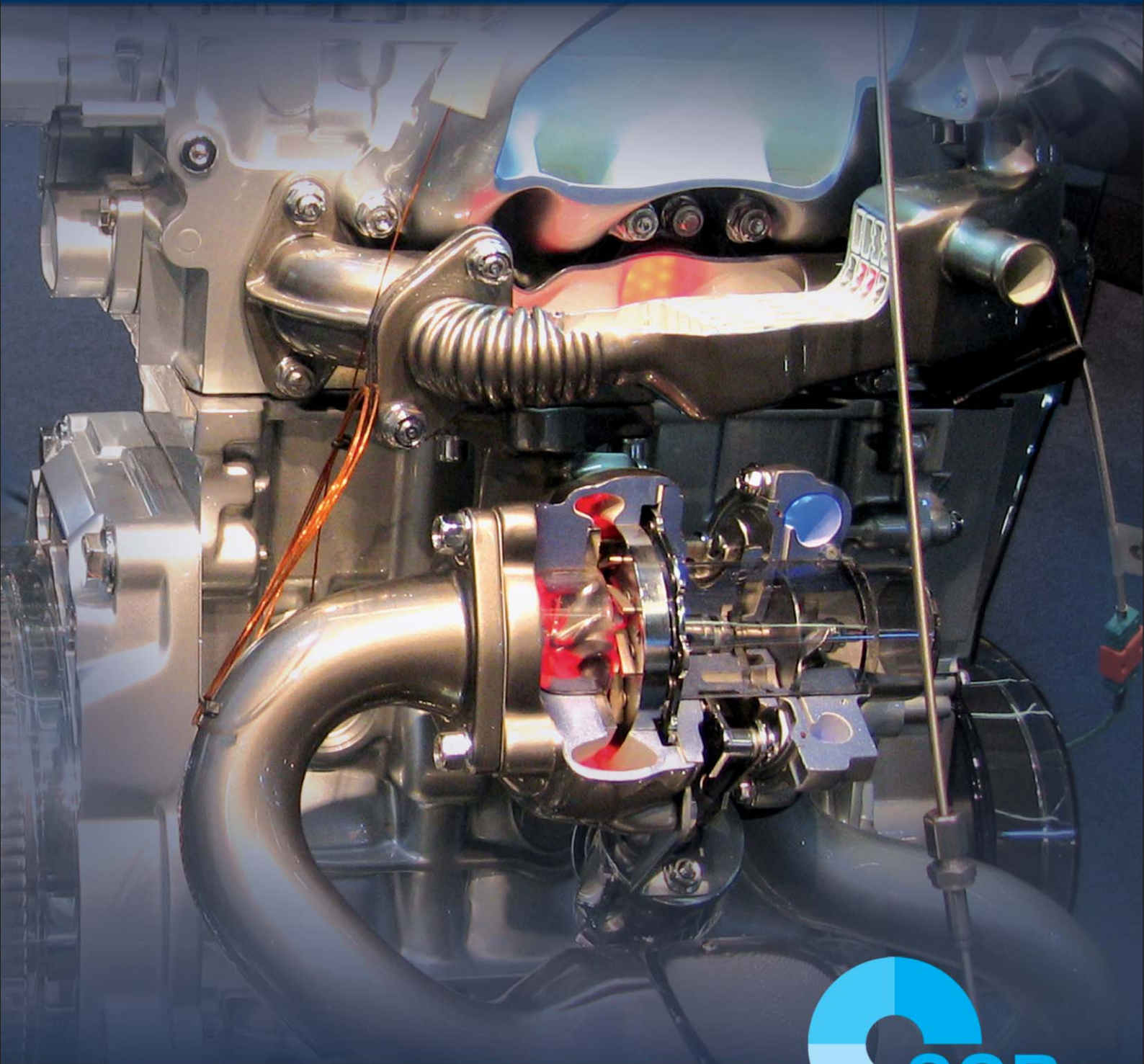


Temperature Measurement in Test Vehicles



www.sab-worldwide.com



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THERMO 8-PLUG AND 16-PLUG CONNECTOR T 065

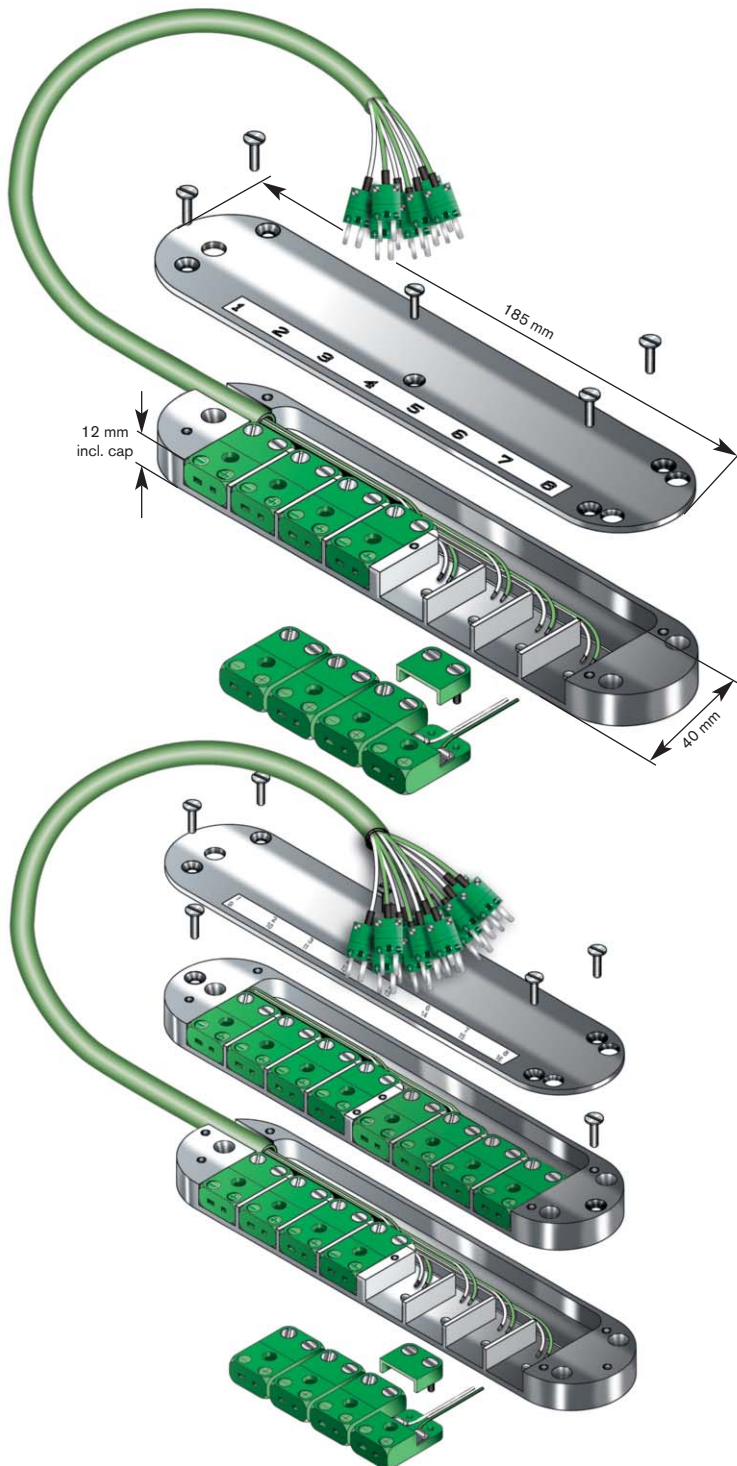
Also available in
type J + T

This item is used in automobile industry, for example in test vehicles. Thermocouples can be easily connected. In case of failure, the faulty element can be exchanged without much effort. Test engines require temperature measurements at the most different points, e.g. in oilpans, cooling tubes and combustion gases, etc.. Cables coming from the different measuring points can be plugged into the connector conveniently. Advantage: reduced wiring effort.

In general the application makes sense, whenever there are many measuring points and far distances that have to be overcome.



Optionally
connection end 2



8-PLUG CONNECTOR

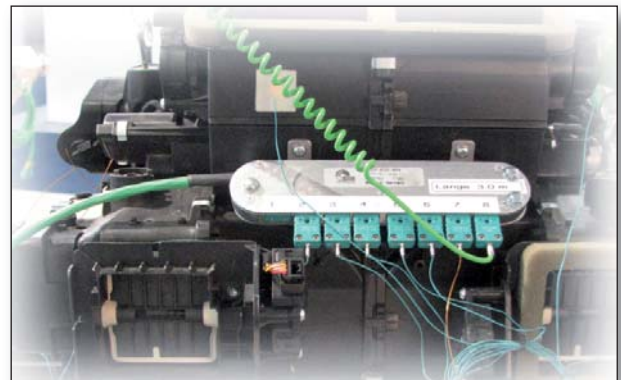
Technical data

cable type:	THL KX
standard:	DIN EN 60584
construction:	strands / FEP / FEP
section:	0,22 mm ²
no. of cores:	16
connection end 1:	8 miniature sockets type K in one aluminium housing, 2-pole miniature socket
item no.:	T065-041-572

16-PLUG CONNECTOR

Technical data

cable type:	THL KX
standard:	DIN EN 60584
construction:	strands / FEP / FEP
section:	0,22 mm ²
no. of cores:	32
connection end 1:	16 miniature sockets type K in one aluminium housing, 2-pole miniature socket
item no.:	T065-045-179



The photo shows an 8-plug connector used in automobile industry for example in test vehicles. Thermocouples can be easily connected.

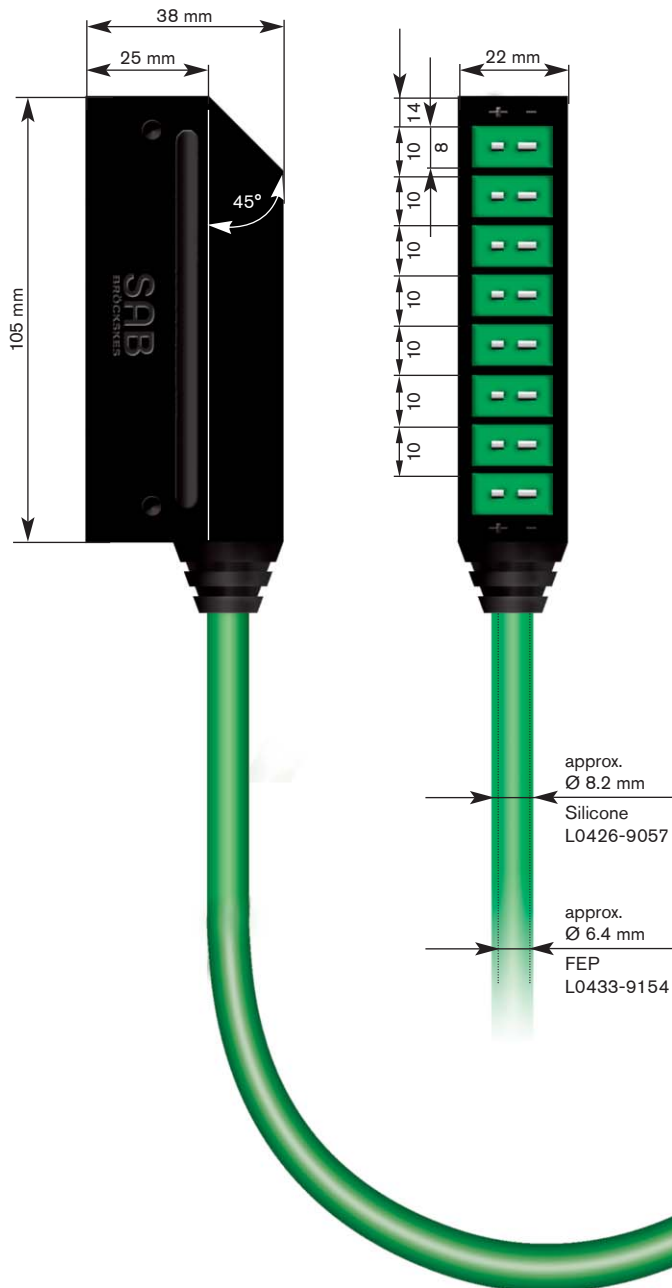
THERMO 8-PLUG PLASTIC CONNECTOR T 065

Also available in
type J + T

This item is used in automobile industry, for example in test vehicles. Thermocouples can be easily connected. In case of failure, the faulty element can be exchanged without much effort. Test engines require temperature measurements at the most different points, e.g. in oilpans, cooling tubes and combustion gases, etc. Cables coming from the different measuring points can be plugged into the connector conveniently. Advantage: reduced wiring effort.

Furthermore, the plastic connector offers recessed grips for easy handling. On request we are able to provide the company logo as well as individual fixing bores. Due to the plastic housing damages in the passenger area are avoided.

The small and space saving construction form offers an advantage compared with aluminium connectors.



8-PLUG CONNECTOR

Technical data

cable type:	THL KX 15-16 L
standard:	DIN EN 60584
construction:	strands / FEP / FEP
section:	0,22 mm ²
no. of cores:	16
connection end 1:	8 miniature sockets type K in a plastic housing, miniature socket 2 poles
item no.:	T065-046-047

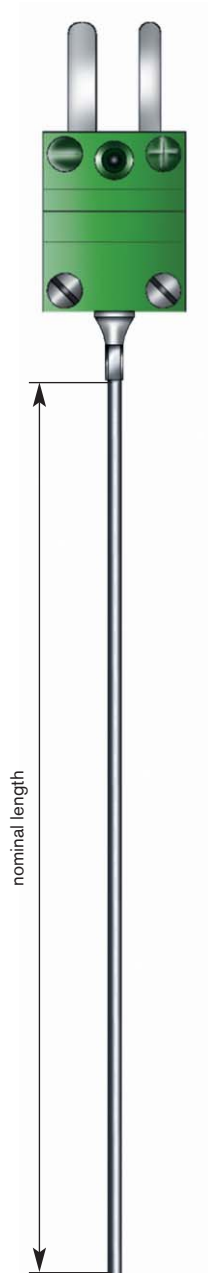


- connection end 2 acc. to order
- connection cable alternatively with TPE conductor insulation and twisted pairs available

STANDARD MINERAL INSULATED THERMOCOUPLE MTE 302

All purpose mineral insulated thermocouple!

Equally available with batch certificate and identification on request.



THERMOCOUPLE:

- 1 x J 1 x K
 2 x J 2 x K other thermocouples: _____

SHEATH - Ø:

- 0,5 mm 1,5 mm 3,0 mm 6,0 mm
 1,0 mm 2,0 mm 4,5 mm other sheath-Ø: _____

SHEATH MATERIAL:

- 1.4541 2.4816 other sheath materials: _____

CONNECTION ELEMENTS:

- without plug miniature socket
 standard plug high temperature socket
 miniature plug high temperature plug
 standard socket

ACCESSORIES:

- without _____

TOLERANCE/ MEASURING TIP:

- class 1, form A
 class 1, form B
 class 2, form A
 class 2, form B

NOMINAL LENGTH:

_____ mm

▶ thermocouple	1 x type K
▶ limit deviation	class 1
▶ standard	DIN EN 60584
▶ measuring point	form A, insulated measuring point
▶ connection element	miniature thermoplug
▶ max. temp. at plug	+ 200°C
▶ temperature range	-40°C up to +1000°C
▶ sheath	Ø 1,5 mm
▶ material no.	2.4816 / Inconel 600
▶ nominal length	150 mm
▶ item no.	T302-036-053

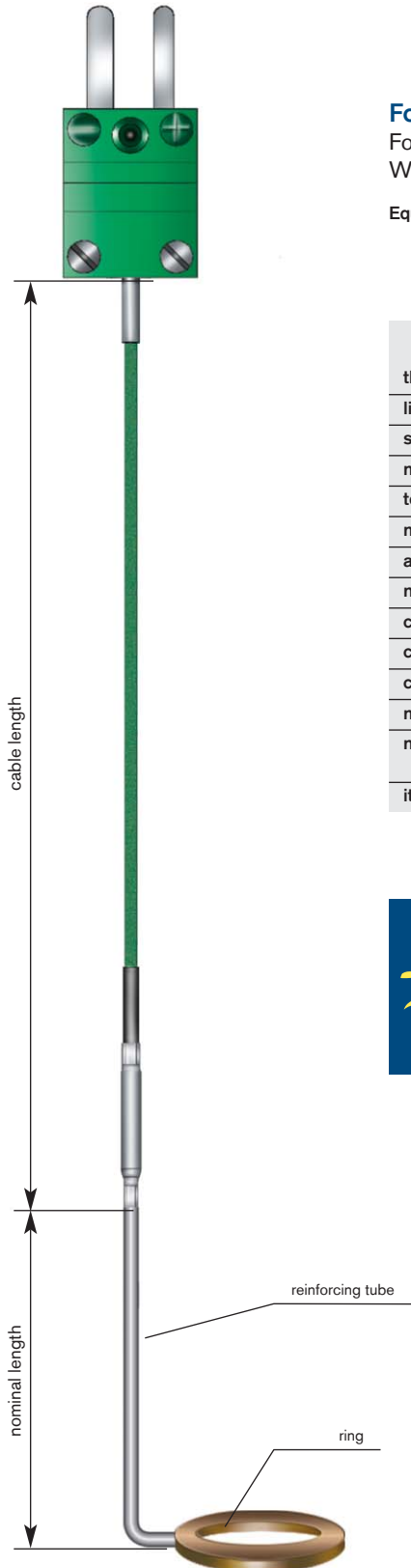


Also available in
type J + T

For the application in automobile industry.

For the easy measurement at the sealing ring of spark plugs.
Working with spark plug spanner isn't impeded.

Equally available with batch certificate and identification on request.



Technical data

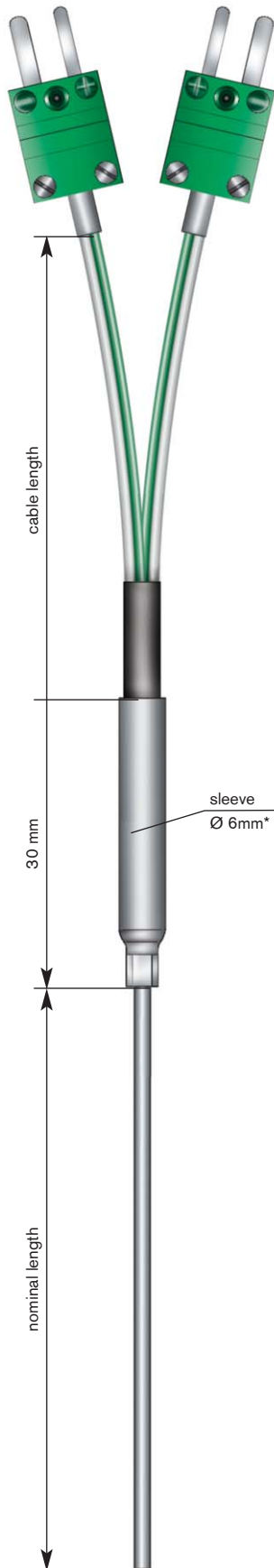
thermocouple:	1 x type K
limit deviation:	class 1
standard:	DIN EN 60584
measuring point:	form A, insulated
temperature range:	-40°C up to +400°C
material no.:	1.4541
accessories:	ring Ø 19 x 13.1 x 2.5 mm / brass
nominal length:	52 mm
connection cable:	thermo-cable KX19L 2 x 0,22 mm ²
cable length:	0,3 m
cable ends:	miniature thermoplug with sleeve
max. temp. at plug:	+200°C
note:	with antikink tube, plug with silicone potting
item no.:	T 207-044-579



- FEP insulated cable on request
- different ring Ø possible
- other dimensions on request

MINERAL INSULATED THERMOCOUPLE MTE 207

with FEP insulated cable (strands / FEP / FEP) 4 x 0,22 mm² up to +180 °C



For the application in automobile industry.

Especially appropriate for temperature measurement at places difficult to reach.

THERMOCOUPLE:

2 x K other thermocouples: _____

SHEATH - Ø:

1,5 mm other sheath-Ø: _____

SHEATH MATERIAL:

1.4541 2.4816 other sheath materials: _____

CABLE ENDS:

bare ends cable lugs M4
 end sleeves miniature thermoplug
 other cable ends: _____

CONNECTION CABLE:

1,0 m 2,5 m 5,0 m
 1,5 m 3,0 m 10,0 m
 2,0 m 4,0 m other length: _____

TYPE OF MEASURING TIP:

form A, without kink protection
 form B, without kink protection
 form A, with kink protection (shrinkable sleeve)
 form B, with kink protection (shrinkable sleeve)
 all types in class 1

NOMINAL LENGTH:

_____ mm



■ Also available as multi step element



▶ thermocouple	2 x type K
▶ limit deviation	class 1
▶ standard	DIN EN 60584
▶ measuring point	form A, insulated measuring point
▶ temperature range	-40°C up to +1000°C
▶ sheath	Ø 1,5 mm
▶ material no.	2.4816 / Inconel 600
▶ nominal length	100 mm
▶ connection cable	L/FEP/FEP 4 x 0,22 mm ²
▶ cable length	0,5 m
▶ cable ends	miniature thermoplug with sleeve
▶ max. temp. at plug	+ 200°C
▶ item no.	T207-044-143

*type of sleeve corresponds to sheath-Ø and connection cable

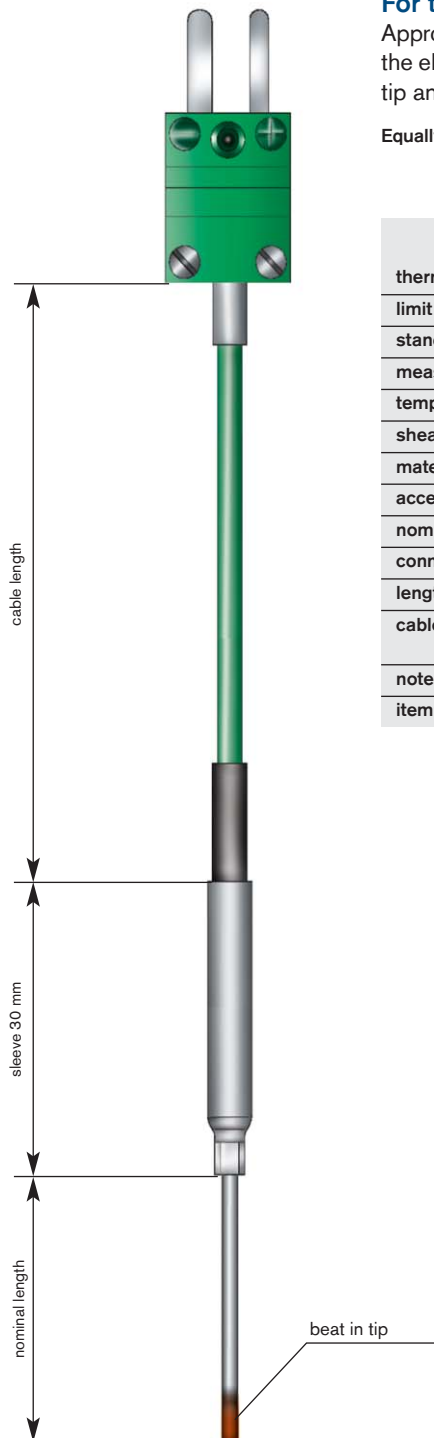
BEAT IN MINERAL INSULATED THERMOCOUPLE MTE 207

with FEP insulated cable (strands / FEP / foil / screen / FEP) 2 x 0,22 mm² up to +180 °C

For the application in automobile industry.

Appropriate for surface temperature measurement. With the help of an appropriate groove, the element can be fixed by beating in. The measuring point is situated behind the copper tip and can easily be identified by the colour difference.

Equally available with batch certificate and identification on request.



Technical data

thermocouple:	1 x type K
limit deviation:	class 1
standard:	DIN EN 60584
measuring point:	form A, insulated
temperature range:	-40°C up to +350°C
sheath:	Ø 1,5 mm
material no.:	1.4541
accessories:	copper tip Ø 1,5 x 5 mm
nominal length:	35 mm
connection cable:	thermo-cable KX19L 2 x 0,22 mm ²
length:	120 mm
cable ends:	miniature thermoplug with sleeve
note:	without kink protection
item no.:	T207-044-539

SURFACE THERMOCOUPLE MTE 290

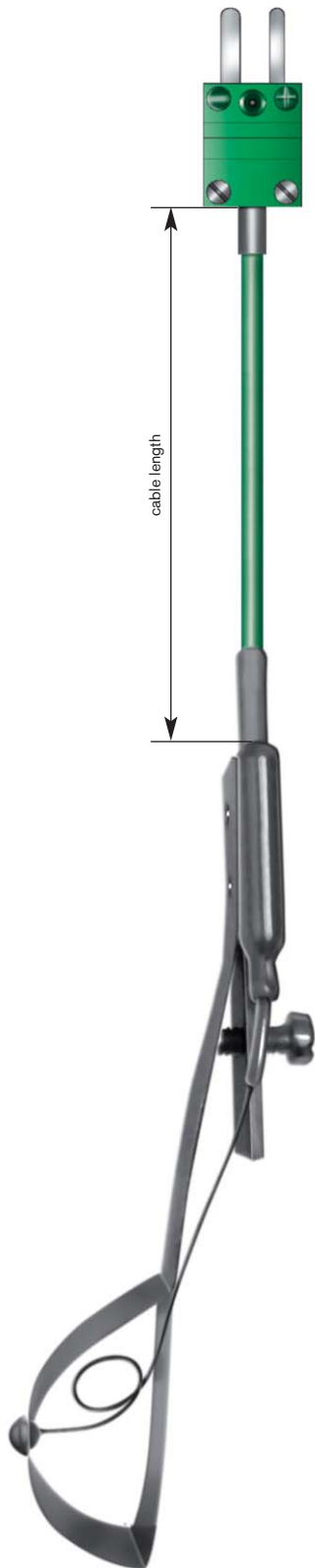
with FEP insulated cable (strands / FEP / foil / screen / FEP)
2 x 0,22 mm² up to +180 °C

up to +800°C

For the application in automobile industry.

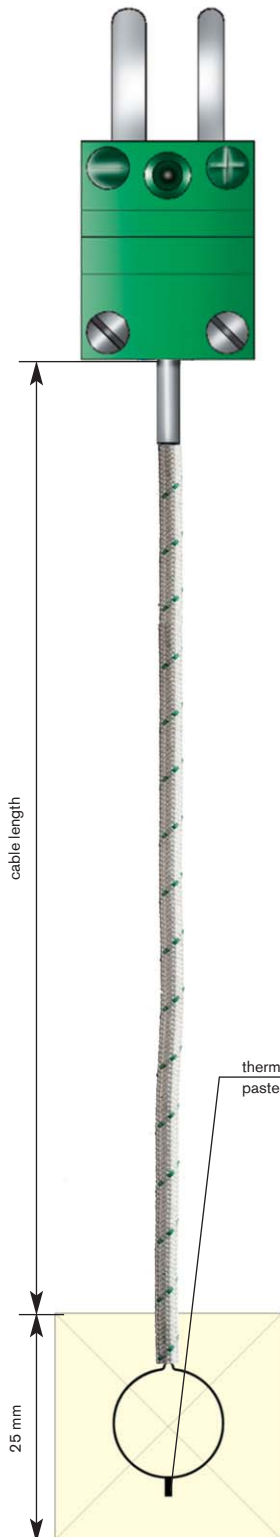
Especially suitable wherever an easy and uncomplicated temperature measurement is required. Advantage: no special preparations necessary at the measuring point. Designed for rotating application.

Equally available with batch certificate and identification on request.



Technical data

thermocouple:	1 x type K
limit deviation:	class 1
standard:	DIN EN 60584
sensor:	MTE Ø 0,5 mm
temperature range:	-40°C up to +800°C
measuring tip:	spherical Ø 6 mm
material:	aluminium
fixing:	2 bore holes
spring:	flat spring
connection cable:	thermo-cable KX19L 2 x 0,22 mm ²
length:	2 m
connection end:	miniature thermoplug with sleeve
item no.:	T290-045-389



For the application in automobile industry.

It is especially appropriate for quick and uncomplicated temperature measurement. Advantage: no special preparation necessary at the measuring points. It only has to be paid attention to the fact that the surface is free of dust, grease and oils.

Equally available with batch certificate and identification on request.

Technical data

thermocouple:	1 x type K
limit deviation:	class 2
standard:	DIN EN 60584
temperature range:	0°C up to +250°C
connection cable:	thermo-cable TH 3G 2 x 0,2 mm Ø
construction:	wire / fiber glass / fiber glass temperature up to +250°C
note:	adhesive pad 25 x 25 mm (2-fold)
cable length:	acc. to order
cable ends:	miniature thermoplug with sleeve
max. temp. at plug:	+200°C



- Also available with FEP insulated cable
- Different dimensions of pad available

Self-adhesive thermocouple in practical application

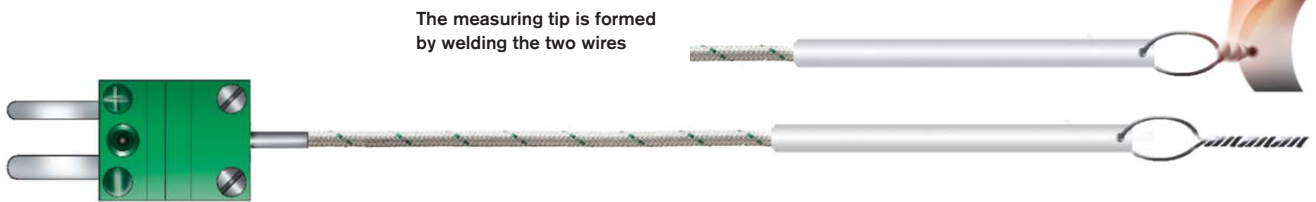
Self-adhesive thermocouples to measure the temperature at the sleeves of the drive shaft.

The data transmission is done by a telemetric device. Several self-adhesive thermocouples can be mounted in a space saving way without any problem.



For an extended temperature range

item no. T 100-043-162



The measuring tip is formed by welding the two wires

This surface thermocouple is applied in the exhaust gas area. It is especially appropriate for a quick and uncomplicated measurement. By welding the measuring tip the sensor can be easily positioned at the required measuring point. By welding the two wires the measuring point is created. Batch certificate and identification can be delivered on request.

Technical data	
thermocouple:	1 x type K
standard:	DIN EN 60584
limit deviation:	class 2
temperature range of cable:	up to +400°C
connection cable:	fibre-glass insulated thermo-cable 2 x 0.50 mm Ø
length:	1.0 m
cable end:	miniature thermoplug with sleeve
note:	welded measuring point Ø 2.5 x 24 mm with ceramic insulation, batch certificate on request
item no.:	T100 - 043 - 162

Application in the exhaust area of vehicles

item no. T 100-044-572



Miniature welding bead with covering

This surface thermocouple with Polyimid cable is also called miniature thermocouple. It is used for example in coil windings, electronic parts and narrow spaces. Batch certificate and identification can be delivered on request.

Application at vehicle electronics

response time in water:	average value taken from 3 measurements
immersion depth 50 mm:	t 0,5 = 2,7 sec. t 0,9 = 4,7 sec.
response time in air:	average value taken from 3 measurements
	t 0,5 = 5,6 sec. t 0,9 = 12,0 sec.

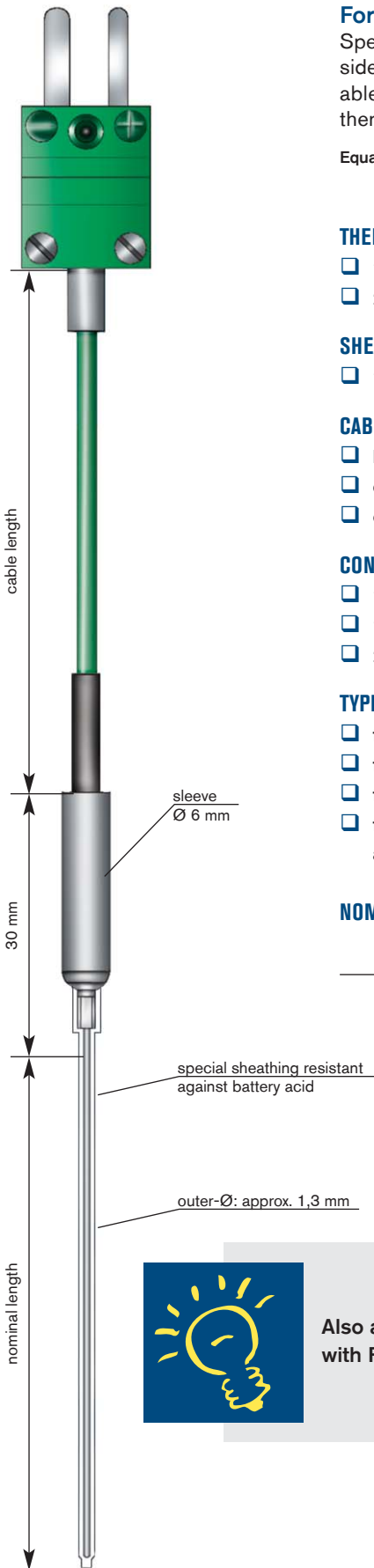


■ Voltage proof up to 600 V DC as modified construction form.

Technical data	
thermocouple:	1 x type K
standard:	DIN EN 60584
limit deviation:	class 1
temperature range:	up to +250°C
connection cable:	THEL K 2 x 0,20 mm Ø / Polyimid item no. L0433-9186, outer-Ø approx. 0,7 mm
length:	2,5 m
cable end:	miniature thermo plug type K with potted sleeve (not pressed) with anti kink tube
measuring tip:	miniature welding bead with covering (form A), directly at the insulation (max. 0,5 mm)
item no.:	T100 - 044 - 572

BATTERY THERMOCOUPLE MTE 841

with connection cable strands (strands / FEP / foil / screen / FEP) 2 x 0,22 mm² up to +180°C



For the application in automobile industry.

Special thermocouple especially appropriate to collect temperatures in batteries. Considerable advantage is the special sheathing resistant against battery acids that enables a temperature measurement directly in the acid without any harm to the thermocouple itself.

Equally available with batch certificate and identification on request.

THERMOCOUPLE:

- 1 x J 1 x K
 2 x J 2 x K other thermocouples: _____

SHEATH MATERIAL:

- 1.4541 2.4816 other sheath materials: _____

CABLE ENDS:

- bare ends cable lugs M4
 end sleeves miniature thermoplug
 other cable ends: _____

CONNECTION CABLE:

- 1,0 m 2,5 m 5,0 m
 1,5 m 3,0 m 10,0 m
 2,0 m 4,0 m other length: _____

TYPE OF MEASURING TIP:

- form A, without kink protection
 form B, without kink protection
 form A, with kink protection (shrinkable sleeve)
 form B, with kink protection (shrinkable sleeve)
 all types in class 1

NOMINAL LENGTH:

_____ mm

▶ thermocouple	1 x type K
▶ limit deviation	class 1
▶ standard	DIN EN 60584
▶ measuring point	form B, grounded measuring point
▶ temperature range	-40°C up to +205°C
▶ sheath	Ø 0,5 mm
▶ material no.	2.4816 / Inconel 600
▶ connection cable	THL KX 19L 2 x 0,22 mm ²
▶ nominal length	100 mm
▶ cable length	3 m
▶ cable end	miniature plug without cable fixing
▶ max. temp. at plug	+ 200°C
▶ fix accessories	special sheathing resistant against battery acid outer-Ø approx. 1,3 mm
▶ item no.	T841-043-030



Also available
with FEP insulated cable

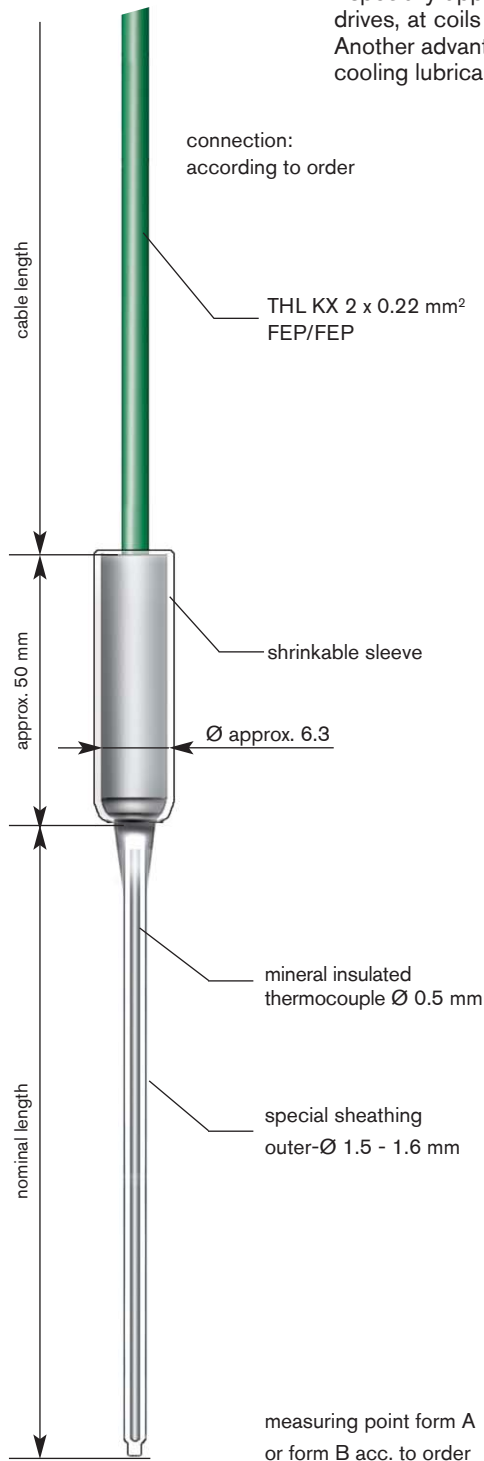
SPECIAL MINERAL INSULATED THERMOCOUPLE MTE 839

Completely coated with special plastic material / measuring tip voltage-stable up to 2 kV/AC / individually tested / batch certificate / temperature range up to + 205°C

For measurements at live parts, for example hybrid drives!

For the application in automobile industry.

Especially appropriate for temperature measurement at live parts in vehicles (at hybrid drives, at coils of electric engines, under cable insulators directly at the conductor etc.) Another advantage is the excellent resistance against acids, chemical agents, fuels, oils, cooling lubricants.



THERMOCOUPLE: SHEATH MATERIAL:

- 1 x J 1.4541
- 1 x K 2.4816
- other thermocouples: _____

CABLE ENDS:

- bare ends
- miniature thermoplug
- other cable ends: _____

CABLE LENGTH:

- 1,0 m
- 1,5 m
- 2,0 m
- 2,5 m
- 4,0 m
- 5,0 m
- 10,0 m
- other length: _____

TYPE OF MEASURING TIP:

- form B, welded measuring tip, class 1

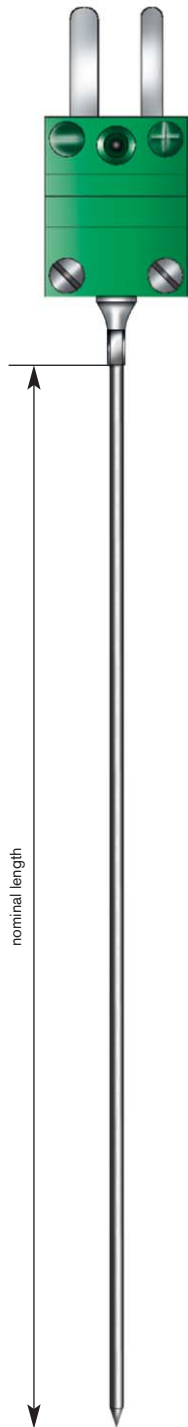
NOMINAL LENGTH:

_____ mm

▶ thermocouple	1 x type K
▶ limit deviation	class 1
▶ standard	DIN EN 60584
▶ temperature range	-40°C up to +205°C
▶ measuring point	form B, grounded measuring point
▶ sheath Ø	0,5 mm
▶ sheath material	2.4816
▶ nominal length	100 mm
▶ connection cable	L-FEP-FEP 2 x 0,22 mm ²
▶ cable length	1 m
▶ cable end	miniature plug
▶ fix accessories	plastic enclosure
▶ note	measuring tip voltage-stable up to 2 kV/AC at ambient temperature, with certification
▶ item no.	T 839-043-862

order example

PLUNGE-IN THERMOCOUPLE MTE 840



For the application in automobile industry.

Especially appropriate to collect temperatures in test vehicles in the vehicle interior. By slight pressure, the plunge-in thermocouple can be placed for example in the seats or neck-rests to collect the temperature.

Equally available with batch certificate and identification on request.

Technical data

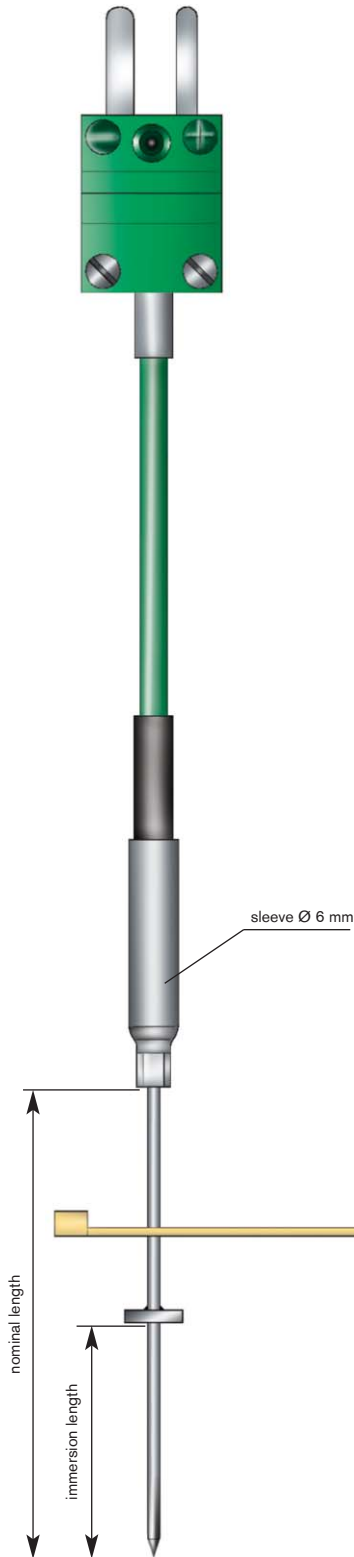
thermocouple:	1 x type K
limit deviation:	class 1
standard:	DIN EN 60584
measuring point:	Form A, insulated measuring point
connection element:	miniature plug
max. temperature at plug:	+200°C
sheath diameter:	Ø 1,5 mm
material no.:	1.4571
temperature range:	-40°C up to +400°C
nominal length:	100 mm plunge-in tip included
item no.:	T 840-021-148



Other nominal lengths
on request

COOLING WATER TUBE THERMOCOUPLE MTE 843

with plate 7 x 7 mm and fixed cable tie
with connection cable (strands / FEP / foil / screen / FEP) 2 x 0,22 mm² up to +180°C



For the application in automobile industry.

Especially appropriate to collect the temperature of the cooling liquid in the cooling tubes at the engine. If temperature collection is no longer required, the sheath can be simply cut behind the high temperature cable tie. Considerable advantage is the achieved time saving, as it is no longer necessary to let off the cooling liquid. The system of cooling tubes remains tight.

Equally available with batch certificate and identification on request.

THERMOCOUPLE:

1 x J 1 x K other thermocouples: _____

SHEATH-Ø: PLUNGE-IN TIP:

1,5 mm without with

CABLE ENDS:

bare ends cable lugs M4
 miniature thermoplug other cable ends: _____

CONNECTION CABLE:

1,0 m 2,5 m 5,0 m
 1,5 m 3,0 m 10,0 m
 2,0 m 4,0 m other length: _____

TYPE OF MEASURING TIP:

form A, without kink protection
 form B, without kink protection
 form A, with kink protection (shrinkable sleeve)
 form B, with kink protection (shrinkable sleeve)

NOMINAL LENGTH:

IMMERSION LENGTH:

_____ mm _____ mm

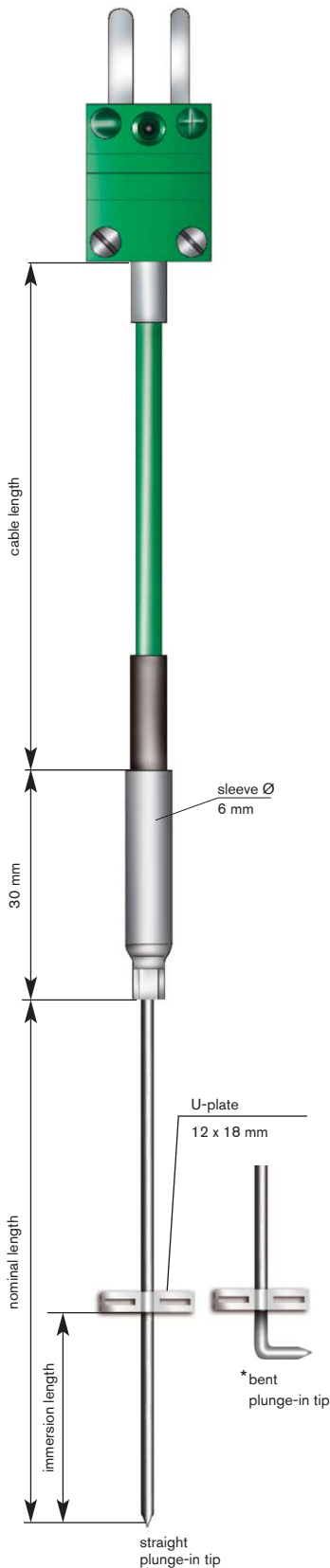
▶ thermocouple	1 x type K
▶ limit deviation	class 1
▶ standard	DIN EN 60584
▶ measuring point	Form A, insulated measuring point
▶ connection element	miniature plug
▶ max. temp. at plug	+200°C
▶ temperature range	-40°C up to +150°C
▶ sheath diameter	Ø 1,5 mm
▶ material	1.4541
▶ nominal length	70 mm (with plunge-in tip)
▶ immersion length	20 mm
▶ connection cable	THL KX 19L 2x 0,22 mm ²
▶ construction	strands/FEP/foil/screen/FEP temperature resistant up to +180°C
▶ cable length	1,5 m
▶ item no.	T843-041-095



- For the different tube-Ø, the nominal length as well as the immersion length can be adapted on request!
- Plunge-in tip by choice

COOLING WATER TUBE THERMOCOUPLE MTE 844

with U-plate 12 x 18 mm and FEP connection cable up to + 180°C for 2 cable ties



For the application in automobile industry.

Especially appropriate to collect the temperature of the cooling liquid in the cooling tubes at the engine. If temperature collection is no longer required, the sheath can be simply cut behind the high temperature cable tie. Considerable advantage is the achieved time saving, as it is no longer necessary to let off the cooling liquid. The system of cooling tubes remains tight.

Equally available with batch certificate and identification on request.

THERMOCOUPLE:

1 x J 1 x K other thermocouples: _____

sheath material: 1.4541

SHEATH-Ø:

1,5 mm

PLUNGE-IN TIP:

without with straight bent*

CABLE ENDS:

bare ends cable lugs M4
 miniature plug other cable ends: _____

CONNECTION CABLE:

1,0 m 2,5 m 5,0 m
 1,5 m 3,0 m 10,0 m
 2,0 m 4,0 m other length: _____

TYPE OF MEASURING TIP:

form A, without kink protection
 form B, without kink protection
 form A, with kink protection (shrinkable sleeve)
 form B, with kink protection (shrinkable sleeve)

NOMINAL LENGTH:

IMMERSION LENGTH:

_____ mm _____ mm

▶ thermocouple	1 x type K
▶ limit deviation	class 1
▶ standard	DIN EN 60584
▶ measuring point	form A, insulated measuring point
▶ connection element	miniature plug
▶ max. temp. at plug	+200°C
▶ temperature range	-40°C up to +150°C
▶ sheath diameter	Ø 1,5 mm
▶ material no.	1.4541
▶ nominal length	70 mm
▶ immersion length	20 mm
▶ connection cable	L-6Y-F-C-6Y 2x 0.22 mm ²
▶ construction	strands/FEP/foil/screen/FEP temperature resistant up to +180°C
▶ cable length	1,5 m
▶ item no.	T844-041-357 * T844-044-531



In order to reuse the cooling water tube sensor, the opening can be closed permanently by the blind plug.

▶ item no.: T061-041-908



■ For the different tube-Ø, the nominal length as well as the immersion length can be adapted on request!

■ Plunge-in tip by choice

FUEL THERMOCOUPLE MTE 850

with connection cable (strands / FEP / foil / screen / FEP)
2 x 0,22 mm² up to +180°C

Also available in
type J + T

For the application in automobile industry.

Especially appropriate to measure the temperature in the fuel line. The small diameter of the thermocouple situated in the middle of the T-tube connector, guarantees a quick response time. Another advantage offers the small diameter of the mineral insulated thermocouple so that neither the flow velocity nor the flow quantity are affected. The screening of the cable offers at the same time mechanical protection as well as protection against electromagnetic interference.

Equally available with batch certificate and identification on request.



flexible part

tube connector



■ The small diameter of the thermocouple guarantees a quick response time for temperature measurement in fuel lines.

■ Also available as flexible type with sheath diameters of 1.0 or 1.5 mm



mineral insulated
thermocouple Ø 0,5

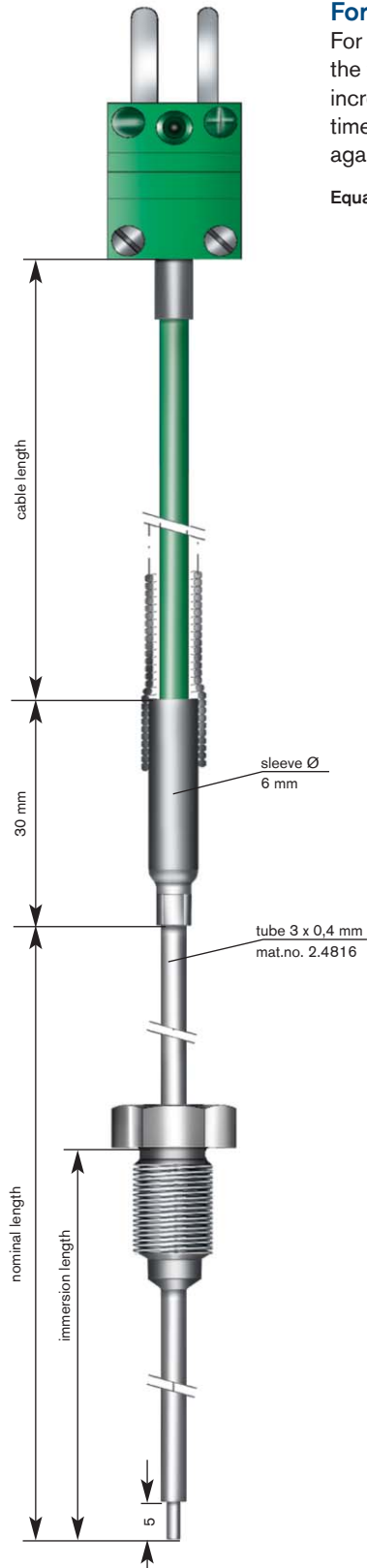
Technical data

thermocouple:	1 x type K
limit deviation:	class 1
standard:	DIN EN 60584
measuring point:	form A, insulated measuring point
sheath:	Ø 0,5 mm, 3 mm reinforcement tube
material no.:	1.4404
temperature range:	-40°C up to +110°C
accessories:	tube connector (brass), synthetic material tube Ø 4 / 6 / 8 / 10 / 12 mm available
cable end:	miniature plug without cable fixing max. temperature at plug +200°C
connection cable:	L-6Y-F-C-6Y 2 x 0,22 mm ²
construction:	strands / FEP / foil / screen / FEP temperature resistant up to +180°C
cable length:	acc. to order

COMBUSTION GAS THERMOCOUPLE MTE 848

with connection cable (strands / FEP / foil / screen / FEP)
2 x 0,22 mm² up to +180°C

Also available in
type J + T



For the application in automobile industry.

For temperature measurement at engine test benches. Especially appropriate to collect the temperature in the combustion gas flow at the manifold. The reinforcement tube shall increase service life. The small diameter of the thermocouple guarantees a short response time. The screening of the cable is equally a mechanical protection as well as protection against electromagnetic interference.

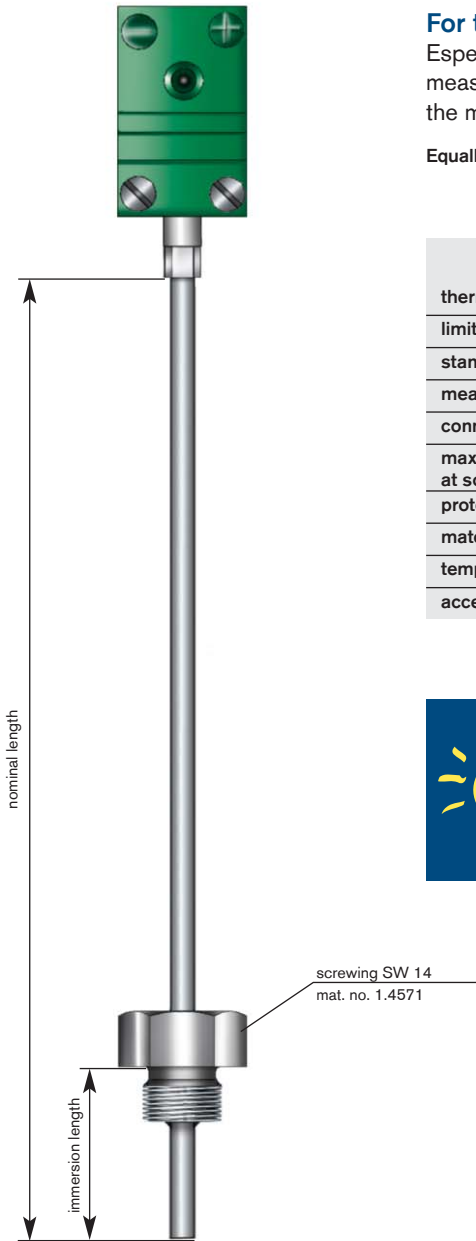
Equally available with batch certificate and identification on request.

Technical data

thermocouple:	1 x type K
limit deviation:	class 1
standard:	DIN EN 60584
measuring point:	form A, insulated measuring point
temperature range:	-40°C up to +1000°C
sheath:	Ø 1,5 mm
material no.:	2.4816 / Inconel 600
reinforcement tube:	Ø 3 mm
accessories:	screwing M 12 x 1,25
material no.:	1.4305
nominal length:	150 mm
cable end:	miniature plug without cable fixing max. temperature at plug +200°C
connection cable:	L-6Y-F-C-6Y 2 x 0,22 mm ²
construction:	strands / FEP / foil / screen / FEP temperature resistant up to +180°C
cable length:	acc. to order
note:	different threads on request



Construction type
also available
without screwing.
Fixing by
clamping screw connection.



For the application in automobile industry.

Especially appropriate to collect the temperature in the exhaust manifold, for temperature measurement in the combustion gas flow. Advantage: by welding a special steel nut onto the manifold, the element can be mounted and exchanged easily.

Equally available with batch certificate and identification on request.

Technical data

thermocouple:	1 x type K
limit deviation:	class 2
standard:	DIN EN 60584
measuring point:	form A, insulated measuring point
connection element:	miniature socket max. +200°C
max. temperature at socket:	+200°C
protecting tube:	Ø 3 mm
material no.:	2.4816 / Inconel 600
temperature range:	-40°C up to +1100°C
accessories:	screwing M 10 x 1



The above mentioned technical data are standard data.

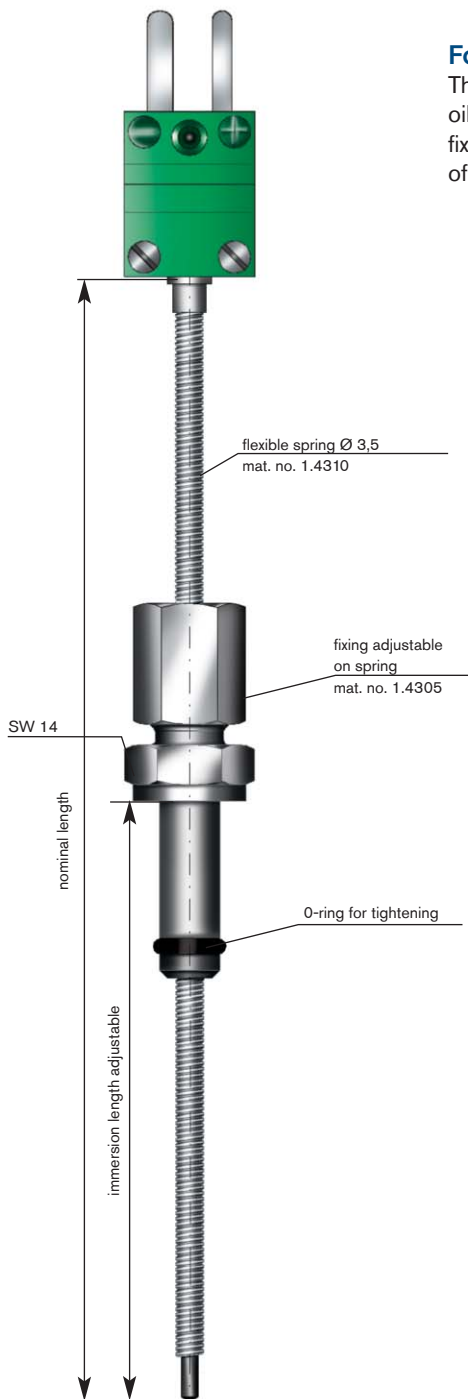
Individual parameters, as for example limit deviation, nominal length, connection cable or connection end can be added or modified on request.

Also available in diameters 1,5 mm, 2,0 mm, 4,5 mm and 6,0 mm.

especially appropriate for temperature measurement in engine oil!

For the application in automobile industry.

This dipstick thermocouple is especially appropriate to collect the temperature in engine oil. The dipstick can easily be inserted instead of the normal oil dipstick. The adjustable fixing tightens the opening so that during operation the oil cannot penetrate. With the help of the fixing, the immersion length of the dipstick can be modified.



Technical data

thermocouple:	1 x type K
limit deviation:	class 1
standard:	DIN EN 60584
measuring point:	form B, grounded measuring point or form A, insulated measuring point
temperature range:	0°C up to +200°C
spring:	Ø 3,5 mm
protecting tube:	Ø 2 mm
material:	special steel
accessories:	adjustable fixing, tightening to Ø 8 mm
nominal length:	1000 mm
connection end:	miniature plug, also available with Lemo socket, max. +200°C
spring length:	acc. to order

Technical data

thermocouple:	1 x type K
limit deviation:	class 1
standard:	DIN EN 60584
measuring point:	form A, insulated
temperature range:	0°C up to +200°C
spring:	Ø 3,5 mm / spring
material no.:	1.4571
accessories:	spring Ø 3,5 x 440 mm
nominal length:	670 mm
connection cable:	THL KX 19 L 2 x 0,22 mm ²
length:	300 mm
item no.:	T860-044-050



Due to the adjustable immersion depth, it can be applied for the most different engine types. Different tightening-Ø on request!



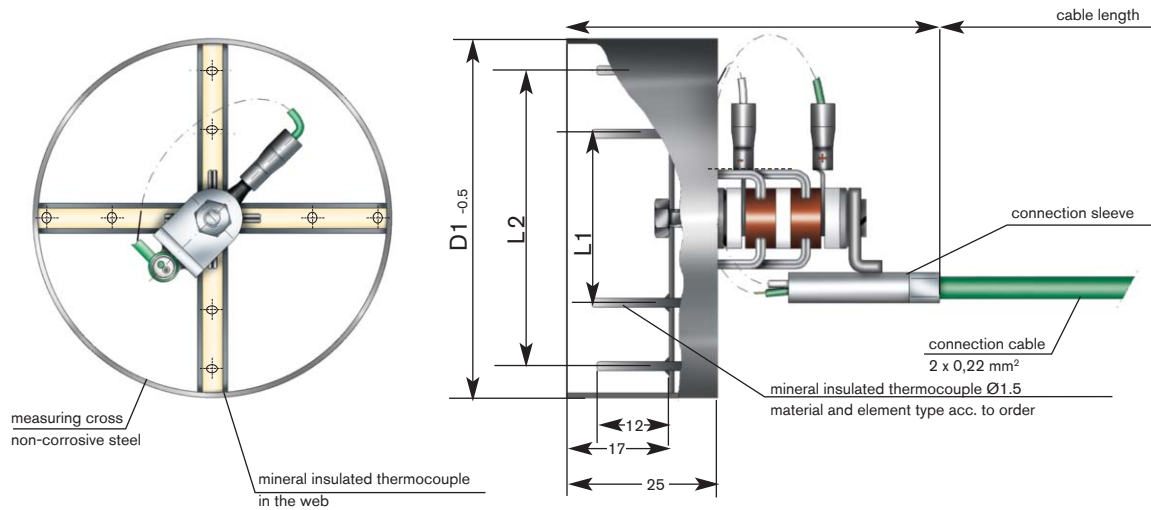
■ Construction with gas tight tube

MEASURING CROSS THERMOCOUPLE MTE 399

with connection cable (strands / FEP / foil / screen / FEP) 2 x 0,22 mm² up to +180°C

For the application in automobile industry.

The measuring cross is applied in air condition technology in the climatic channel. The temperature is taken by 8 individual thermocouples. The sum of the individually taken temperatures is indicated as arithmetical mean.



Technical data

thermocouple:	8 x type L/J/K
limit deviation:	class 1
dimension D1/L2/L1:	see table
standard type L:	DIN 43710
standard type J / K:	DIN EN 60584
measuring point:	form A, insulated measuring point
temperature range type L / J:	0°C up to +200°C
temperature range type K:	-40°C up to +200°C
sheath diameter:	Ø 1,5 mm
material no.:	1.4541
connection cable:	L-6Y-F-C-6Y 2 x 0,22 mm ²
construction:	strands / FEP / foil / screen / FEP temperature resistant up to +180°C
cable end:	miniature plug without cable fixing max. temperature at plug +200°C

D1-0.5	L2	L1
149.5	124	71
124.5	103	60
119.5	100	55
99.5	82	47
89.5	74	43
79.5	66	38
74.5	62	36
69.5	56	33
59.5	49	28
49.5	39	25



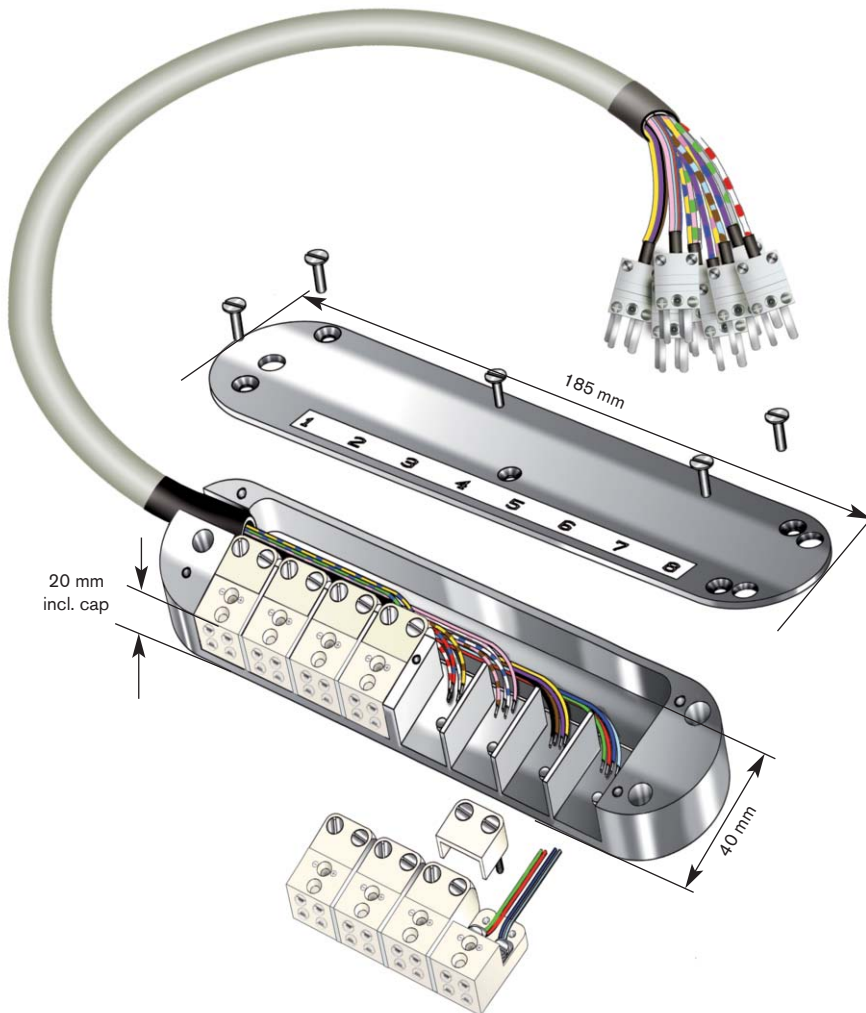
The above mentioned technical data are standard data.

Individual parameters, as for example limit deviation, nominal length, connection cable or connection end can be added or modified on request.

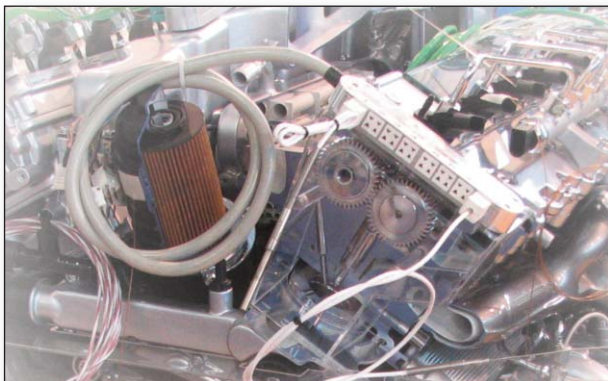
PT 100 / PT 1000 8-PLUG CONNECTOR T 065

This item is used in automobile industry, for example in test vehicles. Thermocouples can be easily connected. In case of failure, the faulty element can be exchanged without much effort. Test engines require temperature measurements at the most different points, e.g. in oilpans, cooling tubes and combustion gases, etc.. Here, the cables coming from the different measuring points can be plugged into the connector conveniently. Advantage: reduced wiring effort.

In general the application makes sense, whenever there are many measuring points and far distances that have to be overcome.



■ optionally
connection end 2



The photo shows an 8-plug connector used in automobile industry for example in test vehicles. Thermocouples can be easily connected.

Technical data

connector for:	PT 100 / PT 1000 4-wire circuit
cable construction:	strands / alternatively PVC / Besilen® / FEP as insulation and outer sheath material
section:	0,34 mm ²
no. of cores:	32
connection end 1:	8 miniature sockets type K in one aluminium housing, 4-pole
connection end 2:	acc. to order
item no.:	T 065-044-013

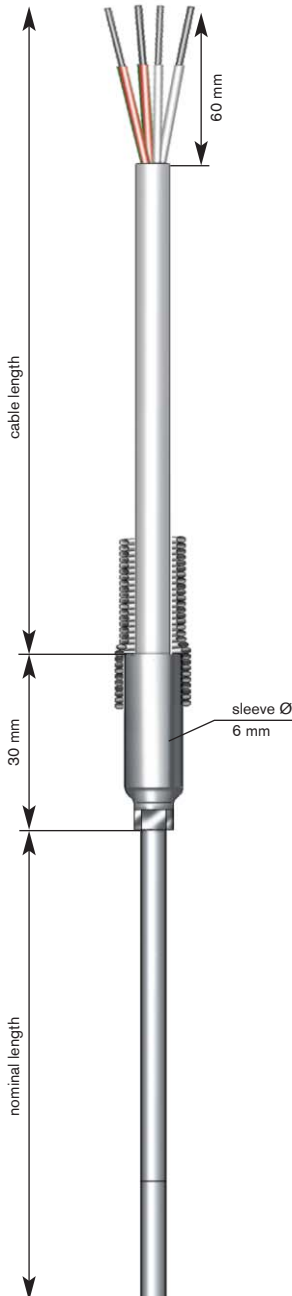
STANDARD MINERAL INSULATED RESISTANCE THERMOMETER MWT 505

with connection cable TTL (4 x 0,18mm²) up to +250°C

also available
for temperatures up to
+600°C!

All purpose mineral insulated thermocouple!

Equally available with batch certificate and identification on request.



RTD:

- 1 x Pt 100 class B 2 x Pt 100 class B
 1 x Pt 100 class A 2 x Pt 100 class A

CONNECTION TYPE OF INNER WIRES:

- 2-wire circuit 3-wire circuit 4-wire circuit

SHEATH-Ø:

- 1,6 mm 3,0 mm 4,5 mm other sheath-Ø: _____

CABLE ENDS:

- bare ends end sleeves
 cable lugs M4 other cable ends: _____

CABLE LENGTH:

- 1,0 m 2,5 m 5,0 m
 1,5 m 3,0 m 10,0 m
 2,0 m 4,0 m other length: _____

MEASURING RANGE:

- 50 up to +400°C with kink protection -50 up to +600°C with kink protection
 -50 up to +400°C without kink protection -50 up to +600°C without kink protection

NOMINAL LENGTH:

_____ mm

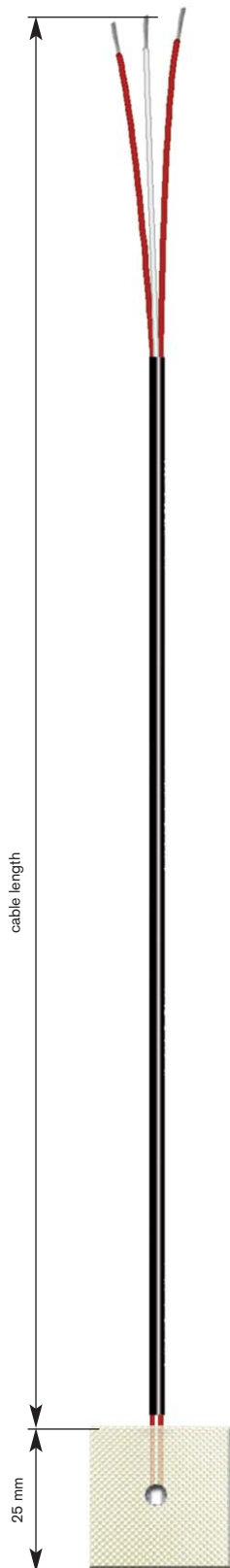
▶ RTD	1 x Pt100, class A
▶ inner wires	4-wire circuit
▶ temperature range	-50°C up to +400°C
▶ sheath diameter	Ø 1,6 mm
▶ material	1.4541
▶ nominal length	150 mm
▶ connection cable	TTL 4 x 0,18 mm ² max. +250°C
▶ cable length	3 m
▶ cable ends	bare
▶ note	with kink protection
▶ item no.	T505-034-051

order
example

SELF-ADHESIVE SURFACE RESISTANCE THERMOMETER T 630

For the application in automobile industry.

It is especially appropriate for quick and uncomplicated temperature measurement. Advantage: no special preparation necessary at the measuring points. It only has to be paid attention to the fact that the surface is free of dust, grease and oils.



Resistance bonded on glass fabric tape

Technical data

RTD:	1 x Pt 100
limit deviation:	class B
standard:	DIN EN 60751
inner wires:	3-wire circuit
temperature range:	-50°C up to +200°C
pad:	25 x 25 mm
material:	fiber glass
connection cable:	TTL 3 x 0,12 mm ² max. +200°C
cable length:	2 m
connection end:	bare ends
item no.:	T630-046-566



■ Different dimensions of pad available

Self-adhesive surface resistance thermometers

Self-adhesive thermocouples to measure the temperature at the sleeves of the drive shaft.

The data transmission is done by a telemetric device. Several self-adhesive thermocouples can be mounted in a space saving way without any problem.



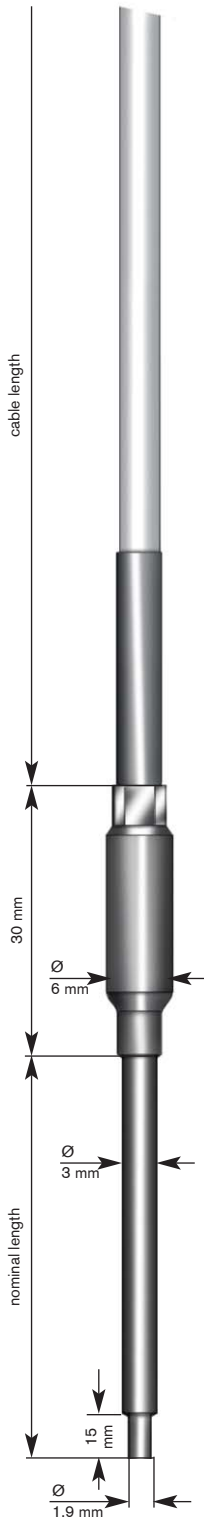
AIRFLOW RESISTANCE THERMOMETER T 870

with special cable FEP/screen/FEP in (4 x 0,15 mm²) up to +180°C

Small measuring tip Ø guarantees quick response times!

For the application in automobile industry.

For temperature measurement at engine test benches. Especially appropriate to collect the temperature of the airflow, for example in the turbocharger. The small diameter of the measuring tip guarantees a quick response time. The screening of the cable offers at the same time mechanical protection as well as protection against electromagnetic interference. Usually fixing can be done by clamping screw connections.



RTD:

- 1 x Pt 100 class B 1 x Pt 100 class A

CONNECTION TYPE OF INNER WIRES:

- 2-wire circuit 3-wire circuit 4-wire circuit

CABLE ENDS:

- bare ends end sleeves
 cable lugs M4 other cable ends: _____

CABLE LENGTH:

- 1,0 m 2,5 m 5,0 m
 1,5 m 3,0 m 10,0 m
 2,0 m 4,0 m other length: _____

KINK PROTECTION:

- with kink protection with kink protection

NOMINAL LENGTH:

_____ mm

▶ RTD	1 x Pt100, class A
▶ inner wire	4-wire circuit
▶ temperature range	0°C up to +180°C
▶ measuring tip	Ø 1,9 x 15 mm
▶ reinforcement tube	Ø 3,0 x 70 mm
▶ material no.	1.4571
▶ connection cable	L/FEP / C / FEP 4 x 0,15 mm ²
▶ cable length	2 m
▶ cable ends	Lemo-plug size: 1
▶ item no.	T870-031-015

order example



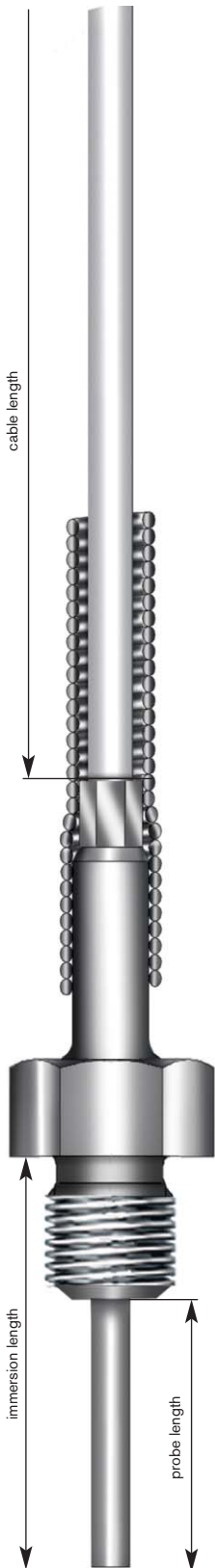
The above mentioned technical data are standard data.

Individual parameters, as for example limit deviation, inner wires, connection cable or connection end can be added or modified on request.

SCREW-IN RESISTANCE THERMOMETER T 871

with connection cable TTL (4 x 0,18mm²) up to + 250°C

Different threads possible on request!



For the application in automobile industry.

For temperature collection at engine test benches. Especially appropriate to collect the temperature in the engine room, for example at the oil pressure switch or wherever the same thread is to be found.

RTD:

- 1 x Pt 100 class B 1 x Pt 100 class A

CONNECTION TYPE OF INNER WIRES:

- 2-wire circuit 3-wire circuit 4-wire circuit

CABLE ENDS:

- bare ends end sleeves
 cable lugs M4 other cable ends: _____

CABLE LENGTH:

- 1,0 m 2,5 m 5,0 m
 1,5 m 3,0 m 10,0 m
 2,0 m 4,0 m other length: _____

KINK PROTECTION:

- with kink protection (shrinkable sleeve) with kink protection

NOMINAL LENGTH:

_____ mm

▶ RTD	1 x Pt 100, class A
▶ inner wire	4-wire circuit
▶ temperature range	0°C up to +250°C
▶ thread	M 10 x 1
▶ probe tube	Ø 3,0 mm
▶ material no.	1.4571
▶ immersion length	25 mm
▶ probe length	17 mm
▶ connection cable	TTL 4 x 0,18 mm ² max. +250°C
▶ cable length	6 m
▶ cable ends	bare
▶ note	with kink protection
▶ item no.	T871-038-835

order example



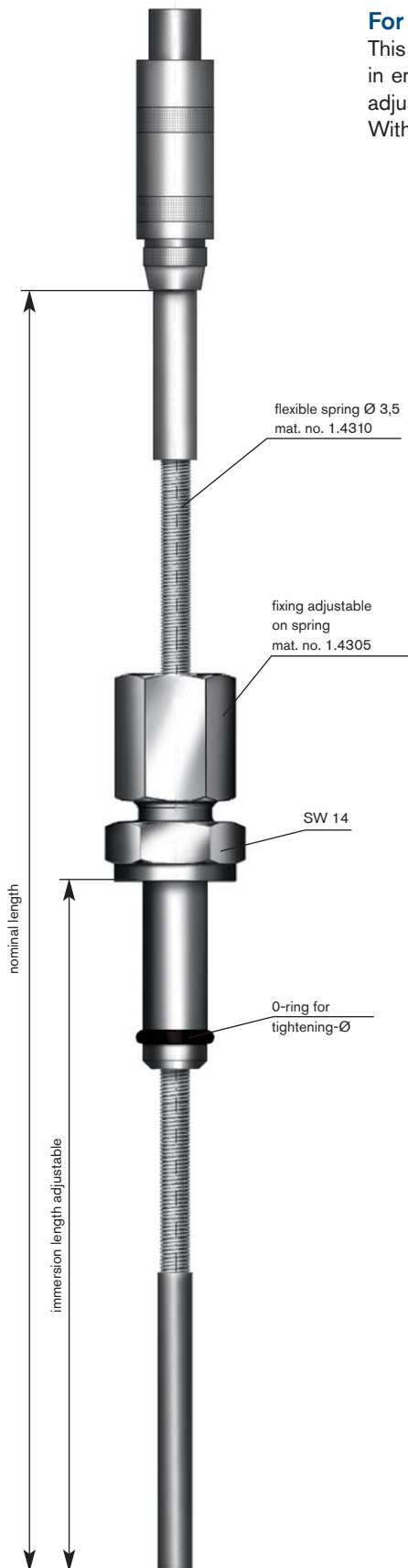
The above mentioned technical data are standard data.

Individual parameters, as for example limit deviation, inner wires, connection cable or connection end can be added or modified on request.

Excellent for
temperaure measurement
in engine oil!

For the application in automobile industry.

This dipstick resistance thermometer is especially appropriate to collect the temperature in engine oil. The dipstick can easily be inserted instead of the normal oil dipstick. The adjustable fixing tightens the opening so that during operation the oil cannot penetrate. With the help of the fixing, the immersion length of the dipstick can be modified.



Technical data

RTD:	1 x Pt 100
limit deviation:	class A
standard:	DIN EN 60751
inner wire:	4-wire circuit
temperature range:	-20°C up to +200°C
reinforcement tube:	Ø 4 x 35 mm
material no.:	1.4571
accessories:	adjustable fixing, tightening to Ø 8 mm
nominal length:	1035 mm
connection end:	Lemo-plug size: 0
item no.:	T861-028-827

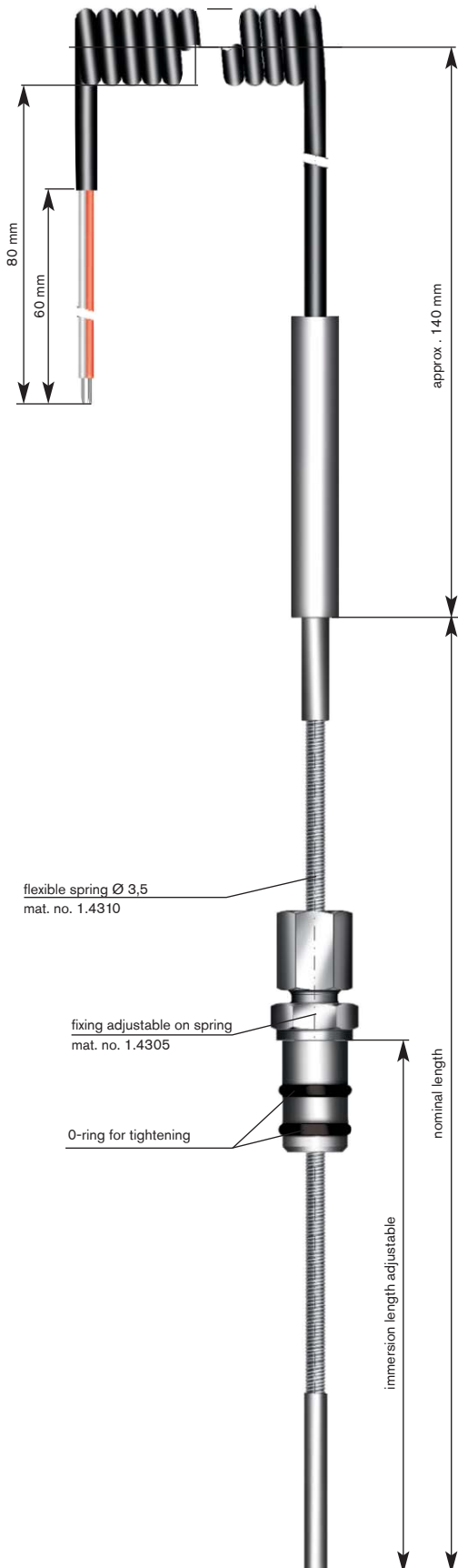


Due to the adjustable immersion depth, it can be applied for the most different engine types.

Different tightening-Ø on request!

DIP STICK RESISTANCE THERMOMETER T 862

with connection cable special spiral cable (4 x 0,14 mm²) up to +90°C



For the application in automobile industry.

This dipstick resistance thermometer is especially appropriate to collect the temperature in engine oil. The dipstick can easily be inserted instead of the normal oil dipstick. The adjustable fixing tightens the opening so that during operation the oil cannot penetrate. With the help of the fixing, the immersion length of the dipstick can be modified.

An additional advantage of the spiral cable is that the element can be put into the required position in case of use and afterwards the cable contracts again like a spring.

Technical data

RTD:	1 x Pt 100
limit deviation:	class B
standard:	DIN EN 60751
inner wire:	4-wire circuit
temperature range:	0°C up to +200°C
probe tube:	Ø 4 x 35 mm
material no.:	1.4571
fix accessories:	adjustable fixing tightening to Ø 11 mm respectively 12,5 mm
nominal length:	1035 mm
connection cable:	special spiral cable 4 x 0,14 mm ²
cable length:	4 m
connection end:	bare
item no.:	T862-035-651



Due to the adjustable immersion depth, it can be applied for the most different engine types.

Different tightening-Ø on request!

ACCESSORIES

Lemo socket for mineral insulated thermocouples and resistance thermometers

2-pole up to max. 200°C		
item no.	size	outer-Ø
T 021-011-146	0	0,64
T 021-011-147	0	1,0
T 021-009-083	1	1,5
T 021-000-600	1	3,0
T 021-011-149	1	4,5
T 021-011-152	2	6,0

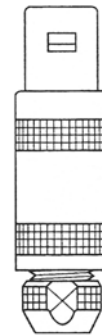
4-pole up to max. 200°C		
item no.	size	outer-Ø
T 021-011-148	0	1,64
T 021-000-599	0	1,0
T 021-011-150	1	1,5
T 021-011-151	1	3,0
T 021-000-677	1	4,5
T 021-000-678	2	6,0



Lemo plug for cable connection

2-pole up to max. 200°C		
item no.	size	outer-Ø*
T 021-011-153	0	3,2
T 021-011-154	1	3,2
T 021-000-594	1	4,7
T 021-011-156	2	3,2
T 021-000-596	2	4,7
T 021-000-597	2	6,4

4-pole up to max. 200°C		
item no.	size	outer-Ø*
T 021-008-967	0	3,2
T 021-011-155	1	3,2
T 021-000-195	1	4,7
T 021-011-157	2	3,2
T 021-011-158	2	4,7
T 021-000-598	2	6,4



*outer-Ø of cable

Cable tie		
item no.	identification	colour
T 098-033-194	standard up to +105°C	black
T 098-033-194	high-temperature up to +150°C	nature

Please note that not all types are available from stock
and that there are possibly min. order quantities!

Thermo plug

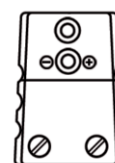
Standard thermo plug up to max. 200°C	
item no.	min.t/c type
T 021-007-056	J (Fe-CuNi)
T 021-007-057	K (NiCr-Ni)

High-temp. thermo plug up to max. 350°C	
item no.	min.t/c type
T 021-007-064	J (Fe-CuNi)
T 021-007-065	K (NiCr-Ni)



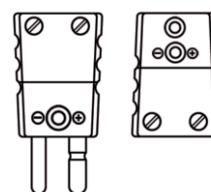
Standard thermo socket up to max. 200°C	
item no.	min.t/c type
T 021-007-104	J (Fe-CuNi)
T 021-000-679	K (NiCr-Ni)

High-temp. thermo socket up to max. 350°C	
item no.	min.t/c type
T 021-007-111	J (Fe-CuNi)
T 021-007-112	K (NiCr-Ni)



Miniature thermo plug up to max. 200°C	
item no.	min.t/c type
T 021-007-071	J (Fe-CuNi)
T 021-007-072	K (NiCr-Ni)

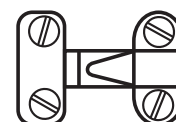
Miniature thermo socket up to max. 200°C	
item no.	min.t/c type
T 021-007-118	J (Fe-CuNi)
T 021-007-119	K (NiCr-Ni)



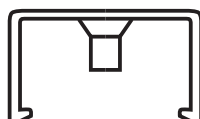
Cable fixing for:

Standard and high temperature plug	
item no.	
T 021-007-035	

Miniature plug	
item no.	
T 021-007-041	



Locking plate	
item no.	
T 021-029-182	

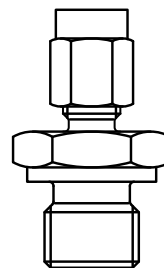


Clamp screw connection made of steel 1.0718 for...

min.t/c ø mm	thread	with pressure ring made of PTFE item no.
1,5	M 8 x 1	T 025-007-148
2,0	M 8 x 1	T 025-007-151
3,0	M 8 x 1	T 025-000-681
4,5	G 1/4 A	T 025-007-157
6,0	G 1/4 A	T 025-000-685

Clamp screw connections made of steel 1.0718 for...

min.t/c ø mm	thread	with tapered ring made of stainless steel 1.4571 item no.
1,5	M 8 x 1	T 025-007-147
2,0	M 8 x 1	T 025-007-150
3,0	M 8 x 1	T 025-000-680
4,5	G 1/4 A	T 025-007-156
6,0	G 1/4 A	T 025-000-684



Clamp screw connections made of stainless steel 1.4571 for...

min.t/c ø mm	thread	with pressure ring made of PTFE item no.
1,5	M 8 x 1	T 025-007-146
2,0	M 8 x 1	T 025-007-149
3,0	M 8 x 1	T 025-007-153
4,5	G 1/4 A	T 025-007-155
6,0	G 1/4 A	T 025-007-160

Clamp screw connections made of stainless steel 1.4571 for...

min.t/c ø mm	thread	with tapered ring made of stainless steel 1.4571 item no.
1,5	M 8 x 1	T 025-007-145
3,0	M 8 x 1	T 025-007-152
4,5	G 1/4 A	T 025-007-154
6,0	G 1/4 A	T 025-007-159









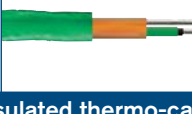



Note:

Clamp screw connections with a thrust collar made of PTFE are appropriate for temperature up to +200°C and for pressures up to 10 bar. Later loosening and moving is possible.











Clamp screw connections with a tapered ring made of steel or stainless steel are appropriate for temperature above + 200°C and for pressures up to 40 bar. By tightening the screw connection, the tapered ring is fixed on the tube and can't be loosened anymore. Therefore, later loosening isn't possible at all.

Please note that not all types are available from stock and that there are possibly min. order quantities!

SURVEY COMPENSATING AND EXTENSION CABLES AS WELL AS CONNECTION CABLES FOR RESISTANCE THERMOMETERS



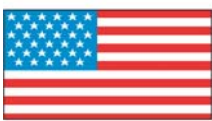

































SAB item no.	Picture	Cable type	T/C type	Insulation	Section	Cond.	Form	Outer-Ø	Temp.-range of insulation	thermoelectric voltage
fibre-glass insulated thermo-cables (wire)										
0489-9002		thermo-cable	type K	GL/GL	2 x 0,2 mm	wire	oval	approx. 0,8 x 1,3 mm	flexible: -25°C upto +200°C fixed: -25°C upto +200°C	DIN IEC 584 class 1, tolerance +/- 1,5°C
0489-2144		thermo-couple-cable	type K	GL/GL	2 x 0,5 mm	wire	oval	approx. 1,9 x 1,1 mm	flexible: -40°C upto +250°C fixed: -40°C upto +250°C	DIN IEC 584 class 1
0489-9003		thermo-cable	type K	GL/GL	2 x 0,8 mm	wire	oval	approx. 2,5 x 1,4 mm	flexible: -25°C upto +200°C fixed: -25°C upto +200°C	DIN IEC 584 class 1
0490-9016		thermo-couple-cable	type K	GL/GL	2 x 0,5 mm	wire	oval	approx. 2,0 x 1,2 mm	flexible: max. +400°C fixed: max. +400°C	DIN IEC 584 class 1
polyimide insulated thermo-cables (wire)										
0433-9138		thermo-couple-cable	type K	KN-Polyimid KP-blank/ Polyimid	2 x 0,2 mm	wire	oval	approx. 0,9 x 0,5 mm	flexible: -40°C upto +250°C fixed: -40°C upto +250°C	DIN IEC 584 class 1, tolerance +/- 1,5°C
0433-9186		thermo-couple-cable	type K	KN-Polyimid KP-blank/ Polyimid	2 x 0,2 mm	wire	oval	approx. 0,7 x 0,5 mm	flexible: -40°C upto +250°C fixed: -40°C upto +250°C	DIN IEC 584 class 1, tolerance +/- 1,5°C
0433-9149		thermo-couple-cable	type K	Polyimid + PTFE/ Polyimid	2 x 0,3 mm	wire	oval	approx. 0,9 x 1,7 mm	flexible: -40°C upto +250°C fixed: -40°C upto +250°C	DIN IEC 584 class 1, tolerance +/- 1,5°C
0433-9168		thermo-couple-cable	type K	KN-Polyimid KP-PTFE/ Polyimid	2 x 0,2 mm	wire	oval	approx. 1,0 x 0,8 mm	flexible: -40°C upto +250°C fixed: -40°C upto +250°C	DIN IEC 584 class 1
polyimide/PFA insulated thermo-cables (wire)										
0433-9196		thermo-couple-cable	type K	KN-Polyimid KP blank/ Polyimid/ PFA	2 x 0,2 mm	wire	round	max. 1,0 mm	flexible: -40°C upto +250°C fixed: -40°C upto +250°C	DIN IEC 584 class 1
FEP insulated thermo-cables (wire)										
0433-9152		thermo-couple-cable	type K	FEP/FEP	2 x 0,2 mm	wire	oval	approx. 1,7 x 1,1 mm	flexible: -40°C upto +180°C fixed: -40°C upto +180°C	DIN IEC 584 class 1
TPE insulated thermo-cable (strands)										
0433-9177		thermo-couple-cable	type K	TPE/TPE	2 x 0,2 mm ²	strands	round	approx. 3,0 mm	flexible: -40°C upto +90°C fixed: -40°C upto +90°C	DIN IEC 584 class 1
FEP/Besilen® insulated thermo-cables (strands)										
0433-9193		thermo-cable	type K	FEP/FEP/ Bi	2 x 0,2 mm ²	strands	round	approx. 3,8 mm	flexible: -25°C upto +180°C fixed: -40°C upto +180°C	DIN IEC 584 class 2

SURVEY COMPENSATING AND EXTENSION CABLES AS WELL AS CONNECTION CABLES FOR RESISTANCE THERMOMETERS

SAB item no.	Picture	Cable type	T/C type	Insulation	Section	Cond.	Form	Outer-Ø	Temp.-range of insulation	thermoelectric voltage
FEP/Besilen® connection cables for resistance thermometers (strands)										
0470-9224		connection cable	tinned copper strands copper figure: 2,7 kg/km	FEP/Bi	2 x 0,14 mm ²	strands	round	approx. 2,8 mm	flexible: -25°C upto +180°C fixed: -40°C upto +180°C	
0470-0423		connection cable	tinned copper strands copper figure: 8,4 kg/km	FEP/Bi	4 x 0,22 mm ²	strands	round	approx. 3,9 mm	flexible: -25°C upto +180°C fixed: -40°C upto +180°C	
3833-9132		connection cable	tinned copper strands copper figure: 19,3 kg/km	FEP/C/ FEP	4 x 0,22 mm ²	strands	round	approx. 3,0 mm	flexible: -55°C upto +180°C fixed: -90°C upto +180°C	
FEP insulated thermo-cables (strands)										
0433-9157		thermo-cable	type K	FEP/FEP	2 x 0,22 mm ²	strands	oval	approx. 2,5 x 1,5 mm	flexible: -25°C upto +180°C fixed: -25°C upto +180°C	DIN IEC 584, tolerance +/- 1°C
0433-9137		thermo-cable	type K	FEP/FEP	2 x 0,22 mm ²	strands	round	approx. 2,0 mm	flexible: -25°C upto +180°C fixed: -25°C upto +180°C	DIN IEC 584, tolerance +/- 1°C
0433-9154		thermo-cable	type K	FEP/FEP	8 x 2 x 0,22 mm ²	strands	round	approx. 6,4 mm	flexible: -25°C upto +180°C fixed: -25°C upto +180°C	DIN IEC 584 class 2
0433-9135		thermo-cable	type K	FEP/FEP	16 x 2 x 0,22 mm ² twisted pairs	strands	round	approx. 7,7 mm	flexible: -25°C upto +180°C fixed: -25°C upto +180°C	DIN IEC 584 class 2
0435-9085		thermo-couple-cable	type K	FEP-F-ZF-D(B)- FEP/F-C(B)-FEP	8 x (2 x 0,5 mm)D	strands	round	approx. 11,0 mm	flexible: -55°C upto +180°C fixed: -90°C upto +180°C	DIN IEC 584 class 1
FEP insulated thermo-cables with screening (strands)										
0435-9037		thermo-cable	type K	FEP/C/ FEP	2 x 0,22 mm ²	strands	round	approx. 2,6 mm	flexible: -25°C upto +180°C fixed: -25°C upto +180°C	DIN IEC 584, tolerance +/- 1,5°C
Besilen® insulated thermo-cables (strands)										
0451-9019		thermo-cable	type K	GL/ Silicone	2 x 0,22 mm ²	strands	round	approx. 3,2 mm	flexible: -25°C upto +200°C fixed: -25°C upto +200°C	DIN IEC 584 class 1

COLOUR CODE AND TEMPERATURE RANGES

for compensating and extension cables

THERMOCOUPLE		 DIN IEC 584	 DIN 43710*	 ANSI MC 96.1	 BS 4937	 NF C 42-324	
Code	Material ⊕ ⊖	Identification		Identification		Identification	
		THL	AGL	THL	AGL	THL	AGL
T	Cu - Cu Ni	 TX -25° to +100°C		 0° to +100°C	 0° to +100°C	 -25° to +200°C	
U	Cu - Cu Ni		 UX 0° to +200°C				
J	Fe - Cu Ni	 JX -25° to +200°C		 0° to +200°C	 0° to +200°C	 -25° to +200°C	
L	Fe - Cu Ni		 LX 0° to +200°C				
E	Ni Cr - Cu Ni	 EX -25° to +200°C		 0° to +200°C	 0° to +200°C	 -25° to +200°C	
	Ni Cr - Ni	 KX -25° to +200°C		 0° to +200°C	 0° to +200°C	 -25° to +200°C	
K	Ni Cr - Ni	 KCA 0° to +150°C				 0° to +150°C	
	Ni Cr - Ni	 KCB 0° to +100°C			 0° to +100°C	 0° to +100°C	
N	Ni Cr Si - Ni Si	 NX -25° to +200°C	 NC 0° to +150°C				
R	Pt Rh 13 - Pt	 RCB/ SCB 0° to +200°C		 0° to +200°C	 0° to +200°C	 0° to +200°C	
S	Pt Rh 10 - Pt						
B	Pt Rh 30 - Pt Rh 6			 0° to +100°C		 0° to +100°C	

The application temperature range of the cable is limited by the highest application temperature of the insulating material or the application temperature range of the conductor material. In all cases the respective lower figure is valid. The compensating cable for the thermocouple type B can also be manufactured, deviating from the corresponding standards, for a temperature range from 0 up to +200°C (S-Type BC-200). Variant colour codes can be manufactured for a minimum order quantity.

* The standard 43710 was withdrawn in April 1994. Therefore, the element types "U" and "L" are not standardized anymore.

THL = extension cable · AGL = compensating cable

1. Temperature as measured variable

For nearly all procedures in research and production, temperature is a factor to be considered. It is of considerable importance as measured variable. For temperature measurements, temperature dependent characteristics of materials can be used, as for example the changing electrical resistance (resistance thermometer), the electromagnetic radiation of hot bodies (radiation pyrometer) and resulting thermoelectric voltage (thermocouple). The different electric contact thermometers are frequently used for the field temperature measurement.

2. Physical basis

2.1. Resistance thermometer

Temperature measurement with the help of resistance thermometers base on the special characteristic of conducting materials to change their resistance dependent on temperature. For metals the resistance increases with rising temperature. In case that the correlation between temperature and resistance is known, the temperature can be determined by resistance measurement. The suggestion to use the temperature dependent resistance of metal conductors for temperature measurement, was first made by Wilhelm von Siemens, the brother of Werner von Siemens in 1861 and was realized in the development of a thermometer for the measurement of deep sea temperatures. The works of H.L. Callendar made the resistance thermometer a precision device in 1886.

2.2. Thermocouples

The first basis of the thermovoltage effect was discovered by Seebeck in 1821. Thirty years later the exact correlations were found out by Thompson. The thermovoltage between 2 different metals depend on the thermal motion of electrons. It is not dependent on the absolute temperature values, but on temperature differences. The higher the temperature difference between "hot" and "cold", the higher the thermovoltage. The voltage at 1 degree Celsius is called the thermoelectric force of the thermocouple. It depends on the nature of the two materials whose connection point is heated.

3. The response time of contact thermometers

The temperature measurement with the help of contact thermometers is generally afflicted with a delayed indication. The result is that a changing temperature is not immediately indicated correctly but only after a certain time when the heat exchange between the measured medium and the temperature probe has been fully realized. This inertia of thermometers shall be as small as possible for certain measuring tasks. This is called the response time of a thermometer which means generally the time constant. Generally spoken: the time constant corresponds to the relation of the capacity of heat absorption and heat release of the thermometer. Both characteristics are mainly determined by:

- heat capacity
- transversal thermal conductivity of the thermometer
- relation of surface to volume of the thermometer
- coefficient of thermal conductivity between medium and surface of the thermometer as well as of the medium velocity, its thermal conductivity and its specific heat.

If a thermometer is suddenly exposed to another temperature, as for example by taking it out of water with a temperature of +20°C and putting it into water of +40°C, the indicated temperature rises almost according to the exponential function. The usual quantity for the changing velocity of such exponential procedures is the time constant. The time constant is equal to the time that passes until 63,2% of the temperature leap is indicated. In many cases, the temperature indication does not change according to the exponential function. For those cases the time constant is not sufficient to characterise the time response. Therefore it is useful to indicate the half-time $z\ 0.5$ and the 9/10 time value $z\ 0.9$. This is the definition of time from the sudden change of temperature to the reach of 50% either 90% of this temperature change. The exponential course shows $z\ 0.5 = 0.693$ (time constant) resp. $z\ 0.9 = 2.303$ (time constant) and the ratio $z\ 0.9/z\ 0.5$ has to be equal to 3.32.

COMPARISON THERMOCOUPLES / RESISTANCE THERMOMETERS

Resistance thermometers

- Platinum resistance thermometers are the most accurate sensors and have the best long-time stability.
Due to the chemical resistance of Platinum, the risk of impurity by oxidation and other chemical influences is reduced.
- High consistency.

Thermocouples

- Larger temperature range than resistance thermometers.
- Small hot junction enables short response time.
- More robust and resistant against mechanical stress.
- Cheaper.

■ General:

A reliable temperature measurement requires a most exact adaptation to the corresponding process. This statement is valid for thermocouples as well as for resistance thermometers.

Characteristics	Resistance thermometer	Thermocouples
■ dimensions	comparatively large sensor surface	small sensor surface possible
■ response time	relatively long	short
■ connection cables	copper cables	thermo compensating cable
■ accuracy	very good	good
■ consistency	very good	satisfactory
■ surface temperature measurement	not possible	possible
■ hot junction	over the whole length of the RTD	punctual
■ robustness	good	very good
■ spontaneous heating	has to be considered	does not occur
■ temperature range	up to +600°C	higher temperature possible
■ cold junction	not necessary	necessary
■ circuit supply	yes	no
■ vibration resistance	relatively sensitive	very rugged

RESPONSE TIMES MINERAL INSULATED THERMOCOUPLES / RESISTANCE THERMOMETERS

■ Mineral insulated thermocouples

Insulated hot junction		Response time in			
(form A) sheath- Ø (mm)	water with 0,2 m/s		air with 2,0 m/s		
	t 0,5 (s)	t 0,9 (s)	t 0,5 (s)	t 0,9 (s)	
0,5	0,06	0,13	1,80	5,50	
1,0	0,15	0,50	3,00	10,00	
1,5	0,21	0,60	8,00	25,00	
3,0	1,20	2,90	23,00	80,00	
4,5	2,50	5,90	37,00	120,00	
6,0	4,00	9,60	60,00	200,00	
8,0	7,00	17,00	100,00	360,00	

Welded hot junction		Response time in			
(form B) sheath- Ø (mm)	water with 0,2 m/s		air with 2,0 m/s		
	t 0,5 (s)	t 0,9 (s)	t 0,5 (s)	t 0,9 (s)	
0,5	0,03	0,10	1,80	6,00	
1,0	0,06	0,18	3,00	10,00	
1,5	0,13	0,40	8,00	25,00	
3,0	0,22	0,75	23,00	80,00	
4,5	0,45	1,60	33,00	110,00	
6,0	0,55	2,60	55,00	185,00	
8,0	0,75	4,60	97,00	310,00	

■ Mineral insulated resistance thermometer

Sheath-Ø (mm)	Response time in			
	water with 0,2 m/s		air with 2,0 m/s	
	t 0,5 (s)	t 0,9 (s)	t 0,5 (s)	t 0,9 (s)
1,6	3,6	5,5	10,8	26,3
3,0	5,2	9,8	20,0	51,0
6,0	10,4	23,2	46,8	121,0

These indications are only reference values as the response time depends on the applied RTD.

■ General:

Mineral insulated thermocouples and mineral insulated resistance thermometers can be bent with a radius of 5 x the outer diameter of the sheath material. Herewith it must be considered that any bending of the measuring tip over a length of 60 mm has to be avoided.

Test certificates:

We offer test reports or test certificates acc. to DIN EN 10204.

1. Test certificate acc. to DIN EN 10204-2.1

charge: 18.00 Euro

Certificate in which the manufacturer confirms that the delivered goods correspond to the requirements of the order without indicating any test results.

2. Test certificate acc. to DIN EN 10204-2.2 (batch certificate)

charge: 23.00 Euro

Certificate in which the manufacturer confirms that the delivered goods correspond to the requirements of the order by indicating results of not specific tests.

3. Inspection certificate acc. to DIN EN 10204-3.1

charge: 29.00 Euro

Certificate in which the manufacturer confirms that the delivered goods correspond to the requirements of the order by indicating test results. plus charge for tests acc. to the following list

The test unit and the execution of the test are determined in the product specification, in official or technical prescriptions and/ or order. The certificate is confirmed by a person independent of production and named by the manufacturer.

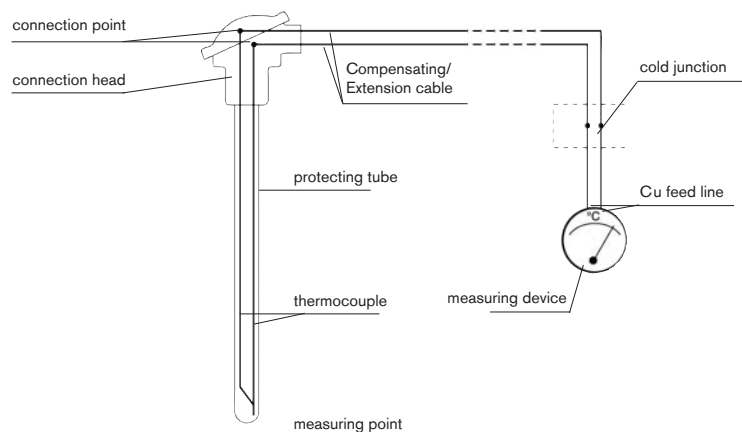
List of individual tests	
Calibration in "Kyrostat" bath:	
Temperature range -50°C up to +50°C	
Basic price	12,10 Euro
Unit price for each test piece and measuring point	4,00 Euro
Calibration in oil bath:	
Temperature range +60°C up to +200°C	
Basic price	12,10 Euro
Unit price for each test piece and measuring point	4,00 Euro
Calibration in AMETEK Trockenblock-Kalibrator:	
Temperature range +50°C up to +320°C, +300°C up to +1205°C	
Basic price	12,10 Euro
Unit price for each test piece	4,00 Euro
Response time in water:	
Determination of 0,1-time, 0,5-time and 0,9-time	
Basic price	16,10 Euro
Unit price for each test piece	5,80 Euro
Response time in air:	
Determination of 0,1-time, 0,5-time and 0,9-time	
Basic price	16,10 Euro
Unit price for each test piece	8,00 Euro

Temperature is an important factor in many areas concerning the environment, scientific research and production. It is a thermo-dynamic variable that defines the heat content of a material. Material strength changes with alternating temperature. As a consequence, the characteristics of materials have to be examined at different temperatures. To obtain a temperature value, defined temperature parameters are used. Here the parameters can be defined, for example, as the freezing and boiling points of water.

For temperature measurement temperature dependent characteristics of materials have to be taken into account. These include such things as thermal expansion (expansion thermometer), the dependence of the electric resistance of metallic conductors (electrical thermometer) and electromotive force (thermocouple) etc.. A temperature measuring device with a thermocouple as a data indicator tends to consist of the thermometer itself with a measuring point, an extension cable, a cold junction with a specified constant temperature and a voltmeter.

The value of the electromotive force (EMF) produced by the thermocouple is determined by the difference between the measuring temperature and the so-called free ends of the thermocouple which are mounted in the connection head. As the connection head is usually relatively close to the measuring point, it is frequently exposed to temperature fluctuations. For this reason, a connection cable with the same thermo-electric properties as the thermocouple is used between the thermocouple and the cold junction.

■ Sketch



■ Materials

We differentiate between thermocouple cable and compensating cable. Cables made of original materials are called extension or thermocouple cables, whereas conductor materials made of substitutes are known as compensating cables.

■ Compensating cables

The compensating wires and strands are composed of alloys which do not have to be identical with the corresponding thermocouple. Substitute material means that the thermo-electric characteristics in the allowed temperature range (usually 0 up to +200°C) for the compensating cable must be the same as those of the corresponding thermocouple. They are identified with the letter "C" adapted to DIN IEC 584. The "C" appears behind the code letter identifying the thermocouple, for example "KC".

■ Extension cables

Extension cables are made of conductors with identical nominal structure to the corresponding thermocouple. They are identified with the letter "X" adapted to DIN IEC 584 which appears behind the code letter identifying the thermocouple, for example "JX". They are normally tested within a temperature range of 0 up to +200°C.

■ Thermocouple cables

Thermocouple cables consist of the same element material as the thermocouple and are tested for the same temperatures. These SAB special cables are manufactured on customer request. PVC, fibre-glass and SABtex insulated or sheathed compensating and extension cables are not suitable for outdoor use. Exception: PVC sheathed solid conductors can be used for underground laying.

Cables for resistance thermometers

Cables with copper conductors have to be laid between thermometer and measuring device. In order to keep faults by cable resistances and their temperature dependent fluctuations as small as possible, an appropriate cable section has to be chosen. Resistance thermometers are manufactured in 2-, 3-, and 4-wire circuit dependent on the required accuracy. By choosing the wire circuit it has to be considered that the cable resistance fully affects the measuring result.

The cables have to be chosen that they are appropriate for their environment that means that they resist against thermal, mechanical and chemical influences. All cable contacts have to be well done. Measuring cable shall be laid > 0,5 m away from any energy cable. In order to suppress electromagnetic or magnetic interferences, the cables shall be screened and have twisted pairs.

BASIC VALUES OF THERMOELECTRIC VOLTAGE IN mV

tempe- rature t 90/°C	type K	type L	type J	type U	type T	type E	type N	type S	type R	type B
	+NiCr -Ni	+Fe -CuNi	+Fe -CuNi	+ECu -CuNi	+ECu -CuNi	+NiCr -CuNi	+NiCrSi -NiSi	+PtRh 10 -Pt	+PtRh 13 -Pt	+PtRh 30 -PtRh 6
	DIN EN 60584	⁽¹⁾ DIN 43710	DIN EN 60584	⁽¹⁾ DIN 43710	DIN EN 60584	DIN EN 60584	DIN EN 60584	DIN EN 60584	DIN EN 60584	DIN EN 60584
-100	-3,554	-4,75	-4,633	-3,40	-3,379	-5,237	-2,407	-	-	-
0	0	0	0	0	0	0	0	0	0	0
100	4,096	5,37	5,269	4,25	4,279	6,319	2,774	0,646	0,647	0,033
200	8,138	10,95	10,779	9,20	9,288	13,421	5,913	1,441	1,469	0,178
300	12,209	16,56	16,327	14,90	14,862	21,036	9,341	2,323	2,401	0,431
400	16,397	22,16	21,848	21,00	20,872	28,946	12,974	3,259	3,408	0,787
500	20,644	27,85	27,393	27,41	-	37,005	16,748	4,233	4,471	1,242
600	24,905	33,67	33,102	34,31	-	45,093	20,613	5,239	5,583	1,972
700	29,129	39,72	39,132	-	-	53,112	24,527	6,275	6,743	2,431
800	33,275	46,22	-	-	-	61,017	28,455	7,345	7,950	3,154
900	37,326	53,14	-	-	-	68,787	32,371	8,449	9,205	3,957
1000	41,276	-	-	-	-	76,373	36,256	9,587	10,506	4,834
1100	45,119	-	-	-	-	-	40,087	10,757	11,850	5,780
1200	48,838	-	-	-	-	-	43,846	11,951	13,228	6,786
1250	50,644	-	-	-	-	-	45,694	12,554	13,926	7,311
1300	52,410	-	-	-	-	-	47,513	13,159	14,629	7,848
1400	-	-	-	-	-	-	-	14,373	16,040	8,956
1450	-	-	-	-	-	-	-	14,978	16,746	9,524
1500	-	-	-	-	-	-	-	-	-	10,099
1600	-	-	-	-	-	-	-	-	-	11,263
1700	-	-	-	-	-	-	-	-	-	12,433

⁽¹⁾Since April 1994 the standard DIN 43710 is no longer valid

Thermoelectric voltage in mV with reference to a cold junction temperature of 0°C.

Ø-TOLERANCES OF MINERAL INSULATED THERMOCOUPLES / THERMOCOUPLE TYPES FORM A, FORM B

Table 1: tolerance of outer- Ø

outer –Ø of cable	nominal value +/- limit dimensions
0,5 mm	+/- 0,025 mm
1,0 mm	+/- 0,025 mm
1,5 mm	+/- 0,025 mm
2,0 mm	+/- 0,025 mm
3,0 mm	+/- 0,030 mm
4,5 mm	+/- 0,045 mm
6,0 mm	+/- 0,060 mm
8,0 mm	+/- 0,080 mm

Thermocouple types form A / form B:

Mineral insulated thermocouples listed in this catalogue are according to DIN EN 61515 with regard to shape, construction and geometrical dimensions or refer to it. Regarding the basic values and tolerances the standards DIN EN 60584-1 and DIN EN 60584-2 are valid.

We furnish mineral insulated thermocouples with insulated hot junction (form A) as standard version acc. to DIN EN 61515

Form A – ungrounded mineral insulated thermocouple

- The measuring tip isn't directly welded to the bottom.

We also manufacture grounded mineral insulated thermocouples (form B) acc. to DIN EN 61515 on customer's request.

Form B – grounded mineral insulated thermocouple

- The measuring tip is electrically connected to the sheath.

Mineral insulated thermocouples keep the given min. insulation resistance acc. to DIN EN 61515 of $\geq 1000 \text{ M}\Omega$ at room temperature.

TOLERANCES OF THERMOCOUPLES

type	standard	material	class 1		class 2		class 3	
			temperature range	(2) limit deviation	temperature range	(2) limit deviation	temperature range	(2) limit deviation
T	DIN EN 60584	Cu-CuNi	-40 up to +350°C	$\pm 0,5^\circ\text{C}$ or 0,40%	-40 up to +350°C	$\pm 1,0^\circ\text{C}$ or 0,75%	-200 up to +40°C	$\pm 1,0^\circ\text{C}$ or 1,5%
(1)U	DIN 43710	Cu-CuNi	-	-	0 up to +600°C	$\pm 3^\circ\text{C}$ or 0,75%	-	-
J	DIN EN 60584	Fe-CuNi	-40 up to +750°C	$\pm 1,5^\circ\text{C}$ or 0,40%	-40 up to +750°C	$\pm 2,5^\circ\text{C}$ or 0,75%	-	-
(1)L	DIN 43710	Fe-CuNi	-	-	0 up to +900°C	$\pm 3^\circ\text{C}$ or 0,75%	-	-
K	DIN EN 60584	NiCr-Ni	-40 up to +1000°C	$\pm 1,5^\circ\text{C}$ or 0,40%	-40 up to +1200°C	$\pm 2,5^\circ\text{C}$ or 0,75%	-200 up to +40°C	$\pm 2,5^\circ\text{C}$ or 1,5%
E	DIN EN 60584	NiCr-CuNi	-40 up to +800°C	$\pm 1,5^\circ\text{C}$ or 0,40%	-40 up to +900°C	$\pm 2,5^\circ\text{C}$ or 0,75%	-200 up to +40°C	$\pm 2,5^\circ\text{C}$ or 1,5%
N	DIN EN 60584	NiCrSi-NiSi	-40 up to +1000°C	$\pm 1,5^\circ\text{C}$ or 0,40%	-40 up to +1200°C	$\pm 2,5^\circ\text{C}$ or 0,75%	-200 up to +40°C	$\pm 2,5^\circ\text{C}$ or 1,5%
S	DIN EN 60584	PtRh 10-Pt	0 up to +1600°C	$\pm 1,0^\circ\text{C}$ or ⁽³⁾	0 up to +1600°C	$\pm 1,5^\circ\text{C}$ or 0,25%	-	-
R	DIN EN 60584	PtRh13-Pt	0 up to +1600°C	$\pm 1,0^\circ\text{C}$ or ⁽³⁾	0 up to +1600°C	$\pm 1,5^\circ\text{C}$ or 0,25%	-	-
B	DIN EN 60584	PtRh30-PtRh6	-	-	+600 up to +1700°C	$\pm 1,5^\circ\text{C}$ or 0,25%	+600 up to +1700°C	$\pm 4,0^\circ\text{C}$ or 0,5%

Classes 1, 2, and 3 are valid for thermocouples.

⁽¹⁾ Since April 1994 the standard DIN 43710 is no longer valid.

⁽²⁾ For the limit deviation, the higher value is valid.

⁽³⁾ 1°C or $[1 + (t - 1100) \times 0,003]^\circ\text{C}$

CHARACTERISTICS OF THERMOCOUPLES

characteristics thermocouples	general	composition	tempera- ture range	suitable application	unsuitable application
type E	base metal thermocouple NiCr - CuNi (nickel-chrome/ copper-nickel) single wires made of non precious metals	EP-leg: 89-90% nickel, 9-9,5% chrome, 0,5% silicium and iron balance: C, Mn, Nb, Co EN-leg: 55% copper, 45% nickel approx. 0,1%, cobalt, iron and manganese	-200°C/+700°C	<ul style="list-style-type: none"> ▶ in pure, oxidizing (air) or neutral atmosphere (inert gases) ▶ high resistance against corrosion ▶ small thermal conductivity 	<ul style="list-style-type: none"> ▶ not sulphuric, reducing or alternately oxidizing and reducing atmosphere ▶ do not apply in vacuum for a long time
type J	base metal thermocouple Fe - CuNi (iron/copper-nickel) single wires made of non precious metals	JP-leg: 99,5% iron, approx. 0,25% manganese, approx. 0,12% copper, balance: other impurities JN-leg: 55% copper, 45% nickel approx. 0,1%, cobalt, iron and manganese	-180°C/+700°C	<ul style="list-style-type: none"> ▶ from 0 - +760°C in vacuum, oxidizing (air), reducing or inert atmosphere (inert gases) 	<ul style="list-style-type: none"> ▶ temperatures below 0°C ▶ sulphurous atmosphere above +500°C ▶ above +760°C only with bigger wire diameters
type K	base thermocouple NiCr - NiAl (nickel-chrome/ nickel-aluminium) single wires made of non precious metals	KP-leg: 89-90% nickel, 9-9,5% chrome, 0,5% silicium and iron, balance: C, Mn, Nb, Co KN-leg: 95-96% nickel, 1-1,5% silicium, 1-2,3% aluminium, 1-3,2% manganese, 0,5% cobalt, balance: Fe, Cu, Pb	-270°C/+1372°C	<ul style="list-style-type: none"> ▶ from +250°C - +1260°C in pure, oxidizing (air) and neutral atmosphere (inert gases) ▶ for higher temperatures bigger wire diameters are recommended 	<ul style="list-style-type: none"> ▶ between +250°C up to +600°C not suitable for exact measurements with quick temperature changes ▶ not appropriate for a longer time with high temperatures in vacuum ▶ do not apply with high temperatures in sulphurous, reducing or alternately oxidizing and reducing atmosphere without protection ▶ do not use in atmosphere favourizing "green mould"
type L	base thermocouple Fe - CuNi (iron/copper-nickel) single wires made of non precious metals	LP-leg: 99,5% iron, approx. 0,25% manganese, approx. 0,12% copper, balance: other impurities LN-leg: 55% copper, 45% nickel, approx. 0,1% cobalt, iron and manganese	0°C/+900°C	<ul style="list-style-type: none"> ▶ from 0°C - +760°C in vacuum, oxidizing (air), reducing or inert atmosphere (inert gases) ▶ above +500°C bigger wire diameters are recommended 	<ul style="list-style-type: none"> ▶ temperatures below 0°C ▶ sulphurous atmosphere above +500°C ▶ above +760°C only with bigger wire diameters
type N	base thermocouple NiCrSi - NiSi (nickel-chrome-silicium/ nickel-silicium-magnesium) single wires made of non precious metals	NP-leg: 84% nickel, 14-14,4% chrome, 1,3-1,6% silicium, ballance (not more than 0,1%): Mn, Fe, C, Co NN-leg: 95% nickel, 4,2-4,6% silicium, 0,5-1,5% magnesium, ballance: Fe, Co, Mn, C, (altogether 0,1-0,3%)	-270°C/+1300°C	<ul style="list-style-type: none"> ▶ from +300°C - +1260°C in pure, oxidizing (air) and neutral atmosphere (inert gases) 	<ul style="list-style-type: none"> ▶ do not use with high temperatures in sulphurous, reducing or alternately oxidizing and reducing atmosphere without protection ▶ do not use with high temperatures in vacuum ▶ do not use in atmosphere favourizing "green mould" ▶ reducing atmosphere
type R	base thermocouple Pt13%Rh - Pt (platinum 13% rhodium/platinum) single wires made of platinum and platinum - rhodium alloy	RP-leg: platinum with 99,99% purity with a rhodium alloy (purity 99,98%) 13±0,05% rhodium portion RN-leg: platinum with 99,99% purity	-50°C/+1768,1°C (melting point) recommended: up to +1300°C	<ul style="list-style-type: none"> ▶ pure, oxidizing atmosphere (air), non aggressive (inert-) gases and short-term in vacuum ▶ above +1200°C type B more appropriate 	<ul style="list-style-type: none"> ▶ reducing atmosphere ▶ metal gases (for example plumb or zinc) ▶ aggressive vapours containing arsenic, phosphor or sulphur ▶ do never use metal protecting tubes with higher temperatures ▶ sensitive against impurities of impure metals
type S	base thermocouple Pt10%Rh - Pt (platinum 10%Rhodium/platinum). single wires made of platinum and platinum - rhodium alloy	SP-leg: platinum with 99,99% purity with a rhodium alloy (purity 99,98%) 10±0,05% rhodium portion SN-leg: platinum with 99,99% purity	-50°C/+1768,1°C (melting point) recommended: up to +1300°C	<ul style="list-style-type: none"> ▶ pure, oxidizing atmospheres (air), non aggressive (inert-) gases and short-term in vacuum ▶ above +1200°C type B more appropriate 	<ul style="list-style-type: none"> ▶ reducing atmosphere ▶ metal gases (for example plumb or zinc) ▶ aggressive vapours containing arsenic, phosphor or sulphur ▶ do never use metal protecting tubes with higher temperatures ▶ sensitive against impurities of impure metals
type B	base thermocouple (Pt30%Rh - Pt6%Rh platinum - 0% rhodium/ platinum-6% rhodium) single wires made of platinum and platinum - rhodium alloy	BP-leg: platinum with 99,99% purity with a rhodium alloy (purity 99,98%) 29,60±0,2% rhodium portion BN-leg: platinum with 99,99% purity with a rhodium alloy (purity 99,98%) 6,12±0,02% rhodium portion	max. +1820°C (melting point) ordinary up to +1700°C	<ul style="list-style-type: none"> ▶ pure, oxidizing atmospheres ▶ neutral atmospheres ▶ vacuum 	<ul style="list-style-type: none"> ▶ reducing atmosphere or such with aggressive vapours or impurities which react with metals of the platinum group, if it isn't protected with a non metal protecting tube
type T	base thermocouple Cu - CuNi (copper/copper-nickel) single wires made of non precious metals	TP-leg: 99,95% copper, 0,02-0,07% oxygen 0,01% impurities TN-leg: 55% copper, 45% nickel approx. 0,1% cobalt, iron and manganese	-270°C/+400°C	<ul style="list-style-type: none"> ▶ from -200°C - +370°C in vacuum, oxidizing (air), reducing or inert atmosphere (inert gases) ▶ with higher temperatures bigger wire diameters are recommended 	<ul style="list-style-type: none"> ▶ above +370°C not appropriate in a hydrogen atmosphere ▶ not appropriate in radioactive environment
type U	base thermocouple Cu - CuNi (copper/copper-nickel) single wires made of non precious metals	UP-leg: 99,95% copper, 0,02-0,07% oxygen 0,01% impurities UN-leg: 55% copper, 45% nickel approx. 0,1% cobalt, iron and manganese	0°C/+600°C (+400°C)	<ul style="list-style-type: none"> ▶ from -200°C - +370°C in vacuum, oxidizing (air), reducing or inert atmosphere (inert gases) ▶ with higher temperatures bigger wire diameters are recommended 	<ul style="list-style-type: none"> ▶ above +370°C not appropriate in a hydrogen atmosphere ▶ not appropriate in radioactive environment

Abbreviations: C= carbon, Mn= manganese, Nb=niobium, Co=cobalt, Fe= iron, Pb=plomb, Cu=copper

CuNi is also called constantan*

APPLICATION TEMPERATURE LIMITS AND APPLICATION ADVICE FOR MINERAL INSULATED MATERIALS

Application temperature limits:

The different mineral insulated thermocouple types have generally a metal sheath made of special steel material no. 1.4541 or of Inconel material no. 2.4816.

Other sheath materials are available on request.

The max. application temperature of mineral insulated thermocouples in pure air without any further harmful gaseous components are as follows:

material no.	sheath material	max. application temperature
1.4541	special steel	800°C
2.4816	Inconel	1100°C

- ▶ An important quality characteristic of the sheath material is its resistance against corrosion
- ▶ With higher measuring temperatures especially with cyclic stress, the wall thickness is reduced by scaling
- ▶ Aggressive gaseous components can be harmful to the sheath material
- ▶ Bigger diameters increase the service life of mineral insulated thermocouples

The above mentioned information do not claim to be complete.

Herewith, we would like to point out that the allowed application temperature and service life of mineral insulated thermocouples are influenced by lots of circumstances.

Mineral insulated material:

The following table shows in which fields mineral insulated materials have good oxidation and alternating temperature resistance. The application temperature limits in different media are as follows:

Measuring medium	Application temperature	
	1.4541	2.4816
air	approx. 800°C	approx. 1100°C
carbon dioxide	approx. 650°C	approx. 500°C
benzene	approx. 100°C	not recommended
benzol	approx. 100°C	not recommended
boric acid	approx. 100°C	not recommended
butyl alcohol	approx. 100°C	not recommended
up to 50°G.L phosphoric acid	approx. 100°C	not recommended
nitric acid	approx. 100°C	not recommended
liquid sodium	not recommended	approx. 750°C
sulphurous air	not recommended	approx. 550°C
chlorine free water	not recommended	approx. 590°C

BASICS OF RESISTANCE THERMOMETERS

Resistance thermometers change their electrical resistance in dependence on the temperature or in other words resistance thermometers use the fact that the electrical resistance of an electrical conductor varies with changing temperature. In order to collect the output signal, the resistance is fed with a constant measuring current and the created voltage drop is measured. Platinum RTDs Pt 100, Pt 500 and Pt 1000 are used as measuring probes. They are standardized acc. to DIN EN 60751. Their resistance is 100 Ω at 0°C. The most different construction types of platinum resistance thermometers are applied in industrial measuring technique.

Our standard mineral insulated resistance thermometers are appropriate for measuring ranges from +600°C. This indicated measuring range refers to the allowed temperature at the measuring tip of the resistance thermometer. In those temperature ranges the Pt 100 resistance thermometer is situated in a fixed characteristic line. Deviations from this characteristic line, also called basic values, are approved according to 2 tolerance classes A and B. Limit deviations please see page 35.

Platinum resistance thermometers are the most accurate sensors and show an excellent long-time stability. Due to the chemical insensitiveness of the platinum, the risk of contamination by oxidation and other chemical influences is reduced.

- high chemical resistance
- consistency
- long-term stability
- easy treatment

The standard value for the accuracy of platinum resistance thermometers is approx. $\pm 0,5\%$ of the measured temperature. They are applied in nearly all fields of industrial temperature measurement.

A reliable temperature measurement requires a most exact adaptation to the corresponding process. This statement can be applied for thermocouples as well as for resistance thermometers. Thermocouples in contrast to resistance thermometers are more simple, more robust, mostly cheaper, applicable in a broad temperature range and have small measuring points. Due to the punctual measurement with thermocouples, they have a quicker response time than resistance thermometers.

Resistance thermometers, however, have a high accuracy and reproducibility and the measuring points are a little bit bigger than those of thermocouples. Due to the planar measurement with resistance thermometers for reasons of construction, they show a slower response time.

TECHNICAL DESCRIPTION MINERAL INSULATED RESISTANCE THERMOMETER

Technical description

1. General information

In general SAB Bröckskes furnishes its insulated resistance thermometers with Platinum Pt 100 acc. to DIN EN 60751. On request we are also able to deliver mineral insulated resistance thermometers with Pt 500, Pt 1000. We recommend the use of Platinum RTDs due to their high level of stability and consistency. Mineral insulated resistance thermometers are often used for temperature measurement in containers, tubes, appliances and machines. They are applied whenever the flexible mounting and dismantling of the measuring probes are of great importance. Please note that mineral insulated resistance thermometers are only appropriate for low pressures and small flow rates.

2. Construction

The flexible and thin special steel tube of sheath contains 2, 4 or 6 inner wires which are pressed into magnesium oxide. The measuring resistance is connected to the inner wires and embedded into magnesium oxide powder. In general, material no. 1.4541 is used as sheath material.

3. Response times

Mineral insulated thermometers have short response times and react quickly onto changing temperatures. You will find the approximate values in the table on page 11.

4. Mounting advice

Our standard mineral insulated resistance thermometers are appropriate for the temperature ranges of -50°C up to +400°C and -50°C up to +600°C. This indicated measuring range refers to the allowed temperature at the measuring tip of the resistance thermometer.

BASIC VALUES OF RTD'S

■ Limit deviations for PT 100 thermometers

abbreviation of RTD Pt 100 DIN EN 60751					
RTD material Platinum					
application range -200 up to +850°C (class B)					
ITS 90 resistance and permitted deviation					
measuring temperature °C	basic value Ω	allowed deviation			
		class A		class B	
		Ω	°C	Ω	°C
-200	18,52	±0,24	±0,55	±0,56	±1,30
-100	60,26	±0,14	±0,35	±0,32	±0,80
0	100,00	±0,06	±0,15	±0,12	±0,30
100	138,51	±0,13	±0,35	±0,30	±0,80
200	175,86	±0,20	±0,55	±0,48	±1,30
300	212,05	±0,27	±0,75	±0,64	±1,80
400	247,09	±0,33	±0,95	±0,79	±2,30
500	280,98	±0,38	±1,15	±0,93	±2,80
600	313,71	±0,43	±1,35	±1,06	±3,30
650	329,64	±0,46	±1,45	±1,13	±3,60
700	345,28	-	-	±1,17	±3,80
800	375,70	-	-	±1,28	±4,30
850	390,48	-	-	±1,34	±4,60

for the term "basic values" see DIN 16160 part 5.

Resistance thermometers with different accuracy classes and validity ranges as for example acc. to DIN EN 60751: 2009-5 (class AA) are available on request.

■ The allowed deviations for Pt 100 measuring resistances are determined by the following equations:

For the temperature range from: -200°C to 0°C:

$$R_t = R_0 [1 + At + Bt^2 + C(t - 100^\circ\text{C})t^3]$$

For the temperature range from: 0°C to 850°C:

$$R_t = R_0 (1 + At + Bt^2)$$

For the platinum quality generally used for industrial platinum resistance thermometers, the following constants are valid in these equations:

$$A = 3,9083 \times 10^{-3} \text{ } ^\circ\text{C}^{-1}$$

$$B = -5,775 \times 10^{-7} \text{ } ^\circ\text{C}^{-2}$$

$$C = -4,183 \times 10^{-12} \text{ } ^\circ\text{C}^{-4}$$

For resistance thermometers that belong to the above context, the temperature coefficient α is defined as:

$$\alpha = \frac{R_{100} - R_0}{100 \times R_0} = \text{and has the numerical value } 0,00385 \text{ } ^\circ\text{C}^{-1}$$

with: R_{100} is the resistance at 100°C and R_0 is the resistance at 0°C.

(for calculation purpose the exact value of $0,00385 \text{ } ^\circ\text{C}^{-1}$ is valid)

■ The allowed deviations for Pt 100 measuring resistances are determined by the following equations:

For Pt 100:

allowed deviations in°C = $(0,15 + 0,002 \times [t])$ for class A,
temperature range: -200°C up to +600°C / 3- and 4-wire circuit

allowed deviations in°C = $(0,30 + 0,005 \times [t])$ for class B
temperature range: -200°C up to +850°C / 2-, 3- and 4-wire circuit

[t] is the numerical value of the temperature in °C without considering the sign

CONNECTION OF RESISTANCE THERMOMETERS

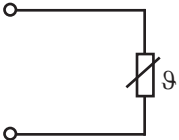
■ Connection of resistance thermometers

Resistance thermometers change their electrical resistance in dependence on temperature. In order to record the output signal, the line drop created by a constant measuring circuit is measured. Acc. to the Ohm's law the following is valid for this line drop:
 $U = R \times I$

In order to avoid the heating of the sensor, a small measuring circuit shall be chosen. A measuring circuit of 1 mA doesn't have any considerable impact. This current creates a line drop of 0,1 V with a PT 100 at 0°C. This measuring voltage has to be transferred to the display for evaluation as accurately as possible. We distinguish between four connection techniques:

■ 2-wire circuit

The connection between evaluation unit and thermometer is made by a 2 conductor cable. Like any other electrical conductor such a cable has a resistance itself in serial mounting with the resistance thermometer. Thus the two resistances are added that is interpreted as a higher temperature by the processing unit. In case of far distances the cable resistance can amount to several ohms and in this way falsify the measuring result.



example:

cable section: 0,35 mm²

spec. resistance: 0,0175 Ω mm² m⁻¹

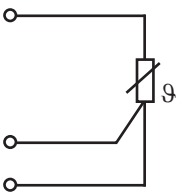
cable length: 50 m

cable material: E-copper (E-CU) $R = 0,0175 \Omega \text{ mm}^2 \text{ m}^{-1} \times \frac{2 \times 50 \text{ m}}{0,35 \text{ mm}^2} = 5,0 \Omega$

5,0 Ω correspond to a temperature change of 12,8°C with a Pt 100. In order to avoid this fault, the cable resistance is compensated electrically: The electronic unit is designed in a way that always a cable resistance of 10 Ω is considered. When the resistance thermometer is connected, a balancing resistance is connected into one of the measuring cables and first of all the sensor is replaced by a 100-Ω-resistance. Now the balancing resistance is changed as long as the display unit shows 0°C. The balancing resistance together with the cable resistance amount to 10 Ω. In most cases the balancing resistance wire is wound so that the balance is done by unwinding the wire. Due to this extensive balancing work, and the unknown temperature impact on the measuring cable, the 2-wire circuit is declining.

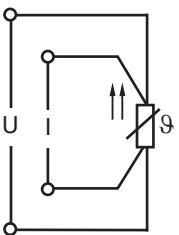
■ 3-wire circuit

In order to minimize the influences of the cable resistance and its temperature dependant fluctuations, the 3-wire circuit is frequently used instead of the above mentioned 2-wire circuit. Therefore, an additional cable is led to a contact of the RTD. Thus 2 measuring circuits are created, one of them being used as reference. Due to the 3-wire circuit, the cable resistance is compensated with regard to its amount as well as with regard to its temperature dependence provided that the 3 conductors have the same characteristics and are exposed to the same temperature. Thus a compensation of the cable resistance is no longer necessary.



■ 4-wire circuit

The best connection type for resistance thermometers is the 4-wire circuit. The measuring result is neither influenced by the cable resistance nor by their temperature dependant fluctuations. A compensation of the cable resistance is no longer necessary. The thermometer is fed with the measuring circuit via cable. Is the incoming resistance of the topped electronics a multiple of the cable resistance, it is to be neglected. Thus the voltage drop is independent from the characteristics of the line. For the 3-wire as well as for the 4-wire circuit it has to be considered that the circuit is not always led to the measuring element. The connection of the sensor to the connection head in the armature, the so called inner circuit, is often done in a 2-wire circuit. This results in the problems of a 2-wire circuit – even to a smaller extent.



U = voltage path
I = current path

INNER WIRES OF RESISTANCE THERMOMETERS

number of precision winding	circuit of inner wires			
	2-wire	3-wire	4-wire	2-wire with loop
Pt 100				
2 x Pt 100				
3 x Pt 100				



FLEXIBLE CABLES

- Halogen-free cables ■ Cable track cables
- Servo motor cables ■ ETFE, FEP, PFA cables
 - Bus cables ■ Torsion cables
- Hybrid and special cables ■ Control and connection cables
 - Data cables ■ Besilen® (Silicone) cables
- Compensating and extension cables ■ Tray cables

TEMPERATURE MEASUREMENT

- Protecting armatures and gauge slides
- Mineral insulated thermocouples and Mineral insulated resistance thermometers
- Temperature measurement in plastic processing industry/Hot runner technique
 - Diesel thermocouples ■ Probe with stainless steel sleeve
 - Temperature measurement in test vehicles
 - Measurement techniques

CABLE HARNESSING

- Harnessed cables acc. to customer's specification
 - Harnessed cable track cables
 - Helix cables ■ Cable harnesses
- Harnessed motor and transmission cables for Siemens and Indramat drives